GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

PAPER 76-33

THE EARLY ORDOVICIAN TRILOBITE GENUS *MISSISQUOIA* SHAW 1951 IN THE SOUTHERN CANADIAN ROCKY MOUNTAINS OF ALBERTA AND BRITISH COLUMBIA

W.T. DEAN

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

1977

GEOLOGICAL SURVEY
PAPER 76-33

THE EARLY ORDOVICIAN TRILOBITE GENUS *MISSISQUOIA* SHAW 1951 IN THE SOUTHERN CANADIAN ROCKY MOUNTAINS OF ALBERTA AND BRITISH COLUMBIA

W.T. DEAN

1977

Printing and Publishing
Supply and Services Canada,
Ottawa, Canada K1A 0S9,

from the Geological Survey of Canada
601 Booth St., Ottawa, K1A 0E8

or through your bookseller.

Catalogue No. M44/76-33
ISBN - 0-660-00833-5

Price: Canada: $2.50
Other Countries: $3.00

Price subject to change without notice

CONTENTS

Illustrations

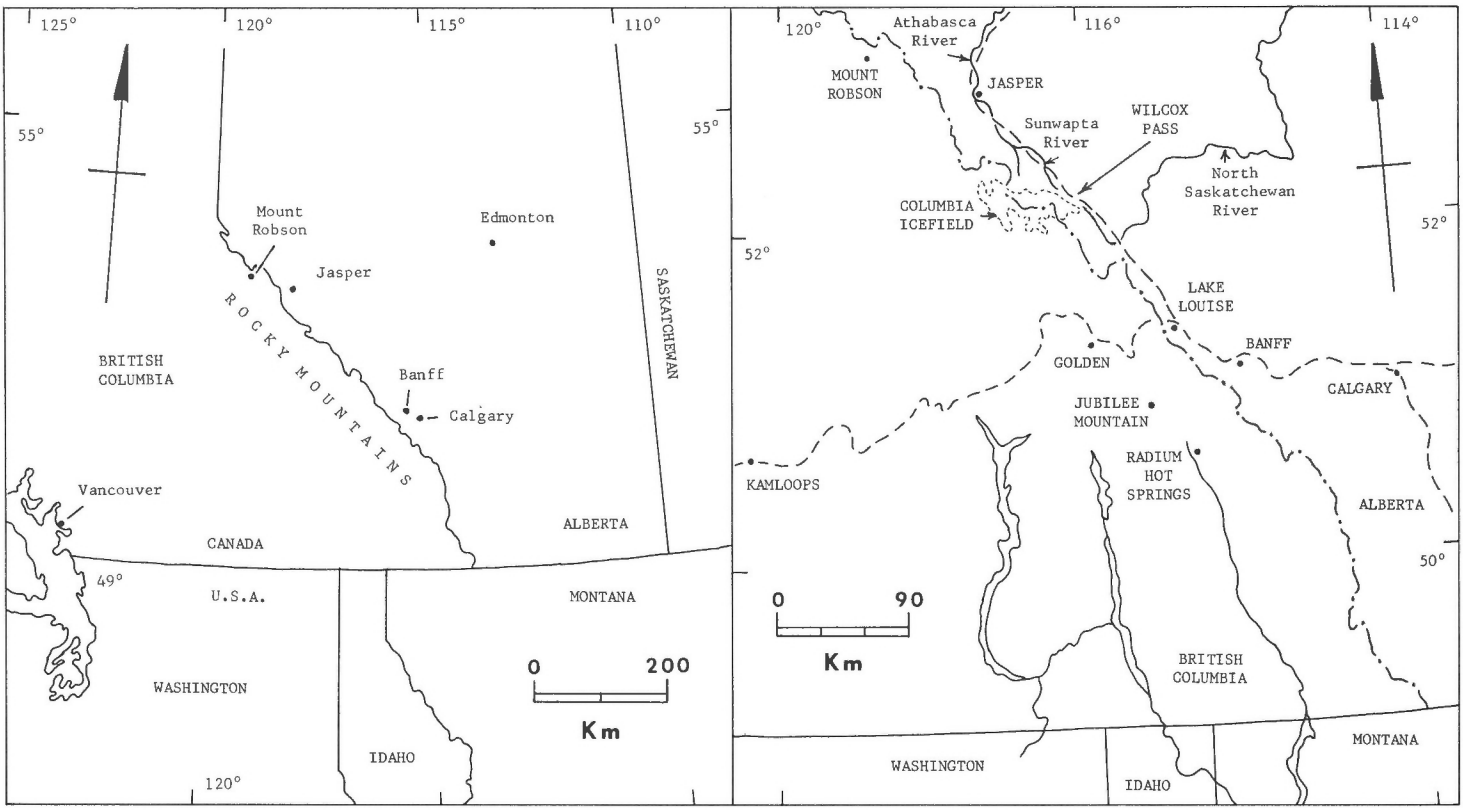


Figure 1. Outline maps showing geographic position of western Canadian localities.

THE EARLY ORDOVICIAN TRILOBITE GENUS *MISSISQUOIA* SHAW 1951 IN THE SOUTHERN CANADIAN ROCKY MOUNTAINS OF ALBERTA AND BRITISH COLUMBIA

Abstract

The early Ordovician trilobite **Missisquoia** Shaw 1951 occurs in at least three areas of the southern Canadian Rocky Mountains. The type material of **Lunacrania** Kobayashi 1955, **Macroculites** Kobayashi 1955 and **Rhamphopyge** Kobayashi 1955 is refigured and all three genera are regarded as junior subjective synonyms of **Missisquoia.** The type specimens of **Hardyia,** of probable Upper Cambrian age, are refigured; specimens from the Jasper area previously assigned to **Hardyia** are shown to belong to **Missisquoia.**

Résumé

Le trilobite **Missisquoia** Shaw 1951 qui date de l'Ordovicien inférieur se présente dans au moins trois régions du sud des montagnes Rocheuses canadiennes. L'auteur reconsidère les descriptions – types de **Lunacrania** Kobayashi 1955, **Macroculites** Kobayashi 1955 et **Rhamphopyge** Kobayashi 1955; il voit dans ces trois genres des synonymes subjectifs (cas de premier examen) du **Missisquoia.** Une nouvelle description des spécimens, types **Hardyia,** probablement du Cambrien supérieur, est donnée; des spécimens provenant de la région de Jasper, qui se classaient jadis parmi les **Hardyia,** sont maintenant attribués au genre **Missisquoia.**

INTRODUCTION

During recent years the trilobite **Missisquoia** has attracted an unusually large amount of attention on account of its claimed potential as a critical zonal fossil at or near the level of what some stratigraphers hope may prove to be the most acceptable boundary between the Cambrian and Ordovician systems in North America.

Described first by Shaw (1951, p. 108) from the Highgate Formation of Highgate Falls, Vermont, **Missisquoia** has since been reported from as far afield as Texas (Winston and Nicholls, 1967), Oklahoma (Stitt, 1971) and the southern Rocky Mountains (Derby **et al.**, 1972). During field-work directed at establishing the highest Cambrian and lowest Ordovician faunal sequence as represented in the Survey Peak Formation and Outram Formation at Wilcox Pass, between Banff and Jasper, Alberta (Fig. 1), material congeneric with **Missisquoia** was collected from rocks about 0.8 m thick within the Basal Silty Member of the Survey Peak Formation. Systematic descriptions of all the Wilcox Pass trilobites and their stratigraphic distribution will be given at a later date, but during the course of the work it became apparent that material assignable to **Missisquoia** had sometimes been misinterpreted and the following account is aimed at stabilizing the generic nomenclature. The writer is indebted to Reuben J. Ross and Brian Norford for critically reading the manuscript, and to Frederick J. Collier who kindly arranged the loan of type material from the U.S. National Museum, Washington, D.C.

In order to re-assess the position of **Missisquoia** it is necessary first to re-examine a number of other genera, the status of which is poorly known. Each is monotypic and has been subject to a variety of interpretations.

Genus **Hardyia** Walcott 1924

Introduced by Walcott (1924, p. 57, Pl. 12, fig. 5) in a short, preliminary paper on Cambrian and Ozarkian trilobites from a variety of areas, **Hardyia** was founded on a single species **H. metion.** No precise locality data were given, though the "Range" was said to be "Ozarkian, Canadian Rockies", and the cranidium of **H. metion** was illustrated by only a simplified outline drawing. Description was confined to the following sentence: "**Hardyia** is a small trilobite with wide fixed cheeks, narrowing rapidly forward, with large occipital ring and very short, faintly indicated glabellar furrows". No assignment to a family was attempted. The following year Walcott (1925, p. 90, 91, Pl. 18, fig. 9) published a slightly expanded description of the cranidium, which is still the only known portion of the exoskeleton, and gave the horizon and locality of **H. metion** as "Ozarkian: (66k) (his locality number) Mons Formation, Ranger Canyon, Sawback Range, Alberta". Additional data for this section were given in a subsequent paper (Walcott, 1928, p. 266) and the fossil locality was stated to occur in Bed 1b within an "Unnamed Formation" between the Lyell Formation and the Mons Formation. However, the latter publication was published after Walcott's death in 1927 and some of the notes used by C.E. Resser in its preparation appear to predate the 1925 paper because Locality 66k was said to contain "a number of undescribed trilobites, including the genera **Hardyia** and **Saukia**". Walcott's 1925 photograph of the holotype cranidium, U.S. Nat. Mus. 70282, shows signs of being embellished by pen and ink but exhibits the salient features of the 1924 drawing. It bears a superficial resemblance to recently published illustrations of **Missisquoia,** and it is perhaps not surprising to find C.H. Kindle (1929, Pl. 1, figs. 16, 17) illustrating as **H. metion** two cranidia (one of which is now re-illustrated, Pl. 1, fig. 1) interpreted here as belonging to **Missisquoia.** The material came from an area 7 miles (11.2 km) north of Jasper, Alberta and was collected by E.M. Kindle (1929) from a limestone bed 10 feet (3 m) thick within what he called the "Sarceen Series", forming part of the "Palisade Section" at Swift's Ranch. In addition to the forementioned two cranidia, a small pygidium illustrated by C.H. Kindle (1929, Pl. 1, fig. 15) as **Tostonia** cf. **iole** Walcott 1925 is here assigned to **Missisquoia.** Two cranidia referred to **Tostonia iole** in the same paper (1929, Pl. 1, figs. 13, 14), together with two cranidia and a free cheek (1929, Pl. 1, figs. 19, 21, 22 only) of "Trilobita, gen.

Original manuscript received: 1 October 1976
Final approved for publication: 29 November 1976

and sp. undet." are better assigned to **Highgatella** cf. **cordilleri** (Lochman). The association of **Missisquoia, Highgatella** and **Symphysurina walcotti** C.H. Kindle (1929, Pl. 1, fig. 18) at the Swift's Ranch section indicates a close relationship to the faunas of the Basal Silty Member of the Survey Peak Formation and is of early Canadian age.

During subsequent years **Hardyia** retreated into obscurity but in the Treatise on Invertebrate Paleontology the genus was placed in the Family Pagodiidae Kobayashi 1935 (Lochman-Balk **in** Moore 1959, p. O 312, Fig. 231, 4a, b) as the only Lower Ordovician representative of what was otherwise a Cambrian family distributed in North America and Asia. The line drawing of the cranidium of **Hardyia metion** in the Treatise is more elaborate than that provided by Walcott and, although somewhat schematic, bears a distinct resemblance to that of **Missisquoia.**

The type specimen USNM 70282 (Pl. 1, figs. 10, 11 and 14) of **Hardyia metion** is small and poorly preserved, as is a previously unfigured topotype (Pl. 1, fig. 13), but the genus can be seen to differ from **Missisquoia** in the following respects: the glabellar outline is more quadrate, with parallel sides; the anterior border is narrower and rim-like; only two pairs of glabellar furrows are present, less strongly developed than in **Missisquoia** and delimiting lateral glabellar lobes which are proportionately larger; the palpebral lobes are set notably farther forwards, in front of the 2p glabellar furrows. The label accompanying the holotype of **H. metion** originally indicated the horizon as being "Mons Formation", as in Walcott's later (1925) publication, but this has been subsequently altered (? by Walcott) to read "Lyell Formation". Whether or not this is true requires further collecting and redescription of the species.

Genus **Macroculites** Kobayashi 1955

Founded on a single incomplete cranidium, GSC 12716, of the type species **M. enigmaticus** Kobayashi (1955, p. 460, 461, Pl. 6, fig. 14), **Macroculites** was assigned by its author to the Family Emmerichellidae Kobayashi 1935. In the Treatise on Invertebrate Paleontology, Henningsmoen (**in** Moore 1959, p. O 523) relegated it to Order and Family Uncertain. The specimen, preserved in crystalline limestone, had been collected earlier by C.S. Evans during his mapping of the Brisco-Dogtooth map-area of southern British Columbia and came from rocks of the McKay Group 0.75 mi (1.2 km) east of the Grant Mine, Jubilee Mountain, south of Harrogate, and 28 mi (45 km) northwest of Radium Hot Springs (Fig. 1). This locality was given the number 24 when subsequently listed by Kobayashi (1955, p. 363), and is not shown in Evans' (1933) account of the area.

The holotype is interpreted here as being a typical **Missisquoia,** though somewhat abraded and incomplete, so that the palpebral lobes and the greater part of the fixigenae are missing and the anterior border is broken-off distally. The almost complete glabella, which has undergone slight lateral compression, shows the characteristic lobation together with a shallow, median indentation of the frontal glabellar lobe. These features and the strongly convex, almost ridge-like form of the fixigenae match closely those of better-preserved material from the Survey Peak Formation (for example Pl. 1, figs. 12 and 15) assigned to **Missisquoia.** Kobayashi's original description and reconstruction (1955, Pl. 9, figs. 6a, b) interpreted as elongated palpebral lobes what are here regarded as the incomplete, adaxial portions of the fixigenae.

Genus **Lunacrania** Kobayashi 1955

The type species, **Lunacrania trisecta** Kobayashi (1955, p. 472, Pl. 7, fig. 8), was founded on a single small cranidium, GSC 12743, which is now re-illustrated (Pl. 1, fig. 8). Like the holotype of **Macroculites enigmaticus,** the specimen was collected by Evans from the McKay Group at Kobayashi's (1955, p. 363) Locality 24, near Harrogate, British Columbia, but is much smaller and probably represents a Meraspis (Degree unknown). The genus was placed by Kobayashi in the Family Shumardiidae, a course followed with some hesitation in the Treatise on Invertebrate Paleontology (Poulsen **in** Moore 1959, p. O 245), where the illustration of **L. trisecta** was essentially a copy of the line drawing used earlier by Kobayashi (1955, Pl. 9, fig. 10).

Kobayashi (1955, p. 472) noted the similarity of the holotype cranidium to one from north of Jasper figured by C.H. Kindle (1929, Pl. 1, fig. 16) as **Hardyia metion** Walcott (see discussion elsewhere in the present paper) and observed that the latter specimen might prove to be assignable to **Lunacrania.** The present work shows that Kobayashi's holotype of **L. trisecta** is conspecific not only with Kindle's specimen but also with the holotype of **Macroculites enigmaticus.** None is conspecific or congeneric with **Hardyia metion** and all three specimens belong to **Missisquoia.** Kobayashi's assertion that **H. metion** "has a broader cranidium and larger and more square glabella" than **L. trisecta** is generally true, and one might add that the former also has narrower, smaller fixigenae with more distinct palpebral lobes set closer to the glabella.

Kobayashi (1955, p. 472) noted that a cranidium from Zone B of the Garden City Formation of Utah figured by Ross (1951, Pl. 35, figs. 1, 2) as "Undetermined genus and species D" was similar to the holotype of **L. trisecta** and might be a member of the Family Shumardiidae. Ross's illustrations show the specimen to be very small, and the occipital ring produced backwards to form a long spine; this feature is unknown in any described species of **Missisquoia,** but the overall appearance is otherwise similar.

Genus **Rhamphopyge** Kobayashi, 1955

Rhamphopyge was erected by Kobayashi on the basis of **R. altipolum** Kobayashi (1955, p. 472, 473, Pl. 6, figs. 9a, b) which was in turn founded on a single distinctive pygidium, GSC 12744. The specimen, now refigured (Pl. 1, figs. 2, 3), was originally obtained by C.S. Evans from the same locality at Jubilee Mountain, British Columbia, as the holotypes of **Macroculites enigmaticus** and **Lunacrania trisecta.** Kobayashi placed the genus in "Order and Family uncertain", a course followed also by Lochman-Balk (**in** Moore, 1959, p. O 524). In a reconstruction of the pygidium Kobayashi (1955, Pl. 9, figs. 8a, b) stated that it was debatable whether the "first segment" at the front of the pygidium belonged to the latter or to

the thorax, and he showed an apparent "second segment" joining with a narrow lateral border to form a smooth strip almost circumscribing the pygidium. It seems clear that the specimen is, in fact, an entire pygidium in which the first two pleurae are particularly well defined, followed by an additional three which are less distinct.

Material almost identical with the holotype has been collected from GSC Loc. 89273, 19.9 m below the top of the Basal Silty Member of the Survey Peak Formation at Wilcox Pass. There it is associated with undoubted **Missisquoia,** and the diminutive type specimen of **Rhamphopyge** is considered here to represent only an immature example of the former genus.

Genus **Missisquoia** Shaw 1951

The type species, **M. typicalis** Shaw (1951, p. 108, Pl. 23, figs. 1-10) from Vermont, was based on several specimens which had been slightly distorted in different directions. The holotype (Shaw, 1951, Pl. 23, fig. 3), a small cranidium considered by its author to represent a young holaspid(?), displays a slightly tapered, subtrapezoidal glabella, with two pairs of glabellar furrows and intermediate in plan between the rectangular outline of very small meraspids and the tapered form of the largest specimens. The last-named are rounded frontally where there is a conspicuous median notch, and carry three or four pairs of glabellar furrows. Cranidia assignable to **M. typicalis** have been found in the Survey Peak Formation at Wilcox Pass, particularly GSC Loc. 92223, 20.1 m below the top of the Basal Silty Member, and also, at a level approximately 0.7 m lower, at GSC Loc. 89269. The largest specimens (for example Pl. 1, figs. 12 and 15) agree well with previously published illustrations whilst smaller cranidia (Pl. 1, fig. 9) may be compared with Winston and Nicholls' (1967) Pl. 13, fig. 6 and exhibit both narrow ocular ridges and a medjan tubercle on the anterior half of the occipital ring.

Paratype pygidia illustrated by Shaw (1951, Pl. 23, figs. 8-10) each show a well-segmented axis and pleural regions, together with a short terminal spine in the case of larger specimens. Shaw did not give figures for the numbers of axial rings and pleurae present but his photographs suggest from nine to twelve and from eight to ten respectively. Segmentation of the pleural regions is particularly evident, with the deep pleural furrows running from the axial furrows to the lateral margins, and the shallower interpleural furrows especially well defined over their abaxial halves.

Subsequently Winston and Nicholls (1967, p. 88) assigned material from the Wilberns Formation in Texas to **Missisquoia typicalis,** and the cranidia illustrated by them agree in all essentials with large specimens figured by Shaw as well as from Wilcox Pass. Photographs of pygidia of **M. typicalis** published by Winston and Nicholls (1967, Pl. 13, figs. 12, 15, 18) show the outline to be more triangular than those in Shaw's illustrations, though this may be the result of their being uncompressed. No figures were given for the number of axial rings and pleurae on the specimens from Texas but the illustrations show up to twelve rings and up to ten pleurae.

Shaw's original description noted (1951, p. 109) the marked morphological changes undergone by the pygidium during ontogeny, the smooth margins of the smallest specimens being followed by successive increases in the number of marginal spines, which appeared successively from front to rear of the pygidium. No terminal spine such as that described by Shaw for pygidia exceeding 2.8 mm in length has yet been observed in any of the material from Alberta, and according to Winston and Nicholls (1967, p. 88) its presence does not depend upon size of individual. One of the specimens illustrated by the latter authors (1967, Pl. 13, fig. 12) has marginal spines developed almost to the tip of the pygidium and may be compared with the pygidium from GSC Loc. 92223, Wilcox Pass, now illustrated (Pl. 1, fig. 5).

Missisquoia nasuta was proposed by Winston and Nicholls (1967, p. 89, Pl. 13, figs. 1, 3, 9) for cranidia which, though generally resembling **M. typicalis,** differed in having the outline bluntly pointed frontally, axial furrows which became shallower or even obsolete anteriorly, and fixigenae which were proportionately wider. No pygidium was described for the species which was stated to occur with **M. typicalis** at a few localities, though the two were found separately at others. The cranidial features of **M. nasuta** are shared by the holotypes of **Lunacrania trisecta** and **Macroculites enigmaticus,** although in the latter case they are less obvious because of the imperfect state of preservation. At GSC Loc. 89273, Wilcox Pass, a similar type of cranidium was found associated with a pygidium showing the characteristics of **Rhamphopyge altipolum.** The latter is distinguished from immature pygidia of **Missisquoia typicalis** illustrated by Stitt (1971, Pl. 8, fig. 3) and in the present paper (Pl. 1, figs. 4, 5, and 7) by its higher, narrower axis which appears particularly swollen towards its tip. Stitt's illustration suggests also that the pleural regions may be more strongly segmented in immature **M. typicalis.**

In view of the resemblances noted above, it is proposed to regard **M. nasuta** and the three species from Jubilee Mountain, British Columbia as conspecific; because **enigmaticus** has page priority over the other 1955 taxa, the appropriate binomen is **Missisquoia enigmatica** (Kobayashi). Although it is possible that **M. typicalis** and **M. enigmatica** represent no more than dimorphs of a single species, the evidence is inconclusive and for present purposes the two specific names are retained.

The status of the foregoing genera and species may be summarized as follows:

Family Missisquoiidae Hupé 1953

Genus **Missisquoia** Shaw 1951

Type species: **Missisquoia typicalis** Shaw 1951 by original designation.

Subjective Synonyms. **Lunacrania** Kobayashi 1955; **Macroculites** Kobayashi 1955; **Rhamphopyge** Kobayashi 1955.

Stratigraphic and Geographic Distribution. In all cases the genus occurs at an approximately similar horizon, in rocks of early Canadian age which form the lowest portion of what has frequently been termed Zone A, or the **Symphysurina** Zone. A **Missisquoia** Zone has been erected to encompass the vertical range of the genus, but the precise relationship of the latter to that of **Symphysurina** is not yet fully documented and it is not clear whether one should use distinct zones of **Missisquoia** and **Symphysurina,**

or simply a **Missisquoia** Subzone within the lower portion of the **Symphysurina** Zone. The problems of separating two such zones were reviewed by Derby **et al.** (1972, p. 509) who demonstrated the stratigraphic overlap of the two eponymous genera.

As yet **Missisquoia** is known only from North America, where it is widespread. It occurs in the Highgate Formation of Vermont; the Wilberns Formation of central Texas; the upper part of the Signal Mountain Limestone in the Arbuckle Mountains, Oklahoma; the McKay Group of the Sawtooth Range, southeastern British Columbia; and the Basal Silty Member of the Survey Peak Formation in the Main Ranges of the southern Rocky Mountains, Alberta.

Missisquoia typicalis Shaw
Plate 1, figures 4, 5, 7, 9, 12 and 15

Missisquoia typicalis Shaw 1951, p. 108, Pl. 23, figs. 1-10.

Missisquoia typicalis Shaw, Winston and Nicholls 1967, p. 88, Pl. 13, figs. 2, 5, 6, 10, 12, 15, 18.

Missisquoia typicalis Shaw, Stitt 1971, p. 26, Pl. 8, figs. 1-4.

Missisquoia enigmatica (Kobayashi)
Plate 1, figures 1, 2, 3, 6 and 8

Hardyia metion Walcott?, C.H. Kindle 1929, p. 146, Pl. 1, figs. 16, 17. Trilobita, gen. and sp. undet., C.H. Kindle 1929, p. 146, Pl. 1, fig. 20 only.

Tostonia cf. **iole** Walcott, C.H. Kindle 1929, p. 146, Pl. 1, figs. 15, 15a only.

Macroculites enigmaticus Kobayashi 1955, p. 460, Pl. 6, fig. 14.

Lunacrania trisecta Kobayashi 1955, p. 472, Pl. 7, fig. 8; Pl. 9, fig. 10.

Rhamphopyge altipolum Kobayashi 1955, p. 473, Pl. 6, figs. 9a, b; Pl. 9, fig. 8.

Missisquoia nasuta Winston and Nicholls 1967, p. 89, Pl. 13, figs. 1, 3, 9.

REFERENCES

Derby, J.R., Lane, H.R., and Norford, B.S.
1972: Uppermost Cambrian – Basal Ordovician faunal succession in Alberta and correlation with similar sequences in the western United States; 24th Int. Geol. Congr. Proc., Sect. 7, p. 503-512.

Evans, C.S.
1933: Brisco – Dogtooth map-area, British Columbia; Geol. Surv. Can., Summ. Rep. 1932, Pt. A, p. 106-176.

Kindle, C.H.
1929: An "Ozarkian" fauna from Jasper Park, Alberta; Can. Field Naturalist, v. 43, p. 145-147.

Kindle, E.M.
1929: The succession of fossil faunas in the eastern part of Jasper Park; Am. J. Sci., v. 48, p. 177-192.

Kobayashi, T.
1955: The Ordovician fossils from the McKay Group in British Columbia, western Canada, with a note on the Early Ordovician Palaeogeography; J. Fac. Sci., Univ. Tokyo, v. 9, no. 3, p. 355-493.

Moore, R.C. (ed.)
1959: Treatise on invertebrate paleontology, Part O, Arthropoda 1; Geol. Soc. Amer. and Univ. Kansas Press, Lawrence, Kansas.

Ross, R.J.
1951: Stratigraphy of the Garden City Formation in northeastern Utah, and its trilobite faunas; Yale Univ., Peabody Mus. Nat. History, Bull. 6.

Shaw, A.B.
1951: The paleontology of northwestern Vermont. I. New Late Cambrian trilobites; J. Paleontol., v. 25, p. 97-114.

Stitt, J.H.
1971: Late Cambrian and earliest Ordovician trilobites, Timbered Hills and Lower Arbuckle Groups, western Arbuckle Mountains, Murray County, Oklahoma; Okla. Geol. Surv., Bull. 110, p. 1-83.

Walcott, C.D.
1924: Cambrian Geology and Paleontology V. No. 2. Cambrian and Lower Ozarkian trilobites; Smithson. Misc. Coll., v. 75, no. 2, p. 53-60.

1925: Cambrian Geology and Paleontology V. No. 3. Cambrian and Ozarkian trilobites; Smithson. Misc. Coll., v. 75, no. 3, p. 61-146.

1928: Cambrian Geology and Paleontology V. No. 5. Pre-Devonian Paleozoic formations of the Cordilleran provinces of Canada; Smithson. Misc. Coll., v. 75, no. 5, p. 175-368.

Winston, D. and Nicholls, H.
1967: Late Cambrian and Early Ordovician faunas from the Wilberns Formation of central Texas; J. Paleontol., v. 41, p. 66-96.

PLATE

Most of the figured specimens are housed in the Geological Survey of Canada, Ottawa and carry numbers with the prefix GSC. Those prefixed USNM are in the U.S. National Museum, Washington, D.C. Specimens coated with ammonium chloride sublimate before being photographed. Photographs by the writer.

PLATE I

Missisquoia enigmatica (Kobayashi)

Figure 1. Cranidium from the "Ozarkian" at Swift's Ranch, 7 miles north of Jasper Park, Alberta, figured as **Hardyia metion** by C.H. Kindle 1929, Pl. 1, fig. 16. GSC 9377. X 10.

Figures 2, 3. Left posterolateral and plan views of small pygidium from McKay Group, Locality 24 of Evans 1933, Jubilee Mountain, southwest of Harrogate, British Columbia. Holotype of **Rhamphopyge altipolum** Kobayashi 1955, Pl. 6, figs. 9a, b. GSC 12744. X 12.

Figure 6. Incomplete cranidium. Holotype of **Macroculites enigmaticus** Kobayashi 1955, p. 461, Pl. 6, fig. 14. Locality and horizon as for Figures 2 and 3. GSC 12716. X 8.

Figure 8. Small, probably immature cranidium. Holotype of **Lunacrania trisecta** Kobayashi 1955, Pl. 7, fig. 8; Pl. 9, fig. 10. Locality and horizon as for Figures 2 and 3. GSC 12743. X 15.

Missisquoia typicalis Shaw

Figures 4 and 7. Plan and oblique left lateral views of small pygidium. Survey Peak Formation, Basal Silty Member, GSC Loc. 92223, 52°13'53"N, 117°13'40"W, Wilcox Pass, between Jasper and Banff, Alberta. GSC 47971. X 15.

Figure 5. Two pygidia, the smaller immature. Horizon and locality as for Figures 4 and 7. GSC 47972. X 12.

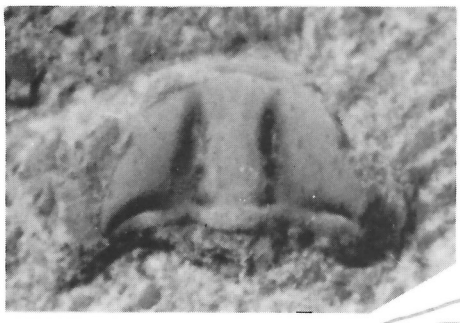
Figure 9. Incomplete, small cranidium showing median tubercle on occipital ring. Horizon and locality as for Figures 4 and 7. GSC 47973. X 15.

Figures 12 & 15. Plan and left anterolateral views of damaged, large cranidium. Note palpebral lobes, anterior border and indentation of frontal glabellar lobe. Horizon and locality as for Figures 4 and 7. GSC 47974. X 7.

Hardyia metion Walcott

Figures 10, 11 and 14. Anterior, left lateral and plan views of holotype cranidium, figured Walcott 1924, Pl. 12, fig. 5. Lyell Formation (see text for discussion), Ranger Canyon, Sawback Range, Alberta. U.S. Nat. Mus. 70282. X 10.

Figure 13. Plan view of poorly preserved incomplete cranidium from same lot as holotype. X 10.

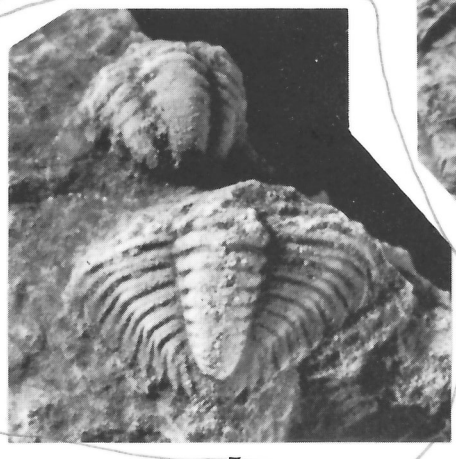


1

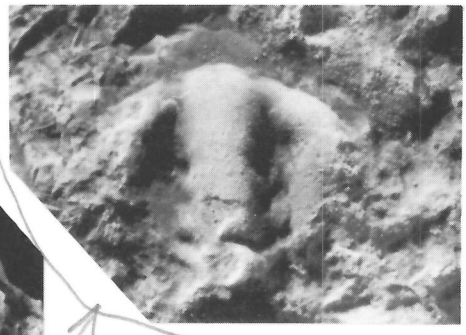
2

3

4



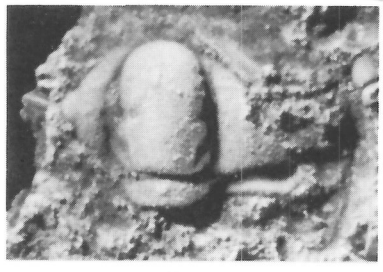
5



6

7

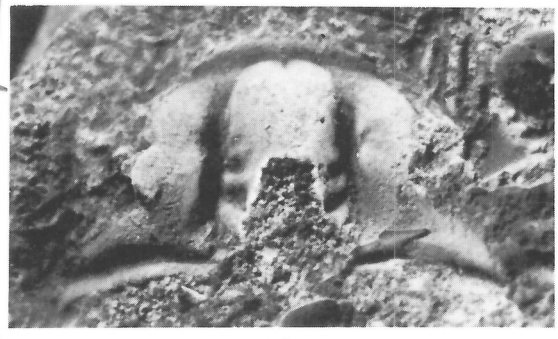
8



9

10

11



12

13

14

15