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PAPER 67-21

MIDDLE CALLOVIAN SEDIMENTARY ROCKS AND GUIDE AMMONITES FROM SOUTHWESTERN BRITISH COLUMBIA

(Report, 2 figures and 3 plates)

Hans Frebold and H. W. Tipper

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CONTENTS

Illustrations

Abstract

The presence of middle Callovian rocks and guide ammonites is established in the Harrison Lake, Taseko Lakes, and Nechako River areas of southwestern British Columbia. Deposits of this age are not known from other parts of Canada except from Vancouver Island. Although lower Callovian beds are widely distributed in the Rocky Mountains, the Canadian Arctic, and Queen Charlotte Islands, such beds have so far not been identified in those areas where middle Callovian is present.

MIDDLE CALLOVIAN SEDIMENTARY ROCKS AND GUIDE AMMONITES FROM SOUTHWESTERN BRITISH COLUMBIA

Introduction

Callovian strata occur in several areas in Western and Northern Canada (Fig. 1, Table I, Table II) and the faunas from several of these areas have been described or discussed in reports by Crickmay (1930b), Frebold (1961, 1963, 1964), and McLearn (1949). Three areas in southwestern British Columbia have yielded middle Callovian faunas, none of which has been described as such. It is proposed in this paper to describe briefly the Callovian stratigraphy and guide faunas of the Taseko Lakes, Nechako River and Harrison Lake areas and to discuss the regional correlations and significance.

Stratigraphy

Taseko Lakes

The Callovian rocks of Taseko Lakes area were unknown until 1963 although one Callovian ammonite had been obtained from earlier investigations (Cairnes, 1943) but has remained unreported. Callovian rocks occur as isolated fault slices along Tyaughton Creek and its tributaries (Fig. 2) and the relation of these slices to each other and to overlying and underlying map units is, in certain aspects, obscure. The interpretation and conclusions presented here, based on a minimum of information, are therefore tentative.

In this area two lithologic units of late Middle Jurassic age must be considered, an upper unit of shale, tuff, siltstone, and greywacke containing middle Callovian ammonites and a lower unit of conglomerate and grit. The lower unit, over 170 feet thick, is composed primarily of well-rounded pebbles of chert with lesser amounts of quartz, argillite, and volcanic rocks. The pebble diameter is usually less than one inch and the conglomerate is well sorted. The matrix is siliceous and the pebbles are closely packed. Many beds can best be described as very coarse grit. These coarse clastic beds commonly yield belemnites, Cylindroteuthis sp. and Pachyteuthis sp., identified by J. A. Jeletzky who indicated that they were probably new species of general late Middle Jurassic affinities. They are similar to presumed Callovian belemnites from the upper part of Yakoun Formation, Queen Charlotte Islands (Jeletzky, pers. comm. 1966). These conglomerates and grits lie below middle Callovian beds with ammonites and could be middle Callovian as well. They could also be of early Callovian age or older. No exact age determination can be made without guide fossils.

Overlying the conglomeratic unit conformably and in places gradationally are rocks of varying lithology. The Callovian strata southeast of Elbow Mountain (Fig. 2) grade from conglomerate into a shale, siltstone, and greywacke section 150 to 200 feet thick. These rock types are interlayered

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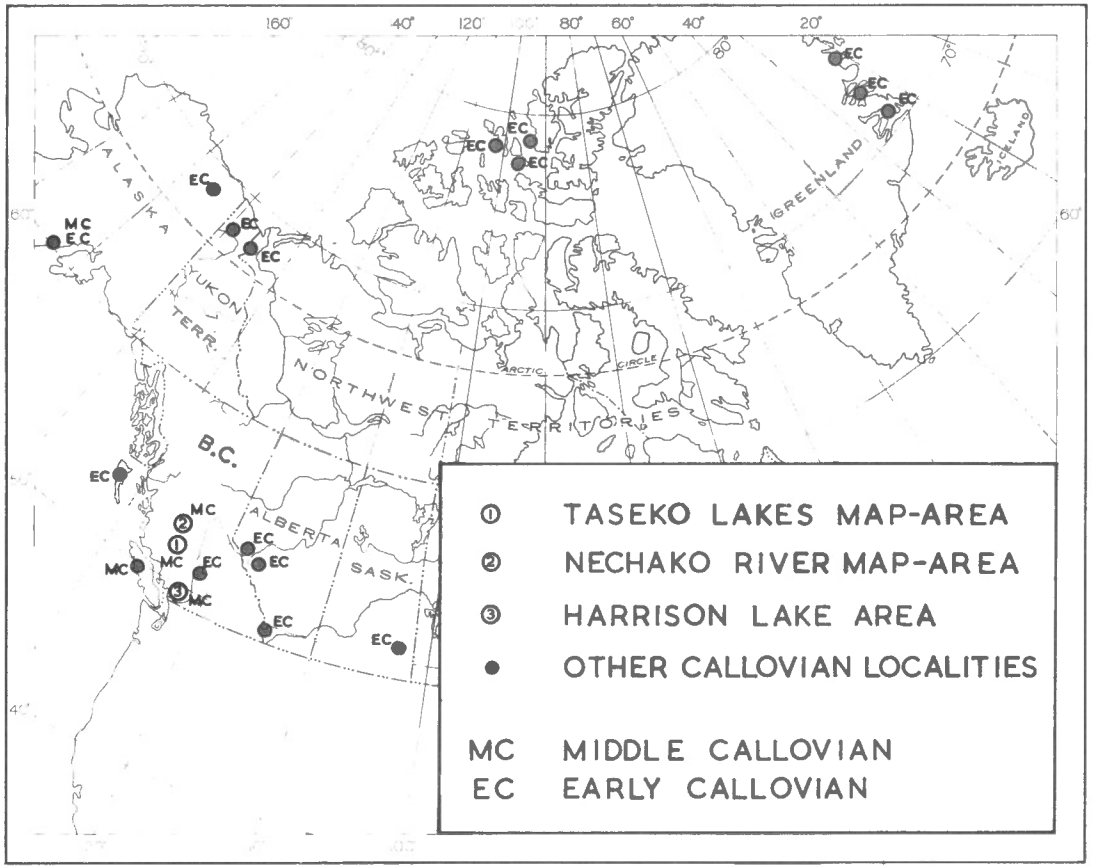

Figure 1. Callovian fossil localities in Canada, Alaska, and Greenland.

in beds up to ten inches thick. Shale and siltstone become dominant and occur in thinner beds upward, grading into an overlying unfossiliferous shale-siltstone sequence of uncertain age. In the Callovian strata shales predominate and commonly occur in regular, thin-bedded, alternating grey and dark grey or black beds one-quarter inch to one and one-half inch thick. Greenish grey shales occur rarely and are tuffaceous. Siltstone and greywacke are generally in thicker beds and are buff-coloured to greenish brown. Wood fragments are common, particularly in the greywacke. Crossbedding or ripple-marks have not been noted.

East of Lorna Lake (Fig. 2) the section overlying the conglomeratic unit differs in many respects to the one just described. These beds, over 300 feet thick, are coarser and contain more volcanic debris. Shales and tuffaceous shales predominate particularly in the upper part but siltstone, greywacke, and grit or fine conglomerate are prominent in the lower part. Shaly limestone lenses are rare. The tuffaceous rocks are characteristically greenish grey or light grey in colour and grade into blue-black shales. The shaly limestone lenses are black. The grits and fine conglomerates are similar to the underlying conglomerate unit but occur in thinner beds up to six inches thick. The shales of this section are similar to those shales in the area southeast of Elbow Mountain and in both sections shales predominate.

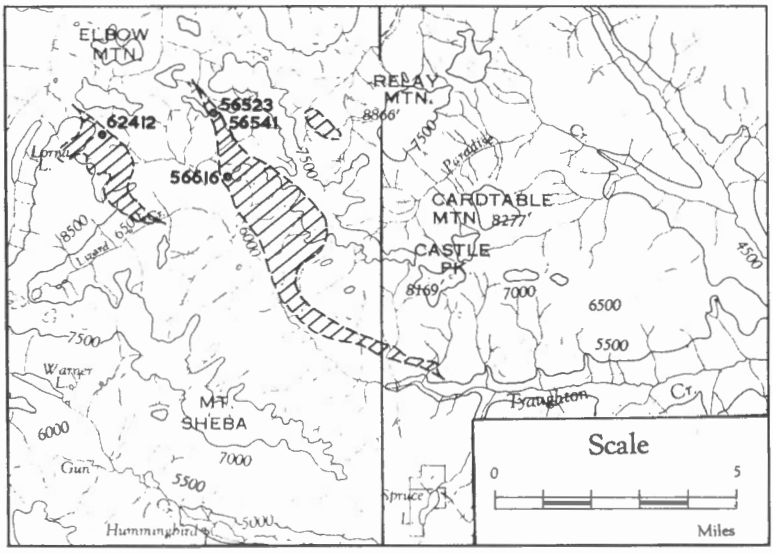

Figure 2. Distribution of middle Callovian rocks in Taseko Lakes area and the fossil localities referred to in this report.

Several fossil localities have provided a varied fauna of ammonites, pelecypods, and belemnites. The localities shown in Figure 2 contain the ammonite fauna herein described and many other localities with poorly preserved or non-diagnostic fauna are known but not indicated here. The Callovian rocks east of Lorna Lake yielded an ammonite fauna including Cadoceras (Stenocadoceras) striatum Imlay, C. (Stenocadoceras) cf. S. striatum Imlay, C. (Stenocadoceras) cf. S. iniskinense Imlay, Pseudocadoceras petelini (Pompeckj), and P. aff. P. grewingki (Pompeckj). In the Callovian rocks southeast of Elbow Mountain the only guide fossils were Lilloettia lilloetensis Crickmay and Lilloettia sp. The age of these faunas is middle Callovian and correlation of these rocks with part of Imlay's (1953) middle third of the Chinitna Formation of Alaska is indicated.

These two sections of middle Callovian strata, which differ in their ammonite fauna and somewhat in lithology, probably belong to two ammonite zones, i.e. the zones of Lilloettia lilloetensis and Pseudocadoceras grewingki. These two zones are closely related in age. Both sections overlie a conglomeratic unit, both are predominantly shale, both include tuffaceous rocks, and both have yielded middle Callovian fauna. These rocks are cut by and bounded by northwest trending faults and one at least is a steeply dipping transcurrent fault. For this reason it is not possible to suggest the relative positions of these beds within the sedimentary basin nor to suggest whether or not the faunas are of precisely the same age.

Overlying the middle Callovian strata is shale and siltstone, 500 to 1,000 feet thick, interbedded in a monotonous, thin-bedded, usually recessive section that is unfossiliferous (Table I). Elsewhere in the area a lithologically identical shale-siltstone section, over 1,000 feet thick contains the early Oxfordian ammonite Cardioceras sp. in its upper beds but the relation to older fossiliferous rocks is unknown. These two shale-siltstone sections are believed to be parts of the same unit and may span the interval between middle Callovian and early Oxfordian or parts of these stages.

The unit of conglomerates and grits, here considered to be of Callovian age, rests unconformably on middle Bajocian beds (Table I) that contain an ammonite fauna including Stephanoceras sp., Stemmatoceras sp., and Witchellia sp. These middle Bajocian rocks are shale, limy shale, siltstone and minor limestone lenses and contrast markedly with the coarse clastic rocks above. Because of this marked lithologic change and the absence of fossiliferous late Bajocian or Bathonian strata or any strata that might be assigned to this interval, an unconformable relation is believed to exist between the middle Bajocian rocks and the conglomerates and grits above. This unconformable contact is nowhere well-exposed but available information does not suggest a large angular discordance.

Whether or not all Callovian time is represented is questionable. Beds carrying a middle Callovian fauna are present. The conglomeratic

TABLE I

Relation of Callovian beds and faunas to older and younger strata and faunas in Taseko Lakes area.

Stage	Lithology	Fauna
early Oxfordian	interbedded black shale and siltstone 1,000 feet	Cardioceras sp.
possibly latest middle Callovian to earliest Oxfordian		unfossiliferous
middle Callovian	shale, siltstone greywacke, conglomerate and limestone 200 to 300 feet	Lilloettia lilloetensis (Crickmay) Cadoceras (Stenocadoceras) striatum Imlay C. (Stenocadoceras) cf. s. iniskinense Imlay Pseudocadoceras petelini (Pompeckj) P. aff. P. grewingki (Pompeckj)
possibly middle or early Callovian or(?) older ?	conglomerate, grit 170 feet ?	Pachyteuthis sp. Cylindroteuthis sp. ?
Bathonian	hiatus	
late Bajocian		
middle Bajocian	shale, siltstone, minor limestone over 900 feet	Stephanoceras sp. Stemmatoceras sp. Witchellia sp.

rocks below the middle Callovian beds are probably Callovian but without an ammonite fauna it is not possible to say whether it is early or middle Callovian. The unfossiliferous shale-siltstone unit overlying the middle Callovian beds may be late Callovian in age but as late Callovian fauna are unknown in the western Canadian Cordillera, it is premature to suggest the presence of late Callovian strata.

Nechako River

In 1952 a marine Callovian fauna was obtained from strata along the upper part of Nechako River, south of Big Bend Creek (Tipper, 1963, pp. 30-31). The best exposures of these rocks and the fossil localities are now flooded. The fossils collected in 1952 have not been figured or described.

These rocks are entirely sedimentary and are mainly black sheared argillites, shales, and limy shales. In places the rocks are finely banded but for the most part the beds are massive. In one locality, two miles south of Big Bend Creek on Nechako River, a 15 to 20 foot bed of black mudstone outcropped and contained large, black, calcareous concretions up to 10 inches in diameter, each of which contained a well-preserved ammonite. The relation of these rocks to other groups in the area is not known as all contacts were drift-covered. As the best exposures are now flooded, further information on these rocks from this area is unobtainable.

The ammonites collected belong to one genus and one species. Originally this ammonite was identified as Lilloettia lilloetensis Crickmay (Frebold in Tipper, 1963, p. 31) but is now considered to be a new species, i.e. Lilloettia tipperi n. sp. Frebold. It is believed to be of middle Callovian age and the rocks are considered to be correlative with part of Imlay's (1953a) middle third of the Chinitna Formation of Alaska and Crickmay's (1962) Mysterious Creek Formation at Harrison Lake.

Harrison Lake

In Harrison Lake area Crickmay has described two formations, the Mysterious Creek Formation of Callovian age and the Billhook Formation of Callovian or Oxfordian age (Crickmay, 1930b, 1962). Part of the fauna obtained from these formations has been described and figured (Crickmay, 1930b) and only additional information will be offered in this respect. The following brief description of the formations was obtained from Crickmay's published reports.

The Mysterious Creek Formation is mainly dark grey or black argillite 2,300 to 2,900 feet thick. In its uppermost beds it is slightly arenaceous. It rests on arkoses, tuffs, sandstones, and argillites, presumably of Middle Jurassic age according to Crickmay. It is overlain by the Billhook Formation, apparently conformably.

A Callovian marine fauna, ammonites, pelecypods, and belemnites, were obtained from several localities in the formation (Crickmay, 1930b). Two different ammonite faunas were collected, at one locality Lilloettia lilloetensis Crickmay, L. mertonyarwoodi Crickmay, and L. buckmani (Crickmay) and at another locality Paracadoceras harveyi Crickmay, Cadoceras catostoma Pompeckj, C. brooksi Crickmay, and Pseudocadoceras schmidti (Pompeckj). In addition Frebold collected a specimen of Pseudocadoceras grewingki (Pompeckj). These faunas are now placed in the middle Callovian. They indicate correlation of the Mysterious Creek Formation with parts of Imlay's Chinitna Formation of Alaska and with the Callovian beds of Taseko Lakes and Nechako River areas.

The Billhook Formation consists of fine-grained, well-stratified, green to grey tuffs and volcanic derived sediments. The fauna obtained from this formation is mainly a pelecypod fauna with a few poorly preserved ammonites but the only age indicated is Jurassic, Callovian or later. The Billhook Formation is overlain unconformably by a coarse conglomerate (Kent Formation) and argillites (Agassiz Prairie Formation) that, for several reasons, are believed to be Oxfordian in age (Crickmay, 1962, pp. 6-7).

Localities

Nechako River area.

GSC loc. 21885 — Nechako River, 2 miles upstream from Big Bend Creek. Coll. H. W. Tipper.
Lilloettia tipperi n. sp. Frebold

Taseko Lakes area.

GSC loc. 56541 — North side of ridge 2 1/2 miles southeast of Elbow Mt. Coll. H. W. Tipper.
Lilloettia lilloetensis Crickmay

GSC loc. 56523 — North side of ridge 2 1/2 miles southeast of Elbow Mountain and 25 feet stratigraphically below GSC loc. 56541. Coll. H. W. Tipper.
Lilloettia lilloetensis Crickmay
Lilloettia sp. indet.

GSC loc. 56616 — On ridge one mile north of junction of Tyaughton and Lizard Creeks. West of saddle at elevation 6870'. Coll. H. W. Tipper.
Lilloettia lilloetensis Crickmay

TABLE II

Correlation of Callovian rocks of Canada and Alaska
and their relation to older and younger strata.

STAGES	Vancouver Island 1	Harrison Lake Area 2	Ashcroft Area 3,4	Taseko Lakes Area 5	Nechako River Area 6	Queen Charlotte Islands 7	Rocky Mountains 8	Cook Inlet, Alaska 9,10	Richardson and British Mts. 11,12	Arctic Islands 12, 13, 14, 15
EARLY OXFORDIAN	Present	Agassiz Fm. / Kent Formation	UNKNOWN	black shale and siltstone	UNKNOWN	UNKNOWN	Green Beds	Chisik Conglomerate Member	Present	Upper Savik Formation
LATE CALLOVIAN	UNKNOWN	UNKNOWN		UNKNOWN			UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN
MIDDLE CALLOVIAN	Present	Billhook Formation / Mysterious Creek Formation		shale and siltstone / gwke. shale siltstone conglomerate / congl., grit	black shale and siltstone			Chinitna and Shelikof Formations		
EARLY CALLOVIAN			shale sandstone conglomerate			Upper Yakoun Formation	Grey Beds			Savik Formation
BATHONIAN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	Present	
LATE BAJOCIAN								Tuxedni Group		UNKNOWN
MIDDLE BAJOCIAN		Probably Present	shale sandstone conglomerate	shale siltstone	Hazelton Group	Lower Yakoun Formation	Rock Creek Member			Lower Savik Formation

1. Jeletzky (1950) 2. Crickmay (1962) 3. Crickmay (1930a) 4. Duffell and McTaggart (1952) 5. This paper 6. Tipper (1963)
7. McLearn (1949) 8. Frebold (1963) 9. Imlay (1953) 10. Imlay (1962) 11. Frebold, Mountjoy, and Tempelman-Kluit (in press)
12. Frebold (1961) 13. Frebold (1964) 14. Tozer (1960) 15. Tozer (1963)

GSC loc. 62412 — Two miles east of south end of Lorna Lake. Coll. H. W. Tipper.
Cadoceras (Stenocadoceras) striatum Imlay
Cadoceras (Stenocadoceras) cf. S. striatum Imlay
Cadoceras (Stenocadoceras)cf. S. iniskinense Imlay
Pseudocadoceras petelini (Pompeckj)
Pseudocadoceras aff. P. grewingki (Pompeckj)

Harrison Lake area.

GSC (no number) — Billhook Creek, a tributary to Mysterious Creek, at 3,100 feet altitude and 4 miles in a direct line from the mouth of Mysterious Creek. Coll. C.H. Crickmay.
Lilloettia lilloetensis Crickmay
Lilloettia mertonyarwoodi Crickmay
Lilloettia buckmani (Crickmay)

GSC loc. 25780 — Deer Creek. Road cut on power line road. West side of Harrison Lake. Coll. H. Frebold.
Pseudocadoceras grewingki (Pompeckj)

GSC (no number) — Deer Creek, 1/4 mile from the mouth. Coll. C.H. Crickmay.
Paracadoceras harveyi Crickmay
Cadoceras catostoma Pompeckj
Cadoceras brooksi Crickmay
Pseudocadoceras schmidti (Pompeckj)

Systematic Descriptions

Family Macrocephalitidae Buckman, 1922
Genus Lilloettia Crickmay, 1930
Lilloettia tipperi n. sp.

Plate I, figures 1-6; Plate III, figure 2.

Lilloettia lilloetensis Frebold, non Crickmay. Tipper, 1963, p. 31.

Material. About 60 specimens at various stages of growth from GSC loc. 21885, Nechako River, 2 miles upstream from Big Bend Creek, Nechako River area. Coll. H.W. Tipper, 1952.

Description. The species is moderately stout, very narrow umbilicate, the whorls embrace each other nearly completely. They are slightly higher than wide in all stages of growth. Smaller specimens are flattened on inner parts of the whorls and convex in outer parts; larger specimens have convex flanks. The venter is moderately narrow, evenly arched at medium sizes, somewhat flatter when young.

The body chamber of mature specimens is represented by more than three quarters of the last whorl. On the holotype and other mature specimens a moderately deep and broad forwardly curved constriction is present at the end of the whorl. On the holotype another much broader and shallower constriction occurs at half the length of the body chamber.

At a diameter of 12 mm the primary ribs are more widely spaced than in later stages of growth. They bifurcate at or somewhat below the middle of the flank. Intercalary ribs are already present at this stage of growth and the secondaries are stronger than the primaries. They are still stronger on the venter where they are arched slightly forward. The point of bifurcation is on or somewhat below the middle of the flank. The secondaries are strongest on the venter.

In larger specimens and particularly on the body chamber the ribs disappear from the inner part of the flanks and become faint and blunt on the outer part and on the venter.

Among the specimens at hand some variations of the thickness and height of the whorls are seen, however they are always higher than wide and the strength of the ribs does not change, except on the last whorl of large specimens.

The suture line is very similar to those of L. lilloetensis Crickmay and L. mertonyarwoodi Crickmay. The lateral lobes are trifid and about as wide as the saddles which are almost symmetrically divided. The ventral lobe has about the same length as the first lateral.

Measurements in millimetres and the ratios of their diameter are as follows:

	Diameter	Whorl height	Whorl thickness	Umbilical width
Holotype GSC 20367	110	60 (0.55)	56 (0.51)	9 (0.08)
Paratype GSC 20368	72	38 (0.53)	33 (0.46)	c. 4 (0.06)
Paratype GSC 20369	72	41 (0.57)	37 (0.51)	4 (0.06)
Paratype GSC 20370	55	31 (0.56)	28 (0.51)	4 (0.09)
Paratype GSC 20371	32	18 (0.56)	17 (0.53)	3 (0.09)
Paratype GSC 20372	12	6.5 (0.54)	6 (0.50)	

The species is named for Dr. H. W. Tipper, Geological Survey of Canada.

Comparisons. In its general outline Lilloettia tipperi n. sp. is similar to Lilloettia lilloetensis Crickmay from which it is distinguished by its much finer and more numerous ribs. Lilloettia mertonyarwoodi Crickmay is distinguished from L. tipperi n. sp. by its outline that is somewhat wider than high in L. mertonyarwoodi while it is somewhat higher than wide in L. tipperi. Furthermore L. tipperi has finer and more numerous ribs than L. mertonyarwoodi. Other species of Lilloettia are easily distinguishable from

L. tipperi by their shape and ribbing. L. buckmani (Crickmay) is depressed and coarse ribbed, L. milleri Imlay is globose and has coarser ribs, L. stantoni Imlay has much coarser ribs.

The species of the genus Lilloettia are closely related to each other and one might be inclined not to consider them as species if Imlay's studies had not shown that in southern Alaska a certain stratigraphic arrangement of the various species is indicated. Some of them seem to be restricted to the lower third of the Chinitna Formation, some to its middle third, and some occur in both the lower and middle third. The fact that L. tipperi was found in large numbers at one and the same locality without being associated with any other species is remarkable.

Occurrence. Lilloettia tipperi n. sp. is hitherto only known from one locality and no other fossil was found associated with it.

Lilloettia lilloetensis Crickmay

Plate I, figures 7-8; Plate III, figure 3

Lilloettia lilloetensis Crickmay, 1930b, p. 62, pl. 18, figs. 1-4, text-fig. 7.
Lilloettia lilloetensis Crickmay, Imlay, 1953, p. 77, pl. 30, figs. 1, 2, 4, 8.

Material. One fragmentary specimen from each of GSC locs. 56541, 56523, 56616 Taseko Lakes area. Collected by H. W. Tipper, 1963.

Description. The specimen GSC No. 20690 found at GSC loc. 56616 is the most complete of the three and represents about three quarters of a whorl of a small to medium-sized specimen. Apparently it is somewhat laterally crushed. It is narrowly umbilicate but as the umbonal region is not well preserved the exact size of the umbilicus is not determinable. The whorl is higher than wide, the venter is rather narrow in the posterior part of the whorl but becomes wider in its anterior part. In the posterior part of the whorl the ribs are very fine. Anteriorly they become rapidly coarser and more widely spaced. Some of the ribs are subdivided at about the middle of the flank into two secondaries. Intercalary ribs are also present. All ribs are stronger on the venter.

The specimen GSC No. 22691 from GSC loc. 56523 is about the same size as the one described above and shows the same features in both general outline and ribbing, i.e. fine ribs in the posterior and coarser, more widely spaced ribs in the anterior part of the whorl.

The specimen GSC No. 22692 from GSC loc. 56541 is the smallest of the three. It is also somewhat laterally crushed. It shows the same outline and the same ribbing as the other two specimens.

Comparisons. The three specimens are younger whorls equal to or somewhat larger in size than the inner whorl of the holotype as illustrated by Crickmay (1930b, pl. 18, figs. 3 and 4). A rubber cast of the imprint of the inner whorl of the holotype (see pl. I, fig. 8) is somewhat more complete than the part illustrated by Crickmay.

The shape and arrangement of the ribs of the three specimens described above agree very well with that of the inner whorls of the holotype. The venters of the Taseko Lakes specimens are, probably due to secondary lateral compression, somewhat narrower than that of the holotype of L. lilloetensis Crickmay.

All other species of Lilloettia are clearly distinguished by their general outline or the shape and strength of the ribs. The new species of Lilloettia tipperi described in this report has at the same stage of growth considerably finer and more numerous ribs.

Occurrence. In the Taseko Lakes area Lilloettia lilloetensis is associated (at GSC loc. 56523) with some poorly preserved small ammonites, a whorl fragment of Lilloettia sp. indet. and an ammonite venter (Lilloettia?).

Family Cardioceratidae Siemiradzki, 1891
Subfamily Cadoceratinae Hyatt, 1900
Genus Cadoceras Fischer, 1882
Subgenus Stenocadoceras Imlay, 1953
Cadoceras (Stenocadoceras) striatum Imlay

Plate II, figure 1

Cadoceras (Stenocadoceras) striatum Imlay, 1953, p. 90, pl. 45, figs. 4-7.

Material. One specimen GSC No. 22693 from GSC loc. 62412, Taseko Lakes area. Collected by H. W. Tipper, 1964.

Description. The dimensions of the fairly well preserved specimen in millimetres and the ratios of the diameter are as follows:

Diameter	Whorl height	Whorl thickness	Umbilical width
c. 66	c. 31 (0.47)	20 (0.30)	11 (0.17)

The specimen is fairly well preserved and is narrow-umbilicate, moderately involute. The whorls are considerably higher than wide, have compressed, only very slightly convex flanks and a narrow venter. The umbilical wall is steep and joins the flanks in a rounded edge. At the end of the whorl it is smooth.

The specimen is septate almost to the end of the whorl. A small preserved part of the body chamber is crushed.

There are numerous rather fine ribs that are stronger on the venter than on the flanks. Most of them are subdivided on or below the middle of the flanks. Intercalary ribs are also present. In the anterior part of the last whorl the ribs become faint and the small part of the body chamber which remains is crushed and appears to be smooth.

The suture line is only visible in parts and cannot be traced accurately.

Comparisons. The specimen is very similar to the holotype of Cadoceras (Stenocadoceras) striatum Imlay (Imlay, 1953, figs. 5, 7) and is identified with this species.

Occurrence. At GSC loc. 62412 the species is associated with Cadoceras (Stenocadoceras) cf. S. striatum Imlay, C. (Stenocadoceras) cf. S. iniskinense Imlay, Pseudocadoceras petelini (Pompeckj) and Pseudocadoceras aff. P. grewingki (Pompeckj).

Cadoceras (Stenocadoceras) cf. S. striatum Imlay

Plate II, figure 2

Material. One specimen GSC No. 22694 from GSC loc. 62412, Taseko Lakes area. Collected by H. W. Tipper, 1964.

Description. The specimen is fragmentary, one side is completely corroded, the other is partly so. About half of the last whorl belongs to the body chamber.

The dimensions in millimetres and the ratio of the diameter are as follows:

Diameter	Whorl height	Whorl thickness	Umbilical width
60	30 (0.5)	19 (0.31)	11 (0.18)

The whorls are higher than wide, the flanks are almost flat, and only slightly convex. The venter is narrow, the umbilical wall is steep, joining the flanks with rounded edge. The ribs are only preserved in part on one side of the body chamber. There are both divided and undivided ribs, also intercalary ribs are present. The ribs are better preserved on the inner whorl. The point of division is about at the middle of the flanks. The ribs are stronger on the venter than on the flanks.

The suture line is deeply corroded and no details are shown.

Comparisons. The specimen is very similar to the one described as C. (Stenocadoceras) striatum Imlay but its poor preservation does not permit precise identification.

Occurrence. At GSC loc. 62413 the specimen is associated with C. (Stenocadoceras) striatum Imlay, C. (Stenocadoceras) cf. S. iniskinense Imlay, Pseudocadoceras petelini (Pompeckj) and Pseudocadoceras aff. P. grewingki (Pompeckj).

Cadoceras (Stenocadoceras) cf. S. iniskinense Imlay

Plate II, figures 3a, b; Plate III, figure 1

Material. One specimen from GSC loc. 62412.

Description. The specimen GSC No. 22695 is a fragment of a large ammonite of which the penultimate and a small part of the last whorl are illustrated. The cross-section is elliptical, higher than wide at all stages of growth and the venter narrowly rounded. The flanks are only very slightly convex, the umbilicus is narrow with steep walls and rounded edge at the joint with the flanks, it opens up in the anterior part of the last whorl and the slope of the

umbilical wall is gentle at this stage of growth. There is a broad and shallow constriction at the end of the preserved part of the last whorl.

In the posterior end of the penultimate whorl, ribs are visible on the inner part of the flank and in the ventro-lateral region. Only the latter ones persist in the central and anterior parts of this whorl. The body chamber is almost smooth.

The suture line as developed at a whorl height of 43 mm is deeply incised. The ventral lobe is shorter than the first lateral. Both the first and the second lateral lobes are trifid and very slender.

The dimensions in millimetres and the ratios of the diameter of the penultimate whorl are as follows:

Diameter	Whorl height	Whorl thickness	Umbilical width
102	49 (0.48)	32 (0.31)	18 (0.18)

Comparisons. Due to unsatisfactory preservation the specimen cannot be positively identified with one of the known species. It is similar to C. (Stenocadoceras) iniskinense Imlay (Imlay, 1953, p. 91, pl. 46, figs. 1,4-9), particularly to Imlay's large specimen (figs. 7, 9) which is the holotype. Unfortunately the inner whorls of the Canadian specimen are not visible and the ribbing at this stage cannot be compared with the holotype. C. (Stenocadoceras) stenoloboide Pompeckj is less compressed and has a more rounded venter.

Occurrence. At GSC loc. 62412 C. (Stenocadoceras) cf. S. iniskinense Imlay is associated with C. (Stenocadoceras) striatum Imlay, C. (Stenocadoceras) cf. S. striatum Imlay, Pseudocadoceras petelini (Pompeckj) and Pseudocadoceras aff. P. grewingki (Pompeckj).

Genus Pseudocadoceras Buckman, 1918
Pseudocadoceras petelini (Pompeckj)

Plate II, figures 4a, b

Cadoceras petelini Pompeckj, 1900, p. 267, pl. 6, figs. 4-6.
Pseudocadoceras petelini (Pompeckj), Imlay, 1953, p. 93, pl. 48, figs. 1-6, 15.

Material. One specimen from GSC loc. 62412. Taseko Lakes area. Collected by H. W. Tipper, 1964.

Description. The fairly well preserved specimen GSC No. 22696 is apparently laterally crushed to a small degree. Its dimensions in millimetres and ratios of the diameter are as follows:

Diameter	Whorl height	Whorl thickness	Umbilical width
46 (maximum)	21 (0.46)	12 (0.26)	12 (0.26)
38	17 (0.45)	11 (0.29)	10 (0.26)

The specimen is moderately involute, the umbilicus fairly narrow, the umbilical wall very low and steep. The last whorl is considerably higher than wide, its cross-section subovate with the greatest thickness below the middle of the flanks. The venter is narrow and grades gently into the flanks.

The ribs are fairly sharp on the flanks and venter. Most of them are bifurcated with the point of division lying slightly below the middle of the flanks, but there are also undivided ribs. Only a few secondary ribs do not join the primaries.

Comparisons. The specimen is similar to Pseudocadoceras petelini (Pompeckj) in the fairly flat whorls and the fine ribbing at about equal stages of growth, but none of the hitherto illustrated specimens of this species attains the size of the Taseko Lakes specimen. Accordingly the mature stage of this specimen cannot be compared. At this mature stage the umbilicus is larger than in any hitherto described specimens of the species. P. grewingki (Pompeckj) has an umbilicus larger than that of P. petelini and also resembles the Canadian specimen.

Occurrence. At GSC loc. 62412 the specimen was found associated with Cadoceras (Stenocadoceras) striatum Imlay, C. (Stenocadoceras) cf. S. striatum Imlay, C. (Stenocadoceras) cf. S. iniskinense Imlay, and Pseudocadoceras aff. P. grewingki (Pompeckj).

Pseudocadoceras grewingki (Pompeckj)

Plate II, figures 5, 6

Cadoceras grewingki Pompeckj, 1900, p. 258, pl. 6, figs. 1a-d, non 2a-c. Pseudocadoceras grewingki (Pompeckj), Imlay, 1953, p. 93, figs. 1-12.

Material. One specimen from GSC loc. 25780, west side of Harrison Lake, collected by H. Frebold, 1955; one doubtful fragment from GSC loc. 62412, Taseko Lakes area, collected by H. W. Tipper, 1964.

Description. The specimen is fragmentary and most of the umbilicus is filled with hard material. The approximate dimensions in millimetres and the ratios of the diameter are as follows:

Diameter	Whorl height	Whorl thickness	Umbilical width
36	14 (0.39)	13 (0.36)	- -

The cross-section is subovate, slightly higher than wide. The greatest thickness of the flanks is below their half height. The flanks are slightly convex and grade into the fairly narrow venter. The umbilicus is fairly wide; at the end of the last whorl the umbilical wall is steep, the transition to the flanks is rounded.

The ribs are bent backward on the umbilical wall, on the flanks and venter they are bent forward. They are fairly sharp and fairly widely spaced. Most of the ribs are bifurcated at slightly below the half height of the flanks but some primaries remain undivided.

Comparison. The specimen is very similar to Pseudocadoceras grewingki (Pompeckj), particularly to the specimens described by Imlay.

The small fragment GSC No. 22698 from GSC loc. 62412 consists of a half whorl with remnants of an inner whorl. It is fairly wide umbilicate and has a ribbing similar to that of the above described specimen. The fragment is listed here as Pseudocadoceras aff. P. grewingki (Pompeckj).

Occurrence. The specimen from GSC loc. 25780 was found associated with fragments of Cadoceratinae, apparently predominantly belonging to Pseudocadoceras. The specimen from GSC loc. 62412 is associated with Pseudocadoceras petelini (Pompeckj), Cadoceras (Stenocadoceras) striatum Imlay, C. (Stenocadoceras) cf. S. striatum Imlay, C. (Stenocadoceras) cf. S. iniskinense Imlay.

Age of the Ammonite Faunas

The ammonites described in this report were found in three areas of the mainland of British Columbia, i.e. in the Harrison Lake, Taseko Lakes, and Nechako River areas. As shown in Table III two different faunas are present in both the Harrison Lake and Taseko Lakes areas, i.e. one with representatives of the genus Lilloettia and the other with Cadoceratinae. In the Nechako River area only the Lilloettia fauna has been found.

The Lilloettia faunas of the Harrison Lake, Taseko Lakes and Nechako River areas are considered to be equivalent or nearly equivalent in age to one another and are at present assigned to Crickmay's zone of Lilloettia lilloetensis (Crickmay, 1930b, pp. 62-63). The faunas containing Cadoceratinae of the Harrison Lake and Taseko Lakes areas are also considered to be equivalent or nearly equivalent in age to one another. In the Harrison Lake area Crickmay (1930b, pp. 55-57) assigned this fauna to his zone of Cadoceras brooksi. This species was based on a poorly preserved ammonite. Imlay (1953, p. 45) considered the possibility that it may be identical specifically with one of the southern Alaska forms and it is preferable to replace the zone fossil by Pseudocadoceras grewingki which is a well-defined species.

It seems to be evident that in southwestern British Columbia the Lilloettia faunas and the Cadoceras faunas exclude each other. This was already recognized by Crickmay by assigning the two faunas to two different zones. Crickmay (1930b, p. 55) states also that Lilloettia occurs "a short distance above Cadoceras". In another publication Crickmay (1931, pp. 41-42) restates his opinion on the relative age of the two faunas and adds that

TABLE III

Composition of the Lilloettia and Cadoceras faunas in southwestern British Columbia.

Zones Mutual age relationship not established with certainty	Harrison Lake area	Taseko Lakes area	Nechako River area
	Lilloettia Fauna	Lilloettia Fauna	Lilloettia Fauna
Lilloettia lilloetensis	Lilloettia lilloetensis Lilloettia mertonyarwoodi Lilloettia buckmani	Lilloettia lilloetensis Lilloettia sp.	Lilloettia tipperi
	Cadoceras Fauna	Cadoceras Fauna	
Pseudocadoceras grewingki	Paracadoceras harveyi Cadoceras catostoma Cadoceras brooksi Pseudocadoceras schmidti Pseudocadoceras grewingki	Cadoceras (Stenocadoceras) striatum Cadoceras (Stenocadoceras) cf. S. striatum Cadoceras (Stenocadoceras) cf. S. iniskinense Pseudocadoceras petelini Pseudocadoceras aff. P. grewingki	unknown

TABLE IV

Tentative correlation of Callovian ammonite faunas in Western Canada.

Stage	Southwestern British Columbia	Queen Charlotte Islands	Vancouver Island	Canadian Rocky Mountains and Foothills
late Callovian	not identified	absent	not identified	absent
middle Callovian (mutual relationship of zones in southwestern British Columbia not established with certainty)	*Lilloettia lilloetensis* zone	absent	*Cadoceras doroschini* *Cadoceras* spp.	absent
	Pseudocadoceras grewingki zone			
early Callovian	*Cylindroteuthis*, *Pachyteuthis* of late Middle Jurassic affinities. Exact age unknown ?	*Kepplerites* spp.	not identified	*Imlayoceras miettense* zone Perishinctids (undescribed)
				Kepplerites mclearni zone
				Kepplerites aff. *K. tychonis* zone
				Warrenoceras henryi zone
early Callovian or late Bathonian				*Paracephalites glabrescen* zone

the Lilloettia fauna occurs near the top of the Mysterious Creek Formation. This would mean that the Lilloettia lilloetensis zone is somewhat younger than the Pseudocadoceras grewingki zone. Because of unsuitable outcrop conditions in the Taseko Lakes area such age relationship could not be confirmed nor does it seem to be indicated at present in southern Alaska.

In a more recent publication dealing with the Jurassic fossils of the Harrison Lake area Crickmay (1962) does not mention the zones he erected previously or their supposed mutual age relationship. The present author is reluctant in expressing an opinion on the relative age of the two zones until it is established in a good section.

A comparison of the Callovian ammonites from southwestern British Columbia with those of other areas shows that they probably do not belong to the early Callovian. In the Fernie Group of the Rocky Mountains, in the Queen Charlotte Islands, in Montana, and in southern Alaska the early Callovian is characterized by the presence of representatives of the genus Kepplerites. In the northwest European Province this genus is, according to Callomon (1955, p. 255), restricted to the early Callovian zones of Proplanulites koenigi and Sigaloceras calloviense. Other early Callovian ammonites of the Fernie Group of the Rocky Mountains and its equivalents in Montana such as Warrenoceras (in Montana described as Arcticoceras by Imlay, 1953) are totally absent in the here described areas of southwestern British Columbia.

A comparison with the ammonite fauna of the basal part of the middle third of the south Alaskan Chinitna Formation that Imlay (1953) correlates with the zone of Sigaloceras calloviense is also negative in so far as certain ammonites described by Imlay as Kheraiceras, Xenocephalites, and Gowericeras are absent in the here described Callovian faunas of southwestern British Columbia.

The association of Pseudocadoceras petelini, P. grewingki, P. schmidti, Cadoceras (Stenocadoceras) striatum, and C. (Stenocadoceras) cf. S. iniskinense and the absence of ammonite genera restricted to the early Callovian indicates correlation with the middle thirds of the Chinitna and Shelikof Formations of southern Alaska that are middle Callovian in age, according to Pompeckj (1900) and Imlay (1953). Imlay (1953, p. 53) considers a correlation of the southern Alaska fauna with the zone of Kosmoceras jason in northwestern Europe. As far as southwestern British Columbia is concerned, the material available at present for study is not considered enough for such a detailed age determination.

As the genus Lilloettia is unknown in the northwest European Callovian no age determination based on that area is possible. In southeastern Alaska the genus has been found according to Imlay (1953, p. 50) in both the lower and middle thirds of the Chinitna Formation but only in the lower third of the

Shelikof Formation. Imlay (1953) places Lilloettia both in the Koenigi and Calloviense zones of the early Callovian and the Jason Zone of the middle Callovian in his stratigraphic Table 5. On this basis no decision about the age of Lilloettia faunas of southwestern British Columbia can be made.

In the Harrison Lake area Crickmay believes as quoted above that the Lilloettia fauna is younger than the Cadoceras fauna, here determined as middle Callovian. If this be the case then in this area the Lilloettia fauna must be considered as middle Callovian in age.

The presence of Callovian strata in southwestern British Columbia has been known since Crickmay's study (1930) but hitherto its middle Callovian age was not suggested. Other Canadian middle Callovian deposits are known from Vancouver Island (Jeletzky,1950). The faunas concerned will be described and evaluated in the near future. They may show slight age differences with those of southwestern British Columbia. All other previously known Canadian Callovian faunas are older, i.e. of early Callovian age (Fig. 1 and Table IV). Such early Callovian faunas as for instance those of the Fernie Group in the Rocky Mountains and those of the upper Yakoun Formation of the Queen Charlotte Islands contain early Callovian Kepplerites and other ammonites that have not been found in the areas where middle Callovian is present, i.e. in southwestern British Columbia and Vancouver Island. Here lower Callovian beds may be primarily absent wholly or in part or may be represented by a non-ammonite bearing facies.

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PLATES

Explanation of Plate I

All figures are natural size. Types are in the collections of the Geological Survey of Canada.

Figure 1. *Lilloettia tipperi* n. sp. Frebold. Holotype GSC No. 20367. Lateral view. Nechako River area. GSC loc. 21885. Middle Callovian.

Figure 2. *Lilloettia tipperi* n. sp. Frebold. Paratype GSC No. 20368. Lateral view. Nechako River area, GSC loc. 21885. Middle Callovian.

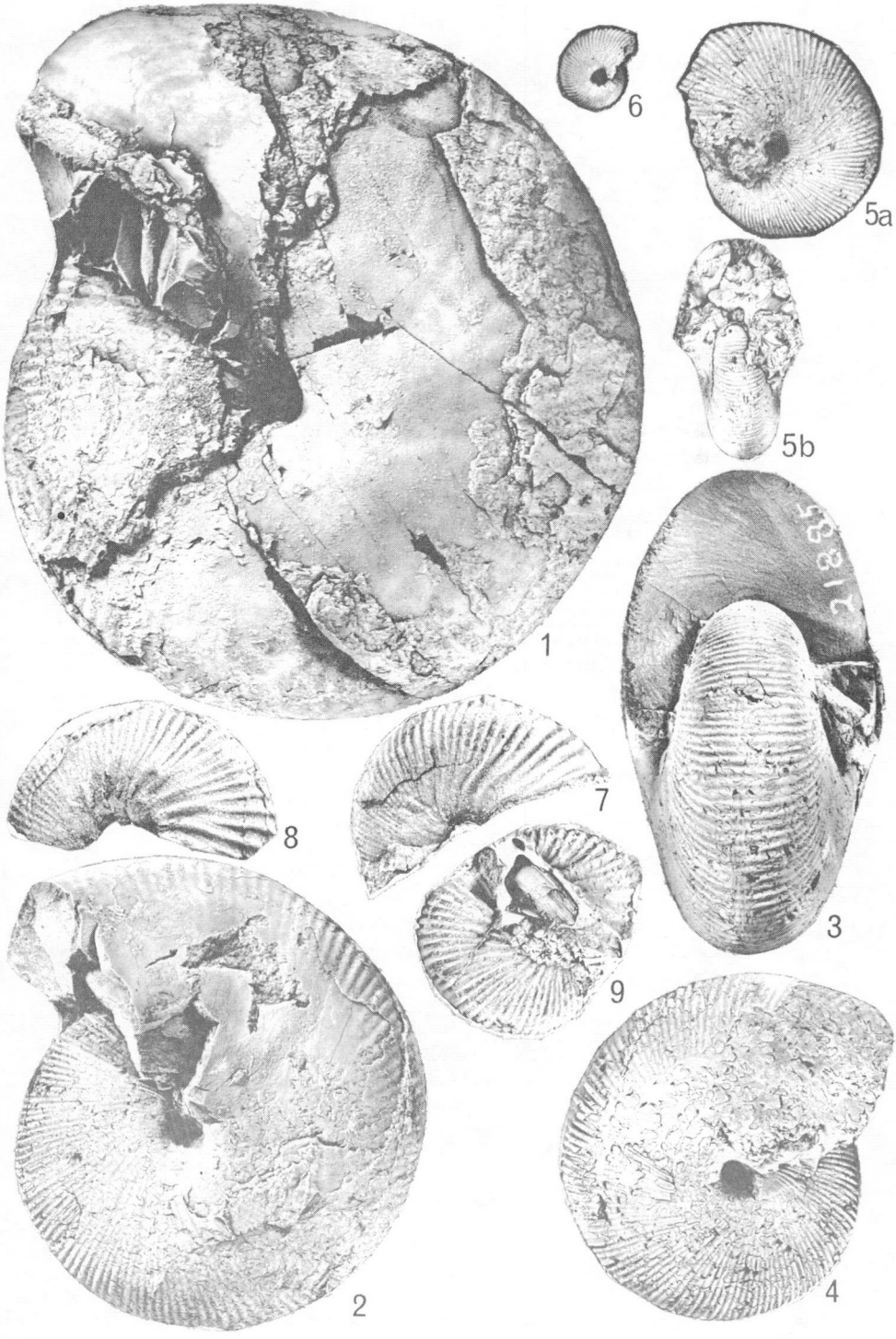
Figure 3. *Lilloettia tipperi* n. sp. Frebold. Paratype GSC No. 20369. Cross-section and venter. Nechako River area. GSC loc. 21885. Middle Callovian.

Figure 4. *Lilloettia tipperi* n. sp. Frebold. Paratype GSC No. 20370. Lateral view. Nechako River area. GSC loc. 21885. Middle Callovian.

Figure 5a, b. *Lilloettia tipperi* n. sp. Frebold. Paratype GSC No. 20371. 5a, lateral view; 5b, venter. Nechako River area. GSC loc. 21885. Middle Callovian.

Figure 6. *Lilloettia tipperi* n. sp. Frebold. Paratype GSC No. 20372. Lateral view. Nechako River area. GSC loc. 21885. Middle Callovian.

PLATE I.



Explanation of Plate II

All figures natural size. Types are in the collections of the Geological Survey of Canada.

Figure 1. Cadoceras (Stenocadoceras) striatum Imlay. Hypotype GSC No. 22693. Lateral view. Taseko Lakes area. GSC loc. 62412. Middle Callovian.

Figure 2. Cadoceras (Stenocadoceras) cf. S. striatum Imlay. Hypotype GSC No. 22694. Lateral view. Taseko Lakes area. GSC loc. 62412. Middle Callovian.

Figure 3a, b. Cadoceras (Stenocadoceras) cf. S. iniskinense Imlay. Hypotype GSC No. 22695. 3a, lateral view; 3b cross-section. Taseko Lakes area. GSC loc. 62412. Middle Callovian. Same specimen as Pl. III, fig. 1.

Figure 4a, b. Pseudocadoceras petelini (Pompeckj). Hypotype GSC No. 22696. 4a, lateral view; 4b, venter. Taseko Lakes area. GSC loc. 62412. Middle Callovian.

Figure 5. Pseudocadoceras grewingki (Pompeckj). Hypotype GSC No. 22697. Lateral view. Harrison Lake area. GSC loc. 25780 Middle Callovian.

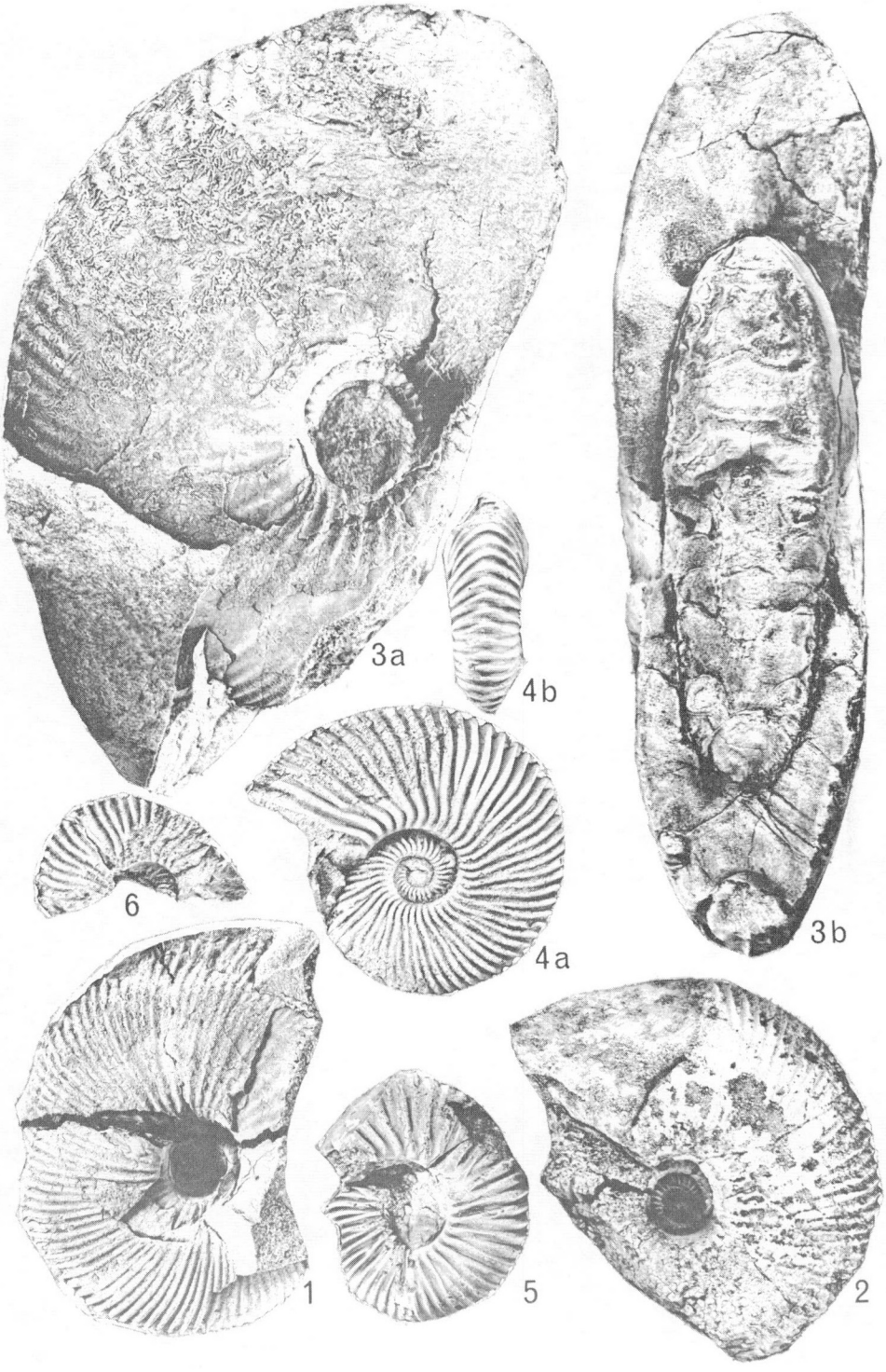
Figure 6. Pseudocadoceras aff. P. grewingki (Pompeckj). Hypotype GSC No. 22698. Lateral view. Taseko Lakes area. GSC loc. 62412. Middle Callovian.

Figure 7. Lilloettia lilloetensis Crickmay. Hypotype GSC No. 22691. Lateral view. Taseko Lakes area. GSC loc. 56523. Middle Callovian.

Figure 8. Lilloettia lilloetensis Crickmay. Hypotype. GSC No. 22690. Lateral view. Taseko Lakes area. GSC loc. 56616. Middle Callovian.

Figure 9. Lilloettia lilloetensis Crickmay. Rubber cast of inner whorls of holotype GSC No. 9698. Lateral view. Harrison Lake area. Middle Callovian.

PLATE II.



Explanation of Plate III

All figures are natural size. Types are in the collections of the Geological Survey of Canada.

Figure 1. Cadoceras (Stenocadoceras) cf. S. iniskinense Imlay. Hypotype GSC No. 22695. Same specimen as Pl. II, fig. 3a, b. Lateral view of last whorl.

Figure 2. Lilloettia tipperi n. sp. Frebold. Paratype GSC No. 20369. Same specimen as Pl. I, fig. 3. Lateral view.

Figure 3. Lilloettia lilloetensis Crickmay. Hypotype GSC No. 22692. Lateral view. Taseko Lakes area. GSC loc. 56541. Middle Callovian.

PLATE III.