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BULLETIN 6

Stratigraphy OF THE Garden City Formation in Northeastern Utah, and Its Trilobite Faunas

BY

REUBEN JAMES ROSS JR.

Department of Geology
Wesleyan University
Middletown, Connecticut

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STRATIGRAPHY OF THE GARDEN CITY FORMATION

INTRODUCTION

SCOPE OF THE STUDY

This is a report on the stratigraphy and the trilobite faunas of the Garden City formation as exposed in portions of northeastern Utah and southeastern Idaho (fig. 1).

Field work was carried out during the summers of 1946 and 1947. Since geologic maps of the area were available, attention was concentrated on the study of fourteen local sections, strategically located and favorably exposed. Eleven of these were measured and studied in some detail. The special search for silicified fossils resulted in the finding of numerous brachiopods, as well as the trilobites; the silicified forms were studied at Yale Peabody Museum during the winters 1946–47 and 1947–48.

ACKNOWLEDGMENTS

I am greatly indebted to Dr. J. Stewart Williams for suggesting the Garden City formation as a subject for study and for several important conferences in the field. My wife aided in the field reconnaissance of the 1946 season, and the extensive collecting of the second summer would have been impossible without the enthusiastic help of John Masters and William Swire, both undergraduates at Yale at the time.

I am equally grateful to Professors Carl O. Dunbar, C. R. Longwell, B. F. Howell, J. T. Gregory, and H. L. Whittington, and Doctors G. A. Cooper, K. M. Waage, John Rodgers, James L. Wilson, Peter Palmer, Alvin Hanson, W. A. Bell, Franco Rasetti, and N. O. Brown. P. A. Morris has aided in the reproduction of text illustrations.

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PREVIOUS EXPLORATION AND STUDY

The Garden City formation was originally named and defined by Richardson (1913, pp. 408–409), who called it the "Garden City limestone" for its exposure in Garden City Canyon, in Sections 3, 4, and 10, T. 14 N., R. 4 E., Randolph quadrangle, west of Bear Lake. It was stated to consist of a "succession of thick and thin bedded gray limestone approximately 1,000 feet thick" and to be characterized by the "presence throughout the formation of a conglomerate or breccia consisting of elongate bits of limestone up to 2 or 3 inches in length, irregularly imbedded in a matrix of similar composi-

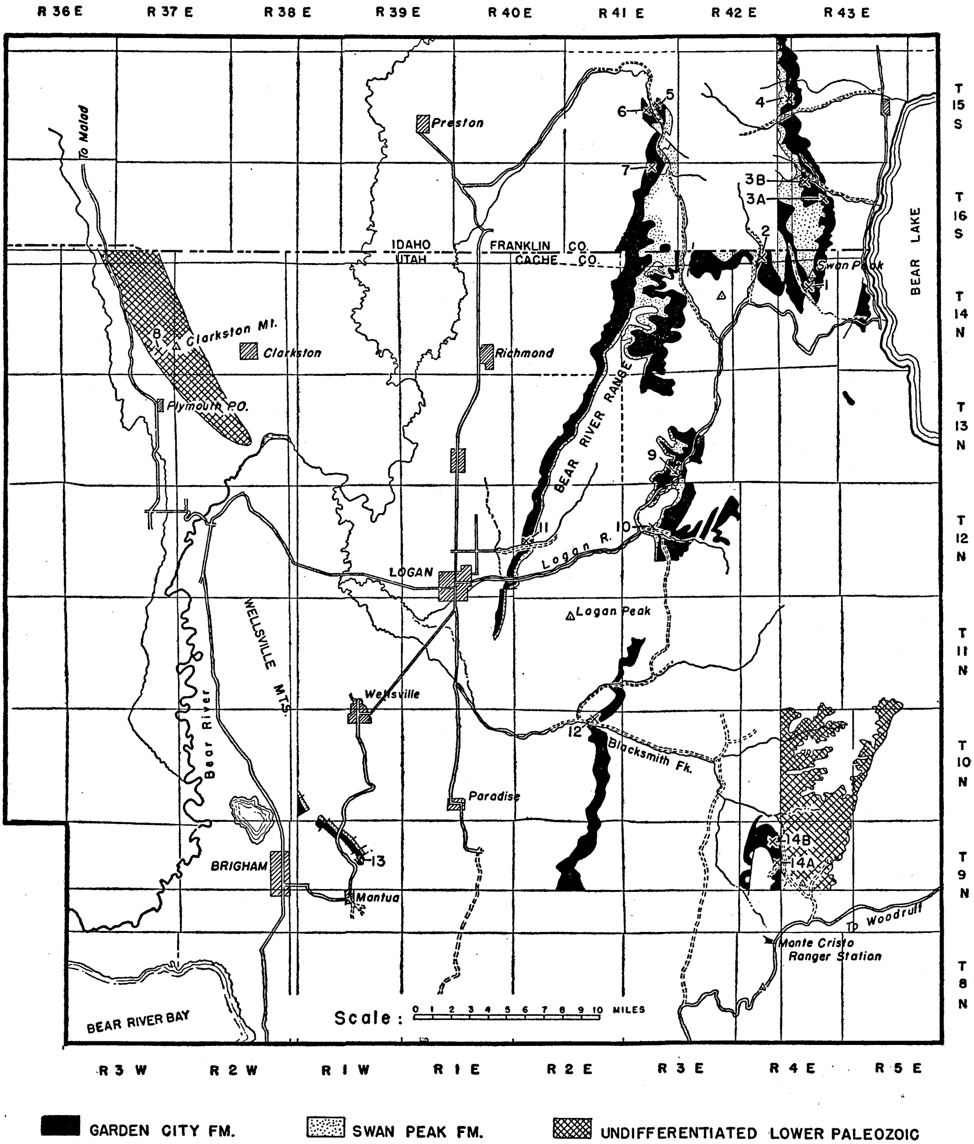


Figure 1. Areal distribution of the Garden City and Swan Peak formations in the Logan and Randolph quadrangles, Utah, and the southern Montpelier and Preston quadrangles, Idaho. Compiled from Butler et al. (1920), Mansfield (1927), Richardson (1941), and Williams (1948).

tion". Richardson further noted that the formation apparently overlay the St. Charles formation disconformably and was overlain by the Swan Peak "quartzite" conformably (1913, p. 408). It was considered to be of Beekmantown age.

The formation was recognized by Mansfield (1920, p. 32 and pl. III) and mapped in the Fort Hall Indian Reservation. There he noted that "the rock is dark gray limestone which contains much chert that weathers with rough surface, the chert becoming reddish". No thickness was given. In his work on southeastern Idaho (1927, p. 57) he practically used Richardson's description verbatim, except that the thickness was increased to 1,250 feet. Mansfield again recognized the Garden City beds in the Portneuf quadrangle (1929, p. 19).

In a discussion of the El Paso limestone, Kirk (1934, p. 456) suggested its contemporaneity with the Garden City formation and stated that the upper part of the underlying St. Charles formation (as then interpreted) was probably Early Ordovician, rather than Late Cambrian, in age.

Deiss, in his study of the Cambrian formations of the Cordilleran region (1938, pp. 1123–1124), discussed the underlying St. Charles formation and its relation to the Ordovician in Blacksmith Fork. He pointed out that 777 feet of the "Upper Cambrian" St. Charles formation, as originally defined, actually held Ordovician fossils and that, therefore, only the lower 400 feet were of Croixian age.

From this point on, Deiss's discussion of the St. Charles formation is confusing, for it is not clear whether he was still writing about the unit as it was originally defined, or whether he was limiting his description to the restricted 400 feet of allegedly definite Late Cambrian age. He continued by mentioning a white-gray dolomite near the top of the St. Charles and went on to state that "the upper 258 feet of the St. Charles consists of dull and blue-gray thick- and thin-bedded, fine- and medium-grained limestone, and intercalated edgewise conglomerates. Irregular chert nodules and lenses occur haphazardly in the upper 200 feet. The limestone and intraformational conglomerates in the upper part of the St. Charles are similar lithologically to those which comprise the lower 93 feet of the Ordovician" (p. 1124).

Deiss collected no fossils in this upper part, which he admitted could not be distinguished lithologically from the Garden City beds. The confusion resulting from this discussion made itself apparent in Richardson's report on the Randolph quadrangle (1941, pp. 13–14), in which the thickness of the Garden City "limestone" was increased to 1,900 feet, as a result of the work of Deiss and others; this increase involved the reassignment of the upper 900 feet of the St. Charles formation to the Garden City. The figure of 900 feet appears to be a rough approximation of the sum of "777 feet" and "258 feet" mentioned by Deiss.

Suffice it to say that the Garden City formation is not 1,900 feet thick anywhere in the Logan quadrangle, let alone at Blacksmith Fork. At its type section (locality 1, fig. 1) it is 1,225 feet thick; at Clarkston Mountain (locality 8), where it attains its greatest thickness in the area covered by this report, it is 1,760 feet thick.

Recently Williams (1948, pp. 1135–1137 and pl. 1) has described and mapped the Garden City and Swan Peak beds in the Logan quadrangle; he has noted the presence of "thick beds of dark gray dolomite at the top of the St. Charles formation", which are good stratigraphic markers used successfully by this author. No fossils have ever been found in this dolomite, but Williams and Maxey (1941, p. 282, fig. 2) and Duncan (personal communication) have found Cambrian fossils in the underlying beds. Williams (1948), furthermore, for the first time recognized and reported the multiple lithology of the Swan Peak strata.

A preliminary report of the present study by this author was published in 1949.

EXTENT OF THE FORMATIONS

Both the Garden City and Swan Peak formations are exposed over a fairly wide area in northeastern Utah and southeastern Idaho. They have been mapped in the northwest corner of the Randolph quadrangle, their type area (Richardson, 1941, pl. I), along the west side of the Montpelier quadrangle (Mansfield, 1927, pl. 9), and over a considerable portion of the Logan quadrangle (Williams, 1948, pl. 1). South of parallel 41° 30′ they are only sketchily known and they are apparently absent from the section in Ogden Canyon (Eardley, 1944, p. 827). The present author has searched in vain for them in the walls of the canyon.

The Preston quadrangle, lying to the north, has never been formally mapped, but portions were reconnoitered by members of the Yale summer course in geology during the 1946 and 1947 seasons; to them I am indebted for the information necessary to fill in outcrop belts in Townships 15 and 16 South, Ranges 41 and 42 East.

The formations also appear further north in the southwest corner of the Portneuf quadrangle (Mansfield, 1929, pl. I), and in scattered patches on the Fort Hall Indian Reservation (Mansfield, 1920, p. 32 and pl. III). They are also known to outcrop in the vicinity of Malad, Idaho (Williams and Duncan, personal communication).

Three areas, originally mapped as undifferentiated Paleozoic, are of note. In the Clarkston Mountain region (T. 13 N., R. 2 W. to T. 14 N., R. 3 W.) a fairly complete Cambro-Ordovician succession is known to exist (Butler et al., 1920, pl. IV; Hanson, personal communication), and the presence of the St. Charles, Garden City, Swan Peak, and Fish Haven formations has been verified in connection with this report. Richardson (1941) mapped a large similar area in the southwest corner of the Randolph quadrangle, which is now known to include the Garden City formation, but no Swan Peak beds. The third area is located in Township 9 South, Range 41 East, which was indicated on Mansfield's index map (1927, pl. I), but not covered by any of his detailed maps of quadrangles. Whether or not this last area includes Garden City and Swan Peak beds is not yet known.

It is of great interest that Lehi Hintze has been able to establish detailed correlation of both formations in the Ibex Range to the southwest on the basis of trilobite zonal assemblages presented on the following pages (Hintze, work in progress, personal communication).

In thickness the Garden City formation varies from 1,760 feet at Clarkston Mountain on the northwest to approximately 1,180 feet on the southeast at Davenport Hollow. It attains approximately 1,400 feet at Mantua on the southwest and at Green Canyon, immediately north of Logan; and reaches 1,225 feet at the type section in Garden City Canyon. In the Fort Hall Reservation Mansfield gave no thickness (1920, p. 32), but he recorded a minimum of 1,130 feet in the Portneuf quadrangle (1929, p. 19).

The Swan Peak's thickness is equally variable. At its type section on Swan Peak the top has obviously been eroded away, but over 300 feet remain. Although part of the section may be cut out by a fault, at least 570 feet are present at Clarkston Mountain. At Mantua the total thickness is about 270 feet, while the formation is absent at Davenport Hollow on the southeast. In St. Charles Canyon it is approximately 500 feet thick.

It then becomes evident that both formations thin to the southeastward and thicken north- and westward.

STRATIGRAPHY

FORMATION BOUNDARIES

In this study the lower boundary of the Garden City formation has been placed at the base of the lowest limestone bed above the thick, gray, brownish-white weathering dolomite of the St. Charles formation. This is the basis on which the two formations were separated by Williams (1948, p. 1135) in mapping the Logan quadrangle; it has been found to be in accord with the fossil evidence for the boundary between the Cambrian and Ordovician at most of the localities studied for this report. In those places where there was lack of evidence for agreement there was similarly a lack for disagreement.

Earliest Ordovician trilobites (Zones "A" and "B", below) occur at an approximately uniform level above the Garden City–St. Charles contact throughout the area studied. Unfortunately no fossils have ever been found in the upper dolomite of the St. Charles formation; its lower limestones contain a Franconian fauna (Williams and Maxey, 1941, p. 284). The exact age of the dolomite is not known, therefore, but may well be equivalent to the Trempealeau.

The lowest beds of the Garden City lie with apparent conformity above this dolomite, there being more evident surfaces of disconformity within the lower 200 feet of the Ordovician formation (pl. 2, fig. 1). Until fossils are secured from the uppermost St. Charles beds it is impossible to be certain as to the exact position of the inter-systemic boundary and as to the disconformable or conformable relations between the two formations.

With the exception of Williams (1948, p. 1136), previous workers have stated that the Garden City beds are overlain directly by Swan Peak quartzite. Actually there is an intermediate zone of shaly and silty beds about 150 feet thick that has generally been overlooked because it is weak and in most places is covered by float (pl. 6, fig. 2). This we find to be a basal member of the Swan Peak formation.

In places there are lenticular layers of limestone near the base of these shales, and higher up there are thick to thin layers of quartzite that increase in importance toward the top, forming a transition into the typical Swan Peak quartzite. Since the shales thus show transitional boundaries with the underlying Garden City limestone, as well as with the overlying quartzite, it is possible that one formation may be the local facies equivalent of the other. Nowhere has faunal evidence been found to substantiate this possibility, and available evidence serves to discourage its further consideration within this area. At a few localities, including localities 2, 8, and 13, thin beds of calcareous or quartzitic sandstone do immediately overlie the Garden City beds.

As a result the top of the Garden City formation was defined as the base of the lowest shale, siltstone, sandstone, or quartzite bed of the Swan Peak formation. This is the basis on which Williams (1948) mapped the formation in the Logan quadrangle and the one found most satisfactory in this investigation.

LITHOLOGY OF THE GARDEN CITY FORMATION

Lithologically, the Garden City formation can be divided generally into two members, the lower being predominantly intraformational limestone conglomerate and the upper being less conglomeratic and very cherty.

The lower member, which comprises about two-thirds of the formation, is a complex of interbedded layers of intraformational conglomerate, muddy limestone, and crystalline limestone with some layers of compact, thinly laminated, crypto-crystalline limestone (pls. 1–3; 4, fig. 1; 5, fig. 1; Ross, 1949, pls. 1, 2). No sequence of beds in this member has yet been verified that can be identified in more than one locality. In fact, an early attempt to match beds of the lower 300 feet of the formation on the north and south sides of Green Canyon (locality 11), some 400 yards apart, was unsuccessful for, as is usual in this member, most of the beds thicken and thin, or lens-out completely, within short distances. Only a few resistant laminated aphanitic limestone beds are at all persistent.

The lensing of individual beds is exemplified on a small scale by a 24-foot ledge 68 feet above the base of the formation at locality 5 (pl. 1). The upper part of this ledge is composed of shaly limestone overlain disconformably by fine-grained crystalline limestone; the latter appears to fill a channel, the lowest point of which is slightly to the right of the white six-inch ruler in plate 2, figure 2.

Ripple marks also occur on bedding surfaces in several localities. The best exposed of these are found on the north side of Green Canyon (locality 11), 86 feet above the base of the formation, on the stripped dip-slope of a limy mudstone (pl. 2, fig. 2). Several feet above this bed another stripped surface reveals a coarse pebble layer (pl. 5, fig. 1) in which the crystalline limestone pebbles are set in a buff mudstone matrix. At locality 5, 315 feet above the base of the formation, ripple marks are roughly preserved in the surface of resistant crypto-crystalline limestone beds.

Cross-bedding in coarsely crystalline limestone was found at the west end of an abandoned road-cut at locality 9, approximately 300 feet below the top of the Garden City formation (Ross, 1949, pl. 1, fig. 2).

Another feature of the lower member of the formation is the random scattering of white to light-gray chert stringers in the lower 300 feet. They are not limited to any one zone of that interval and are not to be confused with black chert in the upper third of the formation from which they are quite distinct. At locality 11 the stringers are found 40 feet above the base, but only their cross-sections are exposed; they lie roughly parallel to the bedding but here and there cut across thin layers. The stringers are much better exposed at locality 7, where on several dip-slope surfaces about 240 feet above the base of the formation they lie in rectilinear patterns which strongly suggest that the emplacement of the chert was controlled by joints (pl. 3, fig. 1). A similar phenomenon on a much smaller scale was found 420 feet above the base of the type section (locality 1), which is clearly related to small joints.

In the middle third of the formation the percentage of intraformational conglomerates is considerably higher than in the lower third, where shaly and muddy limestone and crystalline limestone beds comprise much of the section. In this middle third it is, in places, difficult to decide whether a bed should be considered crystalline limestone, crystalline limestone with muddy limestone pebbles (pl. 4, fig. 1), or intraformational conglomerate with crystalline pebbles in a muddy limestone matrix (pl. 3, fig. 2). As in the lower third, individual beds not only lens-out, but their lithologies may change within several feet. In this portion there are in most localities several beds of a more persistent nature, composed of crudely laminated, crypto-crystalline, resistant limestone (Ross, 1949, pl. 2, fig. 2).

The upper one-third of the Garden City formation is sufficiently uniform throughout the area studied to be recognized with little more than a glance. Unlike the seemingly endless alternations and variations of lithologies of the lower two-thirds, this upper member is made up predominantly of thick, generally resistant beds of crypto-crystalline, dark limestone, composed for the most part of thin, discontinuous, very irregular laminae, one-half to one inch thick. The laminae are separated in most cases by paper-thin layers or partings of mud which give vertical surfaces a peculiar wavy appearance (Ross, 1949, pl. 3, fig. 1).

The most striking feature of this upper member is its high content of chert. In every locality visited, nodules, stringers, and "discontinuous beds" of black chert were found oriented parallel to the laminae of resistant crypto-crystalline limestone beds (pl. 4, fig. 2; Ross, 1949, pl. 3, figs. 1, 2). In all localities studied, there is one zone in which chert makes up at least 50 percent of the exposed rock. Above it the percentage slowly dwindles until at the very highest limestone or dolomite exposure very little or no chert is present. Other cherty zones are present in the formation—one in the lower 300 feet, already discussed, and one inconsistently present at about the midzone, but neither of these is as thick or possesses such a high and persistent chert content. That this upper chert zone has stratigraphic significance appears certain, not only from its presence over a wide area, but also because an identical fauna is found in it throughout the area.

Some rather coarsely crystalline dolomite was found at the very top of the formation at all localities studied, and it has also been recognized by Duncan (personal communication) at Blacksmith Fork and St. Charles Canyon. This was at first believed to be a *bona fide* sedimentary unit, also stratigraphically persistent over a wide area. At locality 13 (Mantua) it was discovered that a fine-grained dolomite bed directly underlay a shaly quartzite bed of the Swan Peak; when this bed was tested with dilute HCl for a distance of 200 feet along the outcrop it was found to change to limestone without any visible line of demarcation between the two. Not only was this the case in a lateral, but also in a vertical sense. As a result, locality 11 (Green Canyon) was revisited. There the HCl test showed limestone present up to the Swan Peak contact, with dolomite localized along and fringing definite finely fractured zones produced by shearing.

At the type section of the Garden City on the south side of Swan Peak (locality 1) exposures are too heavily mantled off the crestlines of ridges to permit the following of a bed for any appreciable distance. Therefore, although there is a thick dolomitized zone at the top of the exposed formation, how persistent it may be within fairly short distances along the strike is not known. Fortunately there is, here, other definite evidence of secondary dolomitization, for in one zone a thin bed of "typical" intraformational conglomerate is now completely composed of coarse crystalline dolomite, the pebbles being reduced to dark-colored relicts in a lighter matrix.

All the visited localities have one feature in common—they are all adjacent or close to zones of faulting. For instance, localities 3A and 3B (Fish Haven Canyon), 1 (Garden City Canyon and Swan Peak), 14A and 14B (Davenport Hollow), and 4 (St. Charles Canyon) are all located along the east edge of the Bannock Overthrust. Locality 5 (Hillyard's Canyon, east) is located on one of the several fault blocks and was measured up the face of a fault-line scarp; Hillyard's Canyon itself is a fault valley. At locality 13 (Mantua) sections were measured on opposite sides of a fault; it was at this locality (see above) that the sedimentary origin of the dolomite was first doubted. At locality 8 (Clarkston Mountain) where the dolomitized zone is thickest, the section is cut by no fewer than three faults just above the Swan Peak contact. It therefore seems possible that the dolomitization is related to faulting; but why it should have acted selectively on certain beds without affecting the underlying portions, if not the whole of the formation, is an enigma.

The possibility that the replacement might have been a result of weathering on the uppermost beds, prior to the deposition of the Swan Peak, must be considered. In St. Charles Canyon (locality 4), however, beds of limestone overlie those of dolomite with no apparent indication of an important break in sedimentation. In many other parts of the formation evidence of disconformities is much clearer. That dolomitization has been caused by weathering is suggested by the exposure along Buck Spring road (locality 14A). Here the Fish Haven dolomite overlies the Garden City with no Swan Peak intervening. The absence of the Swan Peak may indicate a definite break in sedimentation with prolonged weathering, but below the roots of an overturned tree directly below the Fish Haven dolomite, limestone beds were discovered, which had only recently been exposed to the weather. This would seem to indicate that dolomitization at this locality took place only on surfaces exposed to weathering for long periods of time and since the present erosion cycle commenced.

LITHOLOGY OF THE SWAN PEAK FORMATION

The Swan Peak formation is probably the most easily recognized unit in the Paleozoic section of the area studied. Although it resembles the Brigham quartzite at first glance, it is easily distinguished by its prolific trilobite and brachiopod fauna and by the great abundance of worm burrows, fucoid markings (pl. 6, fig. 1), which occur in most of the quartzite beds.

As recorded by Williams (1948, p. 1136) and as stated above, the Swan Peak formation is not entirely quartzitic. Its appearance at the type section (locality 1) is misleading, and the lower half is masked by rusty-colored silty, sandy, and badly weathered quartzite rubble (pl. 6, fig. 2); the figure in the photograph is standing squarely on the Garden City–Swan Peak contact; behind him the lower 170 feet of the formation are float-covered, and the lowest quartzite ledges can be seen in the clumps of mountain mahogany on the right, halfway up the slope. At locality 2, 3 miles to the west-northwest, there is a good exposure along the small gorge of Beaver Creek, in several fault blocks. Here one can see the thick, massive, vitreous quartzites of the upper part of the formation overlying thinner, more fossiliferous beds. Progressively lower the quartzites thin, and more and thicker interbeds of shale are present. Limestone lenses, rich in ostracods, occur in the lowest shales with a few thin calcareous and quartzitic sandstone layers present within approximately 20 feet of the base of the formation. There is little question that the black shales exposed at locality 2 are present but hidden by mantle and float at the type section.

Southward, the upper quartzites thin out. At locality 10 (fig. 14) they have decreased by half, and at locality 12 (Blacksmith Fork) only thin interbeds of quartzite, shale, and lenticular limestone are present in the formation. At locality 14 (Bucks Spring road) the formation is absent.

To the west at Clarkston Mountain (locality 8) 50 feet of thick quartzites and sandstones with calcareous cement directly overlie the Garden City formation. Although no shales were observed near the base of the Swan Peak beds in this region, a short interval overlying the bottom 50 feet of sandstone is covered in much the same manner as the lower part of the type section; this interval may represent shale beds.

DETAILED STRATIGRAPHIC SECTIONS AND COLLECTING LOCALITIES

Of the fourteen localities recorded in the following pages, five (localities 4, 6, 7, 9, 12) were visited only for the purpose of collecting fossils; although each of these was measured, only cursory notes were taken on the lithology. The section at locality 4 was measured to verify the thicknesses reported by Duncan (personal communication); in the field it was possible to recognize the uppermost and lowermost faunal zones that are present at locality 5. Absence of the upper cherty member of the Garden City formation at locality 7, plus topographic peculiarities, leads to belief that the upper part of the section is cut by at least one fault.

Seven of the sections are represented graphically in plate 7; as drawn they are very generalized, since no effort has been made to indicate the relative abundance of the different types of limestone in the lower member of the Garden City formation.

Locality 1. *Swan Peak and Garden City Canyon* (E. ½, Sec. 10, and N.W. ¼, Sec. 11, T. 14 N., R. 4 E.)

This is the type section of the Swan Peak and Garden City formations. The former and the upper 200 feet of the latter are best exposed along the ridge running southeast from the top of the peak, but thick mountain mahogany hinders measuring the lower part of the section. The full section was measured along the spur running south into Garden City Canyon and supplemented with data taken from the traverse of the southeast ridge.

Swan Peak formation:

Top eroded

Vitreous, white, massive quartzite, stained red locally, with thin, red impure fucoidal layers; exposed in large joint blocks, measuring approximately 8′ x 9′ x 4′ .... 22 feet

White quartzite in 6-inch to 3-foot beds 23

Slope covered by mountain mahogany, completely masked; probably underlain by black shale 36

Fucoidal red quartzite and interbedded white quartzite in 6-inch to 1-foot layers, *Orthis swanensis, Eleutherocentrus petersoni.* Zone "M" 87

Slope covered by rusty, silty shale and sandstone "chips" with limy shale at base; this interval corresponds to the black shale and shaly limestone at the base of the formation at locality 2 146

Total exposed thickness:........ 314 feet

Garden City formation:

Upper Cherty member:

Alternating dolomite and limestone beds in zones approximately 20 feet thick. Limestone predominantly aphanitic and laminated, the half-inch laminae being separated by wavy mud partings; beds 3 to 8 feet thick. Black chert stringers increase from scattered nodules 100 feet above the base until they compose 30 percent of the rock near the base. In the lower beds are *Tritoechia* sp., *Diparelasma* sp. (small), *Hesperonomia* sp., *Goniotelus* sp., and a *Niobe*-like pygidium. Zone "J", "K", or "L" (?) 160

Coarse crystalline dolomite with "interbedded" black chert stringers, each in 2–3 inch layers; chert forming 50 percent of the rock. Dolomite gradually grading to limestone in the lower 20 feet. In the upper half are *Blastoidocrinus* cf. *B. carchariaedens, Diparelasma* sp., *Tritoechia* sp., *Hesperonomia* sp., and a digitate proparian pygidium possibly referable to *Parapilekia.* Zone "J" 46

Lower member:

Resistant, aphanitic limestone in thin irregular laminae and minute lenses separated by muddy partings 41

Slope covered by blocky limestone float and sagebrush 82

Thin ledges of buff-weathering, fine-grained muddy limestone and intraformational conglomerate protruding through mantle	36 feet
Thin ledges of coarse intraformational conglomerate in crystalline limestone matrix, protruding through float	52
Resistant, thin-bedded aphanitic limestone in 1-foot layers interbedded with 2–3 inch layers of finely crystalline limestone and intraformational conglomerate	4
Coarse intraformational conglomerate, in a muddy matrix, interbedded and interlensed with coarsely crystalline limestone	20
Crudely laminated muddy limestone	3
Coarse intraformational conglomerate in beds 3 feet thick at top, decreasing in thickness downward to 3-inch to 1-foot interbeds at bottom	53
Massive, aphanitic black limestone in 2–4 foot beds, containing abundant sponges	18
Coarse intraformational conglomerate in 6-inch to 1-foot beds	19
Aphanitic, resistant, laminated limestone; laminae approximately ½ inch thick and separated by wavy mud partings	3
Coarse intraformational conglomerate in a crystalline matrix, in 6-inch to 1-foot beds	12
Aphanitic resistant limestone composed of ½-inch wavy laminae	5
Intraformational conglomerate in both crystalline and muddy matrices with a few thin 2-inch layers of buff-weathered muddy limestone in the lower 25 feet	45
Crudely laminated, resistant, muddy limestone in beds 1–2 feet thick, with interbeds of crystalline limestone and intraformational conglomerate	15
Intraformational conglomerate in a muddy matrix in 2–3 foot beds, interlayered with 1-foot beds in a crystalline matrix	20
Coarse intraformational conglomerate in a crystalline matrix in 6-inch to 2-foot beds, interlayered with crudely laminated muddy limestone	78
Thin ledges of intraformational conglomerate in both crystalline and muddy matrices, protruding through coarse float	21
Float-, soil-, and sage-covered slope	116
Interbedded coarse intraformational conglomerate in a crystalline matrix and crystalline limestone, both varying from 6-inch to 3-foot beds	39
Resistant, aphanitic, laminated limestone beds, 4–5 feet thick, interlayered with muddy limestone and intraformational conglomerate in 3–6 inch beds	34
Thin (3-inch to 1-foot) interbeds of medium-grained intraformational conglomerate, crystalline limestone, and muddy limestone, weathered buff	35
Aphanitic and finely crystalline limestone in 1-inch layers	4
Thin (3-inch to 1-foot) interbeds of medium-grained intraformational conglomerate, crystalline limestone, and buff-weathered muddy limestone	9
Resistant, aphanitic limestone in 3–4 foot layers, with 1-foot interbeds	

of buff-weathered muddy limestone and 2–3 foot interbeds of fossiliferous crystalline limestone. Large nautiloids	51 feet
Crystalline limestone and intraformational conglomerate in a crystalline limestone matrix in beds 3 feet thick at top, thinning downward and changing to muddy, buff-weathered limestone	81
Coarse intraformational conglomerate in a muddy matrix	3
Two- to three-foot beds of resistant intraformational conglomerate in an aphanitic limestone matrix, with thin, less resistant interbeds of muddy limestone, 6 inches thick. Scattered light-gray stringers of chert	64
Resistant, aphanitic, dark gray, laminar limestone in 2–4 foot beds, with thin interlayers of muddy, buff-weathered limestone and some thin lenses of intraformational conglomerate. *Clelandia utahensis, Bellefontia acuminiferentis* at top; *Symphysurina* sp. A at bottom. Zones "B" and "A"	16
Slope covered by coarse, blocky limestone float	37
Total thickness:	1,222 feet

Top of cliff-forming dolomite of the St. Charles formation.

Locality 2. *East side of Beaver Creek, immediately south of the Idaho-Utah state line* (E ½, Sec. 35, T. 15 N., R. 4 E.)

This locality was originally included to establish the presence of black shale beds in the lower part of the Swan Peak formation; these shales are not exposed at the type locality (see above). Although the topmost beds have been eroded, the upper vitreous quartzites and lower fossiliferous quartzitic sandstones total 191 feet in thickness. The underlying black, flaky shales are approximately 147 feet thick with crystalline limestone lenses appearing 20, 35, and 50 feet above the base; thin quartzitic sandstones are present in the lowest 10–15 feet. The brachiopod-trilobite-ostracod faunal assemblage of Zone "M" is abundantly represented in the lower 170 feet.

Because of faulting, the top only of the Garden City formation is exposed, revealing most of the cherty member. Faunal Zone "L" with *Anomalorthis* n. sp., *Orthis* cf. *O. subalata,* and *Blastoidocrinus* sp. is located 105–120 feet below the top of the formation, while the characteristic brachiopods and some of the trilobites of faunal Zone "J" are found 30–40 feet lower.

Locality 3. *Fish Haven Canyon*

The Swan Peak and Garden City formations are poorly exposed on both sides of the canyon approximately 4 miles west of Fish Haven, Idaho. The sections measured were not considered satisfactory because of the thickness of plant and forest cover and because of faulting. The few salient facts concerning this locality have been reported previously (Ross, 1949, p. 484, text fig. 2).

Locality 4. *St. Charles Canyon* (6 miles west of St. Charles, Idaho; Sec. 13, T. 15 S., R. 43 E.)

Like locality 3, this section was found to be unsatisfactory and warrants no further discussion than that previously published (Ross, 1949, pp. 484–485, text fig. 2).

Locality 5. *East side of Hillyard's Canyon* (1.8 miles north of the head of the canyon; S.E. ¼, Sec. 17, T. 15 S., R. 41 E.)

This locality and locality 6, on the other side of the canyon, have provided the bulk of the trilobite faunas collected; these sections are more readily accessible than the type and the fossil preservation is far better.

Swan Peak formation:

Although thinly represented 100 yards east of the top of the section by quartzite beds, only a thin veneer of rusty shale and silty "chips" immediately overlies the Garden City formation at the measured traverse. Because of the thick vegetation separating the two points and the abundance of faults of large displacement along the canyon, it is considered unwise to include any thickness for the Swan Peak here.

Garden City formation:

Upper Cherty member:

Probably slightly eroded at the top.	
Light gray, finely crystalline dolomite and dolomitic limestone, weathering light, yellowish brown	5 feet
Light gray, non-cherty, crystalline limestone. *Protospongia* sp., *Blastoidocrinus* cf. *B. carchariaedens, Anomalorthis* sp., *Syntrophopsis transversa.* Zone "L"	80
Cliff-forming, thick-bedded, thinly laminated, aphanitic limestone with "interbedded" black chert stringers comprising 60 percent of the rock. In the upper half: *Blastoidocrinus* cf. *B. carchariaedens, Hesperonomia* (small indet. sp.), *Diparelasma* sp. (small). Zone "K". In the lower third: *Hesperonomia* sp., *Diparelasma* sp., *Tritoechia* n. sp., *Syntrophopsis* cf. *S. polita, Petigurus* ? sp.	131
Irregularly interlensed, yellow-weathering siltstone and finely crystalline limestone, both fossiliferous. *Hesperonomia dinorthoides, Diparelasma* sp., trilobites of Zone "J"	4
Cliff-forming, thick-bedded, irregularly laminated, aphanitic limestone with "interbedded" black chert stringers comprising 50 percent of the rock. *Hesperonomia* cf. *H. dinorthoides, Diparelasma* cf. *D. typicum, Diparelasma* sp. (small, may be immature), several indet. Asaphid trilobites	151
Lower member:	
Irregularly and thinly bedded crystalline limestone, weathering with pink, chalky blotches on the surface. Contains a "coquina" of fossil fragments	48
Float-covered slope with low ledges of crystalline limestone and intraformational conglomerate protruding. *Trigonocerca typica.* Zone "H"	32
Thin-bedded, finely crystalline limestone	15

Slabby, muddy limestone. *Trigonocerca typica.* Zone "H"	3 feet
Resistant, irregularly laminated, aphanitic limestone	11
Interbedded crystalline limestone and intraformational conglomerate in a crystalline matrix. *Trigonocerca typica.* Zone "H"	15
Float-covered slope	27
Thin ledges of intraformational conglomerate and muddy, laminated limestone, protruding through float. *Bellerophon*-like gastropods, *Protopliomerops contracta. Psalikilus typicum.* Zone "G(2)e"	68
Intraformational conglomerate in a crystalline limestone matrix	5
Irregularly laminated, aphanitic limestone interbedded with coarse intraformational conglomerate, in 2- to 5-foot layers. Partly masked by float. *Menoparia genalunata, Psalikilus typicum.* Zone "G(2)e"	60
Same lithology as above. *Protopliomerops contracta, Jeffersonia peltabella,* undetermined pygidium (pl. 30, figs. 20, 21, 24). Zone "G(2)e"	82
Coarse intraformational conglomerate with pebbles up to 4 inches in diameter, in beds 2–4 feet thick, with minor interlayers of yellow-weathered siltstone; partly masked by mantle. *Dictyonema* sp. in siltstones	76
Laminated, muddy limestone interbedded with thin layers of intraformational conglomerate. *Licnocephala bicornuta, Psalikilus typicum, "Xenostegium" taurus.* Zone "G(2)a"	70
Interbedded, irregularly laminated muddy limestone, coarse intraformational conglomerate, and slabby aphanitic limestone, of which the first forms the thickest layers. Complete trilobite assemblage of Zone "G(2)a"	61
Float-covered slope	68
Ledge of intraformational conglomerate in crystalline matrix. *Hystricurus* ? sp., undetermined pygidium (pl. 30, fig. 27), Undet. Gen. and Sp. C. Zone "G(1)"	1
Float-covered slope	70
Slabby, laminated, muddy limestone with minor crystalline limestone lenses	4
Resistant, aphanitic, irregularly laminated limestone, equally divided by 1-foot coarsely crystalline, fossiliferous limestone bed. Indet. gastropods	8
Float-covered slope	14
Coarse intraformational conglomerate with pebbles up to 3 inches in diameter	2
Compact, cherty laminated limestone in 1- to 2-inch irregular laminae	4
Resistant, massive aphanitic limestone with scattered black chert nodules	20
Slabby, muddy limestone. Complete trilobite assemblage of Zone "E"	1
Float-covered slope	4
Reddish-weathered, muddy, laminar limestone, overlain with erosional unconformity by compact, cherty, aphanitic limestone	6
Float-covered slope	5

Laminated, aphanitic limestone	2 feet
Float-covered slope	16
Compact, aphanitic, light-gray limestone, overlain by muddy, laminar limestone	9
Limy, laminated mudstone, bearing indeterminate graptolites	6
Float-covered slope	25
Compact, laminated aphanitic limestone	8
Float-covered slope	11
Slabby, laminated, aphanitic limestone with scattered chert nodules	15
Interbedded intraformational conglomerate, muddy laminated limestone, and compact intraformational conglomerate in muddy matrix, with scattered chert nodules	8
Thin-bedded, shaly limestone	1
Muddy, irregularly laminated limestone	7
Aphanitic, resistant limestone with scattered chert nodules	8
Intraformational conglomerate and crystalline limestone in irregular layers 2–3 inches thick	29
Coarsely crystalline limestone. *Apheorthis* cf. *A. meeki, Leiostegium manitouense*. Zone "D"	2
Coarse edgewise conglomerate with pebbles up to 5 inches in diameter, and a few thin layers of muddy and crystalline limestone. *Tetralobula* (?) sp. Trilobites of zone "C"	27
Edgewise conglomerate in crystalline limestone matrix, with pebbles up to 2 inches in diameter	17
Float-covered slope	13
Massive, dark gray, fine-grained limestone, deposited with erosional unconformity on underlying beds. *Clelandia utahensis, Hystricurus genalatus, H. politus, Remopleuridiella caudalimbata, Bellefontia* sp. Zone "B"	9
Thick, irregularly laminated muddy limestone, with intraformational conglomerate lenses. *Bellefontia acuminiferentis*	8
Float-covered slope	4
Laminated, light-gray, finely crystalline and aphanitic limestone, with minor amounts of black chert in scattered nodules	13
Float-covered slope	17
Finely crystalline limestone with scattered mudstone pebbles. *Nanorthis* ? sp., *Hystricurus* sp. D, *Pseudohystricurus rotundus, Symphysurina* sp. A. Zone "A"	3
Float-covered slope	32
Total thickness:	1,441 feet

St. Charles formation:
Massive, resistant dolomite.

Locality 6. *Crest of ridge on west side of Hillyard's Canyon*

This section has yielded almost half of the present collection of silicified trilobites. No attempt was made to record detailed lithologies, but distances between faunal zones were carefully measured. The species from each of these are listed below with the *cumulative* distance above the base of the Garden City formation indicated.

Unfortunately the upper portion of the formation is covered by vegetation and soil, so that only the lower 710 feet could be examined.

Garden City formation (lower 710 feet):

Top of measuring	710 feet
Psalikilus typicum, Protopliomerops contracta, Menoparia genalunata, Asaphellus ? sp. B, *Basilicus* ? sp. Zone "G(2)d"	655
Menoparia genalunata, Protopliomerops contracta. Zone "G(2)?"	609
Psalikilus typicum, Menoparia genalunata, Protopliomerops contracta, Basilicus ? sp., *Asaphellus* ? sp. A. Zone "G(2)c"	558
Psalikilus typicum, Menoparia genalunata, Scinocephalus solitecti, Licnocephala bicornuta, L. ? sp., *Macropyge gladiator, Platycolpus* ? sp. Zone "G(2)a"	498
Menoparia genalunata, Protopliomerops celsaora, Asaphellus ? *eudocia.* Zone "G(1)"	480
Amblycranium cornutum, Hyperbolochilus marginauctum, Goniophrys prima, Hypothetica rawi, Hystricurus acumennasus, H. contractus, H. flectimembrus, H. oculilunatus, Parahystricurus fraudator, P. oculirotundus, P. pustulosus, Protopliomerops superciliosa, Pseudoclelandia cornupsittaca, P. fluxafissura, Pseudohystricurus obesus, Pyraustocranium orbatum, Hillyardina semicylindrica, Pachycranium faciclunis, Undet. Genera and Species A, B, and E. Zone "F"	306
Hystricurus aff. *H. robustus, Paenebeltella vultulata.* Zone "E"	273
Amblycranium variabile, Hystricurus robustus, Paenebeltella vultulata, Parahystricurus carinatus, Amblycranium ? *populus.* Zone "E"	207
Amblycranium variabile, Paenebeltella vultulata, Tesselacauda ? sp., undetermined *Apatokephalus*-like species. Zone "E"	152
Clelandia utahensis, Hystricurus genalatus, H. paragenalatus, H. politus, Remopleuridiella caudalimbata, Bellefontia chamberlaini, B. ? *acuminiferentis.* Zone "B"	126–117

St. Charles formation:
Massive dolomite.

Locality 7. *West side of Franklin Basin* (1 mile west of road; Sec. 5, T. 16 S., R. 41 E.)

Like locality 6, this section was measured merely for purposes of faunal zoning and no attempt was made to record lithologies in detail. Although measuring seems to indicate that the Garden City formation is over 1,300 feet thick here, there is no indication of the upper cherty member, which in other places is cliff-forming. This fact, plus the topography, suggests that the west side of Franklin Basin is bounded by one or more faults, rendering the upper portion of the section of questionable value for stratigraphic measurement.

From the well-exposed lower reaches of the formation the most extensive collections of faunal zone "B" were originally taken 125–145 feet above the base. The species secured are *Hystricurus genalatus, H. paragenalatus, H.*

politus, H. ? sp. G., *H.* ? sp. H, *Remopleuridiella caudalimbata, Bellefontia chamberlaini, B.* ? *acuminiferentis, Xenostegium franklinense, Clelandia utahensis, Parahystricurus* ? sp. B, *P.* ? sp. A, Undetermined Genus and Sp. D.

A return visit to this locality during the 1949 field season netted the important discovery of *Symphysurina* in profusion (faunal zone "A") in an interval 19–84 feet above the base of the formation, with a species very close to, if not identical with, S. *woosteri* Ulrich (pl. 23, figs. 7–12; Walcott, 1925, p. 115, pl. 21, figs. 1, 2, 3, 5, 10, 11, not 9), occurring 50 feet above the base. At the 85-foot level a few elements of zone "B" were found to be mixed with this *Symphysurina* fauna, including *Clelandia* and *Hystricurus.*

An earlier collection taken close to the apparent, but surely faulted, top of the formation contained *Psalikilus typicum, P.* ? sp., and *Platycolpus* ? sp.; there is definite indication at localities 5 and 6 that this small assemblage falls between Zones "G(2)a" and "G(2)c", and for this reason it has been given a *tentative* designation of "G(2)b".

Locality 8. *West side of Clarkston Mountain* (Sec. 25, T. 14 N., R. 3 W.)

The base of the Garden City formation is exposed approximately 2,500 feet above U.S. Highway 191.

Fish Haven dolomite:	
Fault ?	
Swan Peak formation:	
Vitreous, white quartzite, thick bedded at top; beds decreasing in thickness downward. *Eleutherocentrus petersoni.* Zone "M"	520 feet
Buff-weathering, white or light gray quartzite with calcite cement; crumbles on weathered surface. Abundant casts and molds of undetermined gastropods and brachiopods	50
Total thickness:	570 feet
Garden City formation:	
Upper Cherty member:	
Irregularly laminated, resistant, finely crystalline, light gray dolomitic limestone and dolomite, weathering light, brownish gray. Laminae separated by "paper thin" mud partings. *Orthis* cf. *O. subalata, Anomalorthis* n. sp. at top; *Hesperonomia* sp., *Diparelasma* sp. near the middle; *Nothorthis* sp. at the base	157 feet
Resistant, irregularly laminated, aphanitic limestone, with black chert stringers "interbedded"	12
Muddy, irregularly laminated limestone	4
Resistant, irregularly laminated, aphanitic limestone with black chert stringers "interbedded". *Diparelasma* sp.	62
Light gray, thinly laminated, non-cherty, crystalline limestone. *Diparelasma* sp., *Hesperonomia* sp., *Tritoechia* n. sp. Complete trilobite assemblage of Zone "J"	10
Dark, blackish-gray, finely crystalline limestone, containing interbeds of black chert, both in layers 2–3 inches thick	41

Resistant, thinly laminated, finely crystalline limestone with black chert content diminishing downward. Irregular laminae separated by paper-thin mud partings. *Dictyonema* cf. *D. flabelliforme, D.* cf. *D. flabelliforme anglicum, Didymograptus* cf. *D. nitidus, Trigonocerca typica.* Zone "H"	135 feet
Lower member:	
Alternating 2- to 3-foot beds of intraformational conglomerate in a crystalline matrix, shelly crystalline limestone, and slabby, buff-weathered, muddy limestone. *Trigonocerca typica, Protopliomerops* sp. Zone "H"	208
Intraformational conglomerate in beds 1–2 feet thick, interbedded with muddy, laminated limestone in beds 3–5 feet thick. *Tetragraptus* sp.	64
Resistant, thinly laminated, aphanitic limestone, containing scattered chert nodules, in beds 2–4 feet thick, interlayered with thin, 6-inch to 1-foot beds of buff-weathered, shaly limestone and occasional 1- to 2-foot layers of intraformational conglomerate. *Dictyonema* cf. *D. flabelliforme, Kirkella* sp. (in lowest beds)	158
Float-covered surface with a few limestone ledges protruding	265
Thin, alternating layers of slabby, finely crystalline limestone and aphanitic, compact limestone	33
Coarse-grained, fossiliferous, crystalline limestone. *Leiostegium* cf. *L. manitouense.* Zone "D"	13
Resistant, irregularly laminated aphanitic limestone	14
Interbedded intraformational conglomerate, crystalline limestone, and aphanitic limestone, with the first comprising over half of the thickness	110
Very coarse, intraformational conglomerate and edgewise breccia, in crystalline matrix; pebbles up to 4 inches in diameter	1
Thin (3-inch to 1-foot) interbeds of light gray, aphanitic limestone, finely crystalline limestone, and intraformational conglomerate in crystalline matrix. Thirty feet above base: *Apheorthis* cf. *A. meeki, Nanorthis* cf. *N. hamburgensis, Pachycranium* ? sp. Zone "C". At the base: *Bellefontia* sp., *Clelandia utahensis* of Zone "B"	182
Float-covered surface	36
Edgewise conglomerate and aphanitic limestone	5
Float-covered surface with occasional thin, crystalline and muddy limestone ledges protruding. Eighty-seven feet above base: *Hystricurus* cf. *H. conicus.* Thirty-eight feet above base: *Bellefontia* sp.	151
Interbedded brownish-weathering dolomite and crystalline limestone, both in 6-inch to 2-foot layers. Twenty-eight feet above base: *Bellefontia* sp.	63
Finely crystalline, light-gray limestone with some intraformational conglomerate lenses. *Bellefontia* sp., *Hystricurus* ? sp.	40
Total thickness:	1,764 feet

St. Charles formation:

Thick, brownish-weathering dolomite.

Locality 9. *Twin Bridges Dugway, Logan Canyon* (N.W. ¼, S.W. ¼, Sec. 34, T. 13 N., R. 3 E.

This locality is situated in the abandoned road-cut on the west side of U.S. Highway 89, at the north end of the dugway. It was visited exclusively for the collection of graptolites, which are plentiful in the more shaly layers exposed for 150 feet along the cut. The exact stratigraphic position of this zone cannot be ascertained inasmuch as many nearly vertical faults are present in the adjacent area; however, it is estimated to be 300–375 feet below the top of the Garden City formation. Fossils possibly referable to *Receptaculites* are abundant immediately above the graptolite zones. The only trilobite specimen collected here is referred to the genus *Asaphelina.*

The graptolites collected include:

Dictyonema cf. *D. flabelliforme*
Dictyonema cf. *D. flabelliforme anglicum*
Tetragraptus cf. *T. quadribrachiatus*
Phyllograptus sp.

Locality 10. *Junction of the Logan River and its Right Fork* (N.E. ¼, Sec. 18, T. 12 N., R. 3 E.)

The Swan Peak formation and the upper 150–200 feet of the Garden City formation are exposed on the north side of the Right Fork; on the west side of U.S. Highway 89 the upper Swan Peak beds are well displayed.

Swan Peak formation:	
Massive, white, vitreous quartzite in beds 4 feet thick	20 feet
White, vitreous, fucoidal and cross-bedded quartzite, weathering rusty brown; beds 6 inches to 2 feet thick	37
Thin and irregularly bedded, aphanitic quartzite in layers ½–2 inches thick	10
Black, flaky shale, weathering rusty brown on the surface. Several thin beds of quartzite are interlayered in the top of this interval	145
Interbedded 1–2 inch layers of silty quartzite, 3-foot beds of quartzite with a calcareous cement, and 1- to 3-inch beds of crystalline fossiliferous limestone and black shale	24
Total thickness:	236 feet
Garden City formation:	
Upper Cherty member:	
Light, brownish-gray dolomite	12 feet
Aphanitic, irregularly laminated, cherty limestone. *Blastoidocrinus* cf. *B. carchariaedens, Anomalorthis* n. sp., *Hesperonomia* sp., *Syntrophopsis transversa, Orthis* cf. *O. subalata, Tritoechia* n. sp. (Collections from this interval were not broken down into separate zones, but have been lumped into a single unit; it is now evident that two or more faunal units are probably present.)	150+
Not exposed below this level.	

Locality 11. *Green Canyon* (N.E. ¼, Sec. 18, and N.W. ¼, Sec. 19, T. 12 N., R. 2 E.)

The complete St. Charles, Garden City, Swan Peak, and Fish Haven sequence is exposed on both sides of the canyon, which cuts at right angles across the strike of the beds. The lowest beds of the Garden City formation are found approximately 1,600 yards east of the canyon's mouth.

Fish Haven dolomite.	
(Unconformity)	
Swan Peak formation:	
Massive, white, vitreous quartzite, in beds 5–8 feet thick	61 feet
Vitreous, white quartzite in beds 4–7 feet thick, with some 1-foot interbeds	21
Thin, 2-inch to 2-foot layers of white quartzite with shaly interbeds	24
Fucoidal, cross-bedded, red and white quartzite in 3- to 4-foot beds with 3-inch beds of silty sandstone and 1-inch layers of red shale	30
Thin-bedded, slabby, silty red quartzite. *Orthis swanensis, Eleutherocentrus petersoni*	7
Black, flaky, rusty-weathered shale	52
Red, thin-bedded quartzite	1
Black, flaky shale	14
Vitreous, white quartzite	3
Black, flaky shale, with thin lenses of fossiliferous limestone. *Anomalorthis* sp., *Orthis* sp.	98
Thin laminae of quartzite with calcareous cement	1
Total thickness:	312 feet
Garden City formation:	
Upper Cherty member:	
Resistant, aphanitic, irregularly laminated limestone with some muddy limestone and intraformational conglomerate interbeds; black chert nodules and stringers increasing in abundance downward in interval until they comprise close to 50 percent of the rock. Upper 35 feet locally dolomitized along fractured zones. From the upper 50 feet: *Anomalorthis* n. sp., *Blastoidocrinus* cf. *B. carchariaedens.* Zone "M"	175 feet
Talus-covered slope	60
Aphanitic, irregularly laminated limestone in 1–2 foot beds, containing scattered black chert nodules and stringers, and interlayered with thick beds of intraformational conglomerate in a crystalline limestone matrix	131
Lower member:	
Intraformational conglomerate in 2- to 5-foot layers, interbedded muddy, thinly laminated limestone in beds 1–3 feet thick. Occasional beds of aphanitic limestone	549
Intraformational conglomerate with pebbles 1–4 inches in diameter, in beds 4 feet thick, interlayered with aphanitic, laminated lime-	

stone and crystalline limestone in beds 1–2 feet thick. From the top: *Menoparia genalunata, Protopliomerops contracta.* Zone "G(2)"	58 feet
Interbeds of crystalline limestone, muddy, weak, laminated limestone, and intraformational conglomerate in crystalline matrix; beds 1–2 feet thick. At the base: *Bellefontia chamberlaini, B. acuminiferentis, Xenostegium franklinense.* Zone "B"	306
Muddy, crudely laminated limestone, aphanitic resistant limestone, both in beds from 6 inches to 7 feet thick, interlayered with occasional thin crystalline limestone beds. Scattered chert stringers	86
Thin, 2- to 4-inch layers of finely crystalline dolomite with scattered white chert stringers	6
Talus-covered slope	34
Total thickness:	1,405 feet

St. Charles formation:
Massive, light brownish-gray dolomite.

Locality 12. *Blacksmith Fork, north side of canyon* (S. ½, Sec. 2, T. 10 N., R. 2 E.; near power house)

The Garden City formation at this locality has been measured by Duncan, who found it to be 1,160 feet thick (personal communication). Although his data are in this author's possession, I have not had the opportunity to study his fossil collections, which are at Princeton University; therefore, tabulation of the section is not presented at this time. Because Duncan had not attempted any fossil collecting from the uppermost beds of the Garden City formation, we secured specimens from the upper 100 feet; these have proved to be identical with the fauna represented in the same interval at locality 10.

The thickness of the Swan Peak formation here is considerably diminished and none of the massive quartzite layers of the type section are present. The total thickness is 105 feet. None of the beds is over 1 foot thick; in general 3- to 6-inch quartzite and sandstone layers, 2- to 4-inch greenish shale layers, and 1- to 3-inch limestone lenses are interbedded. There are nearly as many limestone lenses near the top as quartzite strata at the base. The formation has little surface expression because of the unresistant nature of the shales and the silty character of the quartzites and sandstones.

Locality 13. *Round Hill, north of Mantua* (S.E. ¼, Sec. 10, and N. ½, Sec. 15, T. 9 N., R. 1 W.)

On the east side of U.S. Highway 91 at the north end of the Mantua valley stands Round Hill, on the west side of which the St. Charles–Garden City contact is well-exposed; the east dip-slope side of the hill is overlain near the bottom by the Swan Peak formation. The east slope is, however, so heavily covered with float that it is extremely difficult to observe what lithology underlies it. Fortunately there is on the northeast side of Round Hill a small knoll in which the Swan Peak beds and the upper member of the Garden City formation are exposed and separated from the first section by an east-

west fault. A bright green siltstone bed in the Swan Peak formation serves as an accurate key for connecting the two sections.
Section in knoll on northeast side of Round Hill:

Swan Peak formation: (possibly cut by a strike-fault at the top)	
Massive, thick-bedded, vitreous white quartzite with some cross-bedding	55 feet
Rusty and red quartzite, thin-bedded with thinner interbeds of shale and siltstone; a thin (6″–1′) bright green siltstone, breaking with conchoidal fracture, located 14 feet above the base of interval, is key to correlating between knoll and Round Hill sections. *Eleutherocentrus petersoni, Didymograptus* cf. *D. bifidus,* abundant ostracods. Zone "M"	30
Interbedded greenish shale and thin brownish and white quartzite layers. *Eleutherocentrus petersoni, Didymograptus* cf. *D. bifidus,* abundant ostracods. Zone "M"	159
Total thickness:	244 feet
Garden City formation:	
Upper Cherty member:	
Resistant, compact, aphanitic and finely crystalline limestone, locally dolomitized within 30 feet of the top. Aphanitic beds crudely laminated. Scattered black chert nodules and stringers increasing in number toward bottom. *Blastoidocrinus* cf. *B. carchariaedens, Nothorthis* ? sp. Zone "K" (?)	169 feet
Very cherty, aphanitic, irregularly laminated limestone; chert stringers and "layers" 2–4 inches thick, and comprising 50 percent of rock	96
Resistant, irregularly laminated, aphanitic limestone with black chert stringers and nodules roughly paralleling laminae, comprising 20 percent of rock near bottom. *Receptaculites, Diparelasma* sp., *Hesperonomia* sp., complete trilobite assemblage of Zone "J"	85
Exposed thickness:	350 feet

East-West fault in saddle between knoll and Round Hill.

Section in Round Hill, measured stratigraphically downward from the base of the bright green siltstone bed in the Swan Peak formation (see second item of previous section):

Swan Peak formation:	
Shaly and silty Swan Peak float	125 feet
Mixed Swan Peak shale and quartzite float	45
Total thickness measured:	170 feet
Garden City formation:	
Upper Cherty member:	
Mixed dolomite and black chert float	92 feet
Cherty limestone and dolomite float with black chert forming 50 percent of each block; some dolomite in place at the top of this interval	26

Cherty limestone float, overlying low ledges of dolomitic and aphanitic limestone	74 feet
Interbedded aphanitic, irregularly laminated, cherty limestone and dolomitized limestone; percentage of chert increases downward in this zone until it forms 50 percent of rock at base	136
Interlayered light gray crystalline limestone and intraformational conglomerate in crystalline matrix in beds 2–5 feet thick; scattered black chert nodules	97
Lower member:	
Thin, slabby beds of crystalline limestone, intraformational conglomerate, and muddy, irregularly laminated limestone in beds averaging 6 inches to 1 foot thick	259
Finely crystalline, massive limestone	3
Thin, slabby beds of crystalline limestone, intraformational conglomerate, and muddy limestone	78
Resistant, irregularly laminated, aphanitic limestone in beds 3 feet thick, interlayered with muddy limestone and some crystalline limestone in beds 6 inches to 3 feet thick	30
Low ledges of aphanitic limestone, crystalline limestone, and intraformational conglomerate, protruding through float and soil mantle. *Kirkella* sp., *Dictyonema* sp.	86
Resistant, irregularly laminated, aphanitic limestone in beds 3 feet thick, interbedded with muddy, laminated limestone and some crystalline limestone in layers 6 inches to 3 feet thick	30
Low ledges protruding through float, composed of intraformational conglomerate, crystalline limestone, aphanitic and muddy limestone	105
Thick, 3- to 4-foot interbeds of finely crystalline limestone, intraformational conglomerate, shaly limestone, and aphanitic limestone; 140 feet above the base of this interval: *Tesselacauda* ? sp., *Hystricurus* ? sp.; at base: *Nanorthis* sp., *Syntrophina* ? sp., *Hystricurus* sp. E, *Symphysurina* sp.	283
Float-covered slope	66
Light gray, crystalline dolomite	4
Thin-bedded, finely crystalline limestone, mantled by soil and float	20
Total thickness:	1,389 feet

St. Charles formation:
Massive, light brownish-gray dolomite.

On the basis of field work done during the 1949 season, several additions can be made to the above information on locality 13. The presence of faunal Zone "L" has been established 36 feet below the top of the Garden City formation; the range of Zone "J" was found to extend 30 feet higher than recorded above. Zone "H" was located north of the fault 384 feet below the top of the formation. For the first time Zone "D" was definitely discovered 80 feet above the base and Zone "B" approximately 70 feet above the Garden City–St. Charles contact.

Locality 14. *Davenport Hollow, north of Monte Cristo Ranger Station* (between S.E. ¼, Sec. 5 and W. ½, Sec. 17, T. 9 N., R. 4 E.)

Faunal collections from this locality were so limited and most of the lithology so thoroughly masked that no more space should be devoted to it than that given in the preliminary report (Ross, 1949, p. 489).

FAUNAL SUMMARY

Although the fossils so far collected from the Garden City formation and the overlying Swan Peak beds include sponges, graptolites, pelmatozoans, brachiopods, gastropods, nautiloids, trilobites, and ostracods, time has permitted only a study of the trilobites. A few of the brachiopods have been identified specifically, but most of them only generically. Graptolites have been compared in a cursory manner with forms they closely resemble. Determination of the other forms has not yet been attempted.

The word "prolific" hardly does justice to the trilobite fauna of the Garden City formation. In this report 87 species are described and/or illustrated. Only lack of time has placed this limit on the study, for at least a dozen others have already been secured from the acid-etching baths and await investigation.

Of the 87 species, only 55 have been given specific designations; 49 are new species, while 6 have been previously described. Thirty-two are too scantily represented to warrant specific identification, and only 6 of these have been given unquestioned generic assignment. At least 48 genera are represented, of which 14 were previously known. Twenty-two genera are new; 8 questionable generic assignments have been made; and 5 remain undetermined.

TRILOBITES OF SPECIAL INTEREST

Many of the Lower Ordovician trilobite genera, of course, are already known to have very great geographical ranges. *Hystricurus*, for instance, has been reported from Greenland, Ellesmere Land, North America, and South Chosen. *Leiostegium* occurs in eastern and western North America, as well as in Argentina. *Protopliomerops*, first described from South Chosen, is found in Argentina, North America, and Scandinavia. Of the new genera, *Paenebeltella* Ross is undoubtedly closely related to *Beltella* Lake from the Tremadoc of Great Britain and the Lower Ordovician of Argentina. One of the most striking resemblances of a Garden City form to a British genus is found in the pygidia assigned to *Macropyge* Stubblefield. Although the cranidia are quite different, the resemblance of the pygidia of Poulsen's *Cybelopsis speciosa* from the Upper Canadian of Greenland to the pygidia of *Pseudocybele nasuta* Ross, n. gen. and sp., suggests a close phylogenetic tie between the two.

Two apparent descendents from Cambrian genera are *Goniophrys* Ross, n. gen., and *Carolinites* Kobayashi, both believed to be members of the Family Komaspidae Kobayashi, generally considered to be characteristic of the Croixian. In 1923 Walcott (p. 473) noted the presence of an undetermined species of *Irvingella* in the "Mons formation" (his locality 65w); this zone has since been reassigned to the basal Sarbach beds (Walcott, 1928, p. 330). As far as this author has been able to ascertain, these are the only representatives of the family in rocks younger than Cambrian.

A problem that has recently bothered other students is that of distinguishing between the cephalic parts of *Bellefontia* and *Xenostegium;* this problem, to which there seems to be no satisfactory solution at present, is covered under the generic descriptions, below. Indirectly related is the disposition of two species, *Asaphellus* ? ("*Xenostegium*") *eudocia* (Walcott) and "*Xenostegium*" *taurus* (Walcott). Evidence from the present study is, in my opinion, ample to indicate that they must be removed from the genus *Xenostegium,* but not adequate to warrant definite reference to any other genus at present; the unhappy result is to leave them "dangling" until more complete investigation and additional specimens can be secured.

It should be noted that 20 species have been given questioned generic designations and that 5 are left undetermined; most of the former are known only from one or two specimens and many of these are damaged or slightly deformed. Although the examined material of the latter is suitable negative evidence against their definite reference to previously described genera and species, the positive evidence is too scant to warrant the erection of genera and species which may only serve to clutter pestilently the synonymies of the future.

On the other hand, some of the new species have been based on small samples, an apparent inconsistency with the policy stated above. Such a one is *Hypothetica rawi* Ross, n. gen. and sp., which is represented by only four minute cranidia in the collection. This example is so bizarre a form, that I have no qualms about giving it generic, as well as specific recognition.

APPARENT SMALL SIZE OF THE FAUNA

Several persons have remarked on the small size of most of the specimens in the present collection, expressing the belief that some explanation should be attempted. It has been suggested that the beds in the Logan area may have been deposited in restricted seas and that a dwarfed fauna resulted.

To this suggestion I do not fully subscribe. There are too many samples in which large specimens are badly broken or represented only by large fragments while the perfectly preserved specimens are small. An example is *Hystricurus flectimembrus* Ross, n. sp.; the partial cranidium illustrated in plate 10, figure 33, is badly damaged and is of a size which can be considered "normal"; smaller specimens shown on plates 10 and 11 are better preserved. Similar cases are numerous and not limited to any one type of trilobite.

FAUNAL ZONES

As a result of the compilation of faunal assemblages found in the different stratigraphic sections described above, it appears possible to recognize twelve faunal zones in the Garden City formation and one in the Swan Peak beds. On the following pages each of these zones is given an alphabetic designation, followed by a list of the included species; the lists are not limited to trilobites, but include other forms which were found useful in correlation. The position of each zone has been indicated within the description of measured sections and beside each of the diagrammatic columns in plate 7.

Unfortunately the author has been unable to locate all the zones in all the sections studied, the worst deficiencies being in localities 1 and 14. In the first of these no collections were secured from the upper 100 feet, while the few specimens from the lower beds of the latter furnish too scant evidence for correlation with any of the other localities.

Before presenting the zonal lists it should be noted that one zone—"G"—is rather complex; this zone is based on the occurrence of *Menoparia genalunata* Ross, n. gen. and sp., and *Psalikilus typicum* Ross, n. gen. and sp.; these two species appear together throughout approximately the middle third of the Garden City formation. Within their range two species of *Protopliomerops* occur and provide a basis for dividing Zone "G" into a lower sub-zone, "G(1)"—based on *P. celsaora* Ross, n. sp.—and an upper sub-zone, "G(2)"—based on the range of *P. contracta* Ross, n. sp. This latter sub-zone has been still further divided, into five smaller units, lettered "G(2)a" to "G(2)e".

The faunal zones are:

Swan Peak formation:

M.—*Didymograptus bifidus* (Hall)
Anomalorthis sp.
Orthis swanensis Ulrich and Cooper
Eleutherocentrus petersoni Clark
"*Symphysurus* ? *goldfussi*" Walcott (tentative determination)
Abundant ostracods, possibly referable to *Leperditia*
Orthis michaelis Clark

Garden City formation:

L.—*Anomalorthis* n. sp.
Rhynchocamara n. sp.
Syntrophopsis transversa Ulrich and Cooper
Orthis aff. *O. subalata* Ulrich and Cooper
Blastoidocrinus cf. *B. carchariaedens* Billings

K.—*Nothorthis* sp.
Diparelasma sp.
Hesperonomia sp.
Blastoidocrinus cf. *B. carchariaedens* Billings

J.—*Diparelasma* sp.
Hesperonomia dinorthoides Ulrich and Cooper
Syntrophopsis cf. *S. polita* Ulrich and Cooper
Tritoechia n. sp.
Eleutherocentrus williamsi Ross
Kirkella declevita Ross

Lachnostoma latucelsum Ross
Carolinites genacinaca Ross
Dimeropygiella caudanodosa Ross
Kawina sexapugia Ross
Pseudocybele nasuta Ross
Isoteloides ? sp.

I.—*Retiograptus* sp.
Diparelasma cf. *D. typicum* Ulrich and Cooper
Hesperonomia sp.
Goniotelus sp. (not described; see pl. 15, fig. 12)

H.—*Trigonocerca typica* Ross
Dictyonema, 2 spp.
Didymograptus cf. *D. nitidus* (Hall)

G.—*Menoparia genalunata* Ross
Psalikilus typicum Ross
(2) *Protopliomerops contracta* Ross
e. *Jeffersonia peltabella* Ross
Pygidium (pl. 30, figs. 20, 21, 24)
d. *Asaphellus* ? sp. B
Basilicus ? sp.
c. *Asaphellus* ? sp. A
Basilicus ? sp.
b. *Psalikilus* ? sp.
Platycolpus ? sp.
a. *Scinocephalus solitecti* Ross
Niobe ? sp.
Macropyge gladiator Ross
Licnocephala bicornuta Ross
L. ? sp.
Platycolpus ? sp.
(1) *Protopliomerops celsaora* Ross
Asaphellus ? *eudocia* (Walcott)
"*Xenostegium*" *taurus* (Walcott)
Pygidia (pl. 30, figs. 23, 26, 27)

F.—*Hystricurus oculilunatus* Ross
H. contractus Ross
H. flectimembrus Ross
H. acumennasus Ross
Parahystricurus fraudator Ross
P. oculirotundus Ross
P. pustulosus Ross
P. ? sp. C
Amblycranium cornutum Ross
Hillyardina semicylindrica Ross
Pachycranium faciclunis Ross
Pseudohystricurus obesus Ross
Hyperbolochilus marginauctum Ross
Pyraustocranium orbatum Ross
Goniophrys prima Ross
Undetermined Genus and Species A

Hypothetica rawi Ross
Undetermined Genus and Species B
Pseudoclelandia cornupsittaca Ross
P. fluxafissura Ross
Undetermined Genus and Species E
Protopliomerops superciliosa Ross

E.—*Hystricurus robustus* Ross
H. sp. B
H. sp. C
Parahystricurus carinatus Ross
Amblycranium variabile Ross
A. ? sp.
A. ? *populus* Ross
Pseudohystricurus sp.
Paenebeltella vultulata Ross
Amechilus palaora Ross
Pseudoclelandia lenisora Ross
Pilekia ? sp.
Tesselacauda depressa Ross

D.—*Apheorthis* cf. *A. meeki* Ulrich and Cooper
Leiostegium manitouense Raymond

C.—*Nanorthis* ? sp.
Syntrophina ? sp.
Hystricurus ? sp. I
Symphysurina sp. B

B.—*Hystricurus genalatus* Ross
H. paragenalatus Ross
H. politus Ross
H. ? sp. F
H. ? sp. G
H. sp. H
Parahystricurus sp. A
P. sp. B
Remopleuridiella caudalimbata Ross
Xenostegium franklinense Ross
Bellefontia chamberlaini Clark
B. ? *acuminiferentis* Ross
Clelandia utahensis Ross
Undetermined Genus and Species D

A.—*Nanorthis* sp.
Hystricurus sp. D
Pseudohystricurus rotundus Ross
Symphysurina sp. A
S. cf. *S. woosteri* Walcott (pl. 23, figs. 7–12)
Bellefontia ? sp. (not described; pl. 26, fig. 16)

There is some doubt concerning the assignments of species or genera to one or two of these zones. For instance, *Rhynchocamara* n. sp. has been found associated with the other species of Zone "L" only at localities 10 and

12, and at neither was the upper 100 feet of strata broken down into smaller units.

There is almost certainly some intergrading between Zones "J" and "K", at least as far as the brachiopods are concerned. *Blastoidocrinus* cf. *B. carchariaedens* Billings and *Nothorthis* have not been found in the former, and none of the trilobites of "J" in the latter; but both absences could be caused by incompleteness of collections or failure of the trilobites to become silicified in the higher zone. Fifty feet above the base of the Upper Cherty member of the Garden City formation at locality 1, *Hesperonomia dinorthoides* is associated with *B.* ? *carchariaedens,* and 70 feet above the base of the same member *Tritoechia* is present with a much smaller species of *Hesperonomia.* The differentiation of Zone "K" is, therefore, not always dependable. It is hoped that a critical study of the species of *Diparelasma* alone will eventually prove to be of stratigraphic value in this connection.

The persistence of an upper cherty member of the Garden City formation has been mentioned above. The facts that faunal Zone "L" has been found at localities 2, 3, 5, 8, 11, 13, and 14 in the uppermost zone, and that Zone "J" is present lower in the member at localities 2, 5, 8, 13, and 14 have led to the conclusion that both boundaries of the lithologic unit have a constant time range over most, if not all, of the area studied. Lack of evidence for the presence of Zone "L" at locality 1 can be attributed to an unfortunate choice of rock specimens in the field; when these were placed in hydrochloric acid for etching it was discovered either that none of the enclosed fossils were sufficiently silicified or that silicification had converted not only the fossils but also the entire matrix to chert.

Another useful zone for correlating across the area was found to be Zone "H", based primarily on *Trigonocerca typica* Ross. Since this species occurs in crystalline limestone, rather coarse intraformational conglomerate, and limy siltstone, it appears to be little affected by facies changes and is undoubtedly a good index fossil. It is of interest that another species here assigned to *Trigonocerca*—*T. entella* (Walcott) (1925, p. 112)—was secured from the "Mons formation" (Walcott, 1924, p. 473), associated with *Hesperonomia iones* (Walcott); Walcott's locality is now considered to be in the Sarbach formation (Ulrich and Cooper, 1938, p. 119).

Among the zones which are not entirely satisfactory is Zone "I", which was established on collections from locality 3B alone and may eventually have to be absorbed into Zones "H" or "J". Similarly, the subdivisions of Zone "G" may be shown by future investigation to intergrade so completely that they cannot be properly separated.

Detailed correlations within the lower third of the formation are not satisfactory in several instances. At the type section, locality 1, faunal Zone "B" was located with certainty, but only a single specimen of *Symphysurina* sp. A was found to indicate the position of Zone "A". So limited have been the collections from the base of the section at locality 14 that any attempts to relate their ages to other sections have proven almost hopeless.

From the above discussion it becomes evident that neither the upper nor the lower limit of the Garden City formation varies appreciably, if at all, in age throughout the area studied. Only at locality 14 does any serious doubt remain, and that involves only the lower boundary.

AGE OF THE GARDEN CITY FORMATION

In correlating the various faunal zones of the Garden City and Swan Peak formations considerable use has been made of the Correlation Chart for the Ordovician of North America (Ordovician Sub-Committee, Geological Society of America) now in preparation.

CORRELATION OF THE UPPER CHERTY MEMBER

The brachiopod genus *Anomalorthis* is not known in other regions from beds older than the Chazyan (Joins formation of Oklahoma), according to G. A. Cooper (personal communication). The two genera *Hesperonomia* and *Tritoechia* have not been found in beds younger than Black Rock (uppermost Canadian). Since these last two occur in Zones "J" and "K", but not in "L", and because *Anomalorthis* appears in Zone "L", but not in "K" or "J", it now seems certain that the uppermost strata of the Garden City formation (those in which Zone "L" occurs), as well as the overlying Swan Peak beds, must be assigned to the Chazyan Epoch. This, quite obviously, calls for placing the Canadian-Chazyan boundary between Zones "K" and "L".

The Chazyan aspect of the slightly older Garden City faunas is enhanced by the presence of *Blastoidocrinus* in faunal Zone "K" and of *Kawina* in Zone "J". The first of these has been reported only from the Chazy formation of the East and from the Mazourka formation of the Inyo Range (Phleger, 1933). The latter has been found previously in Chazyan and younger beds of the East (Raymond, 1905, p. 368; 1925, pp. 166–167). Both these forms would seem to indicate that the inter-epoch boundary could be placed even lower, below the occurrence of Zone "K" or within Zone "J", an indication that does not jibe with the brachiopod evidence.

An additional bit of information of interest has been furnished by Rasetti (personal communication) concerning an undescribed species referable to *Carolinites* Kobayashi (equals *Dimastocephalus* Stubblefield (1950a)), from a boulder in the Mystic conglomerate; associated in the same boulder Rasetti discovered a trilobite assemblage which he considers to be the same as that of the Table Head formation of Newfoundland. This assemblage includes *Pseudomera barrandei,* which the present author has never been able to find in the Garden City beds, but which has been secured by Williams in the Logan quadrangle and by Hintze (personal communication) in the Ibex Range from a faunal zone identical in almost all other respects to Zone "J". These facts add some weight to the suggestion that Zone "J" is very close to the Lower-Middle Ordovician boundary. The added value of *Carolinites* as a guide fossil is evident from its occurrence in Australia and Ireland (Stubblefield, 1950).

It may further be noted that the occurrence of *Kirkella* (equals *Asaphus* ?

curiosus and *Billingsura*) cannot be used as a definite argument in favor of the Black Rock age of Zone "J", for it has during this study been discovered in beds well below Zone "H" at locality 8.

To summarize, it can be stated that the division between beds of Lower and Middle Ordovician age falls below the lowest occurrence of *Anomalorthis* and probably above the highest occurrence of *Tritoechia* and *Hesperonomia.* On this basis the upper 30–50 feet of the Garden City formation and the overlying Swan Peak formation are of Chazyan age, while the evidence of some of the trilobites suggests that the boundary might possibly be placed a little lower.

Unfortunately there is no distinct lithologic break to supplement the faunal evidence on this point. The boundary might be placed between the highest cherty beds and the uppermost dolomitic limestone beds of the Garden City formation, but there is no discernible unconformity at this horizon. Furthermore, the chert content does not drop abruptly, but gradually decreases upward. Although there is an obvious lithologic change between the Garden City and Swan Peak formations, it fails, likewise, to coincide with the faunal evidence and is, in my opinion, of no value in placing the inter-epoch division.

CORRELATION OF THE LOWER MEMBER

There is no question that the lower beds, including Zones "A" to "D", are of Gasconade age, as indicated by the presence of *Nanorthis, Syntrophina, Apheorthis, Bellefontia,* and *Clelandia;* the last two of these place Zone "B" as equivalent to the Tribes Hill and Stonehenge formations of the East. The association of *Apheorthis* and *Leiostegium* in Zone "D" shows that its age is latest Gasconade. It should further be noted that Zones "A" and "B" are almost certainly correlative with the McKenzie Hill formation of Oklahoma (Frederickson, 1941, pp. 160–162).

Jeffersonia peltabella Ross, n. sp., a form very similar to *J. missouriensis* Cullison, suggests that Zone "G(2)e" may be correlative with the Rich Fountain formation. If this is true, the rest of Zone "G", Zone "F", and Zone "E" may belong in the Roubidoux interval, while Zones "H" and "I" may fill the gap between the beds of Theodosia and Black Rock age. At best, however, dating of the middle portion of the formation is little more than conjecture and probably must await investigation of other elements of the Garden City fauna.

The possibility of correlation with the Greenland sections, reported by Poulsen (1927, 1937), becomes increasingly evident. The Cass Fjord fauna compares favorably with those of Zones "A" and possibly "B", while the aspect of his fauna from the Nunatami formation is similar in several striking respects to that of the "J" and higher zones in Utah. It may be no mere coincidence, furthermore, that the upper portion of the Nunatami and the lower part of the Swan Peak formations abound in ostracods.

AGE OF THE SWAN PEAK FORMATION

Richardson (1913, p. 409) originally considered the Swan Peak formation to be of Chazyan age, but as Williams (1948, p. 1137) has pointed out, this dating has been questioned recently because of the occurrence of *Didymograptus* cf. *D. bifidus* in the shaly portions of the formation. Since the Lower-Middle Ordovician boundary is placed below faunal Zone "L" within the uppermost beds of the Garden City formation, on the basis of the present study, it becomes obvious that Richardson's original belief was correct.

Of more than ordinary interest in this regard are two collections in the United States National Museum from the Lower Simpson group of Oklahoma. These collections are from U.S.G.S. locality 360K2 (labelled "Oil Creek formation") and from U.S.G.S. locality 199t (labelled "Joins"). They include a species of *Eleutherocentrus,* which appears to be intermediate between *E. petersoni* of Zone "M" and *E. williamsi* of Zone "J". In addition the ostracods of the Oklahoma collections are very similar to, if not identical with, those of Zone "M". Thirdly, so-called "*Symphysurus* ? *goldfussi*" Walcott, which is known in the Utah sections only from Zone "M", is present in these two collections; the genus is known also from a collection in the National Museum to occur in the highest beds of the Pogonip formation of Nevada. In fact, the specimens from the Pogonip in the Museum are so nearly perfect that they should be the basis for revised description; for that reason, a formal revision of the genus and description of its species found in the Swan Peak beds has been withheld in the present work.

On the basis of the faunal evidence in the area under study plus the corroborative evidence afforded by the above-mentioned collections, there is little room for doubt that the Swan Peak formation is earliest Middle Ordovician in age.

CONDITIONS OF DEPOSITION OF THE GARDEN CITY AND SWAN PEAK FORMATIONS

During Early Ordovician time the Logan quadrangle and its environs were the locus of deposition of a great thickness of interbedded and interlensed calcirudites, calcarenites, and calcilutites. To the northwest these deposits thicken appreciably, indicating that the area lay to the east of the axis of the Cordilleran geosyncline.

Within this great thickness of calcareous sediments intraformational conglomerates predominate. The origin of such deposits is generally attributed to mudcracking on emergent flats and the incorporation of the resulting muddy and limy fragments in the next younger deposit. Although we have seen no direct evidence for mudcracks in the Garden City formation, it is conceivable that such evidence could have been removed with slight submergence or the advance of tides and the removal of the muddy chips, flakes, or polygons. There are, moreover, countless thin layers of mudstone, siltstone, and muddy limestone which could have furnished such fragments.

Since many of the enclosed fragments are sharply angular, they certainly could not have been transported more than a very short distance and could not have withstood many changes of tides. In many of the beds well-rounded, finely crystalline, muddy limestone pebbles are incorporated; one of these is exposed by stripping of the overlying beds at locality 11 (pl. 2, fig. 2). Although these pebbles are now firmly lithified, at the time of deposition they may have been rather pasty balls which wave action in shallow water could have rounded easily. In the case illustrated the enclosing mudstone is in part ripple-marked, the profile and pattern of the ripple marks being that commonly attributed to wave, rather than current, action.

In fact, all the ripple marks which were seen in the Garden City beds are of the rhomboidal or symmetrical types generally ascribed to the work of waves. Most have narrow crests separated by shallow, wide troughs. If these had been subjected to current action or had been in existence for any considerable length of time, the crests would probably have become rounded and the troughs filled in. The preservation of such ripples as those illustrated in figure 2, plate 2, suggests that they were formed in rather quiet water and quickly buried.

Channels, such as that illustrated in figure 1, plate 2, may have been scoured by strong underwater currents or by streams flowing across limy mudflats during periods of emergence. Either of these agencies could have produced the scour-and-fill type of cross-bedding of some of the calcarenites (Ross, 1949, pl. 1, fig. 2).

All these features suggest that the surface of deposition was very close to sea-level, at times slightly emergent and at others slightly submergent, throughout the Early Ordovician. Although the lensing character of many beds may be explained by by-passing, it may indicate that shallow encroachments of the sea followed irregular, overlapping patterns.

Although there is no intention of entering into a lengthy discussion of the origin of the black chert of the upper member of the formation, certain interesting features are noted here. A thin-section of this rock shows no clear-cut boundary between the chert and the limestone enclosing it, although the division is obvious on weathered surfaces. That silica has replaced limestone is certain, but the replacement could hardly have been secondary. At locality 8, high in the cherty member a bed was found in which fragments of black chert were enclosed in limestone to form an intraformational breccia; from this fact we may infer that chert was already lithified in the lower beds of the member and was being subjected to erosion at some nearby locality while the higher beds were being deposited. This inference plus the chert's obvious persistence in the same stratigraphic position favors the theory that the chert was replacing limestone penecontemporaneously throughout the time represented by the upper member of the Garden City formation. The erosion of a low-lying or peneplaned land to the east may well have supplied the necessary silica according to Tarr's theory (1917, pp. 426–433), or according to Eardley (1947, p. 340), silica may have been derived from volcanic activity along a western archipelago.

Decreases in thickness of the Garden City formation from 300 to 550 feet are found between locality 8 and the more easterly sections. Originally the possibility was contemplated that the oldest beds represented at locality 8 might have wedged- or lapped-out against the eastern side of the Cordilleran trough, but, because the same faunal units are found near the base of the formation on both east and west, we conclude that the difference in thickness must be attributed to a greater rate of deposition nearer the center of the geosyncline. This is further substantiated by the increased spread between faunal zones in the western section (compare the positions of zones "A" to "D", for instance at localities 5 and 8, fig. 16). There is no certainty that some of the lowest beds are not missing from the base of the section at locality 14, but there is no marked decrease in thickness of the formation which would support this possibility.

The fact that thicknesses at localities 1, 3, 12, and 14 are all close to 1,200 feet might lead us to the belief that the bottom of the trough was almost flat or very gently sloping on the east side. It is possible to approximate the position of the 1,400-foot isopach with a line through localities 11 and 13. If the positions of the 1,500-, 1,600-, and 1,700-foot isopachs are interpolated westward to locality 8 they are much more closely spaced than those to the east. From these it may be inferred that the trough deepened rather rapidly west of the present front of the Bear River Range, and that it lay in a north-northeast direction.

In the Swan Peak formation we find evidence for a marked change in these conditions early in Chazyan time. The change is much more abrupt on the west than on the east, for at locality 8 the Garden City beds are immediately overlain by calcareous quartzites which pass upward into clean, vitreous quartzites, like those which make up the upper part of the Swan Peak formation at its type locality. At localities 1, 2, 4, 9, 10, 11, and 13 there is a considerable thickness of interlayered black shales, siltstones, and thin limestone lenses near the base. Toward the southeast the percentage of shale and limestone increases, that of pure vitreous quartzite decreases, and the thickness of the entire formation decreases to such an extent that it is not represented at locality 14. There are two possible explanations for this phenomenon:

1) The Swan Peak formation may once have existed as a sheet of uniform thickness over the entire area. Since there is an unconformity representing all the rest of Middle Ordovician time between it and the Richmondian Fish Haven dolomite, it is conceivable that the southeast portion of the area studied might have been broadly upwarped and the Swan Peak stripped off in this interval, leaving a northwestward thickening wedge. Such an hypothesis would require an amazingly even and gentle upwarp.

2) The source of the formation was from the northwest or north; only the shales and a few of the sands were swept as far to the southeast as locality 12, the bulk of the formation being deposited closer to the source.

This second explanation may be nearer to the truth than the other, although there almost certainly was some erosion during Middle Ordovician time. Whether the ultimate source of the quartzites lay to the northwest or northeast cannot yet be told from the evidence in this limited area; it is conceivable that an enormous deltaic fan may have spread from some region far to the north and east, of which these deposits are only a lobe.

The presence of lenses of limestone in the basal Swan Peak layers at localities 5 and 11, plus the irregular alternation of black shales and thin quartzites, suggests that some intertonguing with the upper Garden City beds may have taken place during the southeastward encroachment of the formation. If such were the case, we would expect to find that the youngest Garden City strata at locality 8 were older than the youngest beds at localities 11, 12, and 14. The evidence does not substantiate this possibility.

How much of Ordovician time is represented by the Swan Peak formation is not known. As mentioned under the discussion of zonal correlation (above), the Swan Peak beds cannot be older than Chazyan. Since no fossils have so far been secured from the upper compact vitreous quartzites in the northernmost part of the area studied it is possible that these higher beds are even younger. A great hiatus presumably intervenes between the top of the formation and the base of the Richmondian Fish Haven dolomite.

The Swan Peak deposition was probably caused by some orogenic movement or uplift to the north and west, and this may have had its origin in or resulted in a general raising of the Cordilleran trough temporarily above sea-level in this area. Since no trace of an intervening formation has been found between the Swan Peak and Fish Haven strata we may conclude that no deposition took place in the interval or that all evidence of whatever may have taken place has been completely removed.

In summarizing the Canadian and Chazyan history of the area it can be stated that it was the locus of shallow-water, calcareous deposition east of the axis of the Cordilleran trough throughout Early Ordovician time, toward the close of which large amounts of silica were supplied for the formation of chert, probably either by the erosion of a low-lying borderland or from volcanic activity somewhere outside the area. Shortly after the beginning of Chazyan time a sheet of clastics was spread southeastward into the area. The events of post-Swan Peak pre-Richmondian time are unknown.

SUMMARY

The Garden City formation is widely exposed in northeastern Utah and the adjacent portions of southern Idaho, ranging in thickness from about 1,200 feet at its type section near Bear Lake to nearly 1,800 feet at Clarkston Mountain in the Southern Malad Range to the west. As a lithologic unit it is easily distinguished from the dolomite of the underlying Cambrian St. Charles formation and from the black shales, siltstones, and quartzites of the overlying Swan Peak formation.

The Garden City beds can be divided into two members, the lower one, comprising approximately two-thirds of the formation, being composed of numerous alternations of interbedded and interlensed intraformational limestone conglomerates, crystalline, aphanitic, and muddy limestones, and some limy mud- and siltstones. The first of these types predominates. The upper member is characterized by the high content of black chert, in the form of nodules, stringers, and "interbeds", occurring for the most part in irregularly laminated, aphanitic limestone and dolomitic limestone. Minor amounts of intraformational conglomerate, siltstone, and crystalline and dolomitic limestone are also present.

Widespread faunal zones near the base and top of the formation indicate that its lower and upper boundaries vary little, if at all, in age throughout the area studied, although the dating of the lower limit requires further investigation in the southeasternmost part.

A sequence of twelve faunal zones, distributed throughout the formation, proves to be mostly of Canadian (Lower Ordovician) age and contemporaneous with at least a part of the Pogonip limestone of Nevada. The upper 30 to 50 feet of the formation are faunally allied with the overlying Swan Peak formation and are earliest Middle Ordovician (Chazyan) in age. On the basis of trilobites, the lower 100 feet of the formation (including faunal Zones "A" and "B") are correlated with the Tribes Hill and Stonehenge formations of the East, while equivalents of Zones "C" and "D" can be found in parts of the Manitou limestone in Colorado. Because the trilobite faunas of the standard Lower Ordovician section for North America are not well known, it is practically impossible to date the intervening beds in detail.

The prolific trilobite fauna of the Garden City formation includes over 86 species, representing at least 47 genera. Of the species, only 55 are considered to be represented adequately enough in the present collections to receive formal designation, and of these all but 6 are new. Thirteen of the genera to which definite assignments are made have been previously described.

The lithology of the Garden City beds suggests that they were deposited in shallow water; their northwestward increase in thickness, though relatively slight, indicates that they were laid down east of the axis of the Cordilleran geosyncline.

The Swan Peak formation is now known to be composed of a more varied lithology than the original definition implied; in addition to the vitreous quartzites which comprise approximately the upper half at its type section, the lower beds are made up of interbedded black shales, sandy and limy siltstones, and locally some quartzitic and limestone lenses toward the base. With an increase in thickness northwestward, the percentage of quartzite increases, while to the southeast a gradual thinning and wedging-out is accompanied by a decrease in the relative amount of quartzite.

The thinning of the Swan Peak beds may be attributed to broad upwarp to the east resulting in the bevelling of the formation. Another possible interpretation calls for a northwesterly source of the clastics, although no evidence was discovered within the area investigated for a transgressive contact with the underlying Garden City formation. Future studies in western Utah, Nevada, and Idaho may show that the younger faunal zones occur higher and higher relative to the inter-formational lithologic boundary progressively farther to the west. If so, the contact is, indeed, transgressive. If no such evidence is found, post-Swan Peak and pre-Fish Haven (Richmondian) uplift and erosion may prove to be the better explanation for the thinning of the Swan Peak deposits.

SYSTEMATIC PALEONTOLOGY

INTRODUCTORY REMARKS

No system of classification of Trilobites has yet proved to be entirely satisfactory; for this reason no attempt is made here to present a supra-generic taxonomy other than the division into the generally accepted Subclasses Opisthoparia and Proparia. Genera which appear to be related are, however, grouped together in the text. It may be noted that the great wealth of immature specimens on which ontogenetic studies can be based has hardly been touched and awaits future study. For terminology refer to Ross, 1948.

OPISTHOPARIAN TRILOBITES

Genus *Hystricurus* Raymond, 1913

Hystricurus Raymond, 1913, Victoria Mem. Mus. Bull. No. 1, p. 60.

Since its description by Raymond, some twenty species have been assigned to this genus; with the possible exception of two species named by Kobayashi (1934, pp. 540–542) all are from Lower Ordovician (Canadian) formations. The genus occurs in Greenland, Ellesmere Land, the northeastern United States, Missouri, Texas, Nevada, Utah, and South Chosen.

By assembling the information gleaned from so many specific descriptions plus that derived from study of the Garden City material, it is possible to give a somewhat more complete account than the original by Raymond.

Description. Carapace broadly oval in outline (pl. 4, fig. 33; Poulsen, 1927, pl. XVIII, fig. 5); surface pustulose or smooth. Cephalon semicircular with genal spines, gently convex, and surrounded by a marginal furrow and rim; the furrow may be narrow and deep or wide and shallow, and the rim may be concave and unthickened, or narrowly convex and sub-tubular.

Cranidium. Glabella sub-conical, tapering toward front, outlined by a deep dorsal furrow around sides and front. Glabellar furrows absent or represented by shallow pits in dorsal furrow or by non-pustulose patches on sides of glabella. Occipital furrow well defined. Fixed cheeks and brim convex, especially so adjacent to dorsal furrow. Center of eyes located approximately even with or very slightly forward of glabellar midpoint. Palpebral lobes horizontal and possessing a raised lunate rim; length of lobes from one-half to one-third length of glabella. Lobes always extending to rear of glabellar midpoint. Convex brim may extend forward a distance as much as one-half length of glabella. Postero-lateral limbs slender.

Thorax. Number of segments probably eleven (Poulsen, 1927, pl. XVIII, fig. 5). Axis about one-third to one-half total width. Proximal half of each pleuron horizontal, distal half flexed gently ventrad. Crest of axis about twice as high as proximal halves of pleura. Tips spined or bluntly rounded.

Pygidium. Sub-semicircular in outline. Axis bluntly conical, strongly convex, with three to five segments. Pleural platforms divided into four or five pairs of lobes, convexity variable among species. Pygidium surrounded by a marginal furrow which may be deep and narrow or wide and shallow, and by a rim which may be concave and unthickened or narrowly convex and thickened.

GENOTYPE. *Hystricurus conicus* (Billings).

DISCUSSION. As thus defined, the genus *Hystricurus* includes nine of the twenty previously described species plus eight new species from the Garden City beds. The nine, the assignment of which remains unchanged, are:

H. armatus Poulsen, 1937
H. conicus (Billings), 1865
H. cordai (Billings), 1865
H. crotalifrons (Dwight), 1884
H. eurycephalus Kobayashi, 1934
H. megalops Kobayashi, 1934
H. quadratus Poulsen, 1927
H. ravni Poulsen, 1927
H. sulcatus Poulsen, 1937

The published descriptions and illustrations of eight other species indicate that specimens were too poorly preserved to determine whether they belong in the hypodigm of *Hystricurus sensu stricto*, as here conceived. These are:

H. affinis Poulsen, 1946
H. longicephalus Poulsen, 1927
H. mammatus Raymond, 1924
H. missouriensis Ulrich, 1930
H. nudus Poulsen, 1937
H. oneotensis Powell, 1935
H. tuberculatus (Walcott), 1884

The assignment of *H. translatus* Reed is covered under the discussion of the new genus *Parahystricurus*. That of *H. crassilimbatus* Poulsen is deferred to the discussion of another new *Hystricurus*-like genus, *Pseudohystricurus*, characterized by extreme shortness or complete lack of brim. The placement of *H. abruptus* Cullison is as yet indefinite.

Features which are emphasized here in restricting the genus from its former broader sense are the relatively low, uninflated glabella, slender rather than broadly triangular postero-lateral limbs, and relatively long, horizontal, usually almost semicircular palpebral lobes with lunate rims set off by distinct palpebral furrows. All these features are shown by specimens illustrated in plates 8 and 10. It may further be noted that each species assigned with certainty to the genus from the Garden City collection here described possesses an infra-ocular ring between the surface of the eye itself and the ocular platform on each free cheek.

Hystricurus genalatus Ross, n. sp.

Plate 8, figs. 1–13; Plate 9, figs. 1–13, 17–19

DESCRIPTION. Surface densely pustulose, pustules being only 0.2 mm. apart and of approximately uniform size. Glabella depressed, widest just in front of occipital furrow, and evenly rounded on top; its outline very bluntly rounded in front. Glabellar furrows normally represented by two pairs of very shallow depressions impressing sides of glabella (pl. 8, figs. 11, 13). Anterior limb no wider at marginal furrow than immediately in front of palpebral lobes, and in most specimens slightly narrower. Rim densely pustulose and thickened subtubular. Marginal furrow deep and narrow. Brim markedly convex. Lobes with thickened, lunate rims set off by distinct palpebral furrows. Postero-lateral limbs narrow subtrapezoidal, tips blunt; posterior cranidal rim on limbs normally only faintly pustulose. Anterior to palpebral lobes, facial suture runs straight forward or flares very slightly before converging again to marginal furrow; it revolves inward and downward across rim, cutting sharply across doublure (pl. 8, figs. 7–10). Posterior to palpebral lobes, facial suture runs postero-distally across marginal furrow and then turns very sharply to cross rim in a postero-proximal direction (pl. 8, figs. 7, 10) well within genal angle. Free cheeks in front clearly separated by approximately one-third width of anterior limb. Eyes rest on slender infra-ocular rings; ocular platforms little diminished in width from back to front. Genal spines strong, round, slightly curved spikes, approximately as long as cranidial length. Although no hypostome has been found which is definitely assignable to this species, it is almost certain that the anterior margin is connected directly to the posterior edge of the cranidial doublure between the free cheeks (pl. 8, fig. 8).

Number of thoracic segments not known; associated segments possibly referable to this species indicate that the axis forms a semi-circular arch, one-third as wide as the total width of the segment and three times as high as the height of the pleural lobes; pleural lobes horizontal, but bent downward in distal third of each pleuron; pleural tips blunt.

Pygidium not certainly known; types found associated are illustrated on plate 9. Only those shown in figures 1–13, 17–19, are considered as likely candidates for assignment and undoubtedly include pygidia belonging to *H. paragenalatus* Ross (below). Some of these pygidia possess four distinct axial segments and an indistinct fifth segment (figs. 1, 2, 4, and 5), while others have only two clear segments and an indistinct third (figs. 11, 12, 13). Pygidium illustrated in figures 3 and 8 possesses three axial segments with a suggestion of a fourth, but has clearly reached a stage in growth at which posterior thoracic segment has not become completely separated from anterior of pygidium; it is possible that a fifth terminal axial segment would have been added with the shedding of the anterior segment into the thorax; therefore this pygidium is grouped with those illustrated in figures 1, 2, 4, and 5. This first group possesses a subtriangular outline, only slightly convex pleural platforms, a pair of pustules on each axial segment (figs. 2, 7, pl. 9), a prominent pustule approximately halfway between the dorsal furrow and the tip of each pygidial pleuron, and only a very faint up-bending of the thickened, wire-like rim at the posterior midpoint (figs. 7–10, pl. 9). The second group is somewhat more convex, especially in the pleural platforms; the outline is wider and shorter in most cases, and there appear to be no paired pustules; the up-bending of the rim at the posterior midpoint is more distinct (figs. 17–19, pl. 9).

HOLOTYPE. Y.P.M. No. 17926.

PARATYPES. Y.P.M. Nos. 17928–17933 incl.

DISCUSSION. Comparison with *H. paragenalatus* Ross, which this species very closely resembles, is reserved until after that species has been described (below). Comparisons with other species follow. *H. missouriensis* Ulrich (which probably should not be assigned to *Hystricurus s. str.*) possesses narrower fixed cheeks and a shorter brim; its glabella is higher, with a crest line and slightly flattened lateral slopes; pustules are of two sizes. All the remaining comparisons are made from the literature. In *H. conicus* (Billings) the cranidial rim is concave rather than thickened; the length of the anterior limb falls within the variation range of this species, but the midlength of the brim alone is much shorter. The midlength of the anterior limb of *H. crotalifrons* (Dwight) is about half the length of the same feature in this species; the greatest width of the glabella lies between the eye-centers, lessening both anteriorly and posteriorly. In *H. ravni* Poulsen there is a much more pronounced taper of the glabella, which is more abruptly truncated in front, and the fixed cheeks are narrower; the palpebral lobes, however, compare favorably with those in *H. genalatus. H. cordai* (Billings) is smooth. There is some similarity with *H. conicus* Whitfield (1889, p. 61, pl. 13, figs. 15–21), not (Billings), but figures of this form indicate that the pustules are less dense, the fixed cheeks narrower, and the brim anterior to the palpebral lobes narrower than in *H. genalatus.*

The features which are considered to be of especial specific importance are the densely pustulose rim, the shape of the anterior limb which is no wider at the marginal furrow than in front of the palpebral lobes, the short path of the facial suture across the anterior cephalic doublure, and the shape and ornamentation of the postero-lateral limbs.

Occurrence. Zone "B", locality 7, 135–165 feet above base of Garden City formation; locality 5, 85 feet above base of formation; locality 6, 85 feet above base of formation.

Hystricurus paragenalatus Ross, n. sp.

Plate 8, figs. 14–26; Plate 9, figs. 1–13, 17–19

Description. Cephalon not quite semi-circular in outline, margins of free cheeks anterior to genal spines being almost straight; genal spines very long with posterior ends curved postero-proximally. Surface densely pustulose except on cranidial rim; pustules of approximately uniform size. Glabella depressed, widest just in front of the occipital furrow, evenly rounded on top. Outline of anterior of glabella rather sharply rounded. Glabellar furrows represented by two pairs of very shallow depressions in dorsal furrows (pl. 8, fig. 18) or of non-pustulose patches on sides of glabella (pl. 8, fig. 21). Anterior limb always slightly wider at marginal furrow than immediately in front of palpebral lobes. Rim smooth or extremely faintly pustulose in a few cases; although clearly thickened and subtubular, not as strongly convex as in *H. genalatus.* Marginal furrow of moderate depth and not narrow. Brim gently convex. Fixed cheeks and palpebral lobes like those in *H. genalatus.* Postero-lateral limbs very slender, almost trapeziform; in most specimens densely ornamented with sharply pointed pustules (pl. 8, figs. 21, 23). Anterior to palpebral lobes facial suture runs slightly outward before crossing marginal furrow, from which it turns sharply inward and revolves downward across rim, cutting gradually across doublure (pl. 8, figs. 19, 20, 22, 23; compare with figs. 7, 8, and 10). Posterior to palpebral lobes, suture runs postero-laterally to posterior marginal furrow, turning to rear to cross rim two-thirds of distance from dorsal furrow to genal angle; in crossing rim, suture follows a straight course so that tips of postero-lateral limbs are truncated and not rounded as in *H. genalatus* (compare figs. 2, 3, 7, and 10 with figs. 19–22 of plate 8). Free cheeks long and narrow; slender eyes rest above even more slender infra-ocular ring; ocular platform of each only one-fifth as wide as cranidium, both measured on line through eye-centers. Marginal furrows on side and at posterior of cephalon confluent at and extending slightly behind genal angle along dorsal side of spine. Margin almost straight from point opposite anterior "corner" of cranidium as far back as, and in some specimens to rear of, genal angle, giving cephalon a subtrapeziform outline. Genal spines at least three times as long as glabella, curving postero-proximally at their ends, and ornamented on outside with multitude of small, sharp pustules (figs. 19, 21, pl. 8). Portion of each cheek projecting beneath cranidium as part of doublure extends almost to midline in single specimen on which a cheek could be fitted (figs. 16, 21, pl. 8); proportions of other cheeks suggest that they may actually have extended all the way to midline, so that right and left cheeks met at a point. In either case it is probable that the hypostome was not simply attached to the posterior edge of the cranidial doublure, but wholly or in part to the edge of the doublure formed by the two cheeks. No assignment of hypostome yet made for this species.

Thoracic segments not definitely assigned and their number not known. No evidence found to indicate that segments can be distinguished from those of *H. genalatus.*

Pygidium not certainly known; problem of assignment of pygidia discussed under description of *H. genalatus.*

Holotype. Y.P.M. No. 17934.

Paratypes. Y.P.M. Nos. 17935–17840 incl.

Occurrence. Zone "B", locality 7, 135–165 feet above base of Garden City formation; locality 5, 85 feet above base of formation; locality 6, 85 feet above base of formation.

Comparison of *Hystricurus genalatus* and *H. paragenalatus.* A glance at the cranidia figured on plate 8 will indicate that these two species are very similar in cranidial characteristics. Since the two have been found together at three localities, and neither has to date been found without the other associated, it was at first believed that a single species with considerable variation was present. This belief was held until it became quite apparent that two very distinct types of free cheeks were associated which could hardly be reconciled as belonging to a single species. It was then discovered that the cranidia could be separated into two lots on the basis of four morphological features. First, shape of the anterior limb; in *H. genalatus* the cranidial width is no greater, and is usually somewhat less, at the marginal furrow than immediately in front of the palpebral lobes, while in *H. paragenalatus* the opposite is true. Second, the rim of *H. genalatus* is strongly and narrowly convex, densely covered with pustules, and set off from the brim by a deep marginal furrow; in *H. paragenalatus,* on the other hand, the rim is equally narrow but much less convex, its surface is smooth or only very faintly and sparsely pustulose, and it is separated from the brim by a more shallow marginal furrow. Third, the postero-lateral limbs of *H. genalatus* appear bluntly rounded in dorsal view and are usually only sparsely pustulose along the posterior margin; those of *H. paragenalatus* are sharply truncated by the facial suture and normally bear a multitude of sharply pointed pustules along the posterior margin. Fourth, shape of the cranidial doublure as seen in ventral view (figs. 8, 23, pl. 8). In *H. genalatus* it is clear that the facial sutures cut across the doublure abruptly, so that the free cheeks are not in contact; the sutures cut across the doublure in *H. paragenalatus* so gradually that it is not clear whether the free cheeks were separated by more than a suture in all specimens.

In order to test the reliability of these criteria 98 undeformed cranidia were examined and divided on the basis of the characteristics of the rim, 40 having those of *H. genalatus* and 58 those of *H. paragenalatus.* Of the 40, 38 clearly possessed anterior limbs of *H. genalatus* while 2 were of an intermediate type; 34 had postero-lateral limbs of *H. genalatus,* 2 were intermediate, and 4 were of the *H. paragenalatus*-type; in 32 the facial suture cut the doublure abruptly, the courses of 4 were intermediate, 2 were gradual, and 1 was indeterminate. Of the 58, 55 possessed anterior limbs of *H. paragenalatus,* while 3 had the character of

H. genalatus; 51 had the postero-lateral limbs of *H. paragenalatus,* 2 possessed the *H. genalatus* type, and 5 were indeterminate; the facial sutures cut the doublure gradually in 55, abruptly in 2, and in an intermediate fashion in 1. Although

Cephalic proportions / Y.P.M. No.	*H. genalatus*				*H. paragenalatus*		
	17926	17928	17929	17931	17934	17937	17935
1. Length of cephalon / Width of cephalon at occipital ring	—	—	—	.46	.42	—	—
2. Length of glabella / Length of cranidium	.75	.80	.78	.76	.73	.75	.73
3. Distance from posterior margin to intersection of midline and line through eye-centers / Length of glabella	.60	.51	.50	.54	.39	.38	.50
4. Midlength of brim / Length of cranidium	.15	.16	.17	.15	.11	.16	.16
5. Width of cranidium at anterior marginal furrow / Length of cranidium	.85	.77	1.00	.91	1.14	1.03	1.05
6. Length of cranidium / Width of cranidium at postero-lateral limbs	.67	.71	.62	.64	.62	.67	.66
7. Length of cranidium / Width of cranidium at palpebral lobes on line through eye-centers	.87	.88	.72	.77	.75	.80	.79
8. Width of cranidium immediately anterior to palpebral lobes / Width of cranidium at anterior marginal furrow	1.09	1.18	1.08	1.16	.93	.97	.96
9. Width of cranidium at anterior marginal furrow / Width of cranidium at palpebral lobes on line through eye-centers	.74	.68	.72	.71	.86	.83	.83
10. Width of cranidium at palpebral lobes on line through eye-centers / Width of cranidium at postero-lateral limbs	.77	.81	.86	.83	.83	.83	.84
11. Width of glabella on line through eye-centers / Width of cranidium at palpebral lobes on line through eye-centers	.48	.49	.42	.43	.44	.45	.42
12. Width of glabella at its midpoint / Width of glabella at occipital ring	.92	1.00	1.00	1.00	1.00	1.00	1.00
13. Width of ocular platform on line through eye-centers / Half-width of cranidium at palpebral lobes on same line	—	—	—	.46	.17	—	—
14. Length of genal spines / Length of glabella	—	—	—	1.00	3.00	—	—

there appear to be a considerable number of intermediate forms, from this summary, it must be emphasized that no specimen which failed to fit the above grouping with regard to one of the critical characteristics also failed in the other three; for instance, the specimen of *H. genalatus* illustrated in figure 11, plate 8, clearly possesses the postero-lateral limbs of *H. paragenalatus* (and was figured for that reason), but agrees with *H. paragenalatus* in no other respect. There is, therefore, no set pattern of variation in the two populations.

Fourteen different cephalic proportions computed for specimens of the two species illustrated on plate 8 are tabulated above. It will be noted that only the 5th, 8th, 9th, 13th, and 14th of these can be used to differentiate between the two. The 3rd is inconclusive, but suggests a possible sixth means of segregation which may be caused by the more slender shape of the postero-lateral limbs of *H. paragenalatus* (since the eyes may be consistently closer to the posterior margin). It should also be noted that the anterior outline of the glabella is slightly more blunt in *H. genalatus*.

The fact that these two forms apparently always occur together in the Garden City deposits raises the question as to whether two separate species are really present. One must consider the possibility that two sexes of the same species or that two subspecies may be represented. There is absolutely no means of deciding whether the differences between the two are caused by sexual dimorphism, since no living examples of the Trilobita are available to modern investigators; the fact that the important morphological criteria for distinguishing the two do show occasional intermediate characteristics discourages consideration of this possibility.

Some investigators may argue that no two species of the same genus may live together and that, therefore, the two forms in question must be considered subspecies of a single species. Such an argument meets an obvious weakness; the mere fact that these two forms are found together in sedimentary deposits does not necessarily indicate that they lived in the same ecologic niche. They may have been separated in life by some slight difference in diet or in depth of water; in either case the carapaces moulted during growth and those of dead animals would fall to a common resting place on the bottom. The fact that over 200 cranidia can be separated into two groups on the basis of morphological criteria discussed above, plus the fact that no specimen has been found to be intermediate in all these characteristics lead to the conviction that two distinct species of *Hystricurus* are indeed represented here. This is further supported by the association with *H. genalatus* and *H. paragenalatus* of a third species, *H. politus* Ross, n. sp. (below), which possesses a smooth surface and an occipital spine.

Hystricurus politus Ross, n. sp.

Plate 9, figs. 23–24, 27, 28, 32–33; Plate 15, figs. 1–6

It may eventually be found that this species, as here conceived, actually includes more than one species.

DESCRIPTION. Surface of cranidium smooth, except for very faint pustules on brim of some specimens. Glabella sub-ovoid, depressed, widest at occipital ring, occipital spine extending almost horizontally from posterior of glabella. Anterior limb wider than long; no wider at marginal furrow than immediately in front of palpebral lobes, but slightly wider between lobes and furrow. Brim gently convex; marginal furrow deep and narrow; rim narrowly convex, sub-tubular. Fixed cheeks moderately convex. Postero-lateral limbs very slender with narrow tips. Anteriorly, the facial suture runs outward and then inward in a gentle curve across brim to marginal furrow, from which it turns sharply inward to revolve ventrally across rim; from a point on leading edge of rim located one-third width of anterior limb from its sides suture cuts in a diagonal across doublure; the right and left free cheeks apparently do not meet (as is the case with *H. genalatus*) although this is not certain with all specimens. Posterior to palpebral lobes facial suture runs postero-laterad at approximately 80 degrees to cranidial axis to cross posterior marginal furrow and define slender limbs with acutely rounded tips.

Some of the cranidial proportions of the figured specimens follow:

Y.P.M. No.:	17955	17956	17954	17958
1. Length of glabella : length of cranidium	.79	.74	.87	.80
2. Distance from posterior margin to line through eye-centers : length of glabella	.54	.58	.54	.56
3. Midlength of brim : length of cranidium	.18	.18	.13	.25
4. Cranidial width at anterior marginal furrow : length of cranidium	.79	.86	1.19	1.10
5. Length of cranidium : width of cranidium at postero-lateral limbs	.59	.66	.55	.62
6. Length of cranidium : width at palpebral lobes on line through eye-centers	.83	.82	.75	.80
7. Width of cranidium immediately anterior to palpebral lobes : width at anterior marginal furrow	1.12	1.11	1.03	1.04
8. Width at anterior marginal furrow : width at palpebral lobes on line through eye-centers	.65	.71	.73	.88
9. Width at palpebral lobes on line through eye-centers : width of cranidium at postero-lateral limbs	.71	.80	.73	.77
10. Width of glabella on line through eye-centers : width of cranidium at palpebral lobes on same line	.45	.47	.48	.45
11. Width of glabella at midpoint : width of glabella at occipital ring	1.00	1.00	.90	.96
12. Length of palpebral lobes (chord geometrically) : length of glabella	.42	.45	.43	.28
13. Length of occipital spine : length of glabella	.38	—	.54	.31

Associated free cheeks possess long, slender, round genal spines, gently curved to rear, and apparently diverging from cephalic axis by about 60 degrees. Ocular platforms evenly rounded and steep, marginal furrow not deeply incised, and rim subtubular, but not strongly defined. Eyes considerably smaller than would be expected from size of palpebral lobes of most cranidia.

Associated pygidia are illustrated in plate 9, figures 1–22, 25, 26, 29, 30, and discussed under *H. genalatus* (above); of these, those shown in figures 13, 14, and 19 are considered most likely candidates for assignment to this species, because of their smooth surfaces and sharply sloping pleural platforms.

Hypostome and thorax not known.

Holotype. Y.P.M. No. 17955.

Paratypes. Y.P.M. Nos. 17956, 17954, 17958, 17959.

Discussion. The specimens collected of this species were secured from the same zone at localities 6 and 7 and are associated with practically identical forms at both. At locality 6, however, the silicification is extremely delicate and most specimens of this species have been deformed. It is not entirely certain that the differences between specimens from the two localities can be attributed in toto to this fact. One striking difference occurs; at locality 6 none of the specimens collected to date possesses strong palpebral rims (pl. 9, fig. 32), while at locality 7 all of them have well-developed palpebral lobes and rims (pl. 9, fig. 28; pl. 15, figs. 1, 4). Many of the specimens from locality 6 suggest that the palpebral rims have been broken off, but this is not always the case. Since the first assignable free cheeks were secured from locality 6, all with very small eyes (pl. 9, figs. 23, 24), it was assumed that the palpebral lobes never had been larger and that a different species was present than at locality 7. Somewhat later, free cheeks were taken from the material at locality 7 which possess practically identical eyes and suture pattern and still appear to fit the cranidia with more prominent palpebral lobes from that locality. This fact tended to reopen the possibility that all the cranidia at locality 6 had been damaged, as unlikely as it may seem, and that all were of the same species. Since the collections from locality 7 are ample, while those from locality 6 are small, a definite decision is reserved until further collecting can be undertaken.

Occurrence. Zone "B", locality 7, 135–165 feet above base of Garden City formation; locality 5, 85 feet above base of formation; locality 6, 85 feet above base of formation.

Hystricurus oculilunatus Ross, n. sp.

Plate 10, figs. 1–3, 5, 8, 9, 12

Description. Surface of cephalon coarsely pustulose, pustules 0.2 mm. apart and of approximately uniform size. Length of cranidium two-thirds width at postero-lateral limbs and nine-tenths width between eye-centers. Glabella depressed, with crest-line and slightly flattened lateral slopes, widest at midlength. Glabella three-fourths length of cranidium. Width of glabella, measured between eye-centers, 0.75 times its length and 0.5 times width of cranidium at same point. Brim convex, its midlength one-fifth that of glabella. Marginal furrow deep, confluent with occipital furrow. Rim thick, smooth, and marked by fine striae. Palpebral lobes with smooth rims; their length a little more than half that of glabella. Eye-centers located even with glabellar midpoint. Free cheeks arch gently down to border; width of ocular platform along transverse line through eye-centers approximately four-tenths half-width of cranidium on same line. Genal spines short, only half length of glabella. From posterior end of palpebral lobes, facial suture runs distally almost at a right-angle with longitudinal axis, turning sharply posteriorly to cross marginal furrow close to base of genal spine (pl. 10, figs. 1–2); forward from palpebral lobes suture swings slightly outward and then inward so that width of anterior limb at marginal furrow equals or is very little greater than between anterior ends of palpebral lobes. Suture supramarginal at marginal furrow; it turns sharply inward, crossing the rim to become inframarginal at the cranidial midline (pl. 10, fig. 1).

Thoracic segments and pygidium not known. (For possibly assignable pygidia see plate 16, figures 18, 20, 24, 27–28, and plate 18, figures 30–38. For possibly assignable hypostomes see plate 18, figures 21–29.)

Holotype. Y.P.M. No. 17960.

Paratype. Y.P.M. No. 17961.

Discussion. In addition to the holotype there are specimens of which the great majority are immature. A single specimen (Y.P.M. No. 18299) was broken out of limestone matrix at locality 14B (pl. 10, figs. 8, 9, 12) which may actually represent a separate species. Its glabella is relatively a little shorter and the width of the cranidium at the marginal furrow a little wider than in the type specimen; both these factors are well within the variation range of the silicified, *though immature,* specimens of the type locality. All other characteristics are nearly identical with the type specimen.

H. oculilunatus is characterized by the long crescentic rims of the palpebral lobes and the plan of the glabella, which is widest at the midlength. In this last respect it suggests *H. crotalifrons* (Dwight), but the maximum width of the glabella in Dwight's species is located only three-tenths of its length from the posterior. Comparison with other described species is not considered necessary.

OCCURRENCE. ZONE "F", locality 6, 305–340 feet above base of the Garden City formation. Locality 14B, 65 feet above base of Garden City formation.

Hystricurus contractus Ross, n. sp.

Plate 10, figs. 4, 6, 7, and 10

DESCRIPTION. Cranidium very similar to that of *H. oculilunatus,* differing as follows: 1) palpebral lobes slightly closer together; 2) glabella shorter, lower, more evenly rounded, lacking crestline and lateral slopes, and widest adjacent to occipital furrow; 3) marginal furrow shallower; 4) fixed cheeks slightly less convex; 5) anterior facial sutures straight, not flaring, slightly converging, so that width of brim at marginal furrow is nine-tenths width immediately anterior to palpebral lobes; 6) posterior facial sutures running postero-laterally at angle of 60 degrees, turning sharply to rear after crossing posterior marginal furrow. (Compare figures 2 and 7, plate 10.)

Free cheeks not identified. Thoracic segments, pygidium, and hypostome not known. (For possibly assignable pygidia see figures 23, 28, 29, 32, and 33 of plate 17, and figures 30–38 of plate 19. For possible hypostomes see figures 21–29 of plate 19.)

HOLOTYPE. Y.P.M. No. 17962.

DISCUSSION. Species based on fifteen specimens. It may be distinguished from *H. conicus* (Billings) in its longer pustulose brim, sub-tubular, rather than concave, rim, and slightly steeper deflection of brim. The type of *H. megalops* Kobayashi (1934, pl. 6, figs. 8, 9) is too poorly preserved for satisfactory comparison.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Hystricurus flectimembrus Ross, n. sp.

Plate 10, figs. 25, 26, 29–33; Plate 11, figs. 16–18, 20–33

DESCRIPTION. Carapace oval, surface coarsely pustulose. Length of cranidium about six-tenths width at postero-lateral limbs and slightly over nine-tenths width at palpebral lobes. Glabella low, widest at occipital ring, with sides tapering slightly to bluntly rounded front. Two pairs of pits, located in dorsal furrow, indent sides of the glabella; one pair even with fronts of palpebral lobes, the other with midpoint of glabella. Brim very gently convex, its midlength less than two-tenths that of glabella. Marginal furrow narrow and well-defined. Rim thickened and smooth. Palpebral lobes very prominent, not quite semicircular, with narrow thickened rims ornamented by a few pustules. Length of palpebral lobes one-half that of glabella, their greatest width located slightly forward of glabella midpoint. Free cheeks arched gently down to marginal furrow; eyes low; below each eye there is a thin ring (the *plica palpebralis* of Dalman, 1828, p. 12); width of ocular platform more than half width of glabella, both measured along transverse line through eye-centers. Genal spines slightly exceed glabella in length and reach back to fourth thoracic segment (fig. 33, pl. 11); they are curved and smooth. Marginal furrow distinct where it crosses anterior facial suture, but in this species fades out at base of genal spine without joining furrow on postero-lateral limb. Posterior facial suture runs outward at an angle of a little less than 90 degrees with axis of cranidium until well past widest part of palpebral lobe; then turns posteriorly into center of furrow of postero-lateral limb, along which it runs for a short distance before cutting sharply to rear. This course plus the fact that the posterior edge of the postero-lateral limb vaguely parallels it, gives the limb a flexed appearance. Anterior facial suture swings very slightly outward and then inward so that width of anterior limb is the same at marginal furrow as between fronts of palpebral lobes. From marginal furrow suture turns sharply inward, becoming inframarginal at midline of border. In most specimens posterior rim and occipital ring of cranidium bear strong spines; the majority have a long occipital spine with a pair of flanking spines half its length; others have only the flanking spines, while a few are only coarsely pustulose. Number of short spines along posterior border of postero-lateral limbs varies considerably between specimens, but there is in most specimens one just inside facial suture.

Thoracic segments number at least 10; axis a little less than one-third as wide as segment. Each pleural platform horizontal in its proximal two-thirds, but end of each pleuron bends downward at 45 degrees from horizontal. Some pleural tips bluntly falcate, others sharply spined. Relative position of these two types in thorax not determinable. Pair of short, stubby spines at crest of axis, and two or three coarse pustules on slopes. Posterior half of pleuron has five or six evenly spaced pustules between dorsal furrow and tip. Anterior half in the same space has an equal number of minute pustules.

Assignable pygidia illustrated in figures 16–18, 24, plate 11. As in the thorax these show two sizes of pustules on each pleural lobe. Marginal furrow narrow and well-defined and rim thickened; at posterior midline rim and doublure raised slightly to form a small indentation in dorsal plan, which is sub-semicircular. Well-defined axis shows five rings, of which the fifth is obscure; fifth pleural lobe also obscure (see *H. acumennasus,* below).

Hypostome not known, but for those which are possibly assignable see figures 21–29, plate 19.

Holotype. Y.P.M. No. 17972.

Paratypes. Y.P.M. Nos. 17970, 17971, 17973–17979 incl., 18300.

Discussion. This species is easily distinguished by its flexed postero-lateral limbs, almost semicircular palpebral lobes, and the two pairs of pits in the dorsal furrow of the cranidium. Its closest relative is unquestionably *H. acumennasus* Ross, n. sp., from which it is most easily distinguished by the characters of the brim, border, and free cheeks. A poorly preserved cranidium might conceivably be confused with *H. megalops* Kobayashi.

It is of great interest that cranidia less than 3 millimeters long possess a lengthwise, median, pre-glabellar furrow, which connects the dorsal and marginal furrows and divides the brim into a right and left half (pl. 11, figs. 27–32). The same feature is present in the immature forms of *H. oculilunatus, H. contractus, H.* sp. B, *H.* sp. C, and *H. robustus;* it is not present in *H. genalatus,* as far as can be determined, in cranidia as small as a millimeter in length, although a single specimen 1.5 millimeters long bears a faint suggestion of such a furrow. A pre-glabellar furrow is also found in the immature cranidia of all species of *Parahystricurus* described in this report, as well as in several of the adults. It is interesting that a species assigned, probably erroneously, to *Hystricurus* (*H. translatus*) by Reed in 1931 (p. 6) possesses the same feature.

A second feature of considerable interest is best seen in figure 29 of plate 10; in front of the occipital furrow there are three evenly spaced pairs of pustules along the crest of the otherwise smooth glabella of cranidia less than 2 millimeters long. The anterior two pairs are even with the two pairs of pits in the dorsal furrows; if a more posterior pair of pits was present, it would probably be located even with the rear pair of pustules. It may be supposed that these pairs of pustules were "sockets" of attachment for appendicular muscles or that they, in some way, demarcate cephalic segments. With increasing size it is quite obvious that pustulosity of the cranidial surface increased in this species; it, therefore, becomes increasingly difficult to differentiate the pairs of pustules in question on larger specimens. They can still be distinguished on cranidia a little less than 4 millimeters long (observe in order figures 29, 30, 25, and 22 on plate 11). In two of the species of *Parahystricurus* for which partial ontogenetic sequences have been worked out the same phenomenon has been observed (see pl. 12).

Occurrence. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Hystricurus acumennasus Ross, n. sp.

Plate 11, figs. 6, 7, 10, 11, 12, 15

Description. Cephalon moderately pustulose; produced into a broad snout in front. Marginal furrow shallow, distinct on cranidium, but only faintly impressed on free cheeks; rim wide and rounded.

Shape and proportions of glabella identical with those in *H. flectimembrus,* as are presence and position of two pairs of pits in dorsal furrow and features of palpebral lobes. Brim sloping downward at rather steep angle to marginal furrow, only slightly convex; its midlength about one-quarter glabellar length. Rim having shape of equilateral right triangle in which hypotenuse is gently concave. Behind palpebral lobe facial suture practically identical with same feature in *H. flectimembrus.* In front of palpebral lobe, facial suture very distinctive of this species. From anterior end of lobe, suture swings slightly and continually inward, so that width of anterior limb at marginal furrow is only seven-tenths its width at fronts of palpebral lobes. Forward of marginal furrow it makes an angle of close to 45 degrees with a line transverse to the cranidium, and the right and left sutures meet nearly at right angles (figs. 10–11, pl. 11). As a result the anterior rim of the cranidium is rostrate. The facial suture never becomes inframarginal, but remains supra- or intramarginal; the right and left sutures meet a short vertical suture which separates the right and left free cheeks. To accommodate the rostrate border of the cranidium the free cheeks are produced forward to give the cephalon its acuminate appearance. On the free cheeks pustules are limited to the proximal half of the ocular platform.

Thoracic segments: the description of segments given under *H. flectimembrus* probably applies equally well to this species. However, there are a few otherwise indistinguishable associated segments which bear a pair of long, horizontal, backward-directed spines, arising from the lines of downward flecture near the ends of each pleuron. The fact that the almost complete thorax of *H. flectimembrus* (see fig. 33, pl. 11) shows no such spines suggests that the spined segments are assignable to *H. acumennasus.* Therefore, the pygidium illustrated in figure 17, plate 11, is probably that of *H. acumennasus,* and not that of *H. flectimembrus;* still attached to this pygidium is the right half of the posterior thoracic segment, bearing a large spine of the type in question.

Hypostome not known; for those now available for assignment see figures 21–29, plate 19.

HOLOTYPE. Y.P.M. No. 17980.

PARATYPES. Y.P.M. Nos. 17981, 17982.

DISCUSSION. This species is based on seven cranidia and eleven free cheeks. It occurs associated with and is unquestionably very closely related to *H. flectimembrus.* The distinctive features are the course of the facial sutures in front of the palpebral lobes and the acuminate front of the cephalon, differentiating the species from all others in the genus *Hystricurus.*

Mention must be made of additional findings concerning the pygidia which are associated with this species and *H. flectimembrus.* It has been possible to erect two partial ontogenetic sequences in which the smallest pygidia are one millimeter long. In one of these series the smallest specimens possess a pair of spines on the posterior pleural lobes. In the next larger size the pair of spines is located on the fourth pair of pleural lobes, none being present on the other four. With increase in size of the pygidia the segment bearing the pair of spines appears to move forward until the condition existing in figure 17, plate 11, is reached; at this point the segment bearing the spines has barely become separated from the front of the pygidium as the posterior segment of the thorax. In the second series there is no evidence of paired spines.

The conclusions which can be reached from the above observations are (1) that the thorax increased in length during the meraspid stages by the addition of segments from the front of the pygidium, while the pygidium maintained its shape by the addition of segments at the rear; (2) that there must have been at least five segments without spines in the thorax anterior to the first spined segment; (3) that *H. acumennasus* probably possessed at least one spined thoracic segment, while *H. flectimembrus* did not. The third conclusion must be made with caution, for the character of only ten thoracic segments of *H. flectimembrus* is known (pl. 11, fig. 33); it is possible that this species did possess one spined segment providing that it reached the holaspid stage when such a segment was the eleventh. No definite conclusions can be reached on the character of the pygidium of either species until complete carapaces have been found for each.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Hystricurus robustus Ross, n. sp.

Plate 10, figs. 11, 13–16, 20; Plate 14, fig. 27

DESCRIPTION. Cranidium very convex in longitudinal profile; surface coarsely pustulose. Glabellar length over eight-tenths cranidial length; its greatest width at occipital ring, tapering anteriorly to narrowly rounded front. No glabellar furrows, but under side of test shows two pairs of faint swellings on ridge corresponding to dorsal furrow; swellings located even with front of palpebral lobes and even with widest part of lobes. Once swellings, of which anterior pair is fainter, have been determined, it is barely possible to make out two pairs of corresponding very shallow pits in deeply impressed dorsal furrow; in some specimens these pits gently crease the sides of the glabella near its base. Brim unusually short, its midlength 0.11 to 0.13 times length of cranidium. Along its midlength the brim is flattened or very slightly concave, although no median furrow is present. On under side of cranidia less than 2 millimeters long is a longitudinal ridge along midline of brim which connects ridge corresponding to dorsal furrow with ridge corresponding to marginal furrow. On dorsal side of brim pustules are sparse or lacking in middle half. Marginal furrow deep. Rim smooth and thick, carinate instead of rounded (pl. 10, figs. 13, 16). Each palpebral lobe almost entirely occupied by thick crescentic rim, bounded on inside by deep palpebral furrow. Posterior facial suture runs outward and backward at angle of 60 to 70 degrees with longitudinal axis of cranidium; after crossing marginal furrow it turns directly posteriorly to delimit blunt ends of posterolateral limbs. Anteriorly facial suture curves very gently inward, so that width of anterior limb at marginal furrow is little more than three-fourths its width in front of palpebral lobes; from marginal furrow suture turns sharply, crosses the rim, and passes across the posterior edge of the doublure before reaching the midline. Free cheeks almost indistinguishable from those of *Parahystricurus carinatus* (pl. 13, figs. 35, 37; pl. 14, fig. 27). In *H. robustus* ocular platform faintly pustulose, especially on proximal slope near eye; distinct infra-ocular ring present. Heavy sub-carinate genal spine produced backward as far as seventh thoracic segment. Thorax partly known from articulated specimen (pl. 14, fig. 27) of which the axis and right pleural platform of first eight segments remain unbroken; part of cephalon remains also, including posterior half of glabella, right palpebral lobe, and rear half of free cheek. In thorax each pleural lobe a little wider than axis. First segment gently curved to rear and sharply pointed, with single node just proximal to tip on back of pleuron. Toward rear tips of pleura become progressively more blunt. On fourth segment a second small node appears, so that a pair is oriented parallel to longitudinal axis of thorax; these persist posteriorly at least as far as eighth segment. On crest of axis of each segment is another pair of nodes, one node on either side of thoracic midline. Small pustules regularly spaced along back of pleuron; although quite distinct on first three segments, they diminish in size and can barely be seen on the eighth.

Associated pygidia available for assignment are illustrated on plate 19, figures 5–20. Associated hypostomes are shown in figures 1–4 of the same plate.

Holotype. Y.P.M. No. 17964.

Paratypes. Y.P.M. Nos. 17965, 18030.

Discussion. This species is based on fifteen cranidia, one free cheek, and a very small articulated, but broken, carapace. Superficially it bears a resemblance to (*H.*) *crassilimbatus* Poulsen (1927, pl. 5, figs. 6, 7), but that species possesses a much narrower cranidium and practically no brim. The shape of the glabella is nearly identical with that of *H. missouriensis* Ulrich, which lacks a carinate rim and is not nearly as pustulose; comparison of the palpebral lobes and posterolateral limbs is not possible, for they are missing from Ulrich's type specimen, of which a cast is in our possession (these features were added to the original photograph by Ulrich [in Bridge, 1930, pl. 21, figs. 1, 2]). The brim of the Missouri species is more evenly convex.

Certain features of this species are remarkably similar to those of *Parahystricurus carinatus*, from which it is distinguished by the convexity of the glabella, shortness of brim, crescentic palpebral rims, and possession of infra-ocular rings. The features which the two possess in common are the carinate cephalic rim, slope of the free cheeks, and thick, subcarinate genal spine. The relative characters of the thorax and pygidium are not known.

Occurrence. Zone "E", locality 5, 313 feet above base of Garden City formation.

Hystricurus sp. A

Plate 9, figs. 31, 34, 37

A single specimen of this species was collected, and it is so imperfectly preserved that it does not warrant a specific name. That it is distinct from any of the other species collected from the Garden City formation is quite clear.

Description. Cranidium only faintly pustulose. Glabella constricted slightly in front of midlength, depressed and gently rounded. Two shallow pits anterior to midpoint of glabella occur in dorsal furrow on each side and are apparently analogous with glabellar furrows. Marginal furrow broad and rim concave as in *H. conicus* (Billings). Only a single row of pustules persists across brim in front of glabella.

In plan this specimen suggests *H. sulcatus* Poulsen, but the glabella of that species is much more inflated and possesses an occipital spine (Poulsen, 1937, p. 33).

Figured specimen. Y.P.M. No. 18296.

Discussion. Several fragments of cranidia found 210 feet above the base of the Garden City formation at locality 6 strongly suggest this species because of the character of the brim, marginal furrow, and rim. No complete cranidium was found.

Of all species described to date, only the genotype, *H. conicus* (Billings), possesses a marginal furrow and rim of this type. In the genotype, the plan of the glabella is very similar and its length takes up an equal proportion of the midlength of the cranidium. Unfortunately the type specimen of *H. conicus* (Billings), as figured by Raymond (1913, pl. VII, fig. 9), is as poorly preserved as this specimen and no further comparisons can be made.

Occurrence. Locality 14L, 125 feet above base of Garden City formation.

Hystricurus sp. B

Plate 10, figs. 18, 19, 23, 24, 27, 28

Description. This species is represented by three immature cranidia, the largest of which must have been a little less than 3 millimeters in length before it was broken. The other two are almost complete, being 2.2 and 1.2 millimeters in length. There is little difference between the proportions of the two larger specimens; although the smallest is believed to represent an early stage in the meraspid development, its proportions are so different that it may belong to an entirely different species. The specimens are figured as a matter of record.

Attention is called to the possession of a pre-glabellar median furrow on the brim, and nearly flat, reflexed fixed cheeks. Proportions of the smallest specimen are quite different, but are not necessarily inconsistent with differences between holaspids and meraspids of other species.

FIGURED SPECIMENS. Y.P.M. Nos. 17967, 17969.

OCCURRENCE. Zone "E", locality 5, 313 feet above base of Garden City formation.

Hystricurus ? sp. C

Plate 10, figs. 17, 21, 22

DISCUSSION. Like *Hystricurus* sp. B with which it is associated, this species is represented only by three obviously immature cranidia. One of these is figured as a matter of record; other than to call attention to the possession of two pairs of short glabellar furrows no further space is devoted here to its description.

FIGURED SPECIMEN. Y.P.M. No. 17966.

OCCURRENCE. Zone "E", locality 5, 313 feet above base of Garden City formation.

Hystricurus sp. D

Plate 9, figs. 35, 36, 38–41

This species is represented in the Garden City collection by a half dozen imperfect specimens, broken out of a compact limestone matrix. The largest cranidium is 6 millimeters long, and the others are considerably smaller.

DESCRIPTION. Surface coarsely pustulose. Glabella high and sub-ovoid, standing well above fixed cheeks; two pairs of smooth patches on sides, anterior pair even with fronts of palpebral lobes, and posterior pair even with eye-centers. Brim gently convex, may be ornamented with fine, irregular ridges, oriented more or less parallel with midlength, pustules interspersed (figs. 36, 40, 41, pl. 9). Marginal furrow narrow and deep; rim thickened. Palpebral lobes with thickened, crescentic rims ornamented with few minute pustules. Anterior facial sutures diverging slightly, so that cranidial width at marginal furrow is slightly wider than immediately in front of lobes. Eye-lines (faint grooves, not ridges) very faintly defined and strongest close to dorsal furrow, fading out before reaching palpebral rims.

Hypostome, thorax not known. A single associated pygidium is illustrated in figure 10, plate 30. This pygidium may belong to a new *Hystricurus*-like genus, *Pseudohystricurus,* a species of which is also associated.

FIGURED SPECIMENS. Y.P.M. Nos. 18297, 18298, 18334.

DISCUSSION. This species most closely resembles *H. paragenalatus,* and was believed to be conspecific when collections were being made in the field, although the latter occurs about 50 feet higher stratigraphically. It appears to be differentiated by a considerably higher glabella and the possession of eye-line "grooves", which are imperfectly developed.

OCCURRENCE. Zone "A", locality 5, 35 feet above base of Garden City formation.

Hystricurus ? sp. E

Plate 15, figs. 10, 11, 13, 14

DESCRIPTION. Surface smooth. Glabella sub-ovoid, very low, widest between palpebral lobes, narrowly rounded in anterior outline; glabellar furrows lacking. Dorsal furrow narrow, relatively shallow. Brim markedly convex; width immediately anterior to palpebral lobes slightly less than nine-tenths that at anterior marginal furrow. Brim deflexed 45 degrees from glabellar base. Rim wide, moderately convex; marginal furrow shallow. Fixed cheeks slightly convex, possessing distinct, slightly thickened palpebral rims; eye-lines exceptionally faint or lacking. Tips of stout postero-lateral limbs bluntly rounded.

Free cheeks, hypostome, and thorax unknown.

Pygidium approximately semicircular in outline. Axis prominent, composed of five distinct segments. Three distinct pairs of pleura in pleural platforms, each partly divided by a diagonal furrow which is best developed in anterior pair and only rudimentary in third. Shallow marginal furrow sets off a narrowly convex, wire-like rim.

FIGURED SPECIMENS. Y.P.M. Nos. 18325, 18326.

DISCUSSION. All specimens of this species are in a crystalline limestone matrix, none having been found silicified. The species is quite similar to *Hystricurus cordai* (Billings) as figured by Whitfield (1889, see *Bathyurus seelyi,* pl. 13, figs. 8–9), but that species has a narrower, more quadrate glabella and narrower, less pronounced palpebral lobes. Although the pygidia of the two are very similar, the Garden City species has one more ring in the axis, the termination of which is not so broad (Whitfield, 1889, pl. 13, fig. 13). The glabella is nearly identical with that of a specimen identified as *H. cordai* by Raymond from Cow Head, Newfoundland. Were it not for the shape of the postero-lateral limbs, the cranidial shape would compare favorably with that of *H. flectimembrus* n. sp. (above).

OCCURRENCE. Locality 13, 90 feet above base of Garden City formation (zone not recognized).

Hystricurus ? sp. F

Plate 15, figs. 7, 8, 9

DISCUSSION. Single specimen (Y.P.M. No. 17957) found associated with *Hystricurus politus* at locality 7, figured as matter of record. High glabella, inflated brim, flat-topped rim and small palpebral lobes preclude assignment to that species, if not to genus.

OCCURRENCE. Zone "B", locality 7, 135 feet above base of Garden City formation.

Hystricurus ? sp. G

Plate 14, figs. 1, 2, 3

DISCUSSION. Only four imperfectly preserved cranidia of this species have been found, of which the largest is only 1.8 millimeters in length. It may possibly represent an immature stage of *Hystricurus* sp. E (pl. 15, figs. 10, 11, 14), from which it differs in the greater convexity of glabella, lack of convexity of brim, and lack of palpebral rims; although all these characters conceivably could change with growth, comparable changes cannot be demonstrated for any of the other species of *Hystricurus* for which adequate specimens are on hand. It is much more likely that these four specimens represent an entirely different species and, in fact, genus. Until additional specimens can be collected and studied no attempt is made to classify them.

FIGURED SPECIMEN. Y.P.M. No. 18025.

OCCURRENCE. Lowest portion of Zone "B", only at locality 7, 130 feet above base of Garden City formation.

Hystricurus ? sp. H

Plate 14, figs. 9, 10, 13, and 11, 14, 15

DISCUSSION. The half dozen cranidia included under this designation are all very small, and almost certainly immature, the largest (fig. 13, pl. 14) being only 2.75 millimeters long. The general proportions, shape of palpebral lobes, and shape of postero-lateral limbs suggest that these may be immature forms of *Hystricurus,* possibly of *H. genalatus* or *H. paragenalatus,* with which they are associated. However, specimens representing immature stages of these species can be identified with considerable certainty in the collections and do not show such a large degree of cranidial convexity. Furthermore the smaller specimens included here are rather coarsely pustulose, while the larger ones are very nearly smooth; since the associated species are strongly pustulose in the mature forms it seems improbable that these are specifically related; the one smooth associated species, *H. politus,* bears an occipital spine.

FIGURED SPECIMENS. Y.P.M. Nos. 18028, 18029.

OCCURRENCE. Zone "B", locality 7, 135–165 feet above base of Garden City formation.

Hystricurus ? sp. I

Plate 17, figs. 1–3

DISCUSSION. Only one specimen of this species has been found to date, and it is not completely preserved. As a result no attempt is made to assign it generically or to give it a full specific description.

The single cranidium is rather strongly convex with a finely pustulose surface. The glabella is approximately semi-ovoid and defined by deep dorsal furrows which continue around the front. The brim and rim compare favorably with most species of *Hystricurus;* the palpebral lobes are of the type found in that genus, but a little smaller than is common. The fixed cheeks are too narrow and lack the convexity of *Hystricurus.* In many ways this cranidium resembles that of *Onchopeltis spectabilis* Rasetti (1944, p. 250, pl. 38, figs. 1–2) but differs in the lack of glabellar furrows, longer midlength of brim, and narrower rim.

FIGURED SPECIMEN. Y.P.M. No. 18306.

OCCURRENCE. Zone "C", locality 5, 140 feet above base of Garden City formation.

Genus *Parahystricurus* Ross, n. gen.

DESCRIPTION. Cephalon strongly convex, nearly semicircular in outline, surrounded by a narrow marginal furrow and thickened rim; genal angles produced into spines; surface pustulose, but density of pustules varies considerably between species.

Cranidium. Glabella usually inflated, bluntly bullet-shaped in dorsal view; although surrounded by deep dorsal furrow it stands well above fixed cheeks; occipital ring set off by deep, narrow occipital furrow. Glabellar furrows faint or represented only by unpustulose patches on sides of glabella. Brim gently convex or flat in lateral profile, midlength normally short. Brim divided into a right and left half by a pre-glabellar median furrow connecting dorsal and marginal furrows in all cranidia less than 2 millimeters long (in some species it may be almost impossible to detect, but will show as a narrow thickened ridge on the interior of the test); with increase in size there is a general tendency to lose this feature. Palpebral lobes small and completely occupied by the thickened and modified palpebral rim, so that they are bounded from the rest of the fixed cheek by the palpebral furrow; their length one-third glabellar length and whole of each lobe situated anterior to a transverse line drawn through midpoint of glabella. Right and left facial sutures anterior to the palpebral lobes converge very slightly so that cranidial width at marginal furrow is less than its width in front of palpebral lobes. From marginal furrow sutures turn inward, revolving downward across rim and crossing posterior edge of doublure before reaching midline. Posterior to palpebral lobes sutures run directly toward bases of genal spines, defining triangular postero-lateral limbs.

Free cheeks. In most species ocular platform steep and convex. Eye short and in three species almost globular; in no known species is there an infra-ocular ring.

Thorax unknown. No pygidia can be assigned to this genus with certainty.

GENOTYPE. *Parahystricurus fraudator* Ross, n. sp.

DISCUSSION. This genus lacks the very convex fixed cheeks and brim of *Cyphaspis* Burmeister and has a less inflated glabella without basal nodes. *Onchopeltis* Rasetti possesses an even shorter brim, longer cranidial rim, and slender, crescentic palpebral rims; the only species so far described, *O. spectabilis* Rasetti (1944), has two pairs of shallow glabellar furrows. *Parahystricurus* is distinguished from *Hystricurus* Raymond by the more inflated glabella, the small palpebral lobes, lack of an infra-ocular ring, and the more or less triangular postero-lateral limbs.

It is extremely difficult to draw a line between *Parahystricurus* and *Hystricurus* on the shape of the glabella alone. *P. carinatus* n. sp. for instance, possesses a sub-conical, depressed glabella, a fact which seems to ally it with *Hystricurus;* but because of the characters of the brim, fixed cheeks and palpebral lobes, eyes, and facial suture it is placed in *Parahystricurus*. When additional collecting and more detailed zoning are completed it may be found that *P. carinatus* is an intermediate form between the two genera.

It is probable that some of the previously described species of *Hystricurus* are assignable to this genus, but in each of these the figured holotypes are so poorly preserved that no decision can be reached. *H. missouriensis* Ulrich (in Bridge, 1930) lacks the critical palpebral lobes. *H. tuberculatus* (Walcott, 1884), likewise lacks the palpebral lobes and the postero-lateral limbs have been broken; however, the stump of the right postero-lateral limb seems to indicate a shape like that in *P. fraudator*. The resemblance between the outlines of the glabella and the relative widths of fixed cheeks also suggests the possibility that Walcott's species should be assigned here.

Four new species from the Garden City formation are assigned to this genus; they are *P. fraudator, P. oculirotundus, P. pustulosus,* and *P. carinatus.*

In 1931 Reed (pp. 6–7) referred a species which he had previously described and illustrated (1904, p. 86, pl. 12, figs. 3–7) to the genus *Hystricurus,* and compared it favorably with *H. ravni* Poulsen. However, this species differs from *Hystricurus* in the forward position of the eyes, the small palpebral lobes, the blunt, almost quadrate, glabella, the broadly triangular postero-lateral limbs, and the possession of eye-lines; if correctly figured, it also differs in the possession of rudimentary basal lobes on the glabella. It resembles *Parahystricurus oculirotundus* superficially in the first four of these characters and in the pre-glabellar median furrow. The character of the pygidium resembles several of those associated with the various species of *Parahystricurus* in the Garden City formation. Reed's species cannot, however, be assigned here, for its fixed cheeks are far too wide, its anterior facial sutures diverge rather than converge, and it possesses eyelines and basal glabella nodes.

Parahystricurus fraudator Ross, n. sp.

Plate 12, figs. 1–16

DESCRIPTION. Surface of cephalon pustulose, pustules most dense along crest of glabella and on fixed cheeks. Dorsal outline of cranidium nearly a trapezoid. Glabella inflated and bluntly bullet-shaped in outline; highest and widest at midpoint. Two pairs of non-pustulose patches on sides of glabella, one pair slightly behind and the other slightly ahead of midpoint. Brim convex, its midlength a little more than 0.2 glabellar length. Narrow longitudinal median strip without pustules represents position of preglabellar furrow which is present in immature cranidia. Rim faintly pustulose. Palpebral lobes semicircular, short and slightly thickened; separated from remainder of fixed cheek by a straight palpebral furrow; dorsal surface very finely pustulose. Lobes reflexed at an angle of 30 degrees from the horizontal. Portion of fixed cheeks between palpebral lobes and dorsal furrow only slightly convex, but appears far more so because of concentration of pustules. Posterior facial suture runs postero-laterally at an angle of over 50 degrees with cranidial axis, curves only slightly after reaching marginal furrow, and cuts edge of cephalon just inside base of genal spine. Anteriorly, facial sutures converge so that cranidial width at marginal furrow is 0.7 times width in front of palpebral lobes. Free cheeks steep and eyes subglobular; curve of outer edge not even, but a little more convex directly laterad of eye (pl. 12, fig. 9). Genal spine, full length of which is uncertain, takes root from upper side of rim and, therefore, possesses a slight upward flexure near its base (pl. 12, fig. 10). Many tiny denticles present along proximal side of spine.

Characters of thorax not known. Associated pygidia available for assignment are illustrated in figures 23, 28, 29, 32–33, plate 17, and figures 30–38, plate 19. Associated hypostomes are shown on plate 19, figures 21–29.

HOLOTYPE. Y.P.M. No. 17988.

PARATYPES. Y.P.M. Nos. 17989–17994 incl.

DISCUSSION. The characters vary little between cranidia 1.25 millimeters long and those 4.5 millimeters in length (pl. 12, figs. 3, 4, 5, and 11, 15, 16). The greatest difference lies in the density of pustules. In the smallest specimen which could be assigned with certainty to the species there are four pairs of pustules along the crest of the glabella, the posterior pair being on the occipital ring (pl. 12, fig. 4); the pre-glabellar median furrow is evidenced by a depression in the brim. With increasing size there is an increase in the density of pustules, and it becomes increasingly difficult to differentiate the original paired pustules on the glabella, while the pre-glabellar furrow becomes more obscure (see in order figs. 4, 1, 12, 8, and 16, pl. 12). A similar sequence occurs in *P. oculirotundus*, but there are five pairs of pustules on the glabella in that species. Immature cranidia of comparable size of *P. pustulosus* show the same phenomenon, but it has not been observed on the smallest studied cranidium of *P. carinatus*, which is 2 millimeters long (pl. 13, figs. 23–25).

P. fraudator is distinguished from *P. oculirotundus* by the greater width of fixed cheeks (exclusive of palpebral lobes), straightness of palpebral furrow, relatively greater length of the glabella, less distinct pre-glabellar median furrow, and greater density of pustules.

From *P. pustulosus* it is differentiated by inclination of the palpebral lobes, more broadly triangular postero-lateral limbs, and lesser density of pustules. It has so far been impossible to distinguish satisfactorily between the three species in cranidia less than 1 millimeter long.

The sub-conical glabella, narrow palpebral lobes, and carinate rim distinguish *P. carinatus* from any of these three species.

Occurrence. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Parahystricurus oculirotundus Ross, n. sp.

Plate 12, figs. 33–49

Description. Surface of cephalon sparsely pustulose. Glabella swollen, sharply rounded in front, highest at midpoint, and about two-thirds as wide as long. Sides of glabella devoid of pustules. Brim only very gently convex and distinctly cleft in its posterior portion by pre-glabellar median furrow (pl. 12, fig. 49). Palpebral lobes distinctive; palpebral furrow curved, but its outline convex proximally, rather than straight or convex distally. As a result palpebral lobe appears like small sub-circular plate inserted into remainder of fixed cheek. Rotund nature of eye undoubtedly requires modification of thickened palpebral rim in this manner. Palpebral lobes reflexed at 30 degree angle from horizontal. Portion of fixed cheek between palpebral and dorsal furrows extremely narrow. Posterior facial suture runs straight to posterior edge of cephalon at proximal side of base of genal spine at angle of 45 degrees with cranidial axis. Anterior facial sutures converge so slightly that width of cranidium at marginal furrow is 0.9–1.0 times width in front of eyes. Free cheeks steep and eye rotund. Genal spine longer than rest of free cheek, bearing a longitudinal furrow on dorsal side.

Thoracic characters not known. Associated pygidia which are available for assignment illustrated in figures 23, 28, 29, 32, 33, plate 17, and figures 30–38, plate 19. Available hypostomes figured on plate 19, figures 21–29.

Holotype. Y.P.M. No. 18003.

Paratypes. Y.P.M. Nos. 18004–18009 incl.

Discussion. Presence of small paired pustules along crest of glabella has been discussed under *P. fraudator;* in this species there are five pairs (note that small specimen in figure 39, plate 12, does not have one of pustules of anterior pair). As suggested in discussion of *Hystricurus flectimembrus* (above) these paired pustules may represent "sockets" for muscle attachment or indicate position of cephalic segments.

This species is differentiated from *P. fraudator* by the shape of the palpebral lobes, angle of divergence of the posterior facial sutures, lesser density of pustules, and distinct cleft formed by the pre-glabellar median furrow in the posterior portion of the brim. From *P. pustulosus* it is distinguished by the inclination of the palpebral lobes, more broadly triangular postero-lateral limbs, and much narrower portion of the fixed cheeks between the dorsal and palpebral furrows. It is easily told from *P. carinatus* by the shape of the glabella and palpebral lobes, and by the lack of a pre-glabellar median furrow in the latter.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Parahystricurus pustulosus Ross, n. sp.

Plate 12, figs. 17–32; Plate 14, figs. 23, 24, 26

DESCRIPTION. Surface of cephalon very densely pustulose. Moderately inflated glabella narrowly rounded in front. Two pairs of small non-pustulose patches low on sides of glabella, one located even with glabellar midpoint and one even with fronts of palpebral lobes. Brim convex; median pre-glabellar furrow obscure in mature specimens, represented by a narrow non-pustulose "seam". Palpebral lobes horizontal, almost semicircular, occupied entirely by thickened palpebral rims, and bounded proximally by straight palpebral furrows. Posterior facial suture runs postero-distally at an angle of 30 degrees with cranidial axis before turning sharply to rear; end of each postero-lateral limb blunt (pl. 12, figs. 28, 31, 32). Anterior facial sutures converge, so that width of cranidium at marginal furrow is about 0.8 times its width just in front of palpebral lobes. Free cheeks steeply convex, distal outline evenly rounded; entire ocular platform pustulose. Genal spine short.

Characters of thorax not known. Associated pygidia, available for assignment, illustrated in figures 23, 28, 29, 32, 33, plate 17, and figures 30–38, plate 19. Available hypostomes are figured on plate 19, figures 21–29.

HOLOTYPE. Y.P.M. No. 17995.

PARATYPES. Y.P.M. Nos. 17996–18002 incl.

DISCUSSION. Presence of small paired pustules along crest of glabella of immature cranidia discussed under *P. fraudator*. Five pairs in this species.

This species is differentiated from all three of the other species of *Parahystricurus* described in this report by the density of pustules and horizontal palpebral lobes. In addition it is distinguished from *P. fraudator* and *P. oculirotundus* by the angle of divergence of the posterior facial suture and the blunt ends of the postero-lateral limbs. From *P. carinatus* it is also differentiated by the shape of the glabella and lack of median pre-glabellar furrow in mature cranidia of that species.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Parahystricurus carinatus Ross, n. sp.

Plate 13, figs. 23–27, 30–32, 35–37

DESCRIPTION. Cephalon surrounded by a carinate rim; pustules limited to surface of glabella and fixed cheeks. Cranidium, exclusive of postero-lateral limbs, subquadrate in outline. Glabella sub-conical, uninflated, and widest just anterior to occipital furrow. Dorsal furrow deep along posterior sides of glabella, but very shallow at its front. Two pairs of shallow depressions in furrow may slightly indent sides of glabella at its base; one pair located even with glabellar midpoint and other even with anterior ends of palpebral lobes. Brim smooth and almost flat. No pre-glabellar median furrow, but inside of tests of cranidia less than 2 millimeters long shows a narrow thickened ridge in a corresponding position. Marginal furrow not as clearly defined. Rim possesses flat, vertical outer edge. Palpebral lobes very small, about twice as long as wide, and reflexed at

30 degree angle from horizontal, entirely occupied by palpebral rim and bounded proximally by straight palpebral furrow. Posterior facial suture runs postero-distally at angle of 60 degrees with axial line to marginal furrow, then turns sharply to rear well inside genal spine (pl. 13, figs. 27, 37). Anterior facial suture runs straight forward before turning inward, so that width of cranidium at marginal furrow is a little less than width in front of eyes. Like brim, ocular platform of free cheek is almost flat and unornamented; eye low and lacking infra-ocular ring, although such a ring is faintly suggested in three of over thirty specimens. Genal spine stout; considerable vertical thickening in rim at base of spine (pl. 13, fig. 35).

Thorax not known. Associated pygidia illustrated in figures 5–20, plate 19. Associated hypostomes shown in figures 1–4, plate 19.

HOLOTYPE. Y.P.M. No. 18011.

PARATYPES. Y.P.M. Nos. 18010, 18012, 18013.

DISCUSSION. In assigning this species to *Parahystricurus* rather than to *Hystricurus* emphasis is placed on the character of the palpebral lobes, the flat rather than convex brim and fixed cheeks, the lack of an infra-ocular ring, and the subtriangular postero-lateral limbs. As a deciding factor the last of these carries the least weight, for there are several species of *Hystricurus* with postero-lateral limbs of almost the same shape. The very short palpebral lobe, all of which is located forward of the glabellar midpoint and all of which is occupied by the thickened palpebral rim, strongly favors assignment to *Parahystricurus,* as does the lack of convexity in the brim. On the other hand the definitely sub-conical, uninflated glabella seems to indicate a close relationship to *Hystricurus.* It is possible that *Parahystricurus* arose from *Hystricurus* through *P. carinatus* or some similar form.

OCCURRENCE. Zone "E", locality 5, 313 feet above base of Garden City formation. Zone "E", locality 6, 210–260 feet above base of Garden City formation.

Parahystricurus ? sp. A

Plate 14, figs. 5, 8, 12

DISCUSSION. A single, minute cranidium of this species, only 2.4 millimeters long, has been found. Its assignment to the genus *Parahystricurus* is suggested, but definitely not certain. The specimen is certainly immature and shows the same feature of paired pustules on the glabella that occurs in immature forms of some species of *Hystricurus* and *Parahystricurus.* Although the glabella is too rotund for *Parahystricurus,* the small palpebral lobes placed forward of the glabellar midpoint and the triangular postero-lateral limbs suggest that it may be related to that genus.

FIGURED SPECIMEN. Y.P.M. No. 18027.

OCCURRENCE. Zone "B", locality 7, 135–165 feet above base of Garden City formation.

Parahystricurus ? sp. B

Plate 14, figs. 4, 6, 7

DISCUSSION. This species, represented by a single small cranidium, bears several close resemblances to the specimen described above as *Parahystricurus* ? sp. A, and may possibly be an even more immature form of that species. Among the comparable features are position and shape of the palpebral lobes, shape of the postero-lateral limbs, and possession of paired pustules along the brim, fixed cheeks, and bases of the postero-lateral limbs. The rim is somewhat wider and the brim less sharply deflexed (only 60 degrees from the glabellar base); the glabella is lower and shaped more like those of bona fide species of *Parahystricurus.*

Because the figured specimen is the only one so far collected, no attempt is made to classify it, other than to point out its possible relationship with the aforementioned specimen, with which it was found associated.

FIGURED SPECIMEN. Y.P.M. No. 18026.

OCCURRENCE. Zone "B", locality 7, 135–165 feet above base of Garden City formation.

Parahystricurus ? sp. C

Plate 28, figs. 17, 18, 21, 22

DISCUSSION. This species is known only from a single cranidium and one free cheek, both very small. It should, perhaps, be assigned to *Parahystricurus* Ross, n. gen., with the general characteristics of which it agrees favorably; until more specimens are secured no classification is considered advisable, however.

FIGURED SPECIMENS. Y.P.M. Nos. 18186, 18187.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Psalikilus* Ross, n. gen.

(arch rim)

DESCRIPTION. Two species of this genus occur in Zone "G" of the Garden City beds. Both are characterized by very small size, strong cephalic convexity, subcylindrical glabella with deep occipital furrow and two pairs of glabellar creases, narrow, reflexed fixed cheeks, strongly deflexed brim, and acutely up-arched rim.

In both the palpebral lobes are horizontal, possessing crescentic rims. Eyes are globular and genal spines exceptionally long. All cranidial furrows sharply incised, especially the dorsal furrows.

GENOTYPE. *Psalikilus typicum* Ross, n. sp.

DISCUSSION. Only the genotype is described herein. From it the other species differs in the possession of an occipital spine. The glabellar furrows show especially clearly on the ventral side of the cranidium as strong ridges, even when not particularly evident on the dorsal surface.

Psalikilus typicum Ross, n. sp.

Plate 11, figs. 1–5, 8, 9, 13, 14, 19

DESCRIPTION. Surface pustulose. Glabella rounded in front, two pairs of distinct non-pustulose depressions on steep sides of glabella adjacent to very deep dorsal furrows. Brim very short on midline, sharply deflexed at about 50 degrees from glabellar base. Rim markedly thickened, sub-tubular.

Anteriorly facial suture runs in gentle curve to marginal furrow, whence it turns sharply inward, revolving across rim to become infra-marginal at midline;

median suture separates right and left free cheeks. Posteriorly facial suture runs laterally nearly at right angles to midline to define slender postero-lateral limbs.

Marginal furrow on free cheeks well developed but fades out slightly anterior to genal angle. A strong ridge extends from angle between posterior end of palpebral lobe and postero-lateral limb directly laterad to genal angle, whence it curves sharply to the rear to form outer side of genal spine. Posterior marginal furrow (extension of occipital furrow) lies behind this ridge, separating it from posterior rim (extension of occipital ring) and extending to tip of genal spine. Posterior rim reaches its greatest width inside genal angle from which it also extends length of genal spine on proximal side. As a result genal spine appears to be formed by confluence of two posterior segments of cephalon. Close to its inception inner side of genal spine is ornamented with several minute, sharp denticles. Ocular platform steep, evenly rounded, and pustulose; large eyes lack infra-ocular rings.

Thorax, hypostome, and pygidium not known. Associated pygidium illustrated in figures 11, 15, plate 30.

HOLOTYPE. Y.P.M. No. 17985.

PARATYPES. Y.P.M. Nos. 17984, 17986, 17987.

DISCUSSION. This species is easily recognized when found, but because of great relief in its cephalic topography would probably be very difficult to clean out of crystalline limestone matrix. No evidence has been secured to indicate that it ever attains a cephalic length of more than 5 millimeters. Structure of genal spines may prove to be a generic characteristic.

OCCURRENCE. Zone "G", locality 6 (490–560 feet above base of Garden City formation); locality 11, approximately 450 feet above base of formation; locality 5, approximately 530 feet above base of formation. Also locality 7, tentative Zone "G(2)b".

Psalikilus ? sp.

Plate 13, figs. 28, 29, 33, 34; Plate 30, figs. 1–3

DESCRIPTION. This species is distinguished by its prominent globular glabella, very shallow dorsal furrows, uparched anterior rim, sharply deflexed anterior limb and ocular platforms, and nearly horizontal palpebral lobes. Pygidium subtriangular; axis with five rings; pleural platforms horizontal with four pairs of pleura; rim smooth, almost vertical, high, upswept at posterior midline, and overhung by broad terminal "spine".

Unlike typical *Psalikilus* this form lacks any vestige of glabellar furrows, the anterior facial sutures are curved, and the postero-lateral limbs are known to be more triangular. The rotundity of glabella suggests *Petigurus*, but in that genus the greatest height of the glabella is far forward, its front overhanging the brim. The species almost certainly represents a new genus, but sufficient specimens are lacking on which to base a formal description.

FIGURED SPECIMENS. Y.P.M. Nos. 18023, 18024, 18206.

OCCURRENCE. Zone "G(2)b". Originally found at locality 7 apparently over 1,000 feet above base of Garden City formation, where topographic evidence indicated possible repetition of beds by faulting. Collections of 1949 field season, still in preparation, prove this to be true; now known definitely from locality 6 in proper position.

"*Symphysurus* ? *goldfussi*" Walcott

Plate 15, figs. 16–18

DISCUSSION. Specimens from the Swan Peak formation are tentatively assigned to this species, first described from the Pogonip limestone of the Eureka District, Nevada (Walcott, 1884, p. 95). That it does not belong to *Symphysurus* was obviously evident to Walcott, himself.

The Swan Peak species is known only from casts and molds of cranidia, none perfectly preserved; well preserved specimens of the genus from the Pogonip formation are on hand in the U.S. National Museum and should be the basis for generic and specific revision.

The genus appears to have considerable stratigraphic importance. Other specimens from Oklahoma in the U.S. National Museum were secured from U.S.G.S. locality 360 K2 (labelled "Oil Creek formation") and locality 199t (labelled "Joins"); in both cases they are associated with *Eleutherocentrus* and with ostracods similar to if not conspecific with those of the Swan Peak beds.

FIGURED SPECIMENS. Y.P.M. Nos. 18354, 18355, 18357.

OCCURRENCE. Zone "M", localities 3B and 13, in lowest quartzites and quartzitic sandstones of Swan Peak formation.

Genus *Amblycranium* Ross, n. gen.

(blunt skull)

DESCRIPTION. Cephalon transversely elliptical in outline, more convex in longitudinal than in transverse profile, surrounded by a sub-tubular rim, with long genal spines. Posterior margin of cranidium curved forward near ends of postero-lateral limbs toward bases of genal spines. Glabella sub-conical to subcylindrical, sharply rounded in front, unfurrowed. Palpebral lobes semicircular, possessing raised crescentic rims; located entirely forward of glabellar midpoint. Anterior facial sutures converge slightly or run straight to marginal furrow and turn sharply inward, revolving around rim to cut its posterior edge without reaching cranidial midline. Posteriorly suture runs laterad with a faint forward flexure between eye and marginal furrow; it cuts rim behind genal spine without turning to rear, since posterior cranidial margin curves forward to genal angles.

Eyes are rotund and rest directly on ocular platforms without intervening infraocular rings. Platforms almost quarter-circles in outline and convex; at base of genal spine they are swollen and appear to be as much a part of spine-bases as rim.

Hypostome, thorax, and pygidium not known.

GENOTYPE. *Amblycranium variabile* Ross, n. sp.

Amblycranium variabile Ross, n. sp.

Plate 13, figs. 10–18

This is one of three species in the Garden City trilobite fauna on which statistical methods have yet been attempted. It will be noted that the two cranidia illustrated in figures 11 and 14 of plate 13 differ considerably in the width of the cranidium at the anterior marginal furrow, a factor controlled by the course of the facial suture. This difference would be unquestioned grounds for a specific distinction if the two had been found in separate localities or in distinct stratigraphic zones. There are in the present collection over 150 cranidia of this species from two localities, in one of which it ranges through a stratigraphic thickness of 45 feet (locality 6). In the other locality it was collected only from a 1-foot bed about 320 feet from the base of the formation (locality 5), although the actual range in the latter is probably of equal extent. In order to eliminate the possibilities of lateral (geographical) and vertical (evolutionary) variation all the specimens used in the statistical study were taken from the 1-foot bed at locality 5.

It was at first believed that two species were represented in faunal zone "E", until an attempt was made to sort some 80 specimens into separate lots; it was always simple to do this with end-members on the basis of the anterior width of the cranidium, but there are so many intermediate forms that little headway was made. At the suggestion of Dr. J. T. Gregory the statistical method was used to determine whether there were two species, or only one, present.

Approximately 60 cranidia were used to make six basic measurements from which seven ratios were derived. In order to speed the work all measurements were made with the specimens resting on the front of the rim and the tips of the postero-lateral limbs; they were then placed under a camera with the bellows extension set for a magnification of x 10 and readings taken off the ground-glass image with a millimeter scale. The seven resulting ratios are included below in the specific description.

DESCRIPTION. Slender genal spines curving gently posteriorly; surface pustulose; the rim ornamented with minute, evenly spaced spikes. Glabella parallel-sided in its posterior half. Brim very slightly convex with a midlength approximately one-fifth the cranidial length, divided into a right and left half by faint median furrow. Palpebral lobes semicircular, almost completely occupied by crescentic, raised palpebral rims. Course of facial suture in front of palpebral lobes variable; it may run straight forward almost to marginal furrow before turning slightly inward or it may curve inward continuously from the palpebral lobes to rim (compare figs. 11 and 14, pl. 13).

The following ratios will furnish cranidial proportions not covered in above description:

1) Length of cranidum ÷ length of glabella:
   Number of specimens: 61
   Mean: 1.42 ± 0.0108
   Standard deviation: 0.081 ± .0074
   Coefficient of variability: 5.72 ± 0.52
2) Width of glabella ÷ width of cranidium: (both measured on a line through the eye-centers)
   Number of specimens: 59
   Mean: .53 ± .005
   Standard deviation: .04 ± .0037
   Coefficient of variability: 7.6 ± 0.7
3) Width of glabella ÷ length of glabella:
   Number of specimens: 61
   Mean: 0.70 ± .0089
   Standard deviation: .0694 ± .0063
   Coefficient of variability: 9.9 ± 0.9
4) Width at the postero-lateral limbs ÷ length of glabella:
   Number of specimens: 41
   Mean: 2.18 ± .0286

Standard deviation: .183 ± .0202
Coefficient of variability: 8.4 ± 0.93

5) Width of the cranidium at the marginal furrow ÷ length of glabella:
Number of specimens: 58
Mean: .757 ± .0108
Standard deviation: .0827 ± .0077
Coefficient of variability: 10.9 ± 1.01

6) Width of cranidium at the marginal furrow ÷ width of cranidium at palpebral lobes:
Number of specimens: 55
Mean: .582 ± .0206
Standard deviation: .147 ± .014
Coefficient of variability: 8.4 ± 0.8

7) Width of cranidium at marginal furrow ÷ width of glabella on a line through the eye-centers:
Number of specimens: 57
Mean: 1.105 ± .0254
Standard deviation: 0.192 ± .018
Coefficient of variability: 17.4 ± 1.625

From these ratios it is obvious that the most stable proportion is the length of the glabella relative to that of the cranidium. The coefficients of variability in ratios (2), (3), (4), and (6) are reasonable for a single species. It is in the width of the anterior limb at the marginal furrow relative to the *glabellar* width that we see the greatest spread, and it is this ratio (no. 7) which is responsible for the great difference in appearance of the various specimens. The anterior width of the cranidium is, of course, controlled by the facial sutures; it is interesting to note that this measurement compared with the width at the palpebral lobes (also controlled by the facial sutures) has a much less variable relation (ratio no. 6), one that may be considered normal.

If there were two species present in the sample one would expect to find a double-humped frequency curve when the values for ratio number 7 were graphed but this is not the case; the graph shows a single mean although the resulting curve has considerable spread. As a result it is concluded that only one species is present in the sample and that the anterior course of its facial sutures is extremely variable.

Characters of hypostome, thorax, and pygidium not known; associated hypostomes and pygidia illustrated in figures 1–4 and 5–20 of plate 19.

Holotype. Y.P.M. No. 18020.

Paratypes. Y.P.M. Nos. 18019, 18021, 18022.

Discussion. The course of the facial suture is usually considered to be of specific or even generic value in the study of trilobites, but the marked variation in this one species tends to throw some doubts on the reliability of the feature. It should discourage the practice indulged in by some authors of basing four or five species, or even genera, on the differences of facial sutures in a dozen very similar associated cranidia.

This species differs from *A. cornutum*, n. sp. (illustrated in pl. 13, figs. 1–9) in greater midlength of brim, shorter postero-lateral limbs, and location, orientation, and curvature of genal spines. Relative proportions of glabella, size and position of palpebral lobes, curvature of posterior cranidial margin, and width of fixed cheeks relative to glabellar width are practically the same.

Occurrence. Zone "E", locality 5, 320 feet above base of Garden City formation; locality 6, 210–255 feet above base of formation.

Amblycranium cornutum Ross, n. sp.

Plate 13, figs. 1–9

DESCRIPTION. Genal spines very long, based far forward, directed antero-laterally in the proximal third, but curving sharply to the rear so that distal two-thirds is directed postero-laterally. Surface sparsely pustulose. Glabella depressed, sub-conical. Two pairs of non-pustulose patches present on glabellar sides; anterior pair located even with a point one-quarter of glabellar length from its front; posterior pair very slightly forward of glabellar midpoint. Width of cranidium at marginal furrow equal to or slightly narrower than width immediately in front of palpebral lobes. Brim lacking median furrow. Marginal furrow shallow and wide, giving upper surface of rim pseudo-concave appearance. Palpebral lobes short, semicircular. Postero-lateral limbs very long, directed laterally at right angles to cranidial axis; width of cranidium at postero-lateral limbs more than twice cranidial length. Although posterior margin of cranidium curves slightly to rear along each limb, at a point approximately three-fourths of length of each limb from dorsal furrow margin curves sharply forward. Anterior facial suture almost straight, in some cases converging inward very slightly; at a point approximately two-thirds of distance from anterior corner of cranidium to midline it turns sharply postero-laterally across doublure. This fact is shown most clearly by the free cheeks (figs. 6, 8, pl. 13). The free cheeks could not have been in juxtaposition with one another, therefore. Posterior suture runs directly at right angle to cranidial axis, crossing posterior rim in straight line. Ocular platform appears confluent with base of genal spine. Spine exceptionally thick at base which is slightly forward of eye. Postero-proximal edge of spine ornamented with a few very small denticles.

Hypostome, thorax, and pygidium not known. Assignable pygidia and hypostomes illustrated in figures 21–38, plate 19.

HOLOTYPE. Y.P.M. No. 18014.

PARATYPES. Y.P.M. Nos. 18015–18018 incl.

DISCUSSION. This species differs from slightly older *A. variabile* n. sp. most strikingly in the development of the genal spines, but also in the shape of the postero-lateral limbs, shorter brim, lack of preglabellar median furrow, and course of facial suture across anterior doublure. It may, in fact, belong to a separate genus, but the presence of one or two specimens of *A. variabile* like that illustrated in figure 10, plate 13, in the older faunal zone has led to the consideration that the two are related. In these few specimens the brim possesses the shortened character of *A. cornutum;* since, as has been mentioned, the older species is quite variable, it was not considered unreasonable to infer that *A. cornutum* may have descended from these short-brimmed forms.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Amblycranium ? *populus* Ross, n. sp.

Plate 13, figs. 19–22

DESCRIPTION. Cephalon roughly semicircular in outline, with long, diverging, slender genal spines. Surface finely pustulose. Glabella depressed, sub-conical, sharply rounded in front, possessing a crest-line from which sides slope to deep dorsal furrows. No glabellar furrows or non-pustulose patches on sides of glabella.

Brim almost flat, slightly deflexed, with slight suggestion of pre-glabellar median furrow. Marginal furrow shallow. Rim sub-tubular, smooth. Fixed cheeks horizontal, not convex, bearing large semicircular palpebral lobes; lobes located entirely ahead of glabellar midpoint. Each lobe with palpebral rim set off by strong furrow. Postero-lateral limbs broad and long with appearance of the blade of a cutlass. Anterior facial sutures sub-parallel, straight on dorsal side, passing out of posterior edge of doublure halfway between anterior corners of cranidium and midline. Posterior sutures curving gently. Free cheeks bear surprisingly small eyes, considering size of palpebral lobes; infra-ocular rings lacking. Ocular platforms faintly distinguished from rim. Genal spine exceedingly slender and long.

Hypostome, thorax, and pygidium not identified. Associated hypostomes and pygidia illustrated in figures 1–20, plate 19.

HOLOTYPE. Y.P.M. 18043.

PARATYPE. Y.P.M. 18044.

DISCUSSION. Generic assignment of this species is unsatisfactory. It resembles *Hystricurus* in shape of glabella, shape of palpebral lobes and pustulose surface; however, it lacks the convexity of brim and fixed cheeks found in that genus. Although it resembles species of *Parahystricurus* in the lack of infra-ocular rings and forward position of palpebral lobes, it disagrees in shape of the lobes, shape of postero-lateral limbs, and low cephalic profile.

It compares favorably with *Amblycranium cornutum* in regard to length, but not shape, of the genal spines, and to most cranidial features except palpebral lobes and postero-lateral limbs. The cephalon lacks the elliptical outline of both *A. cornutum* and *A. variabile.*

The species may represent a separate genus or be an off-shoot from one or an intermediate between two of the above mentioned genera.

OCCURRENCE. Zone "E", locality 5, 320 feet above base of Garden City formation; locality 6, 210–255 feet above base of formation.

Genus *Eleutherocentrus* Clark, 1935

Eleutherocentrus Clark, 1935, Journal of Paleontology, vol. 9, p. 243.

DISCUSSION. Clark based this genus on *E. petersoni,* an extremely abundant form in the Swan Peak formation and the only previously described species. The original generic description stated that it was "ogygiocarinid", signifying a relationship with *Ogygiocaris* Angelin, 1852. Clark further stated that the genus was related to *Xenostegium* Walcott and *Hemigyraspis* Raymond. As a result of the present study on material far superior to that available to Clark, this relationship, based on the anterior course of the facial sutures, is strongly questioned.

Beautifully silicified specimens of a new, somewhat older species, *E. williamsi* (described below) show that the anterior courses of the facial sutures are such that the free cheeks are not in contact with one another at all; after crossing the marginal furrow each suture revolves around the rim and cuts sharply across the doublure before reaching the cranidial midline. Although there is ample material in the collection here under study which represents Clark's *Eleutherocentrus petersoni,* it has been impossible to verify this characteristic in the genotype, even though specimens are in very fine siltstone; those in quartzite have been even less helpful. Without silicified material of the older species there would be little reason to question the original generic description.

Several other discrepancies appear between *E. petersoni* Clark and *E. williamsi*

n. sp., which are covered in the discussion of the latter on the following pages. These may eventually prove to be of generic rather than specific significance; for the time being, at least, the two are considered congeneric.

The affinities of the genus appear to be closer to *Goniotelus* Ulrich, 1927 (equals *Goniurus* Raymond, 1913), than to any other so far described. Points of agreement are the slightly nasute anterior cranidial rim, almost complete lack of cranidial brim, length of glabella relative to cranidial length, general shape of free cheeks, and spine-bearing pygidium. There are, on the other hand, a number of differences, not all of which are evident from either Billings' or Raymond's descriptions of the species of *Goniotelus*. Through the kindness of Dr. W. A. Bell of the Geological Survey of Canada latex molds of types of three of these have been made available for study; these include the genotype, *G. perspicator* (Billings), *G. caudatus* (Billings), and *G. elongatus* Raymond. The first of these holotypes is a cephalon; the other two are pygidia. An additional mold has been furnished of a small pygidium believed to be that of *G. perspicator,* but not the specimen figured by Raymond (1913, pl. VII, fig. 10). From a study of all three pygidia it is obvious that the terminal spine in *Goniotelus* is an extension of the pleural platform and rim, not of the axis as in *Eleutherocentrus.* The holotype of the genotype indicates that *Goniotelus* possesses a glabella which contracts slightly both in front of and behind the palpebral lobes and that there is a pair of shallow glabellar furrows or depressions, which curve backward from the dorsal furrows near the centers of the palpebral lobes toward the occipital ring without meeting one another. Although obtusely rounded in front, the glabella of *Eleutherocentrus* is almost rectangular in outline and may be very slightly wider anterior to the palpebral lobes than posterior to them. In *Goniotelus* the palpebral lobes are gently curved along the lateral margins, whereas in *Eleutherocentrus* the lobes are semi-circular.

It is also possible that *Eleutherocentrus* may be related to some of the species referred by Cullison (1941) to *Jeffersonia;* such a species might be *J. jennii* Cullison (1941, pl. XXXV, figs. 17–22), which does not agree closely with other species of that genus in the midlength of the brim or length of pygidial pleura.

Eleutherocentrus williamsi Ross, n. sp.

Plate 14, figs. 16–22, 25

DESCRIPTION. Surface pustulose. Cephalon slightly nasute in front of cranidium, surrounded by narrow, thickened, sub-tubular rim, which at genal angles is extended into long, slender spines, diverging 30–40 degrees from the direction of the cranidial midline in their proximal halves and curving gently to the rear. Glabella evenly rounded in transverse profile, depressed; in dorsal view its outline is parallel-sided or expanding very slightly forward, sharply rounded in front, and occupying nine-tenths the cranidial length. Glabellar furrows absent. Occipital furrow deep; occipital ring consuming less than one-fifth length of glabella. Dorsal furrow distinct and continuous around front of glabella. Marginal furrow very shallow and confluent with dorsal furrow in front of glabella, so that brim is lacking. Palpebral lobes occupying almost all of fixed cheeks, being sub-semicircular and half as long along their bases as glabella. Their widest points are located about halfway between glabellar midpoint and occipital furrow. A narrow, thickened palpebral rim borders each lobe and is defined proximally by a shallow furrow. Anterior facial sutures curve slightly inward to marginal furrow, then turn sharply inward to revolve downward across rim; about two-thirds of distance from crossing of marginal furrow to midline, each cuts directly backward across doublure, so that free cheeks are separated by one-third anterior width of cranidium. Posterior facial sutures run directly laterad to define exceptionally narrow postero-lateral limbs; two-thirds of distance to genal spine's base each cuts posterior margin.

Free cheeks bear large, reticulate eyes. Ocular platforms markedly convex and about one-fifth as wide as glabella on line through eye-centers. Rim well defined by marginal furrow anteriorly only.

Hypostome and thorax not known.

Pygidium sub-triangular, exclusive of the terminal spine, with prominent axis of five segments; each segment of approximately equal length, except fifth, which is twice as long as each of other four. Fifth segment produced into long, slender, median spine, about three times as long as rest of pygidium. Rim smooth, not being set off by clear marginal furrow and not crossed by interpleural grooves. Four distinct pairs of pleura in convex pleural platforms. Posterior edge of rim drawn up sharply directly beneath terminal spine.

Holotype. Y.P.M. No. 18031.

Paratypes. Y.P.M. Nos. 18032, 18033.

Discussion. This species can be distinguished from *E. petersoni* Clark by its larger, more posteriorly situated palpebral lobes, much more slender and shorter postero-lateral limbs, and by much shorter fifth axial segment of pygidium; in *E. petersoni* fifth axial segment is equal in length to sum of anterior four segments, exclusive of terminal spine. Correlative with the smaller size of palpebral lobes the eyes of *E. petersoni* are rotund, sub-globular.

Nowhere is the difficulty in comparing silicified specimens with those which are natural molds or casts more clearly brought out than in the comparison of these two species in the present collection. All specimens of *E. petersoni* are in quartzite, siltstone, or black shale; in none has the course of the facial suture on the under side of the rim been ascertainable, although dozens of specimens from the three types of matrix have been examined. On none of these do palpebral rims appear on the lobes and on only a few is it at all clear that the anterior of the cranidium is possessed of a thickened rim, the portion anterior to the glabella on most appearing as a very short, flat brim. It is small wonder that Clark believed his species allied with the Asaphids. Although failure to observe these features in the genotype can be attributed to poor preservation, it is equally possible that they were never present in a manner comparable to that in *E. williamsi;* as a result some uncertainty has arisen concerning the congenerity of the two species.

Adding to this uncertainty is the small size of the palpebral lobes and eyes in *E. petersoni* compared with the new species; here there is no question of preservation. Between the two there is little difference in the position of the forward ends of the lobes or eyes, but the posterior ends have much different locations. In *E. williamsi* there is hardly any space between the back of the lobes and the occipital furrow, while in *E. petersoni* the lobes and eyes are about half as long, thereby requiring the postero-lateral limbs to have considerably greater width (in axial direction) at their bases. In most, but not all, specimens of *E. williamsi* the distance from the dorsal furrow to the tip of the limb is smaller than the width of the glabella at the occipital ring, while in *E. petersoni* the reverse is true. How much value these differences have at a generic level is not at present known; in this instance they are considered to be of interspecific rank.

This last consideration, however, opens another problem in regard to *Goniotelus*, especially in regard to *G. perspicator* (Billings). If it were not for the characters of the glabella, the differences in the palpebral lobes and postero-lateral limbs might be reconciled with those appearing between the two species of *Eleutherocentrus*. (It is noted here that Billings' original figure of *G. perspicator* [1865, fig. 191, p. 205] shows the postero-lateral limbs considerably shorter than they really are.) Although the length and the position of the centers of the palpebral lobes are intermediate between the two species discussed above, the width of the fixed cheeks (including the lobes) is markedly narrower than either. The shape and length of the postero-lateral limbs is intermediate. The course of the facial sutures on the lower surface of the rim is no better known than in *E. petersoni*. It is possible, that the two genera, *Goniotelus* and *Eleutherocentrus*, are synonymous, as increasing knowledge may show them; at present they are considered close relatives, separable on the basis of their respective glabellas, width of fixed cheeks, and mode of origin of the terminal pygidial spines.

OCCURRENCE. ZONE "J", locality 13, 1040–1060 feet above base of Garden City formation; locality 8, 1485–1520 feet above base of formation.

Genus *Hillyardina* Ross, n. gen.

DESCRIPTION. This genus is characterized by its semi-cylindrical glabella with sharply rounded front, large, steeply sloping brim, flat-topped, acutely-edged cephalic rim with convex doublure, very acutely triangular postero-lateral limbs, and small, plate-like palpebral lobes. Fixed cheeks flat, horizontal, narrow.

DISCUSSION. A raised boss in the postero-lateral corner of the ocular platform of the genotype may prove to be of generic significance; it is the easiest means of differentiating cheeks of the genotype from those of associated *Hyperbolochilus marginauctum* Ross, n. sp. (below). Their cranidia are differentiated on the basis of courses of anterior facial sutures and shape of glabella.

GENOTYPE. *Hillyardina semicylindrica* Ross, n. sp.

Hillyardina semicylindrica Ross, n. sp.

Plate 16, figs. 1–9

DESCRIPTION. Surface finely pustulose on cranidium only. Glabella possessing two pairs of non-pustulose patches on sides. Brim gently convex, deflexed at 60 degrees from glabellar base; midlength long, in lateral profile. Brim bearing a very faint median furrow which fades out before reaching marginal furrow. Marginal furrow defined mostly by break in slope. Semicircular palpebral "plates" set off from remainder of fixed cheeks by distinct palpebral furrows curved with concave side laterad. Lobes located even with glabellar midpoint. Distally posterior edge of each postero-lateral limb is ornamented with minute pustules. Anterior facial sutures diverge and then converge slightly to marginal furrow, from furrow turning sharply inward across top of rim and then sharply postero-distally across doublure from sharp leading edge; free cheeks apparently meet only at a single point. Free cheeks with small eyes without infra-ocular rings, convex ocular platforms, and wide flat-topped rim. Raised, rounded, sub-triangular boss within angle between lateral and posterior marginal furrows. Genal spine stout and triangular in cross-section, with sharp edge laterad; spine divided faintly on dorsal surface by continuation of marginal furrow along its entire length; this shown most clearly on immature specimens.

Hypostome, thorax, and pygidium not identified. Associated hypostomes and pygidia illustrated in figures 23, 32, plate 17, and figures 21–38, plate 19.

Slight change in proportions of the cranidium are shown by growth stages. Those 2 millimeters and less in length possess somewhat larger palpebral lobes and are somewhat narrower than the larger individuals.

HOLOTYPE. Y.P.M. No. 18035.

PARATYPES. Y.P.M. Nos. 18034, 18036, 18037.

OCCURRENCE. Locality 6, Zone "F", 305–340 feet above base of Garden City formation.

Genus *Pachycranium* Ross, n. gen.

DISCUSSION. Although the genotype, *P. faciclunis* Ross, n. sp., resembles other genera in several of its characteristics, the combination of these features seems to preclude its assignment to any of them. In no species of *Parahystricurus* is the brim so long or so clearly cleft by a pre-glabellar furrow; nor are any of their cranidia so convex. The species assigned to *Pseudohystricurus* may equal the cranidium in convexity, but possess much shorter brims and differently shaped postero-lateral limbs. *H. semicylindrica* Ross, n. sp., the genotype of *Hillyardina,* differs in the shape of the glabella and the characters of the free cheeks. All these differences constitute negative evidence in favor of the generic distinctness of this species.

On pages which follow a species is described and assigned tentatively to this genus under the designation *Pachycranium* ? sp. It agrees closely with all the features of the genotype except in its lack of any sign of pre-glabellar median furrow on the brim, either in mature or immature stages, but is represented in the collection by only two cranidia (pl. 17, figs. 5 and 15). Whether the lack of this feature is of generic or specific importance is not known and is covered briefly under the discussion of the species.

GENOTYPE. *Pachycranium faciclunis* Ross, n. sp.

Pachycranium faciclunis Ross, n. sp.

Plate 16, figs. 12–13, 17–24, 28–29

DESCRIPTION. Cephalon semicircular in outline, strongly convex, with smooth surface and slender, almost straight, slightly diverging genal spines. Cephalon surrounded in front and on sides by narrow, sub-tubular rim, set off by distinct marginal furrow.

Cranidium dominated by rotund, almost globular glabella, lacking glabellar furrows; dorsal furrows sharply incised. Occipital furrow narrow, deep. Brim in lateral view almost half as long as the glabella, deflexed at an angle of 50–60 degrees from glabellar base. Distinct median pre-glabellar furrow divides brim into two gently convex halves and connects dorsal and marginal furrows. Brim only very slightly wider at marginal furrow than immediately in front of palpebral lobes. Rim narrow and flat-topped; its leading edge almost vertical at midline. Fixed cheeks narrow, composed almost entirely of palpebral lobes, which are small, sub-semicircular plates, separated from remainder of fixed cheeks by short, slender furrows curved with concave side laterad. Lobes located entirely forward of glabellar midpoint. Postero-lateral limbs narrowly triangular. Free cheeks possess evenly convex ocular platforms and lack infra-ocular rings. Posterior edges of cheeks curve sharply forward close to and within base of genal spine.

Hypostome, thorax, and pygidium not known. Hypostomes and pygidia found associated illustrated in figures 23, 28–29, 32–33, plate 17 and figures 21–38, plate 19.

HOLOTYPE. Y.P.M. No. 18038.

PARATYPES. Y.P.M. Nos. 18039–18042.

DISCUSSION. This species, like several others described in this study, shows the development of paired pustules on the otherwise smooth glabella of very young individuals. On none of these immature cranidia have more than two pairs of pustules been found on the portion of the glabella exclusive of the occipital ring. In *Hystricurus flectimembrus* Ross, n. sp., there are four pairs; four pairs also show in *Parahystricurus oculirotundus* Ross, n. sp., and in *P. pustulosus* Ross, n. sp. In *P. fraudator* Ross, n. sp., there are only three. In *Pachycranium faciclunis* no pair appears on the occipital ring, while in each of the aforementioned species it does. What the significance of these pustule pairs is, is not now known; as has been suggested previously, they may represent initial indentation on the inner side of the test for the attachment of appendicular muscles.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Pachycranium ? sp.

Plate 17, figs. 4–6, 9–11, 14, 15

One large cranidium of this species has been secured in a limestone matrix, as well as one small silicified cranidium and free cheek. All three were collected from the same bed in Zone "C" at locality 5. At locality 8, 325 feet above the base of the formation, the species may be present; here collections were made from an extremely compact, fine-grained limestone crowded with a multitude of trilobite fragments and abundant brachiopods, including *Apheorthis*. Although most of the trilobites appear to be conspecific with the form described here, no specimen has been freed from the enclosing matrix adequately enough to make this certain.

DISCUSSION. This species differs from those of *Hystricurus* in the greater convexity of the cranidium, more sharply deflexed brim, narrower and less convex fixed cheeks, narrow, plate-like palpebral lobes, and lack of infra-ocular rings. From *Parahystricurus* it is distinguished by the convexity and shape of the brim and more slender postero-lateral limbs, but agrees rather closely with that genus in other respects. Despite the obvious difference caused by the lack of pre-glabellar median furrow it resembles *Pachycranium faciclunis* Ross, n. sp., so closely that the two may be congeneric. Since this pre-glabellar furrow is present in the immature forms of some species of *Hystricurus* but is lost during the ontogeny, it is not certain whether its presence or absence is of generic value. In some species it quite clearly is present throughout the ontogeny, while in others it is not present at all. In such clear-cut cases I am empirically inclined to believe that the feature has generic significance. As a result the possible congenerity of the species here described with the genotype of *Pachycranium* is merely suggested.

FIGURED SPECIMENS. Y.P.M. Nos. 18051, 18052, 18307.

OCCURRENCE. Zone "C", locality 5, 140 feet above base of Garden City formation. Possibly present at locality 8, 325 feet above base of formation in beds believed to be equivalent to Zone "D" of the more easterly sections.

Genus *Pseudohystricurus* Ross, n. gen.

DESCRIPTION. This genus is erected to include three species from the Garden City formation, which are characterized by strongly convex cranidia, more or less oval glabellas, and very narrow palpebral lobes. In two of the species the glabella is almost globular and suggests some species of *Onchonotus* (Rasetti, 1944); the palpebral lobes in that genus are very small and almost semi-circular, and the anterior cranidial rim and brim have a nasute form.

In addition to the three species, the description of which follows, it is possible that *Hystricurus crassilimbatus* Poulsen and *Hystricurus abruptus* Cullison should be included here.

Although this genus, or at least some of its species, may be closely related to *Hystricurus,* it is in my opinion distinct. In no true *Hystricurus* is the cranidium so convex, the brim so sharply deflexed, the postero-lateral limbs so stout, or the palpebral rims so nearly straight. The name is, therefore, given to signify the disunity between the two genera, rather than to imply any relationship.

GENOTYPE. *Pseudohystricurus obesus* Ross, n. sp.

Pseudohystricurus obesus Ross, n. sp.

Plate 16, figs. 25, 30, 34

DESCRIPTION. Cranidium with pustulose surface, dominated by semiglobular glabella lacking glabellar furrows. Occipital ring lower than remainder of glabella. Occipital furrow distinct. Midlength of brim exceptionally short; brim deflexed at 70–80 degrees from the glabellar base. In anterior view marginal furrow appears very obtusely V-shaped with the apex pointing dorsad. Rim sub-tubular. Fixed cheeks slightly convex. Palpebral lobes comprised entirely of short, very narrow, thickened rims, set off by equally short, sharply incised palpebral furrows; rims have little curvature; their posterior ends are located opposite the glabellar midpoint. Postero-lateral limbs broadly triangular. Anterior facial sutures converge evenly; after crossing marginal furrow sutures turn sharply inward to revolve downward and under rim to pass out of posterior edge of doublure before reaching midline. Posterior facial sutures diverge at approximately 25 degrees from the cranidial axis.

HOLOTYPE. Y.P.M. No. 18049.

PARATYPE. Y.P.M. No. 18048.

DISCUSSION. This species is relatively abundant in Zone "F" at locality 6. It is apparently always minute, none of the cranidia found so far exceeding 2 millimeters in length.

In general proportions this species agrees rather closely with *P. rotundus* Ross, n. sp. It differs markedly in the length of the palpebral rims and in their forward position; the fixed cheeks are somewhat narrower and the postero-lateral limbs are apparently more broadly triangular. If it had not been for the discovery of a single cranidium, here referred to *Pseudohystricurus* sp. below, from Zone "E", which is intermediate in all these respects, the two might not have been grouped in the same genus.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Pseudohystricurus rotundus Ross, n. sp.

Plate 16, figs. 32, 33, 35–37

This species is known from only a half dozen cranidia, none completely preserved; for that reason it should probably not be given a formal name and description. It is one of the few distinctive trilobites found so far in faunal Zone "A" at locality 5, and most of its features can be made out from a composite study of the few cranidia on hand. I have, therefore, taken the liberty of presenting it with a formal designation.

DESCRIPTION. Cranidium relatively short and wide with a pustulose surface; none known to exceed 4 millimeters in length. Glabella greatly inflated, bluntly rounded in anterior outline, its greatest convexity located almost two-thirds of its length from the posterior edge. Single pair of very faint glabellar furrows arises from dorsal furrow opposite glabellar midpoint and runs postero-dorsally up sides of glabella; second pair suggested by exceedingly faint creases or non-pustulose patches slightly farther forward in some specimens. Occipital furrow deep. Mid-length of brim so short that it barely separates dorsal and marginal furrows; brim slightly convex. Narrow, deep marginal furrow sets off thin, presumably subtubular rim. Very slender, gently curved palpebral rim on each fixed cheek set apart by distinct palpebral furrow; rim comes close to touching marginal furrow both at front and at rear on postero-lateral limb. Although exact shape of postero-lateral limbs is not known, they appear to be narrow and to project laterally almost at right angles to cranidial axis. Course of anterior facial suture short and straight to rim.

Free cheeks, hypostome, thorax, and pygidium of this species not known. Although an associated pygidium is believed to belong to *Hystricurus* sp. D (fig. 10, pl. 30), it should perhaps be assigned to this species.

HOLOTYPE. Y.P.M. No. 18301.

PARATYPES. Y.P.M. Nos. 18304, 18305.

DISCUSSION. In the rotundity of its glabella and general outline this little species is reminiscent of *Onchonotus* (compare with Rasetti, 1944, pl. 38, figs. 29–43), but lacks the nasute brim, narrow fixed cheeks, and small palpebral lobes of that genus.

OCCURRENCE. Zone "A", locality 5, 35 feet above base of Garden City formation.

Pseudohystricurus sp.

Plate 16, figs. 26, 27, 31

DISCUSSION. This species is represented by a single cranidium in the collections here under study. In general outline and degree of convexity it resembles *P. rotundus* closely. As in *P. obesus* the brim is more sharply deflexed. Like neither of those two species this possesses a median pre-glabellar furrow on the brim. It shares the forward position of the palpebral lobes shown in *P. obesus,* and the lobes are neither as short as in that species or as long as in *P. rotundus.* Although the postero-lateral limbs of the latter are not completely known, it is believed they resemble the same feature of this cranidium closely.

FIGURED SPECIMEN. Y.P.M. No. 18050.

OCCURRENCE. Zone "E", locality 5, 315 feet above base of Garden City formation.

Genus *Jeffersonia* Cullison, 1944

Jeffersonia peltabella Ross, n. sp.

Plate 17, figs. 7, 8, 12, 13, 16–22

Description. The features of the cranidium of this species agree so closely with those of *J. missouriensis* Cullison (1944, p. 71, pl. XXXIV, figs. 10–13, not fig. 14) that no detailed description will be given other than to indicate the differences between the two. In Cullison's species the rim of the cranidium is wide and concave, while in this species it is very narrow and sub-tubular; in his species the surface is smooth instead of being finely granulose. In *J. peltabella* the midlength of the brim is slightly longer, and the brim a little more convex.

Comparison of the free cheeks of the two species is impossible since none are known for *J. missouriensis*. In this species the free cheeks are a little more than quarter-circles in outline; the genal spines are mere sharply pointed studs. The ocular platforms are convex and rather steep, being granulose on the surface. The narrow rim widens and becomes broadly convex to the rear, filling the major portion of the space within the genal angle. The marginal furrow which is so clearly incised in front of the cranidium gradually becomes wider posteriorly on the free cheeks; it does not approach close to the base of the genal spine, but at a point about halfway between the eye-center and the spine turns inward and then passes onto the postero-lateral limbs. The ventral anterior side of the rims is unusual in that it is rather strongly convex and must have given the cephalon the appearance of riding on a wide, low sled-runner.

In outline the pygidium is roughly semicircular, its length being approximately seven-tenths its greatest width. The length of the well-defined, slightly tapering, bluntly tipped axis is between six and six and one half tenths of the pygidial length, both including the articulating half-ring. In the axis the first two segments are easily distinguished, the third is barely distinguishable, and the posterior end appears to be further undivided. The radius of curvature of the outline of the pleural platforms is equal to the length of the axis. The platforms are bounded distally by a distinct break in slope which cannot rightfully be called a marginal furrow. Each platform bears three segments. The rim comprises all the rest of the pygidium, being exceptionally wide; it slopes evenly down all around and is very slightly convex. The articulating ridges are extremely well-developed along the front of the anterior pair of segments; they are slightly wider at their tips than close to the axis and bear rather sharp "facets".

Holotype. Y.P.M. No. 18056.

Paratypes. Y.P.M. Nos. 18053, 18054, 18055.

Discussion. An additional important point must be discussed in regard to the comparison of pygidia of this species and *J. missouriensis* Cullison. With his original description Cullison figured a pygidium (1944, pl. XXXIV, fig. 14) which he considered assignable to his species. His holotype was a cranidium from his locality 75.2, but his pygidium came from Ulrich's locality 101s. Why he chose this specimen is not clear, for another one (Y.P.M. No. 17168) which he collected from the same locality as the holotype cranidium appears to be the correct pygidium. It is figured here (pl. 15, fig. 15) for comparison with that of *J. peltabella;* the only marked difference between the two is in the manner of preservation and in the fact that the Missouri specimen is a little narrower relative to the length. Since the pygidium described above is assigned with absolute certainty to the figured cranidia and free cheeks, and since it agrees so closely with Cullison's specimen, Y.P.M. No. 17168, there can be little doubt that his specimen is correctly representative of *J. missouriensis.* The specimen Cullison figured (1944, pl. XXXIV, fig. 14) should, it is felt, be assigned to a different species.

Another species which is certainly congeneric with *J. peltabella* and *J. missouriensis* is one figured by Billings and given the name *"Bathyurus" amplimarginatus* (1865, p. 353, fig. 341a); not enough is known of the cranidium of this last species to warrant a critical interspecific comparison, however. A fourth species can be added to this trio, namely *Bathyurellus permarginatus* Cullison, which is based on two pygidia that lack the peculiar pleural pattern of *Bathyurellus* but are close to the forms discussed above.

Occurrence. Zone "G(2)e", locality 5, 750 feet above the base of Garden City formation.

Genus *Hyperbolochilus* Ross, n. gen.

(expanded brim)

Description. This genus is characterized by anteriorly expanding, strongly deflexed, gently convex cranidial brim, flat-topped cephalic rim, semi-oval glabella devoid of all but a strong occipital furrow, narrow fixed cheeks, and small slightly elevated palpebral lobes, the lobes being defined proximally by curving furrows with the concave side of the curve distal.

The anterior facial sutures converge sharply across the top of the rim, and across the doublure run postero-proximally, so that the free cheeks meet only at a point.

This genus bears a superficial resemblance to *Hillyardina* in rough dimensions of brim, flat-topped rim, and fixed cheeks. It shares the same forward position of palpebral lobes relative to glabellar midpoint. *Hyperbolochilus* differs in the lack of pre-glabellar median furrow, shape of glabella, position of furrow on postero-lateral limbs, lack of pustules, and lack of boss within the genal angle. Its anterior courses of facial sutures possess a more pronounced flare on the dorsal surface, although ventrally very similar to *Hillyardina.*

Genotype. *Hyperbolochilus marginauctum* Ross, n. sp.

Hyperbolochilus marginauctum Ross, n. sp.

Plate 17, figs. 24–27, 30–31, 34–35

Description. Cephalon smooth, with slender, slightly curved, backward directed genal spines. Dorsal furrows distinct, but not as sharply incised at the front as at the rear of glabella. Midlength of brim about half that of glabella. Brim gently convex, deflexed at approximately 50 degrees from glabellar base. No real marginal furrow, rim being separated from brim by distinct break in slope. Posterior facial sutures run postero-laterally at angle of approximately 60 degrees with cranidial axis, curving very gently, and crossing posterior marginal furrow less than half the distance between posterior end of eye and genal angle. Eyes extremely small without infra-ocular rings; ocular platforms evenly convex with moderate slope. Marginal "furrow" around front of cephalon and posterior marginal furrow join at acute, backward-directed point near genal angle and continue along dorsal side of genal spine as a single furrow, dividing proximal and distal sides of spine.

Thorax not known. Associated hypostomes illustrated in figures 21–29, plate 19; associated pygidia illustrated in figures 30–38 of the same plate.

HOLOTYPE. Y.P.M. No. 18057.

PARATYPES. Y.P.M. Nos. 18058–18060.

OCCURRENCES. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Paenebeltella* Ross, n. gen.

DESCRIPTION. This genus is very similar to *Beltella* Lake from the Upper Cambrian and Lower Ordovician of Britain and South America; both genera possess sub-trapezoidal cranidia, sub-ovate glabellas, and rather wide, rounded free cheeks of the Olenid-type.

In *Paenebeltella* the surface of the carapace is smooth. Cephalon more than twice as wide as long, gently convex in transverse profile, and rather strongly convex in longitudinal profile. Cranidium approximately twice as wide at postero-lateral limbs as at anterior marginal rim, its length about three-fifths the greatest width. Glabella evenly rounded, sub-ovate, unfurrowed except for well-defined occipital furrow. Midlength of brim very short, about equal to width of narrow, thickened, rounded rim which surrounds cephalon. Marginal furrow narrow and shallow. Fixed cheeks half as wide as glabella at palpebral lobes, which are exceedingly small and slightly convex plates. These plates so oriented that posterior ends seem closer to glabella than anterior ends; this is actually an optical illusion. Anteriorly facial sutures converge in slight curve, while backward they diverge postero-distally at about 30 degrees from cranidial axis cutting edge of cephalon a short distance inside genal spine. Well-preserved specimens of the genotype show that anterior suture almost completely crosses rim immediately after intersecting it, but turns sharply inward and remains within lower side of rim for half the distance between its intersection with marginal furrow and cranidial midline. Ocular ridges present on fixed cheeks of genotype, but very variable in definition on different specimens and obsolete on most cranidia over 8 millimeters long.

Margins of free cheeks evenly curved from front to base of genal spines; laterad to small eye, ocular platform is slightly wider than fixed cheek. Genal spine very slender.

If assignment of pygidium to genotype is correct, its characters are almost identical with those of *Beltella.*

GENOTYPE. *Paenebeltella vultulata* Ross, n. sp.

DISCUSSION. Although the pygidium assigned to the genotype indicates an affinity with *Beltella* Lake, the courses of the anterior facial sutures in that genus diverge slightly (rather than converge) and do not become inframarginal. However, it must be noted that all Lake's specimens (1919, pls. XII and XIII) are badly flattened; in one or two similarly flattened specimens of the genotype of *Paenebeltella* the rim appears to have been "unfolded", creating an appearance which might lead to the conclusion that its facial suture is intramarginal in the same manner. *Beltella* possesses two pairs of shallow glabellar furrows which are lacking in this genus, although in a sample of twenty-five cranidia of the genotype from 1 to 10 millimeters long, two small specimens about 3 millimeters in length possess two pairs of shallow glabellar depressions.

Paenebeltella vultulata Ross, n. sp.

Plate 18, figs. 1, 2, 5, 6; Plate 19, fig. 10

DESCRIPTION. Cephalon about twice as wide at rear as it is long, evenly curved on sides, and straight across front of cranidium. Slender spines curve backward from genal angles. Dorsal furrow narrow, deep, and always discrete from marginal furrow in front of glabella (fig. 6, pl. 18, indicates the presence of a short median pre-glabellar furrow in immature cranidia, but this is not found in adults or in all immature specimens). Ocular ridges discernible on many cranidia, but not a constant feature. Palpebral lobes exceedingly small, slightly convex, and in some specimens appearing to be almost obsolete. They are located a third of the distance from the anterior to the posterior edge of the cranidium.

Free cheeks gently convex, bearing small globular eyes. Length of slender, slightly curved genal spines little more than half cranidial length.

Hypostome and thorax not known; four of the associated types of hypostomes illustrated in figures 1–4, plate 19.

Although the assignment of pygidia cannot be definite until articulated specimens are discovered, the one chosen for this species (pl. 19, fig. 10) is so close to that of *Beltella* and agrees so perfectly in surface texture and shape of the rim with the cranidia of this species that the author is certain the choice is a valid one. Pygidium little more than twice as wide as long, including articulating half-ring. Axis prominent, sub-conical, and composed of three distinct segments, occupying three-fourths the pygidial length. Anterior edges of pleural platforms curved slightly backward. Four pairs of pleura. Rim complete around margin.

HOLOTYPE. Y.P.M. No. 18063.

PARATYPE. Y.P.M. No. 18064.

DISCUSSION. No ocular ridges have been found on cranidia over 8 millimeters in length. In specimens 3 millimeters long they are in most cases represented by a very gentle, narrow flexure (note that no ridges can be seen in fig. 1, but that one does show with low, oblique lighting on the same specimen in fig. 5, pl. 18). A peculiar case of a double ocular ridge is illustrated in the small (1.5 mm.) specimen in figure 6, plate 18, the only one in a sample of twenty-five to show such a feature. The resemblance of this species to *Beltella* probably indicates correlation of its faunal zone with the Tremadoc of Britain and the Lower Ordovician of Argentina.

OCCURRENCE. Zone "E", locality 5, 315 feet above base of Garden City formation; locality 6, 210–255 feet above base of formation.

Genus *Pyraustocranium* Ross, n. gen.

(moth head)

DESCRIPTION. Cephalon short and wide with parallel anterior and posterior margins and rounded sides, bearing very slender, backward directed genal spines based slightly forward of genal angle. Cranidium trapezoidal in outline. Glabella sub-semicylindrical and slightly narrower at front end than at rear; its anterior outline bluntly rounded. Glabellar furrows lacking; occipital furrow deeply impressed. Dorsal furrows deep and confluent around front of glabella. Brim with a width much greater than its midlength and clearly separated from narrow sub-tubular rim by a marginal furrow. Fixed cheeks exceptionally wide and practically inseparable from postero-lateral limbs. Palpebral lobes composed almost entirely of crescentic, thickened palpebral rims, set off by distinct palpebral furrows and connected at their front ends with "anterior corners" of glabella by ocular ridges. Lobes located well forward of glabellar midpoint. Free cheeks narrow, bearing large, inflated eyes; eyes consuming entire width of cheek out to proximal edge of rim. Only portion of cheeks which might be considered ocular platforms limited to space between back side of eye and genal angle. Right and left free cheeks separated at front of cranidium by a very short median suture. Facial suture in front of eyes intramarginal.

GENOTYPE. *Pyraustocranium orbatum* Ross, n. sp.

DISCUSSION. This genus appears to be closely related to such forms as *Parabolina, Leptoplastus,* and *Ctenopyge,* although it may be a case of homeomorphy. From all these and their other Cambrian relatives it differs in the lack of glabellar furrows and the possession of much larger eyes. In almost all the Cambrian genera the ocular platforms of the free cheeks are well developed and much wider than the eyes themselves, while in this genus there are practically no ocular platforms at all. There are a few species of *Ctenopyge* (see Westergard, 1922, pl. XIII) in which the eye is fairly large, but even these do not equal *Pyraustocranium* and have genal spines based far forward and directed almost directly laterad at the proximal ends.

It is of considerable interest that the smallest examined cranidia of the genotype, measuring slightly less than 1.0 millimeters in length exclusive of the occipital spine, lack the antero-lateral and postero-lateral spines found by Raw (1925) in *Leptoplastus salteri.* This lack may possibly be attributed to the fact that the ontogeny of *P. orbatum* has become tachygenetic.

Unfortunately no complete carapace of the genotype has been secured, so that the hypostome, thorax, and pygidium are unknown. None of the pygidia associated have the spined margin found in *Leptoplastus* or *Ctenopyge,* and most of those which are considered likely candidates for assignment to the genotype (pl. 19, figs. 32–38) possess strongly carinate margins.

Pyraustocranium orbatum Ross, n. sp.

Plate 18, figs. 3, 4, 7, 8, 10–14, 16

DESCRIPTION. Surface sparsely pustulose. Cephalon more than twice as wide as long. Cranidium half as wide at anterior as at the posterior marginal furrow. Occipital ring bearing an occipital spine, more than half as long as glabella, although in immature cranidia it exceeds glabellar length. Spine projects backward almost horizontally, apparently lying close above thoracic axis. Midlength of brim slightly less than 0.1 glabellar length. Narrow sub-tubular rim set off by distinct marginal furrow. Fixed cheeks structurally indistinguishable from postero-lateral limbs. Palpebral lobes almost triangular in outline; they bear well-developed palpebral rims set off by distinct palpebral furrows. Palpebral rims straight at anterior ends, but curve almost in a right-angle bend, so that their posterior thirds are directed postero-proximally. Anterior pits located in dorsal furrow, one on either side of glabella immediately anterior to ocular ridge. From marginal furrow facial sutures turn sharply inward and cross top of rim, without revolving completely around it but remaining intramarginal to their juncture with short median suture. Posterior sutures diverge at an angle between 25 and 30 degrees from cranidial midline. At posterior marginal furrow they turn slightly inward to cross posterior rim. Free cheeks little more than support for eyes, which are highly inflated (pl. 18, figs. 10, 11, 16). Genal spines based slightly forward of rounded "posterior corner" of cephalon; almost as long as cranidium and diverge only slightly.

Hypostome, thorax, and pygidium not known. Associated hypostomes illustrated in plate 19, figures 21–29; associated pygidia shown in plate 17, figures 23, 28, 29, 32, 33, and plate 19, figures 30–38. It is extremely unlikely that the pygidia shown on plate 17 are assignable to this species; they almost certainly belong to species of *Hystricurus* or similar forms.

HOLOTYPE. Y.P.M. No. 18072.

PARATYPES. Y.P.M. Nos. 18065–18071 incl.

DISCUSSION. During the ontogeny of this species the cranidial proportions change negligibly, except for the decrease in the length of the occipital spine. At no stage examined to date are there glabellar furrows present. The holotype was chosen because it is the largest specimen of the species collected; on it there appear to be faint glabellar furrows, but these are actually wrinkles caused by slight deformation.

OCCURRENCE. ZONE "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Goniophrys* Ross, n. gen.

(angle eyebrows)

DESCRIPTION. This genus may be assignable to the Family Komaspidae Kobayashi (1935) (restricted by Resser, 1942, pp. 2–4), from all the previously described members of which it is distinguished by the lack of glabellar furrows, the distinctly angular outline of the palpebral rims, and the slightly narrower, sub-ovoid glabella. The characters of the brim and rim of the cranidium are those of *Komaspis* Kobayashi and *Parairvingella* Kobayashi.

The axis of the pygidium is composed of three rings and is very prominent, being bluntly semi-conical; in all the Cambrian species of the family to which pygidia have been assigned the axis is much less convex and is composed of four segments.

GENOTYPE. *Goniophrys prima* Ross, n. sp.

DISCUSSION. The general features of the cranidium, free cheeks, and cephalon compare so favorably with previously described genera of the Komaspidae that their relationship is almost certain. Several species of *Drumaspis* and *Irvingella* have been found in the Upper Cambrian formations of Nevada, Utah, and Idaho, including the St. Charles formation, and it is now reasonable to believe that the family continued into the Lower Ordovician. There is further evidence that it is represented high in the Canadian, if not in the lower Chazyan, by the genus *Carolinites* Kobayashi, in which there is a pair of strong nodes beside the forward-expanding glabella in front of the occipital furrow.

Stubblefield (personal communication) has suggested a possible alternative relationship of *Goniophrys* with *Telephus*, pointing out that it may be a population intermediate between some one of the Komaspidae and the latter genus.

Goniophrys prima Ross, n. sp.

Plate 18, figs. 9, 15, 17–20, 22, 27

DESCRIPTION. Cephalon slightly more than twice as wide as long, asymmetrically oval in outline, and surrounded by a narrow, thickened, rounded rim, and a shallow marginal furrow, with bases of slender genal spines located on opposite sides of glabellar midpoint. Cranidium roughly six-sided in outline. Smooth, unfurrowed, sub-ovoid glabella, with well-defined occipital ring, consumes 0.9 of cranidial length and half its width at postero-lateral limbs. Dorsal furrow does not quite touch anterior marginal furrow at cranidial midline. Fixed cheeks slightly convex, long, and wide; on a line through apices of palpebral rims, each is approximately 0.7 as wide as glabella. Narrow palpebral rims, bounded proximally by a well-defined furrow, begin opposite front of glabella, diverge postero-distally at angle of 25 degrees with cranidial midline for two-thirds their length, then turn at right angles, and end at point slightly to rear of glabellar midpoint. Anteriorly, facial suture turns inward and almost immediately crosses marginal furrow into rim, within leading edge of which it remains to midline, there becoming infra-marginal. Posterior suture runs postero-distally for very short distance before doubling back in blunt curve to cut back edge of cephalon halfway between dorsal furrow and base of genal spine.

Free cheeks composed of a large, probably inflated, eye (as in *Carolinites*, pl. 18, figs. 25, 34), marginal furrow, rim, and slender genal spine, there being no ocular platform.

Thoracic segments incompletely known from a single cranidium with which two were articulate (pl. 18, figs. 15, 17); unfortunately pleura are broken on first segment, and it has been crushed into back of glabella, buckling occipital ring. However, second segment shows pustulose nature of surface and strongly convex axis. Assignment of several associated, similarly ornamented segments is considered with reservation, there being considerable difference between them in relative width of axis and deflection of pleural tips; all, however, are blunt at ends with a minute, backward-pointing spine.

Pygidium of same general form as in *Chariocephalus affinis* (Resser, 1942, pl. I, figs. 18, 19), but possesses much more prominent and well-defined semiconical axis of three, rather than four or more, segments, resting on gently sloping pleural platforms with four pairs of faintly grooved pleura. Rim unbroken and very slightly thickened.

Hypostome of this species not known, but several associated with it are illustrated in figures 21–29, plate 19.

Holotype. Y.P.M. No. 18075.

Paratypes. Y.P.M. Nos. 18073, 18074, 18076.

Occurrence. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Carolinites* Kobayashi, 1940

Carolinites Kobayashi, 1940, Papers and Proc. Roy. Soc. Tasmania (1939), p. 70.
Dimastocephalus Stubblefield, 1950, Ann. Mag. Nat. Hist. (12), vol. 3, no. 28, p. 341.
Carolinites Kobayashi. Stubblefield, 1950, Ann. Mag. Nat. Hist. (12), vol. 3, no. 29, p. 451.

Under the name of *Dimastocephalus* this genus has been so completely described by Dr. Stubblefield (1950 a) and its taxonomic position so adequately discussed that only slight amplification is needed here. From the silicified specimens of the new Garden City species, *Carolinites genacinaca,* it is clear that the anterior facial sutures meet at a very obtuse angle within the cephalic rim and that the two free cheeks are separated by an extremely short median suture. The possibility that a rostral plate was present need no longer be considered, therefore. Although the Utah species also possesses four axial segments in the pygidium, the hindmost fourth pair of pleural grooves is so poorly developed as to be practically non-existent.

Stubblefield has commented sufficiently (1950 b) on the inadequacy of Kobayashi's original description of the genus and its genotype. Until after these have been redescribed and refigured by Singleton (Stubblefield, 1950 b) little is to be gained by an attempt to compare the Utah species with either of those named by Kobayashi (1940, pp. 70–71, pl. XII, figs. 6, 8, 9).

During the course of correspondence with Dr. Stubblefield concerning this genus I expressed the opinion that the characteristic "pre-occipital lobes" might be neither functionally nor structurally part of the glabella. My opinion was based on the fact that such lobes in other genera are normally isolated by backward migration of the inner ends of the pre-occipital glabellar furrows. Only in such Cambrian Komaspids as *Chariocephalus*, *Drumaspis*, and *Irvingella* are the necessary furrows present. Furthermore, stratigraphically below the occurrence of *Carolinites genacinaca*, n. sp., in Zone "F" appears the new, but surely related, genus *Goniophrys* (above), which lacks all trace of glabellar furrows. On the assumption that glabellar furrows had been lost in Komaspids by early Ordovician time and that *Goniophrys* or a *Goniophrys*-like form was the ancestor of the younger genus, it appeared to me that the pre-occipital lobes of *Carolinites* must have been developed in some other independent manner.

This seems further corroborated in *C. genacinaca* by the fact that the dorsal furrows turn sharply inside the lobes, concisely separating them from the glabella proper, while the furrows separating the lobes from the fixed cheeks are very weak, if impressed at all. In this interpretation I find myself in disagreement with Dr. Stubblefield, inasmuch as he considers that the dorsal furrows encompass the pre-occipital lobes distally. He (1950 a) further has pointed out in discussing the taxonomic position of *Dimastocephalus* (equals *Carolinites*) the fact that several species of supra-generically related *Telephus* have pre-occipital lobes (Ulrich, 1930 b, pl. 5, figs. 1–6; pl. 3, fig. 4). In the latter, however, the lobes are peculiar in that they are completely isolated within the glabella, being considerably distant from the dorsal furrows.

During the 1949 field season in Utah additional information has come to light which indicates the presence within Zone "G" of a Komaspid species (not yet described), which, like *Goniophrys*, lacks the lobes in question, but possesses the same sub-quadrate glabella as that of *Carolinites*. No glabellar furrows are present to isolate subsequently appearing pre-occipital lobes.

Further information has been secured from immature specimens etched during the early spring of 1950. These show that in cranidia of *C. genacinaca* less than 1.3 mm. in length there are no lobes present; it then seems evident that the pre-occipital lobes are features of maturity. On no cranidium, down to the smallest so far identified, which is 0.6 mm. in length, is there any sign of glabellar furrows other than the occipital furrow. Immature cranidia are, indeed, very similar to far more mature specimens of *Goniophrys prima*, n. sp. (above). Lack of pre-occipital lobes in the latter (older) species might be attributed to neotenic development such that mature proportions were reached before the lobes were formed. This does not account for the lack of glabellar furrows, which characterize Cambrian Komaspids, in the two Garden City genera.

I, therefore, reiterate the possibility that these lobes are not glabellar lobes at all, but rather some other structures independently developed, and that after development on the fixed cheeks they may have migrated inward to impress the sides of the glabella and dislocate the straight course of the dorsal furrows. A further, strictly hypothetical step might be visualized in which the lobes migrated an additional amount to pass the dorsal furrow and attain the condition found in some species of *Telephus.*

Carolinites genacinaca Ross, n. sp.

Plate 18, figs. 25, 26, 28–36

This species differs little from *C. killaryensis* Stubblefield (1950 a); the most marked distinguishing traits are the slightly narrower cranidium with its length only three-fourths the posterior width, concurrently narrower fixed cheeks, considerably longer genal spines, and lack of telsonic spine on the pygidium.

The pygidial axis is clearly composed of four rings, behind which there is a steeply sloping surface, confluent between the end of the axis and the posterior pleural platform (pl. 18, figs. 28, 32). Pleural grooves are only three in number, although a posterior fourth pair is suggested by a faint dimple close to the dorsal furrows within the posterior pair of pleural nodes.

HOLOTYPE. Y.P.M. No. 18081.

PARATYPES. Y.P.M. Nos. 18080, 18082–18084 incl.

DISCUSSION. It should be noted that the proportions of the glabella of this species change slightly with growth, being somewhat narrower in immature forms. Adult proportions of the glabella are practically identical with those of *C. killaryensis.* However, a line drawn between the front ends of the "pre-occipital lobes" in all specimens of *C. genacinaca* which are large enough to possess them (see generic description above) crosses the glabella very close to its midpoint, but nearer four-tenths the glabellar length from the rear in the Irish species.

OCCURRENCE. Zone "J", locality 5, 1238 feet above base of Garden City formation; locality 8, 1485–1520 feet above the base; locality 13, 1030–1060 feet above the base.

Undetermined Genus and Species A

Plate 18, figs. 21, 23, 24

DESCRIPTION. This tiny species is represented by a half dozen cranidia in the present collection and was at first believed to represent the immature stages of *Goniophrys prima* Ross, n. sp., with which it is associated. Fortunately it has been possible to show that this is not the case and that these specimens are distinct. None is more than 2 millimeters in length.

It is distinguished from *G. prima* by its relatively longer brim, greater width of the cranidium at the anterior marginal furrow, and shorter, evenly curved palpebral rims. It is not known whether the few cranidia collected are immature or whether the species is extremely small at maturity.

FIGURED SPECIMEN. Y.P.M. No. 18077.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Remopleuridiella* Ross, n. gen.

DESCRIPTION. Surface of carapace smooth, showing fine Bertillon markings. Cephalon, excluding parial spines, almost semicircular in outline, gently convex, surrounded by a narrow marginal furrow and narrow, thickened rim. Ventral doublure equal in width to rim. Cranidium wider at postero-lateral limbs than at palpebral lobes. Glabella, exclusive of occipital ring, oval to circular when seen from above, and extended into anterior tongue which curves sharply ventrad to marginal furrow as in *Remopleurides*. No glabellar furrows. Occipital ring flattened and set off from rest of glabella by a shallow, gently curved occipital furrow. Postero-lateral limbs slender, directed slightly to rear. Dorsal and palpebral furrows synonymous, at anterior end starting from marginal furrow barely inside facial suture, running upward along edges of anterior tongue, deepening and flaring outward around expanded glabella; furrows converge posteriorly to their meeting with occipital furrow. Fixed cheeks and palpebral lobes represented only by resulting long palpebral rims. Palpebral rims narrowly crescentic and inflated, possessing a doublure which turns downward and inward to meet top of eye (fig. 10, pl. 20). Anteriorly rims extend down along edges of anterior tongue with decreasing width to marginal furrow (figs. 2, 5, pl. 20). Posteriorly rims extend very slightly to rear of distal ends of occipital furrow.

Free cheeks subtriangular, each with long parial spine taking root from anterior half of rim of cheek. Eyes long and inflated, bluntly rounded at either end. Postero-distal angle of free cheek (genal angle) coincides with tip of postero-lateral limbs of cranidium. Anteriorly cheek narrows to slender point below eye; only its exceedingly narrow doublure extends under anterior tongue. Right and left free cheeks separated by a short rostral suture.

Facial suture intramarginal in front, turning upward and backward at right angles to delineate anterior tongue of cranidium, passing around doublure of palpebral rim, and then turning sharply laterad to define postero-lateral limbs. After crossing posterior rim suture runs in a forward direction on ventral doublure.

Number of segments in thorax not known. Pleura falcate and directed steeply ventrad. Dorsal furrow accentuated by narrow up-arching on leading edge near base of each pleuron.

Pygidium possesses a very short axis and flattened, serrate pleural lobes. Axis composed of a short articulating half-ring, a narrow, sharply convex anterior segment, and a posterior segment shaped like a half-dome. Pleural lobes made up of four to five pairs of flattened, sword-like pleura, of which the innermost pair is the smallest. Hypostome not known.

GENOTYPE. *Remopleuridiella caudalimbata* Ross, n. sp.

DISCUSSION. All the available specimens of free cheeks of the genotype on which the anterior extension of the doublure is preserved appear to indicate that the right and left cheeks are separated by a short median suture.

The close resemblance of this genus to *Remopleurides* Portlock is quite evident, and it is possible that some of the species assigned to the latter belong here. *Remopleurides*, as defined by Portlock (1843, p. 254), and redefined by Salter (1853, pp. 7–10), does not possess glabellar furrows, but has thoracic segments with so-called "fulcral knobs", and a pygidium with *two* pairs of spines, of which the inner pair is always the longer. But equally important is the fact that there are practically no postero-lateral limbs on the cranidium; this is clearly shown in Salter's refiguring of Portlock's types (1853, pl. VIII, figs. 1–4). According to Raymond (1925b, p. 56) *Remopleurides* possesses no cranidial rim.

Remopleuridiella differs from *Remopleurides* especially in having long postero-lateral limbs on the cranidium, in lacking "fulcral knobs", in the greater number of pygidial spines, and in having a distinct marginal furrow and rim on the cephalon.

Caphyra Barrande 1856 (equals *Amphitryon* Hawle and Corda, 1847) was originally differentiated from *Remopleurides* by the presence of glabellar furrows among other characters. Subsequent authors have discarded this feature as unimportant generically (Angelin, 1854, p. 13; Warburg, 1925, p. 79; Reed, 1903, pls. V and VI; Raymond, 1925b, pp. 55–56). As a result *Remopleurides* now includes many species, some with and some without glabellar furrows. Raymond (1905, p. 334), in describing specimens of *R. canadensis* Billings, pointed out that most of them only showed glabellar furrows on the inside of the test. In fact it may be a generic characteristic of *Remopleurides* to present a smooth outer surface of the glabella and a furrowed inner one, but the literature is so lax on this point that its clarification would undoubtedly require reexamination of almost every specific type named so far. For this reason the absence of glabellar furrows on either the interior or exterior surface of the test of *Remopleuridiella* is emphasized.

Remopleuridiella caudalimbata Ross, n. sp.

Plate 20, figs. 1–12

Description. Following relationships valid when cephalon is oriented with eyes level: In longitudinal profile crest-line almost flat in posterior half, but curves steeply ventrad in anterior half, becoming nearly vertical in forward part of anterior tongue. Glabella occupies almost entire dorsal surface of cranidium. Greatest width of glabella approximately equal to its length (measured in longitudinal profile from midpoint of rear edge of occipital ring to midpoint of marginal furrow), and located at its midpoint. Occipital ring occupies posterior quarter of glabella. In anterior profile glabella gently rounded. Palpebral rims widest slightly forward of glabellar midpoint.

Ocular platforms of free cheeks not as wide as eyes. Marginal furrow almost parallels eye and is not deflected at base of parial spine. Spine gently curved and projecting postero-distally at approximate angle of 60 degrees with cranidial midline.

Characters of thorax partially known. The few associated segments which can be assigned show semicircular arched axis which takes up over half total width. Dorsal furrow emphasized by sharp up-bending of leading edge of each pleuron distal to it, a feature which may have led to the "fulcral knobs" of *Remopleurides*. Distinct grooves along pleura. At least one segment may possess axial spine.

Short axis of pygidium set high above flat pleural lobes, composed of a very short and very narrowly convex anterior ring behind which is a quarter-spherical posterior segment. Specimens from localities 5 and 6 have five pairs of flat, pointed pleural spines, of which second pair is longest. In specimens from the same faunal zone at locality 7 there appear to be only four pairs; of these the first is the longest. The silicification of these last is so poor that this count cannot be considered definite; it does, however, raise the possibility that a subspecific difference may exist in the number of pleural spines.

Holotype. Y.P.M. No. 18108.

Paratypes. Y.P.M. Nos. 18107, 18109–18115 incl.

Discussion. Although this species is very similar to those of *Remopleurides* Portlock the pygidium differs considerably. Only two pairs of pleural spines are present in Portlock's genus and it is therefore possible that this Garden City species represents some offshoot from an *Apatokephalus*-like root long prior to the development of *Remopleurides*. Other diagnostic features have been covered in the generic description.

OCCURRENCE. Zone "B", locality 6, 85 feet above base of Garden City formation; locality 5, 86 feet above base of formation; locality 7, 140 feet above base of formation.

Genus *Menoparia* Ross, n. gen.

(crescent-shaped cheek-piece)

DESCRIPTION. This genus closely resembles *Apatokephalus* Brögger, from which it is distinguished by the possession of a crescentic portion of the fixed cheek between the dorsal and palpebral furrows, and by the characters of the pygidium. Like most trilobites of this type, *Menoparia* is characterized by large, almost semicircular palpebral lobes, anterior facial sutures which diverge at more than 90 degrees to give the cranidium a "hammer-headed" appearance in plan, a glabella which is expanded laterally between the palpebral lobes, and a digitate pygidium.

Cephalic surface smooth except for furrows and strong Bertillon markings; rim thickened and rounded, on line through eye-centers giving root to exceptionally long, thin parial spines. Glabella widest at its midpoint. Anterior to palpebral lobes glabella is parallel-sided; its front very blunt in plan. In longitudinal cross-section glabella long and low, sloping rather sharply into dorsal furrow in its anterior third. Only two pairs of glabellar furrows. "First" pair, normally found alongside anterior end of palpebral lobe in related genera, not present. "Second" pair short and straight, slanting proximally and backward from intersection of palpebral and dorsal furrows. "Third" pair sigmoid, as in *Apatokephalus;* right and left furrows of this pair do not meet. Dorsal furrow tangent to marginal furrow at cranidial midline. Pits in anterior part of marginal furrow in large specimens.

Length of large palpebral lobes more than half that of glabella. Palpebral lobe constitutes entire fixed cheek; proximally it is bounded by curved dorsal furrow; distally it bears thick, raised palpebral rim, set off from rest of lobe by sharply curved palpebral furrow. Palpebral and dorsal furrows coincide at occipital furrow and at anterior end of palpebral lobe.

Free cheeks exclusive of genal spine not much longer than eye. Doublure narrow, extending under edge of cheeks only as far as marginal furrow.

Thorax not completely known; pleura sharply falcate and diagonally grooved. Pygidium possesses short prominent axis, composed of three segments, of which posterior one is sharply rounded. Pleura are flat and grooved, projecting backward as sword-like spines, slightly upturned at tips. Four pairs of pleura of which inner pair is always minute. Doublure of pygidium completely covers all of ventral side except portion directly under axis.

GENOTYPE. *Menoparia genalunata* Ross, n. sp.

DISCUSSION. Although monotypic, the combined characters of the genotype set this genus off clearly from any other of the previously described, related genera. The features considered to be of greatest generic value in this instance are the discrete palpebral and dorsal furrows, the lack of the anterior or "first" pair of glabellar furrows, and the number of axial segments and pleural spines in the pygidium.

This genus differs from *Diplapatokephalus* Raymond (1937, p. 1086 and Walcott, 1884, pl. 12, fig. 12; Shimer and Shrock, 1944, pl. 267, figs. 42, 43) in the lack of an anterior pair of glabellar furrows and possession of at least one less segment in the pygidium. Actually Raymond's criterion (grooved pleura) for distinguishing *Diplapatokephalus* is most unsatisfactory, inasmuch as there has been no conclusive demonstration that *Apatokephalus* does not possess the same feature.

Menoparia is distinguished from *Apatokephalus* by the possession of separate dorsal and palpebral furrows between the palpebral lobes, three, rather than five, segments in the pygidial axis, and only four, rather than five or six, pairs of pleural spines in the pygidium. From *Kainella* it is differentiated by the lack of extended brim, and absence of radiating ridges on it; the glabella of *Kainella* is not expanded laterally between the palpebral lobes. *Kainella* also possesses a serrated pygidium, but the axis has five or more segments, and the shape of the pleura gives the entire pygidium a form rather reminiscent of a bat with wings folded. In *Pseudokainella* Harrington (1938) the glabella is not expanded between the palpebral lobes, and the pygidium, with its five axial segments, possesses a far less pronounced serration of the posterior edge than in *Menoparia*. The Cambrian genus *Richardsonella* possesses a longer brim; although Rasetti (1944, p. 256) assigns three species to it with short brims, in none are the dorsal and marginal furrows tangent. Furthermore in most species there are radiating ridges on the brim as in *Kainella*. The glabella in most species of *Richardsonella* is not laterally expanded between the palpebral lobes; Rasetti (1944, p. 256) has assigned a single species with expanded glabella, *R. convexa*, to the genus but this species differs from all others of *Richardsonella* in the possession of the same type of palpebral lobe as is found in *Apatokephalus*, and probably should be reassigned to another or a new genus. The pygidia of *Richardsonella*, as restricted by Rasetti, may possess from three to five segments in the axis and from three to six pairs of pleural spines, an unusual diversity; however, none has the combination of three axial segments and four pairs of pleural spines found in *Menoparia*.

Menoparia genalunata Ross, n. sp.

Plate 20, figs. 13–24, 28, 29, 34–35

DESCRIPTION. Width of glabella at its midpoint approximately seven-tenths its length; its width even with anterior ends of palpebral lobes is one-half the length. Occipital furrow deep.

Between palpebral lobes, dorsal furrow encloses laterally expanded portion of glabella. Width of glabella in occipital furrow equal to width in anterior third, but at posterior edge of occipital ring almost equal to greatest width between palpebral lobes. Anterior ends of posterior, sigmoid pairs of glabellar furrows located even with midpoint of glabella, and halfway between dorsal furrow and cranidial midline; posterior ends even with a point halfway between glabellar midpoint and occipital furrow and also halfway between dorsal furrow and cranidial midline. Ends of anterior pair of glabellar furrows originate at anterior junction of dorsal and palpebral furrows, slanting postero-proximally at an angle of 45 degrees with the cranidial axis; their proximial ends do not quite overlap anterior ends of sigmoid furrows.

Palpebral lobes, which are synonymous with fixed cheeks, form broad crescents the outer edges of which are semicircular. Each lobe divided into two crescentic parts by curved palpebral furrow; distal portion is raised palpebral rim. Inner meniscus-shaped portion of lobe flat and horizontal. Several pits may be present in palpebral furrow. Width of cranidium at palpebral lobes very little greater than its length.

Anteriorly, facial suture briefly parallels, but does not touch dorsal furrow before turning sharply outward at nearly a 90 degree angle; shortly thereafter suture swings gently forward to cut marginal furrow, so that cranidial width at marginal furrow is equal to or slightly less than width at palpebral lobes. Posterior facial sutures cut off short postero-lateral limbs. To date no specimens have been found with postero-lateral limbs surely intact, but their shape can be easily visualized from the small corresponding notch in the free cheeks (pl. 20, figs. 13, 29).

Free cheeks small and slender. Eyes long, slim, semicircular half-cylinders. Marginal furrow shallower than at center of cranidium; rim sub-tubular, confluent with long parial spine.

Thorax incompletely known; thoracic segments associated with and assignable to the species throughout its full stratigraphic range are falcate and diagonally grooved. Pleural lobes of pygidium divided into three large pairs of flattened, sharply pointed, backward-projecting spines, and in most specimens a fourth, inner, minute pair. Actually, inner pair may be absent as it is in one or two immature specimens.

Holotype. Y.P.M. No. 18122.

Paratypes. Y.P.M. Nos. 18116–18120, 18123, 18124.

Discussion. Only mature forms show pits in the marginal furrow of the cranidium and in the palpebral furrows.

This species has a stratigraphic range of 165 feet at locality 6 (from 495 to 655 feet above the base of the Garden City formation). Throughout this range the same cranidia, pygidia, and free cheeks are always associated. In one thin 5-foot zone (525 feet above the base of the formation at locality 6; 520 feet above the base at locality 5) this species is associated with *Scinocephalus solitecti* Ross, n. sp.

The fourth minute pair of pygidial spines in this species may prove to be of generic value. Their presence is the easiest means of distinguishing pygidia from those of *Scinocephalus solitecti* Ross, n. gen. and sp., with which this species is associated low in Zone "G".

Occurrence. Zone "G", locality 6, 495–655 feet above base of Garden City formation; locality 5, 520–800 feet above base of formation; locality 11, 490 feet above base of formation.

Genus *Scinocephalus* Ross, n. gen.

Description. An *Apatokephalus*-like genus characterized by pronounced peaked inflation of the glabella, extremely wide cephalic doublure, and in the pygidium three pairs of flattened spines plus a single minute median spine. Anterior two pairs of glabellar furrows almost obsolete, third pair modified sigmoid, deeply creasing posterior peak of glabella. Pits in cranidial marginal furrow opposed by pits in ventral doublure. Genal spines rooted in rim opposite glabellar midpoint, well forward of squared genal angles. Hypostome not ascertained.

Genotype. *Scinocephalus solitecti* Ross, n. sp.

Discussion. This genus differs from *Menoparia* in its inflated glabella, lack of discrete palpebral and cranidial dorsal furrows, retention of the anterior pair of glabellar furrows, and the possession of a single minute median spine in the pygidium. The truly amazing development of the cephalic doublure differentiates it from all similar genera as far as I have been able to ascertain from descriptions in the literature.

Scinocephalus solitecti Ross, n. sp.

Plate 20, figs. 25, 26, 27, 30–33, 36–38

DESCRIPTION. Cephalon semicircular, with long genal spines arising from the thickened, flat-topped rim opposite glabellar midpoint. Greatly inflated glabella possesses high rounded peak slightly forward of deep occipital furrow; in longitudinal profile crest line slopes evenly forward, steepening anterior to fronts of palpebral rims. Depressed lateral extensions of glabella between palpebral rims form widest part of glabella, but bluntly rounded anterior third is only very slightly narrower. Anterior of three pairs of glabellar furrows tiny, vertical creases at front of palpebral rims; second pair of furrows equally small vertical creases just behind fronts of palpebral rims; third pair of furrows basically sigmoid, but peculiarly modified from type found in species of *Apatokephalus*. This posterior pair deeply creases rear, highly elevated portion of glabella, so that sides of rounded peak are pinched in. Basic sigmoid pattern considerably straightened out; anterior end close to palpebral furrow and even with glabellar midpoint; at two points each furrow gives off very short branch on distal side, so that it appears to have branched dichotomously one-third and two-thirds of its length from its anterior end. Right and left furrows do not meet. Dorsal furrows coincide with palpebral furrows in the manner characteristic of *Apatokephalus* but not of *Menoparia*. In front of glabella confluent dorsal furrows touch marginal furrow in some specimens, but do not in others. No clear distinction between brim and marginal furrow, which is defined distally by abrupt thickening of rim. Small pits are located at regular intervals in marginal furrow. In mature specimens palpebral rims are narrow convex crescents, but in cranidia less than 2.5 millimeters long they are nearly semicircles (compare figs. 26 and 33, pl. 20). Length of palpebral rims about half that of glabella. Anteriorly facial suture turns sharply outward without touching dorsal furrow, running straight to marginal furrow at angle of 60 degrees with cranidial midline. At marginal furrow it turns acutely inward to cross dorsal surface of rim diagonally; at midline it becomes intramarginal, meeting median suture which divides right and left free cheeks. Posteriorly, facial suture runs straight laterad before turning at right angles halfway to genal angle to cut off slender, blunt-tipped postero-lateral limbs.

Free cheeks, except for eyes, almost flat. Ocular platform about three-fourths as wide as cranidium along a transverse line through eye-centers. Slightly depressed groove lies in ocular platform; its distal end is at base of genal spine and proximal end is tangent to posterior part of eye-base (fig. 30, pl. 20). Doublure covers almost entire ventral surface of cheek.

Pygidium possesses extremely small semi-conical axial portion, composed of three segments, posterior one of which is approximately a quarter-sphere. Each pleuron bears a deeply impressed groove. On ventral side pleura not distinct from one another except near tips, since their ventral surfaces form a confluent "doublure", protecting almost entire bottom side; only immediately under axis is ventral surface uncovered.

HOLOTYPE. Y.P.M. No. 18125.

PARATYPES. Y.P.M. Nos. 18121, 18126–18130 incl.

DISCUSSION. In dorsal aspect the cranidium of this species resembles *Richard-*

sonella cristata (Billings) (Rasetti, 1944, p. 256, pl. 39, figs. 51, 51) from which it differs in the coincidence of dorsal and palpebral furrows, and more rotund anterior portion of the glabella.

Occurrence. Zone "G(2)a", locality 5, 520 feet above base of Garden City formation; locality 6, 525 feet above base of formation.

Genus *Kirkella* Kobayashi, 1942

Kirkella Kobayashi, 1942, Geol. Soc. Japan, Jour., vol. 49, pp. 118–121.
Ptyocephalus Whittington, 1948, Jour. Paleontology, vol. 22, pp. 567–572.

It is unfortunate that Kobayashi chose to propose a new designation for this genus and that he could not know that Whittington would later describe almost perfectly preserved specimens of a new species on which he based the synonymous genus *Ptyocephalus*. As a result of Kobayashi's designation the genotype is *Kirkella curiosa* (Billings), for which neither the cephalic nor the thoracic parts are known and for which the originally described specimens of the pygidium are poorly preserved and distorted, as Whittington has indicated (1948, p. 572). Although *K. curiosa* is now the nominal genotype, there can be little doubt that the practical "type" for purpose of reference must be *K. vigilans* (Whittington) (1948, pp. 567–572).

As a result of the collections reported here it is possible to verify Whittington's inferences concerning the character of the cephalic doublure. Silicified specimens of *K. declevita* Ross, n. sp., show clearly that the doublure is very wide, that it is crossed by a median suture separating the right and left free cheeks, and that it is cut away in an even curve near the midline to receive the anterior end of the hypostome (pl. 21, figs. 11, 12; pl. 23, fig. 3).

Important additions can now be made to the generic description regarding the possession of Panderian openings and an elongate flange on the doublure of each free cheek, as illustrated on plate 22, figures 4 and 5. The flanges are analogous with similar structures common to many Asaphid-type trilobites, as described by Siegfried (1936, pp. 31–34, pl. I, figs. 1, 2) and by Whittington (1941, p. 513). The Panderian openings, on both the free cheeks and thoracic segments, are of the "hooded" variety (pl. 23, fig. 1).

Genotype. *Kirkella curiosa* (Billings).

Discussion. Although the genus is unquestionably limited in range to beds of Late Canadian age, it probably is not limited to a single one of the standard subdivisions. The new species, *K. declevita* Ross, is found in Zone "J", but two specimens of another species, *Kirkella* sp., have been found at localities 8 and 13 in beds approximately 500 feet below this zone and appreciably lower than Zone "H".

Kirkella declevita Ross, n. sp.

Plate 21, figs. 1–12; Plate 22, figs. 4, 5; Plate 23, figs. 1–3

Description. This species resembles *K. vigilans* (Whittington) so closely that the two may eventually be proved synonymous if enough specimens of both are discovered to make a statistical study possible. On the basis of our present limited knowledge the two appear to be distinguishable from one another in several ways.

The first of these is easily seen by comparing the hypostomes (see pl. 21, fig.

6 and Whittington, 1948, pl. 83, fig. 8). It will be noted that the postero-lateral wings in Whittington's species possess evenly but sharply rounded anterior margins which flow without break into the straight, convergent postero-lateral margins. In *K. declevita* the postero-lateral margins bear minutely narrow, but very distinct, thickened, straight rims. These rims do not follow the edge around into the posterior notch, nor do they take part in the sharply curved antero-lateral edge of the wings. At its forward end each rim projects slightly outward from the margin, so that the edges of the posterior and anterior portions of the wing are distinct from one another. At the posterior end each rim stops abruptly near the tip of the wing, and on some specimens bears a tiny, distinct, ventrally directed knob. The difference between the two species in this respect cannot be attributed to ontogeny, for the size range of the examined specimens of *K. declevita* includes the size of Whittington's described form. Furthermore Whittington's specimens have been so carefully prepared that there seems little possibility of the rims having been broken off.

The second distinguishing feature pertains to the pygidia; the differences between the two species are, however, so slight that there is some doubt whether they would be valid if large samples of each were available for examination. In *K. vigilans* the dorsal furrows are very faint and poorly developed, while they are much clearer in *K. declevita.* In comparing the outlines of the pygidia great care must be exercised to choose specimens of over 3 mm. length and preferably of equal size, for immature forms of *K. declevita* show that the pygidium goes through a considerable change of shape during the ontogeny (see in sequence figs. 1–5, pl. 21). Exclusive of the short articulating half-ring, the lengths of mature pygidia of *K. declevita* are equal to their widths; in the holotype and Whittington's paratype "A" of *K. vigilans* the length is definitely less than the width; in two specimens collected by Kirk from a different locality and assigned to the latter species the proportion is identical with *K. declevita,* however (Whittington, 1948, pl. 83, figs. 9, 11). These last two specimens also agree with *K. declevita* in the relative length of axial portion, while the axis of the holotype and paratype "A" appears somewhat shorter. Furthermore, if in a horizontal projection a line is drawn between the two postero-lateral angles it will cross the pygidial midline at a point 0.75 or more of the length from the anterior end in *K. declevita* and in Kirk's two specimens of *K. vigilans,* but at 0.7 of the length in Whittington's holotype and "paratype A". Since the specimens on which *K. vigilans* is based were secured from two different localities, it is remotely possible that they include two species.

This possibility and the seemingly picayune differences between the pygidia of *K. vigilans* and *K. declevita* would not have been considered had it not been for the discovery of two specimens, both pygidia and both unquestionably congeneric with these, approximately 500 feet below Zone "J" and appreciably below Zone "H" at localities 8 and 13. These two pygidia, referred to as *Kirkella* sp. below, possess evenly rounded posterior margins; their postero-lateral angles are located further forward than in *K. declevita,* in the manner of its immature forms and of the holotype and "paratype A" of *K. vigilans.* This is still true of the larger of the two specimens, even if allowance is made for its obvious deformation. It then seems likely that there may be some stratigraphic significance in the slight differences described above, and the immature pygidia of *K. declevita* may be recapitulating the adult form of older species, including *K. vigilans,* if the latter is restricted to its holotype and "paratype A".

Additional light is thrown on the character of the doublure of the cephalon and facial suture of the genus by the studied specimens of *K. declevita.* It is clear now that a median suture does separate the right and left free cheeks, as Whittington inferred (1948, pp. 568, 571). From the position of the hypostome, Whittington deduced that the cephalic doublure must be nearly flat and close to the dorsal surface; this fact is also verified (pl. 21, figs. 11, 12). In addition it should be noted that the doublure is cut away along its posterior edge near the midline to receive the front of the hypostome (pl. 23, fig. 3) and that the remainder of the edge is turned upward in front of the eyes (pl. 22, figs. 4, 5). Under the quadrate front of the cephalon the doublure is wide and very closely parallels the slope of the dorsal surface; on the sides of the cephalon it is bent sharply to cover the ventral sides of the free cheeks from the lateral margins to the base of the eyes. It is folded so tightly against the dorsal side of the carapace, in fact, that it is difficult to see how more than a thin film of living tissue could have existed between them. This tight folding of the doublure undoubtedly permitted the underlapping of facets of the thoracic segments as Whittington has indicated.

One Panderian opening is present on each free cheek close to the posterior side of the eye; the opening is protected on the anterior side by a convex hood. Anterior to the opening is a sharp ridge running parallel to the midline and distal to the eye, fading out at the front end (pl. 22, figs. 4, 5).

Holotype. Y.P.M. No. 18138.

Paratypes. Y.P.M. Nos. 18133–18137, 18139–18141, 18364–18366.

Occurrence. Zone "J", locality 13, 1040–1060 feet above base of Garden City formation; locality 8, 1485–1520 feet above base of formation.

Discussion. It is of considerable interest to note that the pygidium of this species, when only a little over 1 millimeter in length, possesses a bilobed posterior outline which is gradually lost during the successive moults in favor of an evenly curved and eventually an angular outline. During this process the relative length of the pygidium increases.

The hypostome may indicate a close relationship with *Trigoncerca typica,* n. gen. and sp., for both have similar middle bodies and maculae, a posterior notch, and postero-lateral wings with straight, convergent postero-lateral edges which are homologous. Were it not for the occurrence of pygidia of *Kirkella* stratigraphically below *T. typica,* one might visualize the development of the *Kirkella*-type hypostome from it by the expansion of the antero-lateral edges of the wings.

The purpose of the ventral ridges of the doublure of the free cheeks appears to be a means of "locking" the edges of the pygidium in place during enrollment. Such structures have been discussed by Siegfried (1936), and Whittington's illustrations (1948, pl. 83, figs. 1, 3, 6) indicate the mechanical feasibility of this interpretation. Siegfried also proposed that the Panderian openings probably had an excretory or reproductive function and that the knobs, hoods, and similar structures commonly allied to them served as "stops" to prevent over-slipping of segments during enrollment. Accordingly the "hood" of the opening on the free cheek in *Kirkella* must have "stopped" the first thoracic segment, and the hood of each succeeding segment have "stopped" the segment behind it. The subparial flanges housed only the edges of the pygidium; Whittington's figures 4 and 6, plate 83 (1948) show that the anterior corners of the pygidium are about even with the posterior ends of the eyes during the enrollment of *K. vigilans.* The corners would then coincide with the posterior ends of the flanges. Similar features are present in *Lachnostoma latucelsum* Ross, n. gen. and sp. (below).

Kirkella sp.

Plate 26, figs. 14, 18

DESCRIPTION. This species is represented by two pygidia, neither perfectly preserved. One of these attains a length of more than 10 millimeters. Although the larger of the two is deformed rather strongly it is evident that neither possesses the distinctly angular posterior outline of *K. declevita* and that the postero-lateral angles are located slightly farther forward. In the larger specimen, which is decorticated, eleven axial rings can be made out plus an articulating half-ring. This number agrees with that found by Whittington in *K. vigilans* (1948, p. 570), although the axial segments are not as well separated in his specimen. The number also agrees with that found in the smallest pygidium of *K. declevita* (pl. 21, fig. 1), suggesting that the total number of pygidial segments remained constant during growth.

FIGURED SPECIMENS. Y.P.M. No. 18329, 18330.

DISCUSSION. The possible significance of these two specimens has been discussed under *K. declevita.*

OCCURRENCE. Zone uncertain. Locality 8, 915 feet above base of Garden City formation; locality 13, 500 feet above base of formation.

Genus *Lachnostoma* Ross, n. gen.

(bearded mouth)

DESCRIPTION. Cephalon semicircular in outline exclusive of genal spines and surrounded on front and sides by flattened rim; rim wide at midline and narrowing progressively to rear. Low, evenly rounded glabella, sub-clavate in outline, and unfurrowed, with a median pustule between posterior ends of small, asymmetrically rounded and reflexed palpebral lobes. No cranidial brim, since dorsal furrows and marginal furrow are confluent around front of glabella. Anterior facial sutures diverge strongly, cross marginal furrow, and turn sharply inward to run along dorsal surface of rim to midline without attaining cephalic edge; here they are met by median suture separating right and left free cheeks (pl. 23, fig. 6). Posterior sutures delimit slender postero-lateral limbs, terminating them halfway between dorsal furrows and genal angles. Ocular platforms of free cheeks steep and evenly convex. Doublures exceptionally wide and possessing Panderian opening and a pair of ridges that cross doublure diagonally from a point on cephalic margin opposite juncture of marginal furrow and facial suture toward proximal side of base of genal spine (pl. 22, figs. 3, 6–8).

Hypostome possesses sub-ovoid middle body, undivided by transverse middle furrow, but equipped with prominent maculae and deep pre-macular pits. Anterior wings broadly triangular and flexed sharply dorsad. Posterior wings unusual in possession of sharply pointed antero-lateral and postero-proximal angles with acutely pointed spike protruding postero-laterally in between. Anterior (sutural) margin gently curved to fit an identically curved cut-away portion in back edge of doublure (pl. 23, fig. 6). Posterior deeply notched, and surface ornamented with fine, more or less concentric Bertillon markings.

Thorax not known. Semicircular pygidium strongly convex; axis sub-semicylindrical, tapering slightly, and only a little shorter than pygidial length. Discrete, pleural platforms completely separated by axis and bounded from flattened rim by sharp break in slope. Doublure wide (pl. 23, fig. 5).

GENOTYPE. *Lachnostoma latucelsum* Ross, n. sp.

DISCUSSION. Many asaphid genera resemble this genus in the general cephalic and pygidial features. There are several species in the Garden City beds alone, of which *"Xenostegium" taurus* (Walcott) might be cited as an example, that have very similar cranidial characteristics; these all differ in one way or another, usually in the possession of glabellar pits. For many of these neither the hypostome nor the free cheeks are known; there are probably many more which have never had the cephalic doublure studied at all. Eventually a great many may prove to be congeneric with *Lachnostoma* on the grounds that similar or identical hypostomes are discovered for them and that they are found to bear the same ridges on the doublure at the sides of the cephalon.

These two features are, as far as this author has been able to ascertain to date, unequalled in any other trilobite. Neither the pygidium nor any other feature can be considered particularly diagnostic for this genus, for all have their counterparts in other forms.

Lachnostoma latucelsum Ross, n. sp.

Plate 21, figs. 13–25; Plate 22, figs. 3, 6–8; Plate 23, figs. 5, 6

DESCRIPTION. Cranidium expanded in frontal outline. Clavate glabella widest halfway between bluntly rounded anterior end and fronts of palpebral lobes. Between palpebral lobes glabella constricted and very slightly wider at posterior end. Median pustule between rear ends of palpebral lobes. Rim exceptionally wide and very slightly convex. Fixed cheeks almost entirely constituted by relatively small, asymmetrically rounded palpebral lobes. Basal length of lobes approximately one-quarter glabellar length; in dorsal view they appear to slant backward; proximal dorsal sides of lobes reflexed at about 50 degrees from horizontal, distal tips being level. Postero-lateral limbs very slender. Anterior facial sutures diverge strongly at an angle of 35 degrees relative to axial line. The two sutures meet at angle slightly less than 140 degrees at axial line without reaching leading edge of rim.

Free cheeks characterized by short, high, steeply sloping ocular platforms (pl. 21, fig. 19). Eyes small and rotund. Toward rear, marginal furrow becomes progressively shallower and approaches closer to cephalic edge, which it attains a short distance in front of base of genal spine. As a result rim pinches out posteriorly against outside of spine. On dorsal surface of spine carinate ridge arises quite abruptly from postero-lateral corner of ocular platform to run length of spine. Doublure remarkable in several respects, among the more obvious of which is great width (pl. 22, figs. 3, 6–8); along axial line it extends to front of glabella, even though posterior edge is cut away slightly to receive hypostome (pl. 23, fig. 6). Beneath ocular platform its edge is approximately halfway between "knife-edge" margin of cephalon and outer side of eye. From point on line between eye-center and genal angle edge of doublure curves posteriorly inward to tip of postero-lateral limb; along back side of cranidium its width becomes half that of limbs. Most noteworthy of all features of cheeks is presence on each of two sharply carinate ridges with deep groove between them on doublure (pl. 22, figs. 3, 6–8). The stronger of two ridges has forward inception at edge of cephalon almost opposite junction of facial suture and dorsal marginal furrow. From here it runs backward, crossing underside of rim on gentle diagonal toward inner side of base of genal spine. Close to base of spine its height decreases abruptly, but ridge continues faintly out along ventral side of spine. Since a similar dorsal ridge exists on spine, spine itself possesses a somewhat diamond-shaped cross-section. Inner of two ridges parallels outer, but is considerably shorter. Anterior end arises from line of flexure on doublure which corresponds to dorsal marginal furrow. Posterior end located almost directly beneath postero-lateral corner of ocular platform; this end, however, sharply rounded in profile, for crest-line turns abruptly inward, upward, and slightly forward (pl. 22, figs. 3, 6–8). Opening of Panderian organ located postero-proximally from end of ridge. No "hood" or boss on any specimen found to date.

Hypostome characterized by peculiar "bearded" appearance of posterior wings, from which generic name is derived. Middle body roughly semiovoid with strongly developed maculae; although surface is deeply creased immediately in front of each macula, middle furrow is not carried across central portion of body. Lateral rims produced into large posterior wings on margin of each of which are three more or less angular "spines". Wings separated from middle body by confluent lateral and posterior furrows, latter fading appreciably at axial line. Anterior angles of wings constitute greatest width of hypostome. Distinct break in slope sets off middle body from anterior wings, which are very strong and flexed sharply dorsad along lines diverging anteriorly at 45 degrees from axis. Fine Bertillon markings arranged in a roughly concentric pattern and interrupted to no marked degree by furrows or maculae.

It is evident from a small free cheek to which a hypostome was fitted and glued in place (pl. 23, fig. 6) that the dorsal edges of the anterior wings must lie beneath the dorsal furrows, almost as far back as the palpebral lobes. This same arrangement is shown in *Bellefontia* (pl. 23, fig. 4) and in *Kirkella* (pl. 23, fig. 3).

Pygidial axis narrow and slender, its width approximating one-fourth pygidial width and length almost 95 percent of pygidial length. It tapers slightly to rear, ending bluntly; sides delimited by distinct dorsal furrows in immature specimens and by sharp break in slope in those which are more mature. Pleural platforms strongly convex; radius of curvature of their circumference slightly less than length of axis. Rim narrowest behind axis and widest opposite pygidial midpoint. Front of anterior "corners" steeply faceted. Although dorsal surface of test shows no segmentation, it is possible to make out at least five very faint rings on axis in decorticated specimens. Similar number of pleural segments can be distinguished with great difficulty. In immature specimens 2 millimeters in length segmentation is little better defined, but at anterior end one or two segments may be clearly and almost perfectly developed, obviously in preparation for migration into thorax.

HOLOTYPE. Y.P.M. No. 18144.

PARATYPES. Y.P.M. Nos. 18142, 18143, 18145, 18146, 18308–18310, 18358, 18359, 18367–18369.

DISCUSSION. The double ridges of the cephalic doublure deserve special notice. If one or the other of each pair is homologous with those of *Kirkella*, the conclusion must be reached that the inner ridges are those against which the pygidial edges rested during enrollment. It then becomes obvious that the cephalon must be markedly wider than the pygidium. Without special provision there would then be no tight fit between the ventral side of the cephalic extremities and the dorsal surface of the pygidial sides, such as is found in *Kirkella*. The outer ridges, then, appear to provide this tight overlap. The sharp rear ends of the inner ridges must have served as "stops" to prevent the pygidium from sliding too far forward relative to the cephalon. "Hoods" over, or boss-like "stops" adjacent to, the Panderian openings are apparently lacking; overslipping of the first thoracic segment must have been controlled in some other manner than in *Kirkella.*

In his description of *Kirkella vigilans* Whittington (1948, p. 571) noted that its hypostome was unique among asaphids with notched hypostomes, in that the greatest width was on the corners of the posterior wings and still forward of the midpoint, while in other similiar asaphids it is usually on the anterior wings. In *L. latucelsum* the greatest hypostomal width is also between the anterior corners of the posterior wings, but is located well to the rear. As in *Kirkella* the Bertillon ornamentation is roughly concentric over the entire hypostomal surface.

OCCURRENCE. ZONE "J", locality 5, 1225 feet above base of Garden City formation; locality 8, 1485–1520 feet above base of formation; locality 13, 1040–1060 feet above base of formation.

Genus *Bellefontia* Ulrich, 1924

Bellefontia Ulrich, in Walcott, 1924, Smithsonian Misc. Coll., vol. 75, no. 2, p. 54, pl. 10, fig. 1; 1925, Smithsonian Misc. Coll., vol. 75, no. 3, pp. 69–71.

DISCUSSION. This genus is represented in the lower Garden City beds by at least three, and probably four, species. So far all specimens have been taken from Zone "B" and from the upper (transition?) beds of Zone "A".

Present collections have raised some question about the definitive characteristics of the cranidium and pygidium; *B. chamberlaini* Clark (pl. 24, figs. 1–7; pl. 25, figs. 10, 12–15) closely resembles both *B. collieana* (Raymond) (the genotype) and *B. nonius* Walcott, but the new species *B.* ? *acuminiferentis,* n. sp., possesses a much wider cephalic rim and poorer definition of the glabella. In addition it bears a tiny spine, rooted in the pygidial rim directly behind the axis. Because of the associations within numerous thin subzones of Zone "B", it has become fairly evident that the pygidium of *Bellefontia* may or may not possess a terminal spine, that species with narrow-rimmed cranidia may show such a feature (especially in immature animals), and that, when present, the spine is normally more closely allied to the rim than the axis of the pygidium.

Two species, not described here, are of note in this connection. One of these, from locality 6, possesses the cephalic features of *B. chamberlaini;* pygidia under 3 millimeters in length all bear spines which appear to be completely lost at maturity. At the top of Zone "A", locality 7, pygidia associated with cephala similar to those of *B.* ? *acuminiferentis* likewise bear spines which are lost by the time the pygidia have reached a length of 4 millimeters. Contrasted with these two are two other species. *B. chamberlaini,* occurring high in Zone "B", lacks a terminal spine in the smallest examined pygidia (pl. 25, fig. 10); the other slightly older species, with cephalon almost identical with that of *B. chamberlaini,* possesses a marked median indentation giving the pygidial rim a faintly bilobed appearance; no specimens under 3 millimeters in length are available to determine whether a spine was present at all.

It then appears that the mere possession of a terminal spine is not sufficient ground in itself to differentiate this genus from *Xenostegium;* the spine, when present in *Bellefontia,* does not clearly interrupt the marginal furrow and may not persist in adult stages. The fact that some pygidia are spined at maturity, some only in the immature stages, and some not at all suggests that the genus was relatively unstable. Differences in cephala of *B. chamberlaini* and *B. ? acuminiferentis,* especially in regard to width of rim, definition of glabella, width of doublure, and shape of hypostomal suture, may eventually prove to be of generic rank.

Unfortunately all the above inferences are based on associations, no complete carapaces of any of the species being known.

Of particular interest is the method of hypostomal articulation, exemplified by specimens of *B. chamberlaini* Clark (pl. 23, fig. 4). It will be noted that the doublures of the two free cheeks meet along a median suture and that each is cut away to receive one-half the anterior edge of the hypostome. The proximal edge of the doublure is flexed upward so that the anterior tip of each dorsally directed wing of the hypostome is flush with it. The result must have been a fairly rigid juncture of hypostome with free cheeks. It further becomes evident that the anterior tips of the hypostomal wings fit beneath the junction of the dorsal and marginal furrows of the cranidium, that the front of the hypostome coincides closely with the front of the glabella, and that the dorsal edges of the hypostomal wings were probably connected by a muscular sheet to the undersides of the dorsal furrows as far back as the palpebral lobes.

Bellefontia chamberlaini Clark

Plate 24, figs. 1–7; Plate 25, figs. 10–15; Plate 22, figs. 1, 2; Plate 23, fig. 4

Description. Since Clark's single cranidial specimen of this species was crushed, it may be well to call attention to several features better shown in the present collections. Glabella slopes steeply at front and on sides anterior to palpebral lobes. Rim at midline only one-tenth as wide as glabella is long. Anterior facial sutures diverge from axial line at 45 degrees. Marginal furrow shallow on free cheeks, curving toward back end of eye well within genal angle. Doublure as wide as rim, cut in markedly at hypostomal suture. Associated hypostomes illustrated in figures 1–3, plate 26. See also plate 23, figure 4.

Additions to Clark's (1935, p. 245) original description of the pygidium of this species pertain mostly to the immature forms. It should be noted, however, that the definition of the axis, even in decorticated specimens, is not as clear as in *B. nonius* Walcott, or *B. collieana* (Raymond), nor does the axis possess the peculiar pinched taper of these two species, except in the immature stages (fig. 14, pl. 25). In some non-decorticated silicified specimens it is practically impossible to distinguish any segmentation at all.

Immature specimens have a triangular outline in the pleural platforms which are separated from the wide, flat rim by a distinct break in slope rather than by a marginal furrow. The axis, which in most trilobites shows clear segmentation in the immature stages, even though it does not in the adults, is almost devoid of rings, except at the anterior end where it is quite clear that segments are about to be shed forward into the thorax (figs. 10, 14, pl. 25). The two immature pygidia illustrated show the knob-like tip of the axis, typical of other species of the genus, although the larger specimens do not.

Figured specimens. Y.P.M. Nos. 18161, 18165, 18166, 18229–18232, 18311, 18331, 18341, 18342, 18371–18374.

Discussion. One of the most interesting features of this species is shown on a single decorticated cranidium, 30 millimeters in length (pl. 22, figs. 1, 2). Immediately in front of the faint occipital furrow there is a tranverse, very obtusely V-shaped ridge with the apex forward; from this apex a narrow median ridge runs anteriorly until it fades out well ahead of the palpebral lobes. Between the V-shaped ridge and the median pustule is a small diamond-shaped, raised area, from the acute ends of which an irregular ridge runs laterally toward the base of each palpebral lobe. Between the lobes on either side of the median ridge are two more transverse, roughly diamond-shaped, raised patches, the right one of which is split by a furrow. Forward of these there are on each side four irregular raised lines, which appear to radiate from a point on the side of the glabella near the posterior apex of the brim.

There can be little question that these raised features represent points of muscle attachment; from back to front of the glabella there are four of these features on each side of the midline, no two alike, but all probably equivalent to the basic four pairs of glabellar furrows of more primitive trilobites. It will be noted that this pattern is considerably different from that described by Sinclair in *Illaenus* (1947, pp. 529–536, pl. I). It is markedly similar to the pattern shown in an incomplete specimen tentatively assigned to *Xenostegium* (pl. 24, fig. 13).

Occurrence. Zone "B", locality 7, 130–140 feet above base of Garden City formation; locality 5, 86 feet above base; locality 11, 125 feet above base; locality 8, 135 feet above base of formation.

Bellefontia ? *acuminiferentis* Ross, n. sp.

Plate 24, figs. 15–18; Plate 25, figs. 6–9

Description. Cephalon semicircular in outline, very slightly convex, surrounded by wide, flattened rim, possessing stout, slightly curving genal spines. Cranidium depressed, with poorly defined glabella; rim obtusely pointed in front. Glabella apparently no wider in front of, than between, palpebral lobes. Doublure of free cheeks equal in width to rim. Marginal furrow in free cheeks sharply curved, but never approaching close to genal angle.

Pygidium typically that of *Bellefontia* except for possession of very slender median spine, projecting from edge of rim, not connected with axis. Axis segmented clearly at anterior end, but rings do not show at rear unless specimens are decorticated. Tip of axis lacks knob-like shape of *B. collieana* (Raymond), and decorticated specimens do not show quite the same tapering axial outline found in *B. nonius* Walcott.

One of several immature pygidia is figured (pl. 25, fig. 6) to show resemblance with equally small specimens of *Xenostegium franklinense* Ross, n. sp., and also to show that the two can be distinguished even at this small stage by clear separation of terminal spine from axis by marginal furrow in *B.* ? *acuminiferentis.*

Holotype. Y.P.M. No. 18347 (pygidium).

Paratypes. Y.P.M. Nos. (pygidia) 18320, 18348; (cephalic parts) 18157, 18163, 18338, 18339, 18370.

Discussion. Although several large cranidia of this species have been secured all are badly deformed by crushing, a fact possibly attributable to their lack of convexity and resulting structural weakness. Despite this all indicate that the glabella is not expanded anteriorly, and all have the characteristic wide rims of the species.

In all features except the terminal spine the pygidium of this species is closest to that of *B. chamberlaini* Clark in the adult stages; the resemblance to the equally immature stages of that species is nowhere near as good. In general this species' pygidium is not unlike that of *Xenostegium douglasense* Walcott or *X.* ? *paradouglasense* Kobayashi, but in neither of those is the terminal spine so clearly unrelated to the tip of the axis.

The assignment of this species to *Bellefontia* is tentative. The great width of the cephalic rim and doublure and poor definition of glabella differentiate it from all other known species. Although holaspid pygidia are similar to those of *Bellefontia* the immature stages resemble *Xenostegium* more closely. It must be noted furthermore that cephala and pygidia are assigned to the same species by association and only by association.

OCCURRENCE. Zone "B", locality 7, 140 feet above base of Garden City formation; locality 1, 40 feet above apparent base.

Genus *Xenostegium* Walcott, 1924

Xenostegium Walcott, 1924, Smithsonian Misc. Coll., vol. 75, no. 2, p. 60; 1925, Smithsonian Misc. Coll., vol. 75, no. 3, p. 124.

DISCUSSION. On the basis of Walcott's original description (1924, p. 60) *Xenostegium* is characterized by its spined pygidium. In 1925 Walcott (p. 124) amplified his description to include the cranidium and changed the genotype from *X. goniocerum* (Meek) to *X. belemnurum* (White), apparently realizing at that time that these two species are not synonymous. To date no complete specimen of any species of the genus has been found, and it is impossible to be certain that the cranidia described by Walcott are actually assignable to the genus.

Kobayashi (1934, pp. 557–558) noted that the pygidia of only three of Walcott's 1925 species should be allied with the genotype since the posterior end of the axis in all the others either is not swollen or is defined by the dorsal furrows clear around the tip; the four species Kobayashi would retain in *Xenostegium* are *X. belemnurum, X. schofieldi, X. shephardi,* and *X. kirki.* He further stated that the pointed shape of the rim of the cranidia assigned by Walcott to *X. taurus, X.* ? *sulcatum,* and *X.* ? *eudocia* was incompatible with that assigned to *X. belemnurum.*

With the exclusion of the last three this author agrees, feeling that "*X.*" *taurus* may be more closely related to such genera as *Ptychopyge* and *Pseudasaphus,* and that "*X.*" *eudocia* may be tentatively reassigned to *Asaphellus* (below). The former is represented in the Garden City beds low in Zone "G" at localities 5 and 6, the latter appearing in the same zone, but collected only at locality 6. With neither has a triangular pygidium in any way resembling that of *Xenostegium* been discovered during this study, although Walcott's illustrations do show such an association in the case of "*X.*" *taurus* (1925, pl. 24, fig. 1).

The specimen on which Walcott based his *X.* ? *sulcatum* (U.S.N.M. No. 70359) is in reality a deformed cranidium of his "*X.*" ? *eudocia,* the "peculiar indentation into the front of the glabella" (1925, p. 128) actually being caused by crushing in an identical manner with that shown by one of the Garden City specimens in figure 27, plate 27; the two are, therefore, synonymous. It should be noted in passing that this species was collected by Walcott from his locality 55z, stated to be in the St. Charles formation; records in the U.S. National Museum indicate that this locality was actually in loose float, and there can now be little doubt that the specimens were originally derived from the overlying Garden City formation.

It is quite obvious that more than one genus has developed a pygidium similar to that of *Xenostegium;* this is clearly shown in the new genus *Trigonocerca* Ross, the description of which is presented on pages which follow. That there is an equally good chance of development of such a pygidium from one that is semicircular within a single genus is evidenced by the European genus *Megalaspis,* in which the variety of pygidial outline is amazing. It is, therefore, possible that the Lower Canadian genus *Xenostegium,* based of necessity entirely on the characters of the pygidium, is no more than a group of species of the genus *Bellefontia.*

This possibility is strongly suggested by cranidia which Walcott assigned to *X. kirki* (1925, p. 127, pl. 24, fig. 18) and to *X. douglasense* (1925, p. 125, pl. 24, fig. 22), both of which are practically indistinguishable from those of *Bellefontia,* especially in their deformed state. Walcott's figured cranidium of the genotype, *X. belemnurum* (1925, pl. 24, fig. 3), is actually broken at the antero-lateral corners and has clearly lost most of the palpebral lobes; the specimen is of little value for purposes of comparison.

From Zone "B" of the Garden City beds comes some evidence which may be of considerable importance. Here two species of *Bellefontia,* described above, are found associated with one of *Xenostegium,* the new species *X. franklinense* (see below). Cranidia and free cheeks of the latter are illustrated in figures 8–14, plate 24. These differ from a typical *Bellefontia,* such as *B. chamberlaini* (pl. 24, figs. 1–7) in the angle of divergence of the anterior facial sutures, wider cranidial rim, more posterior position of the palpebral lobes, length and shape of the genal spine, behavior of the marginal furrow at the genal angle, and shape of the doublure at the hypostomal suture. These cephalic parts are always found associated with pygidia of *X. franklinense* (pl. 25, figs. 1–6) and vice versa; neither has ever been found without the other, although a conscious effort has been made over three field seasons to cast doubt on the association. Although representatives of *Bellefontia* are found throughout Zone "B", including those with a spined pygidium, *X. franklinense* appears to be limited to the upper part of the zone.

No free cheeks have been reported for any previously described species of *Xenostegium* and no well preserved cranidia. Without corroborative evidence it is impossible to be certain that the apparently distinctive features of the cephalon, noted above, have generic value; after three years of intermittent deliberation, I, personally, am convinced that they probably do.

That *Xenostegium* is closely related to *Bellefontia* is evident, especially since the associated hypostomes, although differing in small details (pl. 26, figs. 1–4), are basically the same. The possession of pygidial spines, which are lost or almost completely lost during growth, in immature forms of at least two species of *Bellefontia* (above), may indicate an unstable "experimental" tendency, which resulted in the divergence of *Xenostegium* from a *Bellefontia* stock. Neotenic pygidial development, in which the immature forms of the ancestor "predict" the adult form of the descendant, is well illustrated in *Protopliomerops* (discussed on subsequent pages) and probably applies in this instance equally well.

For lack of better knowledge the genus *Xenostegium* is here restricted to asaphid-type species with *Bellefontia*-like cranidia, free cheeks like those of *X. franklinense,* n. sp., and triangular pygidium with terminal spine; the spine is stout and is based at the tip of the axis, thereby interrupting the marginal furrow. There is no clear demarcation between the axis and spine and the dorsal furrows appear to turn laterally into the marginal furrow on either side. The axis is distinctly defined by the dorsal furrows and shows faint segmentation anteriorly;

the latter is shown much more clearly in immature specimens and in adults which are decorticated, as is the holotype of the genotype (Walcott, 1925, pl. 24, fig. 4). The pleural platforms are moderately convex and are segmented in a manner equivalent to the axis. The rim is wide and almost flat, narrowing slightly toward the posterior midline; it is set off by a break in slope and very shallow marginal furrow, which in decorticated specimens is distinct.

DISCUSSION. Having examined Walcott's type specimens, this author agrees almost entirely with Kobayashi in his restriction of the genus (1934, p. 557). It is now certain that Walcott's original hypodigm includes at least three genera and possibly more. The disposition of *X. taurus* and *X.* ? *eudocia* is as yet indefinite, other than that they should be excluded from *Xenostegium,* simply because adequate specimens have not been secured to date. The new genus *Trigonocerca* has been erected to include the new species *T. typica* Ross, *X. goniocerum* (Meek), *X. euclides* Walcott, and *Symphysurina* ? *entella* Walcott. This new genus can be differentiated from *Xenostegium* in that the terminal spine is separated from the pygidial axis by a slight break in slope, the dorsal furrows do not diverge posteriorly, and the segmentation of the pygidium is faintly shown by minutely narrow, raised, smooth lines, showing only in decorticated specimens (see pl. 26, figs. 5 and 7).

At present it is my opinion that two genera have considerable stratigraphic significance. As yet I have found no species definitely assignable to *Xenostegium* above Zone "B" in the Garden City beds; on the other hand *Trigonocerca typica* is actually the basis for Zone "H", high in the formation.

Xenostegium franklinense Ross, n. sp.

Plate 24, figs. 8–14; Plate 25, figs. 1–6

DESCRIPTION. Cephalon sub-semicircular to sub-trapezoidal in outline, margin of each free cheek being almost straight from point opposite intersection of marginal furrow and facial suture to point one-third length of genal spine from its base. Genal spines long, slender, and curved posteriorly in their distal halves. Cranidium slightly narrower than that of *Bellefontia chamberlaini* immediately anterior to palpebral lobes. Rim distinctly wider. Relative to its own length, width of glabella, both between palpebral lobes and at anterior end, less than in *Bellefontia.* Free cheeks readily differentiated from any assigned to *Bellefontia* on basis of great length of genal spines; in addition, note that marginal furrow very nearly reaches edge of cheek within genal angle (compare figs. 12 and 2, pl. 24) and that distally, posterior edge of cheek curves sharply forward.

Pygidium broadly sub-triangular in outline. Length, exclusive of terminal spine, little more than one-half total width. Spine strong and sharp, one-half as long as remainder of pygidium in specimens in which main body of pygidium is approximately 30 millimeters in length. Spine longer in very small specimens. Axis well defined by dorsal furrows which appear to turn sharply outward into marginal furrow at posterior end; it is practically impossible to distinguish where axis ends and terminal spine begins. First two or three segments easily made out on axis and pleural platforms, but increasingly obscure to rear; this is true of all pygidia down to those which are only 3 millimeters in width. In specimens from 3 to 20 millimeters in width there is little, if any, change in general outline, other than in length of spine. Pleural platforms moderately convex, set off from wide, flattened rim, by well-developed marginal furrow, which in larger non-decorticated specimens may be evidenced by sharp break in slope. Furrow interrupted by base of terminal spine. Doublure equals rim in width, ventral surface closely paralleling that of rim; doublure continues in even curve beneath base of spine, not cut away beneath it.

HOLOTYPE. Y.P.M. No. 18159.

PARATYPES. Y.P.M. Nos. (cephalic parts) 18162, 18158, 18233, 18335–18337, 18319; (pygidia) 18160, 18343, 18345, 18346.

DISCUSSION. Two incomplete cranidia are assigned to this species with reservation. One is only the front portion (pl. 24, fig. 14); although this specimen has a rim which might be considered wide enough to place it in *B.* ? *acuminiferentis* the sides of the glabella are much better defined than in any known specimen of that species. The second specimen (pl. 24, fig. 13) is assigned with some confidence because of the information gleaned from the complementary mold not figured here; this specimen is figured to show the pattern of appendicular muscle attachment, which agrees closely with that of *B. chamberlaini* but differs in the anterior pair of patches, where there are three pairs of sub-parallel raised lines rather than four narrowly radiating pairs.

Apparent relative narrowness of specimen in figure 1, plate 25, not natural; it has been slightly buckled in lateral direction.

With the exception of *X. kirki* Walcott the pygidia of all previously described species of this genus are relatively narrower than those of *X. franklinense;* this is especially true of *X. shephardi* Raymond. Critical comparison with *X. kirki* is hindered by the fact that none of Walcott's figured specimens is undeformed; all are decorticated and strength of segmentation is therefore not comparable. It is quite possible that the two are synonymous.

OCCURRENCE. Zone "B", locality 7, 140 feet above base of Garden City formation; in talus at locality 11.

"Xenostegium" taurus (Walcott)

Plate 27, figs. 6, 7, 11

The questionable assignment of this species to *Xenostegium* has already been adequately covered under the discussion of that genus. It should be noted, however, that this is one of the cranidia with which Walcott found *"Xenostegium"*-type pygidia associated. For this reason it is indeed strange that no such pygidia were found associated in the Garden City beds; those which were found are illustrated on plate 30, figures 23, 26, and 27.

The cranidium of the species is characterized by the wide anterior limb, long midlength of the flat, unrimmed brim, erect, ogival palpebral lobes, anteriorly expanding, low glabella on which there is one pair of pits between the palpebral lobes in place of furrows and a median pustule, and rather slender postero-lateral limbs.

It is easily distinguished from cranidia assigned to *Macropyge* by greater anterior width of the cranidium, and shape and attitude of the palpebral lobes. From both *Asaphellus* ? *eudocia* (Walcott) and *Asaphellus* ? sp. A it is distinguished by these two same features plus the lack of cranidial rim.

The cranidium bears a marked resemblance to that of *Lachnostoma latucelsum* Ross, n. gen. and sp.; the latter, however, lacks glabellar pits or furrows, an occipital furrow, and posterior marginal furrows on the postero-lateral limbs. Its limbs are much narrower and its palpebral lobes a different shape. (See pl. 21, figs. 16, 22, 23.)

Unfortunately no free cheeks or hypostoma were found associated with the specimens of "*X.*" *taurus* which might give some hint of its relationship within the Asaphid trilobites.

Two associated pygidia are illustrated on plate 30, figures 23, 26, and 27. Since the cranidium is obviously wide-brimmed it seems likely that the second of these two pygidia may be assigned to this species, unless the triangular, heavily spined type characteristic of *Xenostegium* is eventually found associated.

FIGURED SPECIMEN. Y.P.M. No. 18168.

OCCURRENCE. Zone "G(1)", locality 5, 428 feet above base of Garden City formation; locality 6, 480 feet above base of formation.

Genus *Trigonocerca* Ross, n. gen.

(triangular tail)

DESCRIPTION. This genus is erected to include the genotype, *Trigonocerca typica* n. sp., *Symphysurina* ? *entella* Walcott (1925, p. 112, pl. 21, figs. 20–24), *Xenostegium goniocerum* (Meek) (Walcott, 1925, p. 127, pl. 24, figs. 5–8), and *X. euclides* Walcott (1925, p. 126, pl. 24, figs. 13–14). It is characterized by the possession of a subtriangular, smooth-surfaced, seemingly unsegmented pygidium with median spine.

Cephalon semicircular, moderately convex, with slender genal spines. In front of glabella is extremely narrow, flat rim, which fades into ocular platforms on free cheeks. Glabella very low and poorly defined; no dorsal, glabellar, or occipital furrows. Palpebral lobes flat, almost horizontal; anterior facial sutures diverge and then turn inward to become intra-marginal at cephalic midline; right and left sutures meet in very obtuse angle. Short median suture separates right and left free cheeks. Hypostome sub-quadrate in outline, with short anterior wings and with lateral and posterior rims extended into sub-rectangular posterior wings, long postero-lateral dimension of which makes angle of 45 degrees with hypostomal midline.

GENOTYPE. *Trigonocerca typica* Ross, n. sp.

DISCUSSION. This genus is clearly distinguished from *Symphysurina* by the divergent course of the facial suture anterior to the palpebral lobes and by the fact that the terminal spine is based in the rim of the pygidium; in the spined species of *Symphysurina* the spine arises from the tip of the axis with the rim passing evenly below it (pl. 28, figs. 19 and 24; Walcott, 1925, pl. 21, figs. 10, 11).

The cranidium is far different from any of the diverse forms assigned by Walcott to *Xenostegium* (1925, pp. 124–129, pl. 24); the pygidial segments are not defined by impressed, intersegmental grooves, and the dorsal furrows do not diverge posteriorly. Segmentation of the pygidium can, in fact, only be distinguished in decorticated specimens, if at all.

Trigonocerca typica Ross, n. sp.

Plate 26, figs. 5–13

DESCRIPTION. Surface of carapace smooth. Cephalon semicircular, strongly convex in longitudinal profile, and gently convex in anterior profile. Glabella low and indistinctly bounded by slight change in slope rather than by dorsal furrow; it occupies almost entire cranidium, except postero-lateral limbs, palpebral lobes, and very narrow, flat anterior rim. In cranidium 4 millimeters long, rim only 0.25 millimeter wide. Fixed cheek limited to palpebral lobe. Lobes horizontal in small specimens but flexed slightly upward in larger ones. Length of each lobe one-third that of glabella. Posteriorly facial suture curves postero-distally to cut rear edge of cephalon half-way between glabella and base of genal spine.

Opposite eye-centers ocular platform of free cheek a little more than one-third width of glabella when seen from above. Although rim can be distinguished at front it fades into ocular platform at rear. Genal spine very slender and projects directly to rear.

General form of hypostome subquadrate. Anterior wings short and rounded, there being no distinct anterior furrow. Lateral rims extended into sub-rectangular posterior wings, postero-distal edges of which lie at angle of 40 degrees with hypostomal midline; posterior angles of wings give hypostome bluntly forked appearance. Postero-lateral furrow deeply impressed; middle furrow faint across midline. Maculae distinct but small.

Pygidium sub-triangular in outline with slightly curving margins; it possesses a short median spine. Outer surface of test absolutely smooth, but inner surface shows very faint segmentation of pleural lobes and axis (figs. 5, 7, pl. 26). Axis narrowly tapered and gently convex, delineated, like rim, by a break in slope, rather than by dorsal furrows. General outline of pygidium changes with growth as shown in ontogenetic series; see figures 9, 8, 6, and 5 of plate 26 in that order.

Holotype. Y.P.M. No. 18147.

Paratypes. Y.P.M. Nos. 18148, 18149, 18333, 18227, 18228.

Discussion. This species differs from *T. entella* (Walcott) in the relatively larger palpebral lobes and the superior definition of the pygidial axis. From *T. euclides* it is distinguished by the shape of the posterior wings of the hypostome and by the fact that the decorticated type of Walcott's species shows its segmentation to better advantage. It is very nearly impossible to tell this species from *T. goniocerum,* which possesses the same closely spaced, poorly defined segmentation; when the cephalic parts of that species are found and identified, it may be possible to declare them synonymous; the pygidia of *T. typica* appear to be a little wider for their length, but this may merely be a difference in growth stage.

A comparison of the immature pygidia of *T. typica* (pl. 26, figs. 8, 9) with those of *Xenostegium franklinense* Ross, n. sp. (pl. 25, figs. 4–6), leaves little doubt that the two belong to separate genera.

Occurrence. Zone "H", locality 8, 1160–1340 feet above base of Garden City formation; locality 3B, approximately 950 feet above base; locality 5, 940 feet above base. Collections of the 1949 field season indicate that the species is also present 348 feet below the top of the formation at locality 13.

Genus *Leiostegium* Raymond, 1913

Leiostegium manitouense Walcott

Plate 27, fig. 1

Description. Only a single very small cranidium of this species was collected, and it is so poorly preserved that it would be impossible to give more than generic identification were it not for the numerous pygidia. These agree so closely in all proportions with those described and figured by Walcott (1925, p. 104, pl. 23, figs. 16, 17, 19) that there can be little question of their identity with his species.

In outline the pygidium is almost semicircular, its length being about two-thirds the width. In *L. quadratum* (Billings), the genotype, the length is three-quarters the width. The first three segments of the axis are distinct; the more posterior ones are practically indistinguishable.

FIGURED SPECIMEN. Y.P.M. No. 18312.

DISCUSSION. A single crushed cranidium without associated pygidia was also found 630 feet above the base of the formation at locality 8. It is probably assignable to this species also.

OCCURRENCE. Zone "D", locality 5, 145 feet above base of Garden City formation; locality 13, 80 feet above base. Reported by Walcott from the Manitou and Cushina formations (1925, p. 104).

Genus *Basilicus* ? Salter

Basilicus ? sp.

Plate 27, figs. 2–5

DISCUSSION. This species resembles *Asaphellus* ? *eudocia* and *Asaphellus* ? sp. A in the plan of the various features of the cephalon, including the possession of a sub-tubular rim, shape of the palpebral lobes, and a pair of glabellar furrows, which strongly constrict the sides of the glabella. It differs from both these in the possession of a median ridge on the brim and in the more slender postero-lateral limbs. From both "*Xenostegium*" *taurus* and cranidia assigned to *Macropyge gladiator* it differs in their lack of rim on the cranidium.

Unfortunately the species is represented in the collections here reported only by very small, clearly immature specimens; for this reason and because of the lack of hypostome, thoracic segments, and pygidium it is not formally classified. It is obviously not known whether the pre-glabellar median ridge is lost with increasing size, but it is known that the other species which resemble it most closely do not possess such a ridge in specimens of comparably small size. Some other, possibly distantly related forms, such as *Basilicus marginalis* (Hall), possess such a ridge.

FIGURED SPECIMENS. Y.P.M. Nos. 18155, 18156.

OCCURRENCE. Zone "G(2)c" and "G(2)d", locality 6, in interval 560 to 600 feet above base of Garden City formation.

Genus *Niobe* ? Angelin

Niobe ? sp.

Plate 27, figs. 24–26, 31

This species is tentatively assigned to *Niobe*, definite assignment being impossible until hypostome and pygidium are identified. General features of the cranidium agree remarkably well with Angelin's original figures of his genotype.

DESCRIPTION. Cephalon smooth and semicircular in outline, exclusive of genal spines; lacking rim. Glabella sub-cylindrical, bluntly rounded in front, lacking glabellar furrows and occipital furrow. Very shallow, narrow dorsal furrows clearly define sides of glabella and are confluent around its front. Brim slightly concave in lateral profile, extending to margin. Palpebral lobes essentially horizontal, almost symmetrical, sub-semicircular flaps; their length four-tenths that of glabella; lobes located opposite glabellar midpoint. Sub-triangular postero-lateral limbs directed slightly posteriorly. Anteriorly, facial sutures run in evenly rounded curves, diverging and then converging to margin, along which they continue inward to their confluence and to junction with median suture, separating free cheeks. Posteriorly, sutures curve evenly postero-laterally to margin across distinct furrow on limbs. Ocular platforms of free cheeks slightly convex; size and shape of eye not known, but probably very low. Distally, platforms become somewhat concave within margin. Genal spines straight, slender, directed to rear.

FIGURED SPECIMENS. Y.P.M. Nos. 18152–18154 incl.

OCCURRENCE. Zone "G(2)a", locality 6, 525 feet above base of Garden City formation.

Genus *Asaphellus* ? Callaway

Asaphellus ? *eudocia* (Walcott)

Plate 27, figs. 17–23, 27

DESCRIPTION. This species was originally described by Walcott (1925, p. 126, pl. 24, fig. 12) on the basis of a single imperfectly preserved cranidium. It was further assigned by him to the genus *Xenostegium,* in which it can no longer remain, as explained under the discussion of that genus, above. The species is questionably assigned to *Asaphellus* for three reasons. The glabellar outline, although very distinct in small, obviously immature, specimens, is exceedingly weak or indistinguishable in front of the palpebral lobes in all the large fragmentary cranidia. Unforked hypostomes are associated, but not one of the forked variety. Pygidia are only faintly segmented and the posterior end of the axis a little more clearly defined than the anterior portion. Furthermore, the pre-occipital "knobs", which are so prominent on immature cranidia, appear to fade with growth.

To Walcott's description can be added the facts that the facial suture is essentially "Isoteliform", the cephalon is surrounded by a narrow, sub-tubular rim, the palpebral lobes are large, flat, almost horizontal flaps, the postero-lateral limbs are stout, and the cephalic doublure no wider anteriorly than the surrounding rim. The associated pygidia are rounded, subtriangular in outline, with a narrow axis and smoothly curved pleural lobes. Axial rings number at least six. There is no surrounding rim.

FIGURED SPECIMENS. Y.P.M. Nos. 18172–18175 incl.

OCCURRENCE. Zone "G(1)", locality 6, 490 feet above base of Garden City formation.

Asaphellus ? sp. A

Plate 27, figs. 12–16

DISCUSSION. The closest relative of this species is certainly *Asphellus* ? *eudocia* (Walcott), from which it can be distinguished by the less prominent glabella, less prominent lateral "knobs" adjacent to the occipital furrow, somewhat smaller palpebral lobes, and much greater width of the doublure.

Since all the collected specimens are surely immature and since no hypostome has yet been found which can be assigned to it with certainty no attempt is made at final classification.

As is the case with *A.* ? *eudocia,* fragments of more mature cranidia than that illustrated show that definition of the glabella and pre-occipital lobes becomes exceedingly weak with increase in size. In this species the relative size of the palpebral lobes is also greatly reduced with increased growth.

FIGURED SPECIMENS. Y.P.M. Nos. 18170, 18171.

OCCURRENCE. Zone "G(2)c", locality 6, 580 feet above base of Garden City formation.

Asaphellus ? sp. B

Plate 28, figs. 1–3, 6–8, 10

DESCRIPTION. This species is represented by only two cranidia and three free cheeks in the present collections; all are small.

The cranidium is almost featureless, the glabella being defined only at the front and only by a slight break in slope. Glabellar and occipital furrows lacking. Palpebral lobes essentially flat, horizontal flaps. Postero-lateral limbs short. Pygidium similar to immature stages of *Kirkella* but more transversely elliptical.

Lacking thorax, hypostome, and mature specimens, identification remains tentative. Postero-lateral limbs not as stout as normally found in *Asaphellus.* Glabella too faintly defined for *Kirkella,* although this species may represent its forerunners.

FIGURED SPECIMENS. Y.P.M. Nos. 18176–18178 incl.

OCCURRENCE. Zone "G(2)d", locality 6, 660 feet above base of Garden City formation.

Genus *Isoteloides* ? Raymond

Isoteloides ? sp.

Plate 27, figs. 28–30

DISCUSSION. This species is included merely as a matter of record, since it is known only from four very small, obviously immature cranidia, from a single locality. None of the cranidia exceeds 2 millimeters in length.

These cranidia are composed almost entirely of glabella, palpebral lobes, and postero-lateral limbs. There is practically no brim or rim, and the fixed cheeks are limited to the lobes. The surface is smooth. Glabellar and occipital furrows are completely lacking.

These facts plus the course of the facial sutures suggest *Isotelus* or *Isoteloides.* Until future collecting makes the study of additional and larger specimens possible no attempt is made at classification of this form.

FIGURED SPECIMEN. Y.P.M. No. 18151.

OCCURRENCE. Zone "J", locality 8, 1485–1520 feet above base of Garden City formation.

Genus *Asaphelina* ? Munier-Chalmas and Bergeron, 1888

Asaphelina Muniers-Chalmas and Bergeron. Thoral, 1935, Thèses Fac. Sci. Univ. Paris, Ser. A., No. 1541, pp. 218–219.

Asaphelina ? sp.

Plate 36, figs. 1–4.

The definite assignment of this species to *Asaphelina* is hindered by lack of cephalic parts; the pygidium and posterior seven segments of the thorax agree so closely with those of *A. barroisi,* the genotype (Thoral, 1935, p. 219), that there seems little room for doubt as to its congenerity. Unfortunately the Garden City species is known only from one single specimen, not enough to form the basis of a specific description.

Description. Seven segments remain in the thorax of the specimen. It appears probable that the first (anterior) segment was removed along with the cephalon. Axial lobe approximately three-tenths as wide as thorax, somewhat wider than in genotype (compare pl. 36, figs. 1, 4 with Thoral, 1935, pl. XX, fig. 1). Segments unfurrowed on dorsal surface; approximately distal halves deflexed sharply. Tips very bluntly falcate. On ventral side each pleuron possesses well-developed doublure on which is located a semi-ellipsoidal boss or "stop", clearly to prevent over-slipping of pleural tips. Posterior to each boss lies deep pit for Pander's organ, completely isolated from proximal edge of doublure. Corresponding to line of deflection of pleural tip diagonal groove (pl. 36, fig. 1) crosses ventral side; similar groove found on pygidium at its front edge. Appendifers well-developed along dorsal furrows, showing distinctly as pits in cast of ventral side (pl. 36, fig. 4) and as small bosses immediately inside the furrows on ventral side of carapace itself (pl. 36, figs. 1, 2). These also have articulating function, for a tongue-like extension of dorsal furrow of each segment rests against antero-lateral face of appendiferal boss on segment to rear.

Pygidium strikingly like that of *A. barroisi* (Thoral, 1935, pl. XX, figs. 1, 2; pl. XXI, figs. 3, 4), although axis is hardly defined at all in Utah species. The posterior spines appear to be a little closer together than in the genotype.

Figured specimen. Y.P.M. No. 18383.

Discussion. This species quite clearly differs from the French genotype in the lack of pleural grooves and complete lack of any trace of segmentation on the pygidium. Thoral (1935, p. 223) points out that in some of the largest of the specimens studied by him the pleural grooving is almost obsolete and limited to the vicinity of deflection of the tips. The Garden City specimen is smaller than several figured by Thoral; poorer definition of its grooving cannot be attributed to size difference, for furrowing in asaphid-like trilobites can be shown to become less distinct with an increase in size within a species. Diagonal grooves on the ventral sides of pleura correspond clearly to dorsal ridges bounding postero-proximal sides of pleural facets in *A. barroisi* (Thoral, 1935, pl. XIX, figs. 1–3).

Without knowledge of the cephalic features or of the exact number of thoracic segments it is impossible to be certain of the congenerity of this with the European species. The pygidial similarity is so striking, however, that their close relationship is more than probable.

Occurrence. Locality 9, approximately 375 feet below the top of the Garden City formation, from black, limy shales, containing *Phyllograptus, Tetragraptus,* and *Dictyonema.*

Genus *Licnocephala* Ross, n. gen.

(fan head)

Description. This genus is at present monotypic, being based on the single new species *Licnocephala bicornuta* Ross. It is characterized by almost complete lack of relief, extremely wide, flat rim around the cephalon, greatly expanded, fan-shaped anterior limb of the cranidium, diminutive oval glabella, narrow eyes surmounted by small semicircular palpebral lobes, and the relatively small area of the free cheeks devoted to the ocular platform. The genal spines are strong and falcate, but may not be important generically.

No hypostome or thoracic segments have been found which can be assigned with confidence to the genotype; although the assignment of pygidium is not absolutely certain it is believed to possess low relief, wide flattened rim, and small axis equivalent to corresponding features on the cephalon, as explained in the description of the genotype.

GENOTYPE. *Licnocephala bicornuta* Ross, n. sp.

DISCUSSION. The relationship of this genus to other trilobites is admittedly uncertain; in the great midlength of the brim, wide rim, and small glabella it resembles the two new genera *Amechilus* and *Hypothetica.* In both these, however, the palpebral lobes are narrow and rimmed and are connected with the glabella by faint ocular ridges; in both, the posterior marginal furrow runs outward along the postero-lateral limbs from each side of the glabella, while in this genus it is clearly forward of the limbs on the free cheeks.

Licnocephala bicornuta Ross, n. sp.

Plate 28, figs. 12–14

DESCRIPTION. Cephalon roughly semicircular in outline, excluding very stout genal spines. Cranidium possesses a greatly expanded, fan-shaped anterior limb. Its width at anterior marginal furrow equal to its length; immediately anterior to palpebral lobes width is slightly less than 0.7 length. Glabella very small, its length equaling close to 55 percent of that of cranidium. Glabella low, sharply rounded in frontal outline, and with short occipital ring set off by deep occipital furrow. Glabellar furrows lacking. Midlength of brim 0.5 that of glabella and six-tenths total length of anterior limb, remainder of which is taken up by flat, wide rim. Fixed cheeks wide. Palpebral lobes located far back on cranidium even with glabellar midpoint. Anterior facial sutures diverge in gently curving course to marginal furrow, turn inward to cross rim, and reach anterior cephalic margin before attaining midline; they then run exactly along cephalic edge confluently and are met by ventral median suture, separating right and left free cheeks. Posterior sutures run directly laterad for half distance to lateral edge of cephalon before turning to rear. It should be noted, especially, that suture is everywhere behind posterior end of marginal furrow, so that furrow does not run outward along postero-lateral limbs as in most other trilobites.

Free cheeks as distinctive as cranidium. Eyes low half-circles set on gently sloping ocular platforms. Each platform directly laterad from eye-center comprises one-half width of cheek piece. Marginal furrow running to rear curves very sharply inward from point opposite eye-centers and continues straight to point located tangent to eye and one-third its circumference from posterior end; it then hugs circumference of eye around to its posterior end. Doublure very slightly wider than rim. No indication of attachment of hypostome. Running diagonally postero-laterally across rim from point opposite eye-center there is on every free cheek examined a distinct flexure which defines antero-lateral edge of genal spine (pl. 28, fig. 12); from this line of flexure dorsal surface of spine rises slightly to rear, so that in cross-section it is narrowly triangular. Because of this feature genal spine appears to arise from marginal furrow rather than from outer edge of rim; it is stoutly falcate in outline.

Hypostome, thorax, and pygidium not known.

The pygidium considered to be the mostly likely candidate for assignment to this species is illustrated on plate 30, figure 25. It is semicircular in outline; axis small and low, half as long as and less than two-tenths as wide as pygidium as a whole. Five segments, in axis of which the narrowly rounded terminal one is the longest. Radius of pleural platform equals length of axis; platforms divided into three pairs of curious pleural segments separated by relatively deep inter-pleural grooves. Low rounded ridge forms anterior two-thirds of each segment and extends outward to reach pygidial margin in anterior pair, about halfway across wide, flat rim in second pair, and only as far as boundary of pleural platform in posterior pair. Doublure very wide, extending as far as pleural platforms. Because of its very low relief, narrow, short axis, and extremely wide, flat rim, the assignment of this pygidium to the species is favored.

HOLOTYPE. Y.P.M. No. 18180.

PARATYPES. Y.P.M. No. 18181 (and pygidium, 18213, tentatively).

DISCUSSION. For some time the possibility was seriously considered that the pygidia here assigned to *Macropyge* (pl. 30, figs. 14, 22) might belong to this species; this consideration was based on the belief that thoracic segments lying behind and within the great falcate genal spines would probably have a similar shape; furthermore the structure and Bertillon ornamentation of these genal spines is remarkably similar to the grotesque pygidial spine of *Macropyge*. The cephalon is so different from that of Stubblefield's genus, however, that this assignment is no longer considered probable.

The fact that the posterior portion of the cephalic marginal furrow is entirely forward of the postero-lateral limbs is believed to be most unusual. Exactly how the furrow crosses from the posterior end of the eye to the dorsal furrow on the cranidium is not known, for the critical portion has been broken from every one of the specimens collected. It seems reasonable to believe that the furrow would provide a line of weakness and that the posterior "corners" of the cranidia have failed along it, removing the postero-lateral limbs. A mental or roughly sketched reconstruction of the cephalon indicates that the limbs must have been exceedingly slender.

OCCURRENCE. Zone "G(2)a", locality 5, 500–550 feet above base of Garden City formation; locality 6, 525 feet above base of formation.

Licnocephala ? sp.

Plate 28, figs. 4, 5, 9

This species is represented in the present collection by a half-dozen very small cranidia, all of which appear to have been deformed in an identical manner by lateral squeezing of the anterior end of the glabella.

DESCRIPTION. Shape of cephalon, as a whole, not known. Cranidium smooth-surfaced, possessing a transversely oval anterior limb, well-developed sub-ovoid glabella, and large, semicircular palpebral lobes. None of specimens retains postero-lateral limbs or occipital ring. No glabellar furrows. From front of glabella extends a short ridge which has strong resembance to "pinched-up" crease in brim; this feature may have been caused by lateral compression of all specimens in same manner. Anterior limb divided about equally between brim and wide, flat rim, by faint marginal furrow.

FIGURED SPECIMEN. Y.P.M. No. 18179.

DISCUSSION. Results of some of the 1949 collecting, not yet prepared for formal presentation, indicate that these cranidia are indeed deformed and that the same or a very similar species ranges stratigraphically higher. In the higher occurrences it appears to be associated with free cheeks like those of *L. bicornuta* and with pygidia such as those illustrated in figure 27, plate 30.

OCCURRENCE. Zone "G(2)a", locality 5, 500–550 feet above base of Garden City formation; locality 6, 525 feet above base of formation.

Genus *Amechilus* Ross, n. gen.

(shovel brim)

DESCRIPTION. This genus is based on four small specimens of the single new species, *Amechilus palaora;* at this time it is impossible to be certain of the characteristics which deserve generic rank, but a few are considered of more than specific importance. Most obvious of these is greatly extended, flattened anterior limb, which makes up almost one-half cranidium and is divided into a long, wide brim and a slightly raised flat-topped rim. Glabella of about equal length with anterior limb and about twice as long as wide, being narrowly rounded in front. Small palpebral rims approximately opposite glabellar midpoint; faint eye-lines cross flat fixed cheeks to point close to anterior of glabella, which may bear one pair of glabellar furrows. Postero-lateral limbs bluntly rounded and wider at their tips than proximally. Facial sutures anteriorly run nearly straight forward to marginal "furrow" before turning inward, so that right and left sutures apparently join in an even arc.

Free cheeks, thorax, and pygidium unknown.

GENOTYPE. *Amechilus palaora,* Ross, n. sp.

DISCUSSION. It is unfortunate that all four of the collected specimens of the genotype are so small, a fact which hampers their study. That they are immature seems likely, although the species may never have grown bigger. Because they are almost completely flat it is unlikely that larger specimens would have survived deposition on a shallow sea floor.

Amechilus palaora Ross, n. sp.

(L.: *pala,* spade; *ora,* rim)

Plate 28, fig. 15

DESCRIPTION. Cranidium spatulate in anterior outline. Glabella low, parallel-sided, occupying slightly more than one-half cranidial length. Posterior fifth of glabella set off by distinct occipital furrow as occipital ring; single pair of faint glabellar furrows slightly to rear of glabellar midpoint. Midlength of brim one-quarter cranidial length. Raised rim about one-sixth as wide as cranidium is long. Fixed cheeks less than one-third width of cranidium; palpebral lobes represented only by small, slightly raised rims. Exceedingly faint eye-lines run from anterior tips of palpebral rims to sides of glabella at points even with cranidial midpoint. Anteriorly, facial suture runs forward with gentle lateral convexity, but decreases radius of curvature rapidly after intersecting marginal flexure and crosses rim in a continuously rounded arc with its mate. In the absence of free cheeks it is impossible to tell whether the suture is supra- or intra-marginal. Postero-lateral limbs wider at extremities than proximally because posterior margin of cranidium curves backward distally.

HOLOTYPE. Y.P.M. No. 18182.

DISCUSSION. Only four very small specimens of this species were collected, none over 2 millimeters long. Although they may be immature forms, their characters are so distinctive that the erection of a new species and genus is considered justified. In plan they are suggestive of *Pseudoclelandia lenisora* Ross, n. sp., with which they are associated; it was at first believed that these might be immature forms of that species and that the great changes in the proportions of the brim had taken place during growth. However, the presence of distinct specimens of this latter species of a size much smaller than the largest one of *A. palaora* obviated any such consideration.

A speculation is ventured into the possible relationship of this species with the new and far more unusual form, *Hypothetica rawi* Ross, n. gen. and sp., which is stratigraphically younger and bears resemblances in the glabella, palpebral rims, eye-lines, and postero-lateral limbs; it is conceivable that by the backward migration of the anterior end of the facial suture the brim of *A. palaora* could have evolved into the amazing fan-shape found in *H. rawi*.

OCCURRENCE. Zone "E", locality 5, 313 feet above base of Garden City formation.

Genus *Hypothetica* Ross, n. gen.

DESCRIPTION. This remarkable opisthoparian genus is characterized by the postero-lateral extensions of the sides of the anterior limb to such an extent that they are nearly joined with the postero-lateral limbs at points behind and to the sides of the eyes. Although no free cheeks have been identified, it appears obvious that almost the entire dorsal surface of the roughly semicircular cephalon must have been covered by the cranidium, the dorsal surface of free cheeks probably being little more than slivers connecting the eyes with the cephalic margins at the genal angles.

The glabella is relatively small and sub-cylindrical, occupying about one-half the cranidial length. It is apparently devoid of glabellar furrows, but possesses a well-defined occipital ring. Prominent palpebral rims are connected to the front of the glabella by distinct eye-lines. The midlength of the gently sloping brim is short, but the rim is excessively wide and flat, and both are extended as the postero-lateral "lobes" of the anterior limb. The posterior margin of the cranidium is curved strongly backward in the distal portions. The facial sutures appear to be continuous and intramarginal entirely around the brim.

GENOTYPE. *Hypothetica rawi* Ross, n. sp.

DISCUSSION. The name of the genotype is taken from the superficial resemblance of its cranidial outline to Raw's interpretation of the cranidial development of the Mesonacid head-plan (1925, pl. XV, fig. 5); I do not, however, consider this genus in any way related to the Mesonacidae, but entertain the possibility that it is ancestral to such forms as *Eoharpes*.

Hypothetica rawi Ross, n. sp.

Plate 28, fig. 11

DESCRIPTION. Three specimens, all cranidia less than 2 millimeters long, were secured from Zone "F" of the Garden City beds.

Cranidium one and one-half times as wide as long and nearly semicircular. Two fixed cheeks and glabella each constitute one-third of cranidial width in usual sense.

Anterior limb bizarre, both sides extending backward in sharply rounded lobes nearly touching postero-lateral limbs; eyes and small wedge of free cheek almost isolated within cranidial surface. Brim forms gently sloping skirt at front of glabella which meets wide, flat, semicircular rim at shallow marginal furrow; width of rim three-tenths cranidial length; at points opposite eyes its distal edge constitutes widest part of cranidium.

On fixed cheeks small, raised palpebral rims, located entirely ahead of glabellar midpoint. Each anterior facial suture turns sharply backward toward tip of postero-lateral limb, barely misses its own posterior course, then turns sharply forward to define blunt postero-lateral lobes of anterior limb, and runs completely around edge of rim, being continuous with its counterpart.

Free cheeks, thorax, pygidium, and hypostome unknown.

HOLOTYPE. Y.P.M. No. 18183.

DISCUSSION. Although free cheeks are not known they must have a very unusual shape. Eye undoubtedly rests at tip of a narrow sliver, which contracts distally (toward cephalic margin) between lobe of anterior limb and postero-lateral limb, and then widens out to fill in genal angle. I expect that the first cheeks found will have a flat doublure as wide as the cranidial rim, constituting an arcuate plate; only in a completely articulated cephalon would one anticipate finding the delicate "ocular platform" and eye intact.

Recently Rasetti (1948, pp. 25–29) has discussed the possible origin of certain Cambrian hypoparian trilobites from forms like *Loganopeltoides*, in which the anterior and posterior courses of the facial suture very nearly or actually meet antero-laterally from the eye. It is my belief that the species here described may have evolved into Chazyan and younger Hypoparia, such as *Eoharpes*, by the meeting and eventual elimination of the anterior and posterior courses of the facial suture postero-laterally from the eye. As yet the evidence is far too sketchy to offer more than a speculation.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Symphysurina* Ulrich, 1924

DISCUSSION. There are at least three species of this genus present in the beds of Zones "A" to "C" of the Garden City formation. "S. cf. *woosteri*" (pl. 23, figs. 7–12) occurs in zone "A"; these particular forms do not, however, possess a distinct median pustule on the cranidium. They agree in all other respects with the genotype, except for the pygidium shown in Walcott's figure 9, plate 21 (1925). Other species are represented by too few specimens to warrant specific designation.

It should be noted that the peculiar pitting of the ventral side of the doublure is clearly a generic characteristic not included in the original description. It is not clear to this author how *Symphysurina* differs from *Tsinania* (Walcott, 1914, pp. 43, 227), other than that one is of Ordovician and one of Cambrian age. Unfortunately the ventral side of the doublure of the latter is not known, but may prove to be the distinguishing feature.

In his description of the genotype, S. *woosteri*, Ulrich (in Walcott, 1925, p. 115) stated that the nine pits of the doublure were "for the reception of the ends of the thoracic segments", presumably during enrollment. It takes only a moment's thought to realize that this is mechanically impossible; each segment "shingles" over the segment to its rear, the posterior segment's pleura lying outside the facets of the pygidium. Presuming that enrollment in *Symphysurina*, like that in other trilobites, placed the bottom of the pygidium in coincidence with the bottom of the cephalon, the tips of the pleura could not have been contained under the pygidium in order to fit in the cephalic pits (pl. 23, fig. 12).

If, on the other hand, the pygidium was narrower and shorter than the cephalon and fitted within the pitted portion of the doublure during enrollment, the "shingled-over" pleura would have been required to cover the surface of the pygidium almost entirely in order to have the tips fit into the pits. To perform this feat of emplacement the posterior segment, for instance, would have had to have in plan a sharp V-shape, and its pleura would have been required to extend about one and one-half times as far laterally from the dorsal furrows as the anterior width of the pleural platforms of the pygidium. To date no such peculiar segments have been found associated.

Symphysurina sp. A

Plate 28, figs. 29, 31–36

DESCRIPTION. Surface pseudo-punctate. Cranidium a little more convex than that of *S. woosteri*, the genotype; outline parallel-sided in front of palpebral lobes and gently rounded along front. Length very little less than width at palpebral lobes, but one and one-quarter times width anterior to lobes. Glabella bounded laterally for almost its entire length by a shallow "dorsal furrow" on each side in decorticated specimens. Widest extension of palpebral lobes located very slightly posterior to median pustule on glabella. Length of lobes little more than one-fourth cranidial length. Behind palpebral lobes each suture runs postero-laterally at an angle of 30 degrees from axial line to cut off short, triangular postero-lateral limbs.

Associated and tentatively assigned free cheek bears large inflated eye and is about three-fourths as wide as long; in plan lateral edge sharply rounded, lacking genal spine. Ocular platform diminishes in width from front to rear within shallow marginal furrow. Thickened rim increases in width posteriorly until it equals ocular platform directly laterad to eye; then diminishes again to rear.

Hypostome, thorax, and pygidium not known.

FIGURED SPECIMENS. Y.P.M. Nos. 18315, 18316, 18190.

DISCUSSION. Although the pygidium of this species is not certainly known a single silicified pygidium (pl. 26, fig. 17) and several fragmentary cranidia were originally secured from the beds immediately below Zone "B" at locality 7. The cranidia could not be distinguished from those described here. The pygidium is practically featureless, it being barely possible to make out a raised axial portion comprising one-half the total length and approximately one-third the width. This small specimen is twice as wide as long, is evenly convex, and shows no segmentation or differentiated rim.

Three species of this genus have been described possessing rounded free cheeks; these are *S. illaenoides* (Billings), *S. eugenia* Walcott, and *S. elegans* Poulsen. The first of these has never been figured in full to show more than the pygidium; the second is figured so poorly that it is difficult to make comparisons (Walcott, 1925, pl. 21, figs. 25–29, 31); the third does not possess the thickened rim on the free cheeks or as wide fixed cheeks as this species.

Subsequent collecting at locality 7 during the 1949 season has revealed forms apparently conspecific with S. sp. A; these were located above S. cf. S. *woosteri* but below the typical Zone "B" fauna. Associated pygidia are practically smooth, evenly convex, and semicircular in outline. The axis is distinguishable only in decorticated specimens. In addition the later collections have revealed several specimens of apparently identical, but silicified, free cheeks well within Zone "B"; only two small, poorly preserved cranidia have been found associated with these, however.

Occurrence. Zone "A", localities 1 and 5, 35 feet above base of Garden City formation. May range higher into Zone "B" based on collections from locality 7.

Symphysurina sp. B

Plate 28, figs. 19, 23, 24, 30

Description. General dimensions of cranidium almost identical with those of *Symphysurina* sp. A, but considerably less convex. "Dorsal furrows" cut across bases of palpebral lobes and practically touch facial suture in front of lobes. Median pustule on glabella located behind glabellar midpoint, one-third of length from posterior edge of cranidium.

Characters of free cheeks, hypostome, and thorax not known.

Pygidium almost two and one-half times as wide as long, excluding long median spine projecting from end of faintly defined axis. Surface absolutely smooth, lacking furrows on axis or pleural platform. Rim continuous under and unaffected by base of spine.

Figured specimens. Y.P.M. Nos. 18313, 18314, 18188.

Discussion. This species is close to S. *spicata* Ulrich (Walcott, 1925, p. 113, pl. 21, figs. 12–18) but the cranidium of that species appears to be narrower; although the dorsal surface of the pygidium is smooth and unfurrowed in both species, there is no more than a faint suggestion of segmentation of the axis on the ventral side of the test in S. sp. B., while Ulrich's species clearly shows axial rings and one pair of grooves on the pleural platform in decorticated specimens.

Occurrence. Zone "C", locality 5, 140 feet above base of Garden City formation.

Genus *Clelandia* Cossman, 1902

Harrisia Cleland, Bulletin of American Paleontology, vol. 3, Bull. 13, 1900, p. 225 (127).
Clelandia Cossman, Revue Critique de Paléozoologie, vol. 6, 1902, p. 52 (*Harrisia* pre-occupied).

Description. This genus includes trilobites with small, subtriangular cranidia, completely enclosed on the sides and in front by wide, steeply sloping free cheeks; the cheeks are not separated, but form a continuous yoke around the front of the cephalon. The glabella is short and sub-conical. There are no palpebral lobes, and the eyes are minute. Both the cephalon and the pygidium are strongly convex, the latter possessing a well-defined, semi-conical axis, pleural platforms which are bent sharply downward in the distal half, and a narrow, slightly thickened rim.

The only previously assigned species is the genotype, C. *parabola* (Cleland), from the Tribes Hill formation of New York. Raymond (1937, pl. I, fig. 25) has figured a specimen from the same formation showing a large occipital spine, a feature which had apparently been broken from Cleland's type material. The specimen from the Oneota dolomite figured by Powell in 1935 (pl. 13, fig. 8) as a pygidium of *Hystricurus oneotensis* is almost certainly a cephalon of *Clelandia* (Palmer, personal communication).

The cranidium of this genus bears a close resemblance to that of *Westonaspis* Rasetti (1945, pp. 474–475, pl. 62, figs. 16–17; 1946, p. 546, pl. 1, figs. 14–16), from the Levis and Gorge formations. Rasetti's genus differs in the possession of three distinct pairs of glabellar furrows and palpebral lobes, although the latter are exceptionally small. If it is found that his genus has the same type of free cheeks, it is probably the ancestor or one of the ancestors of *Clelandia.*

Clelandia utahensis Ross, n. sp.

Plate 29, figs. 1–4, 6–9

Description. Cephalon almost a quarter-sphere in shape, smooth and lacking rim or marginal furrow. Cranidium bluntly triangular in outline, moderately convex. Length three-fourths greatest width, which is slightly forward of marginal furrow on postero-lateral limbs. Width between eyes approximately 0.8 times length. Surface smooth, ornamented with fine Bertillon markings. Glabella subconical, depressed, and evenly rounded in anterior profile, without glabellar furrows. Occipital ring defined by faint, occipital furrow, extending laterally across dorsal furrow as posterior marginal furrow. Short occipital spine projecting backward at a low angle. Brim, fixed cheeks, and postero-lateral limbs slightly convex, surrounding glabella as gently deflexed band. Facial suture continuous around front of cranidium; even with anterior end of glabella, right and left sutures converge to indicate position of eyes, then flare outward to rear. Rear margin of cranidium curved gently backward on each side to give postero-lateral limbs a bluntly falcate appearance. Free cheeks connected by continuous semitubular band, forming both anterior cephalic margin and doublure. Eyes exceptionally small, almost obsolete. Ocular platforms smooth and sharply deflexed; width increases to rear. Genal spines short, sharp studs.

Pygidium semicircular in outline. Semi-conical axis with three segments. Pleural platforms set off from axis by narrow dorsal furrow, almost horizontal in proximal halves, and nearly vertical in distal halves. No marginal furrow. Rim continuous and very slightly thickened. First three pairs of pleural lobes separated by distinct inter-pleural furrows which extend to rim; fourth pair indistinct. Shallow grooves visible on anterior pair of pleura. Articulating half-ring extended laterally along leading edges of first pair of pleura.

Hypostome not known.

Holotype. Y.P.M. No. 18192.

Paratypes. Y.P.M. Nos. 18193–18196.

Discussion. This species differs from *C. parabola* (Cleland) in its longer brim, wider fixed cheeks, and more convex pygidium. Cleland's holotype possesses one pair of slight depressions on the glabella which may be glabellar furrows or the result of deformation.

Although the cheek illustrated in plate 29, figures 8 and 9, is not complete, the yoking margin is almost entire; ample material is present in the collections to prove that the cheeks are indeed all one piece, but most of these are slightly deformed or rather coarsely silicified.

Occurrence. Zone "B", locality 6, 85 feet above base of Garden City formation; locality 5, 86 feet above base of formation; locality 7, 140 feet above base of formation; locality 1, 40 feet above base.

Genus *Pseudoclelandia* Ross, new genus

(fake *Clelandia*)

There is no evidence for the relationship of *Pseudoclelandia* with *Clelandia* Cossman, the name being applied as a warning against possible identification with that genus because of a superficial resemblance in cranidial outline and shape of the glabella.

DESCRIPTION. Cephalon semicircular, moderately to strongly convex; surface pustulose. Cranidium broadly rounded in front, nearly parallel-sided anterior to eyes, and broadening rapidly behind eyes. Glabella sub-conical, sharply rounded in front. No glabellar furrows, but a deep occipital furrow sets off at least rear quarter of glabella as occipital ring. Deep dorsal furrow continuous in front and may be connected with marginal furrow by median furrow, which divides convex brim into right and left halves. Midlength and convexity of brim vary between species; they vary almost as much within a single species. Fixed cheeks are about one-fourth as wide as cranidium; immediately adjacent to eyes bent very slightly upward; in only one of species described here, *P. lenisora,* is there any sign of a palpebral lobe, a minute rim bounded distally by a tiny furrow. Anterior facial suture curves only slightly inward; before reaching marginal furrow it decreases radius of curvature; almost immediately after crossing furrow suture becomes intramarginal.

Free cheeks have been secured only for genotype, *P. cornupsittaca.* These evenly rounded in outline, steeply sloping, and possessing minute genal spine close to facial suture. Eye extremely small, appearing as little more than slight thickening in angle between anterior and posterior limbs of facial suture. Cheeks appear to be separated by median suture, unlike *Clelandia.*

Hypostome, thorax, and pygidium unknown.

GENOTYPE. *Pseudoclelandia cornupsittaca* Ross, n. sp.

DISCUSSION. The genus is distinguished from *Clelandia* in the possession of discrete free cheeks and well-developed cranidial rim.

At first glance only the first two of the three species, *P. lenisora, P. fluxafissura,* and *P. cornupsittaca,* appear congeneric. The last two occur in the same stratigraphic zone, slightly above *P. lenisora,* and between them have been found several intermediate specimens. Unfortunately the collections are too small to be sure that the two species completely intergrade or that they are completely separate. At present it is believed that an evolutionary sequence is represented by these three, running from *P. lenisora* to *P. fluxafissura* to *P. cornupsittaca.* In this series the length of the glabella relative to the cranidial length changes very little, but the glabellar width increases progressively; similarly the rim widens (meaning that the midlength of the brim shortens). The backward curvature of the posterior margin near the ends of the postero-lateral limbs also increases. Lastly it should be noted that *P. lenisora* shows no preglabellar median furrow, but its inception is suggested by a faint, narrow median swelling on the under side of the test. In *P. fluxafissura* the furrow is present but faint, while in the genotype it is deep. The zone from which these last two were collected is almost 40 feet thick; when more detailed work is undertaken it will be possible to ascertain whether they are actually separated stratigraphically.

In general aspect the cranidium of this genus is very similar to that of *Westonaspis* Rasetti (1945, p. 475, pl. 62, figs. 16, 17; 1946, p. 546, pl. 1, figs. 14–16) from which it may well have been descended. In Rasetti's genus the glabellar furrows are retained, but in such respects as the minute size of palpebral lobes, shape of brim, glabella, and postero-lateral limbs, and relative convexity the two genera compare very closely.

Pseudoclelandia cornupsittaca Ross, n. sp.

Plate 29, figs. 11, 12, 13, 16, 19

Description. Cephalon nearly a quarter-sphere in general shape; posterior margin bent backward at lateral extremities which are tipped by minute genal spines. Glabella semi-conical, two-thirds as long as cranidium; width at occipital ring little greater than length. Dorsal furrow very deep, connected by equally deep median furrow with anterior marginal furrow. Brim and fixed cheeks markedly convex, especially so adjacent to dorsal furrow. Midlength of brim little more than one-tenth cranidial length. Rim thick, wider at cranidial midline than on either side. Adjacent to eyes fixed cheeks flexed very slightly upward. No palpebral lobe or rim. In most specimens facial suture crosses rim diagonally and at midline forms obtuse infra-marginal point with its mate, thus giving rim appearance of very blunt parrot's beak. Behind eyes suture makes broad, even, antero-distally convex curve to posterior margin, almost immediately within genal spine.

Free cheeks steep-sided with minute eyes. Marginal furrow becomes increasingly indistinct posteriorly; doublure as wide as rim.

Thorax, pygidium, and hypostome unknown.

Holotype. Y.P.M. No. 18199.

Paratype. Y.P.M. No. 18200.

Discussion. This species is differentiated from *P. fluxafissura,* n. sp., by the beak-like shape of the anterior cranidial rim, the deep median preglabellar furrow, relatively wider glabella, and wider anterior rim. It was at first believed that *P. fluxafissura* merely represented the immature stages of *P. cornupsittaca,* because there was a considerable size difference in the earliest discovered specimens; although additional specimens obviated this possibility, there still remain several intergrading forms. One or two possess facial sutures which are continuous across the front of the rim as in *P. fluxafissura* without producing a "beak", while two specimens of the latter have the wide rim of *P. cornupsittaca.* For this reason this species is believed to be derived from, or at least very closely related to, *P. fluxafissura,* which is obviously congeneric with the slightly older *P. lenisora.*

It should be noted that *P. cornupsittaca* bears a strong resemblance to *Liostracinoides vermontanus* Raymond (1937, p. 1092, pl. 1, fig. 20) from the lower Gorge formation. Raymond's species differs in the much narrower glabella, far more slender postero-lateral limbs, a flat, evenly curved rim, and lack of pustules. Comparison has been made with the only known specimen of this species, which is also the genotype of *Liostracinoides.* In the Garden City collection there are eleven cranidia and two free cheeks of *P. cornupsittaca.*

Occurrence. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Pseudoclelandia fluxafissura Ross, n. sp.

Plate 29, figs. 14, 17, 18

Description. Cranidium evenly rounded in anterior outline. Glabella similar to that of *P. cornupsittaca* in size and shape. Dorsal furrow shallow and connects with marginal furrow by very narrow, shallow median furrow. Brim and fixed cheeks only slightly convex. Midlength of brim almost one-fifth cranidial length. Marginal furrow very shallow and almost imperceptible on some specimens, setting off narrow rim. Fixed cheeks similar to *P. cornupsittaca.* Facial suture intra-marginal and continuous from right to left under anterior rim. Posterior to eye its course similar to, but more angular than, that in *P. cornupsittaca,* cutting off bluntly ended, less falcate postero-lateral limb.

Free cheeks, thorax, hypostome, and pygidium unknown.

HOLOTYPE. Y.P.M. No. 18198.

DISCUSSION. Comparison with *P. cornupsittaca* has been covered under the discussion of that species and in the description above. *P. lenisora* is differentiated by its much narrower glabella, lack of pre-glabellar median furrow on dorsal surface of test, presence of minute palpebral rims, and much more slender postero-lateral limbs. Furthermore, the facial suture in front of the eyes breaks its course noticeably in the change from a supra- to intra-marginal condition in the older species.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Pseudoclelandia lenisora Ross, n. sp.

(L.: *lenis,* gentle; *ora,* rim)

Plate 29, figs. 5, 10, 15

DESCRIPTION. Glabella narrow, depressed sub-conical, occupying about 0.7 cranidial length. Dorsal furrow distinct; in one of six collected cranidia exceedingly faint pre-glabellar median furrow can be made out on brim, but on others its position only partly indicated by faint ridge on under side of test close to dorsal furrow. Rim obscurely defined by faint marginal furrow. Midlength of brim about one-fifth cranidial length. Brim lacking in convexity, lateral profile forming even slope with crest of glabella. Fixed cheeks flattened, bearing minute, raised palpebral rims. Anteriorly, definite break in course of facial suture in transition from supra- to intra-marginal condition. Posteriorly, suture runs laterad before turning sharply to rear to define bluntly tipped, slender postero-lateral limbs.

Free cheeks, hypostome, thorax, and pygidium not known.

HOLOTYPE. Y.P.M. No. 18197.

DISCUSSION. Most of the diagnostics of this species have been covered under the descriptions of the genus and the two preceding species; an additional means of differentiation is the slightly more posterior position of the eyes.

OCCURRENCE. Zone "E", locality 5, 313 feet above base of Garden City formation, associated with a fauna which occurs 210–240 feet above base at locality 6.

Undetermined Genus and Species C

Plate 29, figs. 20, 21, 24

DISCUSSION. This species is known only from a single cranidium in the present collection; the author has identified it also in material collected by Duncan presumably from the same stratigraphic zone in Blacksmith Fork (Princeton University collections).

The pygidia associated with this cranidium are illustrated on plate 30, figures

23, 26, and 27. If narrowness of rim can be correlated between the cranidium and pygidium, that shown in figures 23 and 26 is the more likely candidate for assignment.

FIGURED SPECIMEN. Y.P.M. No. 18201.

OCCURRENCE. Zone "G(1)", locality 5, 428 feet above base of Garden City formation.

Genus *Platycolpus* ? Raymond

Platycolpus ? sp.

Plate 29, figs. 22, 23, 25–34; Plate 30, figs. 12, 13, 16

DESCRIPTION. This species is characterized by the almost quarter-spherical shape of cephalon and pygidium, well-developed glabella defined in front as well as on sides by dorsal furrows and lacking all but occipital furrow. Genal angles rounded. Cephalic rim sub-tubular, wide, defined by marginal furrow which fades toward genal angles. Brim discrete from glabella and rim. Cephalic doublure narrow in front, very wide between genal angles and eyes; Panderian organs similar to those of *Illaenus esmarkii* (see Siegfried, 1936, text fig. 7). Palpebral lobes large.

FIGURED SPECIMENS. Y.P.M. Nos. 18202–18205 incl., 18223.

DISCUSSION. This species resembles those of *Platycolpus* to some extent in the shape of glabella, shape and size of palpebral lobes, shape of postero-lateral limbs, cranidial rim, and pygidium, and possession of a tubercle on the occipital ring (Rasetti, 1944, pl. 39, figs. 7–16). It almost certainly is not congeneric, however, for the brim is far more extensive, the eyes placed further to the rear, and the fixed cheeks wider. The pygidial axis is much more poorly defined.

The features of the cranidium, especially the glabella, palpebral lobes, and rim, distinguish this species generically from *Bumastus, Nileus,* and *Illaenus,* each one of which it resembles to some extent. These features, plus the absence of pits in the cephalic doublure and the presence of Panderian "slits", differentiate it from *Symphysurina.* There is little doubt that the species represents a new genus.

A feature of some interest appears on the glabella of one specimen (Y.P.M. No. 18203, pl. 29, fig. 31); along the midline there is a very faint, smooth ridge, from which four pairs of curving, bilateral branches run down the sides of the glabella. Each of these curves with convex side forward. They branch from points located 15 percent, 25 percent, 50 percent, and 70 percent of the glabellar length from the anterior end. These are certainly appendicular muscle scars, with the occipital ring, constituting the five basic segments of the glabella.

OCCURRENCE. Zone "G(2)a", locality 5, 500–600 feet above base of Garden City formation; locality 6, 525 feet above base of formation. At locality 7 the species is associated with *Psalikilus* ? sp. as well as with *Psalikilus typicum* Ross, n. sp.; here its relative stratigraphic position is uncertain, since the beds from which it was taken are clearly within a displaced fault-block; it is therefore placed in the tentative Zone "G(2)b" at this locality.

Undetermined Genus and Species B

Plate 28, figs. 16, 20, 25–28

DISCUSSION. This species is represented in the present collection by few specimens, none of which is well preserved, and all of which are cranidia. These are characterized by a pronounced convexity, almost complete lack of definition of the glabella, a well-developed, sub-tubular anterior rim, short and broadly triangular postero-lateral limbs, and extremely narrow palpebral lobes.

From *Platycolpus* ? sp. this species differs in the shape and small size of palpebral lobes and in the more broadly triangular and shorter postero-lateral limbs. Were it not for the anterior definition of the glabella it might be assigned to *Symphysurus*.

Figured specimens. Y.P.M. Nos. 18184, 18185.

Occurrence. Zone "F", 305–340 feet above base of Garden City formation.

Genus *Macropyge* Stubblefield

Macropyge gladiator Ross, n. sp.

Plate 30, figs. 14, 22; Plate 27, figs. 8–10

Description. Pygidium composed almost entirely of a sharp stout telson; anterior one-quarter separated by a slight constriction to form axis proper. No axial segmentation visible in largest specimens. Faint suture runs length of telson on dorsal side with Bertillon markings placed diagonally on either side. Pleural lobes variable depending on size of specimen; in larger forms lobes inconspicuous, flattened, narrowly triangular "skirts", without interpleural grooves.

Thorax composed of at least eight segments, pleura of which are clearly grooved and more or less falcate; axis appears to consume somewhat less than one-third total thoracic width.

Asaphid-type cranidium tentatively assigned to this species illustrated on plate 27, figures 8–10.

Holotype. Y.P.M. No. 18132.

Paratypes. Y.P.M. Nos. 18131, 18169.

Discussion. The pygidia and one specimen showing the apparently complete but obscurely preserved thorax agree very closely in details with those described and figured by Stubblefield (1927, pp. 140–143, pl. 4, figs. 13, 14). Even the faint median line along the telson is present with Bertillon markings making the same postero-laterally directed chevron pattern on the dorsal surface. There are the same number of thoracic segments, eight, becoming more falcate toward the rear; the axial portion of the thorax is equally narrow.

In none of the specimens is it possible to differentiate the pygidial axial segments as clearly nor is the axis itself as well defined as in *M. chermi* Stubblefield (1927, pl. 4, fig. 14). Although the pleural lobes appear wider in the specimen (Y.P.M. No. 18131) illustrated in plate 30, figure 14, than in the British species, in others they are equally narrow. This difference is clearly related to ontogenetic stage. With decrease in size of pygidia, not only are the pleural lobes marked by an increasing number of interpleural grooves but the pleura themselves are sharply pointed and falcate, as are those of the mature thorax. Pygidia 3 millimeters long possess four pairs of pleural spines while those 2 millimeters in total length have six pairs. The greatest number so far counted is seven pairs. On pygidia only 1 millimeter in length these pleura are so small and undeveloped that the border apparently lacks serration, and the pygidium has about the same outline as that of a mature *Xenostegium*.

Dr. Stubblefield has very kindly examined specimens of three associated cranidia and has suggested (personal communication) congenerity with *M.*

chermi of the kind illustrated in figures 8–10, plate 27, remarking on the presence in both of pre-occipital "pseudo-basal" lobes, similar course of the anterior facial suture in nearly attaining the dorsal furrow in front of the eye, and similar very oblique course across the front of the cephalic brim. One difference cannot be reconciled, for *M. chermi* possesses three pairs of glabellar furrows, while this species shows only two. The palpebral lobes of *M. gladiator* are relatively smaller and the postero-lateral limbs more stout. Dr. Stubblefield has also called my attention to the genus *Lichapyge* Callaway (1877, pp. 667–668, pl. XXIV, fig. 8). The pygidium of this genus (like that of *M. chermi,* from the Shineton shales) is similar to the holaspid minus two stage of *M. gladiator* except for the very much shorter and narrower telson. Callaway's original specimen is only about 3 millimeters in total length, the axis alone being one-half as long. It is of considerable interest that pygidia of *M. gladiator* in which the axis is of the same length also show two falcate pleural spines. The fact that *Macropyge* maintains a long telson throughout its development eliminates the possibility that *Lichapyge* is congeneric, but the two may be closely related.

Providing that the cranidial assignment is correct the Utah species appears to be related to the Asaphid-type trilobites. In general the cranidium bears some resemblance to those of *Ptychopyge* and *Pseudasaphus* as well as to "*Xenostegium*" *taurus* (Walcott) (pl. 27, figs. 6, 7, 11). None of the associated hypostomes is of the forked type, however.

OCCURRENCE. Zones "G(2)a", locality 5, 527 feet above base of Garden City formation; locality 6, 525 feet above base. Collections made during the 1949 field season, on which study is not complete, indicate that the genus, if not this species, ranges through 50–75 feet of younger strata, extending its probable time range at least through zone "G(2)b".

Genus *Dimeropygiella* Ross, n. gen.

DESCRIPTION. This genus is monotypic to date, being based on the new species *Dimeropygiella caudanodosa* Ross, which so closely resembles species of *Dimeropyge* Öpik (Sinclair, 1946, pp. 854–855, 859–860) that the Garden City form is believed to represent its progenitors.

In both genera the cephalon is strongly convex, semicircular in outline, and pustulose. Both possess sub-tubular cephalic rims, steeply deflexed brims, and palpebral lobes composed of no more than raised rims. In both the facial sutures anterior to the palpebral lobes turn inward from the marginal furrow, run diagonally inward and downward on the rim, and meet at an angle on the leading edge. The pygidia of both genera possess pleural platforms which are horizontal in their proximal two-thirds, but are flexed sharply ventrad distally; along the line of flexure the pleural segments bear accentuated pustules (pl. 35, figs. 25, 26; Öpik, 1937, Taf. XII, figs. 1, 2).

There are several respects in which the Garden City species differs from those described by Öpik and Sinclair, however. Its cranidial brim is split into two halves, since the marginal and dorsal furrows are tangent in front of the glabella; in *Dimeropyge* the brim is fully developed. In *Dimeropyge* the fixed cheeks are somewhat wider and exceptionally convex, especially in the genotype, while in *Dimeropygiella* no convexity is evident. Although the pygidia of the two genera are similar in outline, that of the new genus possesses five distinct axial and pleural segments, two more than are present in Öpik's. Furthermore the pleural ribs lack the peculiar sub-triangular portions found at the front of each segment near the line of flexure in *Dimeropyge*.

Genotype. *Dimeropygiella caudanodosa* Ross, n. sp.

Discussion. Since *Dimeropyge* has been reported only from beds of Middle Ordovician age in North America, the occurrence of this new, but certainly closely related genus in Zone "J", close to and below what this author considers to be the boundary between the Lower and Middle Ordovician in Utah, is of considerable interest. It joins the several other genera from this zone which seem to be transitional from "typically" Early to Middle Ordovician in age.

Dimeropygiella caudanodosa Ross, n. sp.

Plate 35, figs. 18, 22–28

Description. Cephalon strongly convex, dominated by rotund glabella, surrounded by well-developed sub-tubular rim and marginal furrow, and possessing a coarsely pustulose surface. Glabella sub-ellipsoidal in shape, lacking glabellar furrows, creased by deep occipital furrow. Glabella highest at midpoint. Dorsal furrows deep, tangent to marginal furrow. Portion of rim on cranidium broadly triangular in outline and strongly convex, having "beaked" aspect in lateral view. Fixed cheeks narrow, sloping sharply downward forward from and behind palpebral lobes; portion of cheeks exclusive of palpebral lobes bears longitudinal row of strong pustules on each side of cranidium, which runs along dorsal furrow from anterior marginal furrow back to posterior marginal furrow on postero-lateral limbs. This row of pustules undoubtedly carried backward along entire length of animal on each side of axis, for it is represented by a single pustule on posterior rim of cranidium and by most proximal of pustules on each of pleura of pygidium. One-half of fixed cheeks, not taken up by row of pustules, belongs to narrow, reflexed palpebral lobes. Lobes slightly thickened and gently arcuate, set off by deep, almost straight palpebral furrows; each lobe composed entirely of palpebral rim on which are three or four tiny pustules. Postero-lateral limbs bluntly triangular, strongly deflexed laterally. Anterior facial sutures converge slightly until halfway to marginal furrow, then converge sharply to run straight across marginal furrow and dorsal side of rim to dorsal side of base of large forward-directed pustule on leading edge of rim. From base of this pustule each suture then runs downward and inward across leading edge of rim to reach midline on rim's ventral side. The fact that the suture passes around the dorsal side of the pustule gives the lateral view of the rim of the cranidium its "beaked" appearance (pl. 35, fig. 18). Posterior facial sutures diverge at almost 40 degrees from axial line as seen in dorsal view, cross posterior marginal furrow, then turn straight to rear to delimit blunt tips of postero-lateral limbs.

Free cheeks almost quarter-circles in outline. Genal spines little more than strong pustules, located immediately distad to facial sutures. Eyes large and bulbous, lacking infra-ocular rings. Ocular platforms slightly convex and strongly deflexed, separated from strongly developed rim by deep marginal furrow. Rim considerably wider at rear than at front of each cheek; although pustulose on dorsal surface, ornamented with concentric ridges and grooves on ventral side. At anterior end, adjacent to facial suture, each cheek bears prominent pustule on leading edge of rim. Toward this pustule lines of ornamentation on ventral side of rim are gathered (pl. 35, fig. 24).

Hypostome and thorax unknown.

Pygidium roughly semicircular in outline, possessing well-defined, tapering, moderately convex axis of five segments. At tip of axis is a pair of very strong pustules or knobs. Five pairs of pleural segments, differentiated by deep inter-pleural grooves. Rim not sub-tubular, but entire and uncut by inter-pleural grooves. Along crest of each pygidial segment, on both axis and pleural platforms, is a row of pustules.

HOLOTYPE. Y.P.M. No. 18217.

PARATYPES. Y.P.M. Nos. 18218–18220 incl.

DISCUSSION. This species differs from *Dimeropyge* in the greater number of pygidial segments, shorter midlength of brim, more nasute rim, narrower and less convex fixed cheeks, and almost complete lack of genal spines. The glabella is more inflated than in any of the species described by Sinclair (1946) and in this respect is identical with the genotype of *Dimeropyge* (*D. minuta,* see Öpik, 1937, Taf. II, figs. 3–5). With the Scandinavian species it shares the row of strong pustules along the fixed cheeks and palpebral lobes limited to nearly straight, short thickened palpebral rims.

OCCURRENCE. Zone "J", locality 8, 1485–1520 feet above base of Garden City formation; locality 13, 1030–1060 feet above base.

PROPARIAN TRILOBITES

Öpik (1937) and Prantl and Pribyl (1947) have attempted to revise the Proparia on the basis of characters of the palpebral lobes, ocular ridges, and thoracic segments. On the basis of the present study it is my opinion that these features are indeed of special importance. It is, however, obvious from the material prepared to date that complete ontogenies of each of the proparian species described here can be worked out in the near future. Enough information may then be available to draw some lasting conclusions on the relationships of these forms.

It is already clear that at least two major divisions of the Proparia are represented in the Garden City beds. The first of these is represented by *Kawina* Barton, a genus which Öpik (1937, pp. 89–90) places in the Cyrtometopinae. The second division is represented by *Protopliomerops* Kobayashi; the classification of this form has to date been indefinite, mainly because the thoracic segments, hypostome, and critical features of the cranidium have been inadequately described. In my opinion *Protopliomerops* is probably a forerunner of such forms as *Cybele sensu stricto,* the phylogenetic line passing through the new genus *Pseudocybele,* described below.

Genus *Pilekia* ? Barton

Pilekia ? sp.

Plate 35, figs. 8, 9, 10

DESCRIPTION. This species is known from a single small cranidium, which is not complete and is only 1.8 millimeters in length. This cranidium compares favorably with the genotype of *Pilekia* Barton in outline, including rounded postero-lateral angles, in shape of glabella, location of highest point on glabella, number and orientation of glabellar furrows, and apparent antero-lateral direction of posterior cranidial margin when glabella is held level along its base. The deflexion of the postero-lateral limbs is not as strong as in *P. apollo.*

FIGURED SPECIMEN. Y.P.M. No. 18285.

OCCURRENCE. Zone "E", locality 5, 305 feet above base of Garden City formation.

Undetermined Genus and Species D

Plate 35, figs. 1, 2

DESCRIPTION. This species is known from numerous very small cranidia, none of which exceeds 1.5 millimeters in length. In outline these are roughly semicircular with a stout occipital spine projecting backward almost horizontally.

The glabella is semicylindrical and at the occipital ring about one-third as wide as the cranidium; it appears to reach or very nearly reach the anterior margin of the cranidium. From the specimens on hand it is not certain whether an anterior rim is developed or not on the cranidium. There is no clear indication of glabellar furrows, but the occipital furrow is well developed, as are the posterior marginal furrows. Although no palpebral lobes or ocular ridges are apparent, the course of the facial suture indicates that the eyes were probably located opposite a point on the midline one-third the cranidial length from the anterior end.

FIGURED SPECIMEN. Y.P.M. No. 18283.

DISCUSSION. The species is figured and mentioned here merely as a matter of record. Since it was collected from Zone "B" it is the oldest proparian discovered in the Garden City beds. The specimens secured may represent immature stages of a larger form which will be discovered in the future.

OCCURRENCE. Zone "B", locality 6, 85 feet above base of Garden City formation.

Undetermined Genus and Species E

Plate 35, figs. 3–5

DISCUSSION. As in the case of *Pilekia* ? sp., above, this species is known from a single, poorly preserved cranidium only 3 millimeters in length. Unfortunately the anterior cranidial rim and part of the anterior lobe of the glabella have been broken off, removing some of the critical features of the palpebral lobes and ocular ridges.

It serves, however, to show that more than one sub-division of the proparian trilobites is present in Zone "F". It clearly cannot be included in the same group with *Protopliomerops* and may belong to Öpik's sub-family Cyrtometopinae; lacking any knowledge of the thorax or pygidium, a definite assignment becomes impossible.

FIGURED SPECIMEN. Y.P.M. No. 18284.

OCCURRENCE. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Genus *Kawina* Barton, 1915

Kawina Barton, 1915, Washington University Studies (St. Louis), ser. 4, vol. 3, pt. I, No. 1, pp. 101–151.

DISCUSSION. In his description of this genus Barton (1915, pp. 117–118) stated that the posterior limbs of the facial sutures cut the margin at the genal angles or even slightly proximal to them. None of the species previously assigned possesses genal spines, the genal "angles" being rounded, as in *Calymene*. In *K. sexapugia* Ross, n. sp., from the upper Garden City beds, there are well-developed spines immediately within the sutures.

Two other features should be added to the generic description, which probably were not visible in the material studied by Barton. The first of these is the peculiar punctation of the free cheeks and thoracic segments. The second is the fact that the marginal furrow intersects the dorsal furrow almost at right angles at the distal end of the anterior glabellar furrow. At this intersection there is, therefore, a very minute pit; this is homologous with the "anterior pit" of Whittington (1941a, p. 21; 1941b, pp. 514–517) and is also found in the several species of *Protopliomerops* described in this report.

A fourth addition to be made to the original generic description concerns the pygidium. In the original figures of the genotype, *Kawina vulcanus* (Billings), an incomplete, associated pygidium was illustrated (Billings, 1865, p. 284, fig. 271 a, b, c.); neither Raymond (1905, pp. 367–369) nor Barton (1915, p. 117) considered the association strong enough evidence to include this pygidium in the specific description of the genotype. We can now confirm it beyond question on the basis of almost identical pygidia always associated with the cranidia of *K. sexapugia* in the Garden City beds (fig. 13, pl. 35). The outline of the axis is very nearly an equilateral triangle, composed of the articulating half-ring, three well-defined segments, and an indistinct, flattened, triangular terminal segment; the three pairs of pleura are flattened, dagger-shaped, and point postero-distally at from 30 degrees in the anterior pair to less than 10 degrees at the posterior pair.

The genus has been reported to date only from beds of Chazyan age and in the Cow Head breccia. Its association in the Garden City beds at locality 6 with *Kirkella declevita* Ross, n. sp., in the lower half of the Cherty member, plus the fact that the lowest occurrence of *Anomalorthis* is in the upper half of the Cherty member, indicate that *Kawina's* range should probably be extended downward into the uppermost Canadian, at least in the West, from where it may have been a migrant into northeastern North America.

Kawina sexapugia Ross, n. sp.

Plate 35, figs. 6, 7, 11–17, 19–21

Description. Entire surface granulose or very finely pustulose; puncti clearly discernible on free cheeks, on axial portion of thorax, and in two rows running laterally along thoracic pleura. Cephalon strongly convex and apparently semicircular in outline, excluding genal spines. Cranidium somewhat triangular in outline with slender genal spines based immediately within posterior ends of facial sutures; glabella inflated, steep-sided, and sharply rounded along crest line. In lateral profile front end barely overhangs anterior rim, but there is no marked swelling or crest immediately anterior to occipital furrow as in *K. vulcanus* or *K. billingsi.* Anterior pair of glabellar furrows slant a little forward of vertical in lateral view, middle pair curves very slightly backward, and third curves more strongly backward in a very open "S", so that proximal ends are directed toward midline. Dorsal furrows converge anteriorly before confluently defining rounded frontal outline of glabella. Fixed cheeks narrowly triangular and deflexed in front of and behind extremely narrow palpebral rims. Rims lie entirely forward of glabella midpoint, are less than one-fifth as long as glabella, and are bounded on proximal side by tiny furrow. Absolutely no ocular ridge. Anterior to rims facial sutures run straight across marginal furrow and dorsal side of cephalic rim, converging slightly, at margin turning sharply inward along front of margin as epistomal or rostral suture. From single specimen of free cheek it appears that doublure of cheek does not extend inward past imaginary anterior extension of dorsal furrow, but is cut on each side by a short longitudinal furrow. This indicates that doublures of two cheeks are separated by a short, wide, nearly horizontal epistomal plate. This is corroborated when hypostome is fitted into place with anterior wing condyles under anterior pits; space between hypostome and front edge of rim then requires intervention of such a plate. Posterior to eyes facial sutures run postero-laterally to genal angles, crossing lateral portion of marginal furrow about halfway between eyes and angles.

Hypostome granulated like dorsal surface of carapace, subcircular in outline. Middle body strongly convex with short posterior lobe, set off by a shallow middle furrow; at midline posterior lobe comprises between 10 and 15 percent of length of entire middle body. No maculae. Lateral rims extended into long, narrow inconspicuous posterior wings, between which outline is shallowly notched at posterior midpoint. Confluent lateral and posterior furrows deep; anterior furrow distinct but shallow and squeezed out between anterior lobe and front or sutural edge. Anterior wings small and bent sharply dorsad, each bearing sharp boss or condyle on antero-dorsal surface, represented by pit on opposite side.

The only thoracic segment found in the material studied is almost identical with the anterior segment of the pygidium. Axis occupies one-third width and is depressed convex; pleuron flattened, turned sharply to rear in distal half which is complete sheath. Fulcral ridges (see Öpik, 1937, pl. XVIII, (f)) present at mid-width of pleuron, but as in cranidium there are no prolonged ventral appendifers. Articulating half-ring occupies two-fifths of axial length, and posterior doublure turned under axis for half this length.

Axis of pygidium slightly convex and triangular in outline, composed of three distinct segments and small obscure terminal segment. Three pairs of pleura flattened and broadly dagger-shaped.

Unusual punctations appear in ocular platform and rim of free cheek, but without any obvious pattern; similarly they lack any clear arrangement on axis of thoracic segment, but on pleuron are roughly in two rows, one close to anterior edge and one close to posterior edge. Dorsal surface of articulating half-ring granulose, while remainder of axis is smooth. This smoothness carried outward along edges of pleuron, area in between being granulose. Where one of the puncti is located in this granulose portion it is surrounded by a smooth, crater-like rim.

HOLOTYPE. Y.P.M. No. 18289.

PARATYPES. Y.P.M. Nos. 18290–18295 incl.

DISCUSSION. Although this species appears to differ from any previously described in the possession of genal spines, it should be noted that there is a reduction of these spines with growth in all proparian species reported here; this fact is equally well shown in this species (compare figs. 11 and 20, pl. 35). It can be differentiated from *K. vulcanus* and *K. billingsi* not only in the longitudinal profile of the glabella, but also in the course of the proximal ends of the posterior glabellar furrows. The fixed cheeks between the eyes are considerably narrower in *K. chazyensis.*

It may be of interest to note that the bases of the genal spines in immature specimens of *K. sexapugia* are located a considerable distance inside the facial sutures (pl. 35, fig. 17); this may indicate that the spines are moved relatively outward during growth or that the sutures migrate inward.

The possession of a punctate surface on the free cheeks and thoracic segments is indeed unusual. Whether these were the loci of setae it is, of course, impossible to tell. None of the cranidia shows these puncti on the glabella or fixed cheeks, but it should be noted that both the single free cheek and the single partial segment which were secured clearly belong to larger specimens than do any of the collected cranidia. It is possible that larger cranidia might show these features likewise.

OCCURRENCE. Zone "J", locality 8, 1485–1520 feet above base of Garden City formation; locality 13, 1030–1060 feet above base.

Genus *Tesselacauda* Ross, n. gen.

(mosaic tail)

DESCRIPTION. Detailed characteristics of this genus are left to the description of the genotype and only known species, *Tesselacauda depressa* Ross, n. sp., certain features of which are considered to be of generic importance. These are:

The rather unusual pygidium with its flat pleural platforms, divided into four pairs of paddle-shaped pleura by deep, concise grooves or furrows; the diagonal grooving of the first two pairs of pygidial and of all the thoracic pleura with the grooves running antero-laterally; the method of loose thoracic articulation; and the indistinct division between the anterior cranidial rim and the palpebro-ocular ridge (for definition, see under *Protopliomerops,* below).

These features not only serve to distinguish the genus but appear to furnish the basic elements from which such forms as *Protopliomerops* could have evolved. The closest reported relative of this genus is believed to be *Pilekia* Barton (1915), which has pleura grooved in an almost identical manner; in that genus, as shown by *P. apollo* (Billings) (see Raymond, 1913, pl. IV, figs. 1 and 2), the portion of each pleuron posterior to the groove is produced into a long spine. Like *Pilekia, Tesselacauda* possesses five axial segments and four pairs of pleura on the pygidium. In passing, it may be noted that the pygidium of *Pilekia olesnaensis* differs from that of *P. apollo* only very slightly in the shape of the anterior portion of the posterior pair of pleura; why Prantl and Pribyl (1947, Tab. VI, fig. 6) have assigned this species to *Parapilekia* is not clear.

From casts of Billings' and Raymond's type material of *P. apollo* it has been possible to establish the presence of palpebro-ocular ridges in that species. The original specimens are apparently poorly preserved at the anterior ends, and it is not possible to be absolutely certain whether these ridges are a continuation of the cranidial rim or whether they were discrete from the rim. They appear to originate from the dorsal furrow close to its intersection with the anterior glabellar furrows, the distal ends being located opposite the ends of the third pair of glabellar lobes. If the ridges prove in better preserved material to be continuations of the cranidial rim, the close relationship of *Pilekia* with *Tesselacauda* is, in this author's opinion, unquestionable; even if they are discrete from the cranidial rim, the two genera may well be "cousins", for the palpebro-ocular ridges of immature specimens of *Tesselacauda* are separated from the rim by a furrow (pl. 31, fig. 27) which is partially lost with growth (pl. 31, fig. 31).

When describing *Protopliomerops* Kobayashi (1934, p. 570) suggested an evolutionary series from that genus to *Pilekia* with a reduction in the number of pygidial segments. The closeness of *Tesselacauda* to *Pilekia* and the fact that the opposite trend is illustrated by the proparian genera of the Garden City beds, to be discussed below, are against this interpretation. Kobayashi based his sequence on several genera from scattered localities of Europe, North America, and the Orient, having no good stratigraphic sequence to substantiate his proposal.

GENOTYPE. *Tesselacauda depressa* Ross, n. sp.

Tesselacauda depressa Ross, n. sp.

Plate 31, figs. 27–31; Plate 34, figs. 1–4, 18.

DESCRIPTION. Cephalon sub-semicircular in outline, only slightly convex; surface sparsely pustulose, except on fixed cheeks and postero-lateral limbs, which are pseudo-punctate. Glabella low and broadly rectangular, but evenly rounded in frontal outline; orientation of glabellar furrows and size of different lobes as in *Protopliomerops superciliosa* Ross, n. sp. (see below), but in this species lobes are practically flat-topped, so that furrows appear to be cut sharply or "etched" into dorsal surface. This is true of dorsal, marginal, and palpebral furrows on the cranidium, the pleural grooves on the thoracic segments, the interpleural furrows on the pygidium, and the posterior portion of the marginal furrow on the free cheeks. However, a pair of short notches, or incipient furrows, cuts proximal edge of anterior cranidial rim slightly in front of anterior glabellar furrows, which indicate position of anterior pits. Immediately distad to these notches the rim is flexed slightly downward, and if it were not for the distinctness of the other furrows this flexure might pass for a furrow. On adjacent portion of free cheek marginal furrow coincides with this flexure and is equally shallow, but to rear becomes deeply incised. At first glance furrow on cranidium which runs from anterior corner of glabella to facial suture in front of eye appears to be marginal furrow, and the apparent rim appears to be serving also as a palpebro-ocular ridge. Free cheeks show clearly that this is not the case, but that the marginal furrow is in reality the faint flexure distal to the anterior pit. The portion of the *apparent* rim between the anterior pit and the eye is actually the palpebro-ocular ridge, very concisely defined along its posterior edge by a deep furrow, but only faintly defined along the anterior edge by a faint flexure.

In front of eye facial sutures run straight across dorsal surface of rim, converging very slightly, at margin turning inward to points forward of dorsal furrows, from which they run postero-proximally across doublure. Along margin they are joined by a transverse epistomal or rostral suture. From these facts it is obvious that the horizontal doublures of the two free cheeks are separated by a short, wide epistomal or rostral plate. Behind eyes facial sutures run laterad to marginal furrow before curving to rear to cross rim diagonally, well forward from genal angle.

Eye small, situated erectly on narrow ocular platform. Rim of free cheek subtriangular in cross-section; dorsal side slopes downward to margin from which flat, horizontal doublure turns under; directly under marginal furrow proximal edge of doublure turns vertically upward, almost touching bottom of furrow. Outline of portion of doublure extending beneath front of cranidium forms a small, horizontal triangle.

Number of thoracic segments not known; each composed of semicircularly arched axis and evenly sloping pleura, terminating in blunt spines. Diagonal furrow crosses each pleuron, running distally from back to front.

Pygidium composed of triangular, slightly convex axis of five segments, of which last is a terminal plate without pleura. Pleura flat and more or less paddle-shaped with squared ends; separated by deeply incised interpleural furrows, curving backward from dorsal furrow. On anterior pair a diagonal groove starts from point in dorsal furrow halfway between front and back of segment, running outward to antero-lateral corner. On second pair groove starts in same manner but reaches front edge of pleuron halfway between dorsal furrow and pygidial margin. No diagonal grooves on third and fourth pairs, the last of which barely encloses the terminal axial segment.

Middle body of hypostome oblong and strongly convex, divided by discontinuous, shallow middle furrows into a large anterior and a short posterior lobe; no maculae. Lateral and posterior furrows deep; surrounding lateral and posterior rims form continuous wide flange without posterior wings. Lateral and posterolateral pair of spines on rim. Anterior wings short, bluntly triangular, and directed antero-laterally; on each of their antero-dorsal surfaces are strong articulating condyles.

HOLOTYPE. Y.P.M. No. 18278.

PARATYPES. Y.P.M. Nos. 18276, 18277, 18279–18282 incl.

DISCUSSION. The probable ancestral relation of the genus which this species represents with *Protopliomerops* will be discussed below in a special section. In this connection the poor definition of the anterior side of the palpebro-ocular ridges should be noted, for it is duplicated in the most immature stages of *Protopliomerops superciliosa* Ross, n. sp. It should also be noted that immature pygidia of *T. depressa* (pl. 31, fig. 29) are spinose and may have as many as seven pairs of discrete pleura and eight axial segments. The immature pygidia can be easily distinguished from those of other genera in the possession of diagonal pleural grooves, oriented as in the adult.

As in some other proparian genera the genal spines of immature cranidia are well developed, being lost at maturity; in this species the anterior edge of the palpebro-ocular ridges appears to be better defined in the immature stages than later in life, but still is not as clearly delineated as in such forms as *Protopliomerops superciliosa*, n. sp. (compare figs. 27 and 20 of pl. 31).

OCCURRENCE. Zone "E", locality 5, 305 feet above base of Garden City formation.

Genus *Protopliomerops* Kobayashi, 1934

Protopliomerops Kobayashi, 1934, Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. II, vol. III, pt. 9, pp. 568–572.

DISCUSSION. Kobayashi's original description of *Protopliomerops* is as follows: "Cephalon semi-circular, with genal spines; glabella elongately subquadrate, rounded in front, marked with three pairs of discontinuous lateral furrows and transverse occipital furrow; eye anterior, opposite first glabellar lobe; facial suture proparian. Pygidium consists of five or six axial and pleural segments besides triangular caudal segment; pleural segments produced into short spines."

There are three new species from the Garden City beds which are considered assignable to this genus, each of which is easily distinguished and each of which holds to a definite stratigraphic zone; eventually it may be necessary to erect two or three new genera on these forms, but there is little to be gained from such a procedure at this stage in our knowledge. These three species in ascending stratigraphic order are *P. superciliosa* Ross, n. sp., *P. celsaora* Ross, n. sp., and *P. contracta* Ross, n. sp.

From their study several important questions have arisen concerning the genotype, *P. seisonensis* Kobayashi, which are unfortunately answered in neither the published description nor the original illustrations. Fortunately, on the other hand, Kobayashi furnished the U.S. National Museum with several specimens of his species, which this author has been able to examine. From these it has been possible to establish that the characteristics of the palpebro-ocular ridges and the thoracic segments are essentially the same as in *P. superciliosa* Ross, n. sp. Harrington has described and illustrated similar palpebro-ocular ridges in an Argentinian Lower Ordovician species, which he assigns to *P. primigenius* (Angelin) (1938, pp. 183–184, pl. VI, figs. 9, 12, 14, 15, 20).

In 1937 Raymond erected the new genus *Strototropis* (p. 1126, pl. 3, fig. 24), based on a single cranidium of the genotype, *S. laeviuscula* from the Highgate formation. This cranidium possesses palpebro-ocular ridges apparently of the same type as those of *P. superciliosa,* but Raymond states that the facial suture "turns abruptly outward in front of the palpebral lobes". Since the specimen is in a limestone matrix, it is believed possible that what he considered to be a suture may actually be no more than the deep furrow separating the front of the palpebro-ocular ridge from the anterior cranidial rim. I have had no opportunity to study Raymond's type, but if this is the case there is little reason for the separation of his genus, especially when all the pygidia bear five pairs of spines, as in *Protopliomerops.* Raymond went to considerable lengths to differentiate this specimen from *Parapilekia,* a genus erected by Kobayashi in his discussion of *Protopliomerops,* but for some reason failed to make any comparison with the latter genus.

The following additions are made to the generic description of *Protopliomerops* Kobayashi on the basis of the Garden City material; this author is confident that these are valid for the genotype, with the possible exception of the hypostome.

The cranidium bears a pair of prominent ridges connecting the proximal sides of the eyes with the dorsal furrows, each ridge contracting to a point located slightly in front of the distal end of the anterior pair of glabellar furrows. Distally the ridges may expand to semiglobular lobes adjacent to the eyes. On the anterior and posterior sides they are bounded by deep furrows, the anterior one of which is the marginal furrow of the cephalon; the posterior of the two apparently corresponds to the palpebral furrow of other trilobites. Distally they are limited by the facial suture adjacent to the eye. Since they appear to be a combination of "ocular ridges" and "palpebral lobes" found in other trilobites, these ridges are designated the *palpebro-ocular ridges* or *lobes.*

At the intersection of the dorsal furrow and the two furrows bounding the palpebro-ocular ridge a pit is formed, equalling the "anterior pit" of Whittington (1941, p. 21); on the ventral side of the test the pits show as strong bosses for the articulation of the hypostome (Whittington, 1941, p. 514), and on their tips may be tiny sockets probably for the attachment of muscles or ligaments (pl. 31, figs. 14, 15) as on the mamela of *Cidaris.*

In front of the cranidium and separated from the rim proper is an epistomal plate, the width and length of which vary between species. Because of the variable shape of this plate the terms "length" and "width" are here used relative to the dimensions of the carapace as a whole, and not to the epistomal plate alone; i.e., the length of the epistomal plate may be considerably less than its width. In some species (*P. celsaora*) the plate is so oriented that its height must be synonymous with length.

Anterior to the eyes each facial suture immediately crosses the marginal furrow into the rim, in which it turns sharply inward and curves slightly downward; before reaching the cranidial midline the suture turns almost at right angles ventrad across the rim, thereby separating the sides of the epistomal plate from the free cheeks. At their right-angle change in course the sutures are met by the transverse epistomal or rostral suture defining the front or dorsal side of the plate.

The hypostome is semi-ovoid, with strongly convex middle body divided into a large anterior and a smaller posterior lobe by a very shallow middle furrow or constriction. The lateral and posterior furrows are very deep and set off a thick, convex, semi-tubular rim. There are no posterior wings, but the outer edge of the rim is ornamented with three pairs of spines and, in some species, a median posterior spine. The anterior wings are short and triangular, each being equipped with a strong boss or condyle on the antero-dorsal side.

The pleural spines of the thorax and pygidium are not grooved. Those in the posterior portion of the thorax and the pygidium are simple, pointed sheaths; in two of the Garden City species the anterior thoracic pleura possess tips very suggestive of claws (pl. 34, fig. 15). The method of thoracic articulation in the Garden City proparians will be covered below in a discussion devoted to that subject.

Protopliomerops superciliosa Ross, n. sp.

Plate 31, figs. 16–26; Plate 32, figs. 1–16; Plate 34, figs. 5–8, 19

DESCRIPTION. Surface finely pustulose or granulose, except on fixed cheeks and postero-lateral limbs, which are pseudo-punctate. Adult forms much more finely pustulose than immature ones. Cephalon about 2.5 times as wide as long; anterior outline evenly curved; posterior outline curved slightly forward proximally to blunt genal spines, which are directed laterally. Convexity in longitudinal and transverse profiles gentle. Glabella subquadrate to broadly rectangular in outline, with rounded anterior "corners"; widest at fourth glabellar lobe; narrowing slightly forward, greatest width of frontal lobe being only three-fourths that of fourth. In dorsal view lines drawn between distal ends of glabellar and occipital furrows intersect cranidial midline at points 0.13, 0.37, 0.60, and 0.90 times glabellar length from front. Palpebro-ocular ridges not much thicker at distal ends than close to glabella, where proximal end of each appears as if inserted into anterior glabellar furrow. Anterior pit deep, but not obvious on dorsal surface; corresponding boss on ventral side of test strong, but apparently lacks small socket found in *P. celsaora*. Anterior rim semi-tubular, but posterior to free cheeks becomes slightly flattened. The few specimens of free cheeks which have been secured are little more than tubular segments of the rim on which a small convex plate, the visual surface of the eye, stood erect; none have been collected with the eye intact. In front of eye each facial suture immediately crosses marginal furrow into rim, turning sharply inward and slightly ventrad. At point slightly inside projection of dorsal furrow it cuts sharply to rear across doublure; because rim of cranidium possesses no doublure, but on free cheeks it is so well developed that rim is almost a complete tube, it is evident that there must have been a very short, wide rostral or epistomal plate between cranidial rim and hypostome.

Number of thoracic segments not known; axis comprises approximately one-fifth total width, each ring forming a semicircular arch. Proximal half of each slender pleuron horizontal, distal halves being flexed ventrad at about 45 degrees. Articulation of thorax will be discussed on later pages. Almost entire distal half of each pleuron is a sharp spine; in posterior portion of thorax these undoubtedly curve slightly to rear to conform with pygidium, while at anterior end they probably bend gently forward to fit back of cephalon.

Pygidium possesses a strongly segmented, depressed, triangular axis, composed of five rings, corresponding to five pairs of spinose pleura, plus small terminal segment. Pleura splayed out in much the same manner as in *Parapilekia*, the only difference being that there is one more pair of which the posterior one does not enclose the terminal axial segment.

Hypostome varies considerably in outline (compare figs. 18 and 20, pl. 31) and possesses three pairs of marginal spines, a lateral pair and two postero-lateral pairs.

HOLOTYPE. Y.P.M. No. 18266.

PARATYPES. Y.P.M. Nos. 18267–18275 incl.; also twenty-seven specimens included under Y.P.M. No. 18323 in series illustrating ontogeny.

DISCUSSION. This species is differentiated from *P. celsaora* and *P. contracta*, both new species, by its meagre expansion of the distal end of the palpebro-ocular ridge, its narrow, tubular, unelevated rim, three pairs of spines on the hypostome, splayed-out pygidium, and somewhat broader glabella. It is very similar to the genotype, *P. seisonensis* Kobayashi (1934, p. 571, pl. VII, figs. 11–13; pl. VIII, figs. 16–17), but in that species the anterior width of the glabella is slightly greater. The pleural spines of the pygidium are, however, much longer, and the glabella less convex; comparison with other features is unsatisfactory. *P. granulatus* Kobayashi possesses a much narrower glabella and six pairs of pygidial pleura; it may represent an immature form of *P. punctatus* Kobayashi, the pygidium of which is similar. *P. superciliosa* is easily distinguished from *P. primigenius* (Angelin) (Harrington, 1938, pl. VI, figs. 9, 12, 14, 15, 20) in that the Argentine species possesses grooved pleura and a wider glabella. Because of the pleural grooves, I would be inclined to remove Harrington's species from *Protopliomerops*, in fact.

It should be noted here that a pygidium very similar to the one belonging to this species occurs over the entire area studied in the upper 200 feet of the Garden City formation; the pattern is usually outlined in black against a light-weathering matrix. The author has never succeeded in etching or chiseling one of these pygidia out of the matrix for study, but the pleural spines appear somewhat more strongly flexed ventrad than in *P. superciliosa*. Two cranidia found in adjacent limestone lenses of the Swan Peak formation at locality 11 lack the distinctive palpebro-ocular ridges of *Protopliomerops* and may be assignable to the same genus, or even the same species, as those pygidia. This occurrence serves as a warning againt correlations based on proparian pygidia with five pairs of splayed-out pleural spines without definitely assignable cranidia.

Another warning is given by the amazing specimen illustrated in figure 1, plate 32. If the right half of this cranidium were all that had been discovered, we could hardly have escaped the conclusion that it represented an unusual species with three genal spines. It can be plainly seen, however, that this animal has developed pathologically. The left side of the cephalon shows a normal posterior margin which pinches out at the right dorsal furrow; the first thoracic segment on the left side is aborted to such an extent that only a shrunken pleuron remains, the axis having become incorporated in the left side of the occipital ring. The left side of the second thoracic segment is fully developed, but at the right it passes into the posterior rim of the cephalon. The three spines at the right genal angle then represent from front to back the original genal spine, the tip of the first thoracic segment, and the tip of the second segment. There are more than one hundred other cranidia of this species from the same collection, none showing any such abnormalities.

The ontogeny of this species will be discussed below under a separate heading.

Occurrence. Zone "F", locality 6, 305–340 feet above base of Garden City formation.

Protopliomerops celsaora Ross, n. sp.

(L.: *celsus,* upright; *ora,* rim)

Plate 31, figs. 1–15; Plate 34, figs. 9–12, 20; Plate 35, fig. 29

Description. Carapace oval in outline with a thorax of at least fifteen segments. Surface very finely granulose. Cephalon roughly semicircular, and strongly convex in transverse profile, with thickened rim which is compressed in an anterior-posterior direction in front of cranidium so that it is much narrower than high and is folded back on front of glabella. Glabella slightly narrower in front than at posterior lobes; furrows deep and oriented as in *P. superciliosa.* Marginal furrow so deep in front, however, that it is difficult to see the anterior portion of the frontal glabellar lobe, which would almost certainly appear truncated in specimens in a limestone matrix. Dorsal furrows drop abruptly from fixed cheeks and are very deep. Anterior pits well developed with corresponding strong ventral condyles on tips of which are small sockets (pl. 31, fig. 15). Pits located at junction of marginal, dorsal, and anterior glabellar furrows, but character of bosses under test indicates that they are more closely related to marginal furrow than to dorsal and glabellar furrows. Palpebro-ocular ridges very slender in proximal halves, considerably inflated distally. In front facial suture cuts immediately into rim, turning sharply inward; within rim it runs horizontally for a little more than one-third anterior cranidial width, then turns directly ventrad across it. As a result ends of free cheeks are truncated and between them we infer presence of an almost quadrate epistomal plate, separated from the rim above by a slightly arched suture between the two facial sutures (figs. 1, 4, 10, pl. 31). Behind eye facial suture runs laterally two-thirds of distance to marginal furrow before turning to rear to cross rim diagonally slightly ahead of genal angle. Free cheek composed of small, upright, convex eye, narrowly acute, subtriangular ocular platform, and wide, evenly curved rim. At front, rim of cheek fits under cranidium vertically; to rear its height diminishes gradually to join depressed, sub-tubular post-cranidial rim.

Thorax composed of slender, spine-like pleura, and prominent but narrow axis occupying about one-fourth width. Anterior pleura flexed slightly forward to conform with outline of cephalon, while those at rear bend backward parallel to pygidial pleura. Pleural tips of undetermined number of anterior segments carry auxiliary spine or nub, so that tip has appearance of very slender, sharply pointed mitten with "thumb" pointing forward (pl. 34, figs. 12, 20).

Pygidium has six segments, last of which forms axial termination and is devoid of pleura. In this species pleura are closer together than in *P. superciliosa,* but do not touch except at doublure. In their distal halves they are flexed gently, but distinctly ventrad.

The hypostome possesses three pairs of marginal spines plus a blunt median spine. Like the dorsal surface of the carapace it is finely granulose.

Holotype. Y.P.M. No. 18258.

Paratypes. Y.P.M. Nos. 18257, 18259–18265 incl., 18324.

Discussion. This species differs from all others previously described in the formation of the pre-cranidial rim, which is very narrow and high and is "folded" back to cover part of the frontal glabellar lobe. The pygidium, hypostome, and free cheeks are almost indistinguishable from those of *P. contracta,* but there are slight differences; the pygidial axis of the latter is a little narrower, the middle body of its hypostome is more slender, and the portion of the rim of its free cheek projecting under the cranidial rim is markedly shorter. The palpebro-ocular ridges of *P. celsaora* are easily distinguished in that their slim proximal halves are distinct from the abruptly inflated distal halves; in this species it might be advisable to divide the ridges on this basis into ocular ridges and palpebral lobes, rather than applying the inclusive term.

OCCURRENCE. Zone "G(1)", locality 6, 480 feet above base of Garden City formation; locality 7, collected 1100 feet above base, but exact stratigraphic position open to question because of possible faulting.

Protopliomerops contracta Ross, n. sp.

Plate 33, figs. 15–19, 22–32

DESCRIPTION. Cephalon strongly convex in transverse profile, sub-semicircular in outline; surface granulose except on fixed cheeks and postero-lateral limbs which are pseudo-punctate. Glabella sub-pyriform, about two-thirds as wide at frontal as at pre-occipital lobe. Frontal lobe appears to be abruptly truncated in some specimens. In addition to normal three pairs of glabellar furrows there is an additional pair of small creases in this lobe, located immediately inside anterior pits; these are not oriented in the same direction as the furrows, being more transverse; because of their obvious relation to the pits, they are believed to have furnished points of attachment for the hypostomal muscles and to be specialized features, not glabellar furrows in the usual sense. Dorsal and marginal furrows deep; anterior rim prominent and sub-tubular. Palpebro-ocular ridges composed almost entirely of erect sub-hemispheric lobes, proximal portions being reduced to points directed toward anterior pits, which are located well forward of anterior glabellar furrows. Each facial suture in front of palpebral lobe turns sharply inward within rim, running horizontally for a litte over one-third anterior cranidial width before turning sharply ventrad to separate free cheeks from rostral or epistomal plate. Width of this plate estimated to be three-fifths its length (equals height in this species); epistomal suture slightly arched. Behind eye facial suture runs laterad for two-thirds distance to marginal furrow and then turns backward at angle of approximately 60 degrees from cranidial midline; from its intersection with marginal furrow it curves more sharply inward and downward to cross rim slightly anterior to genal angle.

Free cheeks have wide, flattened, sub-tubular rim, which at its extension beneath cranidium is vertical; progressively rearward its upper edge "twists" inward, so that entire rim becomes more nearly horizontal. Eye relatively small and projects as convex plate above narrow ocular platform.

Characters of thorax not known, other than that the associated segments are almost identical with those of *P. celsaora.* Pygidial axis composed of six segments, of which first five have spinose pleura swept back parallel to midline; posterior pair more firmly coalesced around terminal axial segment than in *P. celsaora.*

Although very similar to that of *P. celsaora,* the hypostome is a little more slender.

HOLOTYPE. Y.P.M. No. 18253.

PARATYPES. Y.P.M. Nos. 18246–18252 incl., 18255–18256.

DISCUSSION. This species differs from *P. celsaora* in the sub-pyriform outline of the glabella, reduction of the proximal portion of the palpebro-ocular ridges, and slightly greater degree of coalescence of the pygidial spines; the rim is not folded back over the anterior glabellar lobe, although it appears to truncate it in some specimens. Although easily distinguished from *Pseudocybele nasuta* Ross, n. gen. and sp., it has in common with that species an accessory pair of creases on the glabella; in both forms the anterior pits and the distal ends of the palpebro-ocular ridges hold a similar forward position, being related in some way with each other. Since the anterior pits are definitely points of articulation for the hypostome it appears that the eyes must then be connected in an unknown manner with the hypostome. *Protopliomerops deferrariisi* Harrington possesses a somewhat similar sub-pyriform glabella, but the eyes are located much farther to the rear; an unusual ocular ridge runs from the anterior glabellar furrow postero-laterally across the fixed cheek in that species, distinguishing it from all others of the genus, and probably is strong enough grounds for separating it from the genus entirely.

Occurrence. Zone "G(2)", locality 6, 525–660 feet above base of Garden City formation. Locality 5, within this same interval (specimens from this locality were collected during the field season before accurate taping of sections was undertaken; as a result only an approximation of the stratigraphic zone can be given). Locality 11, 480–490 feet above base of formation.

Genus *Pseudocybele* Ross, n. gen.

Description. Carapace elongate oval in outline with a narrow slightly tapering axis comprising about one-fifth the width. Surface finely granulose except on fixed cheeks and postero-lateral limbs of cranidium, which are pseudo-punctate.

Cephalon roughly semicircular in outline, markedly convex, with obtusely nasute anterior projection of cranidial rim. Glabella elongate oval to subrectangular in outline; glabellar furrows about one-third as long as glabellar width, diverging antero-laterally at an approximate angle of 75 degrees from cranidial midline. In front of three pairs of basic glabellar furrows may be an accessory pair of faint transverse creases adjacent to anterior pits, which are located at intersection of dorsal and marginal furrows. Dorsal and marginal furrows deep and narrow; latter forms marked crease between rotund, proximally pointed palpebral lobes and narrow, semi-tubular rim; rim encloses deep median pit located in marginal furrow in front of glabella. Boss on ventral surface of test, produced by this pit, is believed to be point of attachment for one or more anterior hypostomal muscles. Anterior pits located forward of anterior glabellar furrows, and in their distal sides the pointed inner extremities of the palpebral lobes end. In front, facial suture crosses marginal furrow into rim and turns horizontally inward to base of nasute anterior projection; it then turns ventrad at right angles to separate extension of rim of free cheeks from a narrow, angled epistomal plate. In order to conform to angular median outline of rim, epistomal plate must be shaped somewhat like stem of a boat. Behind eye facial suture runs laterally for a short distance before curving evenly postero-laterally across rim slightly ahead of genal angle.

Middle body of hypostome ovoid and divided into larger anterior and smaller posterior lobe by a shallow middle furrow; anterior wings short and stout with strong articulating bosses on antero-dorsal surfaces. No posterior wings on subtubular rim, which is set off by a deep continuous postero-lateral furrow; three pairs of spines and long, strong, median, ventrally curved spine ornament rim, however. On some specimens of the genotype a slightly callused area is present at the middle of the anterior rim, apparently for the attachment of muscles leading to the anterior pit in front of the glabella.

Thorax composed of spinose, ungrooved segments. Pleural lobes about twice as wide as axis and curve evenly ventro-laterally. Articulation of the same type as in *Protopliomerops*. There appear to be six axial segments in the pygidium, the posterior one possessing pleura and forming a boss-like termination to the axis. Proximally all six pairs of pleura pressed one against another, but distal ends of anterior two or three pairs may flare outward slightly. The posterior pair encloses rear of terminal axial boss, and distal ends appear to have anastomosed to form a typically Cybelid termination.

GENOTYPE. *Pseudocybele nasuta* Ross, n. sp.

DISCUSSION. At first glance this genus bears a strong resemblance to such forms as *Cybele* Löven and its relatives (see Reed, 1928, pp. 70–76). This resemblance is attributable to the nasute anterior rim, prominent palpebral lobes, and confluent, posterior pygidial pleura. There are several important differences, however. In this genus the palpebral lobes are bounded in front by the deep marginal furrow and in back by an equally distinct palpebral furrow; in *Cybele* and *Cybelina* Reed the palpebral lobes form high stalks and are not set off from the fixed cheeks by furrows. Although it may exist, no median pit in front of the glabella has been reported for these genera. Furthermore, although the pygidial pleura are confluent in much the same manner, these always possess a greater, usually a much greater, number of axial segments than pairs of pleura. That this genus is ancestral to these Middle Ordovician forms is entirely possible; recently Holliday has reported several species of *Ectenenotus*, which he assigns to the family Cybelidae Holliday, from the Ordovician (presumably the Pogonip formation) of Nevada (1942, pp. 475–476). Since these are believed to be from a somewhat younger fauna than is represented in the Garden City formation, *Pseudocybele* may be their phylogenetic predecessor.

The relationship of this genus with *Protopliomerops* will be covered in the discussion of proparian evolution below. In my opinion the most important differences are the acquisition of a point of attachment for the anterior hypostomal muscles, and the addition of at least one more pleural segment in the pygidium to form the Cybelid terminus. Although the palpebral lobes are much different from those of *Protopliomerops superciliosa*, they are not much removed from those of *P. contracta;* furthermore, the thoracic articulation is essentially the same in both genera. The inferred anastomosis of the posterior pygidial pleura appears to be the result of regular evolutionary sequence; the axial characters may not be far distant from those of *Cybele* or *Cybelina*, and, if the theory that the segments increase in progressively younger forms is correct, are not so far removed from *Ectenenotus*.

It is of interest that *Pseudomera* Holliday possesses a similar pre-glabellar pit and may therefore represent an offshoot from the same stem; it, however, raises the possibility that this feature may have been developed independently in several lines of descent.

Pseudocybele nasuta Ross, n. sp.

Plate 33, figs. 1–14; Plate 34, figs. 13–17, 21–27

DESCRIPTION. Cranidium twice as wide as long, posterior margin slightly backswept distally. Glabella strongly convex in transverse profile, somewhat inflated, sloping rather steeply from crest line; lines drawn between anterior pits, and distal ends of glabellar and occipital furrows in dorsal view, intersect cranidial midline at points 0.1, 0.2, 0.4, 0.6, and 0.75 times glabellar length from front. Furrows increase in depth and width to rear. Appendifers on ventral surface weak below anterior pair of furrows, increasing in size to occipital furrow. Accessory transverse creases present adjacent to anterior pits in some of the larger specimens, but lacking on others. Dorsal furrows deep on either side, but only one-half as deep as marginal furrow.

Only one complete free cheek has been found associated with the species; this indicates that the nearly vertical anterior portion of the rim is about twice as high as wide and extends under the cranidial rim to the base of the triangle containing the anterior median pit; it also shows that the facial suture turns directly ventrad from this basal angle of the triangle. Posteriorly, lower edge of rim "twists" outward, so that it appears to become wider and lower to conform with posterior rim of cranidium. Ocular platform narrow, and eye convexly dish-shaped.

On anterior lobe of hypostome there may be a small patch of fine pustules, which are a little coarser than the rest of the granulose surface.

Thorax, as shown by a single small complete specimen (pl. 33, figs. 3, 6, 7, 8, 12), composed of fourteen or fifteen segments. It is practically impossible to tell where the thorax ends and the pygidium begins, even when the under side of the doublures is examined. Axis from one-fourth to one-fifth as wide as segments and highly arched. Pleura flexed evenly downward and at tips have a slight tendency to bend forward. Anterior segments of pygidium have this same tendency although they "hug" each other closely in the proximal halves.

The pygidium of this species is unfortunately not well understood. The only complete silicified specimens collected to date are for some unknown reason extremely small and clearly immature. One of these (pl. 34, figs. 21–23) only 1.05 millimeters in length, possesses eight axial segments, the anterior seven of which have pleura. The posterior pair of pleura are pressed tightly together at the tips, surrounding the narrowly triangular eighth axial segment. Other large mature specimens have been collected from locality 5, but these are all casts in fine siltstone. In these last the number of pleural segments is diminished to five. Behind and actually between the pleura of the posterior pair of these five there is a long triangular portion which appears to be constituted by the almost complete "joining" of a sixth pair of pleura; between the proximal ends of the "sixth" pair of "coalesced" pleura lies a very small terminal axial segment. This condition is illustrated in plate 34, figure 27, and text figure 2.

An added complication arises from the fact that some of the siltstone casts do not clearly show any small "sixth" axial ring, but only a large triangular terminus having the outline of the "coalesced" "sixth" pair of pleura; the result bears a strong resemblance to pygidia illustrated by Poulsen (1927, pl. XX, figs. 9, 42) for *Cybelopsis speciosa,* but lacking pits.

It is this author's present belief that the siltstone specimens showing the "sixth" axial ring and apparent "coalescing" of the "sixth" pair of pleura may be casts of the ventral side of the carapace, while those showing only a typically Cybelid triangular axial termination are casts of the dorsal side. Only further collecting and better preserved specimens can clarify the question. If my interpretation is correct, it seems probable that the large triangular terminus of this genus and also of others related to *Cybele* may have its origin in the "joining" and further modification of a posterior, sixth pair of pleura. Considering the developmental pattern of the other studied proparian species, a more correct explanation for the formation of the terminus is that the posterior segment never completely split to produce discrete pleura. (See also Poulsen, 1927, fig. 6 and pl. XX, fig. 9.)

HOLOTYPE. Y.P.M. No. 18235.

PARATYPES. Y.P.M. Nos. 18234, 18236–18245, 18332, 18381.

DISCUSSION. The similarities and differences of this species compared with species of *Protopliomerops* have already been discussed under the generic description, as has its possible relationship with Cybelidae. Although there are representatives of the meta-protaspid and later growth stages in the present collection these have not yet been worked into an ontogenetic sequence. In these young forms it is practically impossible at our present state of knowledge to find features distinctive from equally small specimens of *Protopliomerops,* with the exception of the pre-glabellar median pit. This is developed shortly after the anterior pits and on some of the cranidia less than a millimeter in length can be made out slightly behind the anterior marginal furrow. Although its ventral boss is present in these, there is no corresponding pit in the glabella; the pit does not become evident until the boss has migrated to a position on the front of the furrow.

Like the species of *Protopliomerops* and *Tesselacauda,* the immature forms possess long genal spines, which diminish and are eventually lost with an increase in size. The possession of genal spines is therefore of little import specifically in any of these three genera unless specimens of identical size are compared.

Although there may be some other explanation, it is here believed that the pygidium of the species possesses six pleural segments basically, as described above, and that the sixth pair of pleura has been modified to form the typical Cybelid terminus. If this belief is correct, *P. nasuta* possesses one more pair of pleura than *Protopliomerops;* this possibility may not be apparent in mature specimens with the Cybelid termination fully developed and only the anterior five pleural segments remaining discrete.

There is no question concerning the fact that the immature pygidia of the species are composed of a greater number of segments than the adult. This parallels the condition found in *Tesselacauda* and *Protopliomerops.* It is known that segments are shed into the thorax from the pygidium during growth until four pleural pairs remain in the former and five in the latter. If *Pseudocybele nasuta* actually does possess a sixth basic pair of pleura in the adult pygidium it is obvious that a series exists, which with the development of the palpebro-ocular ridges, hypostome, and thoracic articulation indicates an evolutionary progression, discussed on pages to follow.

OCCURRENCE. Zone "J", locality 5, 1,235 feet above base of Garden City formation; locality 8, 1,485–1,520 feet above base; locality 13, 1,030–1,060 feet above base; locality 14A, in the light brown, silt and shale layers, 80 feet below top of Garden City beds (1,036–1,056 feet above base).

NOTES ON EVOLUTIONARY TRENDS OF GARDEN CITY PROPARIA

There is no intention of entering into a general discussion of the family relationships of the Garden City Proparia here, remarks being limited to three genera and five species, collected from the formation. The importance of these lies in the fact that they are restricted to certain stratigraphic zones and indicate definite evolutionary trends; in ascending stratigraphic order these are: *Tesselacauda depressa* Ross, n. gen. and sp., *Protopliomerops superciliosa* Ross, n. sp., *P. celsaora* Ross, n. sp., *P. contracta* Ross, n. sp., and *Pseudocybele nasuta* Ross, n. gen. and sp., all described above.

The trends with which this discussion is concerned affect the palpebro-ocular ridges or lobes, the epistomal plate, the hypostome, the thorax, and the pygidium. Text figures 2 and 3 show most of the essential features.

EVOLUTIONARY TRENDS OF THE CRANIDIUM (FIG. 2)

(1) *Palpebro-ocular ridges.* In *Tesselacauda depressa* (fig. 2, *1a*) the posterior margins of the palpebro-ocular ridges are clearly delineated from the rest of the fixed cheeks by deep palpebral furrows, but separation from the anterior rim is only incipient, there being a small notch in the proximal side of the rim slightly forward from the anterior glabellar furrow and a gentle flexure crossing the rim toward the marginal furrow on the free cheek. In *Protopliomerops superciliosa* (fig. 2, *2a*) this notch has extended laterally to separate the palpebro-ocular ridge from the rim and to connect distinctly the marginal furrows of the cranidium and free cheeks; the ridge is long and of an almost uniform width and height. The ridges of *P. celsaora* (fig. 2, *3a*) have become considerably expanded at the distal ends, while the proximal halves have contracted. The final condition is reached in *P. contracta* (fig. 2, *4a*) and holds in *Pseudocybele nasuta* (fig. 2, *5a*), in both of which the eyes have moved in closer to the glabella, the ridges have become greatly inflated at the distal ends and reduced at the proximal ends to little more than semi-conical points. Between these last two species the only difference is in the greater relative size of the ridges in *P. nasuta.*

(2) *Anterior pits* (Whittington, 1941, p. 21). It will be noted that a pit is formed at the intersection of the dorsal and marginal furrows slightly forward of the anterior glabellar furrows in the first three species discussed above (actually at the notch or incipient marginal furrow in *Tesselacauda*); this is the anterior pit, which on the ventral surface of the test forms a condyle for the attachment of the hypostome (Whittington, 1941, p. 514). In *Protopliomerops contracta* and *Pseudocybele nasuta* the pits have moved well forward from the anterior glabellar furrows, and two very small creases have appeared on the glabella adjacent to them; these creases are not considered to be glabellar furrows in the usual sense, but to have a special purpose for the attachment of hypostomal muscles. When the anterior pits were located adjacent to the anterior glabellar furrows the hypostomal muscles could share the resulting sub-glabellar ridge with whatever appendage was attached thereto; however, after the anterior pits migrated forward some other point of attachment was probably necessary, and for this purpose I believe the pair of shallow creases was developed.

(3) *Hypostome* (fig. 2, *1b–5b*). Only in the ornamentation of the lateral and posterior rims do the hypostomes of the five species differ to any great degree. On the oldest there is a pair of lateral spines and a pair at the postero-lateral "corners", in the second another pair has been added at the "corners", in the third a blunt median spine supplements these three pairs, and in the fourth and fifth this spine increases in length. The median spine in *Pseudocybele nasuta* is, furthermore, bent strongly ventrad, a fact which may lead us once more into the realm of speculation. In front of the glabella and within the nasute, angular rim there is a deep pit in this species; as in the case of the anterior pits this one is represented on the under side of the test by a strong boss, which, if the epistomal

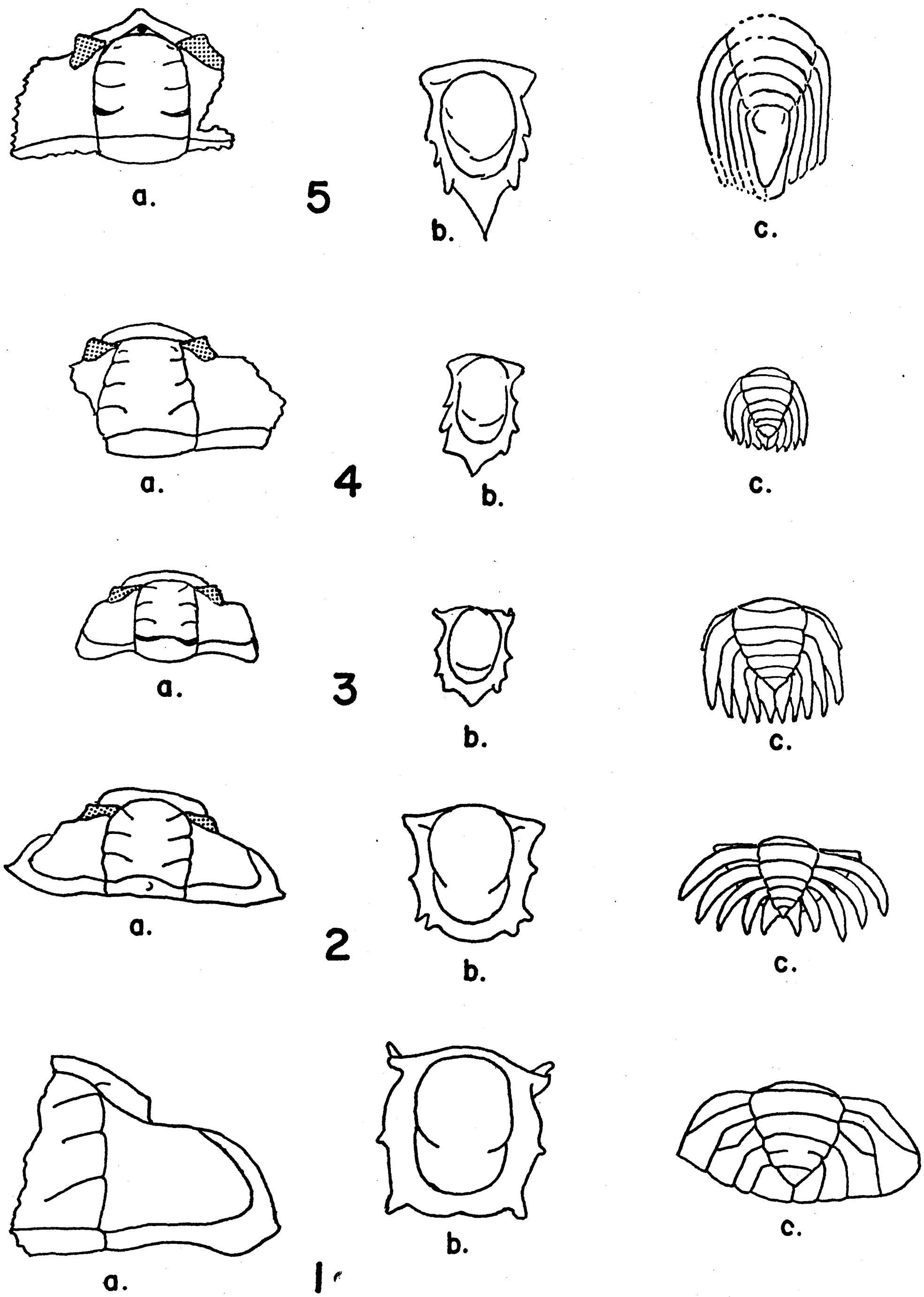


Figure 2. Generalized sketches illustrating the evolutionary trends of the cranidia, hypostomes, and pygidia of Garden City proparians: (1) *Tesselacauda depressa,* (2) *Protopliomerops superciliosa,* (3) *Protopliomerops celsaora,* (4) *Protopliomerops contracta,* and (5) *Pseudocybele nasuta.*

plate were in place, would be behind it and very close under the front of the hypostome. On the leading edge of the hypostome at its midline there is a slightly callused area, from which a short muscle or ligament could easily have run to the pre-glabellar boss. If this were so, the hypostome undoubtedly was not held rigid, but could be moved in a dorso-ventral direction with a fulcrum at the anterior pits. If the anterior muscle contracted, the long posterior spine would be forced downward and perhaps held against the bottom as a "rake" or "probe", possibly for the unearthing of food.

(4) *Epistomal plate.* In the Pliomeridae and Cheiruridae the doublures of the right and left free cheeks extend under the front of the cranidium, but do not reach the midline; between them there is a sub-rectangular plate, separated from the upper portion of the rim by the transverse epistomal suture and from the cheeks on either side by the facial sutures. I have adopted the use of the words "length" (synonymous with "height" in some species) and "width" relative to the carapace as a whole when dealing with this feature; i.e., the length of the epistomal plate may be considerably less than its width. In the series from *Tesselacauda* to *Pseudocybele* the length of this plate increases while the width decreases. In the former it is barely as long as the width of the anterior rim, is flat and horizontal, and possesses a width equal to the anterior width of the glabella between the dorsal furrows. *Protopliomerops superciliosa* shows little change from this condition, except that the epistomal plate is probably shaped to continue the sub-tubular roll of the rim. In *P. celsaora* the rim is folded back so sharply across the anterior of the glabella that its "doublure" has become vertical (see pl. 31, figs. 1, 10). The epistomal plate has taken on a quadrate shape with a gently curved dorsal side and has become vertical; its width is only one-half that of the glabella. These same conditions are present in *P. contracta,* but in *Pseudocybele nasuta* the epistomal plate is no longer flat, being bent in a sharp angle along a vertical line, and fitting under the median nasute point of the cranidial rim; a single free cheek in the collection indicates that its height and orientation are comparable with *Protopliomerops contracta.* It should be noted that I have been unable to find a single one of the epistomal plates of any of the discussed species, but their positions and shapes have been deduced from visual reconstruction of each cephalon from the cranidium, free cheeks, and hypostome (pls. 31–34).

EVOLUTIONARY TRENDS OF THE PYGIDIUM AND THORAX (FIG. 2, *1c–5c*)

Correlative changes in the number of segments in the pygidia are also indicated in text figure 2. The sequence runs from *Tesselacauda depressa* with five axial rings and four pairs of diagonally grooved pleura to the species of *Protopliomerops* with six axial rings and five pairs of pleura, and eventually to *Pseudocybele* with an increase of at least one more pygidial segment. In the pygidium of *Tesselacauda depressa* there are five axial segments and four pairs of paddle-shaped pleura, the anterior two pairs of which bear diagonal grooves. Immature pygidia may have as many as eight axial segments and seven pairs of spinose pleura (pl. 31, fig. 29), there being a definite reduction in the number with growth. If this species were directly ancestral to *Protopliomerops,* in which there is one more segment in the adult pygidium, the latter's development would appear to be neotenic, although as will be shown later, the ontogeny of *P. superciliosa* seems to recapitulate some of the features of the cephalon of *T. depressa.*

Since the anterior segment of the pygidium is almost always similar to the posterior segment of the thorax, it is wise to deal with both the pygidium and thoracic segments in presenting a theory on the development of the thoracic articulation in *Protopliomerops* from a *Tesselacauda*-like ancestor.

In the first place it will be noted that there is on the proximal half of the front edge of the anterior pygidial pleuron of *P. superciliosa* a very narrow convex strip, separated from the pleuron proper by a narrow, but distinct furrow (text

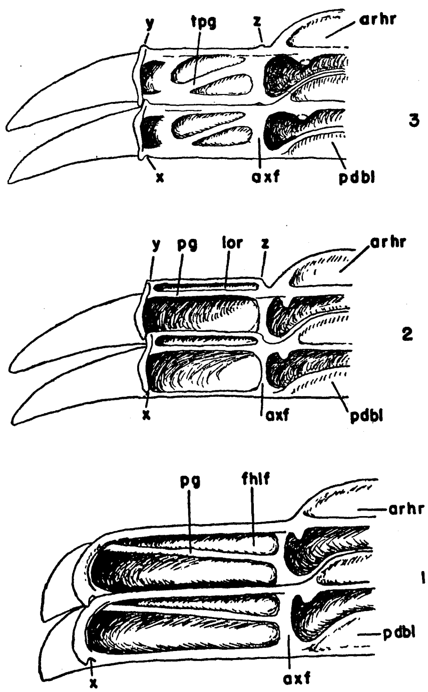


Figure 3. Idealized sketch of the thoracic articulation devices of (1) *Tesselacauda depressa,* n. gen. and sp., (2) *Protopliomerops superciliosa,* n. sp., and (3) *Ceraurus pleurexanthus,* the last after Størmer. All greatly magnified and showing the ventral side of the right half of each segment.

fig. 3, *2*); we find that this strip acts as a crude articulating device, and that its antero-distal corner (y) fits snugly inside the notched posterior end of a vertical ridge on the preceding segment (x). Furthermore, the posterior edge of the preceding pleuron fits into the furrow (pg) separating the narrow strip (lor) from the pleuron proper. It then becomes evident that this furrow (pg) performs the same function as the axial articulating furrow, located between the axial ring and the articulating half-ring (arhr); therefore, hereafter it will be referred to as the *lateral articulating furrow.* The ridge anterior to it (lor) is designated the *lateral articulating ridge.*

Öpik (1937, pl. XVIII) and Størmer (1939, pl. 11) have illustrated an almost identical device in two species of *Ceraurus;* the latter author's figure is roughly reproduced as text figure 3, *3*. In this genus the anterior "corners" of the lateral articulating ridge are produced into crude condyles (y and z); although Størmer's sketch indicates that the ridge itself is reduced to a flat flange, it is clear from

Öpik's photographs that it retains some convexity. In *Ceraurus* the articulating sockets (x), only the distal one of which is indicated on the reproduction (fig. 3, 3), are on the posterior edge of the pleuron, while in *Protopliomerops* the distal socket is well forward.

Having established the existence of an articulating device in *Protopliomerops* and called attention to its modifications in the younger genus *Ceraurus,* its derivation remains to be considered.

As already noted the two anterior pairs of pleura on the pygidium of *Tesselacauda* are diagonally grooved (text fig. 2, *1c;* pl. 31, figs. 28, 29), as are the pleura of the thorax (text fig. 3, *1;* pl. 34, figs. 1–4). The pleural grooves are oriented just opposite to those in *Ceraurus* and in fact to those in most trilobites with grooved pleura, for in this species they run antero-distally, rather than postero-distally, across the segment. Compared to the younger genera discussed above, the articulation of the segments is very rudimentary; the posterior edge of each pleuron is "shingled" over a flat anterior flange on the pleuron behind it. This flange distally curves backward and is at the same time flexed ventrad, so that it is vertical under the end of the pleuron. In its steeply curved, posterior edge there is a slight notch (x), into which the leading edge of the anterior flange of the next posterior pleuron fits. This method of articulation tends to limit the flexibility of the test because the articulating sockets (x) are located close to the tips of the strongly arched segments; as soon as any effort is made to enroll, the animal must either pull apart at the axis or articulation at the sockets be discontinued to allow the pleural ends to swing past each other. In *Protopliomerops superciliosa* the proximal portion of each pleuron is almost horizontal, the greatest part of the ventral flexure being outside the ends of the lateral articulating ridges; as a result there is a flat "hinge" between each segment, giving freedom to the pleural ends to move past one another when enrollment becomes necessary. The first change, then, from *Tesselacauda* to *Protopliomerops,* is the proximal movement of the articulating sockets. The second is the development of a pair of lateral articulating ridges. It is conceivable that the anterior flange on the segments of *Tesselacauda* could have acquired a certain degree of convexity to fulfill this assignment, but it must be noted that the pleura of *Protopliomerops* are not grooved and that the grooves in *Ceraurus* run counter to those in *Tesselacauda.* Although we have no intermediate forms and no proof, it is the author's belief that the front halves of the pleura (fhlf) of this genus could have been modified to form the lateral articulating ridges of *Protopliomerops,* and that the pleural groove of the former has become the lateral articulating furrow of the latter. If this theory is correct, reconciliation of the apparently great differences in form between the two has been considerably enhanced and their relationship seems all the more likely. A change in the number of pygidial pleural segments from four in *Tesselacauda,* to five in *Protopliomerops* and to six or more in *Pseudocybele* is indicative of a natural evolutionary sequence.

Although no perfect mature specimens of pygidia of *Pseudocybele nasuta* are present in the collections, they are known to be similar in general form to those of *Cybelopsis speciosa* Poulsen (1927, pl. XX, figs. 9, 42, 43, and text fig. 6).

ONTOGENY OF *PROTOPLIOMEROPS* KOBAYASHI, AS EXEMPLIFIED BY *P. SUPERCILIOSA* ROSS, NEW SPECIES

An ontogenetic suite of *P. superciliosa* is shown on plate 32, figures 2–16 and in text figure 4. The smallest protaspis (fig. 4, a) is only 0.27 millimeters long; it is almost circular in outline and is distinctly trilobed with a narrowly oval and, as far as can be told, unsegmented axis. On its margins it bears three main pairs of spines, an antero-lateral, a lateral, and a postero-lateral pair. In addition there is a fourth pair of spines located at the rear of the axis. Between the axis and the antero-lateral pair of spines there is a shallow notch in the margin, which apparently made room for the eyes and free cheeks. The next largest carapace (0.3 millimeters long and 0.4 millimeters wide) retains the three main pairs of spines but the fourth posterior pair has disappeared. The glabella, which is already divided into five rings, extends almost to the front of the test, there being a slim anterior rim already developed, which thickens considerably between the glabella and the antero-lateral spines. Behind the rim the palpebral furrow, not the marginal, has become clearly incised between the "corners" of the glabella and the base of the spines, and the anterior pits are well developed. It is also certain at this stage that the leading edge of the rim is cut back slightly by facial sutures in front of which there must have been minute free cheeks or possibly a single transverse "cheek" all across the front of the cephalon. Whether the eyes extended along the sutures or were limited to that part of the cheeks nearest the antero-lateral spines, I am unable to ascertain, but the latter was probably the case.

The third specimen (text fig. 4, c; pl. 32, fig. 4) is 0.47 millimeters long and 0.6 millimeters wide. It is clearly divided into a cranidium and pygidium. The postero-lateral spines (3) have become the genal spines, the lateral pair (2) remains unchanged in relative size and position, and the antero-lateral pair (1) is still located on the posterior side of the end of the thickened portion of the rim, which, it is now clear, is modified to serve as a combined ocular ridge and palpebral lobe between the front of the glabella and the antero-lateral spine. The glabella is distinctly divided into five segments, the anterior one of which is somewhat expanded. Between the stages represented by the second and third specimens three segments have been added *behind* the occipital or fifth glabellar segment to form the pygidium. There is absolutely no possibility in this species that the occipital segment has been added from the front of the pygidium, as Warburg and others have suggested is the case for all trilobites. A similar interpretation of the ontogeny of *Liostracus linnarsoni*, on which Warburg's conclusions were in part based, is considered equally suitable, if her illustrations (1925, fig. 6) are correct. In the present species the segments of the pygidium are added one by one until it possesses at least three pairs of pleural spines and a terminal axial segment. Since these segments are added to the pygidium before any thoracic segments are released, the addition of each segment represents a substage within the meraspid-zero stage of Raw (1925, p. 226) or a full stage within the metaprotaspid period of Størmer (1942, p. 96). How many of these substages exist in the ontogeny of *P. superciliosa* is still uncertain. The pygidium apparently becomes loosened from the cranidium with the addition of the fourth pair of pleural spines (pl. 32, fig. 13), but it acquires at least six pairs (pl. 32, fig. 16), which is one more than is present in the adult pygidium (pl. 31, fig. 19). Since it can be shown in suites of other species that the thorax is built up by the shedding of segments from the front of the pygidium, it is conceivable that there may be as many as nineteen substages in the meraspid-zero (or metaprotaspid) stage, before the first thoracic segment is shed as the meraspid-one stage. Only by examining the pygidial doublure of an ontogenetic series of articulated carapaces can this question be settled. This author is therefore unable to give stage designations to the remaining specimens in the series, although he is almost certain

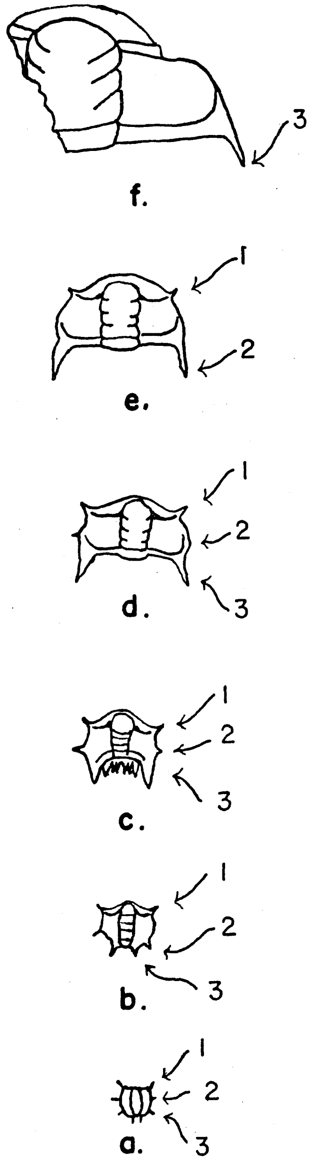


Figure 4. Generalized sketches of six stages in the ontogeny of *Protopliomerops superciliosa*, n. sp., illustrating specimens shown in figures 2, 3, 4, 7, 8, and 10, plate 31 (x 15). The three basic pairs of protaspid spines are numbered for comparison with Raw's theory of the development of Proparia. In figure *e* the genal spine should be numbered 3 instead of 2.

that the holaspid condition is reached when cranidia attain a length of a little less than 2 millimeters, at which size they possess all the features of definitely adult forms.

To return to the development of the cranidium alone, we will skip the fourth and fifth specimens (pl. 32, figs. 5, 6) in which the lateral spines (2) have become reduced, until in the sixth specimen (text fig. 4, d; pl. 32, fig. 7) there is little more than a pair of stumps to indicate their former position, although the antero-lateral spines remain well developed. There is little difference between this and the seventh except for the great reduction of these spines (text fig. 4, e; pl. 32, fig. 8), which in the eighth cranidium have completely disappeared (pl. 32, fig. 9). In the series from the second through the eighth specimen the anterior cranidial rim has continued to serve as a combined palpebral lobe and ocular ridge, there being no doubt in the fourth to eighth specimens that the eye was located immediately inside the antero-lateral spine. Because of the exposed, forward position of the eye, the spine may very well have acted as a guard which was no longer needed when the visual surface moved back even with the first glabellar furrow in the stage represented by the eighth specimen. Between this and the ninth cranidium (text fig. 4, f; pl. 32, fig. 10) there has been a definite change in the construction of the anterior rim; a furrow equalling the true marginal furrow of the adult has appeared separating the true anterior rim from a distinct palpebro-ocular ridge, which runs laterally from the first glabellar furrow to the facial suture adjacent to the eye. In this change the rim has undoubtedly gone through a condition resembling or identical with that found in the adult of *Tesselacauda depressa* (text fig. 2, *1a;* pl. 31, fig. 31). At the same time the glabellar furrows have become disconnected along the crest line and limited to the flanks. The only changes in the cranidium from this point in its growth are the filling out of the glabella and the reduction of the genal spines to mere nubs.

CONCLUSIONS REACHED FROM THE STUDY OF THE ONTOGENY

In 1925 Raw advanced the theory from his study of the ontogeny of *Leptoplastus salteri* that the basic trilobite protaspis possessed three pairs of lateral spines, which at first glance would seem to correspond to those on the first specimen of *P. superciliosa* (text fig. 4, a); the anterior pair he called procranidials, the middle pair the parials, and the postero-lateral pair the metacranidials. The first of these, according to Raw, is located in front of and inside the eyes, and in this particular we find his theory inapplicable to *Protopliomerops,* in which the so-called "procranidial spine" is located *outside* the eye, and occupies the position assigned by Raw to the "parial spine" in proparian trilobites (1925, pl. XV, figs. 1, 3, and explanation, p. 319). This condition throws some doubt on the validity of the theory where it concerns the development of the Proparia through the rotation or loss of two of the three basic pairs of spines, although it agrees in that the "metacranidials" form the genal spines.

Størmer (1941, pp. 121–124, fig. 14) has come to the conclusion that the segmentation represented by the adult trilobite carapace is secondary and cuts across the original segmentation of the soft parts, which were drawn back diagonally on either side of the axis. It is his contention, for instance, that the segment forming the genal spine originally belongs to the pre-occipital glabellar lobe (fourth from the front), and that the transverse segmentation indicated by the development of the posterior thickened rim and marginal furrow which links the genal spine to the occipital segment is secondarily derived immediately prior to the meraspid-one stage. As far as the posterior of the cephalon is concerned I am unable to present any evidence for or against this view; the posterior rim does not become visible until the rudimentary pygidium has acquired three pairs of pleural spines, between which transverse segmentation is clearly displayed, both in *Protopliomerops superciliosa* and in *Pseudocybele nasuta.* If Størmer is correct, when there are only two pairs of pygidial spines the segmentation should be diagonal, so that the first pair is linked to the occipital ring and the genal spine of the cephalon linked to the pre-occipital ring. With a magnification of x 65, I have been unable to detect any segmentation in this region of the carapace at this stage except the distinct transverse division of the cephalon from the pygidium.

Størmer, further, bases his idea of original diagonal segmentation on the fact that the eye ridges of such forms as *Paradoxides* and *Holmia* curve strongly back on both sides of the glabella, and appear to be connected with the posterior half of the anterior glabellar lobe. To this posterior half he gives the designation "antennal segment", and to the anterior half of the first lobe and all that lies in front of it he gives the name "pre-antennal segment". Generalizing for all trilobites, he then presents the following definition of the "antennal segment" (1941, p. 123): ". . . comprising the primary first or frontal lobe of the glabella, the eye-ridges . . . the palpebral lobes and a narrow, wedge-shaped portion behind them." This definition may suit the Mesonacid and related trilobites perfectly, but it cannot possibly apply to *Protopliomerops,* except in the adult forms. Størmer indicates that the anterior end of the eye or the proximal end of the ocular ridge is connected with the posterior part of the anterior glabellar lobe throughout the ontogeny, and that the lobe may expand forward with growth to incorporate a part of the "preantennal" segment. In *Protopliomerops* this is not the case; the anterior transverse rim of the cephalon is the first feature to appear after the glabella, and is clearly separated from it by a marginal furrow between the anterior pits which form equally early. The rim may then represent an early segment of the body to which the eyes are attached, the cephalon being composed of at least six segments—the five glabellar lobes and the rim. During growth the anterior lobe appears to shrink, rather than expand, relative to the overall proportions of the glabella, and it is not until late in the ontogeny that the rim seems to "drape" backward along the sides of the glabella toward the rear of the anterior lobe, at which time the portion of the rim between the glabella and the anterolateral spines is split by a furrow into a true anterior rim and a palpebro-ocular ridge. In this process, as has already been mentioned, the cranidium recapitulates the conditions found in the adult of *Tesselacauda depressa.* The newly formed palpebro-ocular ridge may possibly represent an additional segment, secondarily formed to include the posterior half of the anterior glabellar lobe and the eyes; and thus approximate in the adult the condition proposed by Størmer.

If this speculation is so, we cannot apply Størmer's theory of basic segmentation to *Protopliomerops,* for the eyes would be required to migrate into the segment represented by the anterior glabellar lobe secondarily, rather than being in it to begin with. Since his case seems so well founded for the Mesonacid and related trilobites, we may here be dealing with one of the fundamental differences between them and the Proparia.

When the group of five species is considered together it is evident that the proximal end of the palpebro-ocular ridge is in some way related to the anterior pits and hence to the articulation of the hypostome, for in the species whose anterior pits are located forward of the anterior glabellar furrows proper the ridges are located likewise, always ending at the pits. It therefore appears that any connection with the frontal lobe of the glabella is indirect, not being related to any fundamental segmentation of the body unless through the hypostome.

The rather peculiar development of the pygidium is paralleled in both *Tesselacauda depressa* and in *Pseudocybele nasuta.* In the immature forms of all three it acquires a greater number of segments than are contained in the final product; this phenomenon has also been reported in *Ceraurus pleurexanthus* by Whittington (1941, p. 500). It is evident that the process by which the pygidium loses segments to the thorax stops when four pleural pairs remain in *Tesselacauda,* when five remain in *Protopliomerops* and possibly when six basic pairs remain in *Pseudocybele.* The evolution of the pygidium is, therefore, neotenic, inasmuch as this process is arrested in *Protopliomerops* at a step equal to the Meraspid (n–1) stage of *Tesselacauda.*

The unusual development of the pygidium discussed above should serve as a warning when generic identifications are based on the number of pygidial segments; unless the pygidia in question are definitely adult (having completed the process of shedding segments into the thorax) serious errors may result. None of the pygidia from the five species studied have certainly reached mature proportions when less than 2 millimeters long. This agrees closely with Whittington's findings in *C. pleurexanthus* (1941, pl. 73, fig. 24).

WORKS TO WHICH REFERENCE IS MADE

ANGELIN, N. P. (1854) *Paleontologica Scandinavica,* fasc. II, pp. 1–92, pls. 1–42.

BARTON, D. C. (1915) *A revision of the Cheirurinae with notes on their evolution,* Washington University Studies (St. Louis), vol. 3, pt. 1, pp. 101–152.

BILLINGS, E. (1859) *On the Crinoideae of the Lower Silurian rocks of Canada; Canadian Organic Remains,* Dec. IV, Geol. Surv. Can., pp. 17–28, pl. I

—— (1865) *Paleozoic Fossils,* vol. I, Geol. Surv. Can., pp. 1–420.

BRIDGE, JOSIAH (1930) *Geology of the Eminence and Cardareva quadrangles,* Missouri Bur. Geol. and Mines, vol. 24, p. 16, pl. 21, figs. 1 and 2.

BRÖGGER, W. C. (1898 [1896]) *Über die Verbeitung der Euloma-Niobe Fauna in Europa,* Nyt. Mag. Naturvidensk, pp. 16–22, fig. 5.

BUTLER, B. S., et al. (1920) *The ore deposits of Utah,* U.S. Geol. Surv. Prof. Paper 111, 672 pp., 74 figs., 57 pls.

CALLAWAY, C. (1877) *On a new area of Upper Cambrian rocks in South Shropshire,* Quart. Jour. Geol. Soc. London, vol. 33, pp. 652–672, pl. XXIV.

CLARK, T. H. (1935) *A new Ordovician graptolite locality in Utah,* Jour. Paleontology, vol. 9, pp. 239–246, pl. 24.

CLELAND, H. F. (1900) *Calciferous of the Mohawk Valley,* Bull. Am. Paleont., no. 13, pp. 1–22, pls. 15 and 16.

CULLISON, J. S. (1944) *The stratigraphy of some Lower Ordovician formations of the Ozark Uplift,* Bull. Univ. Missouri School Mines and Met., vol. 15, no. 2, pp. 1–112.

DEISS, C. F. (1938) *Cambrian formations and sections in part of the Cordilleran trough,* Geol. Soc. Am. Bull., vol. 49, pp. 1067–1168.

DWIGHT, W. B. (1884) *Recent explorations in the Wappinger Valley limestone of Dutchess County, New York,* Am. Jour. Sci., 3rd ser., vol. 27, pp. 249–259, pl. 7.

EARDLEY, A. J. (1944) *Geology of the north-central Wasatch Mountains, Utah,* Geol. Soc. America Bull., vol. 55, pp. 819–894.

—— (1947) *Paleozoic Cordilleran geosyncline and related orogeny,* Jour. Geol., vol. 45, pp. 309–342.

FREDERICKSON, E. A., JR. (1941) *Correlation of Cambro-Ordovician trilobites from Oklahoma,* Jour. Paleontology, vol. 15, pp. 160–163.

HARRINGTON, H. J. (1937) *On some Ordovician fossils from northern Argentina,* Geol. Mag., vol. 74, pp. 97–124.

—— (1938) *Sobre las faunas del Ordoviciano Inferior del norte Argentino,* Revista del Mus. La Plata (nueva serie), tomo I, pp. 109–289.

——, and LEANZA, A. F. (1942) *Sobre algunos trilobites nuevos o poco conocidos del Ordovicico Argentino,* la Revista del Mus. La Plata (nueva serie), tomo II, pp. 131–141.

—— —— (1943) *La faunula del Tremadociano Inferior de Salitre (Bolivia),* Revista Mus. de La Plata (nueva serie), tomo II, pp. 343–356.

HOLLIDAY, SAMUEL (1942) *Ordovician trilobites from Nevada,* Jour. Paleontology, vol. 16, pp. 471–478, pls. 73–74.

HOLM, GERARD (1897) *Palaeontologiska notiser,* no. 4, Geol. Foren i Stockholm Forhandl., vol. 19, pp. 465–468, pl. 8, figs. 3–5.

HOWELL, B. F., et al (1947) *Terminology for describing Cambrian trilobite genera,* Jour. Paleontology, vol. 21, pp. 72–76.

HUDSON, G. H. (1907) *On some Pelmatozoa from the Chazy limestone of New York,* Bull. 107, N.Y. State Mus., pp. 97–131, 10 pls.

KIRK, E. (1934) *The Lower Ordovician El Paso limestone of Texas and its correlatives,* Amer. Jour. Sci., 5th ser., vol. 28, pp. 443–463.

KOBAYASHI, T. (1934) *The Cambro-Ordovician formations and faunas of South Chosen, Part II, Lower Ordovician faunas,* Jour. Fac. Sci. Imp. Univ. Tokyo, sec. II, vol. 3, pt. 9, pp. 521–585.

—— (1935) *On the Kainella fauna of the basal Ordovician age found in Argentina,* Jap. Jour. Geol. and Geogr., vol. 12, pp. 59–67, pl. XI.

—— (1936) *Three contributions to the Cambro-Ordovician faunas,* Jap. Jour. Geol. and Geogr., vol. 13, pp. 163–184.

—— (1940) *Lower Ordovician fossils from Caroline Creek, near Latrobe, Mersey River District, Tasmania,* Papers and Proc. Roy. Soc. Tasmania for 1939, pp. 67–76, Plate XII.

LAKE, P. (1919) *A monograph of British Cambrian trilobites,* Paleontograph. Soc., London. Part V, pp. 89–120, pls. 11–14.

—— (1931) *A monograph of British Cambrian trilobites,* Paleontograph. Soc., London. Part VI, pp. 121–148, pls. 15–18.

MANSFIELD, G. R. (1920) *Geography, geology, and mineral resources of the Fort Hall Indian reservation, Idaho,* U.S. Geol. Surv., Bull. 713, pp. 1–152.

—— (1927) *Geography, geology, and mineral resources of part of southeastern Idaho,* U.S. Geol. Surv. Prof. Paper 152.

—— (1929) *Geography, geology, and mineral resources of the Portneuf Quadrangle, Idaho,* U.S. Geol. Surv. Bull. 803, pp. 1–110.

ÖPIK, A. (1937) *Trilobiten aus Estland,* Univ. Tartu, Geol. Inst., Pub. 52, pp. 1–136, pls. 1–26.

PHLEGER, F. B. (1933) *Notes on certain Ordovician faunas of the Inyo Mountains, California,* Bull. Southern Cal. Acad. Sci., vol. 32, pt. I, pp. 1–21.

PORTLOCK, J. E. (1843) *Report of the geology of the County of Londonderry,* pp. 254–257, pl. I, figs. 1–6.

POULSEN, C. (1927) *The Cambrian, Ozarkian, and Canadian faunas of Northwest Greenland,* Meddelelser om Grønland, vol. 70, pp. 282–310, 332–343, pls. 18–20.

—— (1937) *On the Lower Ordovician faunas of East Greenland,* Meddelelser om Grønland, vol. 119, no. 3, pp. 1–72, figs. 1–18, pls. 1–8.

—— (1946) *Notes on Cambro-Ordovician fossils collected by the Oxford University Ellesmere Land exploration, 1934–5,* Quart. Jour. Geol. Soc. London, vol. 102, pp. 299–337, pls. 19–24.

POWELL, L. H. (1935) *A study of the Ozarkian faunas of southeastern Minnesota,* Sci. Bull. No. 1, Sci. Mus. St. Paul Instit., pp. 1–78, pls. 1–17.

PRANTL, F., and PRIBYL, A. (1947) *Classification of some Bohemian Cheiruridae (Trilobitae),* Actae Musei Nationalis Pragae, vol. IIIB, no. 1, pp. 1–44, 6 pls.

RASETTI, FRANCO (1943) *New Lower Ordovician trilobites from Levis, Quebec,* Jour. Paleontology, vol. 17, pp. 101–104.

—— (1944) *Upper Cambrian trilobites from the Levis conglomerate,* Jour. Paleontology, vol. 18, pp. 229–258, pls. 36–39.

RASETTI, FRANCO (1945) *New Upper Cambrian trilobites from the Levis conglomerate,* Jour. Paleontology, vol. 19, pp. 462–478, pls. 60–62.

—— (1946) *Revisions of some Late Cambrian trilobites from New York, Vermont, and Quebec,* Am. Jour. Sci., vol. 244, pp. 537–546, 1 pl.

—— (1947) *Notes on techniques in invertebrate paleontology,* Jour. Paleontology, vol. 21, pp. 397–399.

—— (1948) *Cephalic sutures in Loganopeltoides and the origin of "Hypoparian" trilobites,* Jour. Paleontology, vol. 22, pp. 25–29.

RAW, F. (1925) *Development of Leptoplastus salteri and other trilobites,* Quart. Jour. Geol. Soc. London, vol. 81, pt. 2, pp. 223–324, pls. XV–XVIII.

RAYMOND, P. E. (1905) *The trilobites of the Chazy limestone,* Ann. Carnegie Mus., vol. 3, no. 2, pp. 334–335, pls. 10–14.

—— (1910) *Notes on Ordovician trilobites. II, Asaphidae from the Beekmantown,* Ann. Carnegie Mus., vol. 7, no. 1, pp. 35–44, pl. 14.

—— (1911) *Trilobites of the Chazy of the Champlain Valley,* 7th Rept. Vt. Geol. Surv., pp. 213–248, pls. 32–39.

—— (1913) *A revision of the species which have been referred to the Genus Bathyurus,* Victoria Mem. Mus. Bull. No. 1, Can. Geol. Surv., pp. 51–69.

—— (1925) *Some trilobites of the Lower Middle Ordovician of eastern North America,* Bull. Mus. Comp. Zool. Harvard Coll., vol. LXVII, no. 1, pp. 1–180, pls. 1–10.

—— (1937) *Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont,* Bull. Geol. Soc. Amer., vol. 48, pp. 1079–1146, pls. 1–4.

REED, F. R. C. (1906) *The Lower Paleozoic trilobites of the Girvan district,* Paleontograph. Soc. London, pp. 1–186, pls. 1–20.

—— (1928) *Notes on the Family Encrinuridae,* Geol. Mag., vol. 65, pp. 50–77.

—— (1931) *The Lower Paleozoic Trilobites of Girvan,* Supplement no. 2, Paleontograph. Soc. London, pp. 1–30.

RESSER, C. E. (1942) *New Upper Cambrian trilobites,* Smithsonian Misc. Coll., vol. 103, no. 5, pp. 1–136, pls. 1–21.

RICHARDSON, G. B. (1913) *The Paleozoic section in northern Utah,* Am. Jour. Sci., ser. 4, vol. 36, pp. 406–416.

—— (1941) *Geology and mineral resources of the Randolph Quadrangle, Utah-Wyoming,* U.S. Geol. Surv., Bull. 923, pp. 1–53.

ROSS, R. J., JR. (1948) *Revisions in the terminology of trilobites,* Am. Jour. Sci., vol. 246, pp. 573–577.

—— (1949) *Stratigraphy and trilobite faunas of the Garden City formation, northeastern Utah,* Am. Jour. Sci., vol. 247, pp. 472–491.

SALTER, J. W. (1853) *British organic remains,* Mem. Geol. Surv. United Kingdom, Decade VII, pl. VIII, pp. 7–10, figs. 1–5.

SCHMIDT, F. (1907) *Revision der Ostbaltischen Silurischen Trilobiten,* Abteilung VI, Mem. Imp. Acad. Sci., St. Petersburg, vol. 20, no. 8, pp. 1–104, pls. I–III.

SHIMER, H. W., and SHROCK, R. R. (1944) *Index fossils of North America,* John Wiley and Sons, Inc., pp. 599–655.

SIEGFRIED, P. (1936) *Ueber das Pandersche Organ bei den Asaphiden des Ostbaltischen Ordoviciums,* Pub. Geol. Inst. Univ. Tartu, no. 49, pp. 1–42, 12 figs., 9 pls.

SINCLAIR, G. W. (1946) *The Ordovician trilobite Dimeropyge,* Am. Jour. Sci., vol. 244, pp. 854–860, 1 pl.

Sinclair, G. W. (1947) *Muscle scars in the Ordovician trilobite Illaenus,* Am.
Størmer, L. (1939) *Studies on trilobite morphology, part I, The thoracic ap-*
Jour. Sci., vol. 245, pp. 529–536.
pendages and their phylogenetic significance, Norsk geol. Tidsskrift, vol. 19, pp. 143–273, 12 pls.

—— (1941) *Studies on trilobite morphology, part II, The larval development, the segmentation and the sutures, and their bearing on trilobite classification,* Norsk Geol. Tidsskrift, vol. 21, pp. 49–164, 2 pls.

Stubblefield, C. J. (1950 a) *A new Komaspid genus of wide distribution in early Ordovician times,* Ann. Mag. Nat. Hist. (12), vol. 3, no. 28, April, pp. 341–352, pl. II.

—— (1950 b) *Dimastocephalus Stubblefield 1950, Carolinites Kobayashi 1940.* Ann. Mag. Nat. Hist. (12), vol. 3, no. 29, May.

——, and Bulman, O. M. B. (1927) *The Shineton shales of the Wrekin District,* Quart. Jour. Geol. Soc. London, vol. 83, pp. 96–144, pls. 3–4.

Tarr, W. A. (1917) *Origin of the chert in the Burlington limestone,* Am. Jour. Sci., ser. 4, vol. 44, pp. 409–452.

Thoral, M. (1935) *Contribution à l'étude paléontologique de l'Ordovicien inférieure de la Montagne Noire et Revision sommaire de la faune Cambrienne de la Montagne Noire.* Thèses Fac. Sci. Univ. Paris, Ser. A., No. 1541, pp. 1–362, 35 pls.

Ulrich, E. O. (1930 a) *Systematic paleontology—Trilobita,* in Bridge, J., *Geology of the Eminence and Cardareva quadrangles,* Missouri Bur. Geol. and Mines, ser. 2, vol. 24.

—— (1930 b) *Ordovician trilobites of the Family Telephidae and concerned stratigraphic correlations,* Proc. U.S. Nat. Mus., vol. 76, art. 21, pp. 1–101, 8 pls.

——, and Cooper, G. A. (1938) *Ozarkian and Canadian Brachiopoda,* Geol. Soc. American Spec. Paper No. 13, pp. 1–323, 58 pls.

Walcott, C. D. (1884) *Paleontology of the Eureka District,* U.S. Geol. Surv. Mem. VIII, pp. 1–286.

—— (1923) *Nomenclature of some Post Cambrian and Cambrian Cordilleran formations* (2), Smithsonian Misc. Coll., no. 8, vol. 67, pp. 457–476.

—— (1924) *Cambrian and Lower Ozarkian trilobites,* Smithsonian Misc. Coll., vol. 75, no. 2, pp. 53–60, pls. 9–14.

—— (1925) *Cambrian and Ozarkian trilobites,* Smithsonian Misc. Coll., vol. 75, no. 3, pp. 62–146, pls. 15–24.

—— (1928) *Pre-Devonian Paleozoic formations of the Cordilleran provinces of Canada,* Smithsonian Misc. Coll., no. 5, vol. 75, pp. 175–368.

Warburg, Elsa (1925) *The trilobites of the Leptaena limestone in Dalarne,* Bull. Geol. Instit. Upsala, vol. 17, pp. 1–435, pls. 1–11.

Westergard, A. H. (1922) *Sveriges Olenidskiffer,* Sver. Geol. Undersökning, Ser. Ca, no. 18, pp. 1–205, 16 pls.

Whitfield, R. P. (1886) *Notice of geological investigations along the eastern shore of Lake Champlain,* Bull. Am. Mus. Nat. Hist., vol. 1, no. 8, pp. 293–348, pls. 24–35.

—— (1889) *Observations on some imperfectly known Fossils from the Calciferous Sandrock of Lake Champlain,* Bull. Am. Mus. Nat. Hist., vol. 2, no. 2, pp. 41–63, pls. 7–10.

WHITTINGTON, H. B. (1941a) *The Trinucleidae—with special reference to North American genera and species,* Jour. Paleontology, vol. 15, pp. 21–41.

—— (1941b) *Silicified Trenton trilobites,* Jour. Paleontology, vol. 15, pp. 492–522, pls. 72–75.

—— (1948) *A new Lower Ordovician trilobite,* Jour. Paleontology, vol. 22, pp. 567–572, 2 pls.

WILLIAMS, J. STEWART (1946) *Geologic map of the Logan Quadrangle, Utah,* published by Utah State Agric. College.

—— (1948) *Geology of the Paleozoic rocks, Logan Quadrangle, Utah,* Bull. Geol. Soc. Amer., vol. 59, pp. 1121–1164.

——, and MAXEY, G. B. (1941) *The Cambrian section in the Logan Quadrangle, Utah and vicinity,* Am. Jour. Sci., vol. 239, pp. 276–285.

Fig. 1. Bottom of ledge, 70 feet above base of Garden City formation at locality 5, showing irregular and lenticular laminae and minor disconformities. Dark laminae are crystalline, light ones very muddy limestone.

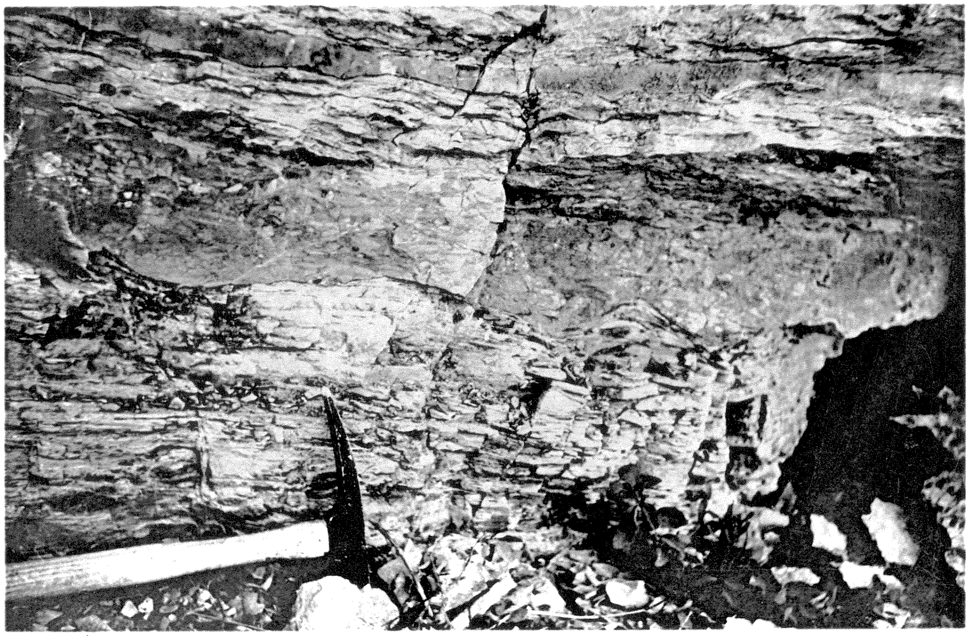


Fig. 2. Bottom of same ledge, 30 feet to right (south) of portion shown above, illustrating change in lithology. Basal part is much more muddy and weaker; middle layers shown in figure 1 have given way to lens of coarse intraformational conglomerate with distinct disconformity below it.

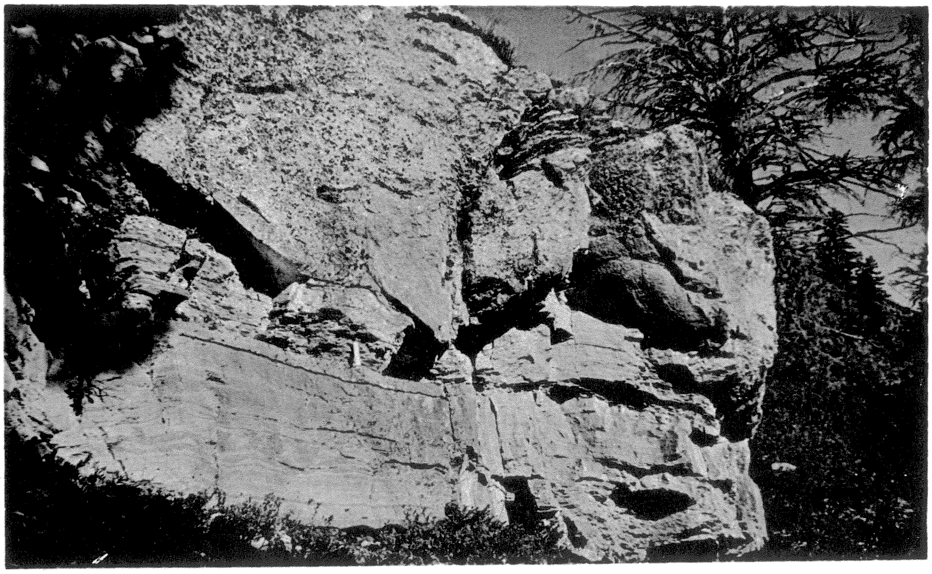


Fig. 1. Ledge, 80 feet above base of Garden City formation, locality 5, showing thick, massive, finely crystalline limestone disconformably overlying portion shown in plate 1, figures 1, 2. Deepest part of apparent channel fill located slightly to right of white, 6-inch rule.

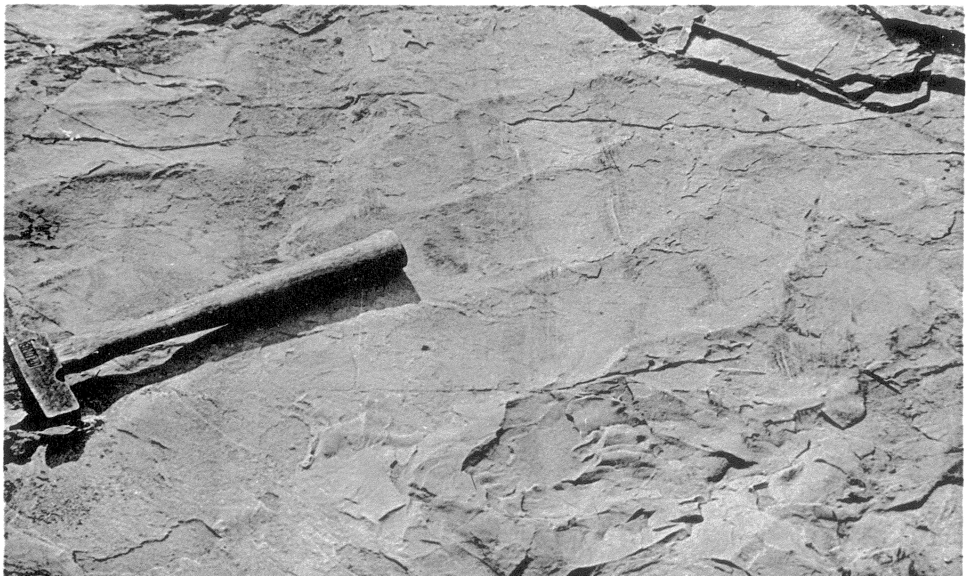


Fig. 2. Ripple marks on a dip-slope surface, 86 feet above base of Garden City formation, locality 11. (See also Ross, 1949, pl. 1, fig. 1.)

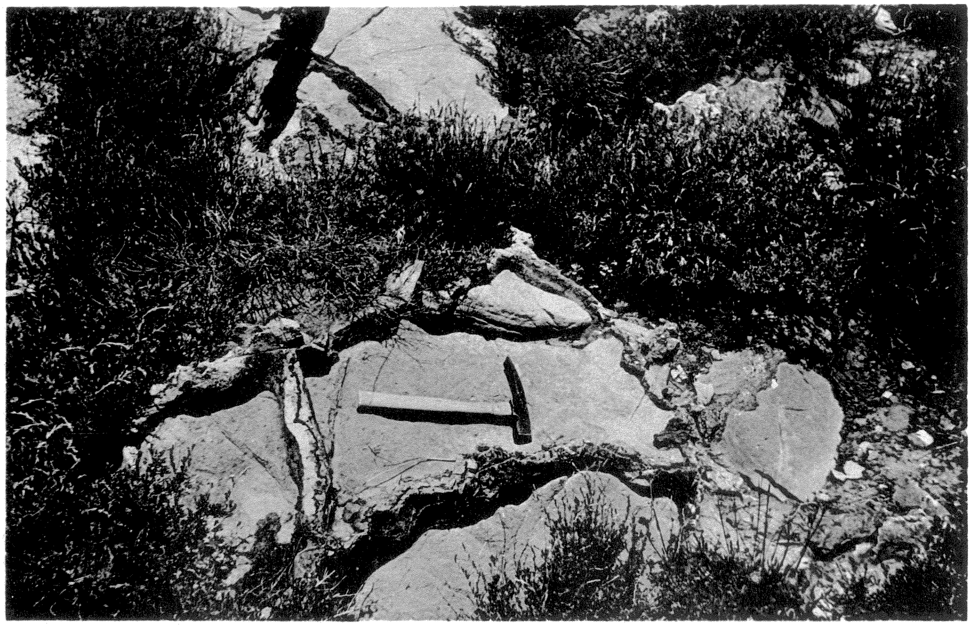


Fig. 1. White chert stringers, forming a rectilinear pattern on a dip-slope surface, 240 feet above base of Garden City formation, locality 7.

Fig. 2. Float-block of intraformational conglomerate, composed of crystalline limestone pebbles in a muddy limestone matrix, 540 feet above base of Garden City formation, locality 1. (Contrast with Ross, 1949, pl. 2, fig. 1, where composition of pebbles and matrix is reversed.)

Fig. 1. Jointed surface of a bed of coarse intraformational conglomerate, approximately 270 feet above base of Garden City formation, locality 5. Matrix is coarsely crystalline limestone; pebbles show great variety, ranging from limy mudstone to crystalline limestone.

Fig. 2. Black chert "layers" almost completely replacing slabby and crudely laminated dolomitic limestone, locality 8, 200 feet below top of Garden City formation. (See also Ross, 1949, pl. 3, fig. 2.)

Fig. 1. Limestone pebble conglomerate, exposed on dip-slope surface about 3 feet above surface shown in plate 2, figure 2. Lens cap is 42 millimeters in diameter. (See also Ross, 1949, pl. 1, fig. 1.)

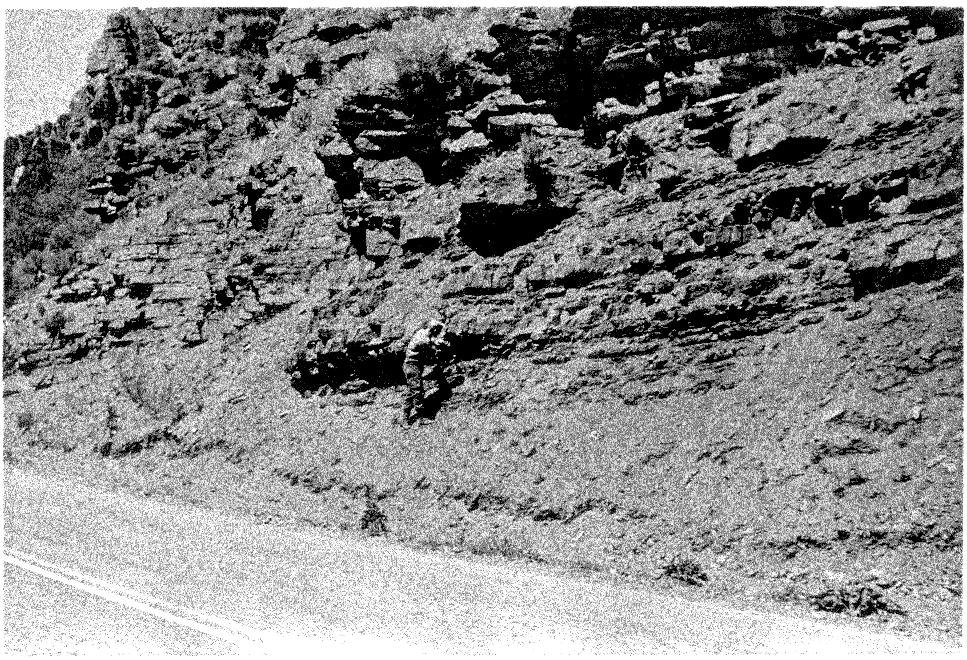


Fig. 2. Interbedded shales and quartzites of the Swan Peak formation, exposed in a road cut on the west side of U.S. Highway 91, at the junction of the Logan River and its right fork. Locality 10.

Fig. 1. Float-block of Swan Peak quartzite, showing the characteristic fucoidal markings found on the under sides of many beds. Locality 10.

Fig. 2. Top of Swan Peak from the south-southeast. The figure is standing directly on the Garden City–Swan Peak contact. This is the type locality of the Swan Peak formation. Ledges of the quartzite can be seen protruding high on the slope and at the peak.

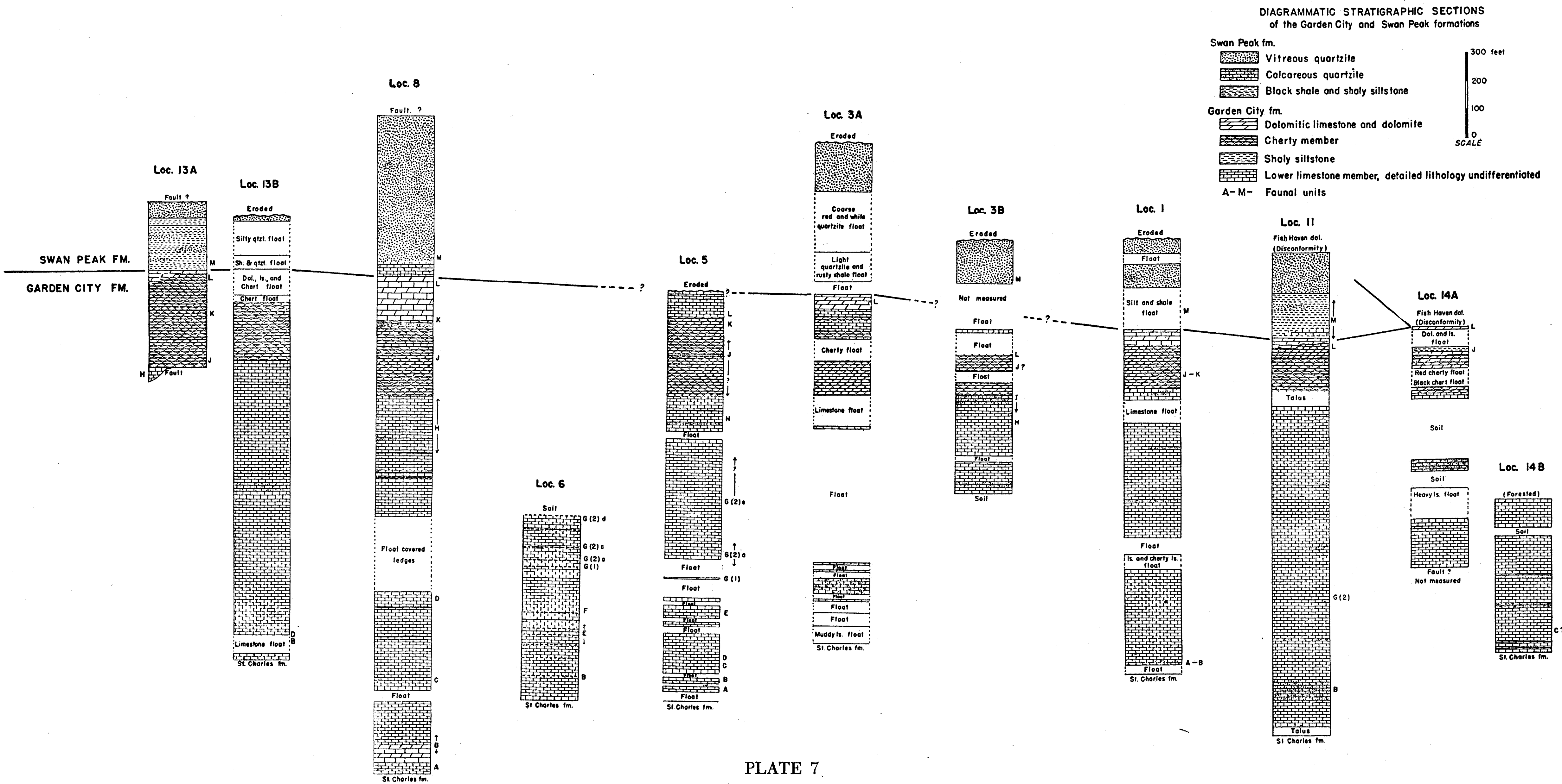


PLATE 7

Fig. 1. Generalized diagrammatic stratigraphic sections of the Garden City and Swan Peak formations. For location of sections see text figure 1.

PLATES 8 TO 36

All specimens, except those shown in plate 32 and figure 4, plate 23, were whitened before photographing with magnesium oxide (Rasetti, 1947, pp. 397–398). Unless otherwise noted, specimens are silicified and mounted with synthetic resin glue on the heads of insect pins. In all photographs of silicified specimens pins have been touched out; since photographs were taken against a black background, no other retouching was done, except in the case of a few in limestone matrices of which note is made in the legend.

All photographs, other than figures 2–16 of plate 32, were taken with a Leica camera, standard focusing attachment with ground glass, lens extension tubes, and either an Elmar 50 millimeter or 35 millimeter lens. Lighting was provided by two ordinary 40-watt electric lamps in normal desk-light reflectors. Low contrast Panatomic-X film was used.

Thickness of each specimen was measured with a petrographic microscope equipped with highest power objective by focusing first on the lowest point of the fossil and then on the highest; the difference in height was then read off the micron scale on the focusing knob. By using standard lens formulae it was possible to photograph each specimen so that its thickness never exceeded the computed depth of field range of a given lens and extension tube combination; since 35 millimeter negatives must be enlarged it was desirable to secure the largest possible image directly without exceeding the depth of field limit.

Before any fossil photographs were taken, a millimeter scale was photographed, with each of the lens and lens tube combinations. The combination used for each specimen was then carefully recorded. Before enlargement of each negative to the final print it was then possible to project the negative of the scale and adjust the final negative to the magnification desired.

PLATE 8

HYSTRICURUS

Hystricurus genalatus Ross, n. sp.

Figs. 1, 2, 5. Holotype, cranidium; anterior, dorsal, and lateral views, x 4. Y.P.M. *17926*. Zone "B", locality 6.

3, 4, 6. Paratype, cranidium; dorsal, anterior, and lateral views, x 4. Y.P.M. *17928*. Zone "B", locality 7.

7. Paratype, free cheek lacking eye; dorsal view, x 4. Y.P.M. *17932*. Zone "B", locality 7.

8. Paratype, cranidium; ventral view, showing short course of facial sutures across rim, x 4. Y.P.M. *17930*. Zone "B", locality 7.

9, 12, 13. Paratype, cranidium with free cheek of almost correct size glued in place; anterior, lateral and dorsal views, x 4. Y.P.M. *17931*. Zone "B", locality 7.

10. Paratype, free cheek with eye and infra-ocular ring preserved, showing abrupt course of facial suture across doublure; dorsal view, x 4. Y.P.M. *17933*. Zone "B", locality 6.

11. Paratype, cranidium; dorsal view, x 4. Y.P.M. *17929*. Zone "B", locality 7.

Hystricurus paragenalatus Ross, n. sp.

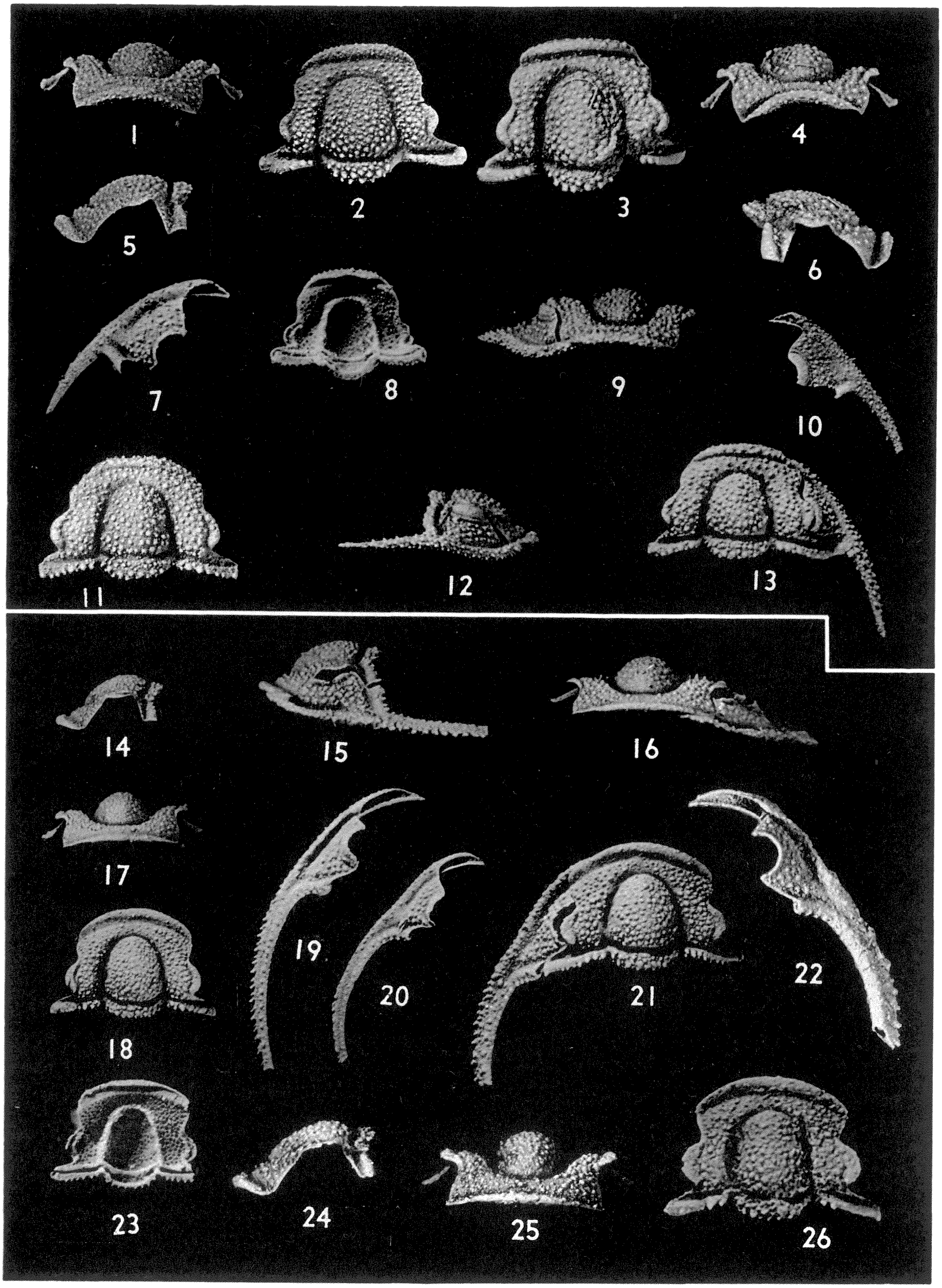
Figs. 14, 17, 18. Holotype, cranidium; lateral, anterior, and dorsal views, x 4. Y.P.M. *17934*. Zone "B", locality 7.

15, 16, 21. Paratype, cranidium with free cheek of approximately correct size glued in place, x 4. Y.P.M. *17937*. Zone "B", locality 7.

19, 20, 22. Paratypes, three free cheeks; dorsal views, x 4. Y.P.M. *17939, 17938, 17940* respectively. Zone "B", locality 7.

23. Paratype, cranidium; ventral view, showing gradual course of facial sutures cutting ventral side of rim, x 4. Y.P.M. *17936*. Zone "B", locality 7.

24, 25, 26. Paratype, cranidium; lateral, anterior, and dorsal views, x 6. Y.P.M. *17935*. Zone "B", locality 7.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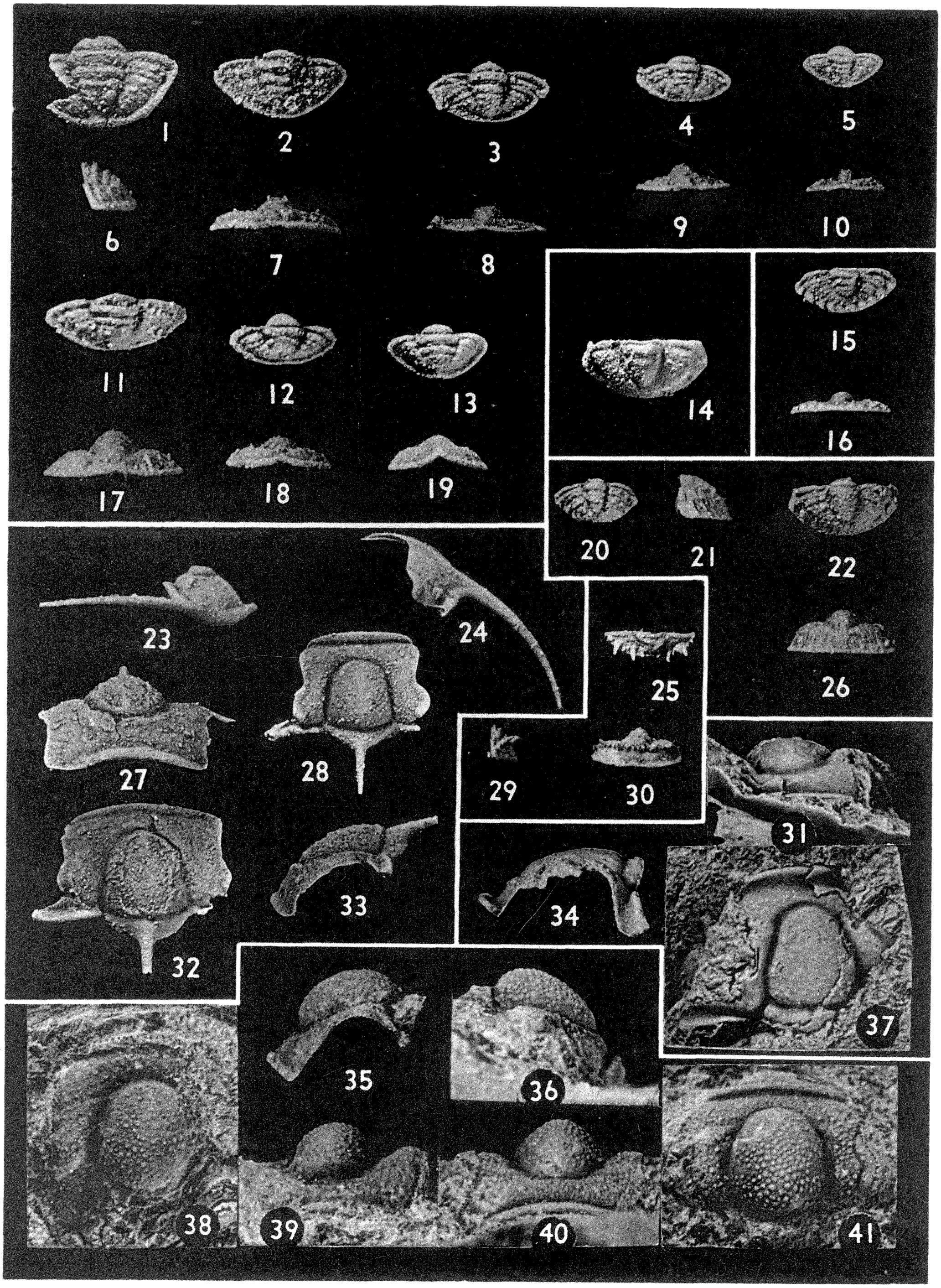
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PLATE 9

HYSTRICURUS

Indefinitely assigned pygidia from zone "B".

Figs. 1–13, 17–19. Pygidia believed to be assignable to *Hystricurus genalatus* Ross, n. sp., *H. paragenalatus* Ross, n. sp., or *H. politus* Ross, n. sp. (1) dorsal view, x 4; Y.P.M. *17941.* (2, 7) dorsal and posterior views, x 5; Y.P.M. *17942.* (3, 8) dorsal and posterior views, x 6; Y.P.M. *17943.* (4, 9) dorsal and posterior views, x 6; Y.P.M. *17944.* (5, 10) dorsal and posterior views, x 6; Y.P.M. *17945.* (6, 11, 17) lateral, dorsal, and posterior views, x 6; Y.P.M. *17946.* (12, 18) dorsal and posterior views, x 6; Y.P.M. *17947.* (13, 19) dorsal and posterior views, x 5; Y.P.M. *17948.*

(Y.P.M. *17491* and *17498* from locality 6; others from locality 7.)

14. Pygidium, dorsal view x 4; Y.P.M. *17949.* Probably referable to *Hystricurus politus* Ross, n. sp. Zone "B", locality 6.

15, 16. Pygidium, dorsal and posterior views, x 6; Y.P.M. *17950.* Species undetermined. Zone "B", locality 7.

20–22, 26. Pygidia tentatively referred to *Clelandia utahensis* Ross, n. sp. (20) dorsal view, x 6; Y.P.M. *17951.* (21, 22, 26) dorsal and posterior views, x 6; Y.P.M. *17952.* Zone "B", locality 7.

25, 29, 30. Pygidium, dorsal, lateral, and posterior views, x 6; Y.P.M. *17953.* Genus and species undetermined. Zone "B", locality 7.

Hystricurus ? *politus* Ross, n. sp.

Figs. 23, 24. Paratype, free cheek; lateral and dorsal view, x 4. Y.P.M. *17959.* Zone "B", locality 6.

27, 32, 33. Paratype, cranidium; anterior, dorsal, and lateral views, x 4. Y.P.M. *17958.* Zone "B," locality 6.

28. Paratype, cranidium; dorsal view, x 4. Y.P.M. *17954.* Zone "B", locality 7.

Hystricurus sp. A.

Figs. 31, 34, 37. Cranidium; anterior, lateral, and dorsal views, x 3. Y.P.M. *18296.* (Fig. 34 retouched to black out matrix.) Locality 14B, 125 feet above base of Garden City formation; possibly within zone "E".

Hystricurus sp. D.

Figs. 35, 38, 39. Cranidium, poorly preserved; lateral, dorsal, and anterior views, x 4. Y.P.M. *18297.* Zone "A", locality 5.

36, 40, 41. Cranidium, lacking both postero-lateral limbs; lateral, anterior, and dorsal views, x 6. Y.P.M. *18298.* Zone "A", locality 5.

PLATE 10

HYSTRICURUS

Hystricurus oculilunatus Ross, n. sp.

Fig. 1. Paratype, free cheek; dorsal view, x 4. Y.P.M. *17961*. Zone "F", locality 6.

2, 3, 5. Holotype, cranidium; dorsal, anterior, and lateral views, x 4. Y.P.M. *17960*. Zone "F", locality 6.

8, 9, 12. Large cranidium, not silicified; anterior, lateral, and dorsal views, x 3. Y.P.M. *18299*. Locality 14B, 65 feet above the base of the Garden City formation.

Hystricurus contractus Ross, n. sp.

Figs. 4, 6, 7. Holotype, cranidium; anterior, lateral, and dorsal views, x 6. Y.P.M. *17962*. Zone "F", locality 6.

10. Paratype, cranidium; dorsal view, x 4. Y.P.M. *17963*. Zone "F", locality 6.

Hystricurus robustus Ross, n. sp.

Figs. 11, 14, 15. Paratype, cranidium; anterior, lateral, and dorsal views, x 4. Y.P.M. *17965*. Zone "E", locality 5.

13, 16, 20. Holotype, cranidium; anterior, lateral, and dorsal views, x 5. Y.P.M. *17964*. Zone "E", locality 5.

Hystricurus sp. C.

Figs. 17, 21, 22. Cranidium; anterior, lateral, and dorsal views, x 6. Y.P.M. *17966*. Zone "E", locality 5.

Hystricurus sp. B.

Figs. 18, 19, 23. Cranidium, slightly distorted; anterior, lateral, and dorsal views, x 6. Y.P.M. *17967*. Note pre-glabellar median furrow. Zone "E", locality 5.

24, 27, 28. Cranidium, very immature, possibly not conspecific with above specimen; anterior, dorsal, and lateral views, x 10. Y.P.M. *17969*. Note length of glabella and palpebral lobes.

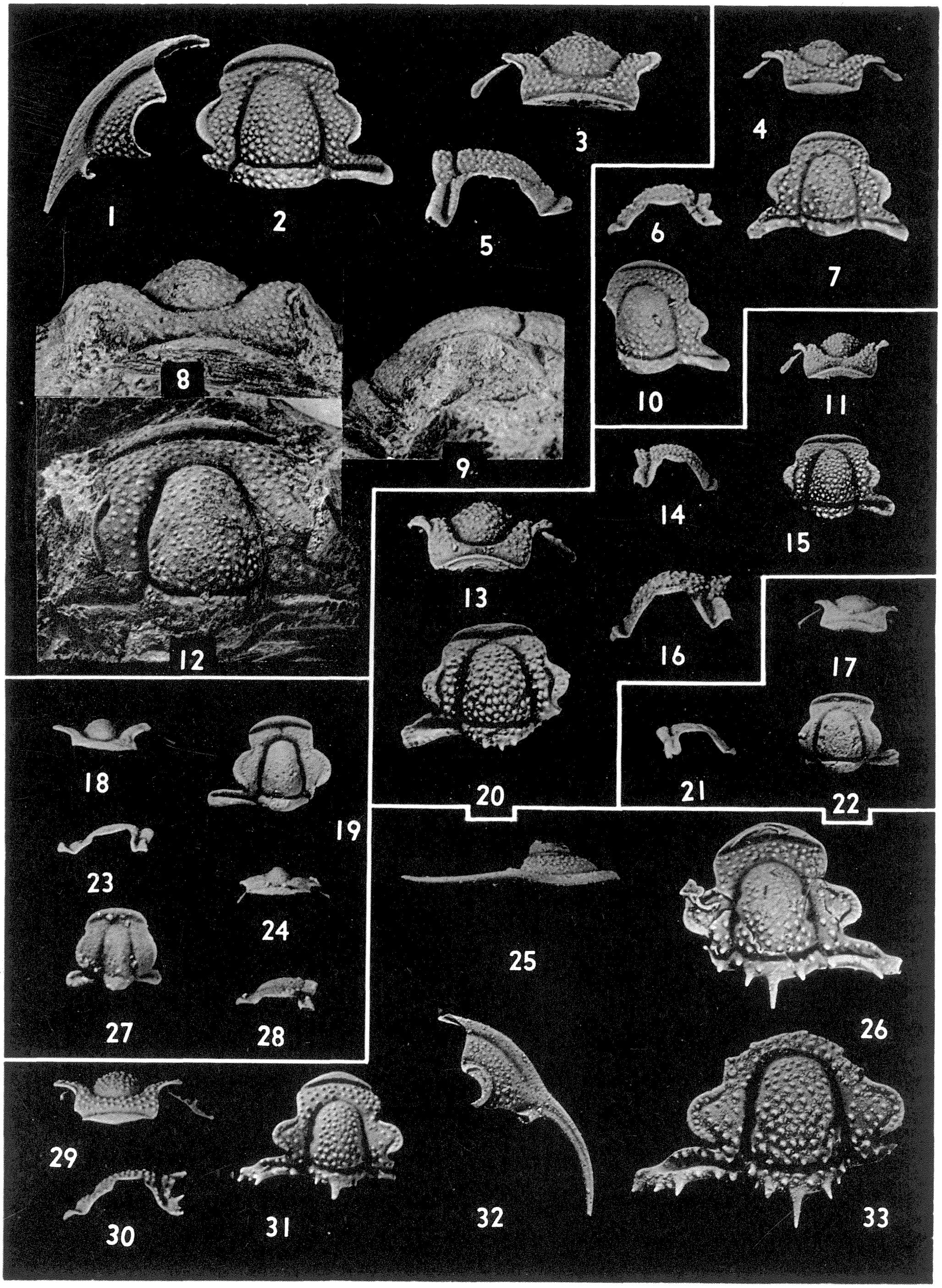
Hystricurus flectimembrus Ross, n. sp.

Figs. 25, 32. Paratype, free cheek; lateral and dorsal views, x 4. Y.P.M. *17973*. Zone "F", locality 6.

26. Paratype, cranidium; dorsal view, x 4. Y.P.M. *17971*. Zone "F", locality 6. Note paired pits in dorsal furrow.

29, 30, 31. Holotype, cranidium; anterior, lateral, and dorsal views, x 3. Y.P.M. *17972*. Zone "F", locality 6.

33. Paratype, cranidium, partly damaged; dorsal view, x 3. Y.P.M. *17970*. Zone "F", locality 6.



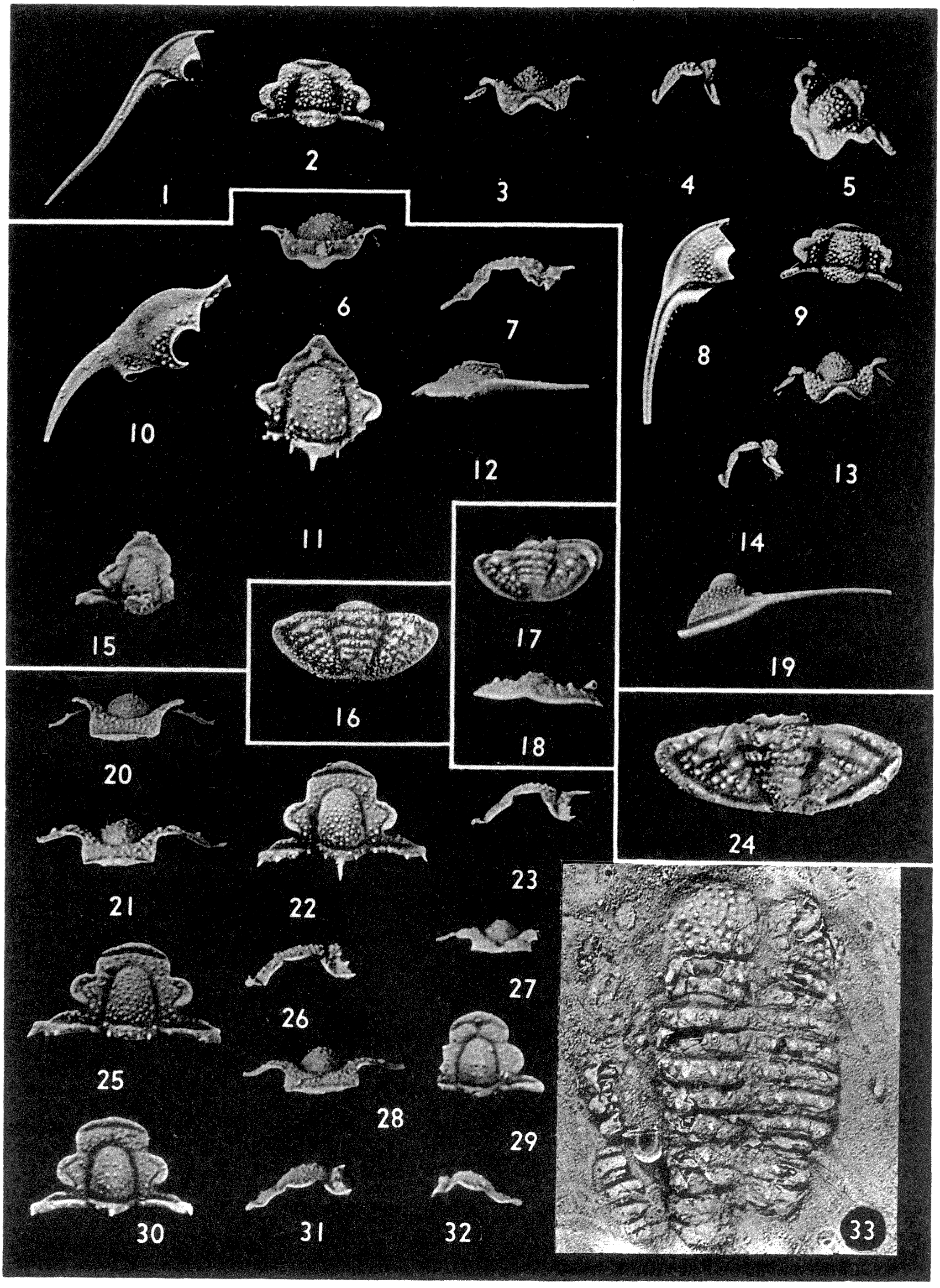

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PLATE 11

PSALIKILUS, HYSTRICURUS

Psalikilus typicum Ross, n. gen. and sp.

Fig. 1. Paratype, free cheek with genal spine slightly deformed; dorsal view, x 5. Y.P.M. *17984*. Zone "G"; this specimen from "G(2)a", locality 6. Note structure of genal spine.

2, 3, 4, 5. Holotype, cranidium; dorsal, anterior, lateral, and antero-lateral dorsal views, x 4. Y.P.M. *17985*. Zone "G"; this specimen from "G(2)a", locality 6.

8, 19. Paratype, free cheek; dorsal and lateral views, x 4. Y.P.M. *17987*. This specimen from Zone "G(2)c", locality 6.

9, 13, 14. Paratype, cranidium; dorsal, anterior, and lateral views, x 4. Y.P.M. *17986*. This specimen from Zone "G(2)c", locality 6.

Hystricurus acumennasus Ross, n. sp.

Figs. 6, 7, 11. Holotype, cranidium; anterior, lateral, and dorsal views, x 4. Y.P.M. *17980*. Zone "F", locality 6. Postero-lateral limbs broken.

10, 12. Paratype, free cheek; dorsal and lateral views, x 4. Y.P.M. *17982*. Zone "F", locality 6.

15. Paratype, cranidium; dorsal view, showing that postero-lateral limbs are essentially the same as those of *H. flectimembrus* Ross, n. sp., x 6. Y.P.M. *17981*. Zone "F", locality 6.

17, 18. Pygidium tentatively assigned to this species, though possibly referable to *H. flectimembrus;* right half of posterior thoracic segment, bearing large spine, still attached; dorsal and posterior views, x 6. Y.P.M. *17983*. Zone "F", locality 6.

Hystricurus flectimembrus Ross, n. sp.

Figs. 16, 21–33. All specimens from Zone "F", locality 6. (20, 22, 23) Paratype, cranidium, x 4; Y.P.M. *17974*. (16) Pygidium tentatively assigned, x 4; Y.P.M. *17978*. (24) Pygidium tentatively assigned, x 8; Y.P.M. *17979*. (21, 25, 26) Paratype, cranidium, x 5; Y.P.M. *17975;* note disappearance of pre-glabellar median furrow compared with smaller specimens. (28, 30, 31) Paratype, cranidium, x 6; Y.P.M. *17976;* note pre-glabellar median furrow and paired pustules on glabella. (27, 29, 32) Paratype, cranidium, smallest identified, x 8; Y.P.M. *17977;* note well-developed pre-glabellar furrow and smooth surface, except for paired pustules on glabella. (33) Paratype, incomplete cephalon and thorax, x 2; Y.P.M. *18300;* faint trace of edge of right free cheek discernible and tip of genal spine preserved opposite fourth thoracic segment.

PLATE 12

PARAHYSTRICURUS

Parahystricurus fraudator Ross, n. gen. and sp.
(All figures x 4, except 3–5 which are x 8; all specimens from Zone "F", locality 6.)

Figs. 1, 2. Paratype, cranidium; dorsal and anterior views. Y.P.M. *17992.*

3, 4, 5. Paratype, cranidium, smallest specimen identified; lateral, dorsal, and anterior views, x 8. Y.P.M. *17993.*

6, 7, 12. Paratype, cranidium; lateral, anterior, and dorsal views. Y.P.M. *17991.*

9, 10. Paratype, free cheek; dorsal and lateral aiews. Y.P.M. *17994.*

8, 13, 14. Paratype, cranidium. Y.P.M. *17989.*

11, 15, 16. Holotype, cranidium; lateral, anterior, and dorsal views. Y.P.M. *17988.* Note two pairs of non-pustulose areas on sides of glabella and that pre-glabellar median furrow is indicated only by absence of pustules.

Parahystricurus pustulosus Ross, n. sp.
(Figures 17–19 x 8; 20–32 x 4; all specimens from Zone "F", locality 6)

Figs. 17, 18, 19. Paratype, cranidium, the smallest specimen identified; dorsal, lateral, and anterior views. Y.P.M. *17998.*

20, 21, 22. Paratype, cranidium; dorsal, lateral, and anterior views. Y.P.M. *17999.*

23, 24, 25. Paratype, cranidium; anterior, lateral, and dorsal views. Y.P.M. *18000.*

26, 27, 32. Paratype, cranidium; lateral, anterior, and dorsal views. Y.P.M. *17996.*

28, 29. Paratype, free cheek; dorsal and lateral views. Y.P.M. *18001.*

30, 31. Paratype, free cheek; lateral and dorsal views. Y.P.M. *18002.*

Parahystricurus oculirotundus Ross, n. sp.
(Figures 33–35 x 8; 36–49 x 4; all specimens from Zone "F", locality 6)

Figs. 33, 34, 35. Paratype, cranidium, smallest specimen identified; dorsal, anterior, and lateral views. Y.P.M. *18007.*

36, 37, 38. Paratype, cranidium; dorsal, anterior, and lateral views. Y.P.M. *18005.*

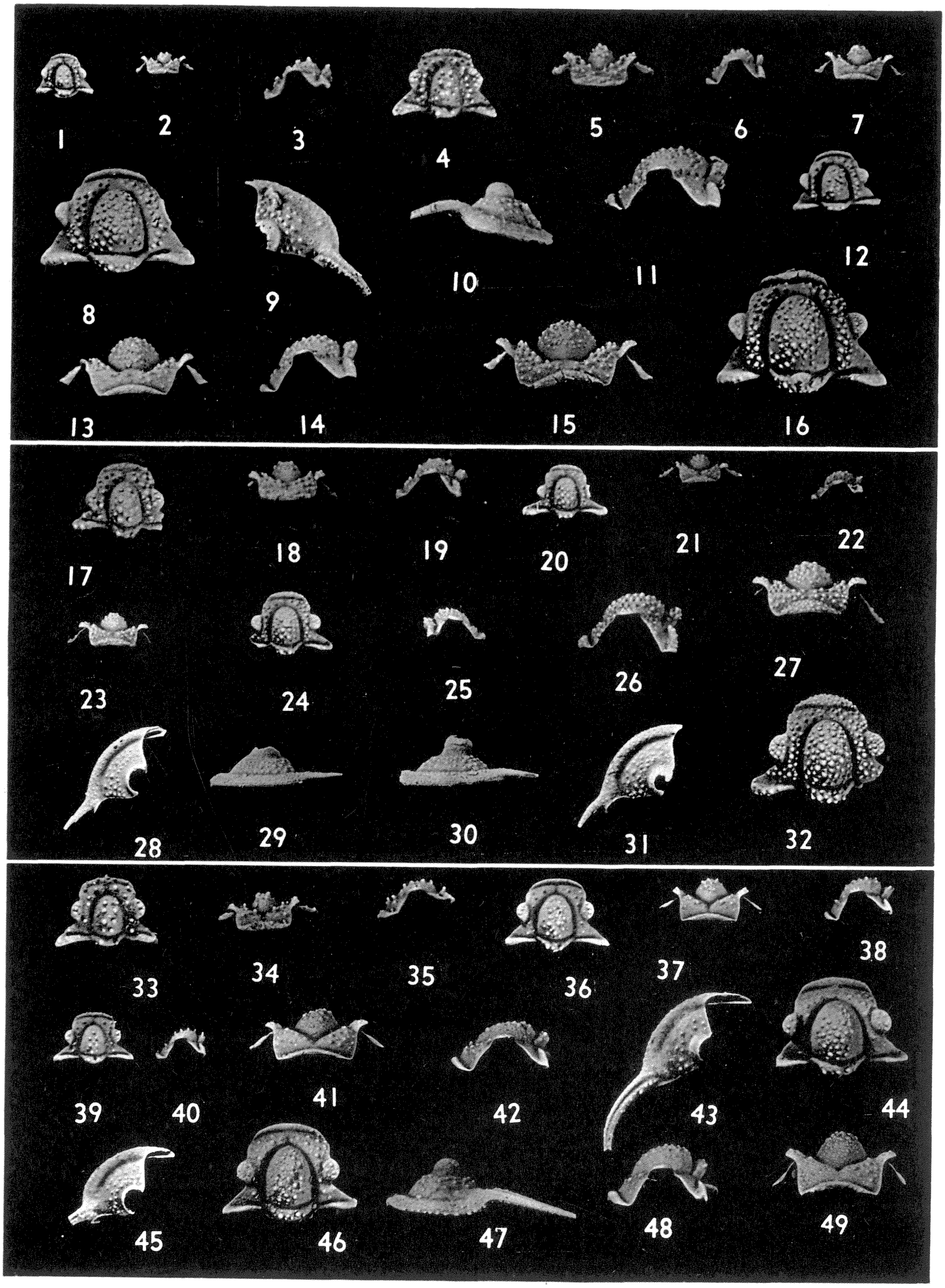
39, 40. Paratype, cranidium; dorsal and lateral views. Y.P.M. *18006.*

41, 42, 46. Paratype, cranidium; anterior, lateral, and dorsal views. Y.P.M. *18004.*

43, 47. Paratype, free cheek; dorsal and lateral views. Y.P.M. *18008.*

44, 48, 49. Holotype, cranidium; dorsal, lateral, and anterior views. Y.P.M. *18003.*

45. Paratype, free cheek; dorsal view. Y.P.M. *18009.*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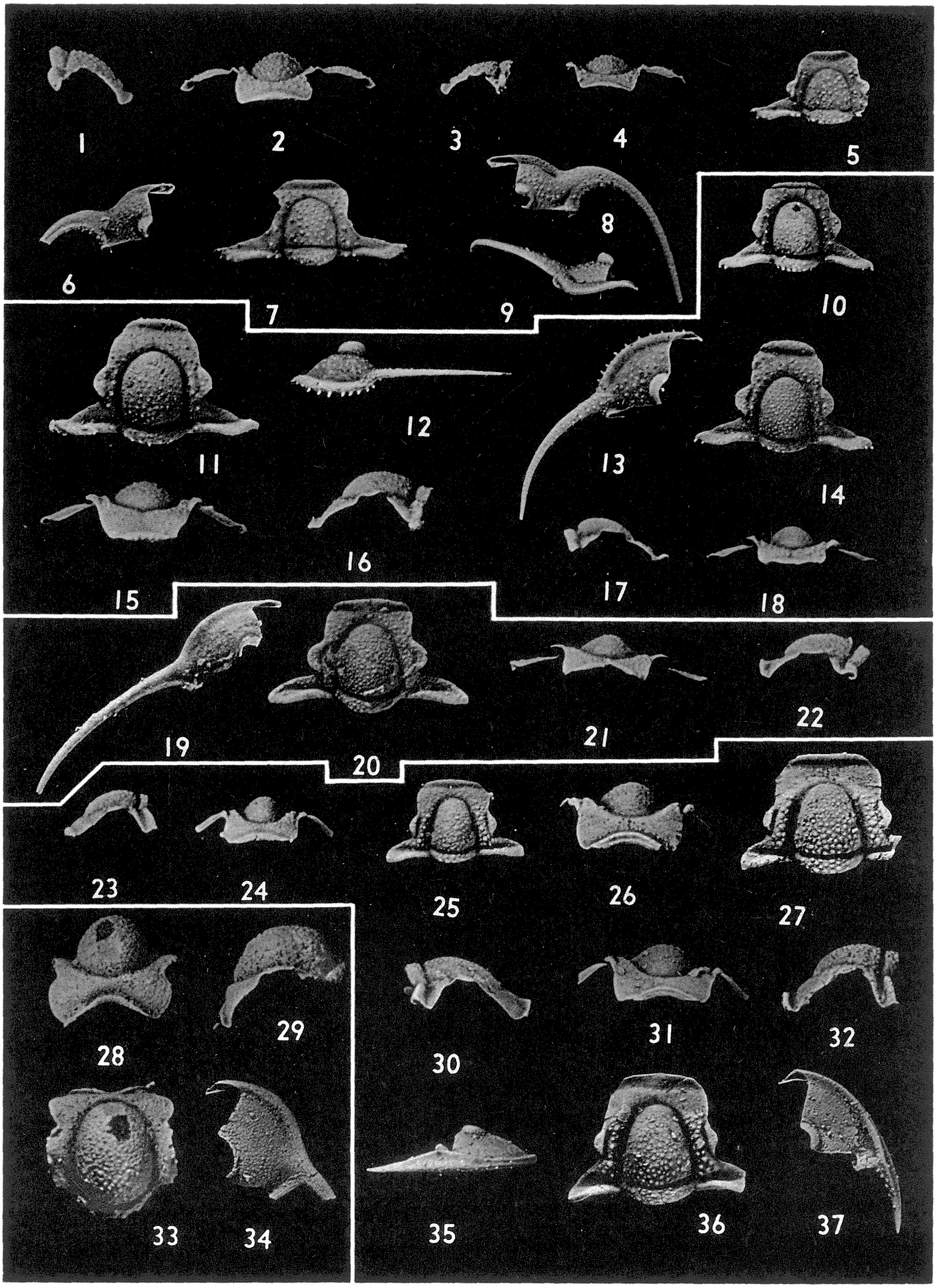
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PLATE 13

AMBLYCRANIUM, PARAHYSTRICURUS

Amblycranium cornutum Ross, n. sp.
(Figured specimens from Zone "F", locality 6)

Figs. 1, 2, 7. Paratype, cranidium, lacking palpebral lobes; lateral, anterior, and dorsal views, x 5. Y.P.M. *18015.*

3, 4, 5. Holotype, cranidium, lacking right postero-lateral limb; lateral, anterior, and dorsal views, x 4. Y.P.M. *18014.*

6. Paratype, free cheek, genal spine incomplete; dorsal view, x 4. Y.P.M. number not assigned, since specimen was accidentally smashed after photographing.

8, 9. Paratype, free cheek; x 5. Y.P.M. *18018.*

Amblycranium variabile Ross, n. gen. and sp.

Fig. 10. Cranidium, tentatively assigned to this species; possibly a variant intermediate between *A. variabile* and *A. cornutum.* Dorsal view, x 6. Y.P.M. *18021.* Zone "E", locality 5.

11, 15, 16. Paratype, cranidium; dorsal, anterior, and lateral views, x 6. Y.P.M. *18019.* Zone "E", locality 5.

12, 13. Paratype, free cheek; lateral and dorsal views, x 6. Y.P.M. *18022.* Zone "E", locality 5.

14, 17, 18. Holotype, cranidium; dorsal, lateral, and anterior views, x 6. Y.P.M. *18020.* Zone "E", locality 5.

Amblycranium ? populus Ross, n. sp.

Fig. 19. Paratype, free cheek, imperfectly preserved with posterior "corner" of eye and adjoining portion of ocular platform broken; dorsal view, x 4. Y.P.M. *18044.* Zone "E", locality 5.

20, 21, 22. Holotype, cranidium, with anterior limb slightly buckled; dorsal, anterior, and lateral views, x 6. Y.P.M. *18043.* Zone "E", locality 5.

Parahystricurus carinatus Ross, n. sp.

Figs. 23, 24, 25. Paratype, cranidium; lateral, anterior, and dorsal views, x 6. Y.P.M. *18012.* Zone "E", locality 5.

26, 27, 32. Holotype, cranidium; anterior, dorsal, and lateral views, x 4. Y.P.M. *18011.* Zone "E", locality 5.

30, 31, 36. Paratype, cranidium, very slightly deformed; lateral, anterior, and dorsal views, x 4. Y.P.M. *18010.* Zone "E", locality 5.

35, 37. Paratype, free cheek; lateral and dorsal views, x 4. Y.P.M. *18013.* Zone "E", locality 5.

Psalikilus ? sp.

Figs. 28, 29, 33. Cranidium, lacking postero-lateral limbs and palpebral rims; anterior, lateral, and dorsal views, x 4. Y.P.M. *18023.* Locality 7, zone indefinite (see text); tentatively placed in Zone "G(2)b".

34. Free cheek, lacking eye; dorsal view, x 4. Y.P.M. *18024.* Zone same as cranidium above.

PLATE 14

HYSTRICURUS, PARAHYSTRICURUS, ELEUTHEROCENTRUS

Hystricurus ? sp. G

Figs. 1, 2, 3. Cranidium, not well preserved; anterior, dorsal, and lateral views, x 10. Y.P.M. *18025*. Zone "B", locality 7, from the lowest beds of the zone.

Parahystricurus ? sp. B

Figs. 4, 6, 7. Cranidium; anterior, lateral, and dorsal views, x 6. Y.P.M. *18026*. Zone "B", locality 7.

Parahystricurus ? sp. A

Figs. 5, 8, 12. Cranidium; anterior, dorsal, and lateral views, x 6. Y.P.M. *18027*. Zone "B", locality 7.

Hystricurus ? sp. H

Figs. 9, 10, 13. Cranidium; anterior, lateral, and dorsal views, x 6. Y.P.M. *18028*. Zone "B", locality 7.

11, 14, 15. Cranidium; anterior, lateral, and dorsal views, x 10. Y.P.M. *18029*. Zone "B", locality 7.

Eleutherocentrus williamsi Ross, n. sp.

Figs. 16, 17. Paratype, pygidium, with tip of spine broken; dorsal and lateral views, x 5. Y.P.M. *18033*. Zone "J", locality 13.

18, 20, 21. Holotype, cranidium, lacking left postero-lateral limb; lateral, anterior, and dorsal views, x 6. Y.P.M. *18031*. Zone "J", locality 13.

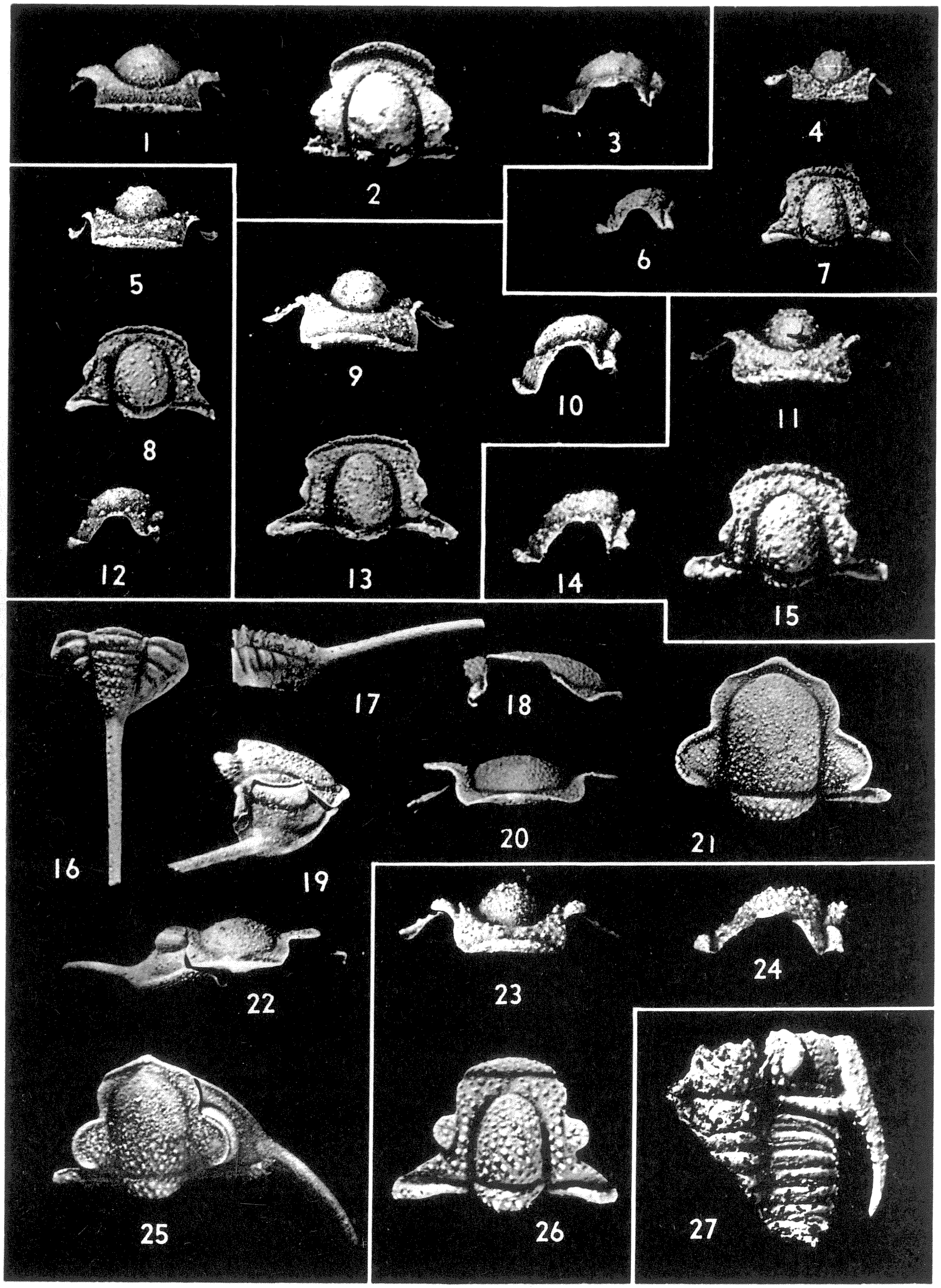
19, 22, 25. Paratype, cranidium with free cheek glued in place; free cheek not quite large enough to fit perfectly; lateral, anterior, and dorsal views, x 8. Y.P.M. *18032*. Zone "J", locality 13.

Parahystricurus pustulosus Ross, n. gen. and sp.

Figs. 23, 24, 26. Holotype, cranidium; anterior, lateral, and dorsal views, x 5. Y.P.M. *17995*. Zone "F", locality 6.

Hystricurus robustus Ross, n. sp.

Fig. 27. Paratype, fragmentary cephalon and thorax; dorsal view, x 10. Y.P.M. *18030*. Zone "E", locality 5.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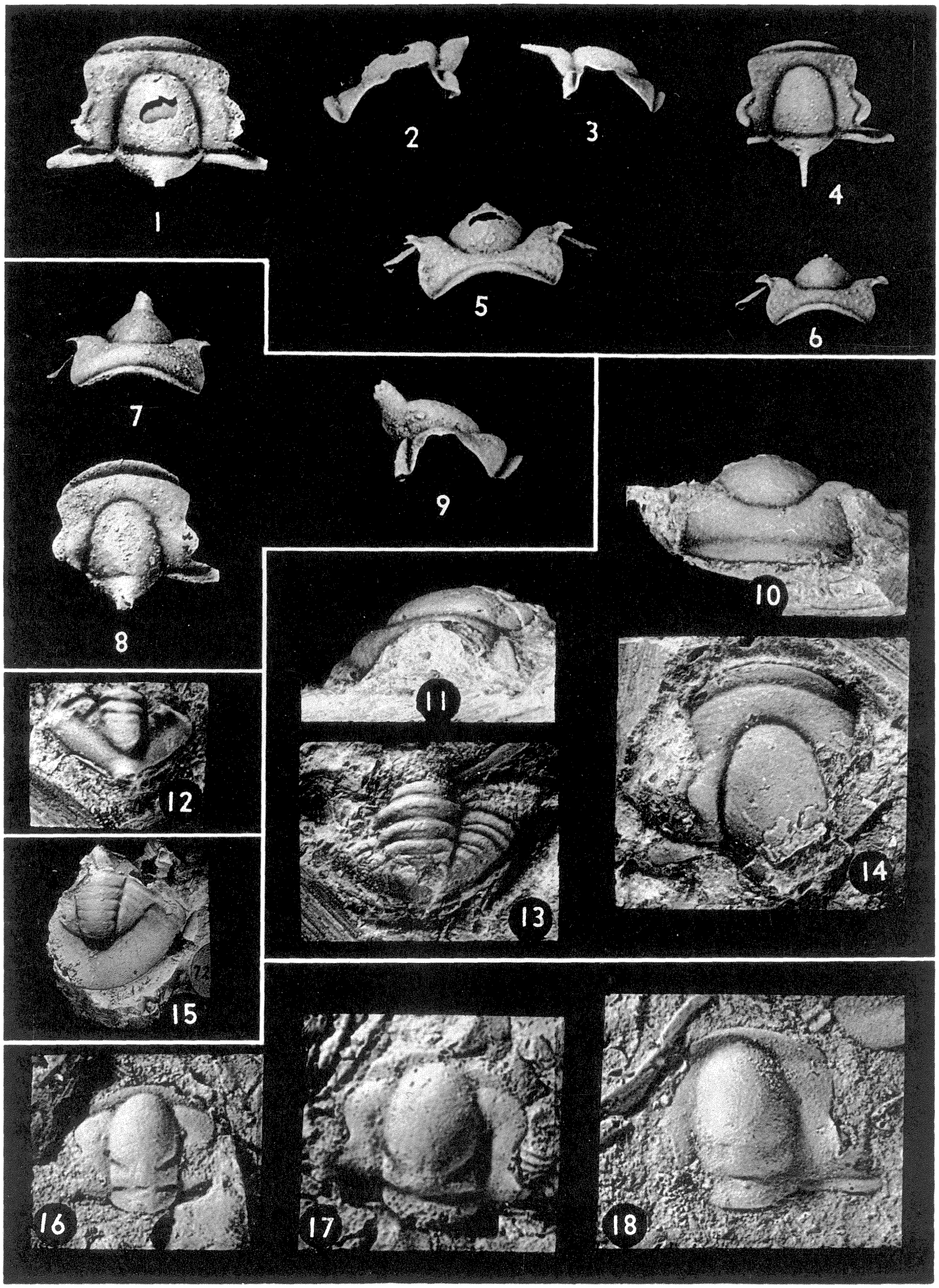
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PLATE 15

HYSTRICURUS, JEFFERSONIA, "SYMPHYSURUS ?"

	Hystricurus politus Ross, n. sp.
Figs. 1, 2, 5.	Paratype, cranidium; dorsal, lateral, and anterior views, x 4. Y.P.M. *17956*. Zone "B", locality 7.
3, 4, 6.	Holotype, cranidium; lateral, dorsal, and anterior views, x 4. Y.P.M. *17955*. Zone "B", locality 7.
	Hystricurus ? sp. F
Figs. 7, 8, 9.	Cranidium; anterior, lateral, and dorsal views, x 4. Y.P.M. *17957*. Zone "B", locality 7.
	Hystricurus ? sp. E
Figs. 10, 11, 14.	Cranidium; anterior, lateral, and dorsal views, x 3. Y.P.M. *18325*. Zone indefinite, 90 feet above base of Garden City formation, locality 13. Specimen in limestone matrix. Left palpebral rim damaged in preparation.
13.	Pygidium; dorsal view, x 3. Y.P.M. *18326*. Same zone as cranidium, locality 13. Matrix limestone.
	Goniotelus ? sp. (not described)
Fig. 12.	Small pygidium, showing stump of terminal spine not based on axis, but on rim; dorsal view, x 4. Zone "I", locality 3B.
	Jeffersonia missouriensis Cullison
Fig. 15.	Paratype, pygidium collected by Cullison from the same locality (his locality 75.2, 1944) as his holotype cranidium; dorsal view, x 1. Y.P.M. *17168*. Rich Fountain formation.
	"Symphysurus ? goldfussi" Walcott
Fig. 16.	Cranidium; dorsal view, x 4. Y.P.M. *18355*. Zone "M", locality 3B. Matrix quartzite.
17.	Cranidium; dorsal view, x 4. Y.P.M. *18357*. Zone "M", locality 3B. Matrix quartzite.
18.	Cranidium; dorsal view, x 4. Rubber cast of the original mold. Y.P.M. *18354*. Zone "M", locality 13. Matrix quartzite.

PLATE 16

HILLYARDINA, PACHYCRANIUM, PSEUDOHYSTRICURUS

Hillyardina semicylindrica Ross, n. gen. and sp.

Fig. 1. Paratype, cranidium; dorsal view, x 4. Y.P.M. *18034*. Zone "F", locality 6.

2, 8. Paratype, free cheek; dorsal and lateral views, x 4. Y.P.M. *18037*. Zone "F", locality 6.

3, 4, 9. Holotype, cranidium; lateral, dorsal, and anterior views, x 4. Y.P.M. *18035*. Zone "F", locality 6.

5, 6, 7. Paratype, cranidium, immature; lateral, anterior, and dorsal views, x 4. Y.P.M. *18036*. Zone "F", locality 6.

Amblycranium ? sp. (not described)

Fig. 10. Cranidium; dorsal view, x 8. Y.P.M. *18046*. Zone "E", locality 5.

14. Cranidium, poorly preserved; dorsal view, x 4. Y.P.M. *18045*. Zone "E", locality 5.

11, 15, 16. Cranidium, possibly a deformed specimen of *A. variabile* Ross, n. sp.; anterior, dorsal, and lateral views, x 8. Y.P.M. *18047*. Zone "E", locality 5

Pachycranium faciclunis Ross, n. gen. and sp.
(All specimens x 4, except that in figures 22, 28 which is x 6; specimens from Zone "F", locality 6.)

Figs. 12, 13, 17. Paratype, cranidium, immature; dorsal, anterior, and lateral views. Y.P.M. *18041*.

18, 20, 21. Paratype, cranidium; anterior, dorsal, and lateral views. Y.P.M. *18039*.

19. Paratype, cranidium; dorsal view. Y.P.M. *18040*.

22, 28. Paratype, free cheek; lateral and dorsal views, x 6. Y.P.M. *18042*.

23, 24, 29. Holotype, cranidium with tip of left postero-lateral limb broken; lateral, anterior, and dorsal views. Y.P.M. *18038*.

Pseudohystricurus obesus Ross, n. gen. and sp.

Figs. 25, 30, 34. Holotype, cranidium; lateral, anterior, and dorsal views, x 8. Y.P.M. *18049*. Zone "F", locality 6.

Pseudohystricurus sp.

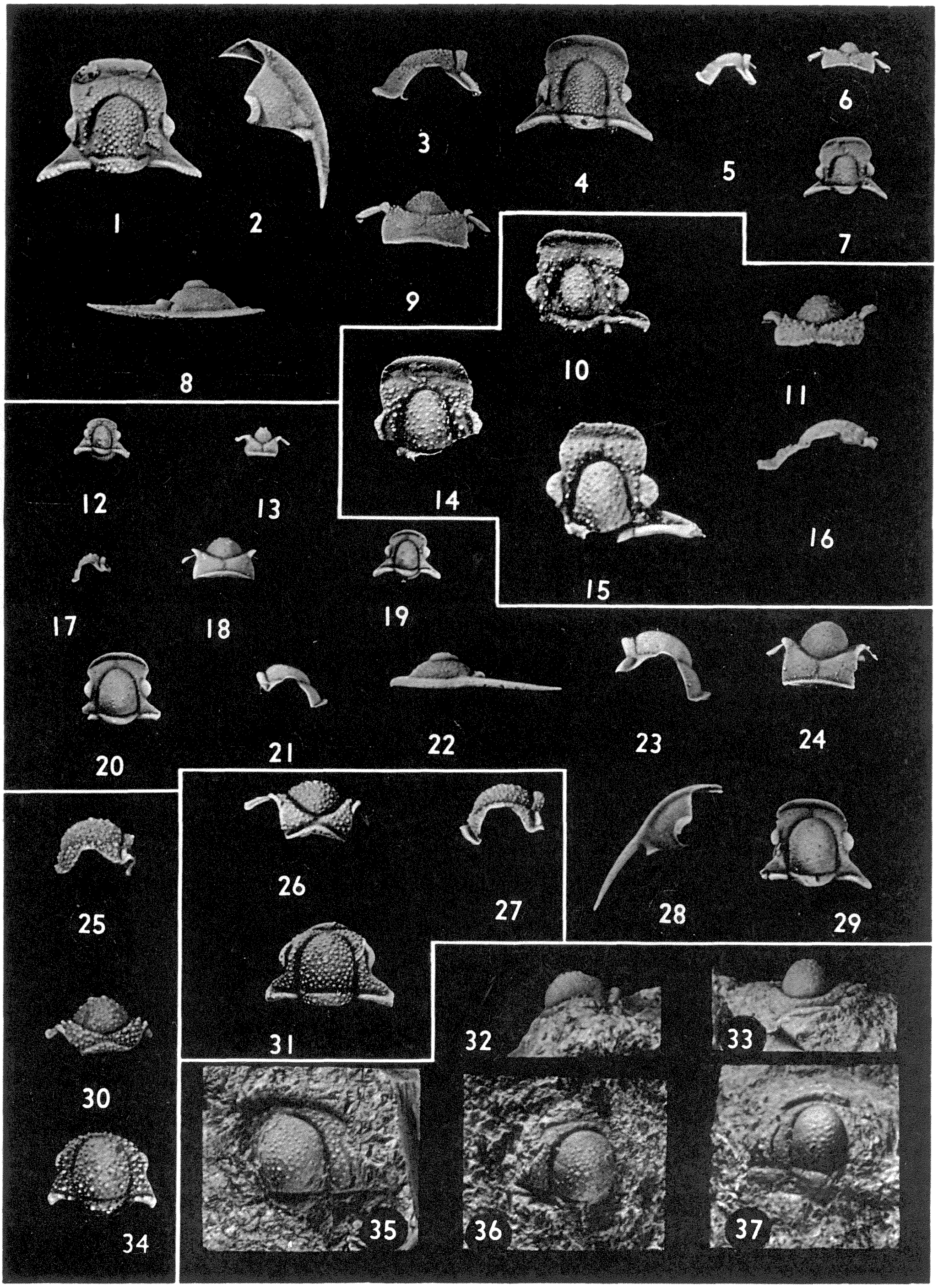
Figs. 26, 27, 31. Cranidium, the only specimen collected; anterior, lateral, and dorsal views, x 4. Y.P.M. *18050*. Zone "E", locality 5.

Pseudohystricurus rotundus Ross, n. sp.

Figs. 32, 33, 37. Holotype, cranidium; lateral, anterior, and dorsal views, x 6. Y.P.M. *18301*. Zone "A", locality 5.

35. Paratype, cranidium, poorly preserved; dorsal view, x 6. Y.P.M. *18304*. Zone "A", locality 5.

36. Paratype, cranidium, very poorly preserved; dorsal view, x 6. Y.P.M. *18305*. Zone "A", locality 5.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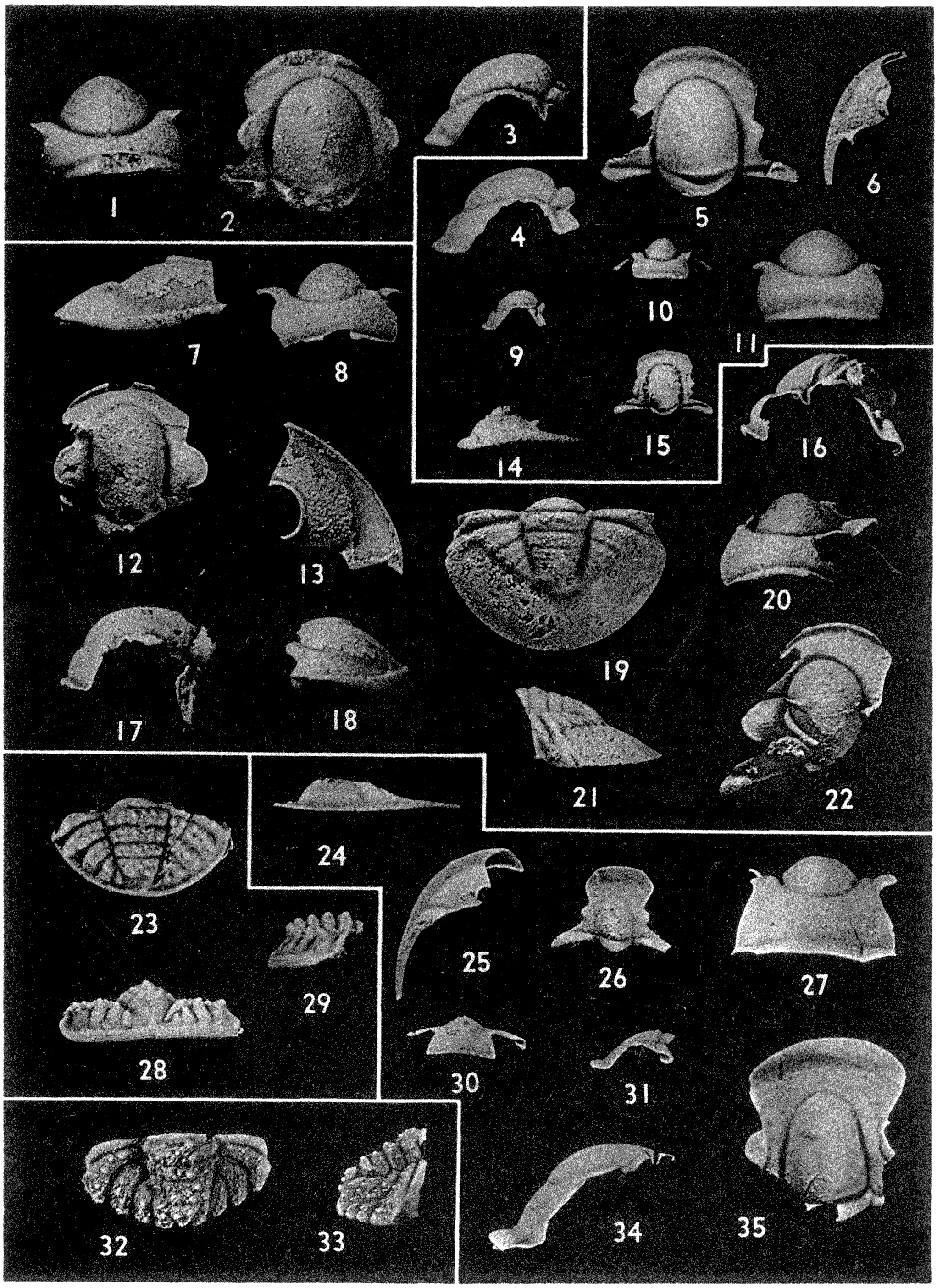

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PLATE 17

JEFFERSONIA, HYPERBOLOCHILUS, HYSTRICURUS ?, PACHYCRANIUM ?

Hystricurus ? sp. I

Figs. 1, 2, 3. Cranidium, with postero-lateral limbs imperfectly preserved; anterior, dorsal, and lateral views, x 3. Y.P.M. *18306*. Zone "C", locality 5. Matrix limestone. (These photographs retouched only to black out matrix.)

Pachycranium ? sp.

Figs. 4, 5, 11. Cranidium, lacking one palpebral lobe and both palpebral rims; lateral, dorsal, and anterior views, x 2. Y.P.M. *18307*. Zone "C", locality 5. (These photographs retouched only to black out limestone matrix.)

6, 14. Free cheek; dorsal and lateral views, x 4. Y.P.M. *18052*. Zone "C", locality 5.

9, 10, 15. Cranidium, immature, but complete; lateral, anterior, and dorsal views, x 4. Y.P.M. *18051*. Zone "C", locality 5.

Jeffersonia peltabella Ross, n. sp. (All specimens from Zone "G(2)e", locality 5)

Figs. 7, 13, 18. Paratype, free cheeks; anterior, dorsal, and lateral views, x 4. Y.P.M. *18055*.

8, 12, 17. Paratype, cranidium, imperfectly preserved, with left postero-lateral limb deformed; anterior, dorsal, and lateral views, x 3. Y.P.M. *18053*.

16, 20, 22. Paratype, cranidium, poorly preserved and distorted; lateral, anterior, and dorsal views, x 3. Y.P.M. *18054*.

19, 21. Holotype, pygidium; dorsal and lateral views, x 4. Y.P.M. *18056*.

Unassigned pygidia from Zone "F" (not described)

23, 28, 29. Dorsal, posterior, and lateral views, x 4. Probably referable to one of the associated species of *Hystricurus*. Y.P.M. *18061*. Locality 6.

32, 33. Dorsal and lateral views, x 4. Y.P.M. *18062*. Locality 6.

Hyperbolochilus marginauctum Ross, n. gen. and sp.

Figs. 24, 25. Paratype, free cheek; lateral and dorsal views, x 5. Y.P.M. *18059*. Zone "F", locality 6.

26, 30, 31. Paratype, cranidium, immature; dorsal, anterior, and lateral views, x 4. Y.P.M. *18058*. Zone "F", locality 6.

27, 34, 35. Holotype, cranidium, with postero-lateral limbs lacking and brim very slightly deformed; dorsal, lateral, and anterior views, x 4. Y.P.M. *18057*. Zone "F", locality 6.

PLATE 18

PAENEBELTELLA, PYRAUSTOCRANIUM, GONIOPHRYS, CAROLINITES

Paenebeltella vultulata Ross, n. gen. and sp.

Figs. 1, 2, 5. Holotype, cranidium with free cheek glued in place; dorsal, lateral, and anterior views, x 4. Y.P.M. *18063*. Zone "E", locality 5. Genal spine encrusted with foreign siliceous material which cannot be removed; slightly retouched in these photographs.

6. Paratype, cranidium, immature; dorsal view, x 6, showing peculiar double ocular ridges found only in one or two specimens. Y.P.M. *18064*. Zone "E", locality 5.

Pyraustocranium orbatum Ross, n. gen. and sp.

Figs. 3, 4, 7, 8. Holotype, cranidium; dorsal, anterior, right lateral, and left lateral views, x 3; right palpebral lobe lacking, apparent glabellar furrows caused by slight deformation. Y.P.M. *18072*. Zone "F", locality 6.

10, 16. Paratype, free cheek with antero-proximal extension of doublure and rim broken off; dorsal and lateral views, x 4, showing the rotund eye. Y.P.M. *18071*. Zone "F", locality 6.

11. Paratype, free cheek lacking only the eye; dorsal view, x 4. Y.P.M. *18069*. Zone "F", locality 6.

12, 13, 14. Paratype, cranidium, immature; dorsal, lateral, and anterior views, x 8. Y.P.M. *18067*. Zone "F", locality 6.

Goniophrys prima Ross, n. gen. and sp.

Figs. 9, 15, 17. Holotype, cranidium with occipital ring damaged, but with part of one thoracic segment attached; anterior, lateral, and dorsal views, x 6. Y.P.M. *18075*. Zone "F", locality 6.

18. Paratype, free cheek, lacking the eye and most of the genal spine; dorsal view, x 6. Y.P.M. *18074*. Zone "F", locality 6.

19, 20, 22. Paratype, pygidium; dorsal, lateral, and posterior views, x 6. Y.P.M. *18076*. Zone "F", locality 6. Foreign silicified material not removable from right side of specimen.

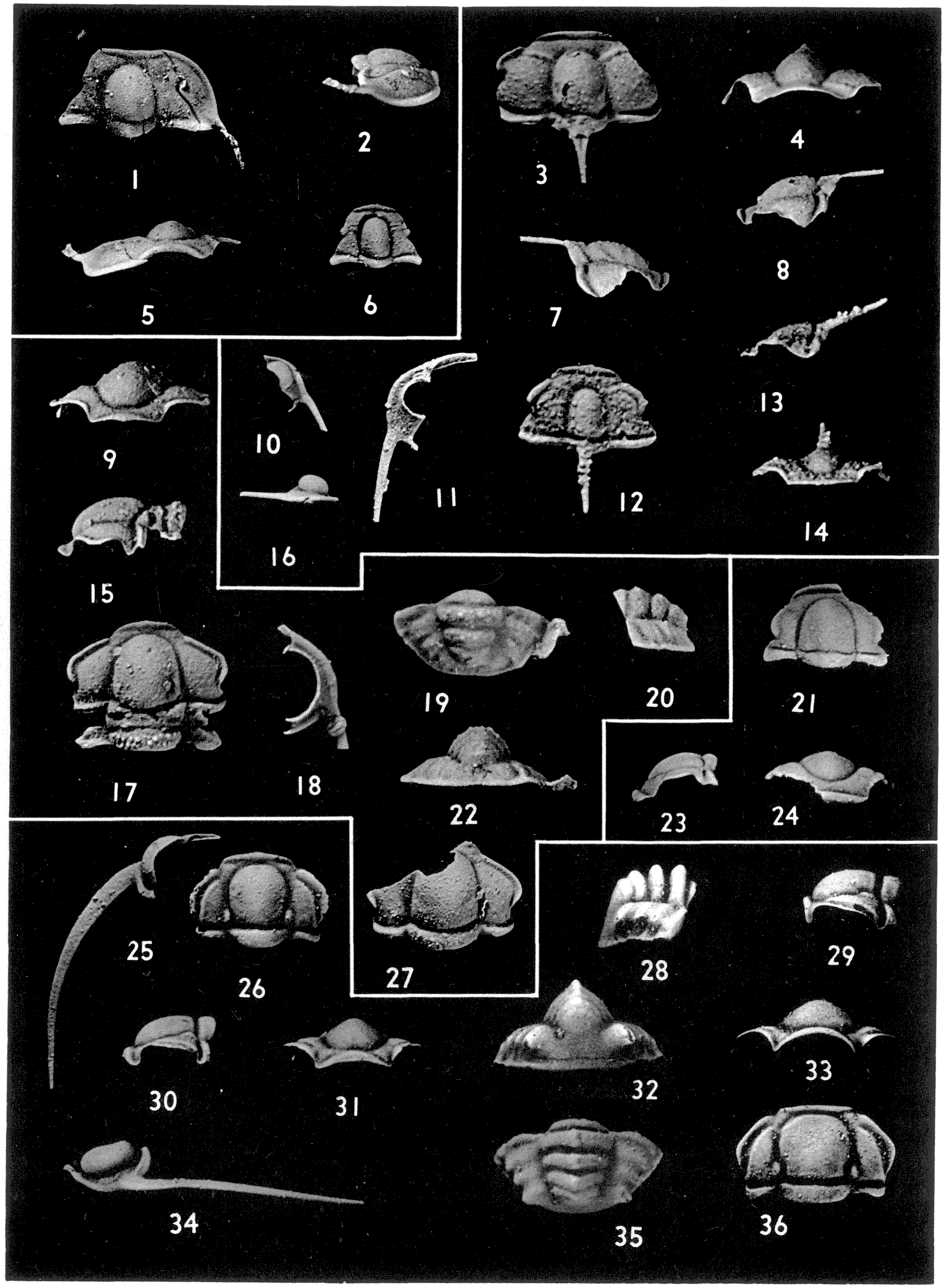
27. Paratype, cranidium with anterior portion broken, but showing posterior portion better than holotype; dorsal view, x 4. Y.P.M. *18073*. Zone "F", locality 6.

Undetermined genus and species A.

21, 23, 24. Cranidium with right half of brim broken; dorsal, lateral, and anterior views, x 4. Y.P.M. *18077*. Zone "F", locality 6.

Carolinites genacinaca Ross, n. sp.

Figs. 25, 26, 28–36. All specimens from Zone "J", locality 8.
(25, 34) Paratype, free cheek, x 6; Y.P.M. *18083*. (26, 30, 31) Paratype, cranidium, x 6; Y.P.M. *18082*. (28, 32, 35) Paratype, pygidium, x 10; Y.P.M. *18084*. (29, 33, 36) Holotype, cranidium, x 6; Y.P.M. *18081*.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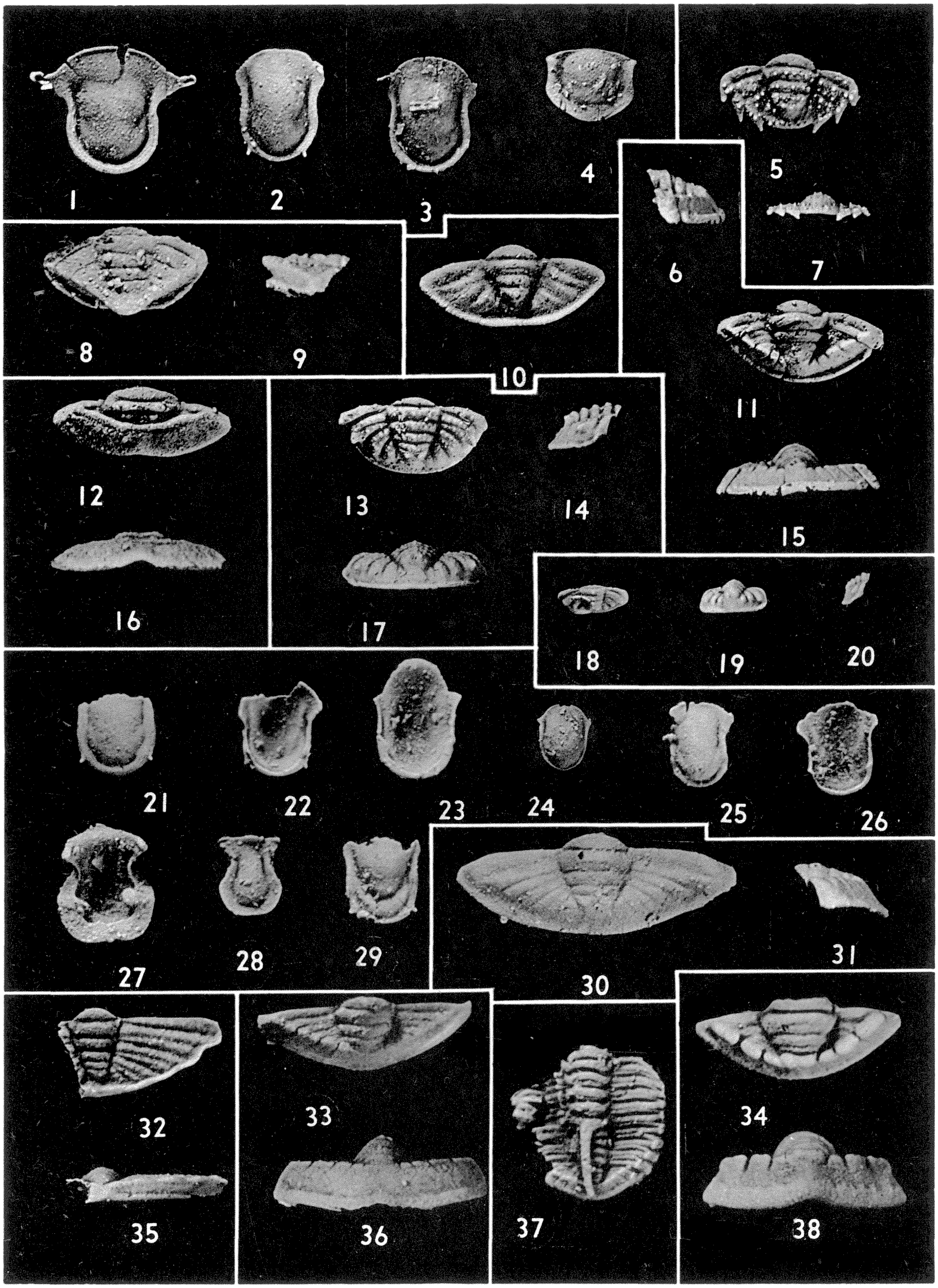
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PLATE 19

UNASSIGNED PYGIDIA AND HYPOSTOMES, ZONES "E" AND "F"

Four unassigned hypostomes, Zone "E", locality 5. (Not described)

Figs. 1–4. (1) x 8, Y.P.M. *18085*. (2) x 10, Y.P.M. *18086*. (3) x 8, Y.P.M. *18087*. (4) x 6, Y.P.M. *18088*.

Paenebeltella vultulata Ross, n. gen. and sp.

Figs. 10. Pygidium assigned with some confidence to this species; dorsal view, x 8. Y.P.M. *18089*. Zone "E", locality 5.

Six unassigned pygidia, Zone "E", locality 5. (Not described)

Figs. 5, 7. Pygidium similar to those of *Protopeltura;* dorsal and posterior views, x 6. Y.P.M. *18079*. May prove to be the correct pygidium for *Paenebeltella vultulata* Ross, n. sp.

8, 9. Pygidium; dorsal and lateral views, x 6. Y.P.M. *18078*.

6, 11, 15. Pygidium; lateral, dorsal, and posterior views, x 4. Y.P.M. *18090*. Possibly referable to *Parahystricurus carinatus* Ross, n. sp.

12, 16. Pygidium; dorsal and posterior views, x 8. Y.P.M. *18091*.

13, 14, 17. Pygidium; dorsal, lateral, and posterior views, x 4. Y.P.M. *18092*. Probably referable to an associated species of *Hystricurus*. (It is of interest that an identical pygidium is in the collections of the U.S. National Museum from the Knox dolomite, U.S.G.S. locality 332 F.)

18, 19, 20. Pygidium; dorsal, posterior, and lateral views, x 6. Y.P.M. *18093*.

Five unassigned hypostomes, Zone "F", locality 6, all x 8. (Not described)

Figs. 21–29. (21, 22) Venter and dorsum of two specimens; Y.P.M. *18094, 18095*. (23, 24) Venter and dorsum of two specimens; Y.P.M. *18096, 18097*. (25, 26) Venter and dorsum of two specimens; Y.P.M. *18098, 18099*. (27, 28) Dorsum and venter of two specimens; Y.P.M. *18100, 18101*. (29) Venter, Y.P.M. *18102*.

Four unassigned pygidia, Zone "F", locality 6. (Not described)

Figs. 30, 31. Pygidium possibly referable to *Pyraustocranium orbatum* Ross, n. sp.; dorsal and lateral views, x 4. Y.P.M. *18103*.

32, 35. Pygidium partly damaged; dorsal and posterior views, x 5. Y.P.M. *18104*. Note overhanging margin.

33, 36. Pygidium; dorsal and posterior views, x 8. Y.P.M. *18105*.

37. Thorax and pygidium of the species above, possessing nine thoracic segments with a long dorsal spine on the fifth segment; dorsal view, x 8. Y.P.M. *18221*.

34, 38. Pygidium, similar to but not conspecific with those in figures 33, 36, and 37; x 12. Y.P.M. *18106*.

PLATE 20

REMOPLEURIDIELLA, MENOPARIA, SCINOCEPHALUS

Remopleuridiella caudalimbata Ross, n. gen. and sp.
(All figured specimens from Zone "B", locality 6; all x 4)

Figs. 1, 2, 3. Holotype, cranidium, coarsely silicified, lacking postero-lateral limbs and part of right palpebral lobe. Y.P.M. *18108.*

4, 5, 9. Paratype, cranidium, lacking postero-lateral limbs. Y.P.M. *18109.*

6. Paratype, cranidium, damaged but retaining delicate postero-lateral limb. Y.P.M. *18110.*

7. Paratype, free cheek, retaining most of the inflated eye; dorsal view. Y.P.M. *18112.*

8. Paratype, free cheek, lacking the eye. Y.P.M. *18111.*

10. Paratype, cranidium; ventral view, showing "doublure-like" character of under side of palpebral lobes and complete lack of glabellar furrows. Y.P.M. *18107.*

11, 12. Paratype, pygidium; dorsal and lateral views. Y.P.M. *18115.*

Menoparia genalunata Ross, n. gen. and sp.
(All figured specimens from locality 6)

Figs. 13, 14, 21–22. From Zone "G(2)a". (13) Paratype, free cheek, x 6; Y.P.M. *18119.* (14, 21) Paratype, cranidium, x 8; Y.P.M. *18118.* (20, 22) Paratype, pygidium, x 8; Y.P.M. *18120.*

Figs. 15–19. From Zone "G(1)". (15, 16) Paratype, pygidium, x 6; Y.P.M. *18117.* (17, 18, 19) Paratype, cranidium, x 8; Y.P.M. *18116.*

Figs. 23, 24, 28, 29, 34, 35. From Zone "G(2)c". (23, 24, 28) Holotype, cranidium, x 6; Y.P.M. *18122.* (29) Paratype, free cheek, x 8; Y.P.M. 18123. (34, 35) Paratype, pygidium, x 6; Y.P.M. 18124.

Scinocephalus solitecti Ross, n. gen. and sp.

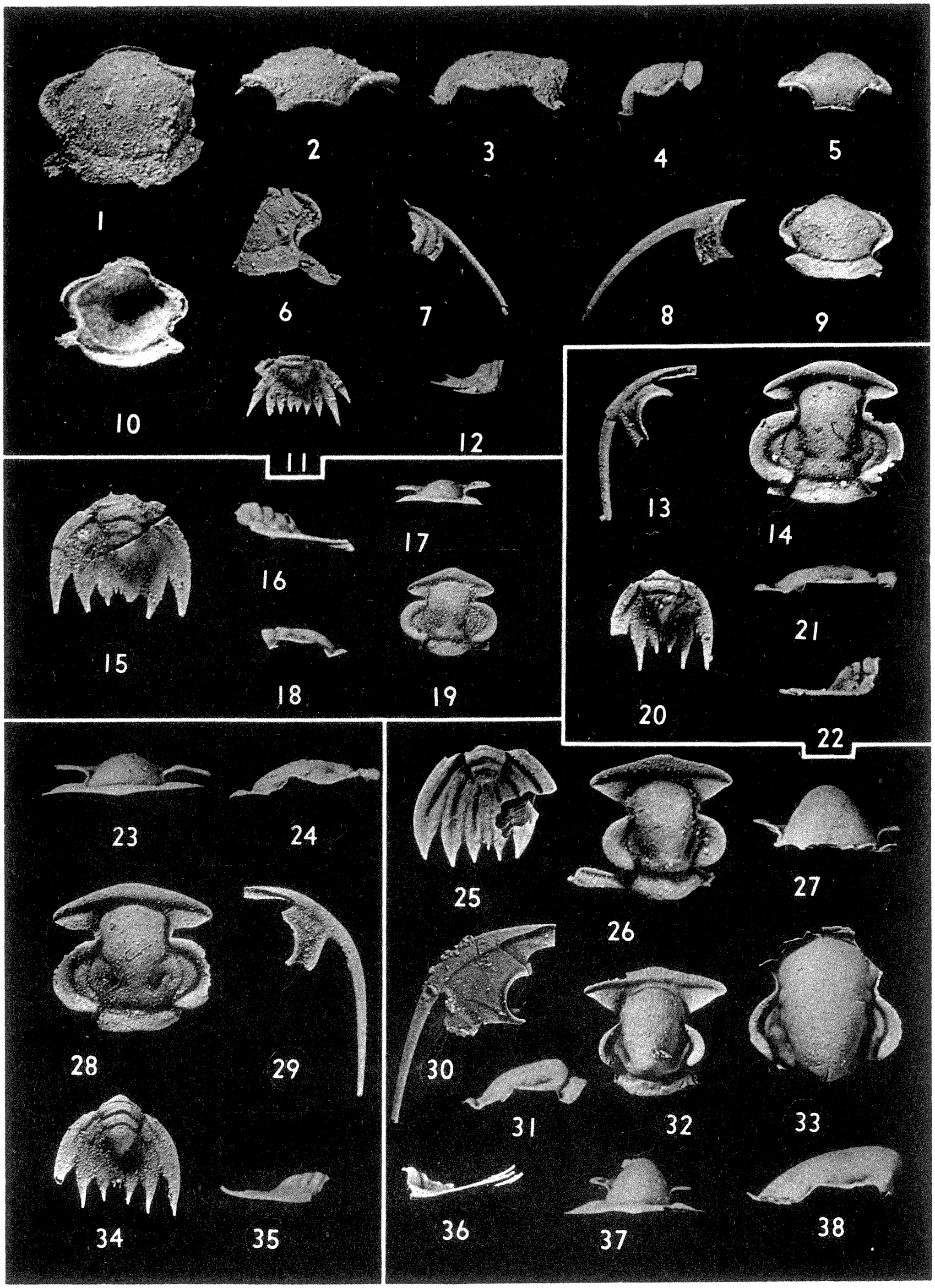
Figs. 25, 36. Paratype, pygidium; dorsal and lateral views, x 4. Y.P.M. *18121.* Note only a single median spine between the third, large pair of pleural spines. Zone "G(2)a", locality 6.

26. Paratype, cranidium; dorsal view, x 8, showing shape of one retained postero-lateral limb. Y.P.M. *18130.* Zone "G(2)a", locality 5.

27, 33, 38. Paratype, partially preserved cranidium; anterior, dorsal, and lateral views, x 4, showing shape of glabella and peculiar development of glabellar furrows. Y.P.M. *18126.* Zone "G(2)a", locality 6.

30. Paratype, free cheek; dorsal view, x 4. Y.P.M. *18128.* Zone "G(2)a", locality 6. Note great development of ventral doublure and slight line of flexure between posterior end of eye and genal angle.

31, 32, 37. Holotype, cranidium, lacking postero-lateral limbs; lateral, dorsal, and anterior views, x 4. Y.P.M. *18125.* Zone "G(2)a", locality 6.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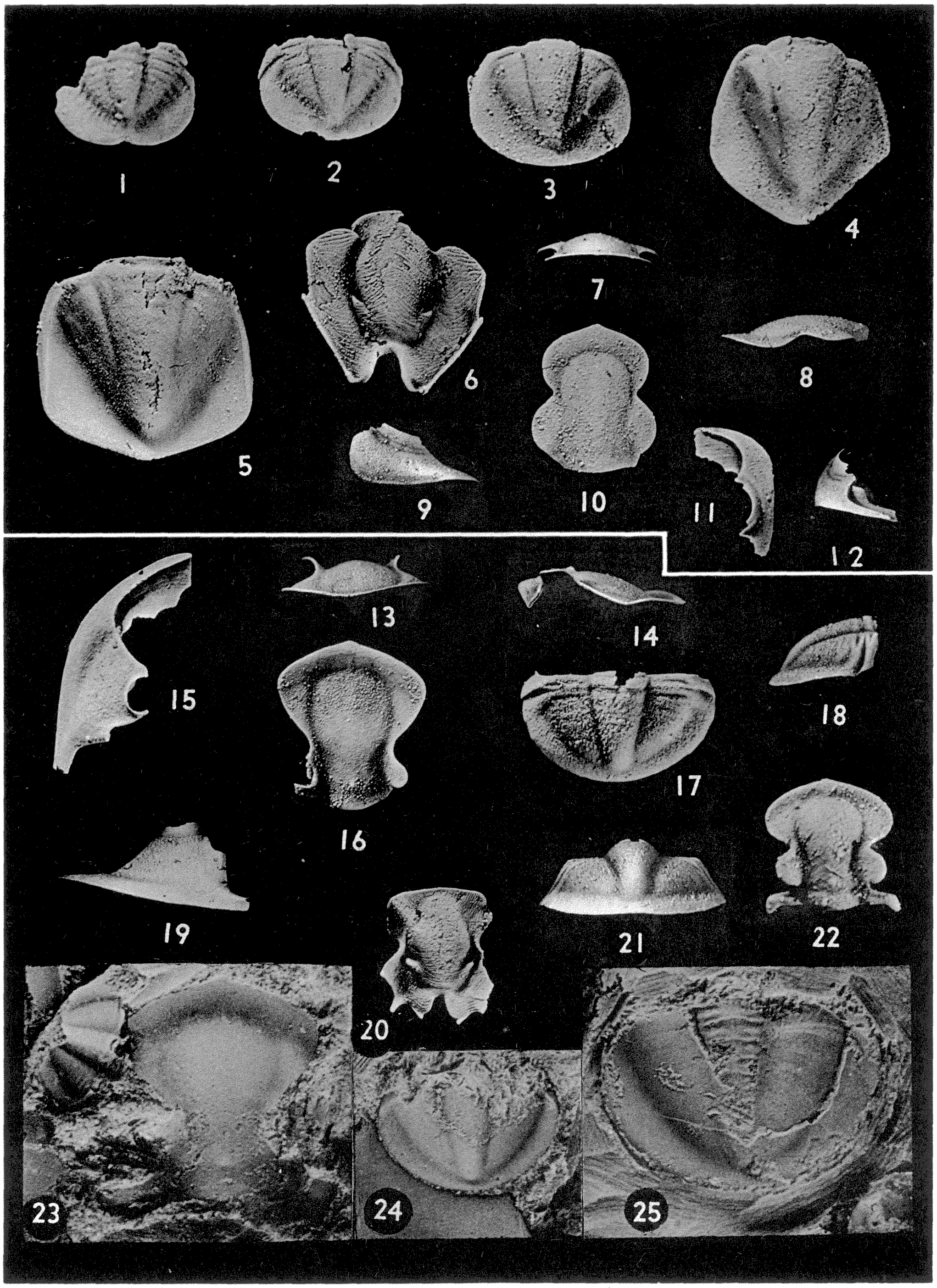
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PLATE 21

KIRKELLA, LACHNOSTOMA

Kirkella declevita Ross, n. sp.

Fig. 1. Paratype, immature pygidium; dorsal view of the smallest identified specimen, x 10. Y.P.M. *18133*. Zone "J", locality 13.

2. Paratype, immature pygidium; dorsal view of a slightly larger specimen, x 7. Y.P.M. *18134*. Zone "J", locality 13.

3. Paratype, immature pygidium; dorsal view of a specimen not quite large enough to have attained the characteristic pentagonal outline of the adult, x 7. Y.P.M. *18136*. Zone "J", locality 13.

4. Paratype, pygidium, slightly deformed by lateral compression and with right postero-lateral "corner" broken off; dorsal view, x 6. Y.P.M. *18137*. Zone "J", locality 13.

5. Holotype, pygidium; dorsal view, x 4. Y.P.M. *18138*. Zone "J", locality 13.

6. Paratype, hypostome; ventral view, showing the straight, rod-like postero-lateral rims of the wings, x 4. Y.P.M. *18140*. Zone "J", locality 13.

7, 8, 10. Paratype, cranidium, lacking postero-lateral limbs; anterior, lateral, and dorsal views, x 6. Y.P.M. *18139*. Zone "J", locality 13.

9, 11, 12. Paratype, free cheek; lateral, dorsal, and anterior views, x 6. Y.P.M. *18141*. Zone "J", locality 13.

Lachnostoma latucelsum Ross, n. gen. and sp.

Figs. 15, 19. Paratype, free cheek; eye and part of genal spine lacking, doublure damaged; dorsal and lateral views, x 4. Y.P.M. *18145*. Zone "J", locality 13.

13, 14, 16. Paratype, cranidium, lacking postero-lateral limbs; anterior, lateral, and dorsal views, x 6. Y.P.M. *18142*. Zone "J", locality 13.

17, 18, 21. Paratype, pygidium, immature, with anterior segment in process of being shed into thorax; dorsal, lateral, and posterior views, x 8. Y.P.M. *18146*. Zone "J", locality 13.

20. Holotype, hypostome; ventral view, x 4. Y.P.M. *18144*. Zone "J", locality 13.

22. Paratype, cranidium; dorsal view, x 6, showing shape of postero-lateral limb; rim deformed and palpebral lobes broken. Y.P.M. *18367*. Zone "J", locality 13.

23. Paratype, cranidium; dorsal view, x 4. Y.P.M. *18308*. Zone "J", locality 5. Limestone matrix.

24. Paratype, pygidium; dorsal view, x 3, showing complete lack of segmentation on dorsal surface. Y.P.M. *18309*. Zone "J", locality 5. Limestone matrix.

25. Paratype, pygidium; dorsal view, x 1.5, showing faint segmentation appearing only on decorticated surface. Y.P.M. *18310*. Zone "J", locality 5. Limestone matrix.

PLATE 22

BELLEFONTIA, LACHNOSTOMA, KIRKELLA

Bellefontia chamberlaini Clark

Figs. 1, 2. Dorsal views of a large cranidium showing raised ridges, apparently for muscle insertion; ridges marked in ink for ease of determination in figure 1. (x 1). Y.P.M. *18331*. Zone "B", locality 11

Lachnostoma latucelsum Ross, n. sp.
(Specimens from Zone "J", locality 13)

Fig. 3. Paratype, free cheek, ventral view showing extent of doublure beneath ocular platform; x 6. Y.P.M. *18362*.

6. Free cheek, fragmental; ventral view showing double ridges and elliptical Panderian opening; x 6. Y.P.M. *18359*.

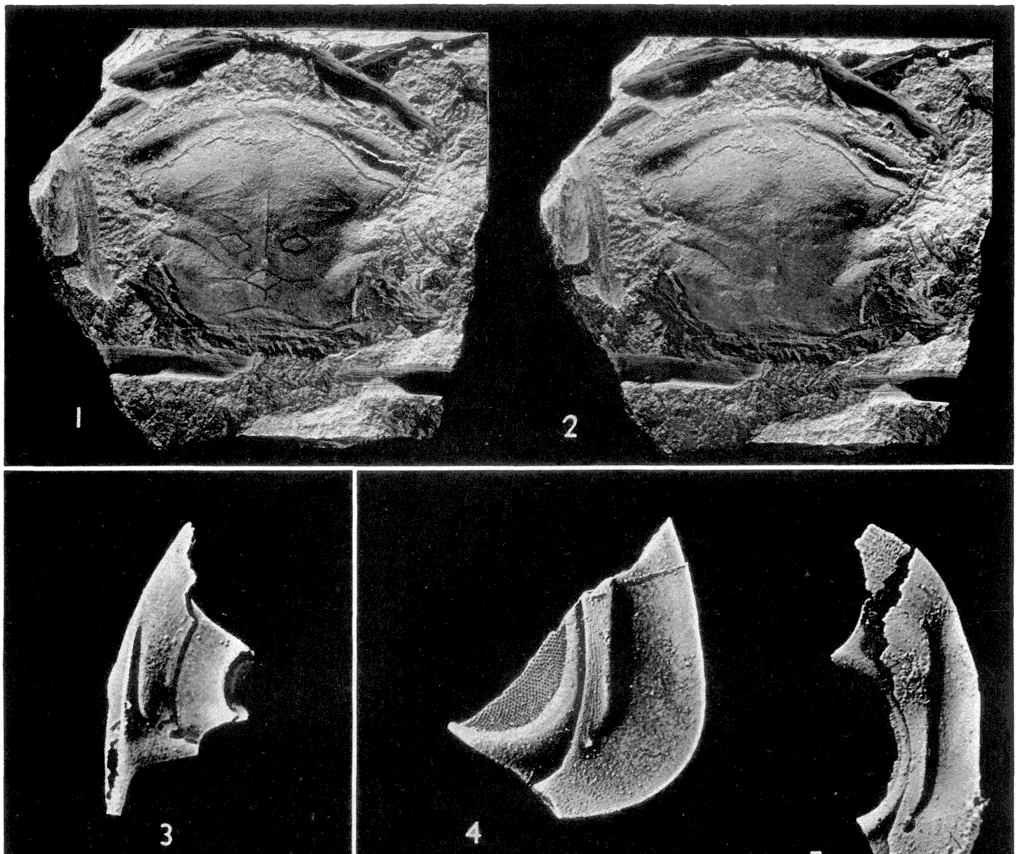
7. Paratype, free cheek, fragmental; ventral view, showing slight lip around Panderian opening and lack of "hood" or boss, x 6. Y.P.M. *18358*.

8. Paratype, free cheek, fragmental; ventral view, showing hypostomal suture and full length of genal spine, x 6. Y.P.M. *18363*.

Kirkella declevita Ross, n. sp.
(Specimens from Zone "J", locality 13)

Fig. 4. Paratype, free cheek, fragmental; ventral view showing posterior portion of cheek, wide doublure, single ridge, "hooded" Panderian opening, and eye lenses, x 6. Y.P.M. *18360*.

5. Paratype, free cheek, damaged; ventral view showing anterior end of ridge on doublure, x 6. Y.P.M. *18361*.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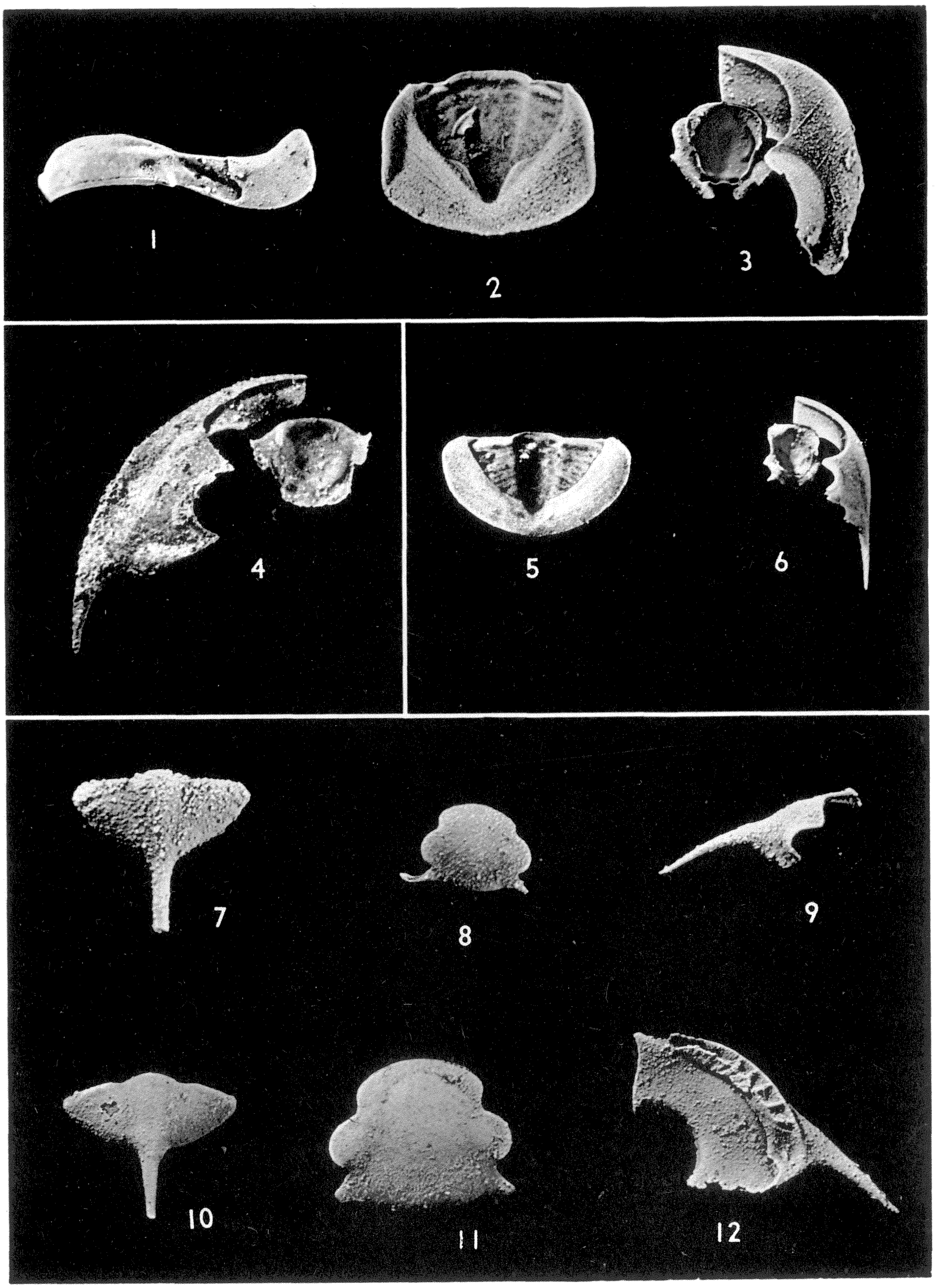
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PLATE 23

KIRKELLA, BELLEFONTIA, LACHNOSTOMA, SYMPHYSURINA

Kirkella declevita Ross, n. sp.
(Specimens from Zone "J", locality 13)

Fig. 1. Paratype, thoracic segment, left pleuron and axis; ventral view, showing doublure and "hooded" Panderian opening; approx. x 6. Y.P.M. *18365.*

2. Paratype, pygidium; ventral view showing extensive doublure, x 6. Y.P.M. *18364.*

3. Paratype, free cheek with hypostome glued in place; dorsal view, x 6. Y.P.M. *18366.*

Bellefontia chamberlaini Clark.
(Specimens from Zone "B", locality 7)

Fig. 4. Free cheek and hypostome; dorsal view showing relative positions of each, x 4. Y.P.M. *18373, 18374.*

Lachnostoma latucelsum Ross, n. sp.
(Specimens from Zone "J", locality 13)

Fig. 5. Paratype, pygidium; ventral view, showing extent of doublure, x 6. Y.P.M. *18369.*

6. Paratype, free cheek with hypostome glued in place; dorsal view, x 6. Y.P.M. *18368.*

Symphysurina cf. *S. woosteri* Walcott.
(Specimens from Zone "A", locality 7)

Fig. 7. Immature pygidium; dorsal view, x 9. Y.P.M. *18380.*

8. Immature cranidium; dorsal view, showing "undertwisted" form of postero-lateral limb, x 9. Y.P.M. *18378.*

9. Immature free cheek; dorsal view, x 6. Y.P.M. *18379.*

10. Pygidium; dorsal view, x 4. Y.P.M. *18377.*

11. Cranidium, probably immature, lacking median pustule and showing practically no definition of glabella; dorsal view, x 4. Y.P.M. *18375.*

12. Free cheek; ventral view showing the pits of the doublure characteristic of the genus, x 6. Y.P.M. *18376.* It should be noted that Ulrich's original contention (Walcott, 1925, p. 115, pl. 21) that these pits seated the tips of the pleura during enrollment is a mechanical impossibility.

PLATE 24

BELLEFONTIA, XENOSTEGIUM

(All figured specimens from Zone "B"; figures 3, 4 from locality 6, figure 13 from locality 5, and all others from locality 7)

Bellefontia chamberlaini Clark.

Fig. 1. Cranidium, silicified but decorticated; dorsal view, x 1.5. Postero-lateral limbs broken. Y.P.M. *18229*.

2. Free cheek; dorsal view, x 1.5. Y.P.M. *18232*.

3, 4. Cranidium of immature individual; dorsal view, x 3, showing shape of postero-lateral limbs. Y.P.M. *18166*.

5. Cranidium; dorsal view, x 3. Y.P.M. *18161*.

6. Free cheek; dorsal view, x 4. Y.P.M. *18231*.

7. Cranidium; dorsal view, x 4. Y.P.M. *18230*.

Xenostegium franklinense Ross, n. sp.

Fig. 8. Cranidium; dorsal view, x 4. Y.P.M. *18233*.

9. Free cheek; dorsal view, x 5. Y.P.M. *18158*.

10. Cranidium; dorsal view, x 5. Y.P.M. *18162*.

11. Free cheek; dorsal view, x 4. Y.P.M. *18337*.

12. Free cheek, damaged but with doublure perfectly preserved; dorsal view, x 3. Y.P.M. *18336*.

13. Cranidium, imperfectly preserved in limestone matrix; dorsal view, x 1, showing faint areas or ridges for muscle attachment. Y.P.M. *18319*.

14. Cranidium, fragmentary but preserving features of rim; dorsal view, x 3. Y.P.M. *18335*.

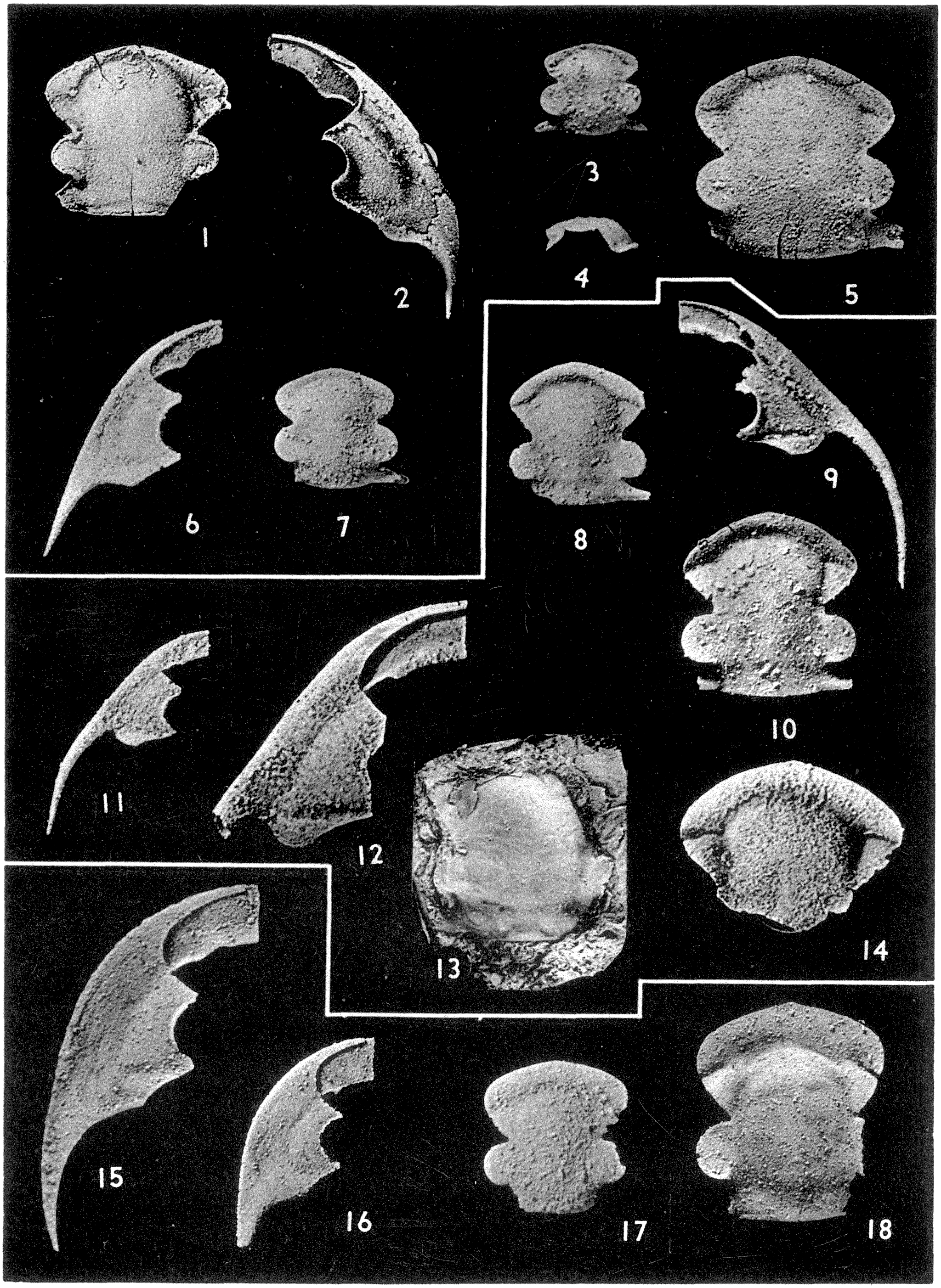
Bellefontia ? *acuminiferentis* Ross, n. sp.

Fig. 15. Free cheek; dorsal view, x 4. Y.P.M. *18163*.

16. Free cheek; dorsal view, x 4. Y.P.M. *18339*.

17. Cranidium, lacking postero-lateral limbs; dorsal view, x 4. Y.P.M. *18338*.

18. Cranidium, damaged; dorsal view, x 4. Y.P.M. *18157*.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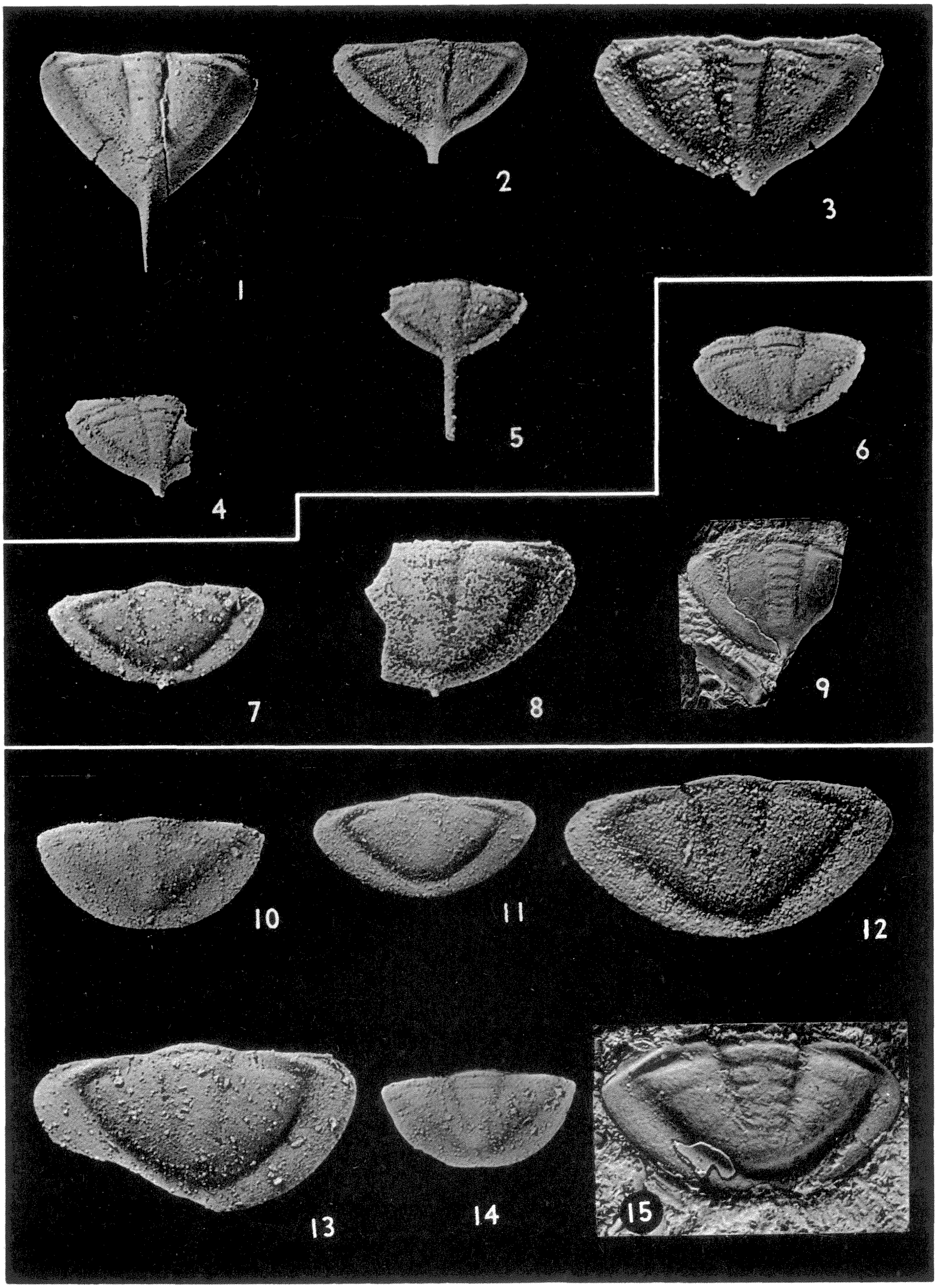
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PLATE 25

BELLEFONTIA, XENOSTEGIUM

(All specimens from Zone "B", figures 9, 15 from locality 5, all others from locality 7.)

Xenostegium franklinense Ross, n. sp.

Fig. 1. Paratype, pygidium, slightly deformed by lateral compression to appear narrower than undeformed specimens; dorsal view, x 2. Y.P.M. *18343*.

2. Holotype, pygidium, with terminal spine broken; dorsal view, x 4. Y.P.M. *18159*.

3. Paratype, pygidium, damaged and immature; dorsal view, x 6. Y.P.M. *18160*.

4. Paratype, pygidium, damaged; a very small specimen showing manner in which marginal furrow is interrupted by base of terminal spine; dorsal view, x 5. Y.P.M. *18345*.

5. Paratype, pygidium, the smallest specimen identified; dorsal view, x 7, showing great length of terminal spine in immature stage and marginal furrow interrupted by spine base. Y.P.M. *18346*.

Bellefontia ? acuminiferentis Ross, n. sp.

Fig. 6. Paratype, pygidium, immature with the posterior thoracic segment still attached and another segment being prepared for shedding into the thorax; dorsal view, x 5, showing that the marginal furrow is not interrupted by the base of the terminal spine (compare with fig. 4). Y.P.M. *18348*.

7. Paratype, pygidium; dorsal view, x 4. Y.P.M. *18370*.

8. Holotype, pygidium, with left side damaged; dorsal view, x 3, showing that terminal spine is almost obsolete. Y.P.M. *18347*.

9. Pygidium, imperfectly preserved; dorsal view, x 1, showing axial segmentation on decorticated surface. Y.P.M. *18320*. Limestone matrix.

Bellefontia chamberlaini Clark.

Fig. 10. Pygidium, immature; dorsal view, x 5. Y.P.M. *18341*.

11. Pygidium; dorsal view, x 4. Y.P.M. *18372*.

12. Pygidium; dorsal view, x 6. Y.P.M. *18165*.

13. Pygidium; dorsal view, x 4. Y.P.M. *18371*.

14. Pygidium, smallest identified specimen; dorsal view, x 5. Y.P.M. *18342*.

15. Pygidium, decorticated in limestone matrix; dorsal view, x 3. Y.P.M. *18311*.

PLATE 26

TRIGONOCERCA, BELLEFONTIA, KIRKELLA, SYMPHYSURINA

Hypostoma from Zone "B", referable to one of the species illustrated on Plate 24.

Fig. 1. Ventral view, x 7. Y.P.M. *18349*. Locality 7.

2. Ventral view, x 3. Y.P.M. *18350*. Locality 7.

3. Ventral view, x 4. Y.P.M. *18352*. Note that middle body is narrower than in two preceding specimens. Locality 7.

4. Ventral view, x 3. Y.P.M. *18167*. Locality 6.

Trigonocerca typica Ross, n. gen. and sp.

Fig. 5. Paratype, pygidium, silicified but decorticated; dorsal view, x 4. Y.P.M. *18150*. Zone "H", locality 8.

6. Paratype, pygidium, not decorticated; dorsal view, x 4. Y.P.M. *18149*. Zone "H", locality 8.

7. Paratype, pygidium; dorsal view, x 1.5, showing faint segmentation in a decorticated specimen in a limestone matrix. (This photograph trimmed to cut out matrix.) Y.P.M. *18333*. Zone "H", locality 3B.

8. Paratype, pygidium, immature; dorsal view, x 7. Y.P.M. *18227*. Zone "H", locality 8.

9. Paratype, pygidium, smallest specimen identified; dorsal view, x 7. Y.P.M. *18228*.

10. Paratype, hypostome; ventral view, x 4. Y.P.M. *18148*.

11, 12, 13. Holotype, cranidium with free cheek glued in place; eye broken and lacking; dorsal, lateral, and anterior views, x 4. Y.P.M. *18147*.

Kirkella sp.

Fig. 14. Pygidium, with right side damaged; dorsal view, x 3.5 approximately. Y.P.M. *18330*. Matrix limestone. Zone indefinite, 915 feet above base of Garden City formation, locality 8

18. Pygidium, distorted and decorticated; dorsal view, x 3. Y.P.M. *18329*. Zone indefinite, 500 feet above base of Garden City formation, locality 13.

Unidentified pygidium, Zone "G" (?), locality 8. (Not described)

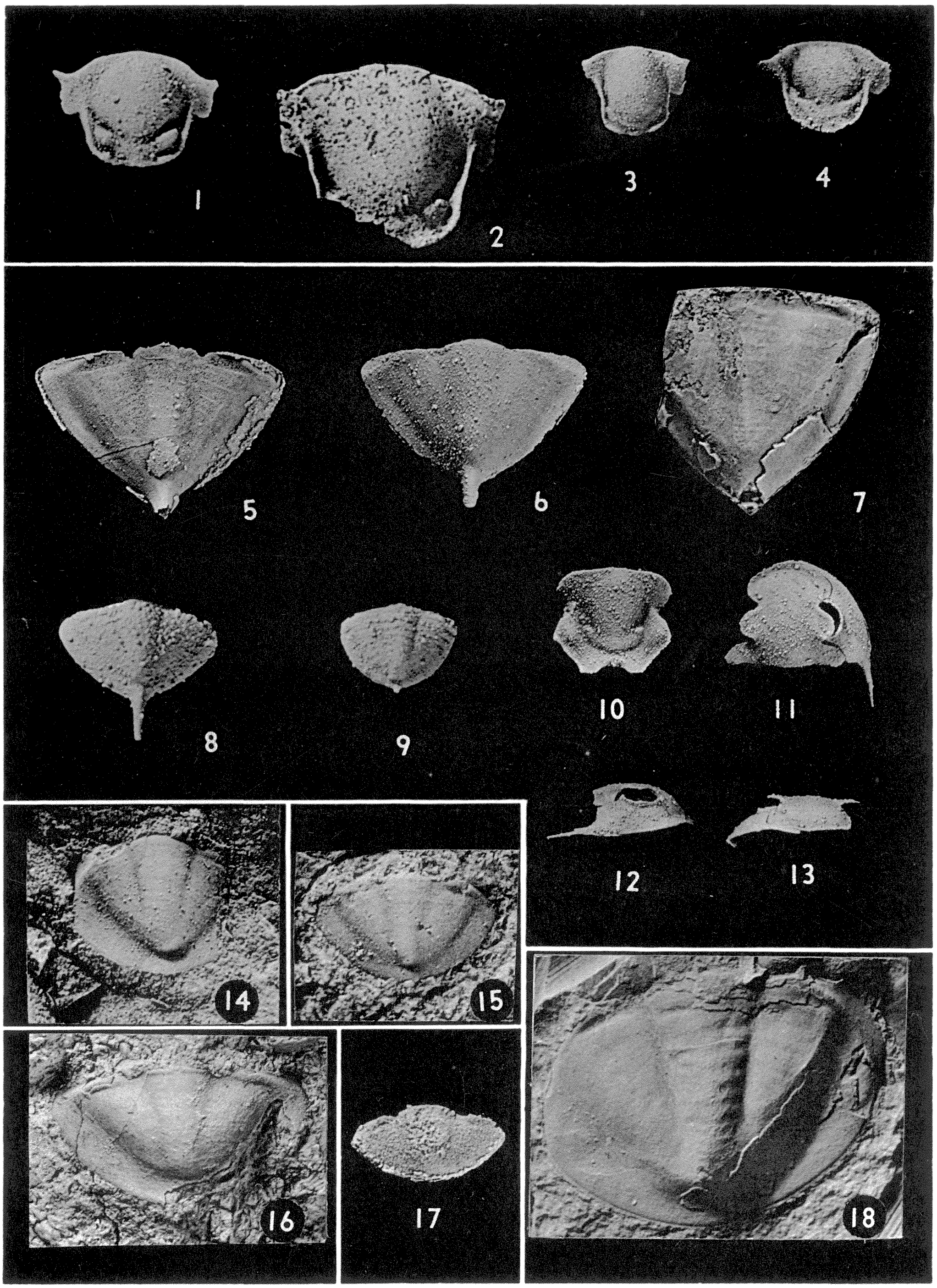
Fig. 15. Dorsal view, x 4. Y.P.M. *18327*. Collected 1,065 feet above base of Garden City formation, locality 8.

Bellefontia ? sp. (Not described)

Fig. 16. Pygidium; dorsal view, x 3. Y.P.M. *18322*. Zone "A", locality 5. Limestone matrix.

Symphysurina sp. A.

Fig. 17. Pygidium tentatively assigned to this species; dorsal view, x 4. Y.P.M. *18190*. From beds immediately below Zone "B", locality 7.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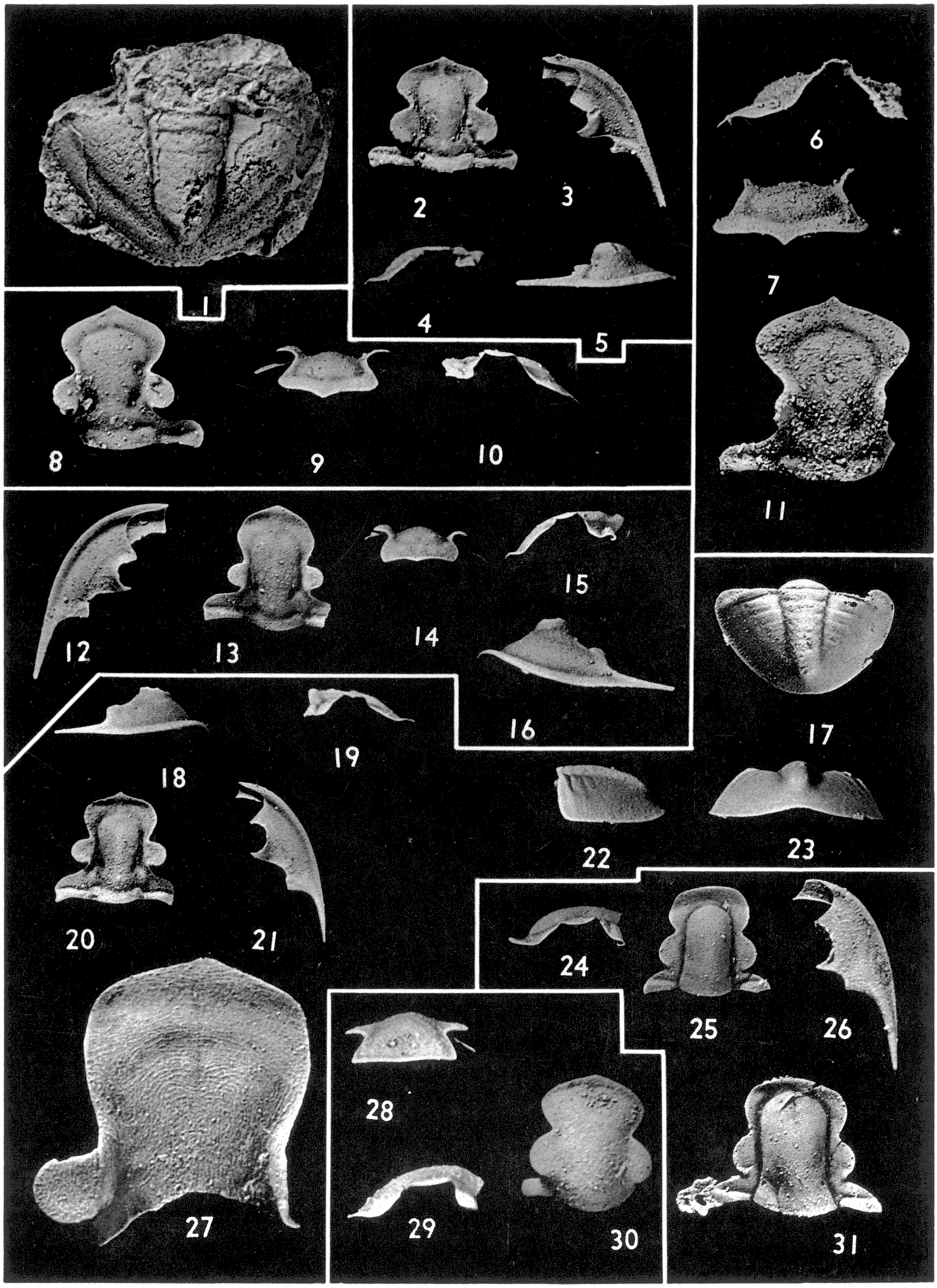
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PLATE 27

LEIOSTEGIUM, "XENOSTEGIUM ?", MACROPYGE, ASAPHELLUS ?, NIOBE ?

Leiostegium manitouense Walcott.

Fig. 1. Pygidium; dorsal view, x 3. Y.P.M. *18312*. Zone "D", locality 5.

Basilicus ? sp.

Figs. 2, 4. Cranidium; dorsal and lateral views, x 8. Y.P.M. *18155*. Zone "G(2)c", locality 6.

3, 5. Free cheek; dorsal and lateral views, x 8. Y.P.M. *18156*. Zone "G(2)c", locality 6.

"Xenostegium" taurus (Walcott).

Figs. 6, 7, 11. Cranidium; lateral, anterior, and dorsal views, x 4. Y.P.M. *18168*. Zone "G(1)", locality 5.

Macropyge gladiator Ross, n. sp.

Figs. 8, 9, 10. Cranidium; dorsal, anterior, and lateral views, x 5. Y.P.M. *18169*. Zone "G(2)a", locality 6. (Tentatively assigned.)

Asaphellus ? sp. A.

Figs. 12, 16. Free cheek; dorsal and lateral views, x 6. Y.P.M. *18171*. Zone "G(2)c", locality 6.

13, 14, 15. Cranidium; dorsal, anterior, and lateral views, x 5. Y.P.M. *18170*. Zone "G(2)c", locality 6.

Asaphellus ? *eudocia* (Walcott).

Figs. 17, 22, 23. Pygidium, associated with and tentatively assigned to this species; dorsal, lateral, and posterior views, x 4. Y.P.M. *18175*. Zone "G(1)", locality 6.

18, 21. Free cheek; lateral and dorsal views, x 4. Y.P.M. *18174*. Zone "G(1)", locality 6.

19, 20. Cranidium; lateral and dorsal views, x 6. Y.P.M. *18173*. Zone "G(1)", locality 6.

27. Cranidium; a large fragmentary specimen showing the Bertillon marking of the surface and the longitudinal fracture and slight crushing of the front of the glabella identical to that found in Walcott's type of *"Xenostegium sulcatum"*; dorsal view, x 8. Y.P.M. *18172*. Zone "G(1)", locality 6.

Niobe ? sp.

Figs. 24, 25. Cranidium; lateral and dorsal views, x 5. Y.P.M. *18153*. Zone "G(2)a", locality 6.

26. Free cheek; dorsal view, x 6. Y.P.M. *18154*. Zone "G(2)a", locality 6.

31. Cranidium; dorsal view, x 4, of a slightly damaged specimen. Y.P.M. *18152*. Zone "G(2)a", locality 6.

Isoteloides ? sp.

Figs. 28, 29, 30. Cranidium, immature; anterior, lateral, and dorsal views, x 10. Y.P.M. *18151*. Zone "J", locality 8.

PLATE 28

LICNOCEPHALA, AMECHILUS, HYPOTHETICA, SYMPHYSURINA

Asaphellus ? sp. B
(Figured specimens from Zone "G(2)d", locality 6)

Figs. 1–3, 6–8, 10. (1, 6, 7) Cranidium, x 6; Y.P.M. *18176*. (2) Free cheek, x 8; Y.P.M. *18177*. (3, 8, 10) Pygidium, tentatively assigned, x 6; Y.P.M. *18178*.

Licnocephala ? sp.

Figs. 4, 5, 9. Cranidium, lacking postero-lateral limbs; x 5. Y.P.M. *18179*. Zone "G(2)a", locality 6.

Licnocephala bicornuta Ross, n. gen. and sp.

Fig. 12. Paratype, free cheek; dorsal view, x 5. Y.P.M. *18181*. Zone "G(2)a", locality 6.

13, 14. Holotype, cranidium; dorsal and lateral views, x 5. Y.P.M. *18180*. Zone "G(2)a", locality 6.

Amechilus palaora Ross, n. gen. and sp.

Fig. 15. Holotype, cranidium; dorsal view, x 10. Y.P.M. *18182*. Zone "E", locality 5.

Hypothetica rawi Ross, n. gen. and sp.

Fig. 11. Holotype, cranidium; dorsal view, x 12. Y.P.M. *18183*. Zone "F", locality 6.

Undetermined genus and species B

Figs. 16, 20, 25–28. From Zone "F", locality 6. (16, 20, 25) Cranidium, poorly preserved, x 4; Y.P.M. *18184*. (26, 27, 28) Cranidium, poorly preserved, x 4; Y.P.M. *18185*.

Parahystricurus ? sp. C

Figs. 17, 18, 21. Cranidium; x 4. Y.P.M. *18186*. Zone "F", locality 6.

22. Free cheek; x 5. Y.P.M. *18187*. Zone "F", locality 6.

Symphysurina sp. B

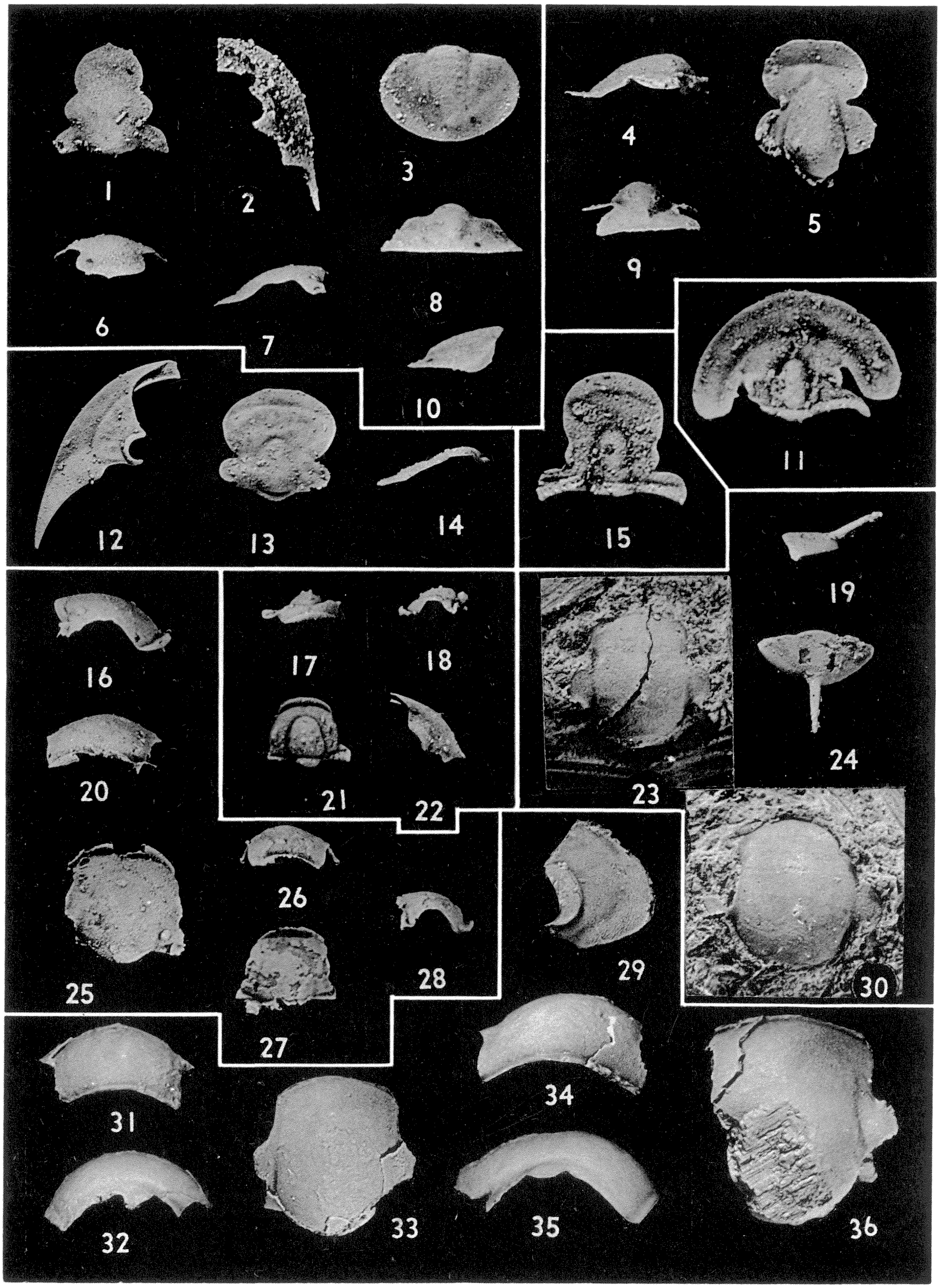
Figs. 19, 23, 24, 30. From Zone "C", locality 5. (19, 24) Pygidium, x 4; Y.P.M. *18188*. (23) Cranidium, x 5; Y.P.M. *18314;* matrix limestone. (30) Cranidium, poorly preserved, x 5; Y.P.M. *18313;* matrix limestone.

Symphysurina sp. A

Fig. 29. Free cheek; dorsal view, x 4. Y.P.M. *18318*. Zone "A", locality 5. Retouched to black out limestone matrix.

31, 32, 33. Cranidium; x 3. An imperfectly preserved and decorticated specimen. Y.P.M. *18316*. Zone "A", locality 5. Retouched only to black out limestone matrix.

34, 35, 36. Cranidium; anterior, lateral, and dorsal views, x 3, of a damaged and decorticated specimen. Y.P.M. *18315*. Zone "A", locality 5. Retouched only to black out limestone matrix.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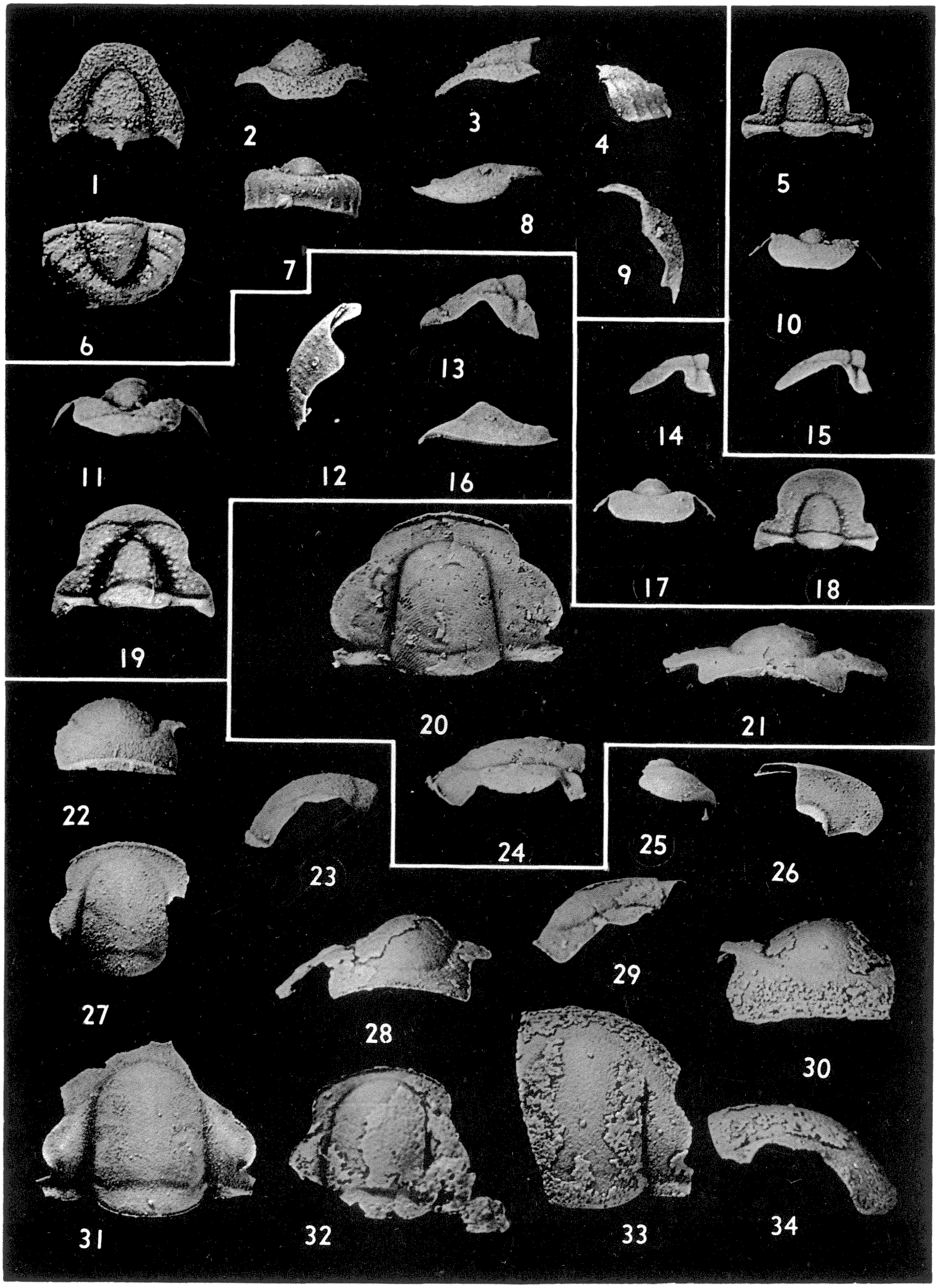
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PLATE 29

CLELANDIA, PSEUDOCLELANDIA

Clelandia utahensis Ross, n. sp.

Figs. 1, 2, 3. Holotype, cranidium; dorsal, anterior, and lateral views, x 6. Y.P.M. *18192*. Zone "B", locality 7.

4, 6, 7. Paratype, pygidium; lateral, dorsal, and posterior views, x 6. Y.P.M. *18195*. Zone "B", locality 7.

8, 9. Paratype, free cheek, with pre-cranidial "yoke" complete, but left side of cheek proper broken off; lateral and dorsal views, x 6. Y.P.M. *18193*. Zone "B", locality 7.

Pseudoclelandia lenisora Ross, n. sp.

Figs. 5, 10, 15. Holotype, cranidium; dorsal, anterior, and lateral views, x 6. Y.P.M. *18197*. Zone "E", locality 5.

Pseudoclelandia cornupsittaca Ross, n. gen. and sp.

Figs. 11, 13, 19. Holotype, cranidium; anterior, lateral, and dorsal views, x 6. Y.P.M. *18199*. Zone "F", locality 6.

12, 16. Paratype, free cheek; dorsal and lateral views, x 6. Y.P.M. *18200*. Zone "F", locality 6.

Pseudoclelandia fluxafissura Ross, n. sp.

Figs. 14, 17, 18. Holotype, cranidium; lateral, anterior, and dorsal views, x 8. Y.P.M. *18198*. Zone "F", locality 6.

Undetermined Genus and Species C.

20, 21, 24. Cranidium; dorsal, anterior, and lateral views, x 5. Y.P.M. 18201. Zone "G(1)", locality 5.

Platycolpus ? sp.

Figs. 22, 23, 27. Cranidium; anterior, lateral, and dorsal views, x 4, of an incomplete specimen. Y.P.M. *18202*. Tentative zone "G(2)b", locality 7.

25, 26. Free cheek; lateral and dorsal views, x 4. Y.P.M. *18205*. Zone "G(2)a", locality 5.

28, 29, 32. Cranidium encrusted with foreign siliceous material; anterior, lateral, and dorsal views, x 4. Y.P.M. *18223*. Zone "G(2)a", locality 6.

30, 33, 34. Cranidium, badly damaged; anterior, dorsal, and lateral views, x 5. Y.P.M. *18204*. Zone "G(2)a", locality 5.

31. Cranidium, damaged; dorsal view, x 3, showing faint pattern of appendicular attachment on glabella. Y.P.M. *18203*. Tentative zone "G(2)b", locality 7.

PLATE 30

MACROPYGE, PSALIKILUS ?, UNASSIGNED PYGIDIA

Psalikilus ? sp.

Figs. 1, 2, 3. Pygidium, tentatively assigned to this species; dorsal, lateral, and posterior views, x 5. Y.P.M. *18206*. Locality 7, zone indefinite; tentatively placed in Zone "G(2)b".

Unassigned pygidium (Not described)

Figs. 4, 5. Dorsal and posterior views, x 6, of a specimen, possibly referable to *Hystricurus*. Y.P.M. *18208*. Zone "F", locality 6.

Unassigned pygidium (Not described)

Figs. 6, 7, 8. Views, x 4. Y.P.M. *18209*. Zone "G(2)c", locality 6.

Figs. 17, 18, 19. Views, x 6, of an immature specimen, probably the same species. Y.P.M. *18210*. Zone "G(2)c", locality 6.

Unassigned pygidium (Not described)

Fig. 9. Dorsal view, x 6, of a specimen, possibly referable to *Hystricurus*. Y.P.M. *18207*. Zone "F", locality 6.

Unassigned pygidium (Not described)

Fig. 10. Dorsal view, x 3. Y.P.M. *18334*. Zone "A", locality 5.

Unassigned pygidium (Not described)

Figs. 11, 15. Dorsal and posterior views, x 8. Y.P.M. *18212*. Zone "G(2)a", locality 6.

Unassigned pygidium (Not described)

Figs. 12, 13, 16. Views, x 4. Y.P.M. *18211*. Locality 7, zone indefinite; tentatively placed in Zone "G(2)b".

Macropyge gladiator Ross, n. sp.

Fig. 14. Pygidium; dorsal view, x 6, of an immature specimen to which parts of the posterior three segments of the thorax are still attached. Y.P.M. *18131*. Zone "G(2)a", locality 6.

22. Thorax and pygidium, encrusted with siliceous material which could not be removed; dorsal view, x 6. Y.P.M. *18132*. Zone "G(2)a", locality 6.

Unassigned pygidium (Not described)

Figs. 20, 21, 24. Lateral, posterior, and dorsal views, x 4. Y.P.M. *18214*. Zone "G(2)e", locality 5.

Unassigned pygidium (Not described)

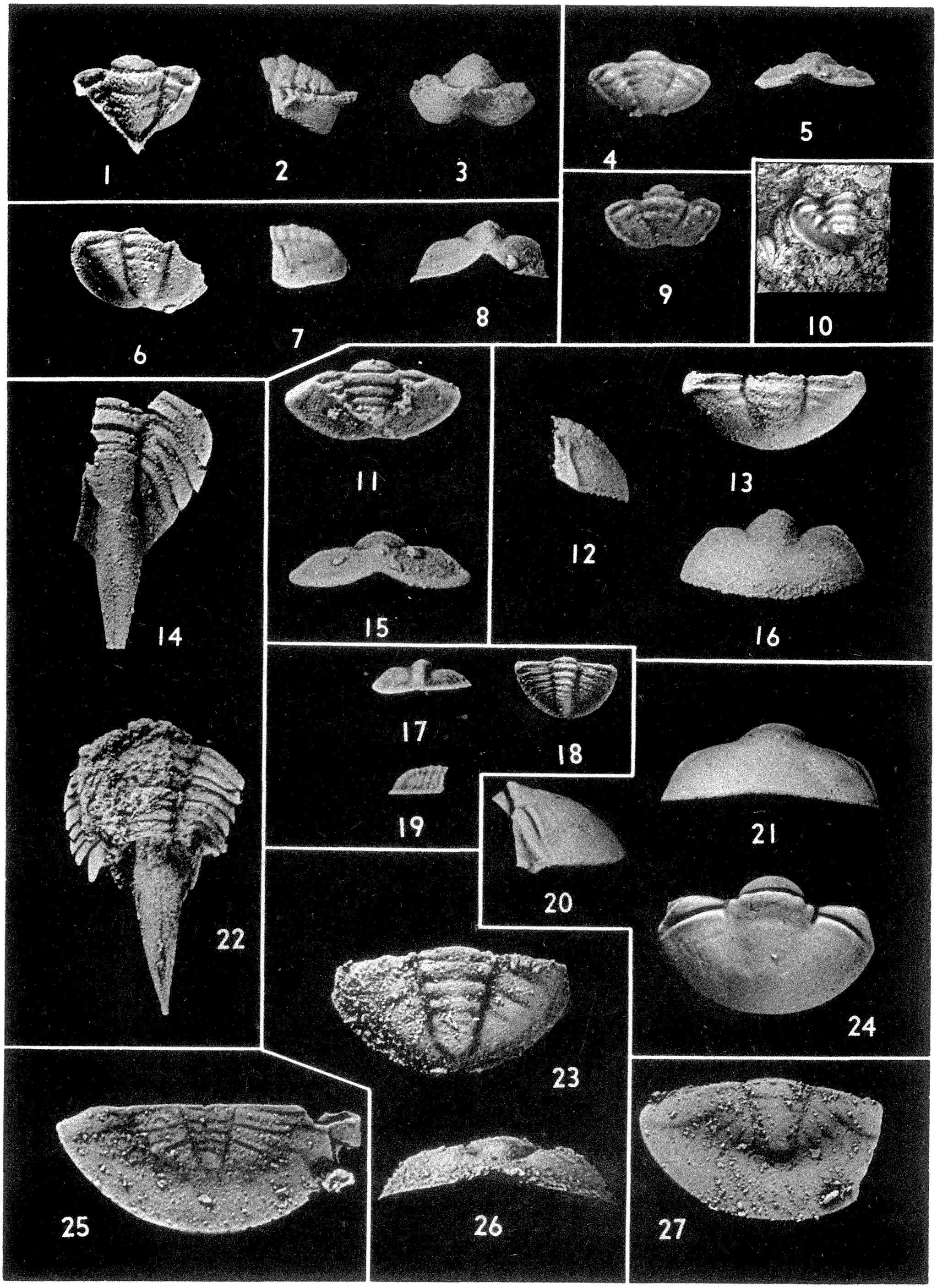
Figs. 23, 26. Dorsal and posterior views, x 4. Y.P.M. *18215*. Zone "G(1)", locality 5.

Licnocephala bicornuta Ross, n. sp.

Fig. 25. Pygidium, tentatively assigned to this species; dorsal view, x 6. Y.P.M. *18213*. Zone "G(2)a", locality 6.

Unassigned pygidium (Not described)

Fig. 27. Dorsal view, x 6. Y.P.M. *18216*. Zone "G(1)", locality 5.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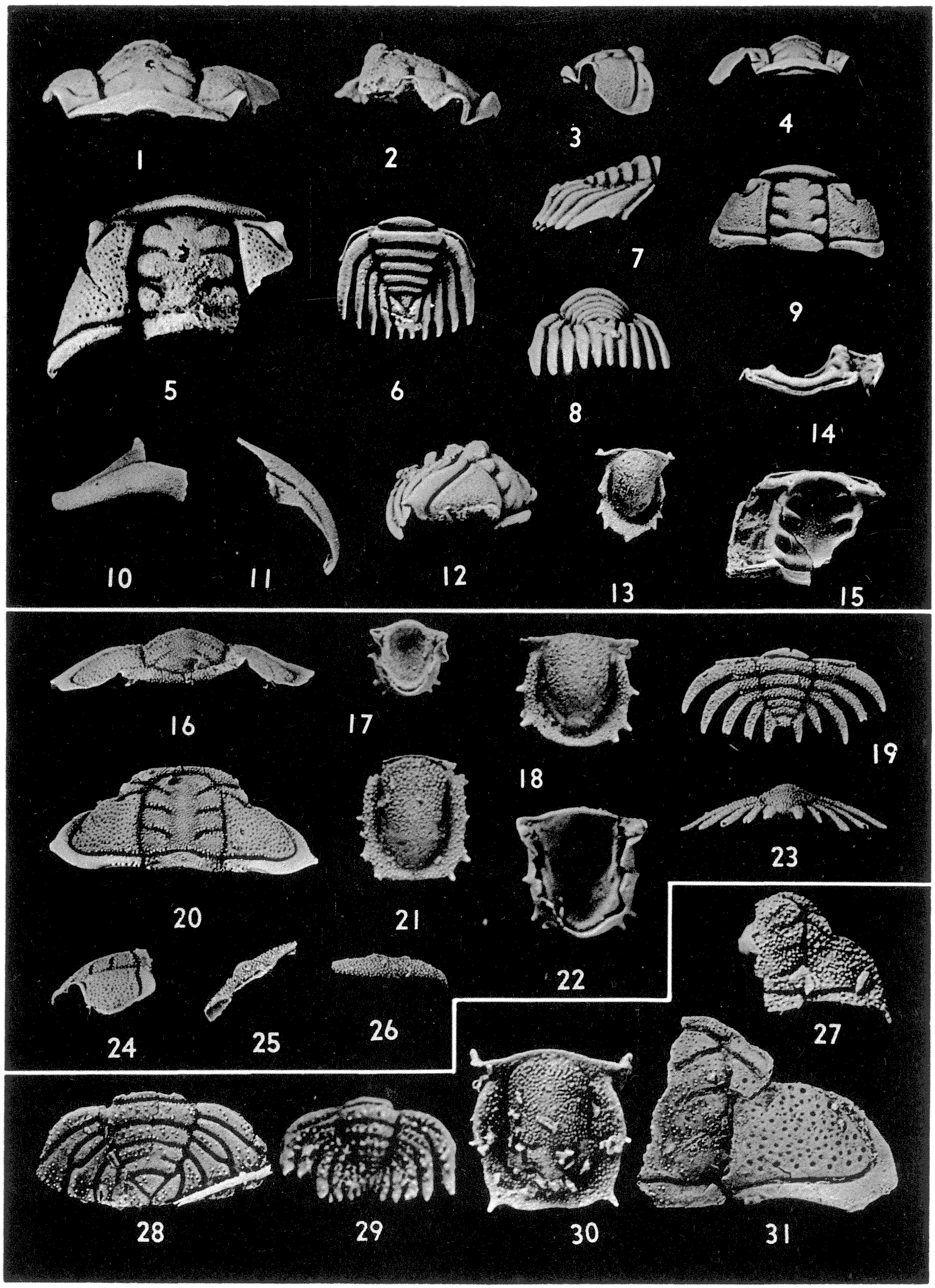
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PLATE 31

PROTOPLIOMEROPS, TESSELACAUDA

Protopliomerops celsaora Ross, n. sp.
(Figured specimens from Zone "G(1)", locality 6)

Figs. 1, 2, 5. Paratype, cranidium, damaged but showing to good advantage the relations of the glabella, palpebro-ocular ridges, and rim and the anterior courses of the facial sutures and epistomal suture; x 4. Y.P.M. *18257*.

3, 4, 9. Holotype, cranidium; x 4. Y.P.M. *18258*.

6, 7, 8. Paratype, pygidium; x 4. Y.P.M. *18259*.

10, 11. Paratype, free cheek; x 4. Y.P.M. *18261*.

12. Paratype, cranidium, and three anterior thoracic segments; lateral view, x 4. Y.P.M. *18260*. Note that this specimen retains very short genal spines, not possessed by most others.

13. Paratype, hypostome; ventral view, x 4. Y.P.M. *18262*.

14, 15. Paratype, cranidium, damaged but showing the condyles for hypostomal attachment, x 4. Y.P.M. *18263*.

Protopliomerops superciliosa Ross, n. sp.
(Figured specimens from Zone "F", locality 6)

Figs. 16, 20, 24. Holotype, cranidium with frontal lobe of glabella slightly damaged; x 4. Y.P.M. *18266*.

17. Paratype, hypostome; dorsal view, x 8. Y.P.M. *18273*.

18. Paratype, hypostome; ventral view, x 8. Y.P.M. *18272*.

19, 23. Paratype, pygidium; x 4. Y.P.M. *18267*.

21. Paratype, hypostome; ventral view, x 8. Y.P.M. *18271*.

22. Paratype, hypostome; dorsal view, x 8. Y.P.M. *18270*.

25, 26. Paratype, free cheek; little more than the rim remains on this specimen, both the eye and ocular platform being broken; dorsal and antero-lateral view, x 4 (left cheek). Y.P.M. *18269*.

Tesselacauda depressa Ross, n. gen. and sp.

Fig. 27. Paratype, cranidium with left half broken away; dorsal view, x 10, of an immature specimen. Y.P.M. *18277*. Zone "E", locality 5.

28. Holotype, pygidium; dorsal view, x 4. Y.P.M. *18278*. Zone "E", locality 5. Note that in other specimens the fourth inter-segmental groove of the axis is not discontinuous.

29. Paratype, pygidium, immature; dorsal view, x 16. Y.P.M. *18279*. Note seven pairs of pleural spines and eight axial segments of which the terminal one is extremely minute. Zone "E", locality 5.

30. Paratype, hypostome; ventral view, x 8. Y.P.M. *18280*. Zone "E", locality 5.

31. Paratype, cranidium with left half broken and right side slightly damaged; dorsal view, x 4. Y.P.M. *18276*. Zone "E", locality 5.

PLATE 32

PROTOPLIOMEROPS ONTOGENY

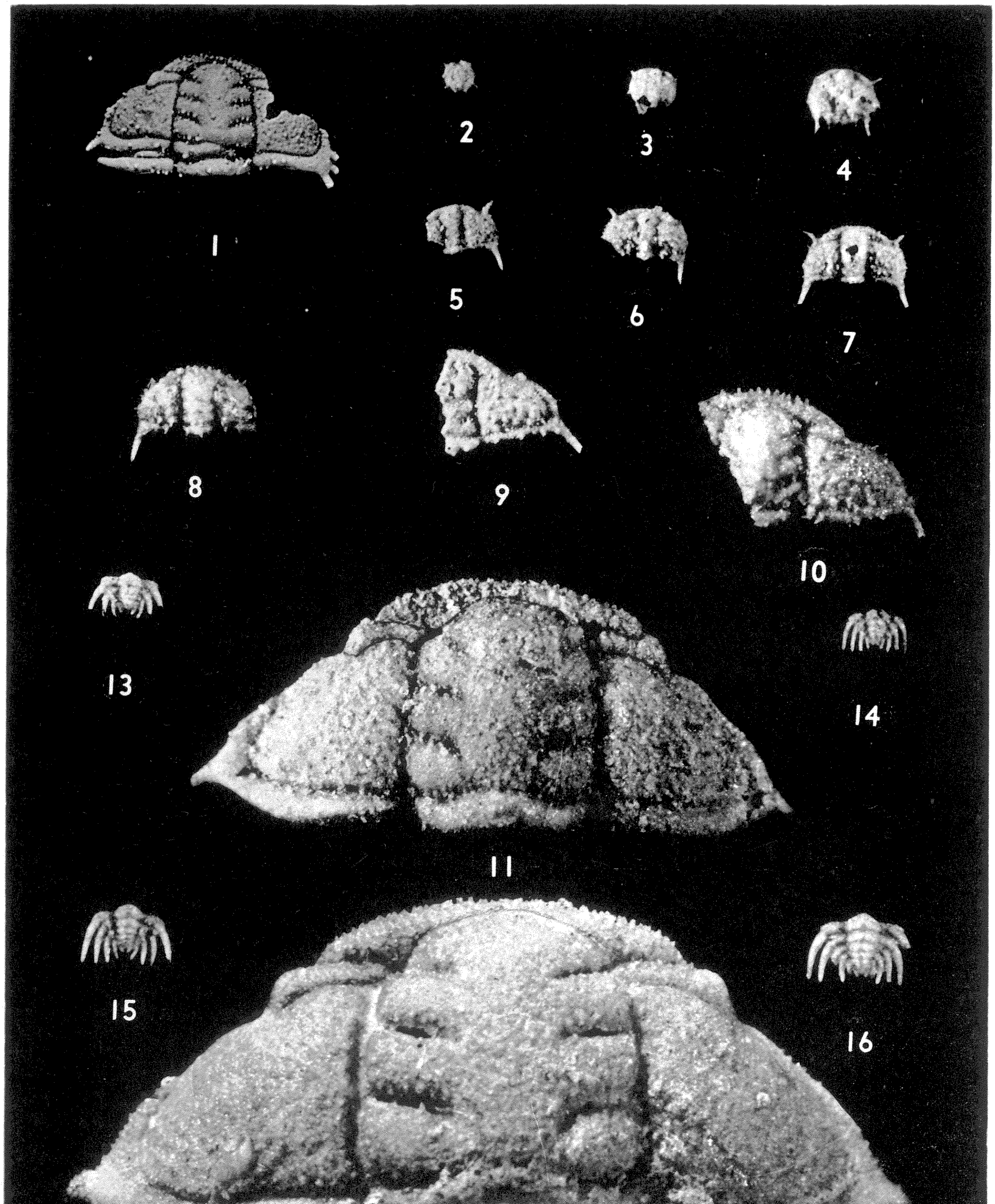
Protopliomerops superciliosa Ross, n. sp.

Fig. 1. Dorsal view, x 8, of a pathologically developed cranidium. Y.P.M. number not assigned; specimen accidentally broken after photographing. Zone "F", locality 6.

2–12. Specimens, all paratypes, illustrating a partial ontogenetic sequence of cranidial development; all dorsal views.

13–16. Specimens, all paratypes, illustrating a partial ontogenetic sequence of pygidial development, following specimens in figures 2–4. All dorsal views. Note that each axial segment appears to be indented at the midpoint of the posterior edge; also that the number of segments increases in number with growth, but that the adult possesses only five pairs of pleura (pl. 31, figs. 19, 23).

(Specimens in figures 2–16 are from Zone "F", locality 6; all are x 15 and all were photographed without the usual coating of magnesium oxide. Full description of these specimens is given in the text under the discussion of the ontogeny of *Protopliomerops superciliosa*. All these specimens, as well as several others, which are included in a mounted ontogenetic suite, are catalogued under the single number, Y.P.M. *18323*.)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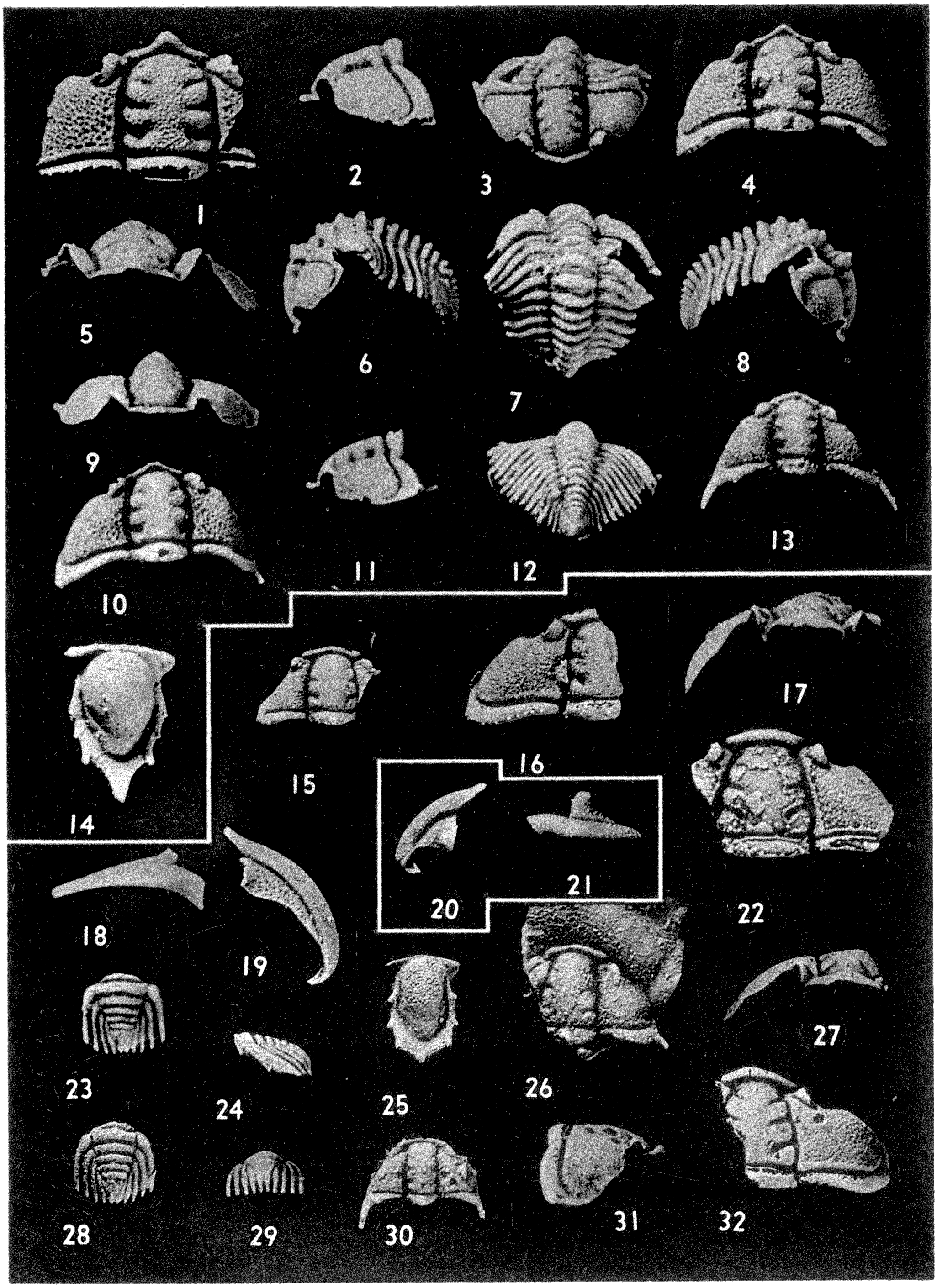
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PLATE 33

PSEUDOCYBELE, PROTOPLIOMEROPS

Pseudocybele nasuta Ross, n. gen. and sp.
(Figured specimens from Zone "J", locality 8)

Figs. 1, 2, 5. Paratype, cranidium, showing faint furrows immediately proximal to tips of palpebro-ocular ridges to which hypostomal muscles are believed to have been attached; x 8. Y.P.M. *18236*.

3, 6, 7, 8, 12. Paratype, complete cranidium, thorax, and pygidium of a very small, immature specimen; anterior, left lateral, dorsal, right lateral, and posterior views, x 8. Y.P.M. *18238*.

4. Holotype, cranidium; dorsal view, x 8. Y.P.M. *18235*.

9, 10, 11. Paratype, cranidium, immature; x 10. Y.P.M. *18234*.

13. Paratype, cranidium, x 10, immature specimen, showing long genal spines characteristic of young stages and only slight development of pre-glabellar pit. Y.P.M. *18237*.

14. Paratype, hypostome; ventral view, x 10. Y.P.M. *18239*.

Protopliomerops contracta Ross, n. sp.

Fig. 15. Paratype, cranidium; dorsal view, x 4, of a damaged specimen. Y.P.M. *18255*. Zone "G(2)d", locality 6.

16. Paratype, cranidium; dorsal view, x 4, of a damaged specimen. Y.P.M. *18252*. Zone "G(2)e", locality 5.

17, 22. Holotype, cranidium, damaged but showing the tapering glabella; x 4. Y.P.M. *18253*. Zone "G(2)e", locality 5.

18, 19. Paratype, free cheek; x 6. Y.P.M. *18247*. Zone "G(2)c", locality 6.

23. Paratype, pygidium; dorsal view, x 8, of an immature specimen. Y.P.M. *18249*. Zone "G(2)c", locality 6.

24, 28, 29. Paratype, pygidium; lateral, dorsal, and posterior views, x 4. Y.P.M. *18248*. Zone "G(2)c", locality 6.

25. Paratype, hypostome; ventral view, x 6. Y.P.M. *18251*. Zone "G(2)c", locality 6.

26. Paratype, cranidium; dorsal view, x 10, of an immature specimen. Y.P.M. *18250*. Zone "G(2)c", locality 6.

27, 31, 32. Paratype, cranidium, damaged but showing the pair of faint furrows (not true glabellar furrows) located immediately proximal to the tips of the palpebro-ocular ridges and believed to be points of attachment for hypostomal muscles; x 4. Y.P.M. *18246*. Zone "G(2)c", locality 6.

30. Paratype, cranidium, the smallest identified specimen; dorsal view, x 10. Y.P.M. *18256*. Zone "G(2)c", locality 6.

Unidentified free cheek (Not described)

Figs. 20, 21. Dorsal and antero-lateral views, x 6; probably referable to *Pseudomera*, illustrated for comparison with figures 18, 19. Note that postero-lateral limb must be considerably shorter than in *Protopliomerops* and that eye is set further to rear. Y.P.M. *18254*. Zone "G(2)e", locality 5.

PLATE 34

THORACIC SEGMENTS OF PROPARIAN GENERA

Tesselacauda depressa Ross, n. gen. and sp.

Figs. 1, 2, 3, 18. Thoracic segment, deformed; anterior, dorsal, posterior, and right lateral views, x 6. Y.P.M. *18281.* Zone "E", locality 5.

4. Thoracic segment, right half only; ventral view, x 6. Y.P.M. *18282.* Zone "E", locality 5.

Protopliomerops superciliosa Ross, n. sp.

Figs. 5, 6, 7, 19. Thoracic segment, very slightly deformed; anterior, dorsal, and left lateral views, x 6. Y.P.M. *18274.* Zone "F", locality 6.

8. Thoracic segment, left half only; ventral view, x 6. Y.P.M. *18275.*

Protopliomerops celsaora Ross, n. sp.

Figs. 9, 10, 11, 20. Thoracic segment; anterior, dorsal, posterior, and left lateral views, x 6. Y.P.M. *18265.* Zone "G(1)", locality 6.

12. Five thoracic segments; ventral view, x 6. Y.P.M. *18264.* Zone "G(1)", locality 6.

Pseudocybele nasuta Ross, n. gen. and sp.

Figs. 13, 14, 16. Thoracic segment from posterior portion of thorax; anterior, left lateral, and dorsal views, x 6. Y.P.M. *18245.* Zone "J", locality 13.

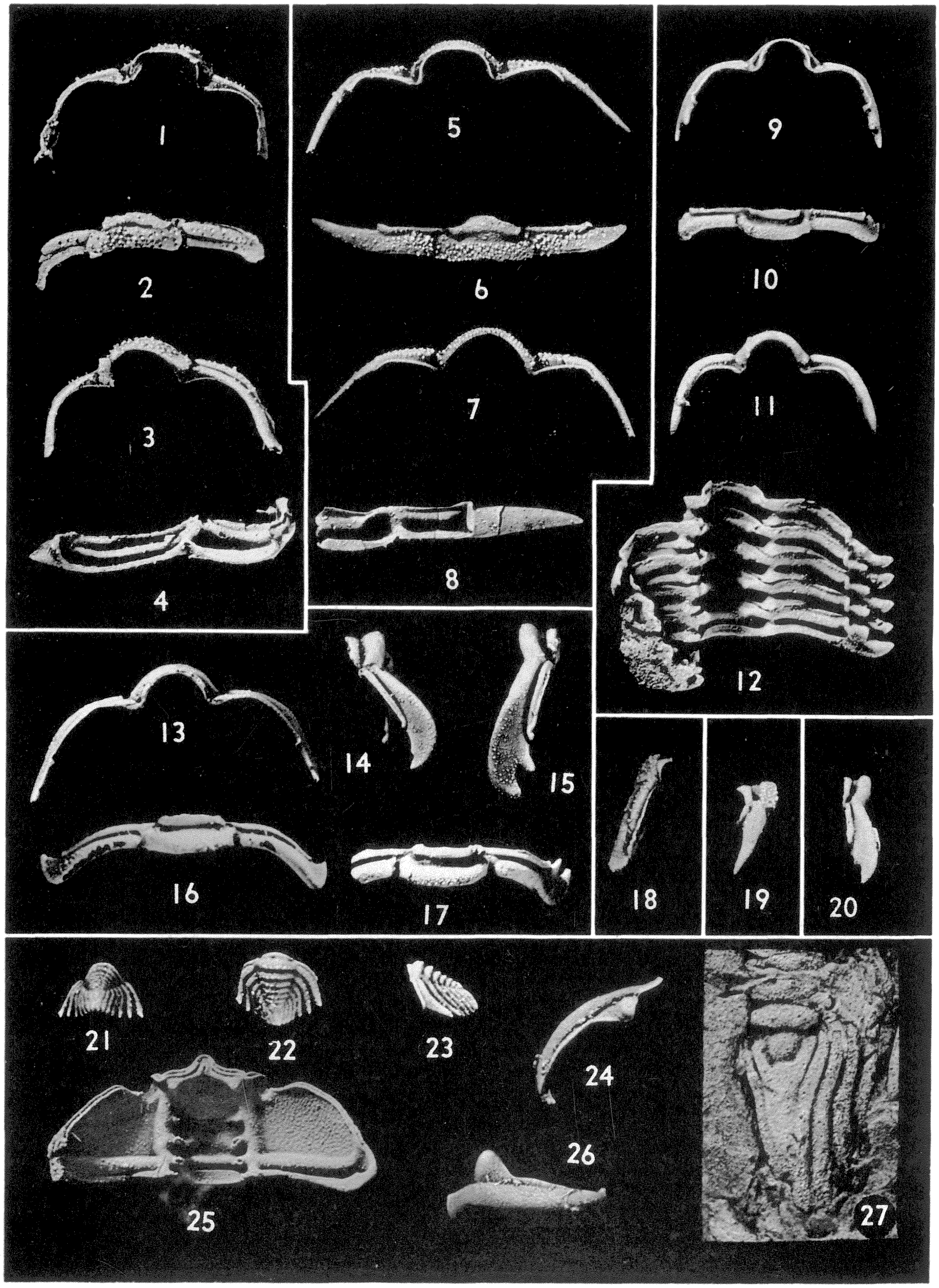
15, 17. Thoracic segment from anterior portion of thorax; right lateral and dorsal views, x 4.5. Y.P.M. *18244.* Zone "J", locality 13.

21, 22, 23. Paratype, pygidium, very immature; posterior, dorsal, and lateral views, x 10. Y.P.M. *18243.* Note that there are seven pairs of pleura and that the seventh pair completely enclose an eighth axial segment which is very much shorter than the pleura. Zone "J", locality 8.

24, 26. Paratype, free cheek; dorsal and antero-lateral views, x 10. Y.P.M. *18241.* Zone "J", locality 8.

25. Paratype, cranidium; ventral view, x 6, showing the three condyles for hypostomal attachment and the appendicular attachments beneath the glabellar furrows. Y.P.M. *18381.* Zone "J", locality 8.

27. Pygidium, an imperfect siltstone cast of the ventral surface; dorsal view, x 5, showing the third, fourth, and fifth axial rings plus a sixth axial terminus; the terminus appears to be enclosed by a coalesced "sixth" pair of pleura and together with them forms the large caudal terminus typical of Cybelids. Y.P.M. *18332.* Zone "J", locality 5. Note that the furrow surrounding the axial terminus on the sides and rear coincides perfectly with the sub-semicircular pattern of paired pits found on the dorsal surface of large, well-preserved specimens of *Cybelopsis speciosa* Poulsen.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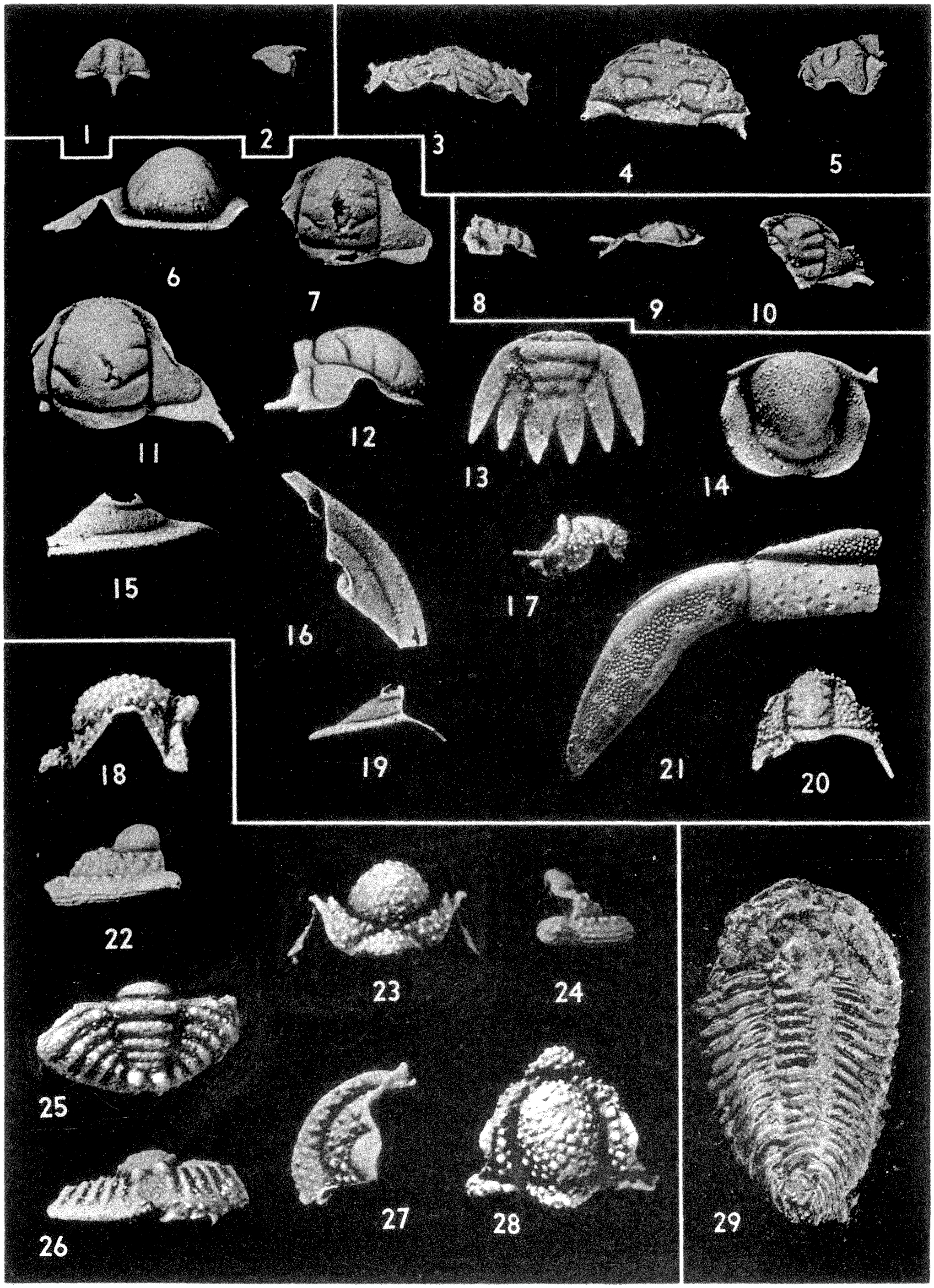
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PLATE 35

KAWINA, DIMEROPYGIELLA

	Undetermined genus and species D.
Figs. 1, 2.	Cranidium; dorsal and lateral views, x 4. Y.P.M. *18283.* Zone "B", locality 6.
	Undetermined genus and species E.
Figs. 3, 4, 5.	Cranidium, damaged; anterior, dorsal, and lateral views, x 4. Y.P.M. *18284.* Zone "F", locality 6.
	Pilekia ? sp.
Figs. 8, 9, 10.	Cranidium, damaged; lateral, anterior, and posterior views, x 6. Y.P.M. *18285.* Zone "E", locality 5.
	Kawina sexapugia Ross, n. sp.
Figs. 6, 11, 12.	Holotype, cranidium with left postero-lateral limb broken; anterior, dorsal, and lateral views, x 6. Y.P.M. *18289.* Zone "J", locality 13.
7.	Paratype, cranidium; dorsal view, x 6. Y.P.M. *18292.* Zone "J", locality 8.
13.	Paratype, pygidium; dorsal view, x 6. Y.P.M. *18291.* Zone "J", locality 13.
14.	Paratype, hypostome; ventral view, x 6. Y.P.M. *18290.* Zone "J", locality 13.
15, 16, 19.	Paratype, free cheek, the only specimen secured; lateral, dorsal, and anterior views, x 4. Y.P.M. *18293.* Zone "J", locality 13.
17, 20.	Paratype, cranidium, immature; lateral and dorsal views, x 10. Y.P.M. *18295.* Zone "J", locality 13.
21.	Paratype, thoracic segment, left half only; dorsal view, x 10, showing peculiar "collared" pores on the dorsal surface; possibly occupied by setae. Y.P.M. *18294.* Zone "J", locality 13.
	Dimeropygiella caudanodosa Ross, n. gen. and sp.
Figs. 18, 23, 28.	Holotype, cranidium; lateral, anterior, and dorsal views, x 10. Y.P.M. *18217.* Zone "J", locality 13.
22, 24, 27.	Paratype, free cheek; left lateral, anterior, and dorsal views, x 10. Y.P.M. *18219.* Zone "J", locality 13.
25, 26.	Paratype, pygidium; dorsal and posterior views, x 10. Y.P.M. *18220.* Zone "J", locality 13.
	Protopliomerops celsaora Ross, n. sp.
Fig. 29.	Cephalon with cranidium imperfectly preserved; dorsal view, x 3. Y.P.M. *18324.* Zone "G(1)", locality 7.

PLATE 36

ASAPHELINA

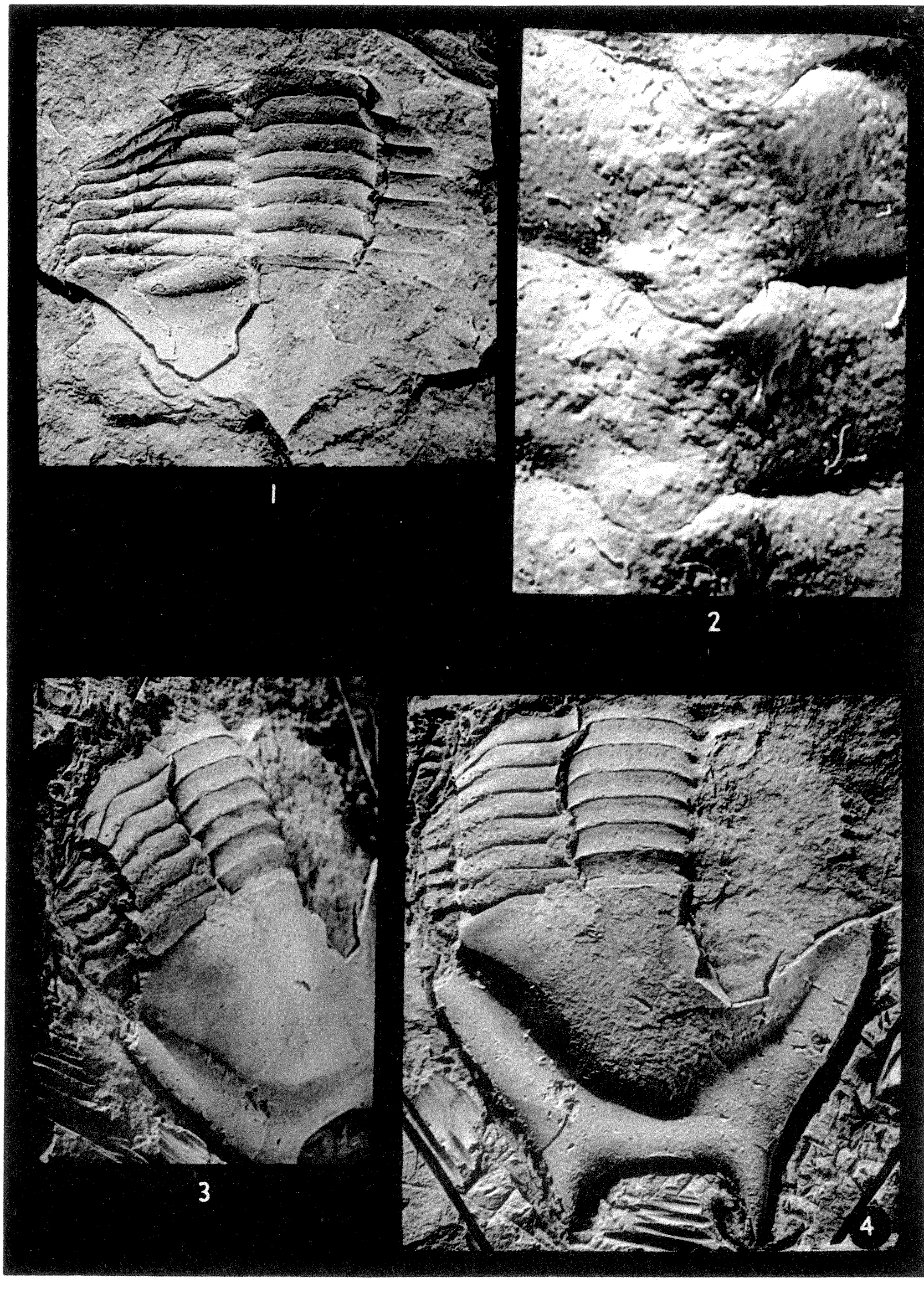
Asaphelina ? sp. (Y.P.M. No. *18383*)
(All figures of the same specimen from locality 9)

Fig. 1. Thorax and anterior part of pygidium, ventral view of right side split from portion shown in figure 4. x 1½.

2. Appendiferal bosses and intersegmental articulation. Small portion of figure 1 enlarged. x 10.

3. Thorax and pygidium, dorso-lateral view, x 1½.

4. Thorax and pygidium, dorsal view, x 1½.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Numbers in bold face type indicate page on which the genus or species is described.