A LOWER CAMBRIAN TRILOBITE FAUNA FROM NEAR CRANBROOK, B.C.

by

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ABSTRACT

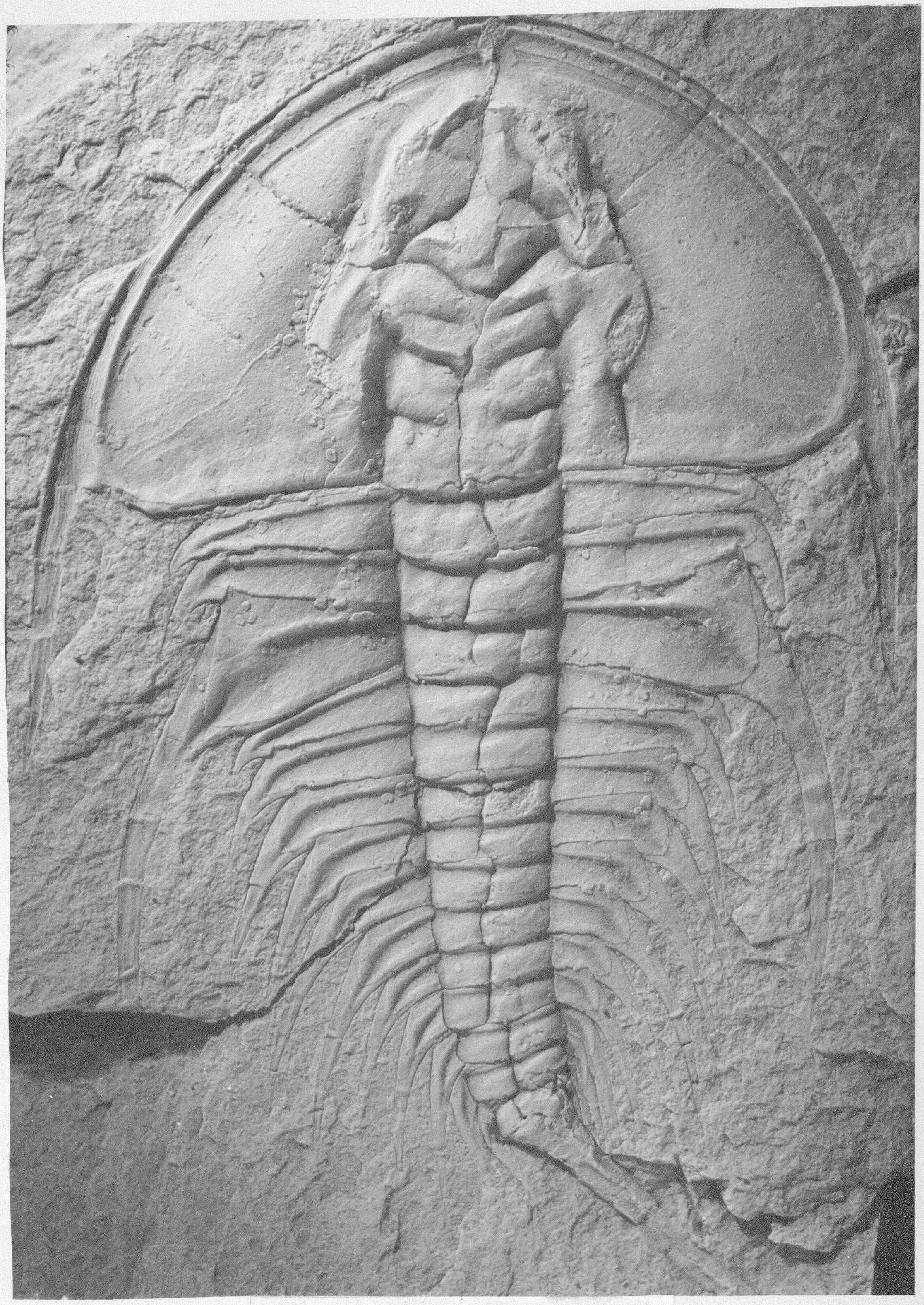
Trilobites typical of the well known *Olenellus* zone of the Lower Cambrian constitute a large collection from the Eager Formation, near Cranbrook, B.C. Their classification is discussed and two new species described: *Olenellus eagerensis* n.sp. and *Olenellus schofieldi* n.sp.

Since the use of certain structures in classifying olenellids has been disputed in the past, these and other less controversial features are critically examined, insofar as they apply to the genera and species present.

From this study the writer assembles criteria which might be used by later workers to redefine the generic and specific positions of selected species of *Olenellus* and *Paedeumias*.

TABLE OF CONTENTS

ILLUSTRATIONS



OLENELLUS GILBERTI MEEK
(x 4.)

A LOWER CAMBRIAN TRILOBITE FAUNA FROM NEAR CRANBROOK, B.C.

INTRODUCTION

The following study is based upon a collection of trilobites, made largely by Mr. C. Garrett, late of Cranbrook, B.C., and bought by the University of British Columbia. The collection was taken from two localities of differing lithology within the Eager Formation. It consists almost entirely of trilobites typical of the well known Olenellus zone, which define the age of the rocks in which they were found as Lower Cambrian.

It may be that conclusions based on observations of fauna from a single locality should be restricted to that particular area. A student faced with only one phase of a larger problem may be-tempted to extrapolate unreasonably. Many generalizations can be quoted from the literature analogous to those of the three blind men describing an elephant. But in the wider field of paleontological research a clue to one of the larger problems may lie at some single locality, providing confirmation of a tentative hypothesis or the refutation of an accepted principle.

The writer regrets the lack of time to continue the study of this excellent collection. It is almost certain that only a few of the legitimate species have been recognized. A great deal more could be learned of the ontogenies, and possibly of specific and generic relationships, of the olenellids, from the scores of immature specimens. No doubt too, additional material collected by palaeontologists conversant with the outstanding problems would provide much valuable information from the stratigraphic and ecological points of view.

In spite of the limitations of time and experience, it is hoped that the observations made here will be of some value in further studies of the olenellids as a whole.

ACKNOWLEDGEMENTS

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CHAPTER I

CRANBROOK AREA

Historical Summary

The first extensive geological work in the Cranbrook Area was carried out by Schofield (1915, 1922).[1] Prior to his 1915 memoir brief reconnaissances had been made by Dawson (1895) and McEvoy (1899). The most recent revision of stratigraphy near Cranbrook was completed by Rice (1937, 1941) a copy of whose 1937 map is included in the present paper.

The presence of the Olenellus zone was first reported between Cranbrook and Fort Steele by Schofield (1922). The fossils he collected were sent to C.D. Walcott, who identified the following trilobites:

Callavia cf. nevadensis Walcott
Wanneria n. sp ?
Mesonacis gilberti Meek
Wanneria cf. walcottanus (Wanner)
Olenellus cf. fremonti Walcott
Prototypus senectus Billings

Walcott is quoted concerning this collection as saying: "This fauna belongs to the upper part of the Lower Cambrian and it is essentially the same as that found above the tunnel at Mt. Stephen, B.C., and is also

1. Dates in parentheses refer to the Bibliography in the back of the report.

found more or less all along the cordilleran system down into southern Nevada." (Ibid. p 12)

The species found by Rice (1937) apparently did not differ to any great extent, since no further faunal information is embodied in his report.

Although professional geologists were mainly interested in the Cranbrook Area from an economic point of view, at least two amateurs became very keen fossil hunters. Col. Pullen and C. Garrett made extensive collections of trilobites and other fossils from two localities, one on the main Cranbrook-Fort Steele road, the second just east of St. Eugene Mission. In this second locality they put in a small adit in grey shale and were rewarded by obtaining a very fine collection, including numerous examples of the young growth-stages of Olenellus, Paedeumias and Wanneria.

Unfortunately, certain local inhabitants, suspecting that such incomprehensible actions were connected with something more remunerative than a "trilobite mine", staked out claims. Collecting had to be discontinued and the adit filled in.

Dr. M.Y. Williams of the University of British Columbia made a fairly extensive collection from both localities in 1934.

The Garrett collection, obtained later by the University, together with that of Dr. Williams, totals some fourteen hundred specimens, and furnishes the material for this study.

STRATIGRAPHY

The presence of Bonnia and Olenellus in the Eager Formation places the age of these rocks in the upper part of the Lower Cambrian (Rasetti, 1951). The Eager argillites, some thousands of feet thick, are underlain by the Cranbrook Formation, which is 600 feet thick. The contact between these two is believed by Rice (1941) to be gradational. The Cranbrook Formation consists largely of quartzite, pebble conglomerate, and some magnesite; although fossils are absent, its age is also assigned to the Lower Cambrian. The Cranbrook rests unconformably on Proterozoic rocks of Upper Purcell Age.

The age relationships of the Lower Cambrian Olenellus zone have recently been studied by Rasetti (1951). Tentatively the Eager Formation may be correlated with Peyto limestone, that is, the top of the Lower Cambrian St. Piran sandstone at Kicking Horse Pass. It is also correlated with the lower part of the Burton Formation at Elko (Schofield, 1922).

LITHOLOGY OF THE *OLENELLUS* ZONE

It is stated by Resser and Howell (1938, p. 207) that:

> "The lithologic similarity of Lower Cambrian strata in all parts of the world is astonishing, and this similarity is particularly noticeable in the shales bearing olenellid trilobites. For the most part, these rocks are clay shales, in many places calcareous, but everywhere fine grained; the joint surfaces are almost universally stained with limonite generally in dendritic form. Moreover there was sufficient calcareous content in the original muds to prevent many tests from being completely flattened."

The Eager Formation is no exception to this statement. According to Rice (1937, p. 21)

> "The bulk of the formation consists of dark grey, often rusty-weathering argillite ... Blue-grey, olive green, and reddish platy argillites also occur in places. They are all soft, easily deformed rocks and are everywhere foliated. The formation is not generally limy, but beds of calcareous argillite may occur in any part of it ..."

It is apparent from the foregoing statements that the *Olenellus* zone is peculiar to a somewhat restricted type of lithology. But within the zone itself, in this case the Eager Formation, certain peculiarities of faunal distribution are superficially apparent.

The trilobites were collected from two localities named here A and B. At locality A, on the main Cranbrook-Fort Steele road (see map in back cover) the rocks are soft limonitic argillites; at B, just south of St. Mary River and east of St. Eugene Mission, they consist of harder, dark grey, rusty-weathering, dolomitic, sometimes sandy argillites. At both localities the dominant forms are Olenellus cf. gilberti and Paedeumias nevadensis; but at B, not only is the proportion of O. eagerensis higher, but here were found the only specimens referred to O. schofieldi and to Bonnia cf. columbensis.

Since the writer did not carry out the collecting himself, numbers of imperfect or incomplete specimens may have been abandoned, with consequent "weighting" of the proportions of species collected. Furthermore, the stratigraphic relationship of the two outcrops is not known, so that it is possible that entirely different ages within the Olenellus zone are represented.

Although no positive conclusion may be drawn from these observations of faunal distribution, the facts do not, at least, contradict the suggestion made by Rasetti (1951, p 82):

> "The Olenellus zone may represent a shaly facies of the Lower Cambrian deposits rather than a definite time interval. In northwestern Vermont, for example, olenellids seem to prevail when the Lower Cambrian is represented by silicious shales, while Bonnia and small ptychoparid trilobites are dominant in limestone or dolomitic formations, regardless of age."

CHAPTER II

TAXONOMIC CONSIDERATIONS

Introduction

Probably no group of trilobites has aroused more controversy and discussion than the olenellids. They are unique in many ways. But for years their peculiarity was not recognized, and the greatest efforts were made to fit them into established schemes of classification. Much of the trouble stemmed from the older conceptions of evolution. A later form, showing superficial resemblance to another, living perhaps millions of years earlier, was considered to be necessarily on the direct line of descent. Homologizing of parts was still a new idea in the last century, of great scientific value, but carried to extremes. Some traces of these abuses have lingered on to the present day.

The controversy arising in the study of olenellids was concerned mainly with the development and origin of two or three features of the carapace: terminal segments, cephalic sutures, and to a lesser extent, cephalic spines. Since an attempt is made in this paper to augment established criteria for distinguishing the shields of certain trilobites, the above features and some others of a less controversial nature are discussed insofar as they apply to the genera and species examined. Furthermore, although the genus Mesonacis has been declared invalid (Resser and Howell 1938), it is possible that at some future time enough data will have been compiled to permit the reintroduction of this controversial name. With this in mind the writer indicates possible criteria for a redefinition of "Mesonacis" (s.s.).

TERMINOLOGY

The terminology used throughout this paper is essentially that of Howell et al. (1947) with some of the modifications suggested by Ross (1948) and adopted by Rasetti (1951).

Since it is suggested that the anterior of the cephalon of olenellids is not separable into fixed and free cheeks, the "brim" is restricted in this paper to mean that part of the cephalic surface at the centre, lying between the frontal lobe and the rim.

To avoid tedious repetition, the axial spine on the 15 thoracic segment is occasionally referred to as "the 15th spine", even when other spines are not present on segments anterior to the 15th.

TERMINAL SEGMENTS

The rudimentary posterior segments of olenellids are only rarely observed. Under conditions of almost perfect preservation they may be concealed by the massive axial spine on the 15th segment, or perhaps folded forward under the thorax. In most specimens, since these segments were probably very fragile, they seem to have been lost entirely.

For many years C.D. Walcott was an influential proponent of the theory that the 15th spine on Olenellus was a telson, like that on Limulus, the modern king crab. The presence of terminal segments and small pygidia in all other olenellid genera decided him to set up Mesonacis rather than Olenellus as the type-genus of the family Mesonacidae. The genotype, M. vermontana, was known to possess ten rudimentary segments, and a small pygidium, posterior to the spine-bearing 15th thoracic segment.

During the course of time, more and more specimens representing established species of Olenellus were found to possess rudimentary segments, necessitating their transfer, by Walcott and his followers, to Mesonacis or Paedeumias, the nearest related genera known to possess such features.

Resser (1928) after showing conclusively that Olenellus did indeed possess rudimentary segments, pointed out that differences in these could be detected at the generic level; those of Mesonacis had definite, grooved pleurae, those of Olenellus had ungrooved pleurae, but those of Paedeumias lacked pleurae altogether.

In 1938, Resser and Howell, in revising the genus Olenellus established the fact that its posterior segments did not necessarily possess pleurae. Generic redescription included certain other characteristics, so as to include forms formerly named Mesonacis. Thus, the names Mesonacis and Mesonacidae were dropped.

Observations

With the exception of Wanneria walcottana, the specimens in the collection, although well preserved, generally exhibit neither the posterior rudimentary segments nor the pygidium. In nearly every complete thorax of Olenellus and Paedeumias the 15th spine is extremely heavy, its base extending fully across the axial lobe, and tapering fairly slowly, so that it effectively conceals whatever lies beneath. One specimen of Olenellus cf. gilberti has no less than three very poorly preserved segments posterior to the spine-bearing 15th, but no pygidium has been observed.

FACIAL SUTURES

The classification of trilobites is largely based upon the development and position of the facial suture, or line of junction of the fixed and free cheeks of the cephalon. It is generally assumed that this was the line along which the trilobite cephalon split during ecdysis, the periodic moulting common to all crustacea. It is possible that the sutures of trilobites are not invariably homologous. According to Stubblefield (1936, p 410):

> "It cannot be denied that the presence of cephalic sutures facilitated ecdysis, but it is at least arguable that the sutures existed only for this purpose."

The olenellids have long been a source of difficulty in taxonomy, since they do not appear to possess these useful structures in functional form, i.e. as a means of facilitating ecdysis. Observations made of specimens since the first description of Olenellus (Hall, 1859) have been variously interpreted. A complete history of the disputes over the facial sutures in olenellids is given by Raw (1937) and Stubblefield (1936).

Briefly, the main opinions concerning facial sutures and their significance may be summarized:

1. Rudimentary - in process of origin or synthesis. (Ibid).

2. Vestigial - or in a condition of symphysis. (Raw, 1937).

Observations

In examining nearly 500 complete cephala of Olenellus and Paedeumias, the writer has made a number of observations:

1. The tendency for the cephalon to break in certain places is indisputable.

   The lines of antero-lateral fracture, interpreted by Bell (1931) and others as facial sutures, have certain characteristics.

   (a) They are seldom symmetrically developed.

   (b) No two cephala have been found with the fractures identical.

   (c) They are no more frequent in occurrence than the longitudinal line of fracture down the approximate centre of the glabella.

   (d) Unbroken cephala show no line, raised or depressed, suggestive of an inherited line of weakness in this direction.

   It is suggested, therefore, that these fractures are entirely mechanical in origin. (see Preservation)

2. The postero-lateral raised line running from under the eye toward the genal angle is as often as not asymmetrically developed. Frequently, this line separates into two or more branches indistinguishable from the venation referred to by Lockman (1947, p. 61). Fracture practically never occurs along or parallel to this line.

   It appears that if this postero-lateral line has structural significance it is not part of a vestigial facial suture, nor, in its present form, does it appear to be a rudimentary suture in the process of origin.

3. The intra-marginal sutures described by Resser (1928) in Olenellus fremonti are clearly exhibited in this collection in the wider-rimmed specimens of Olenellus and Paedeumias, but even more strikingly in the young stages of Wanneria walcottana.

CEPHALIC SPINES

In their earliest larval stages olenellids may develop three pairs of cephalic spines. Of these, the genal spines are retained as a prominent feature in adults of all genera; the intergenal spines are often lost during development; the antero-lateral spines, with the one exception of <u>Olenelloides</u> are, if present at all, restricted entirely to the youngest individuals.

It was suggested by Walcott (1910, p. 237) and has been strongly maintained by Raw (1937, p. 579) that the cephalic spines in olenellids are segmental in origin. As Stubblefield points out (1936, p. 425) there seems to be little justification for this view. Since the intergenal spines in <u>Olenellus</u> and <u>Paedeumias</u> appear to stem from the pre-occipital glabellar lobe and not, as Raw stated, from the occipital, much of his interpretation is rendered invalid.

There seems to be little doubt that the retention of cephalic spines is a primitive characteristic. But whatever their function, if any (Raymond 1928, p. 168) they are taxonomically useful.

Observations

No antero-lateral spines such as described by Walcott have been identified in any of the larval olenellids in the collection, down to the smallest cephalon, 1.25 mm in width, of Paedeumias.

Intergenal spines are more strongly developed than the genals in cephala less than 5 mm. wide of O. cf gilberti and P. nevadensis, but gradually reduce in comparative size during growth. The intergenal spines in these species are usually lost when the cephalon is about 15 mm. in width.

In almost all specimens possessing intergenal spines, a ridge connects the spine almost directly across the cheek to the rear of the post-ocular node, opposite the occipital furrow.

FRONTAL LOBE AND BRIM

The anterior glabellar lobe of olenellids is usually distinctly developed. Its distance from the rim, its size relative both to the succeeding lobes and to the whole cephalon, and its convexity, have all been used as aids in classification. The relative size of the anterior lobe to a large extent governs the shape and taper of the glabella. The separation of rim from glabella by a brim possessing an axial ridge is diagnostic of Paedeumias; the ridge is possibly due to "...compression of the test onto the hypostoma stalk during fossilization." (Resser and Howell 1938 p. 225)

Convexity is itself a relative quantity, most easily estimated in terms of the abruptness of the rise of the anterior lobe from its own frontal margin.

Observations

One of the most striking features of the cephalon of Olenellus eagerensis at all growth stages examined is the extremely abrupt rise of the frontal lobe from the narrow rim.

The frontal lobe of O. cf. gilberti is preceded by a brim and rim of approximately equal width.

Between O. cf. gilberti and P. nevadensis many transitional forms have been observed, with the width of the brim varying from one to three times that of the rim. The rim itself varies in width between specimens otherwise identical; specimen M.Y.1 is typical of O. cf. gilberti except for its broad rim (Pl.II Fig. 8).

The growth stages of O. cf. gilberti and P. nevadensis less than 8-10 mm. in width are indistinguishable; the brim is wide in all cephala examined, and in the better preserved specimens possesses the typical Paedeumias ridge. Consequently, all minute forms of these two species are together referred to "Paedeumias" in this paper.

HYPOSTOMA AND EPISTOMAL PLATE

The hypostoma, if well preserved, may be a valuable aid in identification of olenellids. As in most trilobites, it is a lip-like structure fitting convex down beneath the anterior glabellar lobe. The hypostomae of Wanneria and Paedeumias from the type localities are equipped with denticulate posterior margins; it is believed (Walcott, 1910, p. 328) that Olenellus gilberti possessed the same feature.

In Olenellus and Paedeumias the hypostoma is attached to the epistomal plate, which is in turn apparently connected anteriorly to the doublure, the two together occupying the width of the rim at the axis. The most important diagnostic feature of Paedeumias is the stalked attachment of the hypostoma to the epistomal plate, often indicated dorsally by a narrow axial ridge across the brim.

If the epistomal plate of all members of Olenellus and Paedeumias lies directly under the rim, and the hypostoma no further forward than under the frontal glabellar lobe, since the two must be attached, three conditions can govern the mechanics of attachment. If the rim is adjacent to the frontal lobe the hypostoma and epistomal plate may be attached directly; if the distance between frontal lobe and rim is increased, either the plate and rim must be proportionately wider for direct attachment, or, if the plate remains narrow a stalked attachment must develop. Concerning Paedeumias, Resser and Howell (1938, p. 226) state:

> "The hypostoma is attached to the marginal, or more likely, epistomal plate, by a stalk whose length equals the distance from the glabella to the rim."

Observations

The epistomal plates of O. eagerensis and O. schofieldi have not been observed with any certainty. That of W. walcottana is slightly narrower than the rim, with hypostoma in direct connection. Denticulation has been observed on only one hypostoma associated with a small Paedeumias. No serrations or teeth have been seen on any hypostomae of Wanneria walcottana, although the epistomal plate of this trilobite is as prominently denticulate as that of the holotype.

Two very perfect shields of Olenellus cf gilberti, although lacking the hypostoma, retain the epistomal plate slightly drawn back from the rim. Half-way from the genal angle to the centre the plate is about half the width of the rim, widening to one rim-width at the axis. At this point a narrow section of the plate is missing (see Frontispiece). The brim here is about twice the width of the rim. On a second specimen the plate is unbroken, and a widened portion at the axis is slightly longer than the missing part in the first.

If the original position of the plate was directly under the rim, and the widened or missing part represents the attachment of the hypostoma, such attachment must have been narrower than long, in other words a stalk. This inference cannot be confirmed at present, since no stalk has been directly observed.

The epistomal plate of olenellids seems to have been hooked or anchored in some way at the posterior ends, just inside the genal angle. Flattening of the cephalon during fossilization would pull the ends apart, giving rise to the observed drawing back of the plate from its original position at the rim.

THORAX

In most olenellids the axial spine of the 15th thoracic segment is very large. But the overall aspect of the thorax of Olenellus and particularly of Paedeumias is dominated by the extreme enlargement of the third pleural segments, extending into slender spines.

The shape of the thorax, "wide" or "narrow" of authors, is compounded of several variables: width of axial and of pleural lobes, relative both to each other and to their length, and to a certain extent the degree of lateral or longitudinal compression and flattening subsequent to burial.

The main, central parts of the carapace were rigid and more or less brittle, even when the trilobite was alive, but it is probable that the falcate tips of the pleurae were less so. Consequently, the degree of flexure of these tips, either before or after burial, is diagnostically of little value. But the sharp or gradual angling back of pleurae at a point proximal from the outer tip of the pleural groove may frequently aid in distinguishing specimens. For instance, the pleurae of O. eagerensis usually angle back sharply, whereas those of Paedeumias and most species of Olenellus tend to swing back more gradually.

In some species the relative length of pleural groove to falcate tip reduces uniformly from front to back, as in W. walcottana (Wanner, 1901, p. 267). In this species, where the tips are not unduly extended into spines, the ratio may be used as an indication of the "number" of segment from which an isolated complete pleuron might have come, permitting a rough estimate to be made of the size of original shield.

But the relative length of a selected pleural groove may also be compared between species as a diagnostic aid. If the second pleuron, which is frequently preserved and easily identifiable, is examined, the ratio of length of pleural groove to width of axial lobe is reasonably constant for a particular species. This ratio is in the order of 5:4 in Paedeumias and in most species of Olenellus, but only about 3:4 in O. eagerensis.

POST-OCULAR NODES

Post-ocular nodes in olenellids have been briefly referred to by a number of authors. They are smooth mounds, usually elliptical, "...on the fixed cheeks back of, and inside of, the eyes" (Resser and Howell, 1938, p. 225). On Olenellus and Paedeumias they seem to be best developed in those species whose palpebral lobes are some distance from the posterior cephalic margin.

On O. schofieldi the post-ocular nodes are particularly prominent, evenly sloping up and back from the junction of the dorsal and palpebral furrows to maximum elevation opposite the rear of the 3rd glabellar lobe. At this point they drop away steeply to disappear opposite the occipital furrow. O. eagerensis, on the other hand, possesses long narrow post-ocular mounds of fairly even height (Pl.I Fig.4) extending along the side of the dorsal furrow from inside the palpebral lobe to just back of the occipital furrow.

At this stage in the research, no function may definitely be assigned to post-ocular nodes or mounds. But it seems reasonable to assume that they have some anatomical explanation. As a first working hypothesis it is suggested that they represent the ventral "housing" for paired organs, possibly ovaries, perhaps digestive glands, or both. If they are ultimately proven to reflect internal anatomy they may well be of greater taxonomic value than has hitherto been thought.

ORNAMENTATION

Surface ornamentation is not an important characteristic genetically, but certain species may exhibit unique markings which are diagnostic. Thus, by means of the reticulate surface ornamentation "even a small fragment can be assigned to Wanneria" (Resser and Howell, 1938, p. 246). This type of polygonal pattern has been observed on the dorsal surface of all the larger specimens of W. walcottana in the collection.

The cheek surface of Olenellus schofieldi is unlike that of any other form in the collection, but consists of a pattern of radiating, irregularly inosculating, raised lines, reminiscent of the vein pattern of a leaf. According to Lochman (1947, p. 61) this venation is neither ornamentation nor diagnostic;

> "... but rather it appears to be the impress of an internal anatomical structure on the carapace. As it has been observed in many apparently unrelated genera ranging through the Paleozoic, it is considered to be a feature characteristic of the whole class."

Ornamentation such as that figured by Walcott (1910) on O. gilberti has not been observed on any specimens here. However one incomplete cephalon of O. cf. gilberti exhibits an irregular raised ferruginous network of a different kind. Although the writer thinks that this has an inorganic explanation, that of dendritic precipitation in a narrow fissure, its development may have been determined by the differential chemical influence of an original surface ornamentation.

The pattern of overlapping lines on the tips of pleurae of Olenellus halli (Walcott) figured by Walcott (1910, pl. 31, figs. 10, 11) show them to be roughly transverse on the ventral surface but sub-longitudinal on the dorsal. This rule appears to apply to all the species of Wanneria, Olenellus and Paedeumias in the Garrett collection.

GROWTH STAGES

One of the most important phases of palaeontological research, after the purely descriptive work has been done, is the analysis of observations. Relationships between groups are sought, and efforts made to disentangle evolutionary trends. The greatest use, both economic and purely scientific, can be made of information only when its limitations are known.

The study of perhaps greatest taxonomic value in paleozoology is that of growth stages, for one of the most widely accepted principles has been the biogenetic law; "Ontogeny recapitulates Phylogeny".

The growth stages of only a few olenellids have been studied (Walcott, 1910). But the extent to which theories of evolution have been developed from such studies is best illustrated by reference to Raw (1925, 1927, 1936, 1937). But such theories should be accepted with some caution. It is possible that a trilobite did not start to secrete hard parts capable of fossilization until its development was so far advanced as to provide only doubtful clues as to its relationships. Furthermore, some of the ontogenies described in the past may have been based on insufficient specimens.

Enough material is present in this collection to warrant further work, but the writer regrets the lack of time to complete it himself.

An intensive study should be made of the growth stages of *Paedeumias* and *Olenellus* in this collection, with a view to confirming or contradicting the conclusions reached by Walcott (1910) insofar as they apply to the fauna of the Eager Formation.

PRESERVATION

The *Olenellus* fauna is nearly always comparatively well preserved. Apart from the crushing of very thin, convex tests, which is to be expected even under the best conditions, the fine sediments tend to preserve extremely fragile types of crustacea such as the homopods *Tuzoia* and *Anomalocaris*, and to favor the retention of considerable detail in the olenellids themselves.

The degree of preservation has a very real bearing on taxonomy. Removal of diagnostic details, distortion of structures, and even the superimposition of secondary characteristics of inorganic origin, may all play their part in making identification and classification difficult.

In the material studied here, attention has been drawn to the almost complete absence of pygidia. In this connection, it is regrettable that the thoracic segments of *O. eagerensis* are seldom preserved behind the 4th or 5th, and no pleural segments of *Bonnia* have been found at all. It may be that the apparent absence of intergenal spines in larger specimens of <u>Paedeumias</u> is a matter of incomplete preservation.

The extent of distortion in specimens is often very difficult to estimate. It is reasonable to assume that variations from a common "mean shape" existed in every conspecific trilobite population. If only one recognizable species were present, the variations around the mean would follow a normal distribution curve, with only one maximum point. However, in the course of burial, compaction and subjection to shearing stresses, originally identical forms might conceivably yield in a definite number of ways, limited perhaps by the type of basic structure. This could give rise to a similarly limited number of "types". It is possible that some of the recognized species of trilobites owe their specific stature to such a combination of mainly inorganic circumstances.

The convex cephalic shield of an olenellid in course of flattening, because it is wider than long, may yield more easily along the axis than laterally. Cracks are most likely to develop where greatest tension is effective. Such a point appears to exist at the frontal margin at the centre. Subsequently, the crack would extend backward over the cephalon, permitting maximum vertical movement along the line of maximum convexity, that is, along the glabella. Once the two halves were independent the next point of maximum tension would appear to lie at or near the base of the palpebral lobe. In this way it is possible to account for the commonly observed cephalic cracks: the primary fracture occurring along the axis, the secondary pair fortuitously simulating the anterior branch of the facial suture.

Compression acting in the solid rock may be quite intense, and its manifestation in fossils can sometimes afford a measure of its degree. Several specimens in the collection show two or more cephala, differently oriented, which exhibit distortion. In some, the length to width ratios differ from each other by as much as 40%. Pure compaction, on the other hand may lead to false length-width ratios due to the more intense lateral than longitudinal yielding of hemi-cylindrical structures such as the axis and glabella.

Not all notes on preservation are gloomy. One natural cast of <u>Olenellus cf. gilberti</u> (Pl.II Fig.10) shows two shallow, gently curved depressions tapering forward across the cheek from their origin at the base of the palpebral lobes. Their position and width appear to preclude confusion with "facial sutures", yet they are almost certainly of anatomical significance. Although apparently unsegmented, they are thought to be the impressions of antennules. This observation confirms that of Dunbar, who stated (1925, p. 306) that the antennae[1] of <u>Olenellus</u> "....are simple, project forward, and show no evidence of segmentation".

CEPHALIC AND THORACIC RATIOS

Because so many trilobites are distorted it is often impossible to gauge the original shape of a single specimen. Similarity of shape depends upon similar proportions of component parts. On a distorted specimen the ratio of length to width may be very misleading; but the relative value of measurements made in the same direction tends to be constant for a species regardless of distortion.

Working independently, the writer found that certain cephalic ratios were of diagnostic value: the overall width of the cephalon to that of the occipital ring, and the length of the occipital and three lobes immediately anterior to it relative to that of the palpebral lobes.

Later, this system was modified to bring it into line with the methods suggested by Lochman (1947, p. 60). The cephalic features finally utilized in this

1. Sic

connection were:

1. Relative position of midpoint of eye relative to that of glabella. (Ibid)

2. Width of cheek from dorsal furrow to outside of genal angle relative to width of occipital ring. (Ibid, modified for olenellids)

3. Length of rear four cephalic lobes, including the occipital, to that of palpebral lobes.

4. For the sake of completeness, the thoracic ratio, length of pleural groove to width of axial lobe at the 2nd segment, is included here.

TABLE I

Cephalic and Thoracic Ratios

Average values of 10 typical specimens of each species

Species	1	2	3	4
Olenellus eagerensis	level	1.0-1.25	1.5-1.8	0.6-0.8
O. schofieldi	behind	1.8-1.9	1.4-1.8	1.2-1.3
O. cf. gilberti	"	1.6-1.7	1.25-1.35	1.1-1.2
Paedeumias nevadensis	"	1.7-1.9	1.25-1.35	1.1-1.2

(numbered columns refer to sections in the text)

SYSTEMATIC POSITION OF OLENELLIDS

The facial suture as such does not appear to be present in olenellids. But most of them do possess marginal sutures. The writer is inclined to agree with the following statement by Swinnerton (1919, p. 103):

"Trilobites in common with all other Arthropods shed their more or less rigid external covering or exoskeleton periodically. To accomplish this ecdysis it is necessary for this covering to split somewhere; and it is highly probable that the facial suture was the line along which such splitting took place. There seems however to be a tendency to assume that all lines which served this purpose are homologous. This has introduced unnecessary difficulties into the study of Trilobite classification."

Since the accepted method of classification does involve facial sutures it seems wisest to admit with Poulsen (1932) and Resser (1938) the unique position of the olenellids and to accord them the rank of an order. Because Olenellus, as the first described genus, and one of the most widely distributed, appears to be firmly established as typical, the classification followed here includes these trilobites in the order Olenellida.

GENERIC AND SPECIFIC DISTINCTIONS

Resser and Howell (1938) state that since the genotypes of Olenellus and Mesonacis, O. Thompsoni and M. vermontana do not show sufficient differences, the names "Mesonacis" and "Mesonacidae" must be dropped. They point out that the difference between the posterior segments of these species "exists and has some significance, but it is not now believed to be of generic importance". (Ibid. p. 217)

Since the poor and infrequent preservation of terminal segments has led in the past to so much confusion, it is clear that they cannot constitute the principal criterion for generic distinction. Other criteria, based upon differences in the cephalon and thorax must be used also. It is believed that sufficient difference exists between certain species of Olenellus to justify re-examination of the problem.

If "Mesonacis" were restricted only to such comparatively distinct species as O. eagerensis, M. insolens, M. bristolensis, and perhaps O. vermontanus, a majority of the following criteria might differentiate such a genus from Olenellus or from Paedeumias. But, since the writer is dependent on photographs rather than specimens from other localities, this proposal is made very tentatively.

TABLE II

Possible Generic Distinctions

Characteristic	Paedeumias	Olenellus	Mesonacis
a. Posterior segments	4	2-6	10
b. Centres: eye to glabella (1. p. 27)	behind	behind	level
c. Lateral cephalic ratio (2, p. 27)	1.6-1.9	1.8-1.9	1.0-1.25
d. Longitudinal cephalic ratio (3, p. 27)	1.2-1.4	1.2-1.8	1.5-1.8
e. Lateral thoracic ratio (4, p. 27)	1.0-1.2	1.2-1.3	0.6-0.8
f. Glabellar shape	cylindrical May taper forward	cylindrical	"hour-glass"
g. Brim, anterior to glabella	always	sometimes	never
h. Stalk on hypostoma	always	never	never
i. Intergenal spines	always	frequently	reduced

RECOMMENDATIONS FOR FURTHER STUDY

1. A study should be made of the growth stages of *Olenellus* and *Paedeumias* in the Garrett collection.

2. It is possible that two subspecies of *Olenellus eagerensis* are present, one with narrower cheeks, the other with a more enlarged frontal lobe, than that described in this paper. This should be checked.

3. As indicated by Walcott (1910), Resser (1928) and as observed by the writer, it is possible that *Olenellus gilberti* is a "form species" comprising legitimate species of *Paedeumias* as well as *Olenellus*. Resser (Ibid. p. 9) states: "it seems certain ... that some of the specimens referred by authors to *Mesonacis gilberti* belong neither to that species nor even to *Mesonacis*, but are distinct species of *Paedeumias*." This species should be thoroughly re-examined.

4. As indicated in this paper, if the generic distinctions outlined by Lochman (1947, p. 60) are followed, at least one new genus must be erected on the basis of cephalic characteristics. (See p. 29) This may involve the re-examination of generic distinctions and reclassification of the whole order Olenellida.

CHAPTER III

DESCRIPTION OF GENERA AND SPECIES

Phylum	Arthropoda
Class	Crustacea
Subclass	Trilobita
Order	Olenellida
Family	Olenellidae
Genus	Olenellus Hall, 1862

Barrandia	Hall	N.Y. State Cab. Nat. Hist., 13th Rept. (1860) p. 115.
Olenellus	Hall	N.Y. State Cab. Nat. Hist., 15 Rept. (1862) p. 114.
Mesonacis	Walcott	Am. Jour. Sci., 3rd ser., vol. 29, (1885) p. 328, fig. 1, 2.
Olenellus	Walcott	U.S. Geol. Surv., Bull. 30, (1886) p. 162, 165.
Mesonacis	Walcott	U.S. Geol. Surv., Bull. 30, (1886) p. 158, 165.
Olenellus	Walcott	U.S. Geol. Surv., 10th Ann. Rept. (1891) p. 165, 633.
Mesonacis	Walcott	U.S. Geol. Surv., 10th Ann. Rept. (1891) p. 637.
Mesonacis	Walcott	Smithsonian Misc. Coll., Vol. 53, no. 6 (1910) p. 246, 261.
Olenellus	Walcott	Smithsonian Misc. Coll., vol. 53, no. 6 (1910) p. 248, 311.
Mesonacis	Resser	Smithsonian Misc. Coll., vol. 81, no. 2 (1928) p. 3.
Olenellus	Resser	Smithsonian Misc. Coll., vol. 81, no. 2 (1928) p. 5.
Olenellus	Resser	and Howell, Bull. Geol. Soc. Amer., vol. 49, (1938) p. 217, 218.

The most recent authoritative work on olenellids is that by Resser and Howell (1938). Until a great deal more much needed study has been made of the whole order it is clear that their generic diagnoses of Olenellus and Paedeumias must stand as partial clarification of what had been taxonomic chaos.

But the writer, faced with a fauna in which certain species assigned to *Olenellus* show closer affinities to *Paedeumias* than to other species placed in their own genus, is bound to suggest alternative grouping. It is probable that either a restricted genus *Mesonacis* will have to be revived, or that the genus *Paedeumias* will have to be greatly enlarged at the expense of *Olenellus*; indeed, it is possible that both expedients will be necessary.

The following generic diagnosis of *Olenellus* is summarized and slightly modified from Resser and Howell (1938, p. 217).

Diagnosis

The cephalon is large; the thorax, of many segments, is long and tapering; the pygidium is represented by a small plate.

Cephalon usually semicircular, highly convex, with long genal spines. Facial sutures not functional. Glabella wide, extending to frontal rim, either cylindrical or "hourglass" shaped. Of the three pairs of glabellar furrows, the first connects across the middle, setting off the rounded frontal lobe; the second is frequently reduced to a pair of slits, which in adults fail to reach the dorsal furrow; the third pair of furrows, like the occipital behind it, fails to connect across the glabella. The dorsal furrow is deep, but interrupted by the junction of the frontal and palpebral lobes. The brim is narrow, often only equal to the width of the marginal furrow. Rim varying in width between species, usually fairly narrow, widening slightly toward the genal angles. Palpebral lobes semicircular, separated from the glabella by the dorsal furrow (and post-ocular nodes if present). Eyes large and, like the palpebral lobes, may extend almost to the posterior margin. Facial sutures are not present as such, but possibly are represented postero-laterally by raised, sometimes asymmetrical and bifurcating lines, running from under the eyes toward the genal angles. Cheeks are large and convex. Intergenal spines often present. Genal spines usually large, but smaller when in an advanced position.

Hypostoma strongly convex, about the same size as the frontal lobe, attached directly to a narrow epistomal plate.

Thoracic segments varying in number, but fixed within a single species, usually loosely arranged. Pleurae straight, sharply curving back to long tapering ends. Pleural grooves wide and straight to the fulcrum, where they bend slightly less sharply than the pleurae, and begin to contract slightly more abruptly than the pleural terminations. The fulcral angle and tapered terminations increase posteriorly in proportion to the decreasing length of the pleurae. The rear segments point almost directly backward, partly enclosing the large axial spine on the 15th segment. Varying numbers of small segments posterior to the 15th are terminated by a pygidial plate. These segments are often called rudimentary because they often lack pleural extensions. Except for the fifteenth segment, axial spines are usually absent.

Surface may be irregularly lined.

Olenellus is most easily confused with Paedeumias, from which it differs "...chiefly in the position and size of the glabella, in the wider doublure, and in the direct attachment of the hypostoma to the marginal plate, without the slender stalk of Paedeumias" (Resser and Howell, p.218).

Genotype: Olenellus thompsoni Hall 1862

<u>OLENELLUS cf. GILBERTI</u> MEEK, 1874

Frontispiece; Plate II, Figs. 6-10.

This is one of the commonest species present in the Eager Formation. One of the better preserved specimens is illustrated as the Frontispiece.

From observations of <u>O. cf. gilberti</u> and from statements made by competent workers (Ibid p. 226) it may be inferred that the presence of a brim of considerable width separating a narrow rim from the glabella is indicative of a stalked hypostoma. If this is so, many species now assigned to <u>Olenellus</u> should be transferred to <u>Paedeumias</u>. Of these, <u>O. gilberti</u>, as forecast by Walcott (1910, p. 329) and by Resser (1928, p. 9) should almost certainly be one of the first.

However, since further study, both of the type specimens and of the excellently preserved fossils from the Eager Formation, is prerequisite to such a step, it seems wisest to take no controversial action at this time.

Diagnosis

Apart from the presence of a brim, whose width varies from equal to twice that of the rim, the cephalon conforms to generic description. Intergenal spines subdued or absent in specimens larger than 15 mm in width. The shortness of the palpebral lobes is masked to a certain extent by long, low post-ocular mounds. Marginal and intramarginal sutures present. Rim fairly narrow, but varies slightly between individuals; it widens fairly strongly at the genal angles. Epistomal plate the same width as rim at the front, tapering gently toward the genal angles. Small node or spine on posterior of occipital lobe.

Pleurae of third thoracic segment greatly enlarged making nearly a right angle at the fulcrum. Single small spines on the posterior margins of axial lobes are traceable forward, progressively reducing in size from the 14th segment till they die out altogether at the 3rd. The axial spine on the 15th segment is very large and long, presenting a curious dimpled structure; the minute depressions are arranged in quincunx.

Rudimentary segments were very doubtfully observed on only one specimen; no less than three appear to be present.

Cephalic and thoracic ratios are given in Table I.

Relationships

The most nearly allied forms are those assigned to Olenellus gilberti Walcott, Paedeumias nevadensis (Walcott) and P. clarki Resser.

This species differs from O. gilberti in having shorter palpebral lobes, and certain indications of a stalked hypostoma. From P. clarki it differs in possessing a wider rim. From P. clarki and P. nevadensis it differs in having a narrower brim, a more expanded frontal lobe, and in lacking intergenal spines when adult.

OLENELLUS EAGERENSIS n. sp.
Plate I, Figs. 1-11.

The most striking feature of O. eagerensis is the great width of the axis.

Cephalon is semicircular in front; posterior margin with clearly developed intergenal angle of about 145° in adults, less clearly marked in young specimens. Advanced, fairly small genal spines, always oblique to the axis by an angle of about 20°. Glabella "hourglass" shaped, with strongly convex semi-ellipsoidal frontal lobe touching the rim. Both front pairs of glabellar furrows in adults reduced to slits, the second almost to dimples; in immature forms these two furrows connect across the middle, but the second pair does not extend to the dorsal furrow. Palpebral lobe is short, strongly arched, its tip extending to just behind the third glabellar furrow. Rim is very narrow, widening only slightly at the genal angle. Posterior rim shallow, widened at the intergenal angle. Small intergenal spines are sometimes faintly developed just outside intergenal angles; even when absent, they are represented by a slight thickening of the rim, which is joined by a low ridge to the back of the post-ocular mounds opposite the occipital furrow. Occipital ring wide, with a small posterior spine.

Thorax with broad axis. Pleural lobes comparatively short, sharply angling back and abruptly tapering to short spines. Pleural grooves short, broad, flat, marked off distinctly by a rim both anteriorly and posteriorly. Pleurae of third segment not greatly enlarged. Small axial spines present on all thoracic segments anterior to the 15th; the latter spine is enlarged, but tapers sharply. Nothing is known of segments, or pygidium, posterior to the 15th.

Cephalic and thoracic ratios are given in Table I.

Holotype: Department of Geology, University of British Columbia, No. GT 101. Coll: C. Garrett.

Paratypes: Department of Geology, University of British Columbia, Nos. GT 102-110. Coll: C. Garrett.

Type Locality: Loc. B. Eager Formation, 6 mi. N.E. of Cranbrook, B.C.

Geologic Age: Lower Cambrian.

Discussion

This species of Olenellus shows such striking differences from the genotype, that were the recommendations of Lochman (1947) followed, it would probably be placed in a different genus.

Its closest affinity to figured species is to the drawings reproduced by Walcott (1910, pl. 37, Figs. 8-19) from his previous publications (1884, 1886, 1891) purporting to show the young stages of growth of O. fremonti. The latter species has been restricted by Resser (1928) and proven not to possess advanced genal spines.

O. eagerensis differs from Walcott's figures in having a narrower rim, smaller genal spines, shorter anterior lobe, and wider, more evenly tapering palpebral lobes; but its similarity is apparent in view of Walcott's own tentative identification of "O. cf. fremonti" from the Eager Formation (Schofield, 1922, p. 12).

From "Mesonacis" bristolensis and "M". insolens (Resser, 1928) it differs in having less advanced genal spines, wider intergenal angles, narrower rim, and more rounded frontal lobe. From O. vermontanus it differs in having slightly shorter palpebral lobes, narrower rim, sharper intergenal angles, and a slightly wider cheek.

From other olenellids in the collection the quoted differences are even more marked.

This species is well represented in the collection, and is based on no less than one hundred cephala ranging from 2.4 to 35 mm. in width.

It is named for the Eager Formation in which it is found.

OLENELLUS SCHOFIELDI n. sp.
Plate I, Figs. 12-17.

Cephalon semicircular, slightly trapezoidal in elongated specimens, with an almost straight posterior margin. Glabella narrow, cylindrical, with expanded hemispherical frontal lobe reaching the rim. Glabellar furrows normal for genus; second pair reduced to slits. Palpebral lobes extremely short, their tips extending to opposite the front half of the 3rd glabellar lobe behind the frontal. Post-ocular nodes very prominent and short, rounding down abruptly behind their point of maximum elevation opposite the back of the 3rd glabellar lobe. Rim very narrow, hardly widening at all toward the genal angle. Genal spines slender. Intergenal spines present, joined to back of post-ocular mounds by a slightly raised ridge. A minute occipital spine may be present.

Thorax typical of the genus, but the axis, somewhat narrow anteriorly, appears to taper rather gradually. Pleurae angling back sharply to slender terminations. Third pleurae strongly enlarged. Small axial spines are present on segments posterior to the fifth.

Rudimentary segments and pygidium unknown.

Venation of the cheek surface is strikingly developed on the larger forms, consisting of radiating, irregularly inosculating, raised lines.

The largest cephalon assigned to this species is 32.6 mm. wide by 17.1 mm. long. The ratio of width to length (1.9) for this specimen is believed to be a little high; two other cephala oriented almost exactly at right angles yield an average ratio of 1.8. Other cephalic and thoracic ratios are given in Table I.

Holotype: Department of Geology, University of British Columbia No. GT 201. Coll: C. Garrett.

Paratypes: Department of Geology, University of British Columbia, Nos. GT 202-210. Coll: C. Garrett.

Type Locality: Loc. B, Eager Formation, 6 mi. N.E. of Cranbrook, B.C.

Geologic Age: Lower Cambrian.

Discussion

The shortness of palpebral lobes, the prominent post-ocular nodes, the strongly developed venation and extremely narrow rim serve to distinguish O. schofieldi from all other cordilleran species.

From O. brevoculus it is distinguished by its having a narrower rim and relatively narrower glabella, and from O. fremonti (s.s.) by the narrow rim, straight posterior cephalic margin and possession of intergenal spines.

This species is comparatively rare, only ten specimens being definitely assignable to it in this collection. It is named after S.J. Schofield of the Geological Survey of Canada who first reported the presence of olenellids near Cranbrook.

GENUS PAEDEUMIAS WALCOTT 1910

Paedeumias Walcott, Smithsonian Misc. Coll., vol. 53, no. 6 (1910) p. 304.
Paedeumias Resser, Smithsonian Misc. Coll., vol. 81, no. 2 (1928) p. 5
Paedeumias Resser and Howell, Bull. Geol. Soc. Amer., vol. 49, no. 2 (1938) p. 225.

The redescription of this genus by Resser and Howell (1938 p 225) expresses the essential characteristics:

"The cephalon is large and broad, the thorax has many long-spined segments and terminates in a small plate. The cephalon is semicircular in outline, and probably had considerable convexity. Facial sutures[1] are sometimes traceable back of the eyes. Glabella generally cylindrical with the anterior lobe tapered rather bluntly, and situated some distance from the rim. The dorsal furrows are well impressed except where the eyes join. Rim usually narrow (never wide), increasing but slightly toward the genal angles. A ridge connects the median point of the anterior glabellar lobe with the rim, but it is possible that this feature did not always show on the living animal, resulting from compression of the test on to the hypostoma stalk during fossilization. Eyes large, extending almost to the rear margin;[1] the outer curved edge, and perhaps also the rear portion of the eye lobes, were raised free above the cheek surfaces. Genal spines slender, in adult individuals, extending to about the third or sixth pleuron. Intergenal spines present in all species now definitely assigned to the genus.

The hypostoma is attached to the marginal or, more likely, epistomal plate, by a stalk whose length equals the distance from the glabella to the rim. The hypostoma itself is typical for the family, having five or more teeth on each side of the median line. The plate to which the hypostoma is attached frequently breaks away, sometimes in such a manner as to indicate a hinged attachment between the genal angles and the intergenal spines.

Thorax apparently has nineteen segments. The first fifteen are normal in shape, with the third greatly enlarged. A long heavy spine is present on the fifteenth pleuron.[1] Back of this the York species shows four rather simple segments and finally a small pygidial plate. Small spines, increasing slightly in size rearward, are present on the six or more segments immediately before the fifteenth.

1. Sic

Surface faintly lined in the usual fashion.

Paedeumias differs little from Olenellus except in the position of the glabella and the stalked hypostoma.

Genotype: P. transitans Walcott, 1910"

To the above diagnosis little can be added, but the palpebral lobes and eyes of at least one species, P. nevadensis, are short and extend no further back than the occipital furrow. Similarly the writer maintains personal reservations concerning interpretation of lines back of the eyes as facial sutures.

PAEDEUMIAS NEVADENSIS (Walcott)

Plate II, Figs. 1-5.

Callavia ? nevadensis Walcott, 1910 (pars) Smithsonian Misc. Coll., vol. 53, No. 6 p. 285, pl. 38, Fig. 12.

Paedeumias nevadensis Resser, (1928) Smithsonian Misc. Coll., vol. 81, No. 2, p. 9, pl. 3, Figs. 3-7.

The main specific characteristics are: the bluntly tapering glabella, short palpebral lobes, extending no further than opposite the occipital furrow, and wide brim, about 3 to 4 times the width of the rim.

P. nevadensis is easily confusible with Olenellus cf. gilberti in the Eager Formation. These species apparently overlap in width of brim, size of frontal and palpebral lobes, and in development of axial and intergenal spines. Furthermore, the immature specimens in the collection are practically all of the Paedeumias type, and at this stage in the research could, with equal facility, be referred to O. cf. gilberti, P. nevadensis, or in some cases to P. cf. clarki.

This gives point to the suggestion that these forms, if not conspecific, are here in the process of separating into distinct species. It is believed that a thorough statistical analysis, based on several features, is necessary to check this suggestion.

GENUS WANNERIA WALCOTT, 1910

Wanneria Walcott, Smithsonian Misc. Coll., vol. 57, No. 6 (1910) p. 248, 296.

Wanneria Resser and Howell, Bull. Geol. Soc. Amer., vol. 49, No. 2, (1938) p. 227.

The following diagnosis is based on Resser and Howell (Ibid) and on personal observation.

Entire trilobite ovate, with large, semicircular, highly convex, thin cephalon, which is usually severely flattened in adult specimens. Glabella strongly expanded anteriorly and touching rim. Dorsal furrow deep on thorax but poorly impressed on cephalon. Glabellar and occipital furrows similar to those of

Olenellus, but shallower. Occipital ring with short spine. Rim wide, increasing rapidly toward genal angles. Genal spine strong, rather long, tapering rapidly. Palpebral lobes short, sharply bowed.

Hypostoma large, usually laterally and posteriorly toothed, attached directly to epistomal plate. This plate is wide, and toothed along its inner edge. Epistomal and marginal plates attached throughout full length of the former. Both plates may be striated, but the epistomal plate often shows a reticulate surface.

Thorax in the type species of seventeen segments, which decrease regularly in size, except the last two, which are markedly smaller. Dorsal and axial furrows deeply impressed. The first fourteen axial rings have short spines, progressively longer toward the rear. The fifteenth segment has a very strong axial spine, but the two posterior segments lack spines. Segments nearly straight to fulcrum, with wide pleural furrows, which taper gradually, terminating bluntly at the fulcrum. Pleural extensions curve backward and taper to sharp points.

Pygidium, a small, slightly bilobate plate, with a median ridge, surrounded by tips of rear thoracic segments.

Surface of entire trilobite coarsely reticulate, except marginal plate, which is striated or scaly.

Wanneria is distinguished from all other olenellids by a unique combination of features: expanding glabella, normal third thoracic pleurae, large 15th spine, and coarsely reticulate surface.

Genotype: Olenellus (Holmia) walcottanus, Wanner, 1901

Range: Lower Cambrian of North America and Greenland.

WANNERIA WALCOTTANA (WANNER)

Plate II, Figs. 11-18.

Olenellus (Holmia) walcottanus Wanner, Washington Acad Sci Pr No. 3 (1901) p 267, pl. 31, Figs. 1, 2; pl. 32, Figs. 1-4.

Wanneria walcottanus Walcott (part), Smithsonian Misc. Coll., vol. 53, No. 6 (1910), p. 302, pl. 30, Figs. 1, 2, 5-12; pl. 31, Figs. 12, 13; pl. 44, Fig. 6.

Wanneria walcottana Walcott, Smithsonian Misc. Coll., vol. 64, No. 3, (1916) p. 219, pl. 38, Figs. 1, 2.

Wanneria walcottana Resser and Howell, Bull. Geol. Soc. Amer., vol. 49, No. 2 (1938) p. 228, pl. 9, Figs. 9, 10; pl. 10, Figs. 8-10; pl. 11.

Diagnosis:

One of the largest of the olenellids, up to 17 cm. in width. Cephalon strongly convex. Marginal furrow deep. Broad rim, terminating in large genal spines. Glabella typical of genus. Strongly convex frontal lobe, expanded to one third width of cephalon. Occipital lobe slightly wider than posterior glabellar lobes, rising sharply towards the rear. Occipital spine may be present. Dorsal, glabellar, and occipital furrows shallow. Palpebral lobes deeply crescentic, highly convex, short, and tapering to their termination opposite the last glabellar lobe. Marginal sutures as in Olenellus. Hypostoma large and denticulate.

Thorax typical of genus. Falcate pleural terminations marked with fine, curved, overlapping striae, roughly transverse ventrally and sub-longitudinal dorsally, as in Olenellus. Pleural grooves are wide, gently tapering troughs, terminating somewhat bluntly at the fulcrum. Segments posterior to the 15th, and pygidium, typical of genus.

Surface reticulate, the coarseness of the polygonal network varying directly with size of specimen, not usually visible on those smaller than 25 mm. in width.

More than 100 specimens are present in the collection, ranging in width from 2.5 mm. to 12 cm. In young specimens the convexity is striking. During growth the comparative width of the rim appears to decrease.

Immature forms tend to curl up; segments posterior to the 12th are usually concealed for this reason.

The adult W. walcottana from Cranbrook seem to differ from those in the eastern part of the continent in two details: hypostomae appear to lack teeth, and spines are absent from the occipital ring and from thoracic segments anterior to the 15th.

If these apparent differences are proven to be real, the choice will have to be made between raising these specimens to specific rank, or recognizing that denticulation of the hypostoma is a feature only of subspecific value in classification.

Order Opisthoparida
Superfamily Corynexochoidae
Family Corynexochidae

Genus Bonnia Walcott, 1916

Corynexochus (Bonnia) Walcott, Smithsonian Misc. Coll., vol. 64, No. 5 (1916) p. 325.

Bonnia Raymond, Amer. Jour. Sci., 5th ser. vol. 15, No. 88 (1928) p. 309.

Bonnia Resser, Smithsonian Misc. Coll., vol. 95, No. 4 (1936) p. 6.

Bonnia Lochman, Jour. Paleontology, vol. 21, No. 1 (1947) p. 68.

"Cranidium:
1. Palpebral lobes medium size, back of midline of glabella but not quite as far back as one-third.

2. Glabella either parallel-sided or expanding slowly to a broad front; regular convexity; first two pairs of glabellar furrows often obsolete, posterior pair sometimes well defined; ocular ridge obsolete in about one-half the species.

3. Fixed cheeks approximately one-half (may be a little more) width of glabella.

4. Fixed cheeks horizontal or very slghtly downsloping

5. Posterolateral limbs slightly less than length of occipital ring.

6. No frontal limb, a convex frontal border, marginal furrow at sides only.

Pygidium:

1. Nearly semicircular in outline, 1, 2 or three pairs of anterior marginal spines.

2. Pleural lobes same width as axial lobe, a narrow marginal furrow, a narrow but distinct marginal border.

3. Axial lobe of medium width, cylindrical in shape, extending to border, three clear, one faint segment and a terminal portion." (Lochman, 1947 p. 68-69)

Genotype: Bathyurus parvulus Billings, 1861

Range: Lower Cambrian, North America and Asia

BONNIA cf COLUMBENSIS RESSER

Plate II, Figs. 19, 20.

Corynexochus (Bonnia) senectus Walcott (part), Smithsonian Misc. Coll., vol. 64, No. 5 (1916) p. 319, pl. 55, Figs. 7 - 7c.

Bonnia columbensis Resser, Smithsonian Misc., Coll., vol. 95, No. 4 (1936) p. 9

Two poorly preserved cranidia and one pygidium are present in the collection, conforming to generic description. Tentative specific identification was made by reference to the works cited, especially by comparing with photographs by Walcott (1916). Apparently this was the form Walcott identified as *Prototypus senectus* (Schofield 1922, p. 12).

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PLATE I

<u>Olenellus eagerensis</u>, n. sp. and <u>O. schofieldi</u>, n. sp.

Figs. 1-11. <u>O. eagerensis</u> n. sp. (p. 37)

1. Specimen showing relative size of thorax and base of 15th spine. (X1) Paratype. U.B.C., No. GT102.

2. Holotype (X1) showing occipital and axial spines. U.B.C., No. GT101.

3, 5, 6, 7, 8, 9. (X1) Cephala showing narrow rim, characteristic glabella, and ridge to intergenal angle. Paratypes U.B.C., Nos. GT103, GT105 - GT109. (Note: 8 is a photograph of a plaster cast.)

4. Incomplete specimen showing post-ocular mound and character of pleurae. (X2.3) Paratype, U.B.C., No. GT104.

10. Minute cephalon showing typical proportions. (X5) Paratype. U.B.C., No. GT110.

11. Cephalon (X3.6) doubtfully referred to this species. Note expanded frontal lobe. U.B.C., No. GT111.

Figs. 12-17. <u>O. schofieldi,</u> n. sp. (p. 40)

12, 15, 16, 17, (X1.7, 1.5, 2, 2.6 respectively) characteristic cephala, showing veining, relatively straight posterior margin and short palpebral lobes. Paratypes. U.B.C., Nos. GT203 - GT206.

13. Immature specimen preserving intergenal and axial spines. (X2.5) U.B.C. No. GT202.

14. Holotype (X2.1) showing narrow rim and axis, strong post-ocular node, short palpebral lobe, and veining. U.B.C., No. GT201.

PLATE I

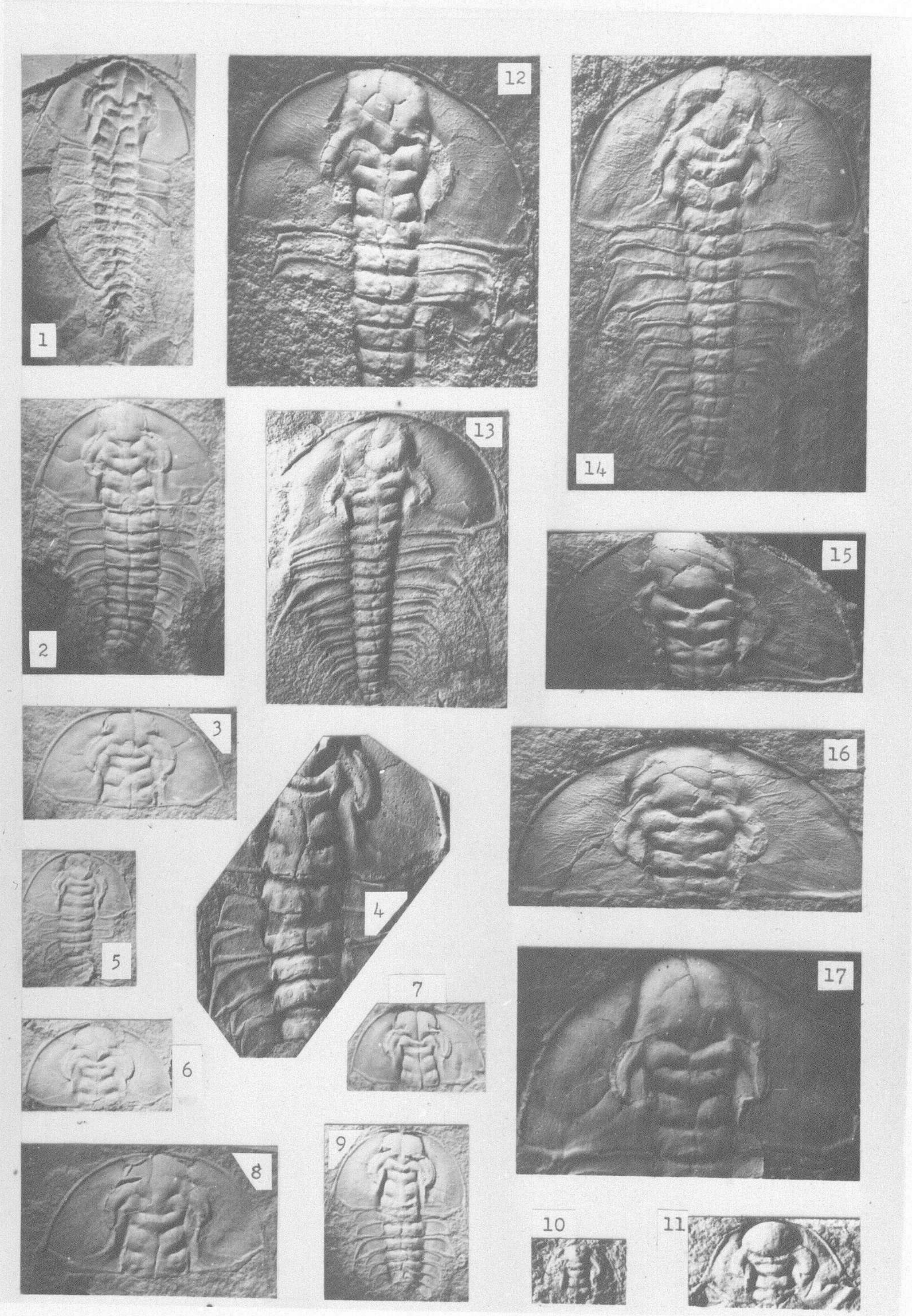


PLATE II

<u>Paedeumias nevadensis</u>, <u>Olenellus cf. gilberti</u>
<u>Wanneria walcottana</u> and <u>Bonnia cf. columbensis</u>

<u>Paedeumias nevadensis</u> (Walcott) Figs. 1-5. (p. 44)

1. Two small complete specimens (X2.7) with spine on 15th segment and short intergenal spines. U.B.C., No. GT301.

2. Very small specimen (X4.7) with at least 10 thoracic segments. Note extremely strong intergenal spines, wide brim traversed by ridge and enlarged 3rd pleurae. U.B.C., No. GT302.

3. Elongated specimen (X4.1) with long 15th spine and 3rd pleurae. Note wide rim with trace of narrow epistomal plate, and intergenal spines reduced during growth. U.B.C., No. GT303.

4, 5. Adult cephala (X1) showing reduction in width of brim and in development of intergenal spines. Nos. GT304, GT305.

<u>Olenellus cf. gilberti</u> Meek Figs. 6-10 (p. 35)

Frontispiece. Ventral cast of complete specimen (X4) showing asymmetrical lines postero-lateral from eyes, broken epistomal plate and structure of 15th spine. U.B.C., No. GT351.

6, 7. Complete shield and cephalon showing narrow brim, axial and occipital spines. U.B.C., Nos. GT352, GT353.

8. Specimen with broad rim and brim of intermediate width (X1). U.B.C. No. MY1. (Dorsal mold, photographed with light from bottom right)

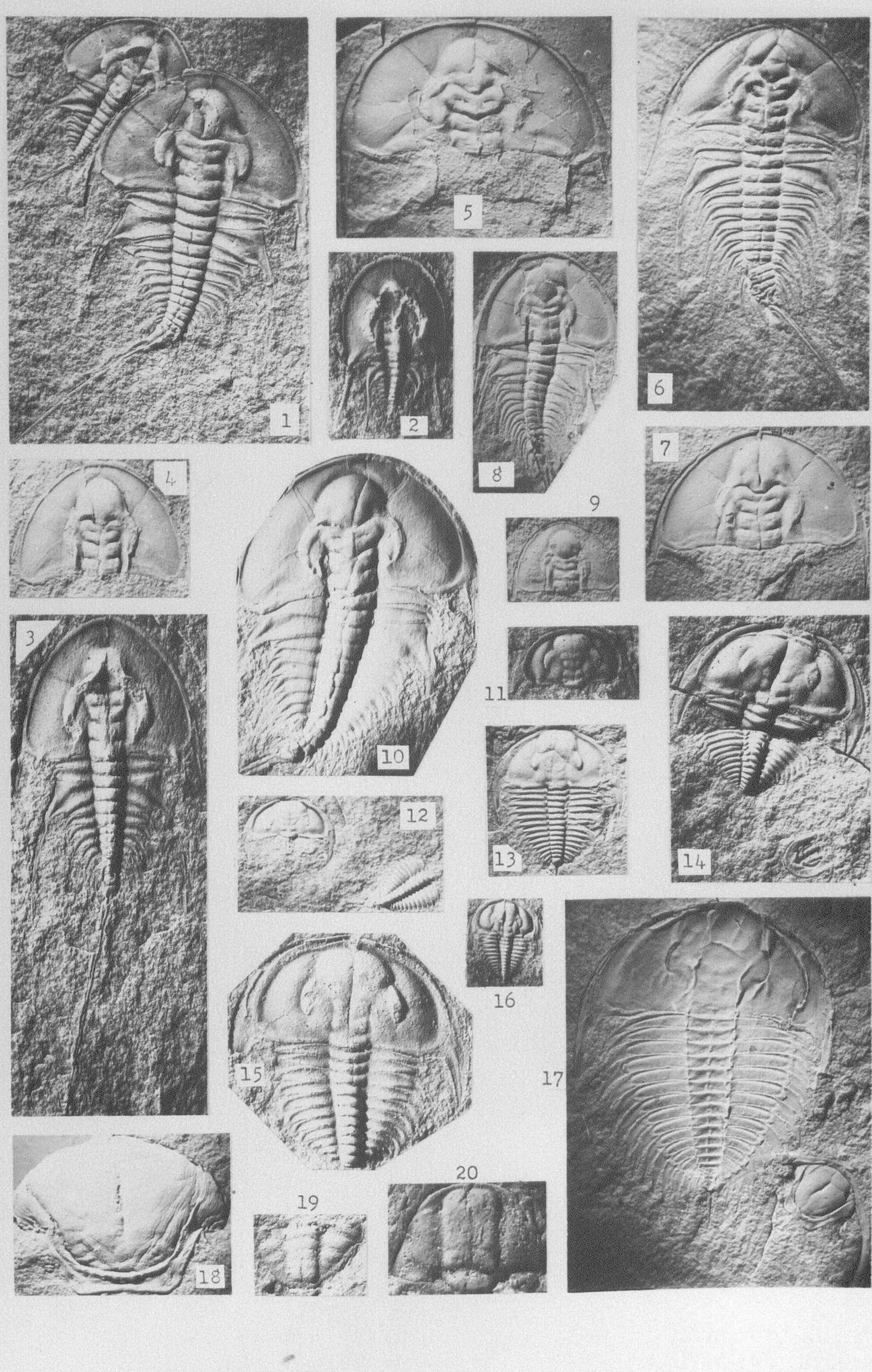
9. Cephalon with wider brim and narrower rim than above. U.B.C., No. GT354.

10. Wide-rimmed specimen showing slight <u>Paedeumias</u>-type ridge on brim. Note marks interpreted as traces of antennules. U.B.C., No. GT355.

<u>Wanneria walcottana</u> (Wanner) Figs. 11-18 (p. 47)

11.- 16. Growth stages showing convexity and proportions of cephala, strong occipital ring, character

PLATE II



of rim, and tendency of small specimens to curl up. Note mold of *Paedeumias* on 14. U.B.C., Nos. GT501 - GT506. (Magnifications 3, 1, 1, 2.7, 4.3, 1, respectively.)

17. Flattened dorsal impression (X0.8) with associated hypostoma and epistomal plate. U.B.C., No. GT507.

18. Large hypostoma (X1) showing striated surface and apparent lack of denticulation. U.B.C., No. GT508.

Bonnia cf columbensis Resser (p. 50)

19, 20. Pygidium and cranidium (X2.5) U.B.C., Nos. GT401, GT402.

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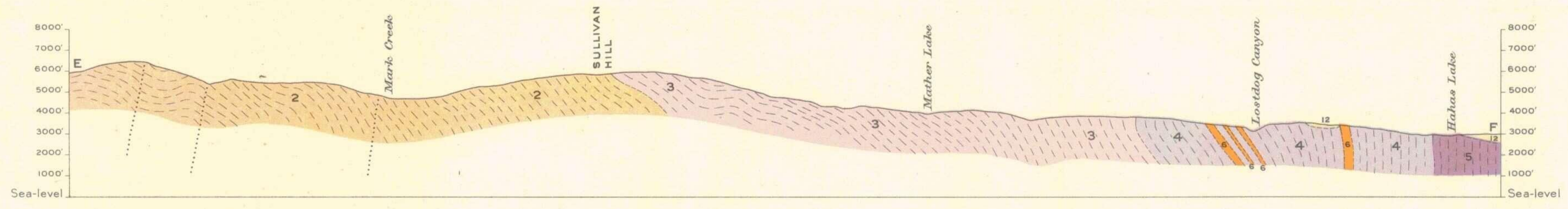
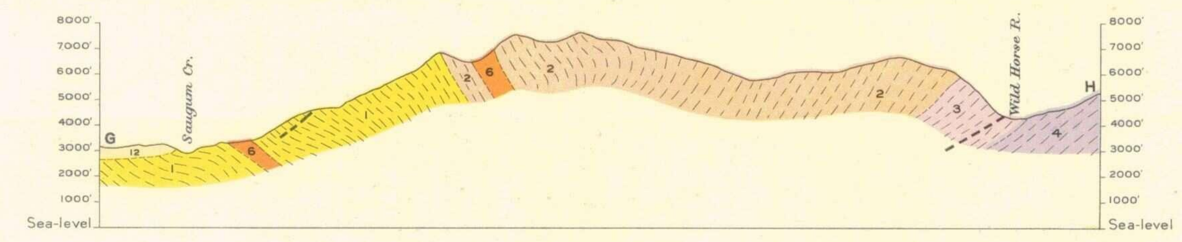
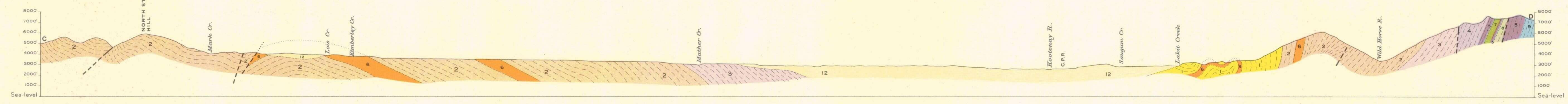
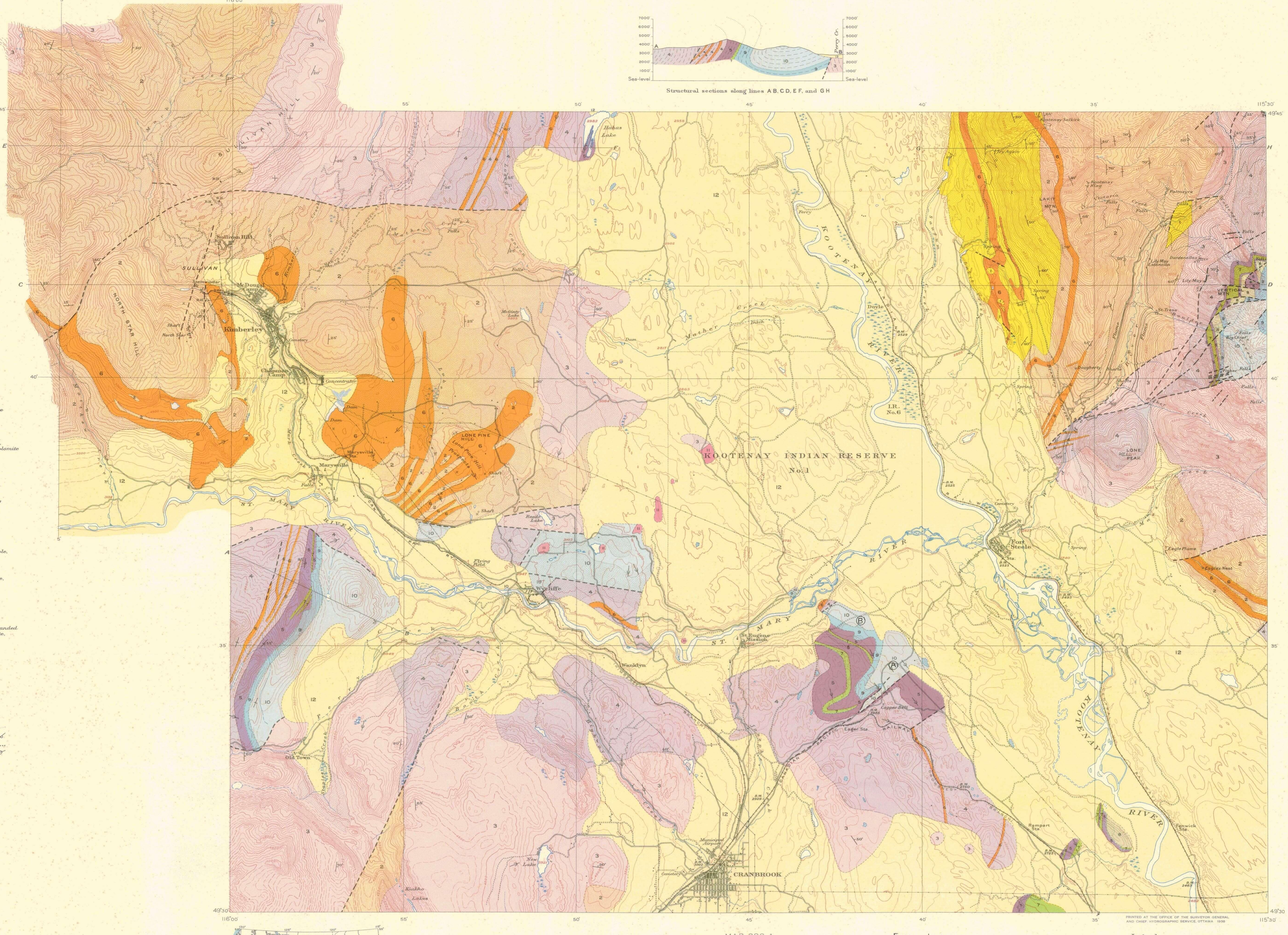




Structural sections along lines A B, C D, E F, and G H



LEGEND

CENOZOIC

MODERN
RECENT AND PLEISTOCENE

12	*Glacial drift; silt, sand, gravel*

MESOZOIC OR CENOZOIC

CRETACEOUS OR TERTIARY

11	*Granodiorite*

PALAEOZOIC

CAMBRIAN
LOWER CAMBRIAN

10	*EAGER FORMATION: argillite*
9	*CRANBROOK FORMATION: quartzite, magnesite*

PRECAMBRIAN

UPPER PURCELL SERIES

8	*GATEWAY FORMATION: argillaceous quartzite, dolomitic argillite, concretionary and pisolitic dolomite*

LOWER PURCELL SERIES

7	*PURCELL EXTRUSIVES: andesitic lava*
6	*PURCELL INTRUSIVES: diorite sills and dykes*
5	*SIYEH FORMATION: highly coloured argillite and dolomitic argillite*
4	*KITCHENER FORMATION: green, grey and purple, buff weathering, dolomitic argillite*
3	*CRESTON FORMATION: green, purple and white, argillaceous quartzite*
2	*ALDRIDGE FORMATION: grey, rusty weathering argillite and argillaceous quartzite*
1	*FORT STEELE FORMATION: white quartzite, banded grey argillite and quartzite, black, limy argillite, grey-green, dolomitic argillite*

Drift covered areas in which bedrock outcrops are few or lacking

Geological boundary (located, approximate, assumed)
Bedding (inclined, vertical, horizontal, overturned)
Fault (located, approximate, assumed)
Glacial striæ

Geology by C. E. Cairnes, 1932; and H. M. A. Rice, 1935.

Scale 1 inch to 200 Miles

Approximate magnetic declination

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MAP 396 A

CRANBROOK SHEET

KOOTENAY DISTRICT
BRITISH COLUMBIA

Scale, $\frac{1}{63,360}$ or 1 Inch to 1 Mile

Miles
Kilometres

Contour interval 100 feet
Elevations referred to Mean sea-level

FOSSIL LOCALITIES

(A) Main Cranbrook-Fort Steele Rd.
(B) East of St. Eugene Mission.

Legend

Road and buildings
Road not well travelled
Trail
Railway
Aerial tramway
Power transmission line
Bridge
Church
School
Post Office
Mine tunnel
Prospect
Bore-hole B.H.
Bench-mark B.M. 2463
Indian Reserve boundary
Tourist camping ground
Lake and stream (position approximate)
Intermittent lake and stream
Marsh
Contours
Contours (position approximate)
Depression contour
Height in feet 5910
Mine dump

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