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LATE UPPER JURASSIC AND EARLY LOWER CRETACEOUS FOSSIL ZONES OF THE CANADIAN WESTERN CORDILLERA, BRITISH COLUMBIA

J. A. Jeletzky

1965

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By

J. A. Jeletzky

DEPARTMENT OF
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PREFACE

This report is based on field work by the author, supplemented by study of extensive fossil collections from late Upper Jurassic and early Lower Cretaceous rocks of a vast area of western Canada. The collections were made by officers of the Geological Survey and others during the course of geological mapping.

The author has made a detailed study of these faunas, mainly species of the genus *Buchia (=Aucella)* and has worked out a practical zonation and correlation of the late Upper Jurassic and early Lower Cretaceous rocks of the region.

J. M. HARRISON
Director, Geological Survey of Canada

OTTAWA, December 3, 1963

Bulletin 103—Spätoberjurassische und frühunterkretazische paläontologische Zonen in den kanadischen Kordilleren Britisch Kolumbiens.
Von J. A. Jeletzky

Бюллетень 103 — Поздние верхнеюрские и ранние нижнемеловые палеонтологические зоны в Западных Кордильерах Канады.
Ю. А. Елецкий

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LATE UPPER JURASSIC AND EARLY LOWER CRETACEOUS FOSSIL ZONES OF THE CANADIAN WESTERN CORDILLERA, BRITISH COLUMBIA

Abstract

Six provisional fossil zones are proposed: (1) *Buchia* cf. *blanfordiana, Substeueroceras stantoni*?, and *Gymnodiscoceras* sp. ind.? — latest Portlandian s. str.?; (2) *Buchia okensis* — Berriasian; (3) *Buchia uncitoides* and *Spiticeras* spp. — Berriasian; (4) *Buchia tolmatschowi, Tollia paucicostata,* and *Tollia mutabilis* — Valanginian; (5) *Buchia pacifica* — Valanginian; and (6) *Buchia crassicollis* s. str. and *Dichotomites quatsinoensis* — Valanginian.

Buchia (better known as *Aucella*) species are rather variable, often facies bound and homoeomorphically similar; they are, consequently, difficult to use as zonal fossils.

The evolution of this genus is dominated by 'reversible morphological shifts'. The use of the following biochronologically important 'irreversible orthogenetic (better named orthoselectionary) trends' in sense of Jeletzky (1955, p. 483) permits, however, separation of homoeomorphs resulting from this iterative evolution and the dating of many *Buchia* faunas on evolutionary grade alone:

(1) Transformation of a narrow, shallow, and anteriorly open (*Meleagrinella*-like) groove on the underside of byssus ear of *B. concentrica* — early *B. mosquensis* into the anteriorly closed, spoon-like excavation of late *B. mosquensis, B. piochii,* and younger species. Progressively stronger bending of byssus ear towards the left valve proceeds simultaneously. The ear lies essentially in the plane of contact of valves in Oxfordian-Kimmeridgian species but becomes markedly oblique to it in the Portlandian s. str. late Berriasian species and, finally, almost perpendicular to it in some Berriasian and Valanginian species.

(2) Replacement of forms with right-handed incurvature of left beaks (*B. concentrica-B. mosquensis*) first by the essentially straight-beaked forms (*B. piochii-B. volgensis-B. keyserlingi-B. werthi*) and then by forms with marked to pronounced left-handed incurvature (*B. tolmatschowi-B. pacifica*). Only the North Pacific lineage reached the last-mentioned evolutionary stage. All contemporary and younger representatives of the Arctic lineage retained essentially straight left beaks.

Buchia species are reliable zonal fossils when closely studied, and are the only fossils abundant enough in the late Upper Jurassic and early Lower Cretaceous rocks of the region to be useful. For these reasons they form the backbone of the proposed zonal sequence. All other fossils, ammonites not excluded, can mostly be used only to control the time ranges of *Buchia* species and to correlate *Buchia* zones with the international standard stages and zones.

Each of the zonal indices proposed is described and figured. Some other important fossils are described and figured; others are figured but not described.

All the proposed zones are valid for the adjacent regions of the Pacific slope of North America from California to Alaska. Most of these zones are, however, not valid for northeastern British Columbia and Arctic Canada, which regions belong to another faunal subprovince characterized by their own sequence of *Buchia* species. These mostly belong to another *Buchia* stock than that which inhabited the Canadian western Cordilleran region. These two stocks are discussed in detail and designated respectively as the 'morphologically progressive' (or North Pacific) and 'conservative' (or Arctic) lineages of the genus.

Several key sections in southern British Columbia and northwestern Washington are correlated by means of the *Buchia* zones. This correlation reveals the extreme complexity of facies changes of the late Upper Jurassic and early Lower Cretaceous rocks of the region, which precludes their correlation by lithological means. The use of palaeontological correlation in preference to all other methods is, therefore, urged for the entire Canadian western Cordilleran region.

Résumé

L'auteur propose d'établir siz zones fossilifères provisoires: (1) Celle à *Buchia* cf. *blanfordiana, Substeueroceras stantoni?*, et *Gymnodiscoceras* sp. ind.? — de la fin du Portlandien s. str.?. (2) Celle à *Buchia okensis*, du Berriasien. (3) Celle à *Buchia uncitoides* et *Spiticeras* spp., du Berriasien. (4) Celle à *Buchia tolmatschowi, Tollia paucicostata* et *Tollia mutabilis*, du Valanginien. (5) Celle à *Buchia pacifica*, du Valanginien, et (6) celle à *Buchia crassicollis* s. str. et *Dichotomites quatsinoensis*, aussi du Valanginien.

Les espèces de *Buchia* (ou mieux *Aucella*) présentent plusieurs particularités variables, dues parfois à leur facies ou à leurs caractères homoeomorphes semblables, de sorte qu'elles ne peuvent guére servir de fossiles types pour les zones.

L'évolution de ce genre est caractérisée par des modifications morphologiques réversibles. Importantes du point de vue biochronologiques, les suivants tendances orthogénétiques irréversibles (ou mieux orthosélectives), au sens de Jeletzky (1955, p. 483), permettent de distinguer les éspeces homoeomorphes qui proviennent de cette évolution répétée et d'établir la chronologie de plusieurs faunes à *Buchia*, d'après leur degré d'évolution seulement, savoir:

(1) La transformation d'une rainure étroite, peu profonde et ouverte à l'avant (comme dans le cas de *Meleagrinella*), située sous l'oreillette du byssus de *B. concentrica-B. mosquensis* primitif, dans un creux en forme de cuiller, fermé à l'avant, du *B. mosquensis* récent, *B. piochii* et d'espèces plus récentes encore. En même temps, on voit que la courbure de l'oreillette progresse peu à peu vers la valve gauche. La plus grande partie de l'oreillette se trouve dans le plan de contact des valves, dans les espèces l'Oxfordien - Kimmeridgien, mais elles devient sensiblement oblique par rapport au plan dans celles du Portlandien s. str. et celles de la fin du Berriasien; enfin, elle est presque perpendiculaire au plan de contact dans certaines espèces du Berriasien et du Valanginien.

(2) Le remplacement de formes à bec gauche courbé vers la droite (*B. concentrica-B.mosquensis*), d'abord par des formes à bec à peu près droit (*B.piochii-B.volgensis-B.keyserlingi-B.werthi*), puis par des formes à courbure vers la gauche, dont certaines sont à peine discernables et d'autres nettement pronouncées (*B.tolmatschowi-B.pacifica*). Seules les familles du Pacifique-Nord ont atteint ce dernier stade de l'évolution. Tous les représentants de la famille Arctique, contemporains ou plus récents, ont conservé des becs gauches presque droits.

Les espèces *Buchia*, lorsqu'on les étudie minutieusement, servent de fossiles caractéristiques aux zones. A cause de leur abondance, ces fossiles sont les seuls qui puissent servir à cette fin, dans les couches de la fin du Jurassique supérieur et du début du Crétacé inférieur. C'est pourquoi ils forment le coeur de la succession zonale proposée. La plupart des autres fossiles, ammonites incluses, ne sont bons qu'à vérifier les intervalles chronologiques des espèces *Buchia* et à rattacher les zones à *Buchia* aux étages et zones établis internationalement.

On décrit et illustre chacun des indices zonaires. Certains autres fossiles importants sont décrits et illustrés, tandis que d'autres sont simplement illustrés.

Toutes les zones proposées sont valides pour les régions voisines du talus du Pacifique, de la Californie à l'Alaska, mais la plupart ne le sont pas pour le Nord-Est de la Colombie-Britannique et le Canada arctique, régions formant une autre sous-province faunique caractérisée par sa propre succession d'espèces *Buchia*. La plupart appartiennent à une rameau de *Buchia* différente de celle qui habitait l'Ouest de la Cordillère canadienne. On traite à fond de ces deux rameaux désignées respectivement sous les noms de rameau morphologiquement progressive (ou du Pacifique-Nord) et de rameau conservatrice (ou de l'Artique).

Les zones à *Buchia* servent à rattacher plusieurs coupes essentiels du Sud de la Colombie-Britannique et du Nord-Ouest de l'Etat de Washington. Cette mise en corrélation révèle l'extrême complexité des variations du facies de la fin du Jurassique supérieur et du début de l'Infracrétacé, ce qui empêche de les rattacher lithologiquement. On préconise donc d'utiliser, pour tout l'Ouest de la Cordillère canadienne, la méthode paléontologique de corrélation, de préférence à toutes les autres méthodes.

INTRODUCTION AND ACKNOWLEDGMENTS

This report, which summarizes the information now available on the macrofossil zonal succession of the late Upper Jurassic (latest Portlandian?) and early Lower Cretaceous (Berriasian and Valanginian) marine rocks of the Canadian western Cordillera, is based on field work on the west coast of Vancouver Island (Jeletzky, 1950) and in Quatsino Sound (Jeletzky, 1954b). The field work was supplemented by study of the regional literature (Crickmay, 1930a, b; 1962) and of numerous fossil collections made by officers of the Geological Survey and other persons.

The richly fossiliferous, thick, and mostly continuous late Upper Jurassic and early Lower Cretaceous sections of western Vancouver Island, which have been studied in considerable detail, are used as the regional standard of reference. Other fossil collections and stratigraphic data used are interpreted here in terms of the standard faunal sequences of the western Vancouver Island.

Standard faunal sequences previously proposed for the late Upper Jurassic and early Lower Cretaceous rocks of the western Cordillera of the Americas, Canadian Arctic, Greenland, Northern Eurasia, New Zealand, and elsewhere, have proved valuable and have made it possible to relate the Canadian western Cordilleran zones proposed here to the international standard stages, to determine the age relationships of some of the zones of that region, and to correlate them with other regional zones. The remarkable similarity of the zonal sequence of our region to those published previously for some other regions has hastened the preparation and greatly increased the reliability of the conclusions presented here.

The interpretation of pertinent foreign data has been greatly facilitated by the kind cooperation of many colleagues in and outside of North America, and all such assistance is gratefully acknowledged.

Special thanks are due to Dr. D. T. Donovan, Department of Geology, University of Bristol, England, Dr. Leo H. Hertlein, Department of Geology, The Science Museum of the California Academy of Sciences, San Francisco, U.S.A., Dr. Joseph H. Peck, Jr., Museum of Palaeontology, University of California, Berkeley, U.S.A., and Dr. C. A. Fleming, Geological Survey of New Zealand, Wellington, New Zealand, who have kindly provided valuable comparative collections and plaster casts of the late Jurassic and early Lower Cretaceous *Buchia* (better known as *Aucella*) and ammonite species from the western United States, east Greenland, and Indo-Pacific region. Sincere thanks are also due to Dr. Peter Misch of the University of Washington, Seattle, who loaned important late Jurassic

and early Lower Cretaceous fossil collections from Nooksack area and Spieden Island, in the northwestern part of the State of Washington adjacent to the Canadian western Cordillera. Dr. Misch also made available important stratigraphical data obtained in the Nooksack area.

Except for the valuable early work of Crickmay (1930a, b; 1962), this is the first attempt at palaeontological zoning of the late Upper Jurassic and early Lower Cretaceous rocks of the region. It is based on detailed study of only a few representative sections supplemented by study of numerous but often stratigraphically uncertain fossil collections brought in by mapping geologists. The results obtained so far are, thus, somewhat preliminary in nature and more detailed field work is needed to test and prove the regional validity of some of the fossil zones proposed.

Some of the specific and generic names adopted for zonal indices and other important zonal fossils are used provisionally and may be subject to later revision; some other names used in the recently published abstract of this report (Jeletzky, 1959) had to be revised here. Nomenclature of North American, Eurasian, and Indo-Pacific species of *Buchia* is in a state of confusion due to the superabundance of names proposed by various workers, as well as to the unsatisfactory descriptions and poor figures of some key species. Some of the most commonly used specific names have proved to be junior synonyms of older names, and it seems likely that other commonly used names will eventually be suppressed. The same is true of the latest Jurassic and early Lower Cretaceous ammonites both at specific and generic level. Therefore, the writer attempted to keep the specific and generic nomenclature as simple as possible, and to apply open nomenclature whenever in doubt about the correct names for the Canadian fossils concerned.

USE AND LIMITATIONS OF *BUCHIA* SPECIES AS INDEX FOSSILS

Species of *Buchia* (better known as *Aucella*) are for the most part the only biochronologically valuable fossils abundant and widespread enough in the late Upper Jurassic and early Lower Cretaceous rocks of the region to be useful as zonal indices. The same is true elsewhere in western and northwestern North America (Imlay, 1957, 1959; Jeletzky, 1958, 1959, 1960, 1961a, b). The zonal sequence proposed here is, therefore, based largely on the succession of *Buchia* species. Most of these palaeontological (as opposed to neontological) species appear to be successive stages of two or more uninterrupted evolutionary lineages. This circumstance strongly increases their biochronological value in providing complete biozones rather than partial fossil zones or teilzones (Jeletzky, 1955, pp. 484-490, 499-501).

Six reasonably refined *Buchia* zones have so far been recognized (Fig. 1). This zonal sequence differs considerably from that recently proposed by Imlay (1959, 1960) for the western Cordillera of the United States, including Alaska. Some of these differences are probably caused by the provincial nature of certain United States and Canadian species (e.g., the apparent absence of the well-defined *Buchia piochii* zone in our region and the absence of *Buchia* cf. *blanfordiana* zone in California and Oregon). Other differences may be due, in part at least, to the incompleteness of the California and Oregon sections used as the standard of reference by Imlay (1959), as for instance the apparent absence of most of the Berriasian stage in these states. Yet other differences arise from Imlay's (1959) more comprehensive concept of *Buchia* species. Imlay has amalgamated several closely related, but nevertheless independent, species (e.g., *Buchia* cf. *blanfordiana* and *B. mosquensis* var. *rugosa* on the one hand and *B. uncitoides, B. tolmatschowi, B. pacifica* n. sp., and *B. crassicollis* s. str. on the other), which characterize successive zones in the Canadian western Cordillera and probably in the United States as well (Fig. 2).

Use of *Buchia* species for a refined zonal correlation is certainly not easy as:

Firstly, all species studied were benthonic forms similar to oysters and *Mytilus* (Sokolov, 1926, p. 32) in their mode of life. Many exhibit considerable range of morphological variation caused by the degree of crowding (op. cit., pp. 31-34; Imlay, 1959) and variation in other living conditions. None of the taxonomically important morphological features of *Buchia* shell lends itself to exact measurement or to statistical treatment.

Secondly, many species apparently were facies controlled and regionally restricted within western and northern North America, whereas other species developed regional or provincial subspecies from one basin to another. Some other species were, however, facies-breaking and circumboreal in their occurrence (e.g., *B. okensis* and *B. crassicollis* s. str.).

Thirdly, the evolution of *Buchia* is dominated by the 'reversible morphological shifts', with only two 'irreversible orthogenetic (better named orthoselectionary) trends' in the sense of Jeletzky (1955, p. 483) recognized so far. It is, consequently, often difficult to separate those morphologically similar forms of *Buchia* that arose repeatedly (iterative evolution) at different times in the same or in different lineages of the genus. The two now known irreversible orthogenetic trends of *Buchia* are discussed herein because of their outstanding biochronological importance.

The first 'trend' in the evolution of *Buchia* consists in the more or less regular irreversible changes of the shape, size, and orientation of the byssus ear and other parts of the ligamental plate of the right valve.

The mid-Callovian (earliest known) to? late Kimmeridgian (inclusive of Vetlianka beds but exclusive of *Dorsoplanites dorsoplanus* zone which does not seem to be distinguishable from *Virgatites (Zaraiskites) scyticus* zone contrary to the opinion of Arkell, 1956, pp. 489-490, 494) representatives of the *Buchia lata-concentrica* (*?=bronni*) — early *B. mosquensis* species group are characterized by the occurrence of a shallow and narrow groove on the essentially flat inner surface (underside) of the byssus ear. This groove may be barely noticeable. Unlike the corresponding groove of the younger *Buchia* species, the groove discussed here is typically wide open at its anterior (Pl. I, figs. 1A-C) and posterior ends. The byssus ear of the *Buchia lata-concentrica (?=bronni)*— early *B. mosquensis* species group is, at that, oriented more or less in the plane of contact of the valves and may be directed either forward or obliquely upward; it is not appreciably bent towards the left valve (Pompeckj, 1901, Pl. XV, fig. 2 *non* fig. 5; this paper Pl. I, figs. 2, 10B, 10F). The byssus notch is accompanied by a gaping slit over a considerable distance backward from its anterior end (Pl. I, figs. 1A, 1C, 2, 10F). The surface of the right ligamental plate is oriented almost directly upward.

The byssus ear, and other parts of the right ligamental plate, of the mid-Callovian to late Kimmeridgian *Buchia* species are, thus, rather similar to those of *Meleagrinella* (*see* Pompeckj, 1901, Pl. XV, figs. 1, 7). This similarity was already responsible for the erroneous assignment of such Oxfordian *Meleagrinella* species as *"Aucella" radiata* (Trautschold) and *"Aucella" impressae* Quenstedt to *Buchia* by Pompeckj (1901).

Most or all of the Portlandian s. str. and early Upper Tithonian (=Aquilonian or Purbeckian) buchias, beginning with the typical (or late) forms of *B. mosquensis* (Buch) s. lato from *Virgatites (Zaraiskites) scyticus* zone of middle Russia and its equivalents (*see* Pavlow, 1907, text-figs. 11, 15, 17; Pl. II, figs. 5C, 20B-20C) and including *B. piochii* var. *russiensis* (Pavlow, 1907, Pl. III, figs. 14B-14C; this paper, Pl. I, figs. 3D-3E), *B. piochii* var. *mniovnikensis* (Pavlow, 1907, Pl. II, figs. 9B-9C; this paper, Pl. I, figs. 4B, 4C, 4D) and *B. piochii* var. *subovalis* (Pavlow, 1907, Pl. III, figs. 13A-13D) from the younger beds, are characterized by a different structure of byssus ear and other parts of the right ligamental plate. Their byssus ear is, relatively speaking, considerably larger and stouter than that of the older *Buchia* species. At the same time it is markedly bent towards the left valve, its anterior surface usually forming an angle from 25 to 50 degrees, and rarely up to 80 degrees (Pl. I, fig. 3E), with the plane of contact of the valves. The lower, anterior margin of the byssus ear extends ridge-like across the anterior end of the groove occurring on the inner surface of the byssus ear, blocking it completely or in part. The posterior end of this groove is more or less markedly constricted. This blocking and constriction, together with the deepening and widening of the middle part of the groove, result in a distinctly 'spoon-like' shape of the inner surface of the byssus ear in this species group. This spoon-like shape of the byssus ear seems to be absent in the older species, with possible exception of some morphologically advanced Upper Kimmeridgian representatives of *B. mosquensis* var. *polita* (Keyserling, 1846) (=var. *tenuistriata* Lahusen, 1888).

The surface of the right ligamental plate of the Portlandian and early Upper Tithonian *Buchia* species group is markedly slanted inward (Pl. I, figs. 3D, 4E and 5D) at angles ranging from 25 to 50 degrees in the material available. Unlike that of the latest Jurassic and early Lower Cretaceous buchias (*see* below), the byssus notch of the species group discussed here only differs from that of the older buchias in its slit being somewhat narrower (Pl. I, figs. 4B, 4D) and/or shorter (Pl. I, fig. 3D).

Plate I, figures 3A-3B, 4B-4E, 5B, 5E illustrate the known range of variation of the byssus ear and other parts of the ligamental plate in this species group on the example of a single Upper Portlandian palaeontological population of *Buchia piochii* s. lato. Most of the specimens are closely similar to that shown in Plate I, figure 4. The specimens transitional between those figured on Plate I, figures 4 and 5 are also fairly common. Those approaching the specimen in Plate I, figure 3, are, conversely, exceptionally rare. They appear to be 'prophetic' of the evolutionary grade of the byssus ear typical of the younger buchias.

The byssus ear of most or all of the latest Jurassic (late Upper Tithonian) and early Berriasian buchias loses the spoon-like appearance of their Portlandian and early Upper Tithonian predecessors. Because of the generally more pronounced bend of the byssus ear, its inner surface is much more deeply excavated and lacks the posterior constriction. Its appearance is that of a rather deep and wide, wedge- to hoof-shaped embayment. This embayment is usually somewhat longer than wide, wide open at its posterior end, and closed at the anterior end. At its posterior end this embayment is either as deep or somewhat deeper than wide. Unlike those of the earlier buchias, the walls of the byssus notch of the here-discussed species group either almost touch each other or are closely pressed together. The angle between the anterior surface of the byssus ear and the plane of contact of the valves seems to vary within the same limits as in the Portlandian and early Upper Tithonian buchias. The values exceeding 40 degrees appear, however, to be the rule in the uppermost Jurassic and early Berriasian buchias and the 50-to-80 degrees angles become fairly common.

So far as known, the previously discussed conditions prevail in the latest Jurassic representatives of *B. fischeriana* s. lato, *B. terebratuloides* s. lato, *B. subinflata,* and *B. unschensis* (Lahusen, 1888, Pl. II, figs. 9-10; Pl. IV, fig. 17, and personal observations on the Canadian material). Judging by some poorly preserved Canadian and American material in the writer's possession, the same is probably true of the latest Jurassic representatives of *B. piochii* s. lato. The same is, finally, true of such early Berriasian species as *B. okensis* s. lato (Pl. IV, figs. 4C, 6D, 10B-10C), *B. volgensis* s. str. (Lahusen, 1888, Pl. III, figs. 7-8, 10-11), and the early forms of *B. uncitoides* s. lato (Pl. IV, fig. 7C).

The late Berriasian and Valanginian buchias are not uniform in the structure of the byssus ear and other parts of the ligamental plate. One group of species, which is largely restricted to northern Eurasia and the Canadian Arctic, retained the foregoing evolutionary grade of the latest Jurassic and early Berriasian species at least until the late Lower Valanginian. This species group includes *B. volgensis* s. str. (Lahusen, 1888, Pl. III, figs. 7-8, 10-11), late forms of *B. terebratuloides,* late forms of *B. okensis* s. lato, and early to typical forms of *B. keyserlingi* s. lato. Only occasionally during the late Lower Valanginian did the immediate descendants of this species group, such as the late forms of *B. keyserlingi, B.* ex. gr. *inflata-sublaevis,* and? *B. crassicollis* s. str., acquire a different, morphologically more advanced structure of the byssus ear (*see* Pompeckj, 1901, Pl. XV, figs. 6, 8-10, 21; this paper, Pl. I, figs. 7, 8; Pl. XXI, fig. 6B). This structure appears to be indistinguishable from that of the byssus ear of the second species group of the late Berriasian to Valanginian buchias described below. These Eurasian *Buchia* species are accordingly described in connection with this unrelated species group rather than with their Berriasian to early Valanginian ancestors.

The second species group includes most or all of the late Berriasian and Valanginian buchias of the Pacific slope of North America. In this group, beginning with its late Berriasian representatives, such as *Buchia uncitoides* s. lato, the anterior surface of the byssus ear usually forms an angle of 70 to 90 degrees with the plane of contact of the valves. This represents a further 'stabilization' of this feature at the highest values already known but exceedingly rare in the Portlandian to early Lower Tithonian buchias, and more common but still rare in the uppermost Jurassic and early Berriasian buchias. Because of the greater value of the above angle, the byssus ear of this second species group becomes rather high when viewed anteriorly and is almost to quite invisible when viewed from the exterior of the right valve (Pl. I, figs. 7, 8A; Pl. IX, figs. 1A, 6A, 14A, 15A, 21A; Pl. XIII, figs. 1A, 4D; Pl. XXI, fig. 6A). At the same time the wedge- to hoof-like shaped embayment of the inner surface of the byssus ear becomes relatively deeper, shorter and wider (Pl. I, figs. 8B, 8E) as compared with that of the latest Jurassic and early Berriasian buchias. In the species group discussed here this embayment is usually deeper than wide and at least as wide at the posterior end as it is long.

The right ligamental plate is usually proportionally wider, thicker and its surface is stronger slanted inward than that of any older *Buchia* species, including the early representatives of the first late Berriasian to Valanginian species group (*see* above) (Pl. I, figs. 8B, 8E; Pl. IX, figs. 14C-14E, 20C, 21C, 21E). The inward slant of 45 to 50 degrees appears to be the rule in this second species group, judging by the material available. Even greater angles may be characteristic of some other insufficiently known Valanginian *Buchia* species.

So far as known, the conditions discussed here prevail in the typical and late forms of *Buchia uncitoides* s. lato (Sokolov, 1908b, Pl. I, figs. 11, 13a-13c; this paper, Pl. IX, figs. 1, 2, 14, 15, 20, 21), *B. tolmatschowi* s. lato (Sokolov, 1908b, Pl. II, figs. 2a-2b; this paper, Pl. XIII, figs. 1, 4; Pl. XV, fig. 4), *B. pacifica* n. sp., Pl. XIX, fig. 4C). The same is true of *B. crassicollis* s. str. (Pl. XX, fig. 8B, Pl. XXI, fig. 6B) and other representatives of *B. keyserlingi-inflata-sublaevis* species group (*see* p. 6).

The walls of the byssus notch are always closely pressed together. In the Valanginian species, at least, they do not leave any visible slit, except at the 'anterior' end (in the late Berriasian and Valanginian *Buchia* species concerned this is actually the lower end, because of the byssus ear being almost perpendicular in relation to the left valve) of the byssus notch (Pompeckj, 1901, p. 326, Pl. XV, figs, 6, 8-10; this paper, Pl. I, fig. 8E).

The evolutionary development of the byssus ear of Berriasian and Valanginian species of northern Eurasia and the Arctic is, thus, considerably retarded as compared with that of the contemporary *Buchia* species of the Pacific slope of North America. This suggests that these Eurasian and Arctic *Buchia* species evolved independently from those of the Pacific slope of North America. This conclusion is supported by the presence of a closely similar discrepancy in the evolutionary rates of development of the left beak of the same two species groups (*see* below).

Transitional forms connecting the mid-Callovian to late Kimmeridgian buchias with the younger species abound in the late Kimmeridgian and early Portlandian s. str. palaeontological populations of *Buchia mosquensis* s. lato. The mid-Upper Tithonian and younger rocks are similarly rich in transitional forms between all other above-discussed, morphologically distinctive species groups of *Buchia*. The evolution of byssus ear and other parts of the right ligamental plate of this genus must have proceeded gradually and without any major evolutionary jumps (Waagen's mutations) throughout.

All *Buchia* species of the Canadian western Cordillera described herein belong to the younger (early Portlandian to Valanginian) species groups. Among them, the latest Portlandian? *B.* cf. *blanfordiana* (Stoliczka) has the evolutionary grade of the late *B. mosquensis* s. lato-*B. piochii* s. lato species group (Pl. XXII, fig. 2). It is, therefore, easily distinguishable from other *Buchia* species described here on the structure of its byssus ear, etc. alone. Among the early Lower

Cretaceous species, *B. okensis* (Pavlow) s. lato, the early forms of *B. uncitoides* (Pavlow) s. lato, as well as the early and typical forms of *B. keyserlingi* (Lahusen) s. lato, are readily distinguishable on the same character from such late Berriasian and Valanginian species as the typical and late forms of *B. uncitoides* s. lato, *B. tolmatschowi* s. lato, *B. pacifica* n. sp., late forms of *B. keyserlingi* and its var. *gigas*, *B.* ex gr. *inflata-sublaevis* and *B. crassicollis* s. str.

This report does not describe any pre-Portlandian *Buchia* species. The taxonomical implications of this irreversible orthogenetic trend, such as the subgeneric separation of mid-Callovian to late Kimmeridgian *Buchia* species from the younger buchias and the adjustment of their specific nomenclature for the pre-Portlandian representatives of *B. mosquensis* s. lato[1], are therefore beyond its scope. It should be noted in passing, however, that the generic name *Anaucella* erected by Pchelintseva (1955, pp. 212-13) for *Buchia* ex gr. *concentrica* (Sowerby) on the distinctions of their shell ornament alone is available for the mid-Callovian to late Kimmeridgian *Buchia* species as a subgenus. The circumstance that this genus is based on *Aucella bronni* Lahusen, 1888, rather than *Buchia bronni* Rouillier, 1845, does not invalidate it under the *Rules of Zoological Nomenclature,* and the same is true of the taxonomic uselessness of the morphological feature (presence of a pronounced radial ornamentation) used by Pchelintseva (1955) for the definition of her genus.

The biochronological value of this irreversible orthogenetic trend principle can hardly be overestimated. Its recognition permits, indeed, the identification and dating of many otherwise morphologically similar (homoeomorph) species and often makes it possible to date *Buchia* collections simply on their evolutionary grade. It is, for example, usually possible to distinguish at a glance between the mid-Callovian to late Kimmeridgian *Buchia (Anaucella)* species and all younger *Buchia (Buchia)* species. Even specifically indeterminable fragments can often be referred to one or the other of these two species groups (subgenera) and dated accordingly, if their right ligamental plate including byssus ear is well enough preserved. In the post-Kimmeridgian representatives it is usually possible to differentiate between the early Portlandian to early Upper Tithonian and latest Jurassic to early Berriasian *Buchia* species using the structure of the byssus ear and other parts of the right ligamental plate alone. The same is true of the differentiation of the other two early Lower Cretaceous species groups from each other.

Single specimens or small samples of the early Portlandian, mid-Upper Tithonian, mid-Berriasian and early Valanginian *Buchia* species may admittedly be difficult to date on the structure of their byssus ear, etc., because of the transitional character of these features. The larger samples are, however, usually datable because of this same transitional nature of their byssus ears and right ligamental

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[1] Throughout this report *Buchia mosquensis* is interpreted in the sense of Pavlow (1907, pp. 22-26), except that a number of closely allied, contemporary and mid- to late-Kimmeridgian forms treated as independent species by Pavlow are here downgraded to morphological variants (e.g., *B. rugosa, B. gracilis, B. rouillieri, B. polita,* etc.).

plates. The coexistence of the morphologically dissimilar representatives of the 'conservative' and 'morphologically progressive' lineages in the late Berriasian and early Valanginian rocks presents a similar problem.

The writer does not know of any exceptions (evolutionary reversals) to the irreversible development of the byssus ear and other parts of the right ligamental plate of *Buchia,* or of any survivors of the *Buchia (Anaucella)* ex gr. *concentrica (? = bronni)*— early B. *mosquensis* in the Portlandian s. str. of later rocks. The existence of such exceptions and survivors is, however, entirely possible and should be carefully looked for in the future.

Some of the irreversible evolutionary changes of the byssus ear of *Buchia* were recognized by Pompeckj (1901, p. 326). They have, however, been completely overlooked by later workers, some of whom stressed emphatically their belief that the hinge structure of all *Buchia* species is essentially similar (Sokolov, 1908a, p. 4).

The second irreversible orthogenetic trend in the evolution of *Buchia* is the more or less regular change of the direction of lateral curvature of the left beak relative to the long axis of the valve. In all hitherto known *Buchia* lineages, forms whose left beaks show marked to pronounced right-handed incurvature are gradually replaced by, first, forms with nearly straight (that is, directed mainly along the long axis of the valve) left beaks, and then by forms whose left beaks show feeble to marked left-handed incurvature. The right beaks remain incurved to the left throughout these three stages. Forms whose left and right beaks show pronounced left-handed incurvature represent the fourth and last known stage of evolution in at least one of the lineages.

To observe the direction of lateral curvature of the left beak, the left valve is placed in the lateral position with its exterior directed towards the observer (as in Pl. I, figs. 6A, 9A, and 10A). The beaks that deviate towards the right from the forward projection of the long axis of the valve are designated as having right-handed incurvature. The right-handed incurvature may be marked (fig. 10A), feeble (fig. 6A), or slight (fig. 9A). The beaks of the left valves shown in Plate VII, figure 9A, Plate VIII, figure 4A, and Plate X, figure 14A have, on the contrary, marked to pronounced left-handed incurvature. Whenever the beak part of the valve is coiled or strongly downward bent, it has to be tilted rather strongly towards the observer in order to see the lateral curvature, or lack of it.

Lateral curvature of the left beak can also be observed when looking into the beak and hinge margin of the valve (as in Pl. I, figs. 9A, and 10F). The beaks that deviate towards the left hand of the observer from the imaginary vertical line dropped down from the highest point of the valve's cross-section are designated as having right-handed incurvature (Pl. I, fig. 10F), those beaks that do not deviate noticeably from this line are straight (Pl. I, fig. 6D), and those that deviate towards the right hand of the observer have left-handed incurvature (Pl. XIII, figs. 1B, 3C, 4B).

The lateral curvature of the left beaks of all *Buchia* species is subject to rather strong individual and ontogenetic variability. It can be either limited to the earliest or latest growth-stages of the beak or affect most or all of its length. One and the same specimen may therefore appear to be slightly or feebly incurved to the right when viewed laterally and virtually straight when viewed from above (Pl. I, figs. 6A and 6D). Some aberrant representatives of *Buchia* cf. *blanfordiana* (Pl. II, fig. 4) exhibit an S-like twist of the end part of the left beak instead of its more or less regular and pronounced right-handed incurvature characteristic of most representatives of this species (Pl. II, figs. 2, 3, 6, 7). The evolutionary stage of any given left beak can, therefore, only be identified correctly by appraising its overall trend rather than the curvature at any particular growth stage. Appraisal of the overall beak configuration of several specimens may be necessary for the postive identification and dating of some *Buchia* collections.

Being always superimposed on such a wide range of individual and ontogenetic variation, this overall regularity of the evolutionary change in the left beak cannot be conveniently expressed in any more rigorously quantitative manner than is done in this report. Even so, this regularity permits the separation of many otherwise morphologically similar homoeomorphic species at a glance and permits dating of *Buchia* collections simply on their evolutionary grade. There are, naturally, exceptions to this empirical rule and future work may, possibly, disclose further exceptions to it.

The late (but not the latest) Jurassic *Buchia* species are, as a rule, characterized by beaks of the left valve having more or less pronounced right-handed incurvature. *B. concentrica* (Sowerby) (=? *B. bronni* Rouillier) and *B. mosquensis* (Buch) best characterize this earliest or first stage of evolution which lasted from mid-Callovian to late Portlandian s. str. Representatives of *B. concentrica* var. *erringtoni* shown in Plate I, figure 10 as well as those of *B. mosquensis* var. *rugosa* and *B.* cf. *blanfordiana* shown in Plate II, figures 1, 2 and in Plate III, figures 4-9 illustrate the characteristic morphology of the left beaks during this first stage of *Buchia* evolution. The forms whose left beaks show left-handed incurvature are unknown in mid-Callovian to late Portlandian s. str. rocks and those with straight to almost straight (that is feebly to slightly incurved to right) left beaks are very rare. Only *B. volongensis* (Sokolov, 1908a) and *B. tschernyshewi* (Sokolov, 1908a) from the late Oxfordian to early Kimmeridgian rocks of Russia and the early representatives of *B.* ex gr. *piochii* from the mid-Portlandian rocks of Eurasia and North America have the latter type of left beaks.

In the late Portlandian s. str. and earliest Upper Tithonian time forms whose left beaks show marked to pronounced right-handed incurvature become largely replaced by those whose left beaks are straight to almost straight. *B. piochii* s. str., *B. piochii* var. *russiensis* and var. *mniovnikensis* and *B. terebratuloides* are good examples of this second stage of *Buchia* evolution. So far as known, the ratio of straight-beaked forms gradually increases in the course of evolution of the *B. piochii-fischeriana-terebratuloides* species group so that the feebly right-handed-incurved forms almost disappear in the latest Jurassic populations of *B. piochii* and *B. terebratuloides*. The contemporary palaeontological populations of *B. fischeriana* s. lato are, however, dominated by forms with feeble right-handed incurvature. Some specimens with slightly to feebly left-handed-incurved left beaks occur in most palaeontological populations of the latest Jurassic *Buchia;* they may become fairly common in such aberrant forms as *B. unschensis* (Pavlow, 1907) and *B. subinflata* (Pavlow, 1907).

Two species groups can be distinguished among the Berriasian buchias according to the evolutionary grade of their left beak. One group, which is largely restricted to northern Eurasia and the Canadian Arctic, retains the feebly right-handed-incurved to straight left beaks characteristic of its uppermost Jurassic predecessors. It is typified by such well-known Russian species as *B. volgensis* s. lato (Lahusen, 1888, Pl. III, figs. 1, 4, 12, 16; Pavlow, 1907, Pl. II, figs. 10A, 11, 12A, 25A, 34A) and *B. terebratuloides* s. lato (Lahusen, 1888, Pl. IV, figs. 1, 4, 10). Another species group, which is largely restricted to the Pacific slope of North America but also occurs in northern Eurasia and the Canadian Arctic, consists of *B. okensis* s. lato (Pavlow, 1907, Pl. I, figs. 10-11; this paper, Pl. IV, figs. 1, 3-6, 8, 10-12, 15, 18-23; Pl. V, figs. 2-10, etc.), *B. uncitoides* s. lato and some other little-known forms. This species group is characterized by feebly to markedly left-handed-incurved left beaks and comprises the third stage of the left beak's evolution. The straight to feebly right-handed-incurved left beaks are relatively rare in this species group, except in the basal Berriasian rocks, where most of the early forms of *B. okensis* s. lato possess this type of left beak. Already these earliest Cretaceous populations include some specimens whose left beak shows slight to feeble left-handed incurvature (Pl. IV, figs. 17, 19) and even rare specimens with the marked to pronounced left-handed incurvature (Pl. IV, fig. 9). The ratio of such forms increases rapidly upward in the sections. Already in the middle and upper parts of *Buchia okensis* zone most of the representatives of this species have either straight or feebly left-handed-incurved left beaks. Only the minority of forms from these beds, mostly belonging to *B. okensis* f. typ. (Pl. V, fig. 2) and *B. okensis* var. *subokensis* (Pl. VI, fig. 3), have left beaks that still possess feeble to slightly right-handed incurvature. The late forms of *B. okensis* s. lato from the top part of its zone and the 'overlap beds' with *Buchia uncitoides* zone mostly possess feeble to marked left-handed incurvature of left beaks (Pl. VI, figs. 1A, 1D, 2A, 2D, 4A, 4D, 6A, 6D; Pl. VII, figs. 2A, 2D; Pl. VIII, figs. 1A, 1D, 2A, 2D, 3A, 3D, 5A, 5D, 6A, 6D; Pl. X, fig. 2). A number of specimens from these beds mostly belonging to *B. okensis* f. typ. and *B. okensis* var. *subokensis,* still possess, however, straight to feeble right-handedly incurved left beaks (Pl. VI, figs. 3A, 3D, 5A, 5D, 9A, 9D; Pl. VII, figs. 1A, 1D, 3A, 3D, 6A, 6D; Pl. VIII, figs. 8A, 8D). So far as known, these more primitive forms range almost to the top of *Buchia uncitoides* zone. It should be noted that most representatives of *B. okensis* s. lato known from the Berriasian rocks of the European Russia (Pavlow, 1907, Pl. I, figs. 11, 17; Pl. IV, fig. 20; Gerassimov, 1955, Pl. XIII, figs. 9, 10), Spitzbergen (Sokolov and Bodylevsky, 1931, Pl. I, figs. 5, 9, and 11) and East Greenland (Spath, 1947, Pl. V, fig. 1) belong to such forms. Only *B. okensis* var. *elliptica* figured by Pavlow (1907, Pl. I, fig. 28) appears to have a slight left-handed incurvature of left beak.

Many of the earliest known representatives of *B. uncitoides* s. lato (Pl. IV, figs. 2A, 2D, 13A, 13D, 16A, 16D) already possess left beaks with feeble to marked left-handed incurvature. Considerable percentage of specimens from these beds (basal part of *Buchia okensis* zone) possesses, however, straight to slightly right-handed incurvature of left beaks. The same appears to be true of the *B. uncitoides* forms occurring rarely in the middle or upper part of *Buchia okensis* zone (Pl. VI, figs. 7A, 7D). Most of the typical and late forms of *B. uncitoides* from the overlap beds and *Buchia uncitoides* zone proper (*see* p. 26) already have feeble to marked left-handed incurvature of left beaks (Pl. VII, figs. 12A, 12D; Pl. VIII, figs. 10A, 10D, 11A, 11D; Pl. IX, figs. 3, 4, 5, 10, 12, 13, 18, 22). A number of specimens with the pronouncedly left-handed incurvature of left beaks (Pl. VII, fig. 9A, 9D; Pl. IX, figs. 17A, 17D, 19A, 19D, 23A, 23D; Pl. X, figs. 14A, 14B) occur in these beds. A number of representatives of typical to late forms of *B. uncitoides* retain, however, straight to feebly right-handed-incurved left beaks (Pl. VII, figs. 14A, 14D; Pl. VIII, figs. 8A, 8D, 12A, 12D; Pl. IX, figs. 9A, 9D, 11A, 11D, 22A, 22D; Pl. X, figs. 3A, 8A, 9A, 10A, 11A; Pl. XI, fig. 8A). Generally speaking, the ratio of forms with marked to pronounced left-handed incurvature of beaks increases gradually upward in the section until these forms become predominant in the top beds of *Buchia uncitoides* zone and in the overlap beds with *Buchia tolmatschowi* zone. Peculiar reversals of this trend occur, however, in some beds in the middle and upper parts of *Buchia uncitoides* zone. In these beds the ratio of specimens with straight to feebly right-handed-incurved left beaks increases sharply to some 25 per cent or even 40 per cent of the total (Pl. X, figs. 3A, 8A, 9A, 10A, 11A; Pl. XI, fig. 8A), only to diminish again sharply in the adjacent beds. The small to medium-sized shells of that type similar to those shown in Plate IX, figures 9, 11, 22 are so similar to *Buchia piochii* s. lato that they are difficult to differentiate from this older species if found alone. Only the circumstance that the earliest (end) parts of left beaks of such forms of *B. uncitoides* tend to have left-handed incurvature even when the rest of the beak has feeble right-handed incurvature (Pl. IX, fig. 9D; Pl. X, fig. 8B) provides a distinguishing feature.

The Valanginian buchias can be subdivided into the same two species groups as the Berriasian buchias.

The evolutionary grade of the left beak of Valanginian buchias of northern Eurasia, European and Canadian Arctic, and northeastern British Columbia apparently changed but little as compared with that of their Berriasian and latest Jurassic predecessors. Some of these species typified by *Buchia keyserlingi* f. typ. (Pl. XIX, figs. 2A, 2C, and 7A) are similar in this respect to such uppermost Jurassic and Berriasian species as *B. unschensis* s. lato, *B. volgensis* s. lato, and *B. terebratuloides* s. lato. Several other early to late Valanginian buchias figured by Pavlow (1907, Pl. V, figs. 28, 30; Pl. VI, fig. 6) appear to be even more primitive in this respect, as they have feeble to marked right-handed incurvature of left beaks. Such important and widespread mid- to late-Valanginian species as *B. inflata* s. lato (Pavlow, 1907, Pl. VI, figs. 5, 7, 8; this paper, Pl. XVII, figs.

2A, 2D, 3A, 3E, 4A, 4D, 6A, 6E), *Buchia nuciformis* (Pavlow, 1907, Pl. III, fig. 28), and *B. sublaevis* s. lato (Pavlow, 1907, Pl. V, figs. 20-22; this paper, Pl. XVI, figs. 6A, 6B; Pl. XVII, figs. 1A, 1D, 5A, 5D) have, however, acquired the feeble to marked (even pronounced in some rare specimens; *see* Pl. XVII, figs. 3A, 3D) left-handed incurvature resembling that of Berriasian *Buchia* species of the Pacific slope of North America. The study of more numerous, better-preserved, and stratigraphically reliable material of *B. keyserlingi* s. lato may subsequently show that its late Valanginian representatives are characterized by a greater percentage of marked left-handed incurvature of left beaks (Pl. XIX, fig. 5) than the early to mid-Valanginian representatives (Pl. XIX, figs. 2, 7). The little-known Hauterivian and Barremian *Buchia* forms of northern Eurasia (northwestern Germany, England) and the Caucasus appear, conversely, to be less advanced than the most advanced Valanginian representatives of the stock. Some of them (e.g., *Buchia werthi* Pavlow, 1907, Pl. IV, fig. 14 *non* figs. 11-13) even appear to be less advanced morphologically than most of its early to mid-Valanginian representatives.

On the whole, the left beak of the Valanginian *Buchia* species of northern Eurasia, etc., did not quite reach the evolutionary grade of the late Berriasian representatives of *B. uncitoides* s. lato from the Pacific slope of North America.

All indigenous early to mid-Valanginian buchias of the Pacific slope of North America, such as *B. tolmatschowi* s. lato and *B. pacifica* n. sp. are characterized by more advanced, pronounced left-handed incurvature of left beaks (Pl. XIII, figs. 1B, 1C, 3A, 3C, 4A, 4B; Pl. XIV, figs. 1A, 1C; Pl. XV, figs. 11A, 12A; Pl. XVI, figs. 1A, 2A, 2D, 3A, 3C, 4A, 4C, 8A, 8C, 9A, 9D; Pl. XVIII, figs. 2A, 2D; Pl. XIX, fig. 8A; Pl. XXII, fig. 3C). Forms whose left beaks are straight to feebly left-handed incurved are unknown in the material studied and even those with fairly marked left-handed incurvature are rare (Pl. XV, figs. 7A, 7B; Pl. XIX, figs. 6A, 6C). This fourth stage in the evolution of the left beak was apparently already attained in the uppermost Berriasian? overlap beds between *Buchia uncitoides* and *Buchia tolmatschowi* zones. This stage is unique, so far as we know, and rather distinctive. Only the (lesser or greater) admixture of the representatives of Eurasian buchias in some of these Valanginian *Buchia* faunas of the Pacific slope of North America (*see* Pl. XVII, figs. 1-6) may complicate its immediate recognition.

Transitional forms (in the structure of the left beak) connecting the extreme forms of every palaeontological population with each other and the successive palaeontological species with one another abound in the material studied whenever numerous collections from several consecutive levels are available. The evolution of the left beak of *Buchia* must, therefore, have proceeded gradually and without any major evolutionary jumps (Waagen's mutations) throughout.

The evolutionary development of the left beak of the Eurasian and Arctic *Buchia* species is strongly retarded as compared with that of the contemporary buchias of the Pacific slope of North America. This marked discrepancy closely parallels the previously described discrepancy in the evolutionary development of byssus ear, etc., in these same geographically isolated species groups. These observations indicate the existence of at least two independent, geographically restricted evolutionary lineages among the Berriasian and Valanginian buchias of the Northern Hemisphere. These two lineages are designated herewith as the conservative or Arctic and morphologically progressive or North Pacific lineages.

In early Upper Valanginian time the morphologically progressive North Pacific *Buchia* lineage apparently died out with the aberrant, late forms of *B. pacifica* n. sp. (*see* below). So far as we know, it became completely replaced by the short-lived offshoot of the conservative Arctic lineage (*B. crassicollis* Keyserling s. str.). *Buchia crassicollis* s. str. is characterized by the strongly downward bent and coiled but mostly straight left beaks (Pl. XX, figs. 1A, 9A, 10A, 10D; Pl. XXI, figs. 2, 5, 7) and slight to feeble left-handed incurvature of right beaks (Pl. XX, figs. 8B, 11A; Pl. XXI, fig. 6A). Not only are the forms with marked to pronounced left-handed incurvature of left beaks rare in this species but some feebly right-handed-incurved left beaks comparable to those of the second evolutionary stage of beaks have been noted as well (*B. crassicollis* var. *solida,* Pl. XX, figs. 8A-8C). This short-lived offshoot of the conservative Arctic stock apparently died out at or before the end of Valanginian time in both North America and Northern Eurasia.

From this discussion, it is apparent that any stratigraphical-palaeontological study of *Buchia,* and subsequent biochronological appreciation must be based on numerous representative samples of palaeontological populations collected bed by bed in appropriately located continuous fossiliferous sections. Only after this material has been closely studied and critically compared with other data available about *Buchia* forms of the same and other geological regions is it possible to understand the approximate course of evolution of the genus in any region and to recognize safely the successive stages of evolution (that is, palaeontological species; Jeletzky, 1955, pp. 484-91) of its regionally or provincially restricted lineages. Some of the difficulties involved in this research have already been discussed in connection with the description of the course of the evolution of byssus ears and left beaks in *Buchia.*

Because of the regional or provincial restrictions of most of the here-discussed *Buchia* species of the Canadian western Cordillera the zonal sequence proposed below is valid only for that region and some adjacent regions of the Cordilleran belt of the United States (Fig. 2). It cannot be used in northeastern British Columbia and in Canadian Arctic regions, as those regions are characterized by a different sequence of *Buchia* species. The occurrence of mixed *Buchia* faunas and interfingering of *Buchia* zones of these two faunal provinces in the Canadian western Cordillera further complicate the overall zonal picture. A practising palaeontologist-stratigrapher must, therefore, know both *Buchia* lineages even if he is concerned with only one of these two faunal provinces. Enough of the typical representatives of the Arctic *Buchia* species are figured in this report to enable the reader to recognize them.

Even after the palaeontological species of *Buchia* have been defined and their approximate stratigraphical and geographical ranges established, it is often impossible to assign single, atypical or juvenile specimens to them. Smaller or larger suites of specimens, including well-preserved, diagnostic morphological variants or growth stages that are unique in the course of evolution of the genus, may be necessary for the positive identification and dating of fossil collections submitted by field geologists.

Formidable as they sound, the obstacles to the practical use of *Buchia* species as zonal fossils are neither unsurmountable nor unduly restrictive. Buchias are so abundant in most sections that it is fairly easy to collect extensive series of morphologically overlapping palaeontological populations and to recognize the course of their evolution in most instances. This was recognized by many workers (e.g., Sokolov, 1908a-b; Lahusen, 1888; Pompeckj, 1901). After the initial collecting and the study of comprehensive collections are completed and palaeontological species reasonably well defined on a regional basis, it is only the non-availability of representative suites of specimens that may defeat the use of *Buchia* species for dating purposes. Field geologists can, however, easily procure large suites comprising scores or even hundreds of specimens of *Buchia* with but little time and effort. As a rule, a sample of some five to twenty specimens should be sufficient for the positive identification and dating of *Buchia* collections, if it includes well-preserved (including beaks and byssus ears) adult representatives of the forms concerned and/or diagnostic morphological variants and growth stages unique in the course of evolution of the genus. Mapping geologists should earnestly consider this simple prerequisite and collect sizable suites of specimens instead of single fossils as so often was done in the past.

OTHER INDEX FOSSILS AVAILABLE

The use of ammonites, which are unrivalled zonal indices in the Mesozoic rocks in most parts of the world, would certainly result in much less laboriously achieved and closer zoning of the late Upper Jurassic and early Lower Cretaceous rocks of the Canadian western Cordillera. Of the ammonites found in most of the *Buchia* zones proposed here, however, over 90 per cent are representatives of phylloceratids and lytoceratids, which are long-ranging, morphologically indifferent, and consequently difficult to use as zonal fossils. The occurrence of ammonites, other than phylloceratids and lytoceratids, is so sporadic that a geologist mapping in the region concerned simply cannot find enough for precise dating and correlation. Several of the ammonites found by the writer are so rare that their zonal value is still uncertain. Consequently, ammonites can be used only to control the time-ranges of *Buchia* species, and to correlate with the standard ammonite zones of other regions and the international standard stages based on the European ammonite zones. Most of the reasonably well-preserved ammonites (other than phylloceratids and lytoceratids) collected to date are figured here. Other biochronologically valuable groups of fossils, such as belemnites, and trigonias, are even rarer than the ammonites. Belemnites are invariably poorly preserved, being softer than the enclosing sedimentary or volcanic rocks.

All other groups of macrofossils found in the late Upper Jurassic and early Lower Cretaceous rocks of the Canadian western Cordilleran region are either too long-ranging or too facies-bound, or both, to be useful as zonal indices.

PROPOSED FOSSIL ZONES

Late Upper Jurassic

Buchia cf. blanfordiana Zone

Stratigraphy and Age

The *Buchia* cf. *blanfordiana* zone is the youngest Jurassic zone known in the region. On the west coast of Vancouver Island, where its stratigraphic position with regard to other fossil zones has been established (Jeletzky, 1950, pp. 33-34), this zone gradationally overlies rocks characterized by the early forms of *Buchia piochii* var. *russiensis* (Pavlow), var. *mniovnikensis* (Pavlow) and allied forms. These are similar to the better-preserved Arctic representatives of these variants shown in Plate I, figures 3-6, 9. Early representatives of *B. piochii* s. str. occur rarely in these beds and no typical or late representatives, such as abound in the late Tithonian rocks of California, have been seen. The rocks with early representatives of *B. piochii* var. *russiensis* and its allies, in turn, gradationally overlie strata characterized by the late (Portlandian only?) forms of *Buchia mosquensis* (Buch), *B. m.* var. *gracilis* (Pavlow), *B. m.* var. *rouillieri* (Pavlow), etc.

On the west coast of Vancouver Island *Buchia* cf. *blanfordiana* zone is overlain disconformably, and possibly with regional unconformity, by the *Buchia okensis* zone (Jeletzky, 1950, pp. 35, 42).

So far as known, *Buchia* cf. *blanfordiana* zone occurs in the Lillooet and Bridge River areas, in the lower (Jurassic) part of the Eldorado Group above the beds with *B. mosquensis* (Buch) and those with the early forms of *B. piochii* var. *russiensis.* The same is probably true in Alaska and also in the Nooksack area in Washington where *Buchia* cf. *blanfordiana* zone occurs at several localities.

The beds with the early forms of *B. p.* var. *russiensis* (Pavlow), etc. of the west coast of Vancouver Island are believed to be of late, but not the latest, Portlandian age. They appear to be either slightly older than or equivalent to the basal beds of *Buchia piochii* zone of California and Alaska. The stratigraphic position of the *Buchia* cf. *blanfordiana* zone indicates that it is either of latest Portlandian (s. str.) or of Upper Tithonian (= Purbeckian) age in terms of the international standard stages (Arkell, 1956). *Buchia* cf. *blanfordiana* zone corresponds, thus, either to the *Buchia piochii* zone or to the *Buchia fischeriana* zone of the adjacent regions of North America (Jeletzky, 1958, 1960; Imlay, 1959).

In the Nooksack area, Washington (U. of Cal., Berkeley, loc. #A-7902) *Buchia* cf. *blanfordiana* is associated with *Buchia* cf. *mosquensis* (Buch) and early forms of *B. fischeriana* comparable to those figured by Pavlow (1907, Pl. IV, figs. 15-16) from the *Virgatites virgatus* zone of the Lower Volgian. This association favours a late Portlandian age for part or all of the *Buchia* cf. *blanfordiana* zone. This conclusion is also supported by a recent early Tithonian dating of *Buchia plicata* zone in New Zealand (Fleming, 1960, pp. 265, 268, Table 1) as *B. plicata* is either closely allied or conspecific with both the Himalayan *B. blanfordiana* and the Canadian *Buchia* cf. *blanfordiana*. The general evolutionary grade of *Buchia* cf. *blanfordiana* corresponds to that of the Portlandian *Buchia* species.

The writer favours latest Portlandian (s. str.) age of *Buchia* cf. *blanfordiana* zone and assumes tentatively that it corresponds only to the lower part of *Buchia piochii* zone of the adjacent regions of North America (Fig. 1). It would seem that in the Canadian western Cordillera the upper half of *Buchia piochii* zone and all of *Buchia fischeriana* zone are missing and are represented only by the erosional gap between *Buchia* cf. *blanfordiana* and *Buchia okensis* zones (Fig. 1).

Palaeontology

A representative suite of specimens of *B.* cf. *blanfordiana* is shown in Plates II and III. *B. fischeriana* var. associated with *B.* cf. *blanfordiana* in the Nooksack area, Washington, is reproduced in Plate III, figures 2 and 3. The belemnite *Cylindroteuthis* aff. *C. obeliscoides* Pavlow and Lamplough, a poor berriasellid ammonite resembling *Substeueroceras stantoni* Anderson, 1945, and a poor oppelioid ammonite resembling *Gymnodiscoceras* Spath, 1925, all from the *Buchia* cf. *blanfordiana* zone on the west coast of Vancouver Island, are reproduced in Plate II, figures 5, 8, 9.

Buchia cf. *blanfordiana* is a large, thick, pronouncedly inequivalve shell. The right valve mostly is irregularly rounded, and is flat (Pl. II, figs. 3C, 6C) to gently convex (Pl. II, fig. 7D; Pl. III, figs. 5B, 8C) in anterior-posterior aspect. The convex valves tend to become gradually and weakly elevated towards the beak, which is small, rounded and only slightly elevated above the surface of the valve (Pl. III, figs. 5B, 8B-C). The cross-section of the right valve is often more or less markedly convex when viewed from above (Pl. II, figs. 3C, 6C), the crest of the longitudinal bulge being predominantly in or close to the middle of the valve.

The byssus ear and other parts of the right ligamental plate of *Buchia* cf. *blanfordiana* (Stoliczka) have the general evolutionary grade of the late (or typical) forms of *B. mosquensis* s. lato and allied mid- to late-Portlandian (s. str.) and Upper Tithonian species (Pl. II, figs. 4B, 7B; Pl. III, figs. 5B, 7B; Pl. XXII, figs. 2B, 2E). The anterior surface of the byssus ear forms an angle of 25 to 40 degrees with the plane of contact of the valves and its underside is distinctly spoon-like. The 'spoon' is, however, rather shallow and the anterior end of the groove is only partly blocked in most specimens studied. Surface of the ligamental plate is tilted inward at some 30 to 40 degrees. The byssus notch is similar to that of *B.*

piochii s. lato and late forms of *B. mosquensis* s. lato in the relative length and width of its open slit.

Byssus ear differs from that of *B. piochii* s. lato in being considerably longer, markedly curved upward and distinctly triangular (Pl. II, fig. 7B; Pl. III, figs. 5B, 7B; Pl. XXII, fig. 2A). Its external appearance is, therefore, more similar to that of the early Portlandian (i.e., late or typical) forms of *B. mosquensis* (Buch) than to that of *B. piochii* s. lato. Furthermore, the byssus ear and other parts of the right ligamental plate of *B.* cf. *blanfordiana* are peculiar in being rather large and massive in comparison with the corresponding features of *B. mosquensis* (Buch) and *B. piochii* (Gabb).

The left valve is thick and more or less regularly and pronouncedly arched in anterior-posterior aspect with the maximum thickness at the middle part of the valve (Pl. II, figs, 2B, 3C, 4C, 6C, 7C-D; Pl. III, figs. 4B, 5C, 6B, 8C). Beak part of left valve is commonly long and more or less tightly coiled. It is also always right-handedly incurved (Pl. II, figs. 2A, 3A, 6A, 7A; Pl. III, figs. 4A, 5A, 6A, 8A). This feature is diagnostic of all representatives of *Buchia mosquensis* (Buch) species group; it indicates that *B.* cf. *blanfordiana* forms part of the oldest evolutionary stage of buchia's beaks.

The sculpture of the shell varies greatly in *Buchia* cf. *blanfordiana.* In one extreme variant the shell surface is covered by coarsely and widely spaced ribs resembling those of *B. mosquensis* var. *rugosa* (Fischer) and *B. okensis* (Pavlow) (Pl. II, figs. 2A-B; Pl. III, figs. 5A-C). This variant was previously compared with *B. m.* var. *rugosa* by the writer (Jeletzky, 1950, p. 34); it differs, however, from this form (Pl. II, figs. 1A-1C) in being considerably larger, thicker and stronger arched. The beak part of this extreme variant of *B.* cf. *blanfordiana* is longer, more tightly coiled and often more irregularly twisted than that of *B. m.* var. *rugosa.* The same features also differentiate this variant from *B. mosquensis* var. typ. and allied Portlandian forms (e.g., *B. m.* var. *gracilis* Pavlow, *B. m.* var. *rouillieri* Pavlow).

Some of the coarsely and distantly ribbed representatives of *B.* cf. *blanfordiana* (Pl. II, figs. 2A, B) are similar to the younger *B. okensis* in general shape, thickness and ribbing habit (Pl. V, figs. 6A, B; Pl. X, fig. 2). The beak part of these representatives is, however, invariably longer, more tightly coiled, and has stronger right-handed incurvature than that of *B. okensis.*

Another morphologically extreme variant of *B.* cf. *blanfordiana* is characterized either by the closely spaced, finer ribbing (Pl. III, figs. 4A, B) or by the irregular fine striation (Pl. II, figs. 3A-C, 6A-C) of the shell's surface. Some stronger ribs and constrictions resembling those of *B. crassicollis* s. str. may also be present (Pl. II, fig. 6A). This variant is analogous to *B. mosquensis* (Buch) f. typ.; it differs from it in the same features as does the coarsely ribbed variant of *B.* cf. *blanfordiana* from *B. mosquensis* var. *rugosa.*

Left valves of some representatives of the closely ribbed or striated variant of *B.* cf. *blanfordiana* have less marked right-handed-incurved, pear-shaped outline (Pl. II, figs. 4A-C; Pl. III, figs. 6A, B) and resemble *B. tolmatschowi* var. *americana* (Sokolov) and *B. crassicollis* s. str.; they differ, however, from these Valanginian species in the still perceptible right-handed curvature of the beak part of the left valve, in the general flatness of the irregularly rounded right valve, and in the lower evolutionary grade of byssus ear and other parts of the right ligamental plate.

A typical representative of *B. mosquensis* var. *rugosa* from the Lower Volgian (= Portlandian s. str.) of Central Russia is reproduced in Plate II, figures 1A-C to illustrate the above discussed morphological differences between *B. mosquensis* s. lato and *B.* cf. *blanfordiana.*

The morphological features that distinguish *B.* cf. *blanfordiana* from its late Kimmeridgian to Portlandian predecessors and Valanginian homoeomorphs are important as its rare Californian? and Alaskan representatives have possibly been confused either with the older *B. mosquensis* var. *rugosa* (Anderson, 1945, Pl. IV, fig. 12; Pl. XII, fig. 3); (Imlay, 1957, p. 85), or with the younger *B. crassicollis* s. lato (Moffit, 1938, Pl. 10, figs. 4-5).

The Canadian *B.* cf. *blanfordiana* is either closely related to or specifically identical with the following Indo-Pacific *Buchia* species: *B. blanfordiana* (Stoliczka, 1866) from the Spiti shales of India, *B. plicata* (Zittel, 1864) from New Zealand, and *B. subpallasi* (Krumbeck, 1938) from Indonesia (compare in Fleming, 1958, 1959). The writer is unable to see any significant morphological distinctions between the Canadian form and any of the above-mentioned Indo-Pacific forms. Nor is he able to point out any significant morphological distinctions between these Indo-Pacific forms, and all three may well be conspecific. However, the Indo-Pacific workers, such as Fleming (1958, 1959), are still uncertain about the taxonomic relationships of local representatives of this species group. Such doubts together with the great variability of the Indo-Pacific forms and the scarcity of well-preserved comparative material available to the writer make it advisable to postpone final decision on the naming of the Canadian form and it is therefore only compared with *Buchia blanfordiana* (Stoliczka, 1866).

A well-preserved extreme variant of *Buchia plicata* (Zittel, 1864) from the lower Tithonian rocks of New Zealand is reproduced in Plate III, figures 9A-C to illustrate the degree of morphological similarity between the Canadian *Buchia* cf. *blanfordiana* and its Indo-Pacific allies.

Early Lower Cretaceous

Buchia okensis Zone

Stratigraphy and Age

This important zone, here placed in the basal Cretaceous, is widespread in the Northern Hemisphere from Central Russia to the Canadian western Cordillera and possibly (Pavlow, 1907, Pl. I, fig. 10) to California.

In the Canadian western Cordillera, *Buchia okensis* zone occurs on the west coast of Vancouver Island (Jeletzky, 1950, pp. 39, 42-43) and also in the Harrison Lake area where it was named *Aucella cascadensis* zone by Crickmay (1930a, b). *A. cascadensis* Crickmay, 1930 and *A. canadiana* Crickmay, 1930 are, however, conspecific with *Buchia okensis* s. lato as used in this report.

Only non-diagnostic *Lytoceras* sp. indet. has been found in the *Buchia okensis* zone in the Canadian western Cordillera. Lower Berriasian (= Infravalanginian) ammonites have been found in this zone elsewhere in North America (Jeletzky, 1960, p. 4) and in northern Eurasia (Bogoslovsky, 1897). *Buchia okensis* zone can, therefore, be correlated with the boreal Ryasanian beds (*Berriasella rjasanensis* zone only?) and with the Tethyan *Berriasella callisto* zone (Fig. 1). It should be noted that the lower part of the Ryasanian where *Buchia okensis* and *Berriasella (Riasanites) rjasanensis* occur is often placed in the latest Jurassic (e.g., Arkell, 1956, pp. 492-3; Casey, 1962, p. 96, text-fig. 1). However, the writer (1961b) considers all the Ryasanian beds to be of basal Cretaceous age and interprets them as a condensed deposit containing faunal mixture of at least two early Berriasian zones of the boreal province and southwestern Europe (Fig. 1).

The correlation of *Buchia okensis* zone with part or all of *Paracraspedites undatus* and *Paracraspedites stenomphaloides* zones of Great Britain (Fig. 1) is offered as a tentative suggestion only. The generally accepted correlation of these zones with the upper part of Ryasanian beds has been recently challenged by Casey (1962), who correlates them respectively with the Upper Portlandian and early Upper Volgian stages of the international standard. Thus Casey (op. cit., pp. 97-98) revives the latest Jurassic dating for the lower part of Spilsby Sandstone as originally proposed by Pavlow (1892).

The writer's unpublished study of suture lines of the ammonites described and figured under the names of *Paracraspedites* and *Subcraspedites* by Swinnerton (1935) from the basement beds of Spilsby Sandstone seems to support the opinion of Casey. None of these ammonites is, indeed, congeneric with the subcraspeditids figured by Russian workers from the Ryasanian beds. The same is true of all Berriasian subcraspeditids from Arctic Canada. Unlike the suture lines of all Berriasian subcraspeditids from Central Russia and Arctic Canada known to the writer, the suture lines of all British *"Subcraspedites"* and *Paracraspedites* figured by Swinnerton (1935, Pl. II, figs. 1B, 1C, 2B, 3B; Pl. III, figs. 2B, 4C; Pl. IV, figs. 1B, 4A) are not ascendant but pronouncedly suspensive towards the umbilicus, and have fewer auxiliary lobes. These sutures are closely similar to those of the Upper Volgian craspeditids or to those of the Portlandian s. str. to Upper Volgian perisphinctids (e.g., *Dorsoplanites, Laugeites,* etc.). The writer cannot, however, endorse the Jurassic dating of the basement beds of the Spilsby Sandstone until it is documented by a detailed description of stratigraphy and palaeontology of all ammonites concerned. These *"Subcraspedites"* and *Paracraspedites* from the basement beds of Spilsby Sandstone could be unrelated earliest Berriasian survivors of Upper Volgian craspeditids or perisphinctids; or they could have been reworked from the uppermost Jurassic beds into the basement beds, as already assumed by Spath (1947, p. 64).

Other claims made by Casey (1962, p. 98) appear to be more doubtful. There seems, for example, to be no valid reason to state categorically that *Ammonites plicomphalus* J. Sowerby 1822 is a latest Jurassic *Craspedites* s. str. close to *C. nodiger.* The writer has studied carefully the relevant literature and plaster casts of both *Subcraspedites plicomphalus* (J. Sowerby, 1822) and *Subcraspedites sowerbyi* Spath (= *A. plicomphalus* J. de C. Sowerby, 1823) and found these two specimens to be too poorly preserved for generic assignment without careful study of their suture lines, which apparently have never been illustrated. There is no reason to think that Casey's (loc. cit.) generic and specific assignment of *A. plicomphalus* J. Sowerby 1822 is based on the suture line, as he does not say a word about it. There are, however, rather strong stratigraphic reasons to think that these two specimens, which have been found at the same locality and are probably conspecific, are of basal Cretaceous and not of the uppermost Jurassic age. Casey states that the horizon of *Ammonites plicomphalus* J. Sowerby 1822 "at Old Bolingbroke, Lincolnshire is thought to be some thirty feet above the base of the sandstone." This statement is in good agreement with that of Neale (1962, p. 291) that "In Lincolnshire *T. stenomphala* is recorded from the Upper Spilsby Sandstone together with *S. plicomphalus* and *S. sowerbyi* . . . Mr. C. W. Wright has recorded the *T. stenomphala* fauna between 20 and 30 feet above the fauna characteristic of Swinnerton's bed D (Donovan, 1957, pp. 145-6)". It is, however, incompatible with Casey's own statement (1962, p. 97) that the records of: *"S. sowerbyi* Spath and *"S." plicomphalus* (J. Sowerby) in association with *"S." stenomphalus* (Pavlow) in the upper part (Spath 1952, Wright *in* Donovan 1957) are not confirmed." The upper part of Spilsby Sandstone is known to carry typical *Buchia volgensis* (Lahusen) a species generally diagnostic of the basal Cretaceous rocks throughout the boreal province (Figs. 1-2). Good figures and descriptions of Pavlow (1896, pp. 549-50, Pl. XXVII, figs. 1, 2) and Woods (1905, pp. 69-70, Pl. X, figs. 1, 2) seem to leave little doubt about the correctness of its specific identification. In Arctic Canada craspeditid forms closely similar externally to *Subcraspedites plicomphalus* and *Subcraspedites sowerbyi* (e.g. *Subcraspedites* aff. *suprasubditus* Bogoslovsky) are known only from the basal Cretaceous zone of *Buchia okensis.*

The validity of Casey's (1962, pp. 96-97) Jurassic dating of *Subcraspedites* Spath 1924 is questionable in view of the probable Berriasian age of *Ammonites plicomphalus* J. Sowerby 1822 and *A. plicomphalus* J. de C. Sowerby 1823. As every genus is based on its type species alone, the nature and age of all craspeditid ammonites described and figured by Pavlow (1892), Swinnerton (1935), and Neale (1962) from the Spilsby Sandstone and Speeton Clay has no bearing on the age and status of *Subcraspedites* unless these ammonites should happen to be contemporary with *A. plicomphalus* of both Sowerbys. This is obviously not so, despite Casey's statement to the contrary, and the evidence available definitely favours the early Berriasian age of *A. stenomphalus* beds at Old Bolingbroke, Lincolnshire. Only the age and taxonomic position of the genus *Paracraspedites* Swinnerton 1935 would, therefore, have to be revised if Casey's late Portlandian s. str. to Upper Volgian dating of basal beds of Spilsby Sandstone is valid, as it may well be. Until this matter is definitely settled by its description, the poorly preserved type of *Subcraspedites* (*Ammonites plicomphalus* J. Sowerby 1822) is assumed to be contemporary and congeneric with the Russian *Subcraspedites* of the Ryasanian beds rather than with the ammonites described and figured under that name by Swinnerton (1935). This means that for all practical purposes the subgenus *Subcraspedites* Spath 1924 has to be interpreted for the time being by its well-described and figured Russian representatives from the Ryasanian beds of Russia and their equivalents.

The facies tolerance and geographical range of *Buchia okensis* s. lato are remarkable. This species abounds without noticeable morphological changes in every possible kind of earliest Cretaceous marine sediment from pure clay shales to coarse conglomerates. Even the infraspecific variation of *B. okensis* remains the same in population samples obtained from these contrasting facies. No geographical subspecies have been noted from middle Russia to the Canadian western Cordillera. Considering its short and constant time-range throughout its realm, *Buchia okensis* is just as reliable an index fossil as are the best of zonal ammonites.

Palaeontology

A representative suite of specimens of *Buchia okensis* s. lato illustrating the range of infraspecific variation found in our region is shown on Plates IV to X and XXII. Plate IV shows the typical forms and extreme variants from the basal beds of *Buchia okensis* zone, Plate V shows those from its middle part, and Plates VI and XXII those from the top part of the zone. The typical forms and extreme variants from the lower to middle parts of the overlap beds between it and the *Buchia uncitoides* zone are shown in Plates VII and XXII, and those from the top part of the overlap beds are shown in Plates VIII and IX. The rare representatives of the species occurring in higher beds are entirely similar to those shown in Plates VII to IX.

The typical form of *B. okensis* has been figured by Crickmay (1930a, Pl. X, figs. 1-2) under the name *Aucella cascadensis*. The holotype of *A. cascadensis* is, however, indistinguishable from the left valve of the Russian representative of the species figured by Pavlow (1907, Pl. I, fig. 11A); it is refigured here in Plate X, figure 2.

Pavlow's (1907, Pl. I, fig. 11A-C) Russian specimen of *B. okensis* from the *Tollia (Subcraspedites) spasskensis* zone of middle Russia is herewith selected as the lectotype of the species. So far as its size and ribbing habit are concerned, this specimen is near the middle of the variation series of *B. okensis*. Such forms are rare in the lower and middle parts of *Buchia okensis* zone of our region and not plentiful in its upper part and overlap beds. Crickmay's (1930a, Pl. X, figs. 1-2) representatives of *B. okensis* f. typ. were probably collected either in the upper part of *Buchia okensis* zone or in the overlap beds with *Buchia uncitoides* zone.

Aucella canadiana Crickmay (1930a, Pl. X, figs. 3-5) is but an extreme morphological variant of *B. okensis* s. lato characterized by much coarser and wider spaced, fold-like concentric ribs. As shown in Plates IV to VIII and XXII, *B. okensis* var. *canadiana* has the same time range as other morphological variants of the species and is connected with them by innumerable transitional forms at all levels. The specimen of *B. okensis* from the Knoxville beds of California figured by Pavlow (1907, Pl. I, fig. 10) appears to be transitional between *B. okensis* f. typ. and var. *canadiana.*

As understood in this report, *B. okensis* s. lato includes not only *B. cascadensis* and *B. canadiana* but also such Eurasian forms as *B. spasskensis* (Pavlow, 1907, Pl. IV, fig. 20; Gerassimov, 1955, Pl. XIII, figs. 9, 10), *B. subokensis* (Pavlow, 1907, Pl. I, fig. 17) and *B. elliptica* (ibid., Pl. I, fig. 28). Of these forms *B. spasskensis* is synonymous with *B. subokensis* on infraspecific level and this name is not used. *B. elliptica* is, however, a distinctive morphological variant characterized by its angular outline. *B. okensis* var. *subokensis* and var. *elliptica* are both characterized by finer and more closely spaced concentric ribbing than *B. okensis* f. typ. So far as the ribbing habit is concerned, they are on the opposite end of the variation series from *B. okensis* var. *canadiana.* Although their ribbing habit is primitive and similar to that of *B. fischeriana* s. lato, *B. okensis* var. *subokensis* and var. *elliptica* have about the same time range as the morphologically more advanced variants of the species (Pl. VI, fig. 3; Pl. VII, figs. 4, 6, 7; Pl. XXII, fig. 4); they intergrade with *B. uncitoides* var. *spasskensoides* (Pl. VIII, figs. 8, 12, etc.) in the overlap beds and are connected with *B. okensis* f. typ. by innumerable transitional forms at all levels.

Contrary to the widespread belief, the shape of the shell of *B. okensis* s. lato is extremely variable. In our material it ranges from angular-subquadrate or trapeze-like in *B. okensis* var. *elliptica* (Pl. V, fig. 8) to a regularly pear-shaped one in its unnamed '*B. volgensis*-like' variant (Pl. V, fig. 5). Long subtriangular forms (Pl. VII, fig. 1; Pl. VI, fig. 8) closely resembling some large representatives of *B. uncitoides* s. lato are also common. The pear-shaped and long, subtriangular left and right valves can only be distinguished from those of *B. volgensis* (Lahusen) (Pl. X, figs. 4, 5) and *B. uncitoides* s. lato (Pl. VIII, figs. 10, 11) by their coarser and wider spaced ribbing habit.

Despite its great variability in shape, *B. okensis* s. lato is easily recognizable because of its large to giant size combined with the uniquely coarse and widely spaced concentric ornament. Additional distinguishing features include the excess of width over height in most representatives, great convexity and considerable thickness of the left valve as opposed to the much thinner to almost flat right valve (Pl. V, figs. 7, 10; Pl. X, fig. 7), an unusually large and angular posterior ear in both valves, feeble but regular downward curvature and the absence of coiling of the left beak, which lacks the abrupt, hook-like bend of *B. volgensis* (Pl. X, fig. 4B) left beak.

The characteristic appearance, evolutionary grade, and infraspecific variation of the byssus ear and the left beak of *B. okensis* s. lato have already been described in connection with the discussion of the irreversible orthogenetic trends in *Buchia*.

The excess of width over height, the well-defined, large and angular ear, the markedly posteriorly oblique shape of the shell, and the almost flat to gently convex right valve distinguish *B. okensis* s. lato from certain variants of *Buchia pacifica* n. sp. (Pl. XVI, figs. 4, 9; Pl. XIX, figs. 3, 6, 8) and *B. keyserlingi* s. lato (Pl. X, fig. 1; Pl. XIX, figs. 5, 7), which may acquire coarse and distant ribbing habit closely similar to that of *B. okensis* f. typ. and var. *subokensis*. *B. pacifica* n. sp. has, furthermore, pronounced left-handed incurvature of left beaks.

Larger size, more distant and coarser ribbing, well-defined, large and angular posterior ear, predominantly straight to feebly left-handed incurvature of left beak, and the greater thickness of the left valve distinguish *B. okensis* s. lato from its apparent ancestor *B. fischeriana* (d'Orbigny, 1845) s. lato. Some halfgrown or medium-sized representatives of *B. okensis* var. *subokensis* (Pl. IV, figs. 5, 9; Pl. VI, fig. 3; Pl. VII, figs. 6, 7) and transitional forms between this variant and *B. uncitoides* var. *spasskensoides* (Pl. VIII, fig. 8), which have left beaks feebly incurved to right may, however, be hard to distinguish from large representatives of *B. fischeriana* s. lato if they are found alone.

Apparently continuous sections bridging the Jurassic-Cretaceous boundary occur in several areas of Arctic Canada (Fig. 2), and *Buchia* faunas of these sections are still being studied. The results already obtained suggest that *B. okensis-uncitoides* stock descended from the late Upper Tithonian *B. fischeriana-piochii-terebratuloides* species group (all three forms may possibly be conspecific) native to that region. The transitional faunas between these two species groups seem to be absent in Arctic Canada. So far as known, the giant forms of *B. okensis* appear suddenly in the basal Berriasian beds of that region and *B. uncitoides* s. lato is not known to be associated with them there. This suggests that the transmutation of *B. fischeriana-piochii-terebratuloides* species group into the *B. okensis-uncitoides* species group occurred either in Northern Eurasia or in the western Cordillera of North America. The former hypothesis is favoured here (Fig. 3).

In the Canadian western Cordillera the Upper Tithonian rocks are unknown (Fig. 1) and the basal beds of *Buchia okensis* zone may be absent also, as its oldest known representatives seem to be more advanced morphologically than those occurring in the mixed faunas of California.

On the west coast of Vancouver Island numerous representatives of *B. okensis* s. lato (Pl. IV, figs. 3, 8, 12, 15, 19, 23) appear suddenly at the base of the Cretaceous rocks. It is the dominant *Buchia* form in these rocks. In these and slightly younger beds comprising the lower part of *Buchia okensis* zone, *B. okensis* s. lato is associated with scarcer buchias transitional to *B. fischeriana* s. lato (Pl. IV, fig. 14), *B. terebratuloides* s. lato (Pl. IV, fig. 17), and *B. uncitoides* s. lato (Pl. IV, fig. 16). Representatives of *B. uncitoides* s. lato (Pl. IV, figs. 2, 7, 13) are also fairly common in these beds. Numerous transitional forms connect all these *Buchia* forms. Except for lack of the giant forms of *B. okensis* s. lato, which are so common in the middle and upper part of its zone (*see* Pls. V-VIII, XXII), these earliest known palaeontological populations of the species include all its known morphological variants.

In the Harrison Lake area the basal 240 feet of the Peninsula Formation (Fig. 4) is unfossiliferous except for a few belemnoid remains (Crickmay, 1962, p. 7). Its younger beds contain giant *B. okensis* forms diagnostic of the middle or upper part of *Buchia okensis* zone. All of the isolated collections of *B. okensis* s. lato available from other areas of the Canadian western Cordillera and adjacent part of the State of Washington appear to be referable to the middle or upper part of *Buchia okensis* zone.

In the Canadian western Cordillera *B. uncitoides* s. lato not only appears simultaneously with *B. okensis* s. lato but occurs throughout its zone. The ratio of these two species may vary strongly and irregularly from one bed to the other within *Buchia okensis* zone, but *B. okensis* s. lato is more numerous than *B. uncitoides* in most beds. Higher up *B. okensis* s. lato gradually becomes less numerous until both species become about equally common. Still higher up in the sections the percentage of *B. okensis* s. lato diminishes fast while that of *B. uncitoides* s. lato increases equally fast. Above this level *B. uncitoides* s. lato becomes the dominant species comprising from 75 to 95 per cent of the palaeontological populations of *Buchia* in all beds underlying *Buchia tolmatschowi* zone. Only single to rare representatives of *B. okensis* s. lato occur in the upper two thirds of these beds and none was seen in the transitional beds to *Buchia tolmatschowi* zone.

The zone of *Buchia okensis* proper can be defined as those beds where this species predominates over *B. uncitoides* s. lato, often comprising 60 to 90 per cent of *Buchia* populations. These beds are about 50 feet thick on the west coast of Vancouver Island, but seem to be much thicker in the Harrison Lake area and elsewhere on the mainland of British Columbia. The next younger beds where *B. okensis* s. lato and *B. uncitoides* s. lato are about equally numerous are designated the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones; they are about 105 feet thick on the west coast of Vancouver Island. The overlap beds are recognizable as an independent subzone whenever larger fossil samples are available; they are, however, treated as the upper part of *Buchia okensis* zone in Figures 1 to 4. The beds where *B. uncitoides* s. lato strongly predominate can be defined as *Buchia uncitoides* zone; they are about 270 feet thick on the west coast of Vancouver Island.

B. okensis s. lato and *B. uncitoides* s. lato are connected by uninterrupted series of transitional forms at all levels and so cannot be sharply separated in our region (Fig. 3). In the Canadian western Cordillera, therefore, *B. okensis* s. lato appears to be no more than an extremely distinctive morphologically but transient evolutionary phase of the North Pacific *Buchia* lineage; it dominates this lineage for a short while developing a host of huge and morphologically extreme forms only to disappear again into less distinctive but longer lasting *B. uncitoides* s. lato. *B. okensis* s. lato is, thus, a typical example of the reversible, quantitative morphological shift in the sense of Jeletzky (1955, pp. 484-86) so far as the evolutionary centre of the North Pacific *Buchia* lineage (that is the Canadian western Cordillera) is concerned. There would be no valid reason to separate *B. okensis* s. lato specifically from *B. uncitoides* s. lato were the former confined to the Canadian western Cordillera. *B. okensis* s. lato is, however, common throughout the Canadian Arctic, European Arctic and Northern Eurasia and seems to be a distinctive and sharply limited, cryptogenic species throughout this vast province (Fig. 3). For that reason, and because of its outstanding biochronological value, it is treated as an independent species in this report.

Buchia uncitoides Zone

Stratigraphy

The best known sections of *Buchia uncitoides* zone have been measured on the west coast of Vancouver Island where it overlies gradationally *Buchia okensis* zone. In that area *Buchia uncitoides* fauna has been referred to as *Aucella* ex gr. *terebratuloides* fauna (Jeletzky, 1950, p. 40).

In the Harrison Lake area *Buchia uncitoides* fauna occurs in the same stratigraphic position as on the west coast of Vancouver Island. There *B. uncitoides* has been, however, described under the names of *Aucella acuticostata, A. catamorpha,* and *A. spasskensoides* by Crickmay (1930a, pp. 46-47, Pl. 9, figs. 2-4). The zonal value of *B. uncitoides* was not recognized by Crickmay (1930a), probably because of the occurrence of overlap beds between this zone and *Buchia okensis* zone. *Buchia uncitoides* fauna is also known from the lower part of the Eldorado Group in the Lillooet and Bridge River map-areas, in the Princeton map-area, and in several other areas of the Canadian western Cordillera.

In California, *B. uncitoides* is known to occur in the basal beds of the Paskenta Formation (Anderson, 1938, p. 105). Anderson's (1938, pp. 106-107, Pl. 8, figs. 8-9) *Aucella lahuseni* from these beds represents, furthermore, an extreme variant of *B. uncitoides* transitional to *B. tolmatschowi* s. lato.

In California *'Aucella crassicollis',* as used by Imlay (1959, p. 163, 1960), appears to be a comprehensive, long-ranging species that amalgamates our *B. uncitoides* s. lato with several younger species of the same lineage. The Canadian zone of *B. uncitoides* probably corresponds with the lower part of Imlay's (1960, pp. 171-2) *Kilianella crassiplicata* zone, in part at least (fig. 2).

On the western slope of the Richardson Mountains *Buchia uncitoides* zone occurs between *Buchia okensis* and *Buchia volgensis* zones (Jeletzky, 1961a).

Elsewhere in the Richardson Mountains it was only doubtfully recorded in the same stratigraphic position. It is not known to occur in any other area of Arctic Canada or in Alaska.

Palaeontology

A representative suite of *B. uncitoides* s. lato illustrating the range of infraspecific variation found in our region is shown in Plates IV to XI. Most of the specimens figured are from the same measured section on the west coast of Vancouver Island.

Plate IV shows the earliest known forms of the species occurring in the lower and middle part of *Buchia okensis* zone. Plate V, figure 1 shows the rare, large representatives from the middle part of the same zone. These are transitional between the '*B. volgensis*-like' variant of *B. okensis* shown in Plate V, figure 5, and *B. uncitoides* var. *spasskensoides*. Plate VI shows the rare but fairly typical representatives of the feebly sculptured variant of the species from the upper part of *Buchia okensis* zone. Similar forms also occur in its middle part. Plate VII shows the more prolific and variable forms of *B. uncitoides* s. lato from the upper part of *Buchia okensis* zone and the lower and middle parts of the overlap beds, and Plates VIII and IX show an even more prolific and variable assemblage from the top part of the same beds. The latter assemblage includes most of the morphological variants characteristic of the overlying *Buchia uncitoides* zone proper. This made it possible to limit the illustrations of the latter assemblage to a few aberrant or otherwise interesting forms; these are shown in Plates X and XI. In addition to the representatives of some figured specimens of Crickmay (1930a) shown in Plate X, figures 6, 12, 13, this suite includes a complete shell of *B. uncitoides* f. typ. (Pl. X, fig. 8) identical with *Aucella acutistriata* Crickmay 1930 and that of a transitional form between the former variant and *Aucella catamorpha* Crickmay, 1930 (Pl. X, fig. 9). Another feebly sculptured to semi-smooth form closely approaching *A. catamorpha* is shown in Plate XI, figure 8. Also shown are three broader and flatter left valves (Pl. X, figs. 3, 10, 11) indistinguishable from the *A. spasskensoides* Crickmay, 1930, and an extremely narrow and high-arched, coarsely ribbed variant whose beaks have pronounced left-handed incurvature (fig. 14). The latter variant is transitional to *B. tolmatschowi* s. lato.

The name *Buchia uncitoides* was introduced by Pavlow (1907, p. 61, Pl. V, figs. 14, 15) for angular and long *Buchia* forms otherwise similar to *B. terebratuloides* (Lahusen). All his specimens were from '*Tollia stenomphala*' beds of the European Russia and '*Polyptychites*' beds of the eastern slope of Northern Urals. This species can, however, be better interpreted from the excellent figures of Sokolov (1908b, Pl. I, figs. 10-13 *non* 14), which clearly show the characteristic morphology of its byssus ear, shape of both valves, variation of ornament from relatively heavy and widely spaced ribbing to fine striation, etc. Sokolov's specimens are from *Tollia stenomphala* beds of the European Russia and apparently equivalent beds of Eastern Siberia.

As already mentioned, Crickmay's (1930a, Pl. IX, fig. 2) *Aucella acutistriata* is the junior synonym of the typical form of *B. uncitoides* s. lato (*see* Pavlow, 1907, Pl. V, figs. 14, 15; Sokolov, 1908b, Pl. I, fig. 10). His *A. spasskensoides* (op. cit., Pl. IX, figs. 3, 4; this paper, Pl. X, figs. 6, 13) is an extreme variant of the same species characterized by the coarser and wider spaced concentric ribs; it is closely similar to the specimen shown in Sokolov's paper (1908b, Pl. I, fig. 11) but includes larger forms with even wider spaced and coarser concentric ribs, which are transitional to *B. okensis* var. *subokensis*. The close affinity of *A. spasskensoides* with the last-mentioned form was clearly perceived by Crickmay (1930a, p. 47) and is reflected in the name given to this variant of *B. uncitoides* s. lato. As already mentioned, *B. uncitoides* var. *spasskensoides* and *B. okensis* var. *subokensis* (= *B. spasskensis* Pavlow) are connected by an uninterrupted series of transitional forms in the overlap beds of the west coast of Vancouver Island. Crickmay's (1930a, Pl. IX, fig. 3) holotype of the variant is one of these forms; its unfigured left valve is closely similar to those shown in Plate VIII, figures 7, 9. *A. catamorpha* (op. cit., Pl. IX, fig. 5) is indistinguishable from the finely striated right valve of *B. uncitoides* s. lato figured by Sokolov (1908b, Pl. I, figs. 13A, B). Similar left valves are shown in Plate IX, figures 13, 18, 23; Plate XI, figure 8. This extreme variant of *B. uncitoides* s. lato is probably ancestral to *B. tolmatschowi* s. lato which is characteristically finely striated.

Buchia uncitoides s. lato is an irregularly rounded to markedly angular, obliquely elongate (posteriorly) shell; characteristically, it is considerably longer than wide but some extremely wide variants may be only slightly longer than wide (Pl. VII, figs. 13, 14; Pl. IX, figs. 1, 2, 3, 4, 16, 19). These extreme variants may be transitional to the early forms of *B. keyserlingi* s. lato (Pl. X, fig. 1; Pl. XI, figs. 1, 5; Pl. XII, figs. 1, 2). The shell is, generally speaking, narrow, high arched and angular in cross-section when viewed from the beaks (Pl. IX, figs. 5D, 13D, 19D, 22D). This flat topped cross-section combined with more or less steeply sloping flanks is particularly characteristic of the late forms of the species. The thickness of the shell is either slightly less than or equal to its width in the typical forms (Pl. X, figs. 8, 9) and late variants (Pl. X, fig. 14). *B. uncitoides* var. *spasskensoides* (Pl. X, fig. 12, etc.) and other (mostly early) variants (Pl. VII, figs. 9, 12) may, however, be considerably thinner than wide and have gradually arching flanks in cross-section. The extreme variability of the shape of both valves does not lend itself to a concise description; it can be more readily appraised visually (*see* Pls. VII to X).

In typical forms of the species (Sokolov, 1908b, Pl. I, fig. 12; this paper, Pl. X, figs. 6, 8) concentric ribs are characteristically fine and closely spaced; they are often very sharp (in *B. uncitoides* var. *acutistriata*) in the specimens with well-preserved shell surface. This feature is, however, taxonomically unreliable, being largely controlled by the mode of preservation. The concentric ornament is also frequently visible on the surface of internal casts (Pl. X, figs. 3, 9, 10, 11). In *B. uncitoides* var. *catamorpha* Crickmay, 1930, the surface of both shell and cast is covered only by fine striae and growth-lines with a few coarser ribs and welts interspersed locally. *B. uncitoides* var. *spasskensoides* Crickmay, 1930 and related forms are, on the contrary, covered by much more widely spaced, coarser concentric ribs (Pl. X, figs. 12, 13, etc.). This variant is on the opposite end of the variation series from *B. uncitoides* var. *catamorpha,* so far as the nature of the ornament is concerned.

The left valve of *B. uncitoides* s. lato is commonly not much larger or thicker than its right valve; both tend to have similar shapes (Pl. X, figs. 9, 14). However, *B. uncitoides* var. *spasskensoides* and other early variants transitional to *B. okensis* s. lato may possess much flatter and broader right valves similar to that of *B. volgensis* and *B. okensis.*

The long, sharp, moderately bent downward but mostly not coiled beak of the left valve does not normally (or only slightly) overhang the somewhat shorter and smaller but equally sharp and incurved right beak (Pl. X, figs. 8C, 9C, 14C). Some rare, aberrant forms resembling *B. tolmatschowi* var. *americana* and probably ancestral to it (Pl. VII, figs. 5, 11) may, however, have pronouncedly bent downward and more or less strongly coiled left beaks.

The characteristic lateral curvature of left beak of *B. uncitoides* s. lato and its infraspecific variation and evolutionary grade, and also the characteristic appearance of the byssus ear, its infraspecific variation, and evolutionary grade, have already been described (pp. 6-7, 12).

The anterior surface of byssus ear is characteristically bent. Its uppermost part forms an angle of 40 to 50 degrees with the plane of contact of the valves. This angle then increases to 65 to 90 degrees within the upper part of the surface (Pl. IX, figs. 14D, 20D, 21D). The lower half of the byssus ear protrudes inward, forming a sharp-edged, claw- to beak-like protuberance (Pl. IX, figs. 14E, 15E, 21E). This protuberance enters the deeply incised, triangular articulation pit (="Gelenkgrube") of the left valve; it is longer and sharper than the protuberance of the most advanced form of *B. piochii* s. lato (Pl. I, fig. 3E). The byssus ear of *B. uncitoides* s. lato is distinctly more advanced than that of either *B. okensis* s. lato, or *B. volgensis* s. str. and *B. keyserlingi* f. typ.; it is much more similar to that of *B. inflata* s. lato (Pl. I, figs. 7, 8) in its shape, relative size and orientation. The only striking difference between the two is the much narrower and longer, pronounced wedge-like outline of the profoundly excavated inner surface of byssus ear in *B. uncitoides* s. lato.

B. uncitoides s. lato differs from its homoeomorph *B. volgensis* s. str. (Pl. X, figs. 4, 5) in its narrower, more elongated, thicker and mostly distinctly subtriangular valves. The narrowly subtriangular, markedly beaked and thick right valve of *B. uncitoides* s. lato (Pl. IX, figs. 1, 2, 14, 15, 20, 21; Pl. X, figs. 8B, 9B, 14B, 14C) contrasts strongly with the irregularly rounded, broad, feebly convex to slightly depressed, often clearly eared but slightly beaked right valve of *B. volgensis* s. str. (Lahusen, 1888, Pl. III, figs. 2, 3, 5, 6, 13, 14, 15; this paper, Pl. X, fig. 5). *B. uncitoides* s. lato also differs from *B. volgensis* s. str. in its much thinner, distinctly pinched, more or less regularly and moderately downward bent left beak (Pl. VIII, fig. 10B; Pl. X, figs. 3B, 8C, 9C, 11B). In *B. volgensis* (*see*

Pl. X, fig. 4) and in *B.* aff. *volgensis* (*see* Pl. III, fig. 1) the broader and blunter beak is abruptly or irregularly hooked and overhangs the much smaller and shorter right beak (*see* also Lahusen, 1888, Pl. III, figs. 3, 5, 13 and 14). The left beak of *B. uncitoides* s. lato is commonly incurved to the left while that of *B. volgensis* s. str. is incurved to right or straight.

Some large representatives of *B. uncitoides* s. lato (Pl. V, fig. 1; Pl. VII, figs. 10, 11) could, perhaps, be considered extreme variants of *B. volgensis* s. str. if found alone; they always occur, however, in association with much more numerous, typical representatives of the species. No typical representatives of *B. volgensis* s. str., such as dominate its populations in the Canadian Arctic and Northern Eurasia, have been found in the Canadian western Cordillera. The same seems to be true of the western Cordillera of the United States and Alaska, except for isolated specimens of *B.* aff. *volgensis* (Lahusen) found in the basal Cretaceous beds of California (Imlay, 1959, pp. 160-1). The writer has seen three specimens of *B.* aff. *volgensis* (Lahusen) from the Nooksack area, Washington (Pl. III, fig. 1), which are closely comparable with the typical representatives of this species from Arctic Canada (Pl. X, figs. 4, 5). These specimens form part of the same fossil collection with *B.* cf. *blanfordiana* and *B. fischeriana* var. (A-7902). They are, however, enclosed in the bluish grey sandstone instead of the purple volcanic tuff or tuffaceous black shale, in which all representatives of the other two species are enclosed. These *Buchia* aff. *volgensis* (Lahusen) have presumably been derived from different (early Lower Cretaceous?) beds.

B. keyserlingi (Lahusen) s. lato differs from *B. uncitoides* s. lato in being a much shorter, broader, relatively thinner and almost equivalve shell, whose left beak is much shorter and blunter, nearly straight or slightly incurved to left (Pl. XIX, figs. 1, 2, 5, 7). It has much more regularly rounded shell outline than *B. uncitoides* s. lato. Even *B. uncitoides* var. *spasskensoides* cannot be easily confused with *B. keyserlingi* s. lato, except where transitional forms between the two are involved. It should be noted, however, that *B. keyserlingi* (Lahusen) var. *visingensis* Sokolov, 1908 from European Russia (Lahusen, 1888, Pl. IV, figs. 21-23), its late Berriasian representatives from the west coast of Vancouver Island (Pl. X, fig. 1; Plate XII, fig. 1), and the late Valanginian forms of the species (Pl. XIX, fig. 5) may sometimes have left beaks with feeble to marked left-handed incurvature comparable to those of *B. uncitoides* s. lato.

B. terebratuloides (Lahusen, 1888 emend. Pavlow, 1907) is more similar to *B. uncitoides* s. lato than *B. keyserlingi* is. *B. terebratuloides* differs from *B. uncitoides* s. lato essentially in the same features as *B. keyserlingi* does but it is persistently smaller. *B. uncitoides* s. lato is best distinguished from *B. terebratuloides* by the more narrow, longer, and distinctly angular outline of its shell combined with the more or less marked left-handed incurvature of left beak. The taxonomic relationships between *B. terebratuloides* and *B. uncitoides* s. lato remain obscure and these two forms may be in part conspecific. The name *B. terebratuloides* (Lahusen, 1888) may be a junior synonym of *B. obliqua* (Tullberg, 1881), if the customary interpretation of Tullberg's (1881, p. 23, Pl. XII, figs.

13-15) description and drawings of *Aucella keyserlingiana* forma *obliqua* is correct.

As already mentioned in connection with the description of the evolution of left beak in *Buchia,* small to medium-sized representatives of *B. uncitoides* s. lato such as are shown in Plate IX, figures 5, 9, 10, 11, 12, 13, 18, 23, may be confused with the older *B. piochii* s. lato. Especially *B. uncitoides* forms in which only the earliest part of left beak has left-handed incurvature may be hard to differentiate from *B. piochii* s. lato. One has often to rely on the higher evolutionary grade of the byssus ear of right valve or on their association with forms having typical (i.e., more marked left-handed incurvature) left beaks for the positive identification and dating of such homoeomorphs of *B. piochii* s. lato. It seems possible that some of the Californian buchias customarily identified as *B. piochii* s. lato and dated accordingly are actually such homoeomorphic variants of *B. uncitoides* s. lato. Some of these specimens have already been identified as *B. uncitoides* by Pavlow (1907, pp. 61, 83).

The closest ally and direct descendant of *B. uncitoides* s. lato is *B. tolmatschowi* Sokolov s. lato which differs from the former species in having a thicker, often narrower shell with the pronounced left-handed curvature of both beaks (Pl. XIII, figs. 1, 3, 4; Pl. XIV, fig. 1; Pl. XV, figs. 4, 7, 10, 11). *B. tolmatschowi* s. lato characteristically lacks the pronounced, closely spaced, sharp ribbing of *B. uncitoides* s. lato on the shell's surface and, even more characteristically, on the surface of the internal cast. The right valve of *B. tolmatschowi* s. lato is more convex and narrower than that of *B. uncitoides* s. lato.

B. pacifica n. sp. is a much shorter and thicker shell than *B. uncitoides.* It does not taper gradually and evenly towards the lower margin from the place of the maximum thickness as *B. uncitoides* s. lato does, but is sharply truncated in that direction (Pl. XV, fig. 12; Pl. XVI, figs. 1-2, 7-10) in the anterior-posterior aspect. Both beaks of *B. pacifica* n. sp. have stronger left-handed curvature and are stronger bent downward (Pl. XVI, figs. 2A, 2D, 3A, 3C, 4A, 4C, 8A, 8C, 9A, 9D; Pl. XVIII, figs. 2A, 2D) than those of *B. uncitoides* s. lato. The much greater thickness and marked truncation of the right valve of *B. pacifica* n. sp. toward the lower margin are particularly distinctive and helpful in its differentiation from the much longer, thinner and gradually tapering (backward) right valve of *B. uncitoides* s. lato.

B. inflata s. lato, *B. sublaevis* s. lato and allied boreal forms (Pl. XVI, fig. 6; Pl. XVII, figs. 1-6) are all much thicker and shorter (often globulous) shells than *B. uncitoides* s. lato. They have, besides, shorter and blunter beaks. Most variants of *B. sublaevis* s. lato are, furthermore, broader and tend to lack the sharp, regular concentric ornament of *B. uncitoides* (except for *B. uncitoides* var. *catamorpha*) and so differ from it also in this respect. The ribbing of some representatives of *B. sublaevis* var. *majuscula* (Tullberg, 1881) may, however, be similar to that of *B. uncitoides* var. *spasskensoides* (Pl. XVI, fig. 6). The same is true of most or all variants of *B. inflata* s. lato. Among these forms the concentric ornament of *B. inflata* var. *crassa* (Pavlow, 1907) (Pl. XVII, figs. 2, 4) is particularly similar to that of *B. uncitoides* var. *spasskensoides.*

B. crassicollis s. str. and its variants are commonly smaller, broader and shorter shells than *B. uncitoides* s. lato. Its left beak is, furthermore, longer, stronger bent downward and more or less markedly coiled (Pl. XX, figs. 1B, 9B, 10B; Pl. XXI, figs. 2B, 5B, 6B, 7B). Only some rare, aberrant forms of *B. uncitoides* s. lato (Pl. VII, figs. 5, 11) may be similar to *B. crassicollis* s. str. in this respect; they are, however, much longer and slender forms with marked to pronounced left-handed incurvature of left beaks. *B. crassicollis* is a much more inequivalve shell than *B. uncitoides* s. lato, its right valve being only feebly convex, broader and more irregularly rounded (Pl. XX, figs. 8B, 8C, 11A, 11B; Pl. XX, fig. 6).

In addition to its name species, the *Buchia uncitoides* zone carries rare early forms of *B. keyserlingi* s. lato. These include thicker, more coarsely ribbed, subtriangular shells apparently referable to *B. keyserlingi* var. *sibirica* (Sokolov, 1908) (Pl. XI, fig. 3) and thinner, more regularly rounded shells apparently referable to *B. keyserlingi* var. *visingensis* (Sokolov, 1908) (Pl. X, fig. 1; Pl. XI, fig. 1; Pl. XII, figs. 1, 2). These forms have been found only locally, and then rarely, in the upper 100 feet or so of *Buchia uncitoides* zone. They seem to intergrade with the extremely broad, short, and markedly ribbed variants of *B. uncitoides* s. lato from the same and older beds (Pl. IX, figs. 3, 19). The left beaks of these forms tend, furthermore, to have stronger left-handed incurvature (Pl. X, fig. 1A; Pl. XII, fig. 1) than those of the younger *B. keyserlingi* f. typ. from East Greenland (Pl. XIX, figs. 2A, 2C, 7A). Our forms could possibly be not the immigrants from the Arctic but an indigenous offshoot of *B. uncitoides* s. lato that became homoeomorphically similar to *B. keyserlingi* s. lato.

Age and Correlation

Diagnostic Tethyan (mainly Indo-Pacific or Andean) ammonites occur rarely in the middle part of *Buchia uncitoides* zone on the west coast of Vancouver Island. These ammonites include *Spiticeras (Spiticeras)* cf. *scriptus* (Strachey) (Pl. XII, fig. 4), *Spiticeras (Spiticeras)* cf. *mojsvari* Uhlig (Pl. XII, fig. 5), *Spiticeras (Spiticeras)* sp. indet. juven. (Pl. XI, figs. 2, 3), *Spiticeras (Groebericeras)* sp. indet.? (Pl. XI, fig. 7), *Berriasella (Protacanthodiscus)* sp. nov. aff. *B. (P.) micheicus* (Bogoslovsky, 1897) (Pl. XI, fig. 4), and *Neocomites* (s. lato) nov. sp. indet. (Pl. XI, fig. 6; Pl. XII, fig. 6).

The first identifiable Berriasian ammonite is *Spiticeras (Spiticeras)* sp. indet. juven. found about 176 feet above the Jurassic-Cretaceous contact and 21 feet above the assigned base of *Buchia uncitoides* zone proper. The last identifiable Berriasian ammonite is *Berriasella (Protacanthodiscus)* n. sp. aff. *B. (P.) micheicus* found about 322 feet above the Jurassic-Cretaceous contact and some 103 feet below the top of *Buchia uncitoides* zone. The generic and specific affinities of this ammonite fauna (or faunas?) indicate that these beds, at least, are of late Berriasian age. Considering the superposition of *Buchia uncitoides* zone on the presumably early Berriasian *Buchia okensis* zone, the former zone must be largely or completely equivalent to the *Thurmannites boissieri* zone of southwestern Europe

(Fig. 1) and *Spiticeras damesi* zone of Argentina (Leanza, 1945). The assignment of the upper 103 feet of *Buchia uncitoides* zone to the late Berriasian is, however, based only on the essential continuity of *Buchia* fauna throughout this zone, and may be subject to revision especially if one considers the similarly slender data used for correlation of the lower part of *Buchia tolmatschowi* zone (*see* below).

The correlation with the boreal province of Northern Eurasia is more difficult. As already mentioned, *Buchia uncitoides* zone overlies conformably and gradationally *Buchia okensis* zone. As the latter is correlated tentatively with the *Berriasella (Riasanites) rjasanensis* zone of the European part of U.S.S.R., it seems logical to correlate *Buchia uncitoides* zone with the next younger boreal zone of *Tollia (Subcraspedites) spasskensis. B. okensis* is, however, known to range into the latter zone and the here-accepted presence of more than one Berriasian fauna in the Ryasanian beds is far from proven. The correlation of *Buchia uncitoides* zone proposed in Figure 1 is, therefore, offered as a tentative suggestion only, and there is yet other reason to question this correlation.

Buchia uncitoides zone is conformably and gradationally overlain by *Buchia tolmatschowi* zone, which appears to be correlative with *"Tollia stenomphala"* zone (renamed *Tollia tolli* zone in this report; *see* Figure 1 and under the discussion of age of *Buchia tolmatschowi* zone). *"Tollia stenomphala"* zone appears to be correlative with the Lower Valanginian of northwestern and southwestern Europe (*Platylenticeras gevrili* zone) because of the general affinities of its ammonite fauna and similar stratigraphic position. The occurrence of *Buchia inflata* (Toula) and its var. *crassa* (Pavlow) in this zone is suggestive of an even younger age, judging by the occurrence of these forms in *Buchia pacifica* zone of our region (*see* p. 46). The Lower Valanginian age of *"Tollia stenomphala"* zone is accordingly accepted as valid in this report (Fig. 1). All Russian workers (Pavlow, 1907; Sokolov, 1908a) insist, however, that in U.S.S.R. *B. uncitoides* s. lato is confined to *"Tollia stenomphala"* zone and ascends into the apparently younger *"Polyptychites"* beds. In the Canadian western Cordillera this species does not ascend into the apparently correlative *Buchia tolmatschowi* zone but is confined to the underlying beds which carry late Berriasian ammonites in their middle part. The reason for this apparent discrepancy in vertical range of *B. uncitoides* s. lato in North America and Northern Eurasia is not clear. It could possibly be due to strong condensation of beds in the critical early Lower Cretaceous sections of the Russian platform resulting in concentration of index fossils of several adjacent zones in one and the same thin bed. This explanation seems feasible as the Berriasian and Valanginian beds of the Russian platform are punctuated by hiatuses, represented by glauconitic and phosphorite-bearing sands (often pebbly), and are extremely thin as compared with the contemporary rocks elsewhere (*see* Gerassimov, 1955, pp. 12-13). Other possible explanations include the reworking of Berriasian buchias from the underlying Ryasanian beds or the presence of an older, so far unrecognized, fauna in the lower part of *"Tollia stenomphala"* zone. The latter explanation is favoured by the circumstance that Gerassimov's (loc. cit.)

fossil lists of *"Tollia stenomphala"* zone include mostly late Berriasian species but few (e.g. *B. inflata*) or none of the Lower Valanginian ammonites and buchias cited and partly figured from the same zone by Pavlow (1889, 1907), Sokolov (1908a, b) and other workers. Sasonov (1951, p. 62) has also suggested the presence of more than one fauna in *"Tollia stenomphala"* zone.

The absence or (?) extreme rarity of the typical *Buchia volgensis* throughout the western Cordilleran belt of North America (including Alaska?) contrasts sharply with the abundance of this species throughout Arctic Canada (Jeletzky, 1958, 1960, 1961a, b). In the Arctic Canada *B. volgensis* s. str. characterizes, besides, a well-defined zone of its own (Fig. 2). There *Buchia volgensis* zone overlies either *Buchia okensis* zone or *Buchia uncitoides* zone (only in the Richardson Mountains?), and appears to be directly overlain by the Lower Valanginian *Tollia* (*Tollia*) cf. *tolli* and *Buchia keyserlingi* f. typ. zone.

The geographical restriction of *Buchia uncitoides* and *Buchia volgensis* in North America and the approximate contemporaneity of their zones in terms of the Berriasian ammonite zones suggest that *Buchia uncitoides* zone is, generally speaking, but a North Pacific faunal facies of the Arctic and Eurasian *Buchia volgensis* zone (Fig. 2). The presence of both zones in superposition in the Richardson Mountains (Jeletzky, 1961a) does not contradict this interpretation as the region concerned lies at the boundary of the realms of both species where their interfingering and/or mixing can be expected. The reported associations of *B. uncitoides* and *B. volgensis* in Siberia and European Russia (Pavlow, 1907; Sokolov, 1908a, b) can also be interpreted as mixed faunas (*see* above). *B. volgensis* and *B. uncitoides* appear to belong respectively to the Arctic and North Pacific *Buchia* lineages (Fig. 3). They are, indeed, not only geographically isolated but exhibit the previously discussed important differences in morphology of left beaks and byssus ears.

Buchia tolmatschowi Zone

Stratigraphy

On the west coast of Vancouver Island *Buchia uncitoides* zone is overlain, apparently conformably and gradationally, by a sequence of beds about 119 feet thick characterized by the abundance of *Buchia tolmatschowi* (Sokolov, 1908) and its variants. This *Buchia* fauna was first referred to as *Aucella* ex gr. *lahuseni,* etc., fauna (Jeletzky, 1950, p. 41) and then later as *Buchia americana* fauna (Jeletzky, 1959, p. 24). The bulk of the *Buchia* forms of this fauna is, however, referable to the typical form of *B. tolmatschowi* (Sokolov, 1908b, p. 13; Pl. II, figs. 1-2), of which *B. americana* Sokolov (1908b, p. 16, Pl. III, figs. 5-7) is only an extreme morphological variant. Hence the proposed change of the zonal fossil's name.

Isolated lots of *B. tolmatschowi* and allied forms have been seen from several areas of the British Columbia's mainland (e.g., Harrison Lake area, Bridge River area, etc.). So far as known, this zone occupies the same stratigraphic position there as on the west coast of Vancouver Island.

As already noted by Sokolov (1908b, pp. 15-16) typical examples of both *B. tolmatschowi* and *B. tolmatschowi* var. *americana* occur in the Paskenta Formation in California. There *B. tolmatschowi* s. lato occurs in the *Tollia (Tollia) mutabilis* zone of Imlay (1960, pp. 174-175), that is to say in the upper, but not the uppermost, part of the comprehensive *"Aucella crassicollis* zone" of Imlay (1959, pp. 175-176).

Buchia tolmatschowi zone is unknown in northeastern British Columbia, Yukon, and Alaska, probably because of palaeozoogeographical reasons. Nor has it been recorded to the writer's knowledge from the Canadian and European Arctic, western Siberia or European Russia.

Palaeontology

A representative suite of specimens of *Buchia tolmatschowi* s. lato is shown on Plates XIII to XV. *B. tolmatschowi* s. lato is a large, thick, almost equivalve (Pl. XIII, figs. 1, 3-4) to markedly inequivalve shell with subparallel to steeply sloping flanks and flattened upper surfaces of both valves. This flattening results in the rounded-trapezoidal to rounded-quadrangular cross-section of the shell (Pl. XIII, figs. 3C, 4B) when viewed from the beaks. The shell is always higher than wide, narrow, long to very long (maximum length at least doubles the maximum width) and subtriangular; its greatest thickness is generally closely behind the beak part, wherefrom it tapers relatively fast and abruptly toward the tips of the beaks and the hinge margin (Pl. XIII, figs. 3B, 4C). The tapering toward the lower margin is, conversely, more or less gradual (Pl. XIII, figs. 3B, 4C; Pl. XIV, figs. 1B, 1D). In some representatives the maximum thickness is in the middle of the shell (in anterior-posterior aspect) and the tapering is about equally gradual in both directions (Pl. XIII, fig. 1D). The anterior-posterior outline of such shells is more or less regularly rounded throughout as opposed to the wedge-like shape of other variants. Beaks may be short and of about equal length (Pl. XIII, figs. 1, 3, 4) or long, irregularly bent, and unequal in length, the left beak being the longer (Pl. XIV, fig. 1; Pl. XV, figs. 7, 10, 11); they are, however, always strongly bent downward and have pronounced left-handed incurvature. When the beak of the left valve is short it does not overhang that of the right valve. When the left beak of *B. tolmatschowi* var. *americana* is longer, however, it tends to strongly overhang the shorter right beak and may be tightly coiled.

The surface of the shell is characteristically devoid of regularly spaced, strong concentric ornament; it is covered either by fine striae with or without a few pronounced constrictions and welts (Pl. XIV, fig. 1) or by irregularly spaced concentric ribs and furrows (Pl. XIII, figs. 3-4); these may be either feeble or strong. The surface of the internal casts has the same sculpture as the shell's surface. The minority of specimens of *B. tolmatschowi* s. lato, which are largely transitional either to *B. uncitoides* s. lato or to *B. pacifica* n. sp. and confined to the basal or top beds of the zone, may have strong, regularly spaced concentric ribs on part or all of the shell surface (mostly on its beak parts only). Even in these specimens, however, the surface of the internal cast is largely devoid of these ribs (Pl. XV, figs. 7, 10, 11).

The characteristic appearance, infraspecific variation and evolutionary grade of byssus ear and left beak of *B. tolmatschowi* s. lato have already been described in connection with the discussion of irreversible orthogenetic trends in *Buchia*. The byssus ear does not seem to differ materially from that of *B. uncitoides* s. lato.

The moderately long, almost equivalve, short-beaked representatives of *B. tolmatschowi* s. lato (Pl. XIII, figs. 3, 4; Pl. XV, fig. 4) agree with the East Siberian cotypes of this species figured by Sokolov (1908b, Pl. II, figs 1, 2) in all essential details of their morphology. These typical forms of *B. tolmatschowi* are, however, associated with much more slender, pronouncedly inequivalve forms with longer and more downwardly bent beaks (Pl. XIV, fig. 1; Pl. XV, figs. 7, 10, 11). The latter forms are indistinguishable from the cotypes of *B. crassicollis* var. *americana* Sokolov (1908b, Pl. III, Figs. 5-7) in all essential morphological details. They are here considered to be but an extreme morphological variant of *B. tolmatschowi* s. lato as they have the same stratigraphical range as the typical forms and the two intergrade at all levels. Another extreme variant of *B. tolmatschowi* s. lato is represented by extra thick forms strongly swollen in the middle (Pl. XIII, fig. 1). This variant characteristically lacks coarse, sharp ribbing both on the shell's surface and on the surface of the internal cast, it has short beaks and is almost equivalve. Thus it is very similar to *B. sublaevis* var. *majuscula* (Pl. XVI, fig. 6; Pl. XVII, fig. 1) but differs consistently from this younger form in having stronger left-handed-incurved beaks and in lacking coarse, sharp, regular ribbing. This variant has the same range as the typical form of *B. tolmatschowi* and intergrades with it at all levels.

B. tolmatschowi s. lato intergrades into *B. uncitoides* s. lato at the base of its zone and mixed faunas of both species occur in these basal beds (overlap beds). Except for the transitional forms in these overlap beds and the rare aberrant specimens higher in the zone, *B. tolmatschowi* s. lato is readily distinguishable from its ancestor (*see* under the description of *Buchia uncitoides*).

At the top of its zone *B. tolmatschowi* s. lato intergrades into *B. pacifica* n. sp. in the same fashion as it intergrades into *B. uncitoides* in the basal part of its range. A mixed fauna of both species occurs in these beds. *B. tolmatschowi* differs from its descendant *B. pacifica* n. sp. in the absence of regularly spaced, sharp concentric ribbing on the surface of its shell and internal cast, in its considerably greater length and lesser width, and in the gradual tapering from the level of maximum thickness to the lower margin as opposed to the characteristic truncation of the shell in *B. pacifica*.

From *B. inflata* s. lato and *B. sublaevis* s. lato (Pl. XVI, fig. 6; Pl. XVII, figs. 1-6), *B. tolmatschowi* s. lato differs in the same features as from *B. pacifica* n. sp. except that these species lack the truncation of the shell toward the lower margin characteristic of *B. pacifica*. The beaks of these forms have less marked left-handed incurvature.

B. tolmatschowi is similar to *B. crassicollis* s. str. in the surface sculpture of its shell and internal cast; it is, however, a larger, more elongated, more nearly equivalve shell than the last-mentioned species. *B. tolmatschowi* also differs from *B. crassicollis* s. str. in its left beaks having pronounced left-handed incurvature and moderate downward bend. This is in contrast with the somewhat tightly coiled, forward directed, and strongly overhanging left beaks of *B. crassicollis* s. str. The left beak of *B. tolmatschowi* var. *americana* is exactly similar to that of *B. crassicollis* s. str. in the degree of coiling and overhanging. These two forms can, therefore, only be distinguished because *B. tolmatschowi* var. *americana* has pronouncedly left-handed-incurved beaks, and is bell-shaped, larger, more posteriorly elongated and less inequivalve shell than its younger homoeomorph.

Diagnostic ammonites have only been found in the upper part of *Buchia tolmatschowi* zone which includes beds transitional to the overlying *Buchia pacifica* n. sp. zone. Most are representatives of the boreal subgenus *Tollia* Pavlow, 1914. Some are specifically identical with *Tollia (Tollia) mutabilis* (Stanton s. lato) (Pl. XV, figs. 2, 6, 8, 9). Others are specifically identical with the closely allied East Greenland species *Tollia (Tollia) paucicostata* Donovan (Pl. XIII, figs. 2, 5-7, 9; Pl. XIV, figs. 4-6). Yet others appear to be transitional between these two species (Pl. XIV, fig. 8). Rare forms closely allied to *Tollia (Tollia?) simplex* (Bogoslovsky, 1902) and *"Surites" poreckoensis* Sasonov, 1951 have also been found (Pl. XIII, fig. 8). Peculiar craspeditid ammonites, genus and species indet. (Pl. XIV, fig. 2) have been found in association with *Tollia (Tollia) paucicostata* Donovan in some sections. These forms are similar to *"Neocraspedites" evolutus* Donovan and *"N." greenlandicus* Donovan (Donovan, 1953, Pl. 23, figs. 3-4) and so also have Arctic affinities. *Neocomites (Parandiceras)* cf. *rota* Spath occurs rarely in association with *T. (T.) mutabilis* in one other section. *T. (T.) paucicostata* Donovan, *T. (T.)* aff. *simplex* and the peculiar craspeditid ammonite, genus and species indet. have not been found in association with *T. (T.) mutabilis* s. lato and *N. (P.)* cf. *rota.* This fact and the association of these more typical *Tollia* species with the typical *Buchia tolmatschowi* fauna suggest that they represent a distinct and older ammonite fauna. *T. (T.) mutabilis* s. lato and *N. (P.)* cf. *rota* have, indeed, only been found in association with the mixed fauna of *Buchia tolmatschowi* and *Buchia pacifica* zones at the top of *Buchia tolmatschowi* zone. The two ammonite faunas concerned have not been observed in superposition in one and the same section. This and the rare occurrence of *T. (T.) paucicostata* Donovan in association with *T. (T.) mutabilis* s. lato and mixed *Buchia* fauna in California (Pl. XIV, fig. 3) make it possible that both faunas are but faunal phases of one and the same ammonite zone. The zonal independence of both faunas is, nevertheless, favoured in this report (Fig. 1). *Tollia (Tollia) paucicostata* fauna is accordingly reproduced as a separate entity in Plates XIII and XIV whereas *Tollia (Tollia) mutabilis* fauna is reproduced on Plate XV.

Imlay's (1956, pp. 1144-5; 1960, pp. 200-1) assignment of *T. (T.) mutabilis* s. lato to *Homolsomites* Crickmay, 1930 is not followed here. The writer considers that the type species of *Homolsomites* (*Olcostephanus quatsinoensis* Whiteaves,

1882) is not congeneric with *T. (T.) mutabilis* s. lato. *Homolsomites* is, furthermore, considered to be junior synonym of *Dichotomites* Koenen 1909 s. lato (=*Neocraspedites* Spath 1924)[1].

Dichotomites quatsinoensis (*see* p. 52) differs from *T. (T.) mutabilis* in the following important features:

1. In the late stages of growth the venter is much more narrowly rounded and the whorl is markedly subtriangular in cross-section with the maximum thickness near the umbilical edge (Pl. XXI, figs. 4A, B);
2. Coarse, strongly forward-inclined ribbing and sometimes weak but swollen basal parts of the primaries are retained on the penultimate and body whorls after the flanks become virtually smooth (Pl. XXI, fig. 11);
3. Suture line is very strongly ascendant, has very long and slender lobes, and is much stronger frilled than that of *T. (T.) mutabilis* s. lato;
4. Ribbing is predominantly bidichotomous during the middle stages of growth (Pl. XX, figs. 6A, 14A, B). Only on the early whorls is the bidichotomous ribbing replaced by the *Tollia*-like dichotomous to trichotomous ribbing characteristic of *T. (T.) mutabilis* s. lato (Pl. XX, figs. 3-5, 7, 13);
5. In early and middle growth stages ribs are much more crowded and finer. The primaries are shorter and the point of their subdivision generally lies very low on the flanks (Pl. XX, figs. 3A, 6A, 13, 14B);
6. Umbilicus is much narrower at all stages of growth (Pl. XX, figs. 2A, 7A, 13; Pl. XXI, figs. 10A, 11);
7. No morphological or stratigraphical overlap is known to exist between *D. quatsinoensis* and *T. (T.) mutabilis* s. lato. These two species always occur separately and in rocks of different ages.

Olcostephanus (Simbirskites) mutabilis Stanton s. lato is a typical representative of the subgenus *Tollia* Pavlow 1914 in most of its diagnostic features. It has the typical ribbing habit of *Tollia* characterized by long, often somewhat incurved and pinched primaries that bifurcate, trifurcate, or quadrifurcate closely above or below the middle of the flanks (Pl. XIV, fig. 7; Pl. XV, figs. 1, 2, 3, 5, 6, 8, 9). Alternating bifurcating and trifurcating ribs are at that restricted to the early whorls (Pl. XV, figs. 2, 8) with the trifurcation being predominant on the later whorls (Pl. XV, figs. 1, 3, 4, 6, 9). Some quadrifurcating ribs are intercalated with the predominant trifurcating ribs close to the beginning of the living chamber (Pl. XV, fig. 6A). Single ribs may occur at intervals at any stage of the growth. *T. (T.) mutabilis* s. lato has numerous constrictions and becomes completely smooth (except for constrictions near the end of the penultimate whorl) (Pl. XIV, fig. 9) just as typical *Tollia* species do. It also reaches as large size as does *T. (T.) tolli* s. lato. The external suture line of *T. (T.) mutabilis* s. lato is, generally speaking,

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[1] Since this was written the writer has examined specimens of *D. bidichotomus* (Leymerie) and *N. semilaevis* (Koenen) in the private collection of Mr. C. W. Wright, London, England. They show well-preserved sutures of polyptychitid rather than craspeditid type. The type species of *Dichotomites* and *Neocraspedites* at least are therefore olcostephanid homoeomorphs of the craspeditid *Homolsomites*, which name is accordingly valid for "*Olcostephanus*" *quatsinoensis* and allied North American craspeditids.

Tollia-like (Pl. XIV, fig. 9); it is only feebly ascendant and has four first order auxiliary lobes and saddles. The first lateral lobe is about as long as the ventral lobe, the second is about three-quarters the length of the first one, and the auxiliary lateral lobes gradually diminish in size toward the umbilical margin. On the penultimate whorl the lateral lobes are relatively stout, although markedly more slender than those of *T. (T.) tolli* s. lato or *T. (T.) paucicostata,* and but little frilled. They become more slender, longer, and stronger frilled on the semismooth part of the penultimate whorls close to the beginning of the living chamber (Pl. XIV, fig. 9). These last-mentioned suture lines become crowded and begin to overlap. *T. (T.) mutabilis* s. lato has a relatively low, strongly embracing, more or less elliptical cross-section with the relatively broadly rounded venter and subparallel flanks (Pl. XIV, fig. 7B; Pl. XV, figs. 1B,C, 3B,C, 6B). The umbilicus is relatively narrow and deep at all stages of growth, about one sixth of each preceding whorl is exposed.

The distinctions of *T. (T.) mutabilis* s. lato from the typical boreal *Tollia* species (including *T. (T.) paucicostata* Donovan and *T. (T.) anabarensis* Pavlow from the early Valanginian beds) are thus limited to:

1. somewhat stouter, subelliptical (instead of high or low oval) cross-section of the whorl with more broadly rounded venter and subparallel flanks;
2. somewhat more slender and long lateral lobes of the suture, and the crowding and overlap of the suture lines in the proximity of the living chamber;
3. Generally considerably greater density of ribbing (Pl. XIV, fig. 7).

These distinctions are too trivial, in the writer's opinion, for generic or even subgeneric separation of *T. (T.) mutabilis* s. lato from other *Tollia* species, considering the extreme infraspecific variability of this species (Imlay, 1960; this paper, Pls. XIV, XV). Similarly slender and long lateral lobes occur in the typical Arctic *Tollia* species, such as *T. (T.) anabarensis* (Pavlow) (1914, Pl. IV, figs. 3A-3B) and in other yet undescribed Canadian forms in the collections of the Geological Survey of Canada. Also crowding and overlap of the adult suture lines occur in some of these forms.

Other distinctive features are highly variable within all *Tollia* species known to the writer. *T. (T.) mutabilis* s. lato includes, for example, extreme variants indistinguishable from *T. (T.) paucicostata* (Pl. XIV, fig. 3). The writer's collections of *T. (T.) paucicostata* from the west coast of Vancouver Island similarly include variants indistinguishable from the more coarsely and sparsely-ribbed variants of *T. (T.) mutabilis* s. lato (Pl. XIV, fig. 8).

All these morphological distinctions of *T. (T.) mutabilis* s. lato combined with the age of its zone indicate its being the youngest known (late Lower Valanginian) evolutionary stage (palaeontological species) of the *Tollia* lineage. *T. (T.) mutabilis* s. lato apparently arose directly out of the more typical yet morphologically advanced and geologically young (earlier Lower Valanginian) *T. (T.) paucicostata* Donovan. The latter species may, however, be a junior synonym of *T. (T.) ana-*

barensis (Pavlow). Whether *T. (T.) tolli* s. lato is the next older stage of the lineage characterized by more slender and higher whorl and stouter lateral lobes is not known. It may be but a geographical subspecies or a morphological variant of *T. (T.) anabarensis (? = (T.) paucicostata).*

The coarser and essentially dichotomously ribbed *Tollia (Tollia)* ex gr. *simplex* Bogoslovsky appear to be an older evolutionary stage of the *Tollia* evolution than *T. (T.) paucicostata,* as they characterize uppermost Ryasanian beds in Russia (Sasonov, 1951, p. 62). On the west coast of Vancouver Island (and in the Canadian Arctic as well), such primitive *Tollia* forms range however up into the beds with *T. (T.) paucicostata* and *T. (T.)* cf. *tolli,* and seem to be connected by transitions with the latter species. The same appears to be true of *"Tollia stenomphala"* zone of Russian platform (Gerassimov, 1955, pp. 12-13).

The intimate connection of *T. (T.) mutabilis* with older *Tollia* species, including its primitive late Berriasian to earliest Valanginian representatives (*Tollia simplex, Tollia poreckoensis,* etc.) invalidates all generic names proposed for the individual evolutionary stages (palaeontological species) of the *Tollia* lineage in recent years (*Surites* Sasonov, 1951, *Chandromirovia* Sasonov, 1951, *Homolsomites* Crickmay emend. Imlay 1956).

T. (T.) mutabilis could be an ancestor of *Dichotomites giganteus* and *quatsinoensis,* which are, in the writer's opinion, early representatives of *Dichotomites.* This is suggested by the morphological similarity of these three species, their stratigraphical relationships, and occurrence in the same faunal realm. *T. (T.) mutabilis* s. lato is, nevertheless, much closer to typical *Tollia* species than these two younger species and so should be left in that subgenus. It simply appears to be a true connecting link (stratigraphically as well as morphologically) between the more typical *Tollia* species on the one hand and early representatives of *Dichotomites* on the other. Introduction of a new generic name for it, or its transfer into the *Dichotomites,* would only obscure its genetic relationships and evolutionary significance.

Age and Correlation

The boreal ammonites occurring in the upper part of *Buchia tolmatschowi* zone indicate that this part of the zone, at least, is of early Valanginian age in terms of the international standard stages. This correlation is supported by the affinities of the *Buchia* fauna of this zone. All its *Buchia* forms (e.g., *Buchia tolmatschowi* et var. *americana*) occur in association with the diagnostic *Buchia* species of the so-called *Tollia stenomphala* zone of the European and Asiatic Russia in Eastern Siberia (Sokolov, 1908b). The Russian *Tollia stenomphala* zone should, however, be renamed. As pointed out by Jeletzky (1961b), the ammonite customarily identified by the Russian workers with the Berriasian (= Infravalanginian) *Tollia (Subcraspedites) stenomphalus* Pavlow emend. Spath, 1947 is an early Valanginian *Tollia* s. str. It is closely allied to *Tollia (Tollia) tolli* Pavlow s. lato (including *T. tolmatschowi* and *T. latelobata*) but seems to differ from it in its coarser and more distinct ribbing and in the lower and stouter whorl section. In these respects the only figured Russian specimen of *"Tollia stenomphala"* is even closer to *T. (T.) anabarensis* (Pavlow) and *T. (T.) paucicostata* (Donovan) and may well be specifically identical with one of these forms (which themselves may be synonymous at the specific level). This indicates that the Canadian *Tollia (Tollia) paucicostata* beds on Vancouver Island are approximately contemporary with some part of *"Tollia stenomphala"* zone of the European and Asiatic Russia (Fig. 1).

The occurrence of *T. (T.) ilekensis* (Sasonov, 1951, Pl. I, figs. 5-6; pp. 61-62) in the *"Tollia stenomphala"* zone of European Russia indicates that this zone also includes equivalents of the *Tollia (Tollia) mutabilis* beds of our region. *T. (T.) ilekensis* is, indeed, either closely allied to or specifically identical with *T. (T.) mutabilis* (*compare* Pl. XV, fig. 9).

As *Tollia (Tollia) tolli* Pavlow s. lato apparently occurs in beds equivalent to the *"Tollia stenomphala"* zone, it has been proposed (Jeletzky, 1961b) as the zonal index for this zone instead of the taxonomically invalid *"Tollia stenomphala"* of the Russian workers (Fig. 1). The customary correlation of the *Tollia tolli* zone with the late Berriasian is untenable as *Tollia tolli* s. lato, *Tollia* cf. *tolli* s. lato and allied forms always occur in association with *Buchia keyserlingi* (Lahusen) f. typ. and other forms of *"Tollia stenomphala"* zone in the Canadian and Siberian Arctic regions (Fig. 2).

Considering the essential unity of *Buchia* fauna throughout *Buchia tolmatschowi* zone, the evolutionary grade of the *Tollia* species occurring in its upper part, and the gradational superposition of this zone on the late Berriasian beds with *Spiticeras* spp., etc., all of the *Buchia tolmatschowi* zone is here correlated tentatively with *"Tollia stenomphala"* zone (now *Tollia tolli* zone) of Russia and with the apparently contemporary *Platylenticeras heteropleurum* zone of northwestern Europe (Fig. 1). Some objections to this correlation have been mentioned in connection with dating of *Buchia uncitoides* zone.

Primitive *Tollia* forms (*T.* aff. *simplex*) comparable to those of the latest Ryasanian beds in Russia (Sasonov, 1951, p. 62) occur in *Tollia (Tollia) paucicostata* beds. This need not necessarily be interpreted, however, as suggestive of the latest Berriasian age of the lower part of *Buchia tolmatschowi* zone, which underlies its *Tollia (Tollia) paucicostata* beds. Similar, coarse-ribbed forms with predominantly dichotomous mode of ribbing are, indeed, known to ascend in the early Valanginian beds with *Tollia (Tollia)* cf. *tolli* Pavlow and *Buchia keyserlingi* (Lahusen) f. typ. in the European and Canadian Arctic, and in the European part of U.S.S.R. (Donovan, 1953, Pl. XXIII, fig. 2; Gerassimov, 1955, pp. 12-13).

Tollia (Tollia) paucicostata (Donovan) and *"Neocraspedites"* spp. closely allied to the craspeditid ammonite, genus and species indet. of *Tollia (Tollia) paucicostata* beds of our region occur in the Valanginian rocks of East Greenland (Donovan, 1953, 1957, p. 207). There they are associated with typical *Buchia keyserlingi* (Lahusen) (Pl. XIX, figs. 2, 7). Other, relatively rare *Buchia* forms of this fauna include *B.* aff. *inflata* (Toula), *B. sublaevis* (Keyserling) and the form apparently indistinguishable from *B. crassicollis* var. *gracilis* (Sokolov, 1908 *non* Lahusen, 1888). Numerous polyptychitid ammonites diagnostic of mid-

Valanginian *Polyptychites keyserlingi* zone of northwestern Europe and Russia are associated with the above-mentioned *Tollia* and *Buchia* forms.

Unless *T. (T.) paucicostata* and *"Neocraspedites"* spp. range into the Arctic equivalents of *Buchia pacifica* n. sp. zone, the Trail Island beds of East Greenland that yielded this interesting fauna must include late Lower Valanginian rocks. Not only the *Tollia (Tollia) mutabilis* beds of our region, but the underlying *Tollia (Tollia) paucicostata* beds should be represented by the Trail Island fauna if the Canadian ranges of the above-mentioned ammonites hold true in East Greenland. The puzzling composition of the Trail Island fauna could perhaps be best explained by assuming it to be a mixed fauna resulting from the condensation of fossils of several Valanginian zones in a single thin limestone bed. If so, the lower part of the *Buchia keyserlingi* zone of the Canadian and European Arctic (Jeletzky, 1958, 1960, 1961a-b) includes beds that are the Arctic faunal facies of *Buchia tolmatschowi* zone.

In California and Oregon *"Homolsomites" mutabilis* zone of Imlay (1960, pp. 174-5) is obviously equivalent to the *Tollia (Tollia) mutabilis* beds of the Canadian western Cordillera, which occur at the top of our *Buchia tolmatschowi* zone. Not only does *T. (T.) mutabilis* s. lato occur in both sequences, but their *Buchia* fauna is identical as well. To illustrate the identity of both faunas well-preserved representatives of *T. (T.) mutabilis* s. lato (Pl. XIV, figs. 7, 9; Pl. XV, figs. 1, 3, 5), *Buchia tolmatschowi* var. *americana* (Pl. XV, Fig. 7) and *B. pacifica* n. sp. (Pl. XV, fig. 12) from the California Academy of Sciences (abbreviated to CAS in this report) loc. No. 1349 near Paskenta, California are reproduced in this report. Typical *B. tolmatschowi* also occurs at this locality. All these Californian forms are identical with those occurring in the transitional beds between *Buchia tolmatschowi* and *Buchia pacifica* zones on the west coast of Vancouver Island (*see* Pl. XV).

In California *T. (T.) mutabilis* s. lato occurs only in the upper part of the comprehensive *"Aucella crassicollis* zone" of Imlay (1960, pp. 174-5) several hundred feet beneath the topmost beds of this zone apparently corresponding to the highest beds of *Buchia pacifica* n. sp. zone (Fig. 2). Whether *T. (T.) mutabilis* s. lato ascends into the *Buchia pacifica* zone in California is not known. This possibility is suggested by the occurrence of *Neocomites (Parandiceras)* cf. *rota* and indeterminate craspeditid ammonites in the basal beds of this zone on the west coast of Vancouver Island.

Buchia pacifica n. sp. Zone

Stratigraphy

On the west coast of Vancouver Island *Buchia tolmatschowi* zone is gradationally overlain by about 98 feet of beds characterized by *Buchia* forms closely allied to but specifically distinct from *Buchia inflata* (Toula) s. lato. These forms are described below as *Buchia pacifica* n. sp. This species, its variants and allied forms often dominate the fauna of the zone almost to the exclusion of other *Buchia* species.

Buchia pacifica n. sp. fauna had been referred to as the *Aucella crassicollis* fauna by Jeletzky (1950, pp. 41-42) and was renamed *Buchia crassa* fauna (Jeletzky, 1959, p. 24) when it became obvious that the customary North American interpretation of *Buchia crassicollis* was erroneous (*see* below). The renaming of this zone proposed in this report is necessitated by the circumstance that most of its *Buchia* forms cannot be matched either with *Buchia inflata* f. typ. or *B. inflata* var. *crassa* of the Canadian and Eurasian Arctic regions and appear to be new to science.

The basal 50 to 60 feet of *Buchia pacifica* n. sp. zone carrying *"Polyptychites"* (now *Tollia (Tollia) mutabilis* s. lato) are now treated as the top part of *Buchia tolmatschowi* zone (i.e., transitional beds between *Buchia tolmatschowi* and *Buchia pacifica* zones), thus raising the lower boundary as compared with its previous interpretation (Jeletzky, 1950, pp. 41-42; 1959, p. 24). The upper part of *Buchia pacifica* zone and its contact with the overlying *Buchia crassicollis* s. str. zone are not exposed on the west coast of Vancouver Island.

Unlike relatively little known *Buchia uncitoides* and *Buchia tolmatschowi* zones, *Buchia pacifica* n. sp. zone is widespread in the western Cordilleran belt of North America from Alaska to California. In the Canadian western Cordillera this zone occurs in many areas (e.g., the west coast of Vancouver Island, Lillooet area, Bridge River area, Harrison Lake area, Princeton area, Caribou area, and southwestern Yukon). In northwestern Washington it is only doubtfully represented in the Nooksack area.

Palaeontology

A representative suite of *Buchia pacifica* n. sp. specimens from the west coast of Vancouver Island, other areas of British Columbia and California is shown on Plates XV, XVI, XVIII, XIX, and XXII. The well-preserved and typical left valve from the Eldorado Group of the Bridge River area is herewith selected as its holotype (Pl. XVI, figs. 1A, B; Pl. XXII, figs. 3A-C). The name *"pacifica"* was selected to stress the fact that, in the present state of our knowledge at least, this species is restricted to both sides of northern Pacific ocean.

B. pacifica n. sp. is a large, short, thick and commonly heavily sculptured shell. The concentric ribbing is equally sharp and prominent on the surface of the shell and on the internal cast; it may be dense (Pl. XVI, figs. 1, 3, 7; Pl. XIX, fig. 4) or more or less widely spaced (Pl. XVI, figs. 4, 9; Pl. XIX, figs. 6, 8). The extreme variants are always connected by transitional forms (Pl. XVI, figs. 2, 8, 10; Pl. XIX, fig. 3). Variants with widely spaced concentric ribs may become similar to *Buchia okensis* of this report. In some aberrant forms concentric ribbing may become obsolete on the surface of certain parts of shell or cast (Pl. XVI, figs. 2, 3; Pl. XVIII, fig. 2; Pl. XIX, fig. 6), and a few completely smooth shells have been seen (Pl. XXI, fig. 3).

The shell is more or less markedly inequivalve, despite both valves being mostly thick and swollen (Pl. XVI, fig. 1; Pl. XIX, fig. 4). The left valve is always larger, thicker, and longer. A sharp, moderately long, strongly incurved left beak commonly overhangs the shorter and smaller but nevertheless sharp and incurved beak of the right valve (Pl. XVI, figs. 1, 2; Pl. XIX, fig. 4). In many representatives, however, the left beak either does not or only slightly overhangs the right beak (Pl. XVI, figs. 4, 8, 9; Pl. XIX, figs. 3, 6, 8).

Although smaller, the right valve is mostly thick to very thick and swollen in the middle part (Pl. XIX, fig. 4). Relatively thin right valves are, however, not uncommon (Pl. XVI, fig. 7). Heavy constrictions and welts occur often on both valves (Pl. XVI, figs. 1, 10; Pl. XVIII, fig. 2). Both beaks of *Buchia pacifica* n. sp. have pronounced left-handed incurvature (Pl. XVI, figs. 3C, 4C, 8C, 9D; Pl. XIX, figs. 3C, 4A,B, 6C). The morphology, evolutionary grade, and infraspecific variability of left beak and byssus ear have already been described in connection with the discussion of the irreversible orthogenetic trends in *Buchia.*

Instead of tapering gradually toward the lower margins from the place of their maximum thicknesses, as is so with all allied *Buchia* forms, both valves of *B. pacifica* n. sp. mostly bend abruptly toward each other within the lower part of the shell (Pl. XVI, figs. 1, 2, 7, 8, 9; Pl. XIX, figs. 4, 6, 8). This results in the truncation of the lower part of the shell. In extreme cases the shell becomes "mushroom-shaped" (Pl. XVI, figs. 1, 2; Pl. XIX, fig. 4; Pl. XXII, fig. 3). Some left valves are truncated both fore and aft (Pl. XVI, fig. 2). Although but feebly developed in some specimens (Pl. XVI, figs. 3, 4, 7, 10; Pl. XIX, fig. 3), this peculiar truncation of both valves is perhaps the most diagnostic single feature of *B. pacifica* n. sp.

The strong swelling and truncation of both valves of *B. pacifica* n. sp. appears to be an adaptation to the extreme crowding of its shells, which mostly occurs in thick banks similar to those of present day oysters or *Mytilus.* The strong swelling and abrupt bends of the valves during the growth of *B. pacifica* n. sp. probably delayed its becoming covered by the sediment or being overgrown by the younger shells of the same species. This adaptation appears to be similar to that of the *Gryphea*-like forms, which repeatedly arose out of the *Ostrea*-like shells in the course of the evolution of the Ostreidae.

B. pacifica n. sp. has been traditionally confused with the geologically younger species *B. crassicollis* s. str. by North American workers (e.g., Anderson, 1938, Pl. 8, figs. 1-7; Jeletzky, 1950, pp. 41-42; Imlay, 1959, pp. 161-4, Pl. 19, figs. 3-6, 9-11, 13-18, 19, 20, 24). Crickmay (1930a, b; 1932, p. 5, footnote 4) was apparently the only North American worker who has correctly used the name *B. crassicollis* s. str.

Among Eurasian workers, Pavlow (1907, Pl. V, figs. 25-26) reproduced *B. pacifica* n. sp. from the Shelton's Ranch near Paskenta, California, under the name of *B. solida* (Lahusen) var. Sokolov (1908b, Pl. II, figs. 3-4) has, however, recognized the distinctiveness of *B. pacifica* and its morphological similarity with *B. inflata* f. typ. et var. *crassa.*

As already pointed out (Jeletzky, 1959, p. 24), the traditional North American use of the name *B. crassicollis* for the *Buchia* form now designated as *B. pacifica* n. sp. is erroneous. *B. crassicollis* s. str. differs from *B. pacifica* n. sp. in the absence of the regular heavy ribbing. *B. crassicollis* s. str. is very finely ribbed or finely striated and the surface of its internal cast is mostly smooth. Only a few deep and broad, irregularly spaced constrictions and welts interrupt this very finely ribbed to smooth surface of the shell. The right valve of *B. crassicollis* s. str. is, as a rule, much thinner than that of *B. pacifica* n. sp. and allied forms; it contrasts strongly with the swollen and strongly arched but not truncated left valve of *B. crassicollis* s. str. whose shape alone resembles that of *B. pacifica* n. sp. Furthermore, the left beaks of *B. crassicollis* s. str. have feeble left-handed incurvature or are straight (Pl. XX, figs. 1, 9, 10), and may even become slightly incurved to right (Pl. XX, fig. 8). This is in strong contrast with the consistently pronounced left-handed incurvature of *B. pacifica* n. sp. The blunt and short, feebly left-handed incurved right beak of *B. crassicollis* s. str. is even more unlike that of *B. pacifica* n. sp. *B. crassicollis* s. str. is, finally, a smaller shell than *B. pacifica* n. sp., it characterizes younger beds and seems to be an offshoot of the Arctic *Buchia* lineage (*see* below). In the Canadian western Cordillera, at least, *B. crassicollis* s. str. and *B. pacifica* n. sp. do not occur together, except in the transitional beds between their zones (e.g., in Nooksack area, Washington; *see* Pl. XXI, figs. 2, 3, 5-7 and in Bridge River area; *see* Pl. XXII, fig. 1) where mixed faunas of both species may occur locally.

Morphological distinctions of *B. pacifica* from the allied forms, such as *B. uncitoides* s. lato and *B. tolmatschowi* s. lato, have already been discussed.

From *B. inflata* f. typ. et var. *crassa* and all hitherto described *Buchia* species of North America and northern Eurasia, *B. pacifica* n. sp. differs in its larger size, thicker and more swollen shell, in the bizarre truncation towards the lower margin and, in many specimens, the 'mushroom-like' shape of both valves. The pronounced left-handed curvature of both beaks is another distinctive feature. Some of these forms (especially *B. inflata* var. *crassa*), may however, be closely similar to some variants of *B. pacifica* in their morphology (*see* below).

In North America, *B. pacifica* n. sp. appears to be restricted to the western Cordilleran belt, where it abounds in its zone everywhere from California to Alaska (*see* below). Outside of western North America it is known only (as *Buchia* aff. *inflata*; Sokolov, 1908b, Pl. II, figs. 3-4) from the Pacific slope of Siberia. The species seems, therefore, to occur only within the marginal regions of the northern Pacific Ocean.

In the Canadian western Cordillera, and apparently also in California (Imlay, 1959, Pl. XIX, figs. 1, 2, 8, 15), the *Buchia pacifica* zone commonly contains variable amounts of other *Buchia* species. Most or all of these *Buchias* are closely allied to or conspecific with *Buchia inflata* (Toula, 1874) f. typ. and var. *crassa* (Pavlow, 1907) (Pl. XVII, figs. 2, 3, 4, 6) and *B. sublaevis* (Keyserling, 1846) s. lato (Pl. XVII, figs. 1, 5). Other than these forms, only *B. keyserlingi* (Lahusen, 1888) s. lato occurs more or less rarely in *Buchia pacifica* zone. All these forms are tentatively interpreted as immigrants from the Canadian Arctic or Pacific slope of Siberia unrelated to *B. pacifica* n. sp. and forming part of the Arctic *Buchia* lineage. The reasons for this interpretation have already been given in connection with the discussion of irreversible, orthogenetic trends in *Buchia.* Some revision of this concept may, however, be necessary as some variants of *B. inflata* s. lato (especially *B. crassa*) seem to intergrade into the typical forms of *B. pacifica* n. sp. (Pl. XVII, fig. 2; Imlay, 1959, Pl. XIX, figs. 3-6, 10, 11, 14, 16-20, 24), in the degree of truncation of their lower parts and that of the left-handed incurvation of their beaks. The same is, furthermore, true of the Russian representatives of this species (Pavlow, 1907, Pl. VI, figs. 7-9; Sokolov, 1908b, Pl. II, figs. 5-6). It is possible, therefore, that *B. inflata* s. lato (or at least some of the forms included by the writer in this comprehensive species) is an offshoot of the North Pacific *Buchia* lineage that became homoeomorphically similar to the mid- to late-Valanginian representatives of the conservative Arctic lineage and spread into the Canadian Arctic and Northern Eurasia.

It seems likely that the Arctic buchias above mentioned are largely restricted to the upper part of *Buchia pacifica* zone throughout the western Cordilleran belt of North America where they may be more numerous than *B. pacifica* n. sp. and its variants. The common association of these forms with *Dichotomites giganteus* and similar ammonites is, in particular, suggestive of this. If so then the *Buchia pacifica* zone may be further subdivisible. More field work is needed, however, to prove or to disprove these phylogenetic and stratigraphic relationships between *B. pacifica* n. sp. and *B.* ex gr. *inflata-sublaevis-keyserlingi.*

Other than phylloceratids and lytoceratids, which are not diagnostic in the present state of our knowledge, the only ammonites found in the *Buchia pacifica* zone of our region are *Neocomites (Parandiceras)* cf. *rota* Spath (Pl. XVI, fig. 5), indeterminate craspeditids, possibly allied to *T. (T.) mutabilis* s. lato, and *Dichotomites* cf. *giganteus* (Imlay, 1960). The first two of these ammonites were found only in the basal beds of the zone on the west coast of Vancouver Island where they are rare. *N. (P.)* cf. *rota* was also found in the same section in the topmost beds of the *Buchia tolmatschowi* zone associated with *T. (T.) mutabilis* s. lato (*see* above). This suggests that the *Tollia (Tollia) mutabilis* zone of Imlay (1960) embraces at least the basal beds of *Buchia pacifica* zone in addition to the uppermost beds of *Buchia tolmatschowi* zone (Fig. 2). *D.* cf. *giganteus* (Imlay, 1960) appears to be common in the upper part of *Buchia pacifica* zone in the Bridge River area, British Columbia (Pl. XVIII, figs. 1, 6, 7).

Age and Correlation

Because of its occurrence between the early Valanginian *Buchia tolmatschowi* zone and the late Valanginian *Buchia crassicollis* s. str. zone, *Buchia pacifica* zone must be largely or entirely of the mid-Valanginian age in the sense of Koenen (1902). It is tentatively correlated with the *Polyptychites keyserlingi* zone (or *Polyptychites michalskii* zone of some Russian workers) of northern Eurasia (Fig. 1). The bulk of the polyptychitid ammonites of the Trail Island fauna of Donovan

(1953, 1957) is believed to represent *Polyptychites keyserlingi* zone of northern Eurasia and *Buchia pacifica* zone of the western Cordilleran belt of North America. *B. pacifica* n. sp. is apparently completely absent in East Greenland and replaced there by *B. keyserlingi* and allied Arctic *Buchia* forms (Fig. 2).

In the Canadian Arctic and northeastern British Columbia *Buchia pacifica* zone should correspond to the middle part of *Buchia keyserlingi* zone where *Polyptychites* ex gr. *keyserlingi* s. lato and *Dichotomites* cf. *giganteus* occur locally (Jeletzky, 1958, 1960, 1961a,b; this paper, Fig. 2). In northeastern British Columbia a peculiar small *B.* aff. *pacifica* characterized by strong swelling and truncation of the lower margins of both its valves combined with very fine ribbing, occurs locally in this part of *Buchia keyserlingi* zone, which confirms the above correlation. A very similar and probably conspecific *Buchia* form has been described and figured by Imlay (1959, p. 161, Pl. XVIII, figs. 1-6, 11) from Alaska under the name of *B. sublaevis* (Keyserling, 1846). This form differs, however, from the Russian species concerned in the already mentioned marked truncation of the lower margins of both valves. In Alaska "*B. sublaevis*" occurs directly below *A. crassicollis* Keyserling emend. Imlay, 1959. The local occurrence of *B. keyserlingi* f. typ., *B. inflata* f. typ. et var. *crassa,* and *B. sublaevis* var. *majuscula* (Pl. XVII, fig. 1) in *B. pacifica* zone of the Canadian western Cordillera further supports the external correlation of this zone proposed here.

B. pacifica n. sp., like *B. uncitoides* and *B. tolmatschowi,* appears to be an indigenous North Pacific species and the last evolutionary stage of the indigenous *Buchia* lineage (*see* below and Fig. 3). The contemporary *Buchia* faunas of the American and European Arctic appear to lack *B. pacifica* n. sp. and are dominated by unrelated local species, members of the Arctic *Buchia* lineage (e.g., *B. keyserlingi, B. sublaevis,* and *B. inflata* f. typ. et var *crassa*). As already mentioned, only sporadic representatives of these Arctic species penetrated into the western Cordilleran belt of North America during *B. pacifica* time.

All Arctic forms of *Buchia* (*B. keyserlingi, B. inflata* f. typ. et var. *crassa*) occurring in *Buchia pacifica* zone of the Canadian western Cordillera are considered by Russian workers to be diagnostic of the so-called '*Tollia stenomphala*' zone and they have been reported to occur in association with *B. tolmatschowi* et var. *americana* in Eastern Siberia (Sokolov, 1908b). Whether this apparent mixture of two zonal *Buchia* faunas is due to lack of accurate collecting or to other reasons is not known (*see* under the discussion of age and correlation of *Buchia uncitoides* zone).

In California, *Buchia pacifica* zone must correspond to the upper part of the comprehensive '*Aucella crassicollis* zone' of Imlay (1959, 1960). There *Buchia pacifica* zone apparently includes all *Buchia*-bearing beds overlying the beds characterized by the association of *B. tolmatschowi* s. lato, *B. pacifica* n. sp. and *Tollia (Tollia) mutabilis* s. lato (CAS loc. 1349 near Paskenta, Cal.). Even the topmost *Buchia* beds of California characterized by a mixed fauna of *B. pacifica* n. sp. and *B. crassicollis* s. str. (CAS locs. 144 and 35502) are believed to be in the top part of *Buchia pacifica* zone because of the occurrence of *Dichotomites giganteus* and absence of *D. quatsinoensis*. This correlation is confirmed by the presence of the rich fauna of typical *Buchia pacifica* et var. uncontaminated by the faunal elements of adjacent *Buchia* zones at the University of California, Berkeley loc. A-7296. Another collection of similarly typical *Buchia pacifica* fauna has been made available by Mr. Stewart Chuber, Stanford University from Glenn County, Elk Creek Quadrangle (15). Exact locality is: "Map 1948, 1:62500, Survey Coordinates: NE1/4 NE1/4 SE1/4, Sec. 16, T. 20N, R. 6W. Unit No. 4, 16,000 feet above base, Salt Creek Section; 50 yards E of N of Stony Gorge Dam in greywackes bearing coquinoid *Buchia crassicollis*." More field work is needed for a more precise delimitation of *Buchia pacifica* zone in California and Oregon from the refined *Buchia* zones underlying and overlying it.

Buchia crassicollis s. str. Zone

Stratigraphy

Except for the undocumented record of *Buchia teutoburgensis* (Weerth) from the presumably Hauterivian *Yaadia lewisagassizi* beds of the Harrison area (Crickmay, 1930a, p. 49; 1962, p. 9) and other, similarly unsupported, records discussed by Imlay (1959, pp. 163-4), *B. crassicollis* s. str. is the youngest *Buchia* species known in the Canadian western Cordilleran region. No younger *Buchia* species are authentically known to exist anywhere in the whole of the western Cordilleran belt of North America. *Buchia crassicollis* zone is widespread in this vast region.

Only *B. crassicollis* s. str., *B. c.* var. *solida* and *B. c.* var. *gracilis* Lahusen, 1888 *non* Sokolov, 1908 are common in this zone, except for its basal beds where mixed faunas of *Buchia crassicollis* s. str. and *Buchia pacifica* zones may occur locally. *B. sublaevis* (Keyserling s. lato), *B. keyserlingi* (Lahusen) and its extreme, giant variant *B. keyserlingi* var. *gigas* (Crickmay, 1930a) occur rarely in some parts of *Buchia crassicollis* s. str. zone in the Canadian western Cordillera.

Buchia crassicollis s. str. zone is unknown on the west coast of Vancouver Island where the early Lower Cretaceous succession ends somewhere in the middle part of *Buchia pacifica* zone (*see* above, and Jeletzky, 1950, p. 42). It is, however, widespread in Quatsino Sound. There *Buchia crassicollis* s. str. zone is the oldest Cretaceous zone known (Fig. 4) and overlaps transgressively middle Jurassic intrusive rocks (Coast intrusions). The same seems to be true in San Juan Islands (McLellan, 1927, and Fig. 4), where on Spieden Island only *Buchia crassicollis* s. str. fauna has been found so far in the Spieden Island Formation. However, in the Harrison Lake, British Columbia and Nooksack, Washington areas *Buchia crassicollis* s. str. zone overlies older *Buchia* zones (including *Buchia pacifica* zone) in apparent conformity. A short period of volcanic activity preceded the deposition of *Buchia crassicollis* s. str. zone in the Harrison Lake area (Fig. 4). As already mentioned, *Buchia crassicollis* zone appears to be absent (a hiatus?) in California (Fig. 2) although the topmost *Buchia*-bearing beds in California could conceivably include its basal part in addition to the topmost beds of *Buchia pacifica* zone.

Isolated collections of *Buchia crassicollis* s. str. fauna are known from several other areas of British Columbia, southwestern Yukon and Alaska (Imlay, 1959, Pl. 19, fig. 12). No information is available about their stratigraphic relationships with other *Buchia* zones described in this report. It is assumed, however, that *Buchia crassicollis* s. str. zone occurs in the same stratigraphic position in these areas as it does in the better known sections of the Canadian western Cordillera and northwestern Washington.

Palaeontology

A representative suite of *Buchia crassicollis* s. str. and its morphological varieties *solida* (Lahusen, 1888) and *gracilis* (Lahusen, 1888 *non* Sokolov, 1908) from Quatsino Sound, the Nooksack area, Washington and Spieden Island (San Juan Islands, Washington) is reproduced in Plates XX and XXI. Representatives of *B. keyserlingi* var. *gigas* (Crickmay 1930a) from *Buchia crassicollis* s. str. zone of the Harrison Lake area (Pl. XIX, fig. 1; Pl. XX, fig. 16) and the mid- to late-Valanginian rocks of East Greenland (Pl. XIX, figs. 1, 5) are also reproduced herein, as well as *B. pacifica* n. sp. from *Buchia crassicollis* zone of the Nooksack area (Pl. XXI, fig. 3) and *B.* aff. *crassicollis* var. *solida* from the same beds of Bridge River area (Pl. XXII, fig. 1).

B. crassicollis s. str. is a small to medium-sized, relatively short and plump shell; it is normally completely devoid of the regular, heavy ribbing characteristic of *B. pacifica* n. sp. Its surface shell is either finely to very finely and closely ribbed (Pl. XX, fig. 11A; Pl. XXI, figs. 5-7) or finely striated (Pl. XX, fig. 8), and its internal casts are mostly smooth (Pl. XX, figs. 1, 9, 10; Pl. XXI, fig. 2). Only a few deep and broad, irregularly spaced constrictions and welts interrupt the surface of the shell or that of the internal cast (Pl. XX, figs. 1, 9, 10, 11; Pl. XXI, figs. 5B, 7B). The right valve is much thinner than the left and its subtriangular, feebly convex shape (Pl. XX, figs. 8B-8C, 11A, B; Pl. XXI, fig. 6B) contrasts strongly with that of the thick, swollen, strongly convex and hook-like bent left valve (Pl. XX, figs. 1, 8, 10). Both valves mostly taper gradually and more or less evenly toward the lower margin from the place of their maximum thickness at or near the middle part of the shell (Pl. XX, figs. 1B, 9B, 10B, 12B). Only in some representatives of *B. c.* var. *solida* Lahusen 1888 (Pl. XX, fig. 8C) does the lower part of the shell become more or less markedly truncated in anterior-posterior aspect and reminiscent of the extreme, late forms of *B. pacifica* var.? (Pl. XXI, fig. 3).

The beak of the right valve is short, small, moderately sharp and somewhat incurved to left (Pl. XX, figs. 8B,C, 11; Pl. XXI, fig. 6). The left beak is, on the contrary, long, essentially straight or only feebly incurved to left (Pl. XX, figs. 1, 9, 10 and 12). Beaks with slightly right-handed incurvature may occur rarely in *B. crassicollis* s. str. (Pl. XX, fig. 8A). The beak is strongly bent downward and more or less strongly coiled (Pl. XX, figs. 1B, 10B, 12A; Pl. XXI, figs. 2B, 5B, 7B). The left beak more or less markedly overhangs the much smaller right beak (Pl. XX, fig. 8C). The morphology, evolutionary grade, and infraspecific variation of the byssus ear have already been described in connection with discussion of the irreversible orthogenetic trends in *Buchia.*

The morphological distinctions of *B. crassicollis* s. str. from other *Buchia* species have already been discussed in connection with the description of the older *Buchia* species of our region.

B. crassicollis s. str. is here interpreted essentially from the description and figures of Lahusen (1888, pp. 24-25, Pl. V, figs. 8-16). Lahusen's (1888) work is the oldest publication that permits the unequivocal interpretation of *B. crassicollis* s. str. as now used by Eurasian workers. The writer is unable to interpret with certainty the original description and figures of *B. crassicollis* (Keyserling, 1846, p. 300, Pl. XIV, figs. 9-12). Taken at face value, they could represent either *B. crassicollis* Lahusen, 1888 or some of its older homoeomorphs, such as *B. gracilis* Sokolov, 1908 *non* Lahusen, 1888, or *B. tolmatschowi* var. *americana* Sokolov, 1908. The writer follows, however, the Russian workers who have always unreservedly accepted the specific identity of *B. crassicollis* (Keyserling, 1846) with the *Buchia* forms so clearly figured and described under the same name by Lahusen (1888) and Sokolov (1908a). Should these two forms prove to be specifically distinct, it would be necessary to use the name *B. solida* (Lahusen, 1888) for the species here referred to as *B. crassicollis* (Keyserling, 1846) s. str. This possible nomenclatural change would neither revive the traditional North American use of the name *B. crassicollis* nor affect the writer's introduction of the new name *B. pacifica* n. sp. for the North American form hitherto known under the name of *B. crassicollis.*

The stratigraphic relationships between *B. pacifica* n. sp. and *B. crassicollis* s. str. and the occurrence of the mixed faunas of these two species near the boundary of their zones are somewhat suggestive of *B. crassicollis* s. str. being a direct descendant of *B. pacifica* n. sp. Some of the *Buchia* forms occurring in these mixed faunas seem to be morphologically transitional between the two species concerned (Pl. XXI, fig. 3; Pl. XXII, fig. 1). None of the critical sections was, however, collected bed by bed. It is, thus, unknown whether *B. pacifica* n. sp. actually transmutates into the younger *B. crassicollis* s. str. in a sequence of morphologically overlapping palaeontological populations or whether the mixed faunas concerned are caused by the accidental chronological and palaeozoogeographical overlap of two homoeomorphically similar but unrelated *Buchia* species. The convergent evolution in nearly contemporary species belonging to allied but independent lineages is a common phenomenon in the geological history of a great many fossil groups; it has already caused many errors in the interpretation of the genetic relationships of the species concerned. It is, therefore, impossible to make any definite conclusions about the genetic connection between *B. pacifica* and *B. crassicollis* s. str. There is, furthermore, other evidence opposed to their genetic connection. The shell morphology of *B. crassicollis* s. str. is, for example, very similar to that of the finely ribbed and relatively thick representatives of *B. keyserlingi* and

B. sublaevis, especially of the *'crassicollis*-like' forms of these species. This similarity was already noted by Sokolov (1908a, pp. 23, 25) and treated as indicative of the genetic affinity of *B. crassicollis* s. str. with the *B. keyserlingi* species group. The presence of *B. keyserlingi*-like variants (Pl. XXI, figs. 5, 7) in some population samples of *B. crassicollis* s. str. supports this conclusion; all the more so as these samples seem to represent the basal beds of *Buchia crassicollis* zone.

The stratigraphic relationships of *Buchia* forms concerned are compatible with *B. crassicollis* s. str. being a specialized offshoot of the *B. keyserlingi-sublaevis-inflata* lineage. *B. crassicollis* s. str. is widespread in northern Eurasia (*see* below) and its zone rests disconformably or even unconformably on older rocks in several areas of the Canadian western Cordillera. All these data support the interpretation of *B. crassicollis* s. str. as an offshoot of the conservative Arctic *Buchia* lineage brought into the North Pacific faunal realm of North America by the late Valanginian transgression (Fig. 3).

The shell morphology of *B. crassicollis* s. str. fits well into the previously discussed general evolutionary trend of the conservative Arctic *Buchia* lineage but does not fit at all into that of the North Pacific *Buchia* lineage of North America. To interpret it as a direct descendant of *B. pacifica* n. sp. one would have to assume that the previously discussed 'irreversible orthogenetic trend' in the evolution of the beaks ceased to be operative and became suddenly reversed in the North Pacific *Buchia* lineage in late Valanginian time. Although admittedly possible, this seems to be less probable than above discussed alternative interpretation of the origin of *B. crassicollis* s. str.

Considering all data available, the writer tentatively assumes *B. crassicollis* s. str. to be an offshoot of the conservative Arctic *Buchia* lineage rather than an immediate descendant of *B. pacifica* n. sp. (Fig. 3). Additional field work and careful fossil collecting in the critical sections of the western Cordilleran belt of North America and Northern Eurasia is needed for a final solution of the problem of its origin.

The ammonite *Dichotomites quatsinoensis* (Whiteaves, 1882) is common in the lower part of *Buchia crassicollis* zone in British Columbia and northwestern Washington (Pl. XX, figs. 2-7, 13-15; Pl. XXI, figs. 4, 9-11). This species was originally described and figured by Whiteaves (1882, p. 82, Fig. 1) as *Olcostephanus quatsinoensis.* The close similarity of the type specimens of *O. quatsinoensis* to *Ammonites (Olcostephanus) bidichotomus* Leymerie has been rightly stressed in the original description. Later Whiteaves (*in* Dawson, 1887, p. 114B) redescribed *O. quatsinoensis* under the name of *Scaphites quatsinoensis.* The type material is from the lower part of *Buchia crassicollis* zone of Forward Inlet, Quatsino Sound, where the species is fairly abundant.

D. quatsinoensis (Whiteaves, 1882) has been described by McLellan (1927, p. 115, Pl. 12, figs. 3-5) under the name *Holcodiscus*? *stantoni* n. sp. and by Crickmay (1930a, pp. 63-4, Pl. 21, figs. 1-4) under the name *Homolsomites poecilochotomus* n. sp. Neither of these workers was aware of the previous publication of the species by Whiteaves (1882, 1887). Imlay (1956, pp. 1143-46, Pl.

120) recognized that *Homolsomites poecilochotomus* Crickmay, 1930 is a junior synonym of *Holcodiscus*? *stantoni* McLellan, 1927. Jeletzky (1959, p. 24) pointed out the priority of *Olcostephanus quatsinoensis* Whiteaves, 1882 over *Holcodiscus*? *stantoni* McLellan, 1927.

Whiteaves' (1882, Fig. 1) figured holotype of *O. quatsinoensis* and his unfigured paratype of the species are reproduced (Pl. XX, figs. 4, 14), together with three small topotypes collected by the writer (Pl. XX, figs. 3, 5, 15). The holotype and one of the paratypes of Crickmay's (1930a, Pl. 21, figs. 2 and 4) *Homolsomites poecilochotomus* from the *Buchia crassicollis* zone of the Harrison Lake area are reproduced (Pl. XX, fig. 13; Pl. XXI, fig. 11) to demonstrate their specific identity with *O. quatsinoensis.* Several topotypes of *Holcodiscus*? *stantoni* McLellan, 1927 (Pl. XX, figs. 2, 6, 7; Pl. XXI, fig. 4) are reproduced for the same purpose.

O. quatsinoensis is here provisionally placed in the *Dichotomites* Koenen, 1909 s. lato because of its characteristic suture line, predominance of bidichotomous ribbing habit in the middle stages of growth, subtriangular cross-section of the whorl in adult state, loss of the ribbing in the middle of the flanks in adult state, and the presence of weakly developed but nevertheless swollen primary ribs near the umbilical margin of the living chamber (Pl. XXI, fig. 11). The names *Neocraspedites* Spath, 1924 and *Homolsomites* Crickmay, 1930a are, in the writer's opinion, junior synonyms of *Dichotomites.* The morphology of *D. quatsinoensis* and its distinctions from *Tollia (Tollia) mutabilis* s. lato have already been discussed.

The closely related and possibly ancestral *Dichotomites* cf. *giganteus* (Imlay, 1960) (Pl. XVIII, figs. 1, 6, 7) occurs in the upper part? of *Buchia pacifica* zone in Bridge River area. This form differs from *D. quatsinoensis* in the better-developed swelling of primary ribs near the umbilical margin (Pl. XVIII, fig. 7A), wider umbilicus (Pl. XVIII, fig. 1), markedly flexed appearance of ribs, lack of the well-defined bidichotomous ribbing habit in the middle stages of growth (Pl. XVIII, fig. 6A) and considerably shorter, thicker and less frilled lateral and auxiliary lobes (Pl. XVIII, figs. 6A, 7B). This early *Dichotomites* form may possibly be a connecting link between *Tollia (Tollia) mutabilis* (Stanton, 1895) and more advanced representatives of the genus *Dichotomites* Koenen s. lato.

Among European species, *Dichotomites complanatus* Koenen (1902, Pl. V, figs. 11-13; Pl. VI, figs. 18, 19) appears to be the closest known ally of *D. quatsinoensis. D. undulatus* Koenen (1902, Pl. V, figs. 5-7) and *carteroni* (d'Orbigny) (1841, p. 209, Pl. 61, figs. 1-3) are other closely related forms. *D. quatsinoensis* differs from these mainly in the absence or feeble development of the swollen primary ribs near the umbilical margin in the late stages of growth. This distinction is merely quantitative, as the holotype of Crickmay's (1930a, Pl. 21, fig. 2; this report, Pl. XXI, fig. 11) *Homolsomites poecilochotomus* has weakly developed, but nevertheless swollen, primary ribs near the umbilical margin. Other distinctions of *D. quatsinoensis* from the European forms, such as the greater forward projection of the secondaries on the venter and somewhat denser and coarser ribbing in the early stages of growth, are even more trivial.

Age and Correlation

All European allies of *D. quatsinoensis* are early Upper Valanginian forms in the sense of Koenen (1902, p. 33). This indicates the general late Valanginian age of the restricted *Buchia crassicollis* zone of our region (Fig. 1). Its lower part carrying *D. quatsinoensis* is presumably older than the *Saynoceras verrucosum* zone of the uppermost Valanginian. In the boreal realm of northern Eurasia the restricted *Buchia crassicollis* zone should correspond to the *Polyptychites polyptychus* and *Dichotomites bidichotomus* zones, which overlie the mid-Valanginian *Polyptychites keyserlingi* zone.

There is little doubt that *Buchia crassicollis* zone, as here restricted, corresponds to *Olcostephanus pecki* zone of Imlay (1960, pp. 175-6). This is indicated by the association of *D. quatsinoensis* with *O. pecki* in northwestern Washington, by the occurrence of *Olcostephanus pecki* at the very top of the Valanginian (i.e. *Buchia*-bearing) sequence in Oregon, and by the occurrence of *Tollia (Tollia) mutabilis* zone in California, Oregon and British Columbia several hundred feet below *Buchia crassicollis* zone that locally contains *D. quatsinoensis*. The occurrence of *D. giganteus,* as well as the absence of *O. pecki* and *D. quatsinoensis* in the topmost *Buchia*-bearing beds of California agrees well with the assumed absence of *Buchia crassicollis* zone there (Fig. 2).

Unlike older Lower Cretaceous North Pacific *Buchia* faunas, *B. crassicollis* s. str. fauna is widespread in the southern part of European Russia and in some parts of Siberia (Lahusen, 1888, Pavlow, 1907, Sokolov, 1908a). In the European Arctic it is present in Timan region, in Spitsbergen, and in King Charles Land (Sokolov, 1908a; Frebold, 1929, 1930, p. 43, Pl. XV, fig. 4). In contrast it is unknown in East Siberia (Sokolov, 1908, pp. 15-17), Greenland (according to the writer's survey of the literature and the revision of *Buchia* collections from Trail Island and Wollaston Forland provided by Dr. D. T. Donovan), Bol'shezemel'skaya Tundra (Sokolov, 1926, p. 38), and other areas of the European Arctic. Its stratigraphic position in relation to other *Buchia* zones and to the standard ammonite zones is not clear in northern Eurasia. Nor does any clear geographical regularity in the absence or presence of *B. crassicollis* s. str. in these regions emerge from perusal of the literature. This possibly results from the frequent occurrence of mixed *Buchia* faunas, and especially from the association of *B. crassicollis* s. str. with the stratigraphically and/or taxonomically misinterpreted late Valanginian forms of the *B. keyserlingi-sublaevis-inflata* lineage. The alleged association of *B. crassicollis* s. str. with mid-Valanginian *Buchia* forms and with those of *"Tollia stenomphala"* zone may have been caused by misidentification of *B. tolmatschowi* var. *americana* and other early to mid-Valanginian homoeomorphs (e.g. *B. crassicollis* var. *gracilis* Sokolov, 1908 *non* Lahusen, 1888). It is, perhaps, significant in this connection that Sokolov (1908b, pp. 15-17; 1926, p. 38) did not find any undoubted *B. crassicollis* s. str. in association with *B. inflata* et var. *crassa, B.*

pacifica n. sp., *B. tolmatschowi* var. *americana,* and *B. crassicollis* var. *gracilis* Sokolov, 1908 *non* Lahusen, 1888 in Eastern Siberia and Bol'shezemel'skaya Tundra. Sokolov (1908b, p. 17, genetical diagram) considers, furthermore, that the true *B. crassicollis* is a younger species than any of the forms mentioned here.

In North America *B. crassicollis* s. str. seems to be absent in the Arctic Canada east of Alaska. Nor has it yet been recorded from northeastern British Columbia. This was believed to be due to a regional regression of the sea from these areas during the mid-Valanginian time (Jeletzky, 1958, 1960, 1961a,b). The more recent finds of ammonites closely comparable with *Dichotomites quatsinoensis* and *D. giganteus* in northeastern British Columbia and Canadian Arctic Archipelago (Ellef Ringnes Island) in association with representatives of *Buchia keyserlingi-sublaevis-inflata* lineage indicate, however, that the absence of *B. crassicollis* s. str. in these regions is due to palaeozoogeographical rather than stratigraphical reasons. During late Valanginian time, Arctic Canada and northeastern British Columbia apparently belonged to the same faunal realm as East Greenland where *Buchia* of the *keyserlingi-sublaevis-inflata* group (Pl. XIX, fig. 5) range up into the highest Valanginian beds of Mount Niesen section and *B. crassicollis* s. str. appears to be absent. The occurrence of *Lyticoceras* in the highest *Buchia*-bearing Valanginian rocks of the Mount Niesen section in Greenland (Donovan, 1957, p. 64, 68-72, Fig. 13) indicates the late Valanginian age of these beds and their contemporaneity with *Buchia crassicollis* s. str. zone of the North Pacific faunal realm. *Buchia keyserlingi-sublaevis-inflata* fauna of this section includes, furthermore, giant forms apparently identical with *B. keyserlingi* var. *gigas* Crickmay, 1930a (Pl. XIX, figs. 1, 5; Pl. XXI, fig. 1) from the *Buchia crassicollis* s. str. zone of Harrison Lake area. This further supports the writer's conclusion that the upper part of *Buchia keyserlingi-sublaevis-inflata* zone of northeastern British Columbia. Arctic Canada, and East Greenland is but the faunal facies of *Buchia crassicollis* s. str. zone of the western Cordilleran belt of North America (Fig. 2).

Latest Valanginian Rocks?

As the age of the top part of *Buchia crassicollis* zone of the Canadian western Cordillera in terms of the ammonite zones of European Upper Valanginian is not definitely established, the uppermost Valanginian rocks of our region may possibly be represented by the unfossiliferous sandstone, locally occurring (e.g., in Quatsino Sound) between the *Buchia crassicollis* s. str. zone and the early Hauterivian *Dichotomites oregonensis* zone. The latter zone is beyond the scope of this report. It is, however, more probable that *Buchia crassicollis* s. str. zone embraces all of the Upper Valanginian, including *Saynoceras verrucosum* zone (Fig. 1). This, in particular, is suggested by the circumstance that *D. quatsinoensis* is apparently restricted to the lower part of *Buchia crassicollis* s. str. zone in the Canadian western Cordillera and in Washington (Imlay, 1960, p. 175).

PROVINCIAL CHARACTER OF FAUNAS

A peculiar but biochronologically important feature of the late Upper Jurassic and early Lower Cretaceous marine faunas of the Canadian western Cordillera is their mixed character. The same is true of the entire western Cordilleran belt of North America from Alaska to California. Some of the zonal faunas discussed in the preceding pages are characterized by a rather unusual association of the Tethyan (mostly Andean and/or Indo-Pacific) ammonites and *Buchia* species with the local ammonites and *Buchia* species and/or the well-known boreal ammonites and buchias. In other instances the boreal faunas alternate either with the Andean or/and Indo-Pacific faunas or with the indigenous faunas. This faunal mixture greatly facilitates interregional correlation of the late Upper Jurassic and early Lower Cretaceous rocks of our region and their placement in the international standard stages based on sections of southwestern Europe containing Tethyan faunas (Fig. 1). The faunal sequence of the Canadian western Cordillera, plays an important role in clarifying, for the first time, the time relationships between several classical Berriasian and Valanginian zones of the Tethyan province and the early Neocomian boreal zones (Fig. 1). The faunal sequence of the Canadian western Cordillera is more valuable in this respect than the mixed faunal sequences of the Central Russia (Ryasan province) and the northern Caucasus, which include only one or two mixed faunas and are partly (e.g., in Ryasan province) represented by condensed deposits.

PHYLOGENY AND ZOOGEOGRAPHY OF NORTH AMERICAN *BUCHIA* SPECIES

Pompeckj (1901, pp. 341-9, Pl. XVII), Pavlow (1907, table opp. p. 84), and Sokolov (1908a,b) concluded that most or all of the *Buchia* species of northern Eurasia and European Arctic ranged over western and northwestern North America and that either few or no local *Buchia* species existed in North America. According to these workers, some of the Eurasian and Arctic *Buchia* species ranged even into South America (*B. crassicollis* var. *brasiliensis* White, *B. terebratuloides* Lahusen), Indian Peninsula (*B. concentrica* (=? *B. bronni*) var. *leguminosa* Stoliczka, *Buchia mosquensis* s. lato) and New Zealand (*B. crassicollis*). These conclusions have been and are still generally accepted as valid the world over, particularly by almost every modern North American worker, including Anderson (1938, 1945) and Imlay (1957, 1959). The description of the late Upper Jurassic and early Lower Cretaceous *Buchia* species of the Canadian western Cordillera given in this report shows, however, that the evolutionary history of the genus *Buchia* (= *Aucella*) is much more complex than hitherto believed by North American and Eurasian workers.

A great many important details of the evolutionary history of *Buchia* still remain obscure. Enough is known, however, to assert that the development of North American *Buchia* species often proceeded independently from that of the contemporary species of the European Arctic and northern Eurasia. As the fullest possible understanding of the evolutionary history of the North American *Buchia* species is a necessary safeguard for their proper biochronological use, an attempt will be made herein to summarize our knowledge of the subject.

Pompeckj (1901, pp. 341-9, Pl. XVII) concluded that the evolutionary centre of the *Buchia* was situated in the vast circumboreal Arctic (or boreal) realm during most or all of its known time range (at least from the late Callovian to the late Valanginian). This conclusion is undoubtedly valid. All students of *Buchia* agree that its principal, circumboreally ranging species form an uninterrupted lineage beginning with *Buchia lata-B. concentrica* (=? *B. bronni*) species group and ending with *Buchia keyserlingi-sublaevis-inflata* (or with *Buchia crassicollis* s. str.) species group (e.g., Lahusen, 1888, p. 26; Pompeckj, 1901, p. 399; Sokolov, 1908a, pp. 4-7, 1908b, p. 17). Pavlow (1907, table opp. p. 84) is the only exception. His alleged "genetical series" of *Buchia* are, however, only morphological series bearing no relation whatsoever to the evolutionary lineages of the genus.

In the writer's opinion, the genetic relationships of the principal, circumboreally ranging *Buchia* species are even simpler than was believed by the abovementioned workers (Fig. 3). Most of the specialized offshoots of this *Buchia* lineage postulated by them seem to be nonexistent; they were postulated because of the exceedingly narrow and strictly typological species concept of these workers. Even Sokolov (1908a, b, 1926) did not appreciate the range of intraspecific variation in *Buchia* species, treating most of their extreme morphological variants (not to mention geographical subspecies) as full species and evolutionary stages of independent lineages. In the understandable, and laudable protest against the excessive splitting of *Buchia* species, Imlay (1959) recently leaned too far in the opposite direction and lumped together several polytypical *Buchia* species considered by the writer to be indubitably valid.

The principal *Buchia* lineage that inhabited a vast circumboreal Arctic (or boreal) realm of the late Jurassic and early Lower Cretaceous times was already named the conservative Arctic lineage for reasons already fully discussed in connection with the description of the evolution of the beaks and byssus ears in *Buchia.*

The study of extensive fossil collections from Arctic Canada and East Greenland, as well as the study of the regional literature and field work (Jeletzky, 1958, 1959, 1960, 1961a-b), indicates that the geographical ranges of most or all the principal species of the conservative Arctic (or boreal) *Buchia* lineage included Greenland, Arctic Canada, and northeastern British Columbia; they show essentially the same genetic relationships there as in northern Eurasia (Fig. 3). These North American regions form, therefore, part of the evolutionary centre of *Buchia* and their sequence of *Buchia* zones is essentially the same as that of northern Eurasia, Spitsbergen, and King Charles Land (Fig. 2). Minor deviations in the evolutionary history and zonal sequence of *Buchia* species in these subprovinces of the boreal realm (e.g., the presence or absence of *Buchia crassicollis* s. str. zone or occurrence of *Buchia* aff. *pacifica* zone in northeastern British Columbia) are deliberately disregarded in this generalized account of the *Buchia* evolution.

The relationships in the Indo-Pacific faunal realm are altogether different. As already emphasized, even *Buchia plicata-blanfordiana-subpallasi* species group of this realm appears to be an indigenous stock, perhaps even a lineage, albeit derived from and still closely allied to the boreal *Buchia mosquensis* (Buch) species group (Fig. 3).

So far as the *"Buchia" malayomaorica* stock is concerned, the undeservedly neglected conclusion of Crickmay (1932, p. 5, footnote 6) that: *"Aucellae* from the more southerly localities, e.g. India, and New Zealand, are very different, and hardly congeneric" appears to be correct. Not only are the time ranges of the representatives of this Indo-Pacific *Buchia* stock quite different from those of the morphologically similar *Buchia concentrica* (=? *bronni*) — *B. lata* species group of the boreal realm (Fleming, 1960, pp. 267-8, table 1; this report, Figure 3), but their hinge structure is peculiar in several respects (Fleming, 1958, pp. 378-9, Figs. 6-7, 9). The *"Buchia" malayomaorica* stock (a lineage?) may well be an independent offshoot of *Meleagrinella* or another pseudomonotid genus that became homoeomorphically similar to the *Buchia concentrica* (=? *bronni*) — *B. lata* species group of the boreal realm. Further discussion of this fascinating taxonomic problem is beyond the scope of the present report[1].

The faunal relationships in the western Cordilleran belt of North America are rather complex and often different from either those in the boreal or those in the Indo-Pacific faunal realm. As one would expect, because of the close geographical proximity of the western Cordilleran belt to the boreal realm, the boreal affinities of its *Buchia* faunas are mostly much stronger than their Indo-Pacific affinities.

As far as we know, and the reliable data are mostly scarce, the Oxfordian to mid-Portlandian rocks of the western Cordilleran belt of North America are characterized by the same *Buchia* species as those of northeastern British Columbia, Alberta, Arctic Canada, and the rest of the boreal realm. These species occur in the same stratigraphic order and seem to have the same genetic ties in western North America as in the other regions above-mentioned (Fig. 3). It is not yet known, however, whether or not the evolutionary development of Oxfordian to mid-Portlandian (s. str.) *Buchia* species of western North America duplicated that of the Arctic *Buchia* species in all essential details. The occurrence of the Indo-Pacific elements (e.g., *B. concentrica* var. *leguminosa* Stoliczka and *B.* ex gr. *spitiensis* Holdhaus) in the late Oxfordian and/or early Kimmeridgian *Buchia* faunas of Vancouver Island has, for example, been claimed by Jeletzky (1950). Similar forms were subsequently found by Imlay (1957, 1959) in the late Oxfordian or early Kimmeridgian rocks of Alaska. It is, however, still uncertain whether these *Buchia* forms are true connecting links between the boreal *Buchia* lineage and the *Buchia spitiensis* stock of the Indo-Pacific realm or merely boreal homoeomorphs of this latter. Only additional field work and careful collecting can solve this problem.

The faunal relationships change abruptly in latest Portlandian (?) time (Fig. 1), as the *Buchia* cf. *blanfordiana* fauna of the Canadian western Cordillera and Alaska is apparently an enclave of the Indo-Pacific faunal realm in the western Cordilleran belt of North America (Fig. 3). This *Buchia* species appears to be unrelated to the next older *Buchia* fauna of the region dominated by *Buchia piochii* var. *russiensis* (Pavlow) and allied boreal forms and an offshoot of the *Buchia plicata-blanfordiana-subpallasi* species group. *B.* cf. *blanfordiana* of the western Cordillera region apparently died out without issue, just as its Indo-Pacific relatives did (Fig. 3). Some revision of this concept may, however, be necessary in the future as we know almost nothing about the Upper Tithonian *Buchia* faunas of the Canadian western Cordillera and only assume them to be identical with those of the boreal realm.

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[1] Since this was written, the writer was able to undertake a special study of "*Buchia*" *malayomaorica* (Krumbeck, 1923) and found it to be an unrelated homoeomorph of *Buchia concentrica* (Sowerby) more closely related to *Meleagrinella* than to *Buchia*. A new genus *Malayomaorica* had to be erected to receive "*Buchia*" *malayomaorica*. This genus properly belongs in the subfamily Oxytominae Ichikawa, 1958 together with *Meleagrinella*, *Aucellina*, and *Arctotis*. The results of this study just appeared in *Palaeontology* (London), vol. 6 (1), pp. 148-160, pl. 21, 1963.

The *Buchia* cf. *blanfordiana* fauna of northwestern Washington, British Columbia, and Alaska appears to be surrounded by the boreal *Buchia* faunas on three sides, unless the rare and insufficiently understood *B*. aff. *B*. *mosquensis* and *B*. cf. *B*. *mosquensis* of Anderson (1945, Pl. IV, fig. 12; Pl. XII, fig. 3) should prove to be the Californian representatives of *B*. cf. *blanfordiana*. The latest Portlandian and early Upper Tithonian (or for that matter latest Jurassic) *Buchia* faunas of California, northeastern British Columbia, and northern Alaska seem to lack any Indo-Pacific elements whatsoever; they are at any rate completely dominated by *Buchia piochii-fischeriana* species group. These faunal relationships may well be due to the fragmentation of the western Cordilleran geosynclinal belt of North America in the wake of the Nevadan orogeny. They could also be caused by the oceanic currents or variation in the climatic conditions. The remarkable uniformity of the Oxfordian to mid-Portlandian *Buchia* faunas suggests, on the contrary, easy marine connections between all parts of geosynclinal belt prior to the Nevadan orogeny and/or the far-reaching uniformity of the climatic conditions all over this belt.

The latest Jurassic *Buchia fischeriana* fauna is so far unknown in the Canadian western Cordillera. It is assumed, however, that it is (or was) present there, as it is present in California, Oregon and Alaska (Fig. 3).

The lowermost Cretaceous *Buchia* faunas of the western Cordilleran belt of North America, appear to be direct descendants of the Upper Tithonian *Buchia fischeriana-piochii-terebratuloides* species group, i.e., direct descendants of the conservative Arctic *Buchia* lineage (Fig. 3). This applies to both *B*. *okensis* s. lato and *B*. *uncitoides* s. lato. The former species occurs throughout western North America, just as its immediate ancestor *B*. *fischeriana* s. lato does. This apparently reflects the widespread boreal transgression during latest Jurassic and earliest Cretaceous times and/or the far-reaching levelling of the climatic conditions throughout northern Eurasia, Arctic and North America.

B. *uncitoides* s. lato is much more restricted geographically than are either *B*. *okensis* s. lato or *B*. *fischeriana* s. lato. This species occurs in eastern Siberia, southern Urals, and Central Russia, and throughout the western Cordilleran belt of North America (including northern Yukon and Mackenzie district of the Northwest Territories). It is not authentically known to occur elsewhere, either in the European and American Arctic or in northern Eurasia, and seems to be replaced by *B*. *volgensis* s. lato in these parts of the boreal realm (Fig. 3). *B*. *uncitoides* s. lato probably originated in the more southerly regions of northern Eurasia as an offshoot of latest Jurassic forms of *B*. *terebratuloides-fischeriana* stock and spread to the North Pacific faunal realm.

In western North America *B*. *uncitoides* s. lato is important in representing the root form of the now emerging indigenous *Buchia* lineage, of which *B*. *okensis* is only a transient but morphologically extreme phase. This lineage dominated *Buchia* faunas of the western Cordilleran belt of North America during the late Berriasian, early Valanginian, and mid-Valanginian times (Fig. 3).

The extremely gregarious, often bank-forming, somewhat *Gryphea*-like, late Berriasian to mid-Valanginian *Buchia* stock of the western North America (and eastern Siberia) was already designated as the morphologically progressive North Pacific *Buchia* lineage because of the early appearance of the pronounced left-handed incurvature of left beaks and morphologically advanced byssus ears in this lineage and its restriction to the North Pacific faunal realm (*see* p. 14).

Beginning in *Buchia uncitoides* time, the juxtaposition of the boreal and North Pacific *Buchia* faunas becomes more and more pronounced until the end of the mid-Valanginian time. It seems correct to say that a new (North Pacific) faunal realm dominated by the progressive North Pacific *Buchia* lineage emerged temporarily at that time between the boreal and Indo-Pacific faunal realms. The contemporary *Buchia* faunas of the northeastern British Columbia, Canadian Arctic, and Greenland were, on the contrary, dominated by the representatives of the conservative Arctic *Buchia* lineage, such as *B. volgensis* s. lato and *B. keyserlingi-sublaevis-inflata* species group (Figs. 2 and 3). The faunal peculiarity of the late Berriasian to mid-Valanginian North Pacific faunal realm of North America is not limited to its *Buchia* faunas. The almost complete (*see* Pl. XXI, fig. 8) absence of representatives of the boreal genus *Polyptychites* (including subgenus *Euryptychites*) s. str. and the common occurrence of the craspeditid genera *Tollia* and *Dichotomites* are equally characteristic of this realm. The considerable admixture of the Tethyan faunal elements (lytoceratids, phylloceratids, *Neocomites, Spiticeras, Groebericeras*?, *Protacanthodiscus, Olcostephanus,* etc.) is yet another distinctive feature of the North Pacific realm.

There is not enough data available to attempt a comprehensive review of the geographical distribution of the contemporary representatives of the conservative Arctic and progressive North Pacific *Buchia* lineages in northern Eurasia, Spitsbergen, and King Charles Land. It should be noted, however, that the late Berriasian and early to mid-Valanginian *Buchia* faunas of eastern Siberia (Sokolov, 1908b) appear to be identical with those of the western Cordilleran belt of North America and distinct from the contemporary *Buchia* faunas of other parts of Eurasia and European Arctic. Only *B. uncitoides* s. lato and *B. okensis* s. lato occur elsewhere in northern Eurasia.

It seems likely that the progressive North Pacific *Buchia* lineage branched off the conservative Arctic *Buchia* lineage (Fig. 3) in response to considerably warmer climatic conditions of the western Cordilleran belt of North America (and eastern Siberia) during latest Jurassic, Berriasian, and early to mid-Valanginian time. The marked provincialism of the Berriasian and Valanginian *Buchia* faunas of western North America, Canadian Arctic, and northern Alaska could, of course, also be explained by the emergence of land barriers across Alaska and Yukon during the time (Yukonia *of* Schuchert, 1910, p. 475, Pl. 49). The improvement of climatic conditions in the North Pacific realm could, in fact, be directly caused by the restriction of inflow of cooler Arctic waters into that realm by these land barriers. The writer believes, however, that the general climatic conditions (i.e., climatic belts) of the Berriasian to mid-Valanginian time, and not the land barriers, were the dominant factors in the emergence of the independent North Pacific faunal realm. The common occurrence of the mixed Tethyan and boreal ammonite and belemnite faunas (climatically tolerant fossil groups) in that realm is hard to understand otherwise. The increasingly luxuriant growth and crowded habitat of the North Pacific *Buchia* species away from the Arctic circle combined with their thick shell, progressively larger size and bizarre shapes point in the same direction, as also does the progressively increasing admixture of the Tethyan ammonites away from the Arctic circle.

The persistence of the broad, relatively flat-valved, thinner shelled, non-bank-forming representatives of the conservative Arctic lineage in the more easterly and northeasterly regions of North America, in Greenland, and elsewhere in the boreal realm, is also best explained not by the influence of land barriers but by cooler climatic conditions, which did not favour lime-secreting processes and development of the extremely crowded colonies of *Buchia*. The frequent occurrence of the mixed *Buchia* faunas of the two lineages in the boundary belt between the boreal and North Pacific faunal realms is especially suggestive of the absence of any impenetrable land barriers separating these realms.

The climatic control was apparently effective in preventing the mass penetration of the representatives of the conservative Arctic *Buchia* lineage into the North Pacific faunal realm. Some stragglers of the *Buchia keyserlingi-sublaevis-inflata* species group were, nevertheless, able to settle there occasionally as shown by the presence of rare early forms of *Buchia keyserlingi* s. lato in *Buchia uncitoides* zone and that of more common representatives of *B. inflata-sublaevis-keyserlingi* species group in *Buchia pacifica* zone. The same seems to be true of the North Pacific faunal realm of eastern Siberia (Sokolov, 1908b).

The North Pacific *Buchia* species were apparently much less tolerant of the climatic conditions than their Arctic counterparts. Except for *B. okensis* and *B. uncitoides,* the root forms of the lineage, not a single occurrence of the representatives of the North Pacific *Buchia* lineage has been authentically recorded in the Berriasian to mid-Valanginian rocks of the boreal realm in North America. The same seems to be true of the European Arctic and northern Eurasia, although an exhaustive search of the geological literature concerned could conceivably necessitate some changes of this concept.

According to the interpretation tentatively accepted in this report, the domination of the North Pacific *Buchia* lineage (and with it the existence of the North Pacific faunal realm) ended more or less abruptly at the beginning of late Valanginian time (Fig. 3). Whether the assumed extinction of *B. pacifica* n. sp., the youngest known representative of the native *Buchia* stock, and the re-establishment of the representatives of the conservative Arctic *Buchia* lineage in western North America was favoured by the deterioration of climatic conditions is not known. It could be that the extremely specialized *B. pacifica* n. sp. simply could not compete with the vigorous, less specialized offshoot of the conservative Arctic stock, which emerged at that time.

This brief summary of the evolutionary history of the genus *Buchia,* as it is now known, shows that the relationships of the Eurasian, Arctic, North American, and Indo-Pacific *Buchia* species are much more complex than hitherto realized. Furthermore, the interprovincial exchange of *Buchia* faunas on specific level was much more limited in space and in time. The lack of realization of these relationships has, not unnaturally, resulted in many miscorrelations of strata because of the unwarranted use of zonal indices well beyond their true geographical ranges. The biochronological use of *Buchia* species is considerably complicated by the realization of the complexity of the evolutionary history of the genus. This is, however, amply compensated for by increased reliability of *Buchia* species as zonal indices on a regional and provincial basis.

ZONAL CORRELATION OF SOME KEY SECTIONS IN SOUTHERN BRITISH COLUMBIA AND NORTHWESTERN WASHINGTON

Surveys of late Upper Jurassic and early Lower Cretaceous rocks of the region in sufficient detail to permit zonal correlation have been few.

Some of the best known sections of southwestern British Columbia and northwestern Washington are correlated biochronologically in Figure 4 to demonstrate the extent of facies and other changes of the uppermost Jurassic and early Lower Cretaceous rocks.

The lithology of the contemporary rocks of all the sections concerned has little in common, and only their fossil content enables us to recognize that the heavy conglomerates of the Spieden Island Formation, arkoses and pyroclastics of the upper Brockenback Hill Formation, and the greywacke sandstones of Quatsino Sound all represent the restricted *Buchia crassicollis* zone. The same applies to the approximate geological contemporaneity of pyroclastics and arkoses of the lower Brockenback Hill Formation with sandstones and siltstones of the west coast of Vancouver Island. Only the fossil content demonstrates, finally, that the lithologically identical sandstones and siltstones of the west coast of Vancouver Island and Quatsino Sound are totally different in age and were deposited by two successive transgressions of the early Lower Cretaceous seas.

Also the extent in time and the degree of completeness of the individual sections shown in Figure 4 vary strongly. The Quatsino Sound section includes only *Buchia crassicollis* s. str. zone and younger Cretaceous rocks transgressively overlapping Middle Jurassic Coast intrusions. The older *Buchia* zones appear to be absent. The section of the adjacent part of the west coast of Vancouver Island includes all older *Buchia* zones discussed in this report. *Buchia crassicollis* zone is, on the contrary, unknown on the west coast, probably because of the lack of exposures. On the west coast, furthermore, only a brief hiatus, and possibly a regional unconformity, occur at the Jurassic/Cretaceous boundary and a thick sequence of late Jurassic rocks completely absent in Quatsino Sound occurs beneath this hiatus.

As now known (Crickmay, 1962), the Harrison Lake section appears to be completely lacking in the late Upper Jurassic *Buchia* zones of the west coast of Vancouver Island. It includes, however, the complete sequence of the early Lower Cretaceous *Buchia* zones and some younger Cretaceous rocks. Spieden Island

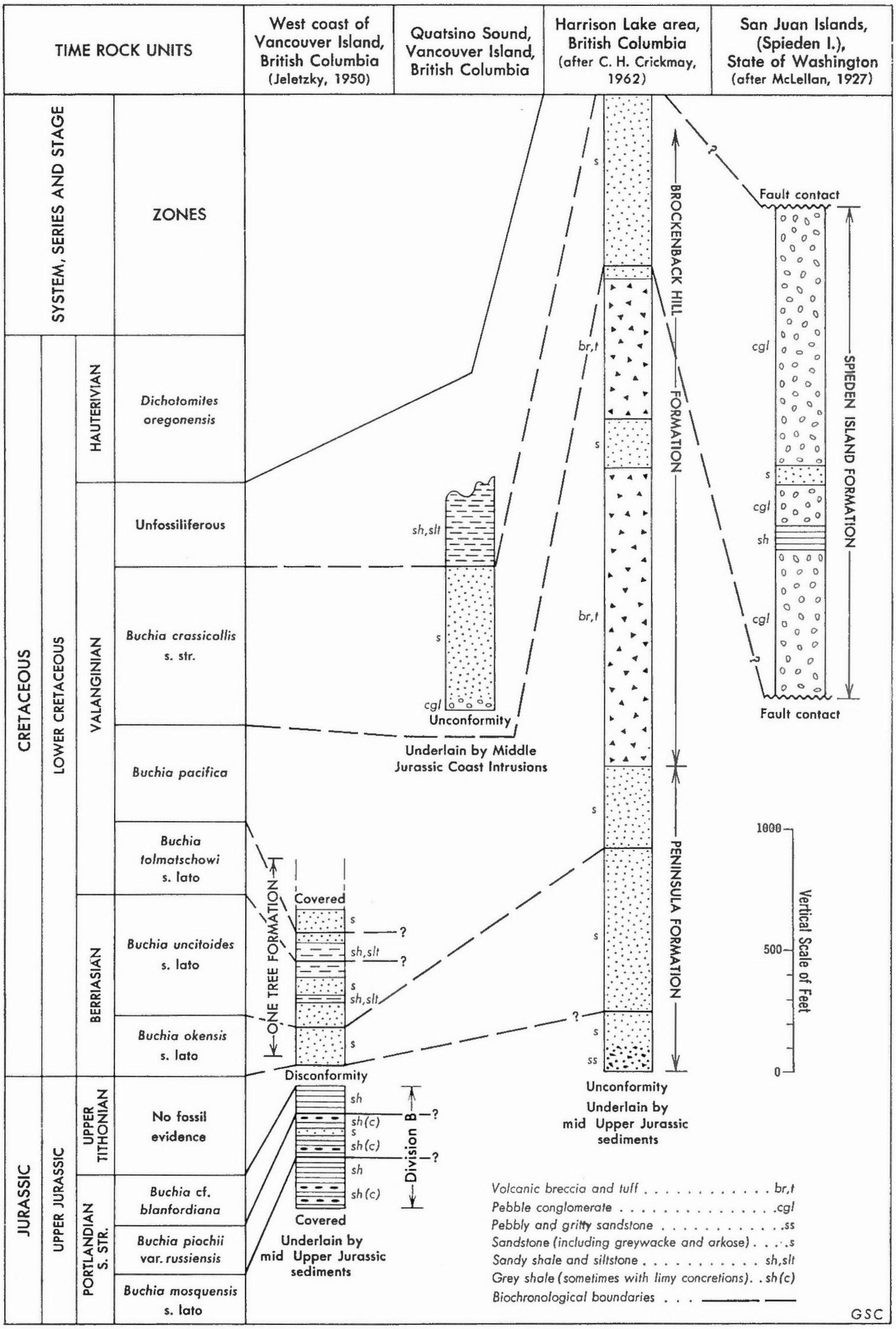

FIGURE 4. Approximate biochronological correlation of some late Upper Jurassic and early Lower Cretaceous sections, Canadian western Cordillera and northwestern part of State of Washington, U.S.A.

section, as now known, apparently exposes only *Buchia crassicollis* s. str. zone. The thick siltstone-sandstone section of the Nooksack area, Washington, is too poorly exposed to be summarized graphically. It includes, however, several *Buchia* zones of the west coast of Vancouver Island section with the addition of *Buchia crassicollis* zone near the top of the succession. The only distinction between the Harrison Lake and Nooksack area sections is the apparent absence of *Buchia okensis, Buchia uncitoides,* and *Buchia tolmatschowi* zones (probably lack of faunas or of the corresponding outcrops rather than a true hiatus) and in the occurrence of pyroclastic rocks in the *Buchia* cf. *blanfordiana* zone in the Nooksack area.

Complex as the already known facies changes of the uppermost Jurassic and early Lower Cretaceous rocks of the region are, the actual picture is believed to be much more complex. There are indications that the early Lower Cretaceous *Buchia* zones are locally represented by shales and siltstones, in part at least, as for example in Bridge River, Lillooet, and Hazelton areas of southern British Columbia. The uppermost Jurassic and early Lower Cretaceous sections of these areas are too little known to be graphically compared with the sections shown in Figure 4. The facies relationships of the late Upper Jurassic and early Lower Cretaceous rocks in central and northern British Columbia and southwestern Yukon cannot even be guessed at because of the lack of measured sections from which enough fossils have been collected.

REFERENCES

Anderson, F. M.

1938: Lower Cretaceous deposits in California and Oregon; *Geol. Soc. Amer.*, Spec. Paper No. 16, 339 pp., 83 pls.

1945: Knoxville series in the California Mesozoic; *Bull. Geol. Soc. Amer.*, vol. 56 (10), pp. 909-1014, 15 pls.

Arkell, W. J.

1956: Jurassic geology of the world; London, Oliver and Boyd, 806 pp., 46 pls., 28 tbls., 102 figs.

Beveridge, A. J., and Folinsbee, R. E.

1956: Dating Cordilleran orogenies; *Trans. Roy. Soc. Can.*, vol. 50, ser. 3, sec. 4, pp. 19-43, 10 pls., 4 figs.

Bogoslovsky, N.

1897: Der Rjasan-Horizont, seine Fauna, seine stratigraphischen Beziehungen und sein wahrscheinliches Alter; *Mat. Geol. Russlands*, Bd. 18, pp. 1-155, 6 pls. (Russian with German summary).

Casey, R.

1962: The Ammonites of the Spilsby Sandstone and the Jurassic-Cretaceous boundary; *Proc. Geol. Soc. London*, Nos. 1593, 1602, pp. 95-100, 1 text-fig.

Crickmay, C. H.

1930a: Fossils from Harrison Lake Area, British Columbia; *Nat. Museum, Canada*, Bull. 63, pp. 33-66, 15 pls., 7 figs.

1930b: The structural connection between the Coast Range of British Columbia and the Cascade Range of Washington; *Geol. Mag.*, vol. 67, pp. 482-491, 2 figs., 1 geol. map.

1932: A new Jurassic Ammonite from the Coast Ranges of California; *Amer. Midland Naturalist*, vol. 13 (1), pp. 1-7, pl. 1.

1962: Gross stratigraphy of Harrison Lake Area, British Columbia; Art. 7, publ. by the author, Calgary, Evelin deMille Books, 12 pp., 1 corr. chart.

Dawson, G. M.

1887: Report on a geological examination of the northern part of Vancouver Island and adjacent coasts; with Appendix I: Notes on some Mesozoic Fossils from various localities on the coast of British Columbia, for the most part collected by Dr. G. M. Dawson in the summer of 1885, by J. F. Whiteaves; *Geol. Surv. Can.*, Ann. Rept. 1886, pt. B, 129 pp., 1 geol. map.

Donovan, D. T.

1953: The Jurassic and Cretaceous Stratigraphy and Palaeontology of Trail ø, East Greenland; *Medd. om. Grønland*, Bd. 111 (4), 150 pp., 25 pls., 14 figs.

1957: The Jurassic and Cretaceous systems in East Greenland; *Ibid.*, Bd. 155 (4), 214 pp., 4 pls., 25 figs.

Fleming, C. A.

1958: Upper Jurassic fossils and hydrocarbon traces from the Cheviot Hills, North Canterbury; *New Zealand J., Geol. and Geophys.*, vol. 1 (2), pp. 375-94, 13 figs.

1959: *Buchia plicata* (Zittel) and its allies, with a description of a new species, *Buchia hochstetteri; New Zealand J., Geol. and Geophys.*, Hochstetter's Centenary Issue, vol. 2 (5), pp. 889-904, 20 figs.

1960: The Upper Jurassic sequence at Kawhia, New Zealand, with reference to the ages of some Tethyan Guide Fossils; *Internat. Geol. Congr., Rept. XXI Sess., Norden,* pt. 21, Other Subjects, Copenhagen, pp. 264-269, 1 tbl., 1 fig.

Frebold, Hans

1929: Die Schichtenfolge des Jura und der Unterkreide an der Ostküste Südwest-Spitzbergens; *Abhandl. Naturwiss,* Verein, Hamburg, Bd. 22 (2-4), pp. 255-292, pls. 33-35, 4 figs.

1930: Verbreitung und Ausbildung des Mesozoikums in Spitzbergen; nebst einer Revision der Stratigraphie des Jura und der Unterkreide in Nowaja Semlja und einem Entwurf der Mesozoischen Entwicklungs-Geschichte des Barentsseeschelfes; *Skrifter om Svalbard og Ishavet,* No. 31, 126 pp., 33 pls., 8 figs.

Gerassimov, P. A.

1955: Rukovodiastchie Iskopaemye Mesozoia Tsentral'nykh Oblastei Yevropeiskoi Chasti USSR (Index Fossils of the Mesozoicum of Central Provinces of the European Part of USSR). Pt. 1; *Gosgeoltekhisdat,* Moscow, 274 pp., 50 pls., 3 text-figs. (Russian).

Gunning, H. C.

1930: Geology and mineral deposits of Quatsino-Nimpkish area, Vancouver Island; *Geol. Surv. Can.,* Sum. Rept. 1929, pt. A, pp. 94-143.

Imlay, R. W.

1956: Stratigraphic and geographic range of the Early Cretaceous Ammonite *Homolsomites; J. Pal.,* vol. 30 (5), pp. 1143-46, pl. 120.

1957: Characteristic Jurassic mollusks from Northern Alaska; *U.S.G.S.,* Prof. Paper 274-D, pp. 69-96, pls. 8-13, 1 corr. chart.

1959: Succession and speciation of the Pelecypod *Aucella; U.S.G.S.,* Prof. Paper 314-G, pp. 155-169, pls. 16-19.

1960: Ammonites of Early Cretaceous Age (Valanginian and Hauterivian) from the Pacific Coast States; *U.S.G.S.,* Prof. Paper 334-F, pp. 167-228, pls. 24-43, 4 tbls., figs. 34-36.

Jeletzky, J. A.

1950: Stratigraphy of the West Coast of Vancouver Island between Kyuquot Sound and Esperanza Inlet, British Columbia; *Geol. Surv. Can.,* Paper 50-37, 52 pp., 1 corr. chart, 1 geol. map.

1954a: Tertiary rocks of the Hesquiat-Nootka area, West Coast of Vancouver Island, British Columbia; with brief comments on adjacent Mesozoic Formations; *Geol. Surv. Can.,* Paper 53-17, 65 pp., 2 geol. maps.

1954b: Geological History of the West Coast of Vancouver Island and Quatsino Sound; *Bull. Geol. Soc. Amer.,* vol. 65, No. 12 (2), p. 1269 (Abstract only).

1955: Evolution of Santonian and Campanian *Belemnitella* and palaeontological systematics; exemplified by *Belemnitella praecursor* Stolley; *J. Pal.,* vol. 29 (3), pp. 478-509, pls. 56-58, 1 fig.

1958: Uppermost Jurassic and Cretaceous rocks of Aklavik Range, Northeastern Richardson Mountains, Northwest Territories; *Geol. Surv. Can.,* Paper 58-2, 84 pp., 1 corr. chart, 1 geol. map.

1959: Uppermost Jurassic and Lowermost Cretaceous zones of the Canadian Western Cordillera; *Proc. Roy. Soc. Can.,* vol. 53, ser. 3, sec. 4, p. 24 (Abstract only).

1960: Uppermost Jurassic and Cretaceous rocks, east flank of Richardson Mountains between Stony Creek and Lower Donna River, Northwest Territories, 106M and 107B (parts of); *Geol. Surv. Can.*, Paper 59-14, 31 pp., 1 corr. chart, 1 geol. map.

1961a: Upper Jurassic and Lower Cretaceous rocks, west flank of Richardson Mountains between headwaters of Blow River and Bell River, 116H and 117A (parts of); *Geol. Surv. Can.*, Paper 61-9, 42 pp., 1 corr. chart, 2 figs.

1961b: Marine Cretaceous macrofossil zones of the Western Interior of Canada and their correlation with the European and United States western interior zones and stages; *XX Internat. Geol. Congr.*, Mexico City, Cretaceous Symposium (in press).

Keyserling, A. von

1846: Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land im Jahre 1843, 2. Reste der Jura-Periode; St. Petersburg, C. Kray, pp. 293-336, pls. 13-22, geol. map.

Koenen, A. von

1902: Die Ammonitiden des Norddeutschen Neocom (Valanginien, Hauterivien, Barremien und Aptien); *Abh. Preuss. Geol.*, L.A., N.F., H. 24, 451 pp., Atlas of 55 pls.

Lahusen, J.

1888: Ueber die russischen Aucellen; *Mém. Com. Géol.*, t. 8 (1), 45 pp., 5 pls., figs. A-C.

Leanza, A. F.

1945: Ammonites del Jurasico superior y del Cretaceo inferior de la Sierra Azul, en la parte meridional de la provincia de Mendoza (Ammonites of the Upper Jurassic and Lower Cretaceous of Sierra Azul in the southern part of Mendoza province); *Anales Museo de la Plata*, n.s., Paleontol: Sec. A; Paleozool., 6, Moluscos, No. 1, 99 pp., 23 pls., 13 figs., 1 corr. chart (Spanish).

Lord, C. S.

1947: Western Cordillera; *in* Geology and Economic Minerals of Canada (Third Edition); *Geol. Surv. Can.*, Econ. Geol. Ser., No. 1, 357 pp., 64 pls., 77 figs., 15 tbls.

Maync, W.

1949: The Cretaceous beds between Kuhn Island and Cape Franklin (Gauss Peninsula), Northern East Greenland; *Medd. om Grønland*, Bd. 133 (3), 291 pp., 4 pls., 70 figs.

McLellan, R. D.

1927: The Geology of San Juan Islands; *Univ. Washington Publ. Geol.*, vol. 2, 185 pp., 22 pls., 10 figs.

Moffit, F. H.

1938: Geology of the Chitina Valley and adjacent area, Alaska; *U.S.G.S.*, Bull. 894, IV + 137 pp., 19 pls., 1 geol. map, 3 tbls.

Neale, J. W.

1962: Ammonoidea from the Lower D Beds (Berriasian) of the Speeton Clay; *Palaeontology*, vol. 5 (2), pp. 272-296, pls. 40-45, 4 text-figs.

d'Orbigny, A.

1841: Paléontologie française. Terrains crétacées. 1. Les Céphalopodes; Publ. by Author, Paris, 662 pp., 148 pls.

Pavlow, A. P.

1892: *In*: A. P. Pavlow & G. W. Lamplugh, Argiles de Speeton and their equivalents; *Bull. Soc. Nat. Moscou*, N.S. t. 5, pp. 181-276, 455-570, pls. 4-28, text-figs.

1896: On the classification of the strata between the Kimmeridgian and Aptian; *Quart. J. Geol. Soc. London*, vol. 52, pp. 542-55, pl. 27, 1 corr. chart.

1907: Enchainement des aucelles et aucellines du Crétácé russe; *Nouveaux Mém. Soc. Imp. Nat. Moscou,* t. 17, 93 pp., 6 pls., 4 figs.

1914: Yurskie i nizhnemelovye Cephalopoda severnoi Sibiri (Jurassic and Lower Cretaceous Cephalopoda of Northern Siberia); *Acad. Imp. Sci.,* St. Petersburg, Cl. Phys.-Math. ser. 8, t. 21 (4), 68 pp., 18 pls.

Pchelintseva (Petrova), G. T.

1955: Novye Aucellidy Verkhnego Triasa i Nizhnei Yury Dalnego Vostaka (New Aucellides of the Upper Triassic and Lower Jurassic of the Soviet Far East); *Materialy VSEGEI (Proceed. Allunion Sci. Res. Geol. Inst.),* Geology, N.S. No. 9, pt. 2, pp. 211-17, 2 pls. (Russian).

Pompeckj, J. P.

1901: Ueber Aucellen und Aucellen-ähnliche Formen; *N. Jarb. Min.* etc., Beil.-Bd, 14, pp. 319-68, pls. 15-17, 2 figs.

Sasonov, N. T.

1951: O nekotorykh maloizutshennykh ammonitakh nizhnego mela (Some little understood ammonites of the Lower Cretaceous); *Bull. Soc. Nat. Moscou,* Geol. Ser., t. 26 (5), pp. 57-63, 6 figs., 1 tbl.

Schuchert, C.

1910: Paleogeography of North America; *Bull. Geol. Soc. Amer.,* vol. 20, pp. 427-606, pls. 41-101.

Sokolov, D.

1908a: Aucellen vom Timan und von Spitzbergen; *Mém. Com. Géol.,* N.S. No. 36, 29 pp., 3 pls. (Russian with German summ.).

1908b: Ueber Aucellen aus dem Norden und Osten von Siberien; *Mém. Acad. Imp. Sci.,* St. Petersburg, Cl. Phys.-Math., ser. 8.

1926: Mesozoiskie okamenelosti iz Bol'schezemel'skoi Tundry i Kashpura (Mesozoic fossils from Bol'schezemel'skaya Tundra and Kashpur); *Travaux, Musée Géol. Acad. Sci.* U.R.S.S. t. 3, pp. 15-62, 2 pls., 6 text-figs. (Russian).

Sokolov, D. N., and Bodylevsky, V. I.

1931: Jura- und Kreidefaunen von Spitzbergen; *Skrifter om Svalbard og Ishavet,* No. 35, 151 pp., 14 pls., 3 text-figs.

Spath, L. F.

1924: On the Ammonites of the Speeton Clay and the subdivisions of the Neocomian; *Geol. Mag.,* vol. 61, pp. 73-89, 1 corr. tbl.

1947: Additional observations on the invertebrates (chiefly Ammonites) of the Jurassic and Cretaceous of East Greenland. I. The *Hectoroceras* fauna of S.W. Jameson Land.

Swinnerton, H. H.

1935: The Rocks below the Red Chalk of Lincolnshire, and their Cephalopod Faunas; *Quart. J. Geol. Soc. London,* vol. 41, pp. 1-46, 4 pls., 6 text-figs.

Whiteaves, J. F.

1882: On the Lower Cretaceous Rocks of British Columbia; *Trans. Roy. Soc. Can.,* sec. 4, pp. 81-86, 3 figs.

Woods, H.

1905: A Monograph of the Cretaceous Lamellibranchia of England; Pteriidae Meek; *Palaeontographical Society,* London, vol. 2, pt. 2, pp. 57-96, pls. 8-11.

PLATES I to XXII

Unless otherwise indicated, all specimens are reproduced natural size. In order to facilitate the comparison of their shapes, the laterally viewed *Buchia* valves are oriented with their hinge margins uppermost, except where lack of space has made such an arrangement impossible.

PLATE I

Figures 1A-1C. *Buchia mosquensis* (Buch, 1844) s. lato. Northeastern Richardson Mountains, N.W.T., Mackenzie District. East slope of Aklavik Range, southern side of nameless creek falling into Husky Channel; about ¾ of a mile south of the top of Mount Gifford. Collected on the float of the basal part of the Lower Shale-siltstone Division. Mid- to Upper Kimmeridgian. GSC No. 17009.

An early form of the species somewhat transitional to *Buchia* ex gr. *concentrica* (Sowerby)-*erringtoni* (Gabb). 1A, Lateral view of interior of right valve with a well-preserved shell layer. Inner surface of byssus ear is simply grooved and oriented approximately in the plane of contact of valves. 1B, Anterior view of the byssus ear, looking straight into the wide open anterior end of the groove (outlined in white) that occurs on its inner surface, X3. 1C, Lateral view of interior of beak part of right valve showing structural detail of inner surface of byssus ear. Byssus notch is painted white. Oriented exactly as in figure 1A, X3.

Figure 2. *Buchia mosquensis* (Buch, 1844) s. lato. Same locality and age as for specimen shown in fig. 1. The same early form of the species as that shown in fig. 1. GSC No. 17008.

Lateral view of exterior of internal cast of right valve. Central part, including beak part, is strongly abraded. Byssus ear (outlined in white) is oriented in plane of contact of valves and shows hardly any bend towards left valve.

Figures 3A-E. *Buchia piochii* (Gabb, 1864) var. *russiensis* (Pavlow, 1907). Prince Patrick Island, N.W.T., District of Franklin. Mould Bay, lat. 76°16′30″N, long. 119°27′9″W; collected on the float of the Mould Bay Formation. Late Portlandian s. str. GSC No. 17010.

A well-preserved, partly matrix-covered right valve. 3A, Lateral view of exterior. Byssus ear is strongly bent towards left valve unlike that of *B. mosquensis* s. lato shown in figs. 1-2. 3B, Anterior view of the same. Anterior surface of byssus ear is rather high in this aspect (measured from left to right). 3C, Posterior view of the same. 3D, Lateral view of the interior, X3. Inner surface of the byssus ear is pronouncedly 'spoon-like' (anteriorly closed; compare figure 3B) in contrast with its simply grooved appearance in *B. mosquensis* s. lato. 3E, Hinge margin and beak viewed from above, to show structural detail of the beak, ligamental plate and byssus ear, X3. Anterior surface of byssus ear forms an angle of some 80° with the plane of contact of valves. Anterior end of the groove occurring on inner surface of byssus ear is almost closed up by ridge-like anterior rim of byssus ear.

Figures 4A-E. *Buchia piochii* (Gabb, 1864) var. *mniovnikensis* (Pavlow, 1907). Prince Patrick Island, N.W.T., District of Franklin. East side of Mould Bay, 2½ miles north of Mould Bay weather station, about 135 feet above base of Mould Bay Formation. Late Portlandian s. str. GSC No. 17117. A well-preserved right valve of a strongly convex form of the variant.

4A, Lateral view of exterior. 4B, Lateral view of interior. Byssus ear is distinctly 'spoon-like' but is much more shallow than that of *B. piochii* var. *russiensis* shown in figures 3D,E. 4C, Anterior view of exterior. Anterior surface of byssus ear is considerably lower in this aspect than that of *B. piochii* var. *russiensis* shown in figure 3B. 4D, Beak part of the interior, X3 and oriented as in figure 4B to show structural detail of the byssus ear and notch. 4E, Hinge margin and the beak viewed from above to show structural detail of the beak, ligamental plate, and byssus ear. The anterior surface of the byssus ear forms an angle of 45° to 50° with the plane of contact of the valves. The anterior end of the groove occurring on the inner surface of the byssus ear is, however, almost completely closed by the ridge-like anterior rim of the latter. The surface of the ligamental plate is slanted inward even stronger than in the specimen shown in figures 3D, 3E.

Figures 5A-E. *Buchia piochii* (Gabb, 1864) var. *mniovnikensis* (Pavlow, 1907). Same locality, age, etc., as for the specimen shown in fig. 4. GSC No. 17118. A well-preserved right valve of a flat variant resembling *B. volgensis* s. str. in its flatness and outline. 5A, Lateral view of the exterior. 5B, Anterior view of the same. The byssus ear resembles that of the specimen shown in fig. 4C but not that of the specimen shown in fig. 3B. 5C, Oblique posterior view showing the general flatness of the valve. 5D, Hinge margin and the beak viewed from above, X3. The ligamental plate, beak, and byssus ear of this specimen are essentially similar to those of the specimen shown in fig. 4E, except that the anterior end of the groove occurring on the inner surface of the byssus ear is only partly closed up by the ridge-like anterior rim of the byssus ear. This specimen is, thus, transitional in the morphology of its groove between the representative of *B. piochii* var. *russiensis* shown in figs. 3D, 3E and that of *B. mosquensis* s. lato shown in figs. 1A-C. 5E Lateral view of the interior of the beak part of the valve oriented exactly as in figs. 3D and 4D, X3. The byssus ear almost lacks the 'spoon-like' appearance diagnostic of most representatives of *B. piochii* s. lato and so is clearly transitional to that of *B. mosquensis* s. lato shown in figs. 1A-C.

Figures 6A-D. *Buchia piochii* (Gabb, 1864) var. *russiensis* (Pavlow, 1907). Same locality, age, etc., as for the specimen shown in figs. 3A-E. GSC No. 17119.

A well-preserved but somewhat fragmentary (at the lower end), small left valve.

6A, Lateral view of the exterior. 6B, Anterior view of the same. 6C, Oblique posterior view of the same. The tip of the beak is concealed by the matrix here and in the figs. 5B and 5D. 6D, Hinge margin and the beak viewed from above.

Figure 7. *Buchia inflata* (Toula, 1874) var. *formosa* (Sokolov, 1908). An early, slender form transitional to *B. keyserlingi* (Lahusen). East Greenland, Inner Wollaston Foreland, section north of Sumpdalen (Maync, 1949, pp. 66-68, bed 2). Upper Valanginian (=Upper Polyptychitan of Spath, 1924, table opp. p. 80). *Min. og Geol. Mus.* property.

Anterior view of both valves almost in the living position showing the appearance of the byssus ear and its articulation with the byssus sinus of the left valve. The external appearance of the byssus ear is essentially similar to that of the most advanced representatives of *B. piochii* s. lato shown in fig. 3.

Figures 8A-E. *Buchia inflata* (Toula, 1874) s. lato. East Greenland, Trail Island, locality 92 of Donovan (1953, pp. 51-52). Middle or? late Lower Valanginian. *Min. og Geol. Mus.* property.

An almost complete right valve. Surface of shell is strongly abraded in the middle; its well-preserved ornament elsewhere is, however, subdued and transitional to that of *B. sublaevis* s. lato. Hinge is completely and well preserved. 8A, Lateral view of the exterior. Byssus ear is so strongly bent towards the left valve that it is almost invisible in this aspect.

8B, Lateral view of the interior. Byssus ear is relatively larger, deeper and its excavated inner part is wider than in the representatives of *B. piochii* s. lato shown in figs. 3D, 4B, 4D, and 5E. It is, furthermore, not constricted at its posterior end and so is 'embayment' — rather than 'spoon-like'. Inner surface of this byssus ear has completely lost its grooved appearance. In the above-mentioned representatives of *B. piochii* s. lato this grooved appearance is still apparent, in part at least. 8C, Anterior view of the exterior. 8D, Hinge margin and the beak viewed from above. Anterior surface of byssus ear forms an angle of 70° to 80° with the plane of contact of the valves. 8E, Lateral view of interior of beak part, X3. Tilted a bit more towards the camera than in figure 8B. Unlike that of the representatives of *B. piochii* s. lato shown in figs. 3E, 4E, and 5D, the ligamental plate is turned inward at some 50° and the lower margin of the anterior surface of the byssus ear does not show any sign of indentation. Byssus notch is narrower than that of *B. piochii* s. lato.

Figures 9A-E. *Buchia piochii* (Gabb, 1864) var. *mniovnikensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 3. GSC No. 17120.

A well-preserved, complete, and large left valve generally similar to that of *B. volgensis* (Lahusen) s. str. in most features. The latter is, however, more oblique posteriorly, generally lacks the well-developed, angular posterior ear (fig. 9A) and the long and straight hinge line (fig. 9B) of *B. piochii* var. *mniovnikensis*.

9A, Lateral view of the exterior. 9B, Lateral view of the interior. 9C, Anterior view of the exterior. 9D Posterior view of the exterior. 9E, Hinge margin and the beak viewed from above.

Figures 10A-F. *Buchia concentrica* (Sowerby, 1827) var. *erringtoni* (Gabb, 1864). Southwestern British Columbia, Tyaughton Lake area, north side of the pass 1¾ miles northwest of the peak of Sheba. Lower part of Eldorado Group. Early Kimmeridgian? GSC No. 17012.

A complete internal cast with valves in an approximately living position. Small patches of the inner shell layer are preserved locally. Byssus ear is largely preserved as an internal cast. Although short and blunt as in all representatives of this species group, left beak shows marked right-handed incurvature. 10A, Lateral view of exterior of left valve.

10B, Lateral view of exterior of right valve showing the ligamental plate and the protruding part of the left beak.

10C, Anterior view of exterior of both valves. 10D, Oblique posterior view of the same. 10E, Hinge margins and beaks of both valves viewed from above. 10F, Same view as in figure 10B, X3. Only hinge and beak parts of the shell are shown. Byssus ear is structurally closely similar to that of *B. mosquensis* s. lato shown in fig. 2 and completely dissimilar to that of *B. piochii* s. lato (figs. 3-5) and *B. inflata* s. lato (figs. 7,8).

PLATE I

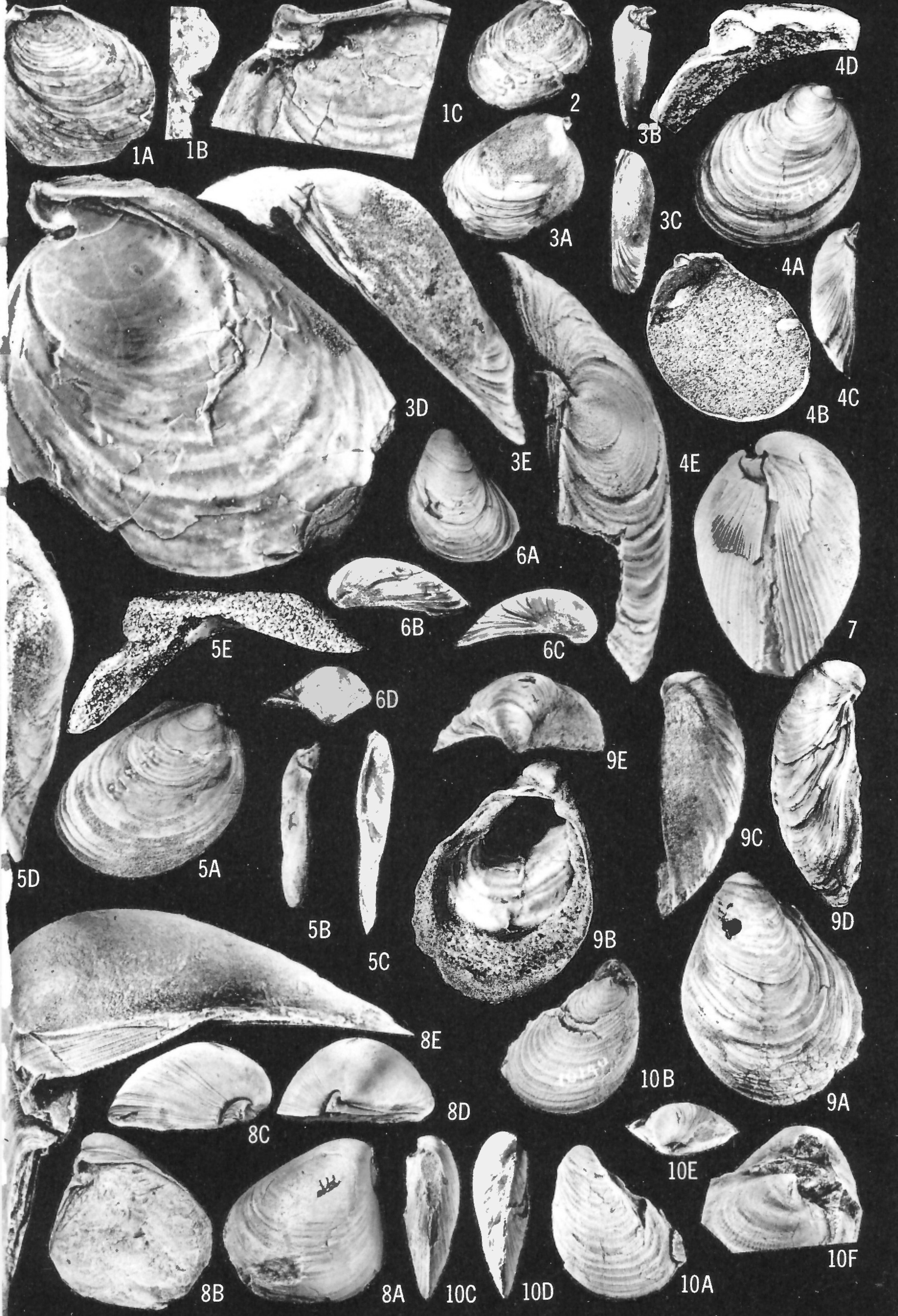
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PLATE II

Figures 1A-C. *Buchia mosquensis* (Buch) var. *rugosa* (Fischer, 1837). Portlandian (Lower Volgian) stage, Moscow. Original in the *Mus. National d'Histoire Naturelle,* Paris, France. GSC No. 16576.

Plaster cast of a typical, medium-sized specimen. Internal cast with no shell layer preserved.

1A, Lateral view of exterior of left valve. 1B, Same view of right valve. 1C, Anterior view of exterior of both valves.

Figures 2A,B. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). West coast of Vancouver Island. West side (tidal shelf) of the main body of Grassy Island. Upper shale member of Division B, 501-503 feet above base of the section and 3 to 5 feet below the Jurassic/Cretaceous contact. Uppermost Portlandian (s. str.)? GSC No. 16577.

An internal cast of left valve with remnants of the inner shell layer preserved here and there.

2A, Lateral view of the exterior. 2B, Anterior view of the same.

Figures 3A-C. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Presumably from the same locality and section as the specimen shown in fig. 2. Collected from a fossiliferous boulder presumably derived from a bed 503-506 feet above base of the section and immediately below the Jurassic/Cretaceous contact. Uppermost Portlandian? GSC No. 16578.

Internal cast of an almost complete shell with some remnants of the inner shell layer.

3A, Lateral view of exterior of left valve. 3B, Same view of right valve and that of the projecting beak part of left valve. 3C, Oblique posterior view of exterior of both valves.

Figures 4A-C. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Locality as for specimen shown in figure 2. Uppermost Portlandian? GSC No. 16579.

Internal cast of an incomplete left valve. 4A, Lateral view of exterior. One of the growth lines (same as in fig. 4C) marked in white to show the outline of the valve. 4B, Exterior of a fragment of right valve viewed obliquely, and underside of beak part of left valve. 4C, Anterior view of exterior. One of the growth lines is marked in white.

Figure 5. Poorly preserved ammonite resembling *Substeueroceras stantoni* Anderson, 1945. Locality and section as for *Buchia* shown in fig. 2. 503-506 feet above the base of the section and immediately below the Jurassic/Cretaceous contact. Uppermost Portlandian? Lateral view of the only crushed specimen found. GSC No. 16580.

Figures 6A-C. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Locality as for specimen shown in fig. 3. GSC No. 16581.

Internal cast of an almost complete shell with considerable patches of the inner and outer shell layers preserved on the beak part (*see* fig. 6C). Same views as for specimen shown in fig. 3.

Figures 7A-D. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Black shale from Church Mt., off the Mt. Baker highway in the eastern part of Sec. 28, and 35, T40N, R7E, Washington, U.S.A. This locality is on the Church Mt. trail. Uppermost Portlandian? Whatcom, Co., Washington, U.S.A., U. of Cal. Berkeley, Cat. No. 34707.

Internal cast of a small but almost complete shell with some patches of shell layer. 7A, Lateral view of exterior of left valve. 7B, Lateral view of exterior of right valve with well-preserved byssus ear and protruding beak part of the left valve. 7C, Anterior view of exterior of both valves. 7D, Oblique posterior view of exterior of both valves.

Figures 8A,B. *Cylindroteuthis* aff. *obeliscoides* Pavlow and Lamplugh, 1892. Same locality, etc., as for the ammonite shown in fig. 5. GSC No. 16582.

8A, Ventral view. Note the long ventro-apical furrow. 8B, Left lateral view. Ventral side is on right. Alveolar part is not preserved.

Figures 9A,B. Poor oppelioid ammonite resembling *Cymnodiscoceras* Spath, 1925. Locality as for ammonite shown in fig. 5. GSC No. 16583.

9A, Lateral view of the only flattened specimen found. 9B, Same view as in fig. 9A X2 to show the details of the sculpture and the serrated keel on the chambered part of whorl.

PLATE II

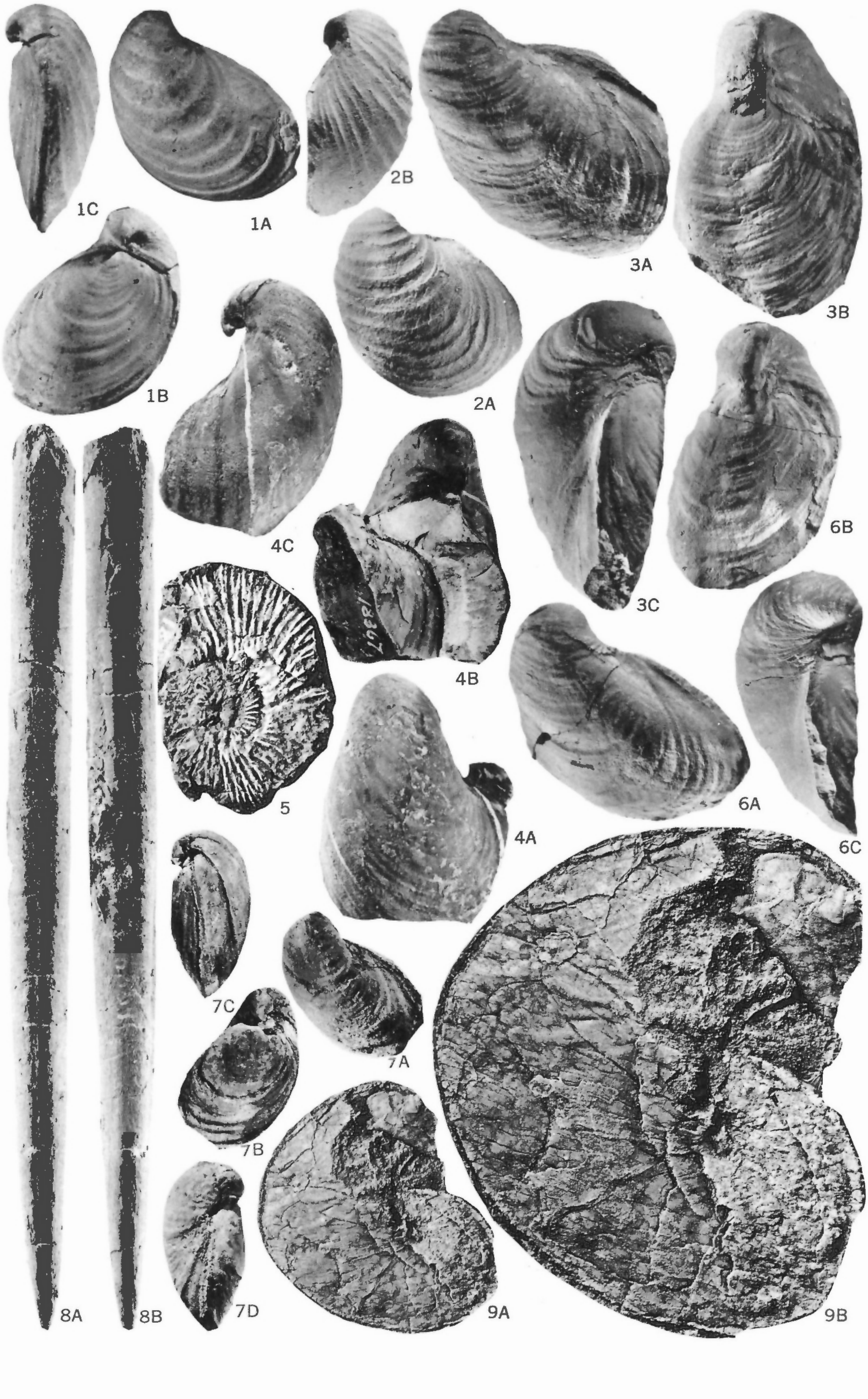

PLATE III

Figures 1A,B. *Buchia* aff. *volgensis* (Lahusen, 1888). Black shale from Church Mt. off the Mt. Baker highway in the eastern part of Sec. 28 and 35, T40N, R7E, Washington, U.S.A. This locality is on the Church Mt. trail. Lowermost Cretaceous (Berriasian?)? Whatcom Co., Washington, U.S.A. U. of Cal., Berkeley, Cat. No. 34708. Although from the same fossil collection as the uppermost Portlandian? *B.* cf. *blanfordiana* and *B. fischeriana* var., this specimen is presumably derived from younger beds (*see* pp. 31, 35).

Internal cast of a large and almost complete left valve with small patches of shell layer. 1A, Lateral view of exterior. 1B, Anterior view.

Figures 2A-C. *Buchia fischeriana* (d'Orbigny, 1845) var. Same locality (but presumably derived from different bed) as for the specimen shown in figure 1. Uppermost Portlandian? U. of Cal., Berkeley, Cat. No. 34710.

Internal cast of a large, almost complete specimen. 2A, Lateral view of exterior of left valve. 2B, Same view of right valve. 2C, Oblique posterior view of exterior of both valves.

Figures 3A-C. *Buchia fischeriana* (d'Orbigny, 1845) var. Same locality (and presumably derived from the same bed) as for the specimen shown in fig. 2. Uppermost Portlandian? U. of Cal., Berkeley, Cat. No. 34709.

Internal cast of an almost complete, small specimen. Considerable patches of the shell layer preserved in places (*see* fig. 3B). 3A, Lateral view of exterior of left valve. 3B, Same view of right valve. 3C, Oblique posterior view of exterior of both valves.

Figures 4A,B. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Same locality (and presumably derived from the same bed) as for specimen shown in fig. 2. Uppermost Portlandian? U. of Cal., Berkeley, Cat. No. 34711.

Almost complete left valve of a small specimen with considerable patches of shell layer preserved on posterior part of valve.

4A, Lateral view of exterior. 4B, Oblique posterior view.

Figures 5A-C. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). West coast of Vancouver Island, West side (tidal shelf) of the main body of Grassy Island. Upper shale member of Division B, 501-3 feet above base of the section and 3 to 5 feet below the Jurassic/Cretaceous boundary. Uppermost Portlandian? GSC No. 16584.

5A, Lateral view of exterior of left valve. 5B, Same view of fragmentary right valve, and underside view of the hinge and beak part of left valve. 5C, Anterior view of exterior of left valve.

Figures 6A,B. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). West coast of Vancouver Island. West side (tidal shelf) of main body of the Grassy Island. Upper shale member of Division B, 503-506 feet above the base of the section and immediately below the Jurassic/Cretaceous contact. Uppermost Portlandian? GSC No. 16585.

An internal cast of almost complete and large left valve with remnants of the inner shell layer here and there. 6A, Lateral view of exterior. 6B, Anterior view. The truncated appearance of posterior margin of shell is caused by its deformation.

Figures 7A-C. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Same locality (and presumably derived from same bed) as for the specimen shown in fig. 2. Uppermost Portlandian? U. of Cal., Berkeley, Cat. No. 34712.

Almost complete medium-sized specimen still covered by inner shell layer. 7A, Lateral view of exterior of left valve. 7B, Same view of right valve, and view of the underside of beak part of left valve overhanging it. 7C, Anterior view of exterior of left valve.

Figures 8A-C. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). Spruce Lake, B.C. Eldorado Group (lower part?). Uppermost Portlandian? coll. by C. E. Cairnes. GSC No. 16586.

Internal cast of an almost complete shell of large typical representative of the species. 8A, Lateral view of exterior of left valve. 8B, Same view of right valve and view of the beak of left valve overhanging it. 8C, Anterior view of exterior of both valves.

Figures 9A-C. *Buchia plicata* (Zittel, 1864). Waikato South Heads, New Zealand, coll. by J. A. Bartrum, University of Auckland. Photographs of plaster cast of one of the topotypes of the species figured by Fleming (1959, p. 893, fig. 3). Lower Tithonian (Puaroan). GSC No. 16587.

9A, Lateral view of exterior of left valve. 9B, Oblique posterior view of same. 9C, Hinge margin and beak part viewed from above. Hinge margin is visible on left of beak.

PLATE III

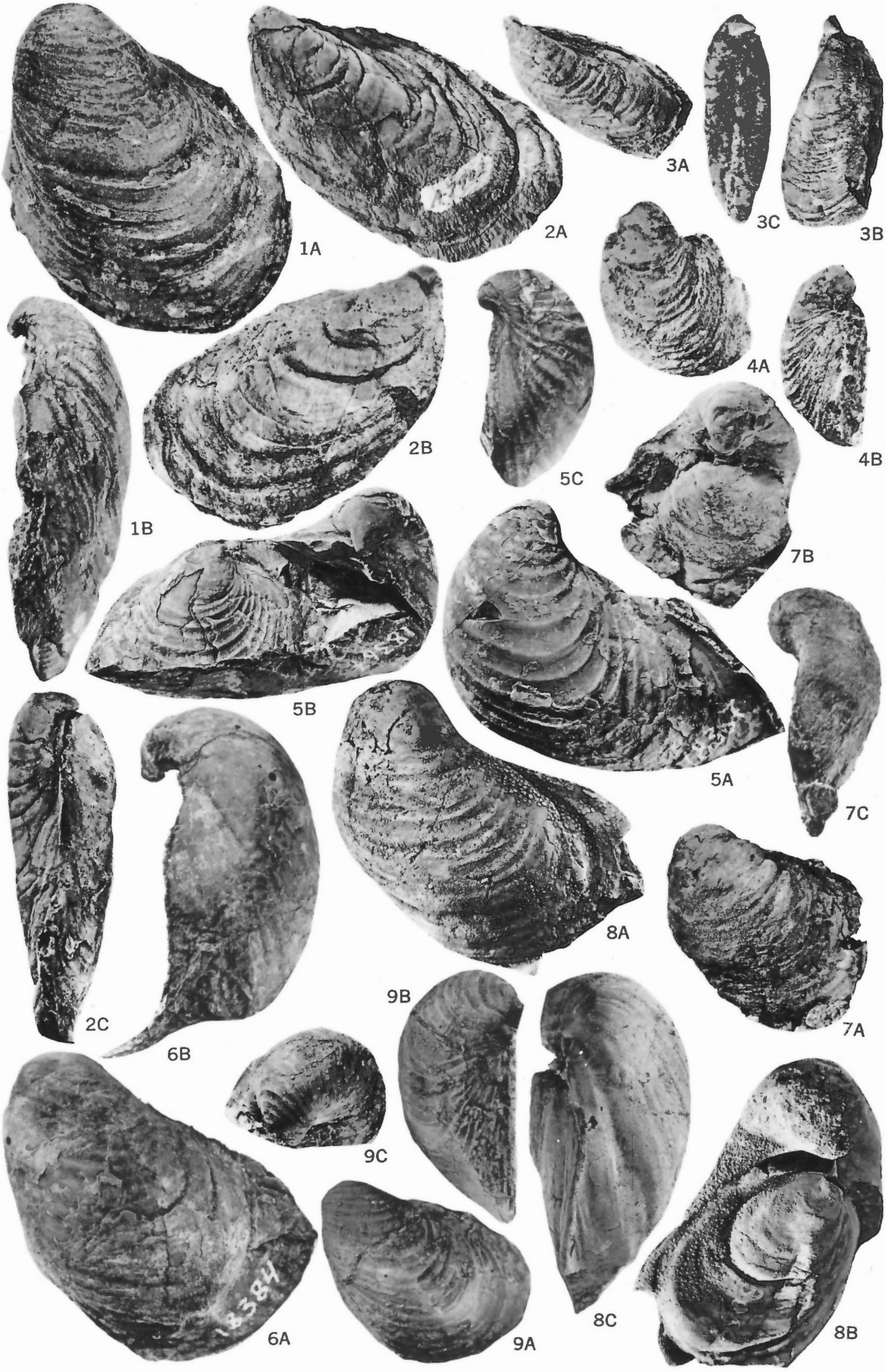
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PLATE IV

Figures 1A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). West coast of Vancouver Island, B.C., west side of main body of Grassy Island. One Tree Formation, 512-13 feet above the base of the section and 6-7 feet above the Jurassic-Cretaceous contact. Lower (basal?) Berriasian. GSC No. 17435.

An internal cast of a fragmentary, medium-sized right valve. Patches of shell layer preserved here and there. The extremely heavy and widely spaced concentric ribs are diagnostic of the variant.

1A, Lateral view of exterior. Most part of posterior ear is broken off. 1B, Oblique posterior view of the same.

1C, Anterior view of the same. Byssus ear is broken off. 1D, Hinge margin and beak viewed from above. Byssus ear and most part of posterior are broken off.

Figures 2A-D. *Buchia uncitoides* (Pavlow, 1907) var. Same locality as for specimen shown in fig. 1. One Tree Formation 506 feet above the base of the section and 0-4 inches above the Jurassic-Cretaceous contact. Basal Berriasian. GSC No. 17436.

Internal cast of a small left valve with considerable patches of poorly preserved inner shell layer. Differs from B. *piochii* s. lato and *B. terebratuloides* s. lato essentially in its angular shape and clearly left-handedly incurved beak. 2A, Lateral view of exterior. Unlike small representatives of *B. okensis* (figs. 12, 15) and transitional forms between *B. terebratuloides-uncitoides* and *B. okensis* (figs. 9, 13-14, 16) the concentric ornament is closely spaced and relatively fine throughout. 2B, Anterior view of same. 2C, Posterior view of same. 2D, Hinge margin and beak viewed from above.

Figures 3A-C. *Buchia okensis* (Pavlow, 1907) f. typ. Same locality, age, etc., as for the specimen shown in fig. 2. GSC No. 17451.

A mostly shell-covered, fragmentary right valve introduced to demonstrate the presence of *B. okensis* f. typ. right above the Jurassic-Cretaceous boundary. 3A, Lateral view of exterior. Posterior ear is completely preserved and the concentric ornament is characteristically much finer and much more closely spaced than in *B. okensis* var. *canadiana* (*see* also Pl. X, fig. 2). 3B, Posterior view of same. 3C, Hinge margin and beak viewed from above. Byssus ear is missing.

Figures 4A-D. *Buchia okensis* (Pavlow, 1907) f. typ. Same locality, age, etc., as for the specimen shown in fig. 1. GSC No. 17437.

An internal cast of a small but otherwise typical right valve. Some patches of poorly preserved shell layer occur. 4A, Lateral view of exterior. Complete byssus ear is clearly visible in the right-upper corner of the photograph. 4B, Oblique posterior view of same. 4C, Anterior view of same. 4D, Hinge margin and beak viewed from above. Anterior surface of byssus ear forms an angle of 35 to 40° with the plane of contact of the valves.

Figures 5A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17438.

A mostly shell-covered, large left valve of a form transitional between *B. okensis* var. *subokensis* and *B. fischeriana* s. lato. The large and angular posterior ear and the appearance of the coarse, widely spaced concentric ribs on the late stage of growth indicate the placement of this form in *B. okensis* var. *subokensis* (=var. *spasskensis* Pavlow, 1907). Same views as for left valve shown in fig. 2. Most of beak is broken off.

Figures 6A-D. *Buchia okensis* (Pavlow, 1907) f. typ. Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17439.

An internal cast of a complete, medium-sized right valve. Some patches of shell layer preserved here and there. Anterior surface of the byssus ear is not any higher than that of *B. piochii* var. *mniovnikensis* shown in Pl. I, fig. 4E in the anterior aspect (fig. 6C). When viewed from above (fig. 6D) it forms an angle of some 40° to 45° with the plane of contact of the valves (fig.6D). The byssus ear retains, therefore, the evolutionary grade of *B. piochii* s. lato. The same views as for specimen shown in fig. 1.

Figures 7A-C. *Buchia* cf. *uncitoides* (Pavlow, 1907) s. lato. Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17440.

An internal cast (some patches of poorly preserved shell layer occur here and there) of a fragmentary, small right valve that cannot be positively identified but probably belongs to the same variant of *B. uncitoides* s. lato as that shown in fig. 2. On morphology alone this specimen could almost as well be placed in *B. terebratuloides* or *B. piochii* s. lato.

7A, Lateral view of exterior. 7B, Anterior view of same. 7C, Hinge margin and the beak viewed from above. Anterior surface of byssus ear forms an angle of about 45° with plane of contact of valves.

Figures 8A-D. *Buchia okensis* (Pavlow, 1907) aff. var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17441.

Internal cast of an almost complete, small left valve transitional between *B. okensis* var. *subokensis* and *B. okensis* f. typ. in its shape and coarseness of the ribbing. Beak part is somewhat incurved to right. The same views as for specimen shown in fig. 2.

Figures 9A-C. *Buchia* aff. *okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17442.

An internal cast of a complete, medium-sized left valve strongly resembling *B. fischeriana* var. *trigonoides* (Lahusen, 1888) in its sculpture and shape. The large and angular posterior ear and the long, markedly, left-handedly incurved left beak indicate, however, that it is a transitional form between *B. okensis* s. lato and *B. uncitoides* s. lato superficially similar to *B. fischeriana* s. lato. 9A, Lateral view of exterior. 9B, Anterior view of same. 9C, Hinge margin and the beak viewed from above.

Figures 10A-C. *Buchia okensis* (Pavlow, 1907) aff. var. *subokensis* (Pavlow, 1907). Same locality and formation as for specimen shown in fig. 1. 506 to 514 feet above the base of the section and up to 8 feet above the Jurassic-Cretaceous boundary. Lower Berriasian. GSC No. 17443.

An internal cast of a large, almost complete right valve with considerable patches of inner shell layer. Specimen is transitional between *B. okensis* var. *subokensis* and *B. okensis* f. typ. being closer to the former in its subtriangular outline (fig. 10A) and feebly developed posterior ear (not visible); its ribbing is identical with that of *B. okensis* f. typ. (*see* fig. 3A). Byssus ear is even more primitive than that of the specimens shown in figs. 4C and 6C. Same views as for specimen shown in fig. 7.

Figures 11A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 10. GSC No. 17444.

Internal cast of a medium-sized, almost complete left valve typical in its outline and beak but transitional to *B. okensis* f. typ. in the coarseness and spacing of its concentric ribs. Same views as for specimen shown in fig. 2.

Figures 12A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17445.

An almost complete, small left valve partly covered by the poorly preserved shell layer. A broader and shorter form of the variant than that shown in fig. 11. The tip of the beak is broken off (figs. 12B,C). Same views as for specimen shown in fig. 2.

Figures 13A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato. Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17446.

An incomplete, small left valve partly covered by the shell layer. Transitional to *B. okensis* var. *subokensis* in its coarser and more distant ribbing habit. Same views as for specimen shown in fig. 2.

Figures 14A-D. *Buchia* aff. *fischeriana* (d'Orbigny, 1845) s. lato. Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17447.

A medium-sized, almost complete left valve partly covered by the poorly preserved shell layer. This specimen resembles *B. fischeriana* s. lato in its general shape but is transitional to *B. okensis* var. *subokensis* in its coarser and more distant ribbing habit. Same views as for specimen shown in fig. 2.

Figures 15A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17448.

A complete, almost entirely shell-covered left valve. Like specimen shown in fig. 12, this specimen probably is a half-grown representative of the variant. Same views as for specimen shown in fig. 2.

Figures 16A-D. *Buchia* aff. *uncitoides* (Pavlow, 1907) s. lato. Same locality, age, etc., as for specimen shown in fig. 10. GSC No. 17449.

A small, almost complete left valve partly covered with the shell layer. This specimen is transitional between the late forms of *B. piochii* s. lato and *B. uncitoides* s. lato. Same views as for specimen shown in fig. 2.

Figures 17A-D. *Buchia* aff. *terebratuloides* (Lahusen, 1888) s. lato. Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17450.

A medium-sized, partly shell-covered, complete left valve indistinguishable from that of *B. terebratuloides* in shape. The coarse and fairly distant concentric ribs suggest, however, that it is rather a transitional form between *B. uncitoides* s. lato and *B. okensis* var. *subokensis*. Same views as for specimen shown in fig. 2.

Figures 18A-D. *Buchia okensis* (Pavlow, 1907) s. lato. Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17452.

A complete, partly shell-covered, medium-sized left valve transitional between *B. okensis* f. typ. and var. *canadiana* in the coarseness (but not spacing) of its concentric ribs. Same views as for specimen shown in fig. 2.

Figures 19A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17453.

A complete, mostly shell-covered, medium-sized left valve combining the subtriangular outline and ill-defined posterior ear with the heavy and widely spaced ribbing diagnostic of the variant. Same views as for specimen shown in fig. 2.

Figures 20A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17454.

An almost complete, partly shell-covered, large left valve. The ribbing is typical of the variant and the beak is somewhat incurved to right as in most early representatives of *B. okensis* s. lato. Same views as for specimen shown in fig. 2.

Figures 21A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, age, etc., as for the specimen shown in fig. 1. GSC No. 17455.

An internal cast (with some patches of shell layer) of an almost complete, large left valve transitional between *B. okensis* f. typ. and var. *subokensis* in its shape and ribbing habit. The beak has feeble left-handed incurvature and the posterior ear is very large and angular. Same views as for specimen shown in fig. 2.

Figures 22A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17456.

A partly shell-covered, medium-sized, almost complete left valve of the same variant as that shown in fig. 21. Same views as for specimen shown in fig. 2.

Figures 23A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for the specimen shown in fig. 2. GSC No. 17457.

A shell-covered, almost complete, smallish left valve transitional between *B. fischeriana* and *B. okensis* s. lato in its pronouncedly elongated and posteriorly oblique shape. It is, however, strongly swollen and has coarse, widely spaced ribs characteristic of *B. okensis* s. lato. Beak is essentially straight. Same views as for specimen shown in fig. 2.

Figures 24A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17458.

A partly shell-covered, almost complete, medium-sized left valve of a form similar to that shown in fig. 23. Posterior ear is large and angular, and beak is essentially straight. Tip of beak is broken off. Same views as for specimen shown in fig. 2.

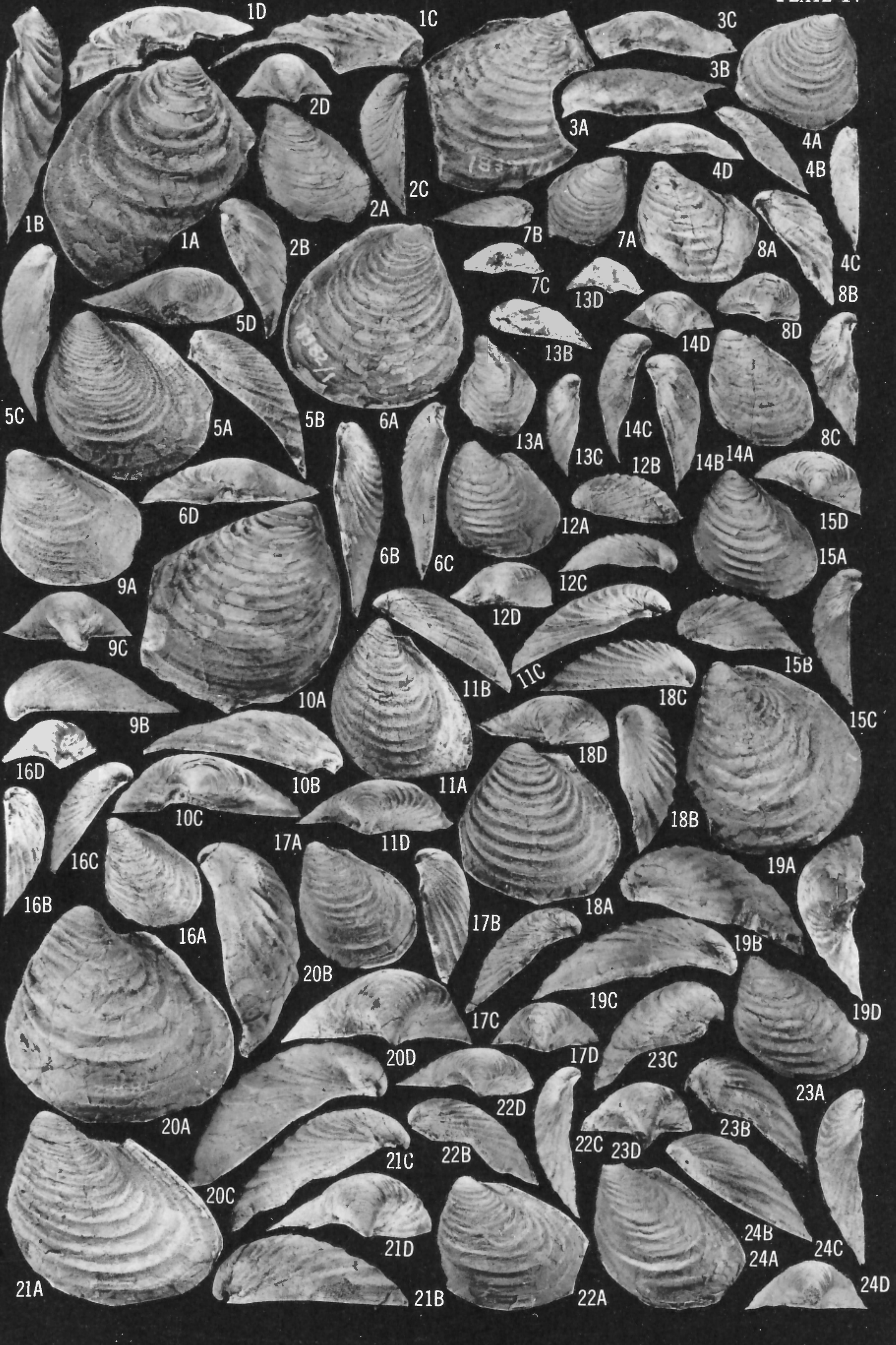
1D
1C
3C
3B
2D
3A
4A
4D
4B
2C
2A
7B
7A
8A
1B
1A
2B
4C
7C
13D
8B
5D
13B
14D
8D
5C
5A
5B
6A
13A
14C
8C
13C
12B
14B
14A
6D
12A
15D
9A
6B
6C
12C
15A
12D
9C
11C
15B
11B
18C
10A
15C
9B
18D
16D
10B
11A
18B
10C
17A
11D
19A
16C
16B
17B
18A
16A
20B
19B
19D
19C
17C
20D
17D
23C
23A
20A
22D
23B
22C
23D
21C
22B
20C
24B
24C
24A
21D
24D
21A
21B
22A

PLATE V

Figures 1A,B. *Buchia uncitoides* (Pavlow, 1907) s. lato var. West coast of Vancouver Island. Main body of Grassy Island. One Tree Formation. Isolated rocky hill on its SE side overlooking the beach about 100 feet SE from the only group of trees on the island. Collected from about 2-foot thick sandstone bed. Lower Berriasian. GSC No. 16588.

Internal cast of medium-size variant transitional towards the *Buchia volgensis*-like variant of *B. okensis* s. lato (*see* fig. 5). 1A, Lateral view of exterior of left valve. 1B, Anterior view of same.

Figures 2A,B. *Buchia okensis* (Pavlow, 1907) s. lato. West coast of Vancouver Island. West side of main body of Grassy Island. One Tree Formation, 514-516 feet above the base of the section and 8-10 feet above the Jurassic/Cretaceous contact. Lower Berriasian. GSC No. 16589.

Internal cast of an incomplete giant left valve transitional between the typical form of the species and var. *canadiana* (Crickmay, 1930). 2A, Lateral view of exterior. 2B, Anterior view of same.

Figures 3A,B. *Buchia okensis* (Pavlow, 1907) f. typ. Same locality as for the specimen reproduced in fig. 1. GSC No. 16590.

Internal cast (a small patch of the shell layer preserved at the posterior margin of the valve; *see* fig. 3A) of a medium-sized left valve of the typical representative of the species.

3A, Lateral view of exterior. 3B, Anterior view of same.

Figures 4A,B. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, etc., as for specimen reproduced in fig. 2. GSC No. 16591.

Internal cast of a complete left valve of a small-sized, *Buchia-volgensis*-like shaped variant of the species that has the ribbing habit of *B. okensis* var. *canadiana*. 4A, Lateral view of exterior; 4B, Anterior view of same.

Figures 5A,B. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, etc., as for specimen reproduced in fig. 1. GSC No. 16592.

An internal cast with considerable patches of the inner shell layer in places. Large left valve of an extreme *Buchia volgensis*-like variant of the species. 5A, Lateral view of exterior. 5B, Anterior view of same.

Figures 6A,B. *Buchia okensis* (Pavlow, 1907) s. lato var. West coast of Vancouver Island. McQuarry Island; middle part of the main body. One Tree Formation, 8-10 feet above the Jurassic-Cretaceous contact. GSC No. 16593.

A medium-sized left valve of a representative of the species transitional to *B. okensis* var. *canadiana* (Crickmay, 1930) in its ribbing habit. 6A, Lateral view of exterior. 6B, Anterior view of same.

Figures 7A,B. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). The same locality, etc., as for specimen shown in fig. 2. GSC No. 16594.

An internal cast with considerable patches of the inner and outer shell layers preserved in places. An almost complete, giant but otherwise typical right valve of the variant. Small valve of *Buchia uncitoides* s. lato is visible on upper left side of fig. 7B. 7A, Lateral view of exterior. 7B, Oblique view of posterior and hinge margins of same.

Figures 8A,B. *Buchia okensis* (Pavlow, 1907) var. *elliptica* (Pavlow, 1907). Same locality, etc., as for specimen shown in fig. 1. GSC No. 16595.

An internal cast of medium-sized left valve. The shell is irregularly deformed in the proximity of its lower margin. 8A, Lateral view of exterior. 8B, Anterior view of same.

Figures 9A,B. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, etc., as for specimen reproduced in fig. 1. GSC No. 16596.

Internal cast of a large left valve transitional between the typical form and *B. o.* var. *elliptica* (Pavlow, 1907). Some patches of inner shell layer preserved in places. Shell is irregularly deformed in the posterior corner of its lower margin. 9A, Anterior view of exterior. 9B, Lateral view of same.

Figures 10A,B. *Buchia okensis* (Pavlow, 1907) f. typ. West coast of Vancouver Island. West side of main body of Grassy Island. One Tree Formation, 551 feet above the base of the section and about 45 feet above the Jurassic/Cretaceous contact. Lower Berriasian. GSC No. 16597.

An internal cast of a large and typical right valve almost duplicating the right valve of *Aucella cascadensis* figured by Crickmay (1930a, Pl. X, fig. 2). 10A, Lateral view of exterior. 10B, Posterior view of same.


1A
2B
2A
3A
1B
5A
5B
6A
4A
3B
4B
9A
6B
8B
7B
8A
9B
10B
7A
10A

PLATE VI

Figures 1A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). West coast of Vancouver Island, B.C., west side of the main body of Grassy Island. One Tree Formation, about 553 feet above the base of the section and 47 feet above the Jurassic-Cretaceous contact. Lower (but not the basal) Berriasian. Top part of *Buchia okensis* zone proper. GSC No. 17459.

Internal cast of an almost complete but somewhat deformed and sheared left valve of the giant representative of the variant, which is distinguished from *B. okensis* f. typ. in its concentric ribs being coarser and much more widely spaced. This particular representative of *B. okensis* var. *canadiana* is much wider than high.

1A, Lateral view of exterior. Most part of posterior ear is broken off. 1B, Anterior view of same. 1C, Oblique posterior view of same. 1D, Hinge margin and beak viewed from above.

Figures 2A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17460.

Internal cast of an almost complete, undistorted left valve with some patches of the shell layer preserved here and there. This smaller specimen is transitional to *B. okensis* f. typ. in its less distant and finer concentric ribbing habit; it is almost as wide as long, and so is transitional between the specimens of *B. okensis* var. *canadiana* shown in figs. 1 and 5 in this respect.

2A, Lateral view of exterior; 2B, Anterior view of same; 2C, Oblique posterior view of same; 2D, Hinge margin and beak viewed from above.

Figures 3A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen in fig. 1. GSC No. 17461.

Internal cast of an almost complete, medium-sized, almost undistorted left valve. This specimen belongs to the broad, subtrigonal form of the variant. Unlike the basal Berriasian representatives of the variant, the beak is slightly incurved to left.

3A, Lateral view of exterior; 3B, Anterior view of same; 3C, Oblique posterior view of same; 3D, Hinge margin and beak viewed from above. Tip of beak is broken off.

Figures 4A-D. *Buchia okensis* (Pavlow, 1907) aff. var. *canadiana* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17462.

Internal cast of an almost complete, large left valve. This specimen is aberrant in its concentric ribbing becoming obsolete and in the local intercalation of weaker ribs between the principal ones. The unusually long and pinched beak part of the valve has marked left-handed incurvature, which may be partly due to its deformation. All these features are suggestive of this specimen being somewhat transitional towards *B. uncitoides* var. *spasskensoides*.

4A, Lateral view of exterior; 4B, Anterior view of same; 4C, Oblique posterior view of same; 4D, Hinge margin and beak viewed from above.

Figures 5A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17463.

Internal cast of complete left valve of a giant representative of the variant. This specimen is much longer than wide and so represents the other extreme form (as compared with that shown in fig. 1) of the variant; it almost duplicates the specimen shown in Pl. X, fig. 7.

5A, Lateral view of exterior; 5B, Anterior view of same; 5C, Oblique posterior view of same; 5D, Hinge margin and beak viewed from above.

Figures 6A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17464.

Internal cast of an almost complete, large left valve of a specimen transitional between that shown in figs. 5 and 8. It is also transitional to *B. okensis* f. typ. in its concentric ribs being more closely spaced.

6A, Lateral view of exterior; 6B, Anterior view of same; 6C, Oblique posterior view of same; 6D, Hinge margin and beak viewed from above. The tip of the somewhat left-handedly incurved beak is broken off.

Figures 7A-D. *Buchia uncitoides* (Pavlow, 1907) var. *catamorpha* (Crickmay, 1930). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17465.

Internal cast of an almost complete, medium-sized left valve. This specimen seems to be indistinguishable from some representatives of *B. uncitoides* s. lato from the upper part of its zone (*see* Pl. IX, fig. 9); it lacks, however, the regular, closely spaced concentric ornament of its typical representatives.

7A, Lateral view of exterior. The beak shows moderate left-handed incurvature; 7B, Anterior view of same; 7C Oblique posterior view of same; 7D, Hinge margin and beak viewed from above.

Figures 8A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, age, etc., as for the specimen shown in fig. 1. GSC No. 17466.

Internal cast of an almost complete, large left valve. Transitional between the *B. fischeriana* var. *trigonoides*-like variant of *B. okensis* shown in fig. 9 and its extreme late form shown in Pl. VI, fig. 4 and Pl. VII, fig. 1. Also transitional between *B. okensis* var. *canadiana* and *B. okensis* f. typ. in the coarseness and spacing of its concentric ribs.

8A, Lateral view of exterior; 8B, Anterior view of same; 8C, Oblique posterior view of same; 8D, Hinge margin and beak viewed from above. The tip of the essentially straight beak is broken off.

Figures 9A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17467.

Internal cast of a complete, large left valve. This unnamed variant is only distinguishable from the representative of *B. fischeriana* var. *trigonoides* figured by Lahusen (1888, Pl. II, figs. 21-22 in its larger size and more widely spaced concentric ribs. From *B. okensis* f. typ. (*see* Pl. X, fig. 2) it differs in its subtriangular shape and in the almost complete absence of posterior ear.

9A, Lateral view of exterior; 9B, Anterior view; 9C, Oblique posterior view; 9D, Hinge margin and beak viewed from above. The unusual flatness of the valve also allies it with *B. fischeriana* var. *trigonoides* (Lahusen *non* Pavlow).


1A
1B
1D
4A
4B
3A
2A
4D
3D
3C
6D
4C
2B
2D
3B
1C
2C
6C
6A
8D
5D
8B
6B
8C
5C
5B
7A
7D
5A
8A
7C
9C
9D
7B
9B
9A
19334/11
19334/7
19334/10

PLATE VII

Figures 1A-D. *Buchia okensis* (Pavlow, 1907) s. lato. var. West coast of Vancouver Island, B.C., west side of the main body of Grassy Island. One Tree Formation, 606 to 606½ feet above the base of the section, and 100 to 100½ feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17468.

Internal cast of a complete left valve of a giant representative of the variant shown in Pl. VI, fig. 8.

1A, Lateral view of exterior; 1B, Anterior view; 1C, Posterior view; 1D, Hinge margin and beak viewed from above. The flat-topped appearance of the cross-section is caused by the lateral deformation of the valve.

Figures 2A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. Same locality and formation as for specimen shown in fig. 1, 600 to 601 feet above the base of the section and 94 to 95 feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17469.

Internal cast of the complete, medium-sized left valve of an unnamed, *B. volgensis*-like variant of the species. The ribbing habit is aberrant in the same way as that of the specimen shown in Pl. VI, fig. 4.

2A, Lateral view of the exterior; 2B, Anterior view; 2C, Oblique posterior view; 2D, Hinge margin and beak viewed from above.

Figures 3A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). Same locality and formation as for specimen shown in fig. 1, about 607 feet above the base of the section and 101 feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17470.

An internal cast of a medium-sized, almost complete left valve of the broad form of the variant transitional to *B. okensis* f. typ.

3A, Lateral view of the exterior; 3B, Anterior view; 3C, Posterior view; 3D, Hinge margin and beak viewed from above.

Figures 4A-D. *Buchia okensis* (Pavlow, 1907) s. lato. Same locality and formation as for specimen shown in fig. 1, 600 to 601 feet above the base of the section and 94 to 95 feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17471.

Internal cast of a somewhat fragmentary, fairly large right valve. The early growth-stages have the ribbing habit of *B. okensis* var. *subokensis* while the late growth-stages have that of *B. okensis* f. typ. The outline is typical of *B. okensis* f. typ.

4A, Lateral view of exterior; 4B, Anterior view; 4C, Oblique posterior view. The byssus ear is missing; 4D, Hinge margin and fragmentary beak viewed from above.

Figures 5A-C. *Buchia* aff. *uncitoides* (Pavlow, 1907) s. lato. Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17472.

Fragmentary left valve of an extremely narrow and high, *B. crassicollis*-like form that appears to be transitional between the extremely narrow and elongate variant of *B. okensis* s. lato (fig. 1) and similar variant of *B. uncitoides* s. lato (figs. 9, 13). The upper part of the valve is shell-covered throughout while its lower part is a somewhat weathered-out internal cast. The pronounced left-handed incurvature of beak and the heavy, widely spaced ribbing habit differentiate this peculiar form from *B. crassicollis* s. str.

5A, Lateral view of exterior; 5B, Anterior view; 5C, Hinge margin and beak viewed from above.

Figures 6A-D. *Buchia* aff. *fischeriana* (d'Orbigny, 1845) var. *stremouhovi* (Pavlow, 1907). Same locality and formation as for specimen shown in fig. 1, 542 to 543 feet above the base of the section and 36 to 37 feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17473.

Internal cast of a somewhat fragmentary, medium-sized left valve of a form that can only be distinguished from the Upper Tithonian *B. fischeriana* s. lato because of such flimsy features as its large and angular posterior ear and the sudden appearance of widely spaced concentric ribs near the lower shell's margin. If found alone, this specimen would probably have been mistaken for *B. fischeriana* s. lato and dated accordingly.

6A, Lateral view of the exterior; 6B, Anterior view; 6C, Oblique posterior view; 6D, Hinge margin and beak viewed from above.

Figures 7A-D. *Buchia okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907). Same locality, age, etc., as for specimen shown in fig. 4 (preserved on the same piece of rock). GSC No. 17474.

An internal cast of a complete, small right valve probably representing the early growth-stage of the variant shown in fig. 4.

7A, Lateral view of the exterior; 7B, Anterior view; 7C, Oblique posterior view; 7D, Hinge margin and beak viewed from above.

Figures 8A-C. *Buchia okensis* (Pavlow, 1907) aff. var. *subokensis* (Pavlow, 1907). Same locality and formation as for specimen shown in fig. 1, 553 feet above the base of the section and 47 feet above the Jurassic-Cretaceous contact. Lower (but not the basal) Berriasian. GSC No. 17475.

Internal cast of a somewhat fragmentary, large right valve transitional between *B. okensis* var. *subokensis* and the extreme forms of *B. uncitoides* var. *spasskensoides* in its finer and more closely spaced concentric ribs. The ribs tend to occur in pairs separated by wider intervals from adjacent pairs.

8A, Lateral view of the exterior; 8B, Anterior view. The byssus ear is missing; 8C, Hinge margin and beak viewed from above.

Figures 9A-D. Transitional form between the *B. volgensis*-like variant of *B. okensis* s. lato and *B. uncitoides* var. *spasskensoides*. Same locality, age, etc., as for specimen shown in fig. 8. GSC No. 17476.

Internal cast of a large but incomplete left valve. Concentric ribs are closely spaced and relatively fine throughout and the beak shows marked left-handed incurvature (fig. 9A). Such specimens have been designated by the writer (1950, p. 40) as "*Aucella* ex. gr. *volgensis*"; they differ, however, from *Buchia volgensis* (*see* Pl. X, fig. 4) in their longer, pinched left beak and its pronounced left-handed incurvature.

9A, Lateral view of exterior; 9B, Anterior view. Unlike that of *B. volgensis,* the beak is not hook-like bent and does not overhang the right valve; 9C, Oblique posterior view of the same; 9D, Hinge margin and beak viewed from above. Beak has marked left-handed (right-handed in this aspect) incurvature.

Figures 10A-C. *Buchia* aff. *okensis* (Pavlow, 1907) s. lato. Same locality, age, etc., as for specimen shown in fig. 8. GSC No. 17477.

Internal cast of a form apparently representing the extreme development of the *B. volgensis*-like variant of *B. okensis* s. lato (*see* fig. 2); it may, however, be transitional between this variant and the *Buchia* forms shown in figs. 9 and 13. Although it is indistinguishable from *B. volgensis* s. str. (*see* Pl. X, fig. 4) in its shape, proportions and the thickness of the preserved part of the beak, this specimen is believed to be unrelated to it because of its *Buchia okensis*-like posterior ear and heavy and widely spaced concentric ribbing (fig. 10A).

10A, Lateral view of exterior; 10B, Anterior view; 10C, Hinge margin and beak viewed from above. Most of the beak is missing.

Figures 11A-C. *Buchia* aff. *uncitoides* (Pavlow, 1907) s. lato. Same locality and formation as for the specimen shown in fig. 1, 607⅓ to 607½ feet above the base of the section and 101⅓ to 101½ feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17478.

A complete left valve of the same extremely narrow and high, *B. crassicollis*-like form as that shown in fig. 5. The upper half is mostly covered by poorly preserved shell layer while the lower half is an internal cast. The ornament is strongly reduced throughout suggesting that this specimen is closer to *B. uncitoides* s. lato than that shown in fig. 5.

11A, Lateral view of the exterior; 11B, Anterior view; 11C, Hinge margin and beak viewed from above.

Figures 12A-C. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). Same locality, age, etc., as for specimen in fig. 11. GSC No. 17479.

A partly shell-covered, medium-sized, incomplete left valve of a specimen transitional between the variant of *B. okensis* shown in fig. 1 and the typical representatives of the variant (*see* fig. 14).

12A, Lateral view of the exterior; 12B, Anterior view. The beak's hook-like bend is the result of deformation; it is actually only slightly left-handedly incurved; 12C, Hinge margin and the beak viewed from above.

Figures 13A-D. The same transitional form between *B. volgensis*-like variant of *B. okensis* s. lato and *Buchia uncitoides* var. *spasskensoides* as that shown in fig. 9. Same locality, age, etc., as for specimen of a similar form shown in fig. 8. GSC No. 17480.

Internal cast of an essentially complete, fairly large left valve. This specimen retains some heavier and widely spaced concentric ribs against the background of strongly subdued, fine and closely spaced ribbing.

13A, Lateral view of the exterior; 13B, Anterior view; 13C, Posterior (oblique) view; 13D, Hinge margin and beak viewed from above.

Figures 14A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). The same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17481.

Internal cast of an almost complete, fairly small specimen with the valves still in the normal position. The right valve matches closely that of the holotype of the variant (Pl. X, fig. 13). As already noted by Crickmay (1930), *B. u.* var. *spasskensoides* strongly resembles *B. okensis* var. *subokensis* (= *B. spasskensis* Pavlow) in its general shape and ribbing habit; it only differs from it in its feeble to marked left-handed incurvature of left beak.

14A, Lateral view of exterior of the left valve; 14B, Anterior view of both valves. The tip of the left valve is broken off; 14C, Oblique posterior view of both valves; 14D, Hinge margins and beaks of both valves viewed from above.

PLATE VII


4B
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8A
6D
6C
6B
11B
5A
1A
10C
9D
10B
8B
10A
11A
14D
9B
11C
9C
9A
13B
14A
12B
13A
12A
12C
13C
13D
14C
14B

PLATE VIII

All specimens shown in figures 1 to 12 inclusive are from "West coast of Vancouver Island, B.C., in the middle of the southern part of the main body of Grassy Island. One Tree Formation, 661 to 661½ feet above the base of the section and 155 to 155½ feet above the Jurassic-Cretaceous contact. Lower Berriasian, top part of the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones".

Figures 1A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. GSC No. 17482. Internal cast of a fairly large, incomplete left valve of an unnamed late variant of the species combining the angular outline of *B. okensis* var. *elliptica* (*see* Pl. V, fig. 8) with the heavy and very widely spaced concentric ribbing of *B. o.* var. *canadiana.* The strong left-handed incurvature of beak is characteristic of this variant.

1A, Lateral view of the exterior; 1B, Anterior view; 1C, Oblique posterior view; 1D, Hinge margin and beak viewed from above.

Figures 2A-D. *Buchia* aff. *okensis* (Pavlow, 1907) s. lato. GSC No. 17483. A fairly large but incomplete posteriorly, partly shell-covered left valve of a form transitional between the variant of *B. okensis* s. lato shown in fig. 1 and *B. uncitoides* var. *spasskensoides* shown in fig. 8. This form combines the angular outline, great thickness and marked left-handed incurvature of beak of the former with the heavy but much more closely spaced and often paired concentric ribs of the latter.

Same views as for specimen shown in fig. 1.

Figures 3A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. GSC No. 17484. Large and almost complete, partly shell-covered left valve of another unnamed late variant of the species combining the heavy and very widely spaced concentric ribs of *B. o.* var. *canadiana* with the *B. volgensis*-like outline (fig. 3A) and *B. uncitoides* var. *spasskensoides*-like cross-section and pronounced left-handed curvature of the beak (fig. 3D).

Same views as for specimen shown in fig. 1.

Figures 4A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. GSC No. 17485. Internal cast of a complete medium-sized left valve of a late variant retaining most of the diagnostic features of *B. okensis* f. typ.; its beak is, however, long with slight left-handed incurvature, and the outline is largely *B. volgensis*-like.

Same views as for specimen shown in fig. 1.

Figures 5A-D. *Buchia* aff. *okensis* (Pavlow, 1907) s. lato. GSC No. 17486. Internal cast (with some patches of the shell layer) of a large, almost complete left valve transitional between *B. okensis* s. lato var. shown in fig. 4 and *B.* aff. *uncitoides* var. *spasskensoides* shown in fig. 9. This specimen is still close to *B. okensis* s. lato in its general shape; its concentric ribs are subdued, however, and finer, second order ribs are intercalated locally with the heavier ribs.

Same views as for specimen shown in fig. 1.

Figures 6A-D. *Buchia okensis* (Pavlow, 1907) s. lato. GSC No. 17487. Internal cast (with some patches of shell layer) of a large and complete left valve combining the pear-like outline and ill-developed posterior ear of a *B. volgensis*-like variant with the coarse and distantly spaced concentric ribs of *B. okensis* var. *canadiana.* The dichotomous rib in the middle of the shell is a pathological feature.

Same views as for specimen shown in fig. 1.

Figures 7A-D. *Buchia* aff. *okensis* (Pavlow, 1907) s. lato. GSC No. 17488. A partly shell-covered, somewhat incomplete, large left valve transitional between that of *B. okensis* s. lato var. shown in fig. 4 and that of *B.* aff. *uncitoides* var. *spasskensoides* shown in fig. 9 in its outline and ribbing; it is, however, considerably thicker than either of them and approaches the left valve shown in fig. 2 in this respect. The beak is unusually short and obtuse.

Same views as for specimen shown in fig. 1.

Figures 8A-D. *Buchia* aff. *uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17489.

Internal cast of a large and complete left valve transitional between *B. okensis* var. *subokensis* (*see* Pl. VI, fig. 3; Pl. IV, fig. 11) and *B. uncitoides* var. *spasskensoides* (*see* fig. 12; Pl. IX, fig. 22; Pl. X, fig. 12). This specimen combines the general shape, feebly right-handedly incurved beak and the large, angular posterior ear of the early forms of *B. o.* var. *subokensis* (Pl. IV, figs. 11, 15) with the heavier but closer spaced and sometimes clearly paired concentric ornament and the greater thickness of *B. u.* var. *spasskensoides.*

Same views as for specimen shown in fig. 1.

Figures 9A-D. *Buchia* aff. *uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17490.

A partly shell-covered, large but incomplete left valve combining the broad and angular shape of *B. okensis* aff. var. *elliptica* and related forms of the species shown in figs. 1 and 2 with the ill-defined posterior ear and heavy but more closely spaced and locally paired concentric ribs of *B. u.* var. *spasskensoides.* Transitional between these forms but morphologically closer to the latter.

Same views as for specimen shown in fig. 1.

Figures 10A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17491.

Internal cast (with some patches of the shell layer) of an unusually large, almost complete left valve of the extreme *B. volgensis*-like form of the variant. This specimen matches closely the original specimen of *B. u.* var. *spasskensoides* shown in Pl. X, fig. 12 in its outline; it is, however, much thicker than this latter and the more widely spaced but lower concentric ribbing of its early growth stages is replaced by more closely spaced but higher and sharper concentric ribs in the later growth-stages (fig. 10A). This specimen resembles closely some shells placed in *Buchia volgensis* by Pavlow (1907, Pl. II, figs. 10, 12) and was originally identified by the writer (1950, p. 40) as *Aucella* ex gr. *volgensis* Lahusen; it is, however, a considerably thicker and narrower shell with the longer, stronger pinched and markedly left-handedly incurved beak. The latter lacks, furthermore, the hook-like bend and does not overhang the right valve in *B. volgensis*-like fashion.

Same views as for specimen shown in fig. 1.

Figures 11A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17492.

A partly shell-covered, incomplete, large left valve of the same extreme form of the variant as that shown in fig. 10. This specimen is even more similar to *B. volgensis* in its hook-like bend and somewhat overhanging beak; it differs from *B. volgensis,* however, in all other above-mentioned (*see* under descr. of fig. 10) features.

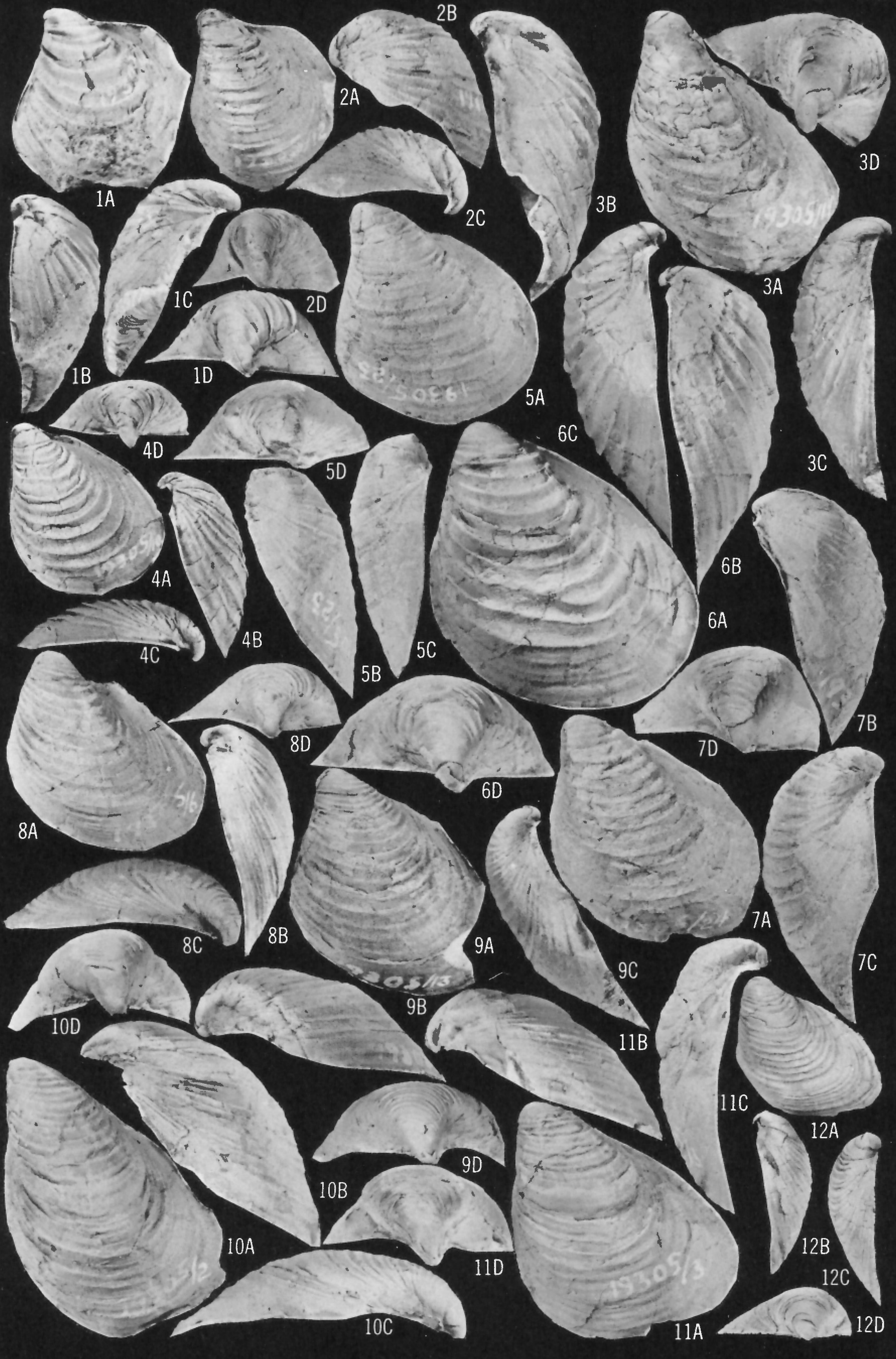
Same views as for specimen shown in fig. 1.

Figures 12A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17493.

Internal cast of an almost complete, small left valve of a fairly typical representative of the variant. The almost complete absence of the posterior ear and the coarse but closely spaced and locally paired concentric ribs distinguish it from the otherwise closely similar *B. okensis* var. *subokensis.* If encountered alone, small specimens of this type can easily be mistaken for *B. fischeriana* s. lato; they can only be distinguished from the latter because of the coarser and higher concentric ribs and more or less marked left-handed incurvature of left beak.

Same views as for specimen shown in fig. 1.

PLATE VIII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8B
8C
8D
9A
9B
9C
9D
10A
10B
10C
10D
11A
11B
11C
11D
12A
12B
12C
12D

PLATE IX

All specimens shown in figures 1 to 23 inclusive are from "West coast of Vancouver Island, B.C., in the middle of the southern part of the main body of Grassy Island. One Tree Formation, 661 to 661½ feet above the base of the section and 155 to 155½ feet above the Jurassic-Cretaceous contact. Lower Berriasian, top part of the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones".

Figures 1A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17494.
Internal cast (some patches of poorly preserved shell layer) of a large, incomplete right valve of a form transitional to *B. u.* var. *acutistriata*. Byssus ear seems to be almost perpendicular to the plane of contact of the valves because of its incomplete preservation (fig. 1D).
1A, Lateral view of the exterior; 1B, Anterior view; 1C, Oblique posterior view; 1D, Hinge margin and beak viewed from above.

Figures 2A-D. *Buchia uncitoides* (Pavlow, 1907) var. *acutistriata* (Crickmay, 1930). GSC No. 17495.
Internal cast of a fairly large, complete right valve. Considerable patches of shell layer occur around the beak. Concentric ribs are much finer, much more closely spaced, higher and sharper than those of *B. u.* var. *spasskensoides* (*see* fig. 1). This is true of the internal cast as well as of the shell's surface. Same views as for specimen shown in fig. 1.

Figures 3A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17496.
Internal cast of a complete juvenile valve probably belonging to the young representative of the transitional form shown in Pl. VIII, fig. 8.
Same views as for specimen shown in fig. 1.

Figures 4A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17497.
Internal cast of a complete juvenile left valve of a typical representative of the variant. The valve is relatively more narrow and elongate; it is, furthermore, covered by more closely spaced and sharper ribs than that of the left valve shown in fig. 3. Same views as for specimen shown in fig. 3.

Figures 5A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17498.
Internal cast of a small and incomplete left valve of an extremely narrow and elongate variant of the species. This unnamed variant can be easily confused with *B. piochii* s. lato it differs, however, from it in its marked left-handed incurvature of beak (fig. 5D) and in the much narrower and higher cross-section (figs. 5B, 5D). Same views as for specimen shown in fig. 3.

Figures 6A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17499.
A partly shell-covered, small, and complete right valve transitional between var. *spasskensoides* and var. *acutistriata* in its ribbing habit. The anterior surface of the completely preserved byssus ear (fig. 6D) forms an angle of only 40 to 45° with the plane of contact of the valves; it is, consequently, of the same evolutionary grade as that of some forms of *B. piochii* var. *russiensis* (Pl. I, fig. 5). Same views as for specimen shown in fig. 1.

Figures 7A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. GSC No. 17500 Internal cast (with some patches of the shell layer) of a large but incomplete and distorted right valve probably representing the late variant shown in Pl. VIII, figs. 1 and 2. Most of the posterior and byssus ear is broken off. Same views as for specimen shown in fig. 1.

Figures 8A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. GSC No. 17501. A partly shell-covered incomplete juvenile left valve probably belonging to the late variant shown in Pl. VIII, fig. 1. The beak shows stronger left-handed incurvature than is apparent in figs. 8A and 8D. Same views as for the specimen in figure 1.

Figures 9A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17502. A partly shell-covered, half-grown, incomplete and somewhat deformed left valve of the same variant as shown in fig. 5. Same views as for specimen shown in fig. 1.

Figures 10A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17503. Internal cast of an almost complete juvenile left valve of the same extreme variant as that shown in figs. 5 and 9. The left-handed curvature of the beak is apparently increased by the anterior-posterior deformation of the valve. Same views as for specimen shown in fig. 1.

Figures 11A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17504. Internal cast of an almost complete, juvenile left valve of the same extreme variant as that shown in figs. 5, 9 and 10. This specimen could hardly have been distinguished from *B. piochii* s. lato if found alone. Same views as for specimen shown in fig. 1.

Figures 12A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17505. Internal cast of an almost complete left valve transitional between that of the variant shown in figs. 5, 9 and 10, and that of *B. uncitoides* var. *catamorpha* shown in figs. 13 and 18. This specimen is only distinguishable from some variants of *B. piochii* s. lato in the stronger left-handed curvature of the end part of its beak (fig. 12D). Same views as for specimen shown in fig. 1.

Figures 13A-D. *Buchia uncitoides* (Pavlow, 1907) var. *catamorpha* (Crickmay, 1930). GSC No. 17506.
A mostly shell-covered, incomplete left valve of a fairly typical but half-grown representative of the variant. The sculpture of the shell's surface and that of the cast's surface is reduced to faint striae and growth-lines interrupted here and there by isolated faint concentric ribs and constrictions. The beak shows strong left-handed incurvature. Same views as for specimen shown in fig. 1.

Figures 14A-E. *Buchia uncitoides* (Pavlow, 1907) var. *acutistriata* (Crickmay, 1930). GSC No. 17507.
Internal cast (with some patches of the shell layer) of an almost complete, medium-sized right valve with well-preserved byssus ear and anterior part of the ligamental plate (figs. 14D, E). The anterior surface of the byssus ear is characteristically bent in the middle and ends in a sharp tooth-like ridge projecting upward (figs. 14B, 14D, 14E).
Figures 14A-14D are the same views as for the specimen shown in fig. 1; fig. 14E. Oblique view of the interior. The beak and ligamental plate are tilted towards the camera, X3.

Figures 15A-E. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17508. Internal cast (with some patches of the shell layer) of a large, incomplete right valve of a variant characterized by the irregular and subdued ornament. The byssus ear is well preserved but most of the ligamental plate is preserved as an internal cast (fig. 15E). Same views as for specimen shown in fig. 14.

Figures 16A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17509.
A mostly shell-covered, large but incomplete right valve of a broad form of the variant. Same views as for specimen shown in fig. 1.

Figures 17A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17510.
A mostly shell-covered, almost complete left valve of a half-grown specimen transitional between *B. u.* var. *acutistriata* and the extreme *B. piochii*-like variant shown in figs. 5, 9, 10-12. Same views as for specimen shown in fig. 1.

Figures 18A-D. *Buchia uncitoides* (Pavlow, 1907) var. *catamorpha* (Crickmay, 1930). GSC No. 17511.
Internal cast of an almost complete, medium-sized left valve essentially similar to the smaller valve shown in fig. 13. Same views as for specimen shown in fig. 1.

Figures 19A-D. *Buchia uncitoides* (Pavlow, 1907) var. *acutistriata* (Crickmay, 1930). GSC No. 17512.
Internal cast of a complete, small left valve of a broad form transitional to *B. u.* var. *spasskensoides* in its shape and spacing of the concentric ribs. Same views as for specimen shown in fig. 1.

Figures 20A-E. *Buchia uncitoides* (Pavlow, 1907) var. *acutistriata* (Crickmay, 1930). GSC No. 17513.
A large but rather incomplete typical right valve of the variant, mostly shell-covered. The ligamental plate is completely preserved but most of the anterior surface of the byssus ear, including its sharp ridge, is broken off (fig. 20E). Same views as for specimen shown in fig. 14.

Figures 21A-E. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17514
Internal cast (considerable area of the shell layer preserved around the beak and hinge margin) of a small, almost complete right valve of the same variant as that shown in fig. 15. The ligamental plate and byssus ear are completely preserved and typically developed (figs. 20D, E). The longitudinal striation of the ligamental plate is clearly visible in fig. 20E. Same views as for specimen shown in fig. 14.

Figures 22A-D. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). GSC No. 17515.
Internal cast of an almost complete, medium-sized left valve transitional to *B. u.* var. *acutistriata* in the sharpness of its concentric ribs and at the same time transitional to *B. okensis* (Pavlow, 1907) var. *subokensis* (Pavlow, 1907) in its well-developed posterior ear and outline. The beak is virtually straight, which is somewhat unusual for the species and variant at the level of the overlap beds. Same views as for specimen shown in fig. 1.

Figures 23A-D. *Buchia uncitoides* (Pavlow, 1907) s. lato var. GSC No. 17516.
A mostly shell-covered, almost complete, medium-sized left valve of the same variant as that shown in figs. 15 and 21. This unnamed, *B. piochii*-like variant appears to be transitional between *B. u.* var. *acutistriata* and var. *catamorpha*. The beak has pronounced left-handed incurvature, which distinguishes this specimen from *B. piochii* s. lato at a glance. Same views as for specimen shown in fig. 1.

PLATE IX


1D
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5A
5C
4B
9D
10D
13D
10B
13B
6A
2A
9B
10C
10A
11D
1B
6D
9C
11C
12B
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13C
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12C
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23A
22C

PLATE X

Figures 1A-C. *Buchia keyserlingi* var. *visingensis* (Sokolov, 1908). West coast of Vancouver Island. Southern rocky fringe of Grassy Island. One Tree Formation, 919-920 feet above the base of the section and 413 to 414 feet above Jurassic/Cretaceous contact. Upper Berriasian. GSC No. 16599.

Internal cast of a large and typical left valve incomplete in the posterior part.

1A, Lateral view of the exterior; 1B, Anterior view; 1C, Oblique posterior view.

Figure 2. *Buchia okensis* (Pavlow, 1907) f. typ. Harrison Lake area, B.C. 350 yards west of the shore of the lake and 1,200 yards north of the mouth of Deer Creek. Peninsula Formation. Lower Berriasian. GSC No. 9657.

Such forms seem to be characteristic of the top beds of *Buchia okensis* zone and of the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones. This is the reproduction of the holotype of *Aucella cascadensis* Crickmay (1930a, Pl. X, fig. 1). This typical specimen of *B. okensis* virtually duplicates its holotype (herein designated) figured by Pavlow (1907, Pl. I, figs. 11A-C).

Lateral view of the exterior of left valve.

Figures 3A,B. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). West coast of Vancouver Island. West side of the main body of Grassy Island near its southern end. One Tree Formation, 678-679 feet above the base of the section and 172-173 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Lower part of *Buchia uncitoides* zone closely below beds with *Spiticeras* spp. etc. GSC No. 16600.

An internal cast of a large left valve closely similar to that of the holotype of *B. uncitoides* var. *spasskensoides* (Crickmay, 1930).

3A, Lateral view of the exterior; 3B, Anterior view.

Figures 4A,B. *Buchia volgensis* (Lahusen, 1888) s. str. Northern Richardson Mountains, N.W.T. On Martin Creek, about 1-3/5 miles west of junction with Donna River, lat. 68°12′N; long. 135°34′W. Lower Sandstone Division, Buff Sandstone Member, Upper Berriasian. *Buchia volgensis* zone. Coll. by the Mobiloil Co. of Canada, Ltd., 1946. GSC No. 16601.

An internal cast of a fairly typical left valve. 4A, Lateral view of the exterior; 4B, Anterior view of the same.

Figures 5A,B. *Buchia volgensis* (Lahusen, 1888) f. typ. Same locality, etc., as for specimen shown in fig. 4. GSC No. 16602.

An internal cast of a large and typical right valve. 5A, Lateral view of the exterior; 5B, Oblique anterior view of the same. The byssus notch is at the extreme upper end of the photo. Note how flat the valve is.

Figure 6. *Buchia uncitoides* (Pavlow, 1907) var. *acutistriata* (Crickmay, 1930). Holotype. The same locality, etc., as for specimen shown in fig. 2. Probably from the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones. This is the reproduction of the figured specimen of Crickmay (1930a, Pl. IX, fig. 2). GSC No. 9656.

Lateral view of the exterior of left valve. Large specimen with preserved shell layer.

Figure 7. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). The same locality, etc., as for specimen shown in fig. 2. Probably from the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones. This is a reproduction of the figured specimen of Crickmay (1930a, Pl. X, fig. 3). GSC No. 9655.

Lateral view of the exterior of right valve and that of the underside of protruding beak part of left valve.

Figures 8A-C. *Buchia uncitoides* (Pavlow, 1907) var. *acutistriata* (Crickmay, 1930). West coast of Vancouver Island, B.C. Southern fringe of Grassy Island. One Tree Formation, 829-832 feet above the base of the section and 323-326 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras* spp. etc. GSC No. 16603. Almost complete and typical specimen with the shell layer preserved.

8A, Lateral view of the exterior of left valve; 8B, Same view of right valve and that of the underside of the beak part of left valve; 8C, Oblique posterior view of the exterior of both valves.

Figures 9A-C. *Buchia uncitoides* (Pavlow, 1907) s. lato. Same locality and section as for specimen shown in fig. 8. 769 to 773 feet above the base of the section and 263 to 267 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras* spp. etc. GSC No. 16604.

An internal cast of a medium-sized, almost complete specimen transitional between *B. uncitoides* var. *acutistriata* and var. *catamorpha*. Some patches of shell layer preserved in places, especially on the right valve.

9A, Lateral view of the exterior of left valve; 9B, Same view of right valve; 9C, Anterior view of the exterior of both valves.

Figures 10A,B. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). Same locality, etc., as for specimen shown in fig. 3. GSC No. 16605.

Internal cast of a medium-sized left valve. 10A, Lateral view of the exterior; 10B, Anterior view.

Figures 11A,B. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). The same locality, etc., as for specimen shown in fig. 3. GSC No. 16664.

An internal cast of a large left valve. 11A, Lateral view of the exterior; 11B, Anterior view.

Figure 12. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). Paratype. Harrison Lake, B.C. West shore of a little bay on the southwest shore of the peninsula. Peninsula Formation. Upper Berriasian. This is the reproduction of the specimen figured by Crickmay (1930a, Pl. IX, fig. 4). Probably collected from the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones. GSC No. 9652.

Almost complete, large left valve with mostly preserved shell layer. This specimen is transitional between *B. uncitoides* var. *acutistriata* and var. *spasskensoides* in the prominence and spacing of concentric ribs. Lateral view of the exterior.

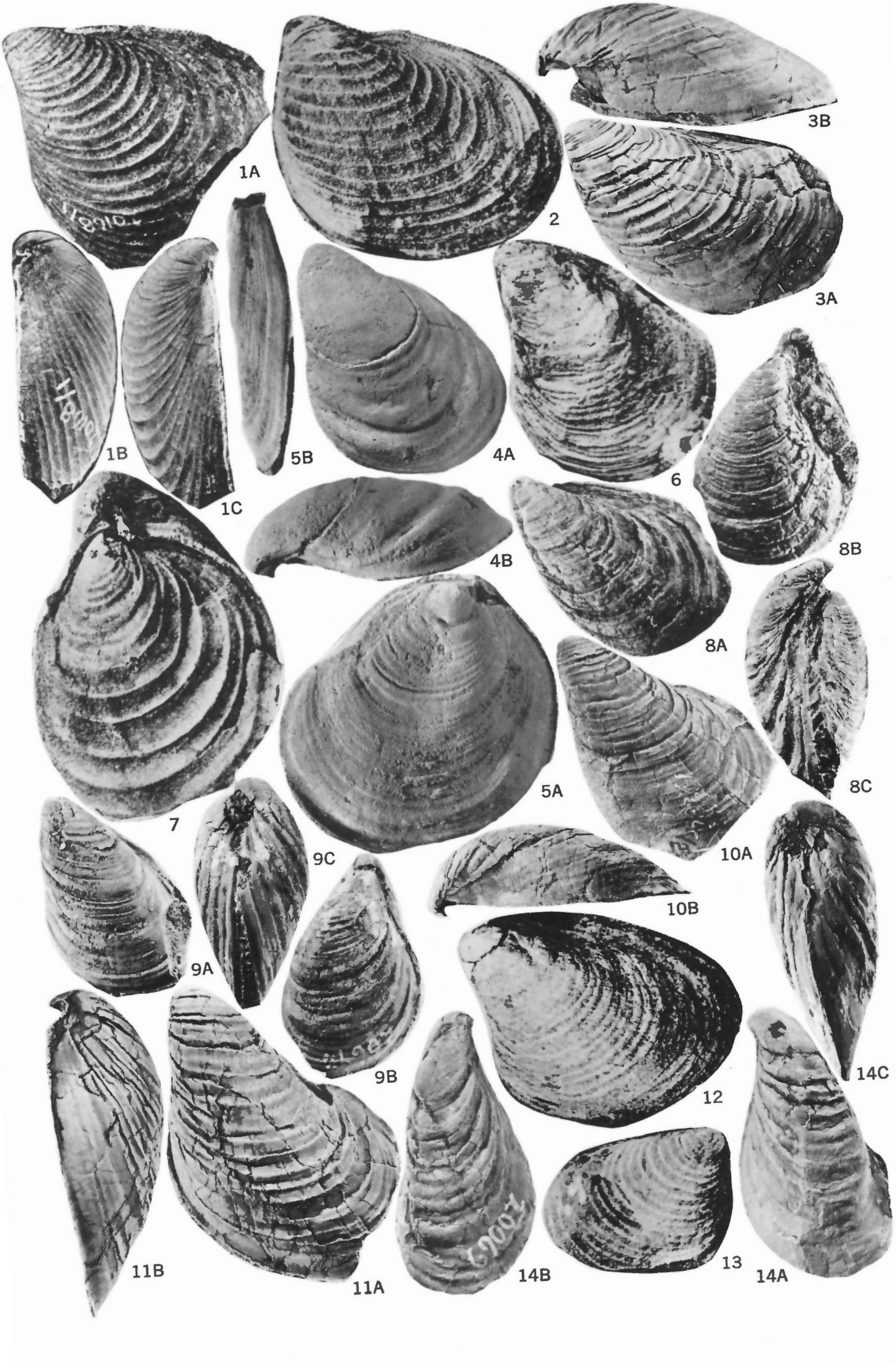
Figure 13. *Buchia uncitoides* (Pavlow, 1907) var. *spasskensoides* (Crickmay, 1930). Holotype. Harrison Lake, B.C. West shore of a little bay on the southwest shore of the peninsula. Peninsula Formation. Upper Berriasian. This is the reproduction of the specimen figured by Crickmay (1930, Pl. IX, fig. 3). Probably collected from the overlap beds between *Buchia okensis* and *Buchia uncitoides* zones. GSC No. 9651.

Lateral view of the exterior of a medium-sized right valve. An internal cast. This specimen is actually transitional between more typical representatives of the variant and *B. okensis* var. *subokensis*.

Figures 14A-C. *Buchia uncitoides* (Pavlow, 1907) var. West coast of Vancouver Island, B.C. Southern fringe of Grassy Island. One Tree Formation, 765 to 769 feet above the base of the section and 259 to 263 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras* spp. etc. GSC No. 16606.

An internal cast of a somewhat distorted, almost complete specimen partly covered by remnants of the inner shell layer. This specimen is transitional to *Buchia tolmatschowi* s. lato. 14A, Lateral view of the exterior of left valve; 14B, Same view of right valve; 14C, Anterior view of the exterior of both valves.

PLATE X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14A

PLATE XI

Figures 1A,B. *Buchia keyserlingi* (Lahusen, 1888) var. *visingensis* (Sokolov, 1908). The same locality, etc., as for the specimen reproduced in Pl. X, fig. 1. GSC No. 16607.

An internal cast of an almost complete left valve of a half-grown representative. 1A, Lateral view of the exterior; 1B, Oblique posterior view.

Figures 2A-C. *Spiticeras (Spiticeras)* sp. indet. juven. (possibly young representative of *S. (S.) scriptus* Strachey 1865). West coast of Vancouver Island. Southern end of the main body of Grassy Island; 699 to 702 feet above the base of the section and 193 to 196 feet above the Jurassic/Cretaceous contact. One Tree Formation. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16608.

2A, Lateral view of the partly crushed specimen; 2B, Lateral view of the other side; 2C, Ventral view of the earlier part of the whorl shown in figs. 2A,B.

Figure 3. *Spiticeras (Spiticeras)* sp. indet. juven. West coast of Vancouver Island. Southern end of the main body of Grassy Island. One Tree Formation, 682 feet above the base of the section and 176 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. This is the lowermost bed in which representatives of the genus *Spiticeras (Spiticeras)* have been found. GSC 16609. Lateral view of the only partly flattened specimen found.

Figures 4A-D. *Berriasella (Protacanthodiscus)* nov. sp. aff. *B. (P.) micheicus* (Bogoslovsky, 1897). West coast of Vancouver Island. Southern rocky fringe of Grassy Island. One Tree Formation, about 828 feet above the base of the section and 322 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16610.

4A, Lateral view of the only fragment found; 4B, Lateral view of the other side; 4C, Cross-section of the septate part of the same; 4D, Cross-section of the living chamber and the venter of the earliest part of the whorl preserved.

Figures 5A-C. *Buchia keyserlingi* (Lahusen, 1888) var. *sibirica* (Sokolov, 1908). The same locality, etc., as for the specimen shown in Pl. X, fig. 1. GSC No. 16611.

Internal cast of a typical but fragmentary left valve of a half-grown specimen. 5A, Lateral view of the exterior; 5B, Anterior view; 5C, Oblique posterior view.

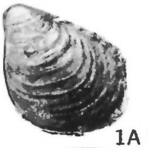
Figures 6A-C. *Neocomites* s. lato n. sp. indet. West coast of Vancouver Island. Southern rocky fringe of Grassy Island. One Tree Formation, 793 to 795 feet above the base of the section and 287 to 289 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16612.

6A, Lateral view of the complete specimen; 6B, Ventral view of the early whorl that is covered by the part of the early whorl shown on the extreme lower left of fig. 6A; 6C, Ventral view of the part of the early whorl shown on the extreme lower left of fig. 6A. The specimen is septate to the end, even though it is almost smooth on the largest whorl (fragment) preserved.

Figure 7. *Spiticeras (Groebericeras)* n. sp. indet.? West coast of Vancouver Island. Southern rocky fringe of Grassy Island. One Tree Formation, 789 to 792 feet above the base of the section and 283 to 286 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16613. Lateral view of the only uncrushed fragment found.

Figures 8A,B. *Buchia uncitoides* (Pavlow, 1907) var. *catamorpha* (Crickmay, 1930). West coast of Vancouver Island. Southern rocky fringe of Grassy Island. One Tree Formation, 792 feet above the base of the section and 286 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16614.

Internal cast of a medium-sized fairly typical left valve of the variant. This left valve matches closely those figured by Pavlow (1907, Pl. V, figs. 14-15) and Sokolov (1908b, Pl. I, figs. 10, 12, *non* 14). 8A, Lateral view of the exterior. 8B, Anterior view.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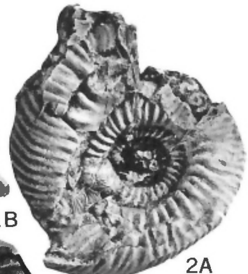
1B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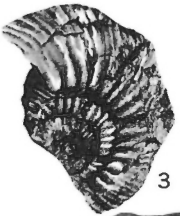
2C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4A


4B

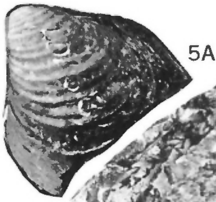

4C


4D


5B


5C


2B


5A


6A


6B


6C


7


8A


8B

PLATE XII

Figures 1A-C. *Buchia keyserlingi* (Lahusen, 1888) var. *visingensis* (Sokolov, 1908). The same locality, etc., as for the ammonite figured in Pl. XI, figs. 4A-D. GSC No. 16615.

An internal cast of a medium-sized, typical left valve. 1A, Lateral view of the exterior; 1B, Oblique posterior view; 1C, Anterior view.

Figures 2A-C. *Buchia keyserlingi* (Lahusen, 1888) var. *visingensis* (Sokolov, 1908). The same locality, etc., as for specimen reproduced in Pl. X, fig. 1. GSC No. 16616.

An internal cast with patches of the inner shell layer preserved. A half-grown representative of the variant. 2A, Lateral view of the exterior of left valve and that of the underside of the hinge margin of right valve; 2B, Lateral view of the exterior of right valve and that of the underside of the beak part and hinge margin of the left valve; 2C, Anterior view of the exterior of both valves.

Figures 3A,B. Peculiar phylloceratid ammonite, genus and species indet. West coast of Vancouver Island. Southern end of the central body of Grassy Island. One Tree Formation, 710 to 713 feet above the base of the section and 204-7 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16617. 3A, Lateral view of the only fragment found; 3B, Ventral view.

Figures 4A-C. *Spiticeras (Spiticeras)* cf. *scriptus* (Strachey, 1865). Same locality, etc., as for the specimen shown in Pl. XI, fig. 2. GSC No. 16618.

4A, Lateral view; 4B, Ventral view; 4C, Dorsal view.

Figure 5. *Spiticeras (Spiticeras)* cf. *mojsvari* Uhlig, 1903. Same locality, etc., as for the specimen shown in fig. 4. 724-725 feet above base of the section and 218-219 feet above the Jurassic/Cretaceous contact. Upper Berriasian. Beds with *Spiticeras,* etc. GSC No. 16619. Lateral view of the fragment of the living chamber.

Figure 6. *Neocomites* s. lato n. sp. indet. Lateral view of the early whorl of the specimen shown in Pl. XI, fig. 6B. GSC No. 16612.

PLATE XII

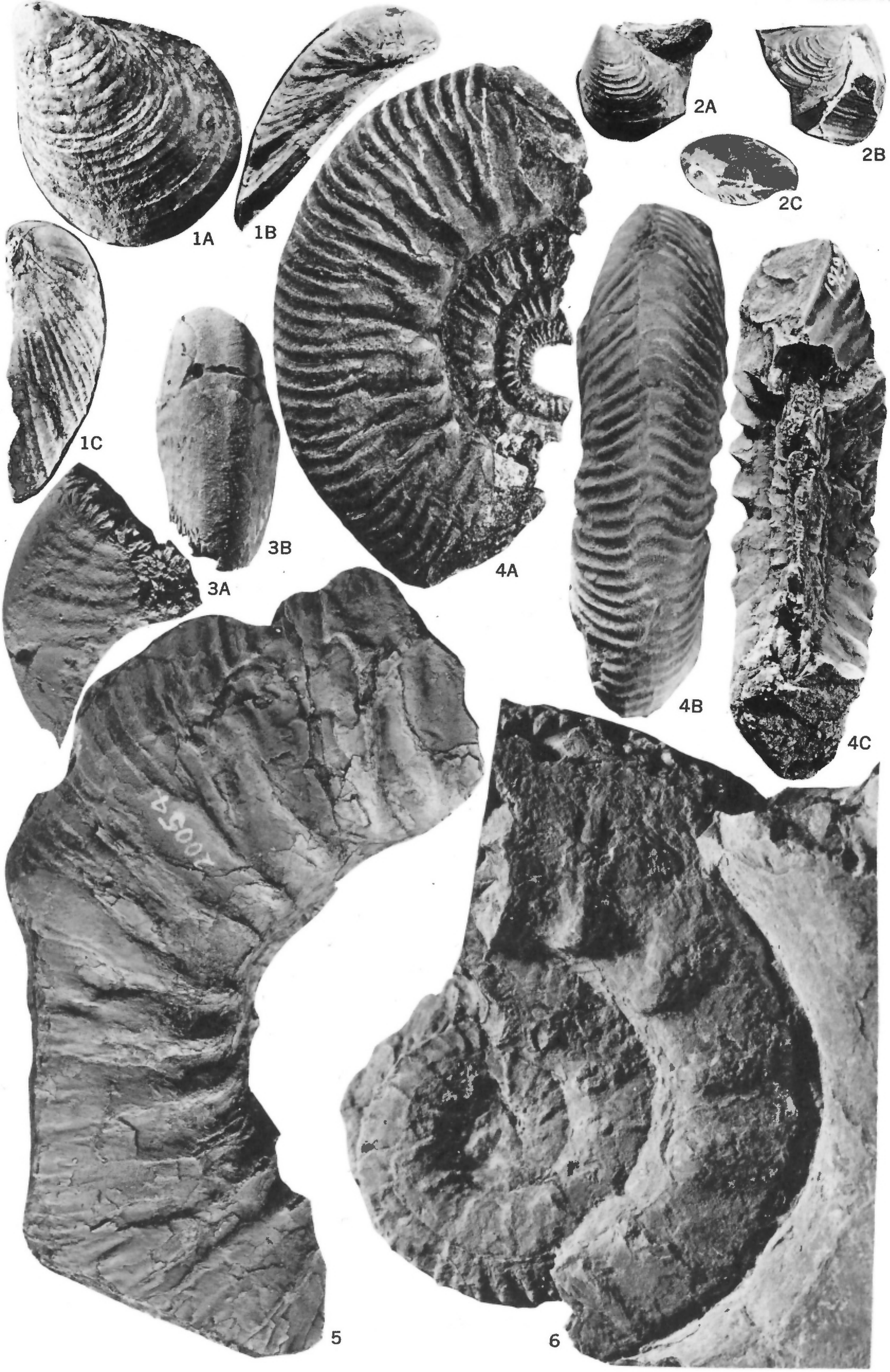


Plate XIII

Figures 1A-D. *Buchia tolmatschowi* (Sokolov, 1908) var. West coast of Vancouver Island. Clark's (One Tree) Island. North part of western shore bearing due north from the only trees on the island and some 20-30 feet from the water's edge at high tide. One Tree Formation. Lower Valanginian. Beds with *Tollia (Tollia) paucicostata* etc., which correspond to the upper but not the uppermost part of *Buchia tolmatschowi* zone on Grassy Island. GSC No. 16620.

Almost complete representative of an extremely sturdy and large variant. Shell layer preserved over most part of both valves.

1A, Lateral view of the exterior of right valve and that of the underside of the beak part of the left valve; 1B, Hinge and beak parts of both valves viewed from above; 1C, Lateral view of the exterior of left valve; 1D, Anterior view of exterior of both valves.

Figures 2A,B. *Tollia (Tollia) paucicostata* (Donovan, 1953). Same locality, etc., as for the specimen shown in figure 1. GSC No. 16621. 2A, Lateral view; 2B, Ventral view. Juvenile, partly distorted representative of the species. Alternation of dichotomous and trichotomous ribs is characteristic of this stage of growth in *Tollia.*

Figures 3A-C. *Buchia tolmatschowi* (Sokolov, 1908) s. lato. Same locality, etc., as for the specimen shown in fig. 1. GSC No. 16622. Internal cast of a complete left valve with some patches of inner shell layer preserved on its beak part. A form transitional between that shown in fig. 4 and *B. tolmatschowi* var. *americana.* 3A, Lateral view of the exterior; 3B, Anterior view; 3C, Hinge margin and the beak part viewed from above. The beak actually only slightly overhangs the right valve (as in fig. 4B).

Figures 4A-D. *Buchia tolmatschowi* (Sokolov, 1908) f. typ. Same locality, etc., as for specimen shown in fig. 1. GSC No. 16623.

Internal cast of a complete and typical representative of the species. 4A, Lateral view of exterior of left valve; 4B, Hinge margins and beak parts of both valves viewed from above; 4C, Anterior view of exterior of both valves; 4D, Lateral view of the exterior of right valve.

Figures 5A-C. *Tollia (Tollia) paucicostata* (Donovan, 1953). West coast of Vancouver Island. South-southwest end of a larger islet situated some 400 yards northeast of the main body of Grassy Island and about the same distance northwest of Clark's (One Tree) Island. One Tree Formation. Lower Valanginian. Beds with *Tollia (Tollia) paucicostata* equivalent to the upper but not the uppermost part of *Buchia tolmatschowi* zone on Grassy Island. GSC No. 16624.

5A, Lateral view; 5B, Cross-section; 5C, Ventral view. Undeformed fragment of an intermediate whorl showing characteristic ribbing and whorl shape of the species.

Figures 6A-D. *Tollia (Tollia) paucicostata* (Donovan, 1953). Same locality etc., as for specimen figured in fig. 1. GSC No. 16625.

6A, Lateral view; 6B, Lateral view of the other side; 6C, Cross-section; 6D, Ventral view. Undeformed fragment of an intermediate whorl showing characteristic ribbing and whorl shape of the species. Almost duplicates the fragment shown in fig. 5.

Figures 7A,B. *Tollia (Tollia) paucicostata* (Donovan, 1953) var. Same locality, etc., as for the specimen shown in fig. 5. GSC No. 16626.

7A, Lateral view; 7B, Ventral view. Fragment of an intermediate whorl of a more slender and more finely ribbed variant of the species.

Figures 8A,B. *Tollia (Tollia?)* aff. *simplex* (Bogoslovsky, 1902). Same locality, etc., as for specimen shown in fig. 1. GSC No. 16627.

8A, Lateral view; 8B, Ventral view of the living chamber. An almost complete but mostly flattened specimen. Note the persistence of dichotomous ribbing habit to the end of the living chamber.

Figure 9. *Tollia (Tollia) paucicostata* (Donovan, 1953). The same locality, etc., as for specimen reproduced in fig. 1. GSC No. 16628.

Lateral view of the living chamber of an almost complete but flattened representative of the species. Although most or all of the living chamber is preserved, the sculpture does not become weakened even at its very end.

Plate XIII

PLATE XIV

Figures 1A-D. *Buchia tolmatschowi* (Sokolov, 1908) var. *americana* (Sokolov, 1908). Same locality, etc., as for specimen reproduced in Pl. XIII, fig. 5. GSC No. 16629.

Internal cast of a typical and complete left valve with a patch of shell layer preserved on its beak part. 1A, Lateral view of exterior; 1B, Anterior view; 1C, Hinge margin and beak viewed from above. Beak actually overhangs right valve as shown in this photo. 1D, Posterior view of the same. Hinge margin is visible (oblique view) underneath the beak part of the valve.

Figures 2A-C. Craspeditid ammonite, genus and species indet. (Apparently closely allied to *"Neocraspedites" groenlandicus* Donovan, 1953). Same locality, formation, section, bed and age as for specimen reproduced in Pl. XIII, fig. 1. GSC No. 16630. 2A, Lateral view; 2B, View into the aperture; 2C, Ventral view of the oral end (living chamber) and earliest part of the whorl visible in fig. 2B.

Figure 3. *Tollia (Tollia) paucicostata* (Donovan, 1953). Paskenta Formation, *Tollia (Tollia) mutabilis* zone. Late Lower Valanginian. 6 miles NE of Paskenta, California, U.S.A., and ½ mile south of Wilcox house. CAS loc. 1349. CAS Cat. No. 12373.

Lateral view of an extremely coarsely and sparsely ribbed form indistinguishable from the more densely ribbed morphological variants of *T. (T.) paucicostata* (Donovan, 1953) from Vancouver Island (*see* fig. 8).

Figures 4A,B. *Tollia (Tollia) paucicostata* (Donovan, 1953). Same locality, etc., as for the specimen figured in Pl. XIII, fig. 5. GSC No. 16631.

4A, Lateral view of the somewhat deformed, fragmentary last whorl. Only the oldest fifth of the whorl visible in the photo is septate. The rest is occupied by the living chamber. The ornamentation does not weaken at all on the living chamber. 4B, Cross-section of the living chamber and the venter of the septate part of the whorl.

Figures 5A,B. *Tollia (Tollia) paucicostata* (Donovan, 1953). Same locality, etc., as for specimen figured in Pl. XIII, fig. 1. GSC No. 16632.

5A, Lateral view of a flattened specimen; 5B, Same with part of the outer whorl taken off to show sculpture of inner whorl with its alternation of bifurcating and trifurcating ribs. A finely and densely ribbed variant transitional to *T. (T.) mutabilis* s. lato.

Figures 6A,B. *Tollia (Tollia) paucicostata* (Donovan, 1953). Same locality, etc., as for specimen figured in Pl. XIII, fig. 1. GSC No. 16633.

6A, Lateral view; 6B, Lateral view of the other side. A typical coarsely and distantly ribbed representative of the species.

Figures 7A,B. *Tollia (Tollia) mutabilis* (Stanton) var. *mutabilis* Imlay, 1960. Same locality as for specimen reproduced in fig. 3. CAS Cat. No. 12374.

7A, Lateral view. Note extremely dense ribbing contrasting sharply with that of typical representatives of *T. (T.) paucicostata* shown in figures 3, 4, 6; 7B, Cross-section of the same.

Figures 8A-C. *Tollia (Tollia) paucicostata* (Donovan, 1953) var. Same locality, etc., as for specimen reproduced in Pl. XIII, fig. 5. GSC No. 16634.

8A, Lateral view; 8B, Lateral view of the other side; 8C, Ventral view. As far as the density and coarseness of ribbing is concerned, this variant is indistinguishable from the specimen from *Tollia (Tollia) mutabilis* zone figured in fig. 3. It possibly had just as elliptical and obtuse a cross-section as the typical representatives of *T. (T.) mutabilis* s. lato but is too strongly deformed to be certain about it.

Figure 9. *Tollia (Tollia) mutabilis* (Stanton, 1895) var. *mutabilis* Imlay, 1960. Same locality as for specimen reproduced in figs. 3, 7. CAS Cat. No. 12375.

Lateral view of the penultimate whorl of a flattened, large but otherwise typical representative of the species. The sculpture almost disappears near the end of the whorl, which is septate to very end. Fourth auxiliary lobe is concealed by steep umbilical shoulder.

PLATE XIV

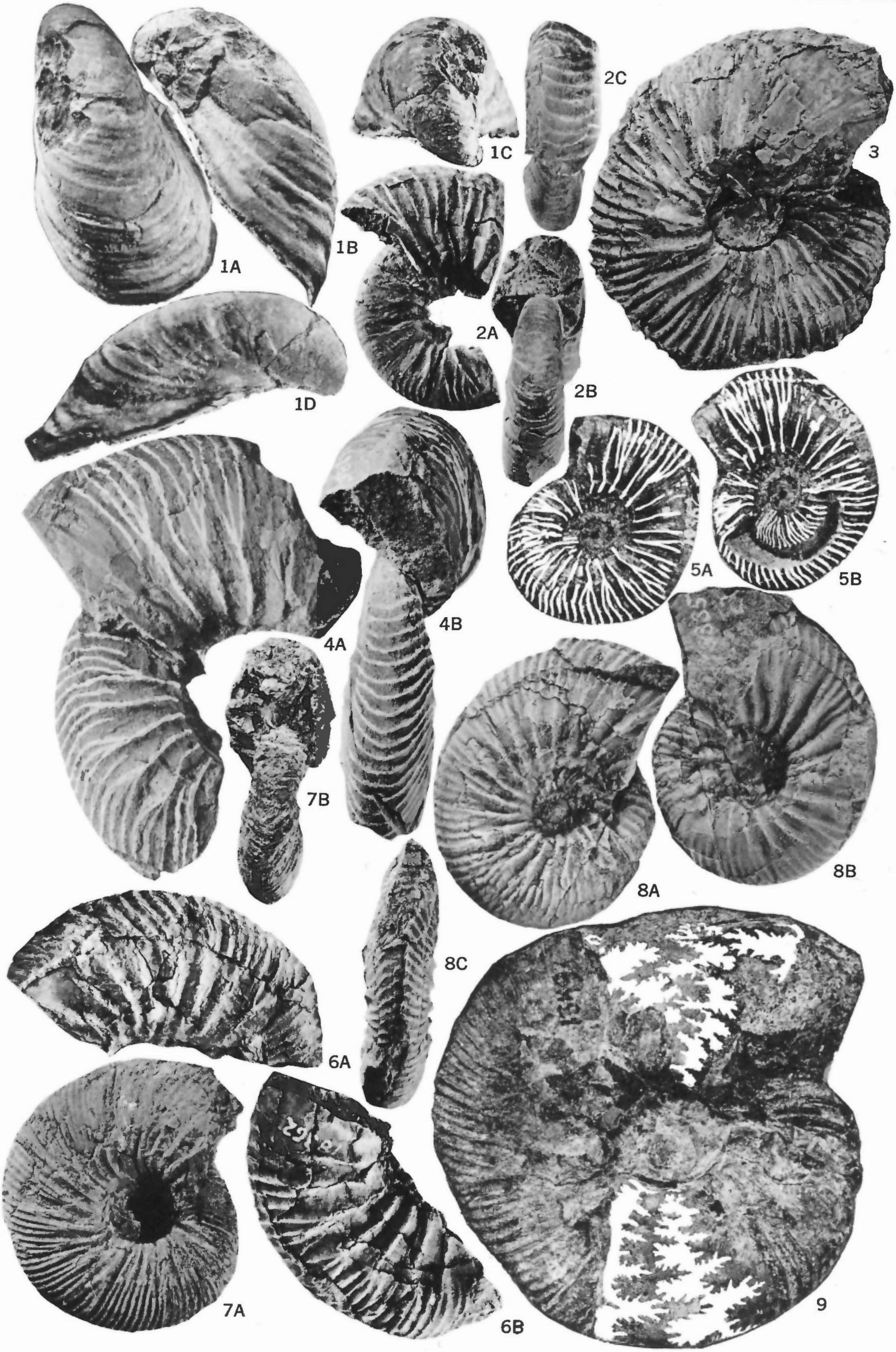


PLATE XV

Figures 1A-C. *Tollia (Tollia) mutabilis* (Stanton, 1895) var. *tehamaensis* (Andersin, 1938). Holotype. The same locality, etc., as for specimen figured in Pl. XIV, fig. 3. CAS No. 5943. Photographs of the plaster cast of the specimen.

1A, Lateral view; 1B, Ventral view; 1C, Cross-section of the whorl and the venter of its earlier part.

Figure 2A-D. *Tollia (Tollia) mutabilis* (Stanton, 1895) s. lato. West coast of Vancouver Island. Southern end of the southern rocky fringe of Grassy Island. One Tree Formation, 1046-50 feet above the base of the section and 540-544 feet above the Jurassic/Cretaceous contact. Late Lower Valanginian. Beds with *T. (T.) mutabilis* s. lato, etc. GSC No. 16635.

2A, Lateral view, X2; 2B, The same X1; 2C, Cross-section; 2D, Ventral view. The fragment is somewhat deformed. Note the extremely dense and fine ribbing and the low cross-section of the whorl diagnostic of the species.

Figures 3A-C. *Tollia (Tollia) mutabilis* (Stanton, 1895) var. *burgeri* (Anderson, 1938). The same locality, etc., as for the specimen figured in Pl. XIV, fig. 3. CAS No. 12376., 3A, Lateral view; 3B, Cross-section of whorl and venter of its earlier part; 3C, Ventral view.

Figures 4A-C. *Buchia tolmatschowi* (Sokolov, 1908) f. typ. Same locality, etc., as for the ammonite figured in fig. 2. GSC No. 16636.

Internal cast of a typical, almost smooth right valve with some patches of the shell layer. 4A, Lateral view of the exterior; 4B, Oblique posterior view; 4C, Anterior view.

Figures 5A,B. *Tollia (Tollia) mutabilis* (Stanton, 1895) var. *mutabilis* Imlay, 1960. Same locality, etc., as for specimen figured in Pl. XIV, fig. 3. CAS No. 12377. 5A, Lateral view; 5B, Cross-section.

Figures 6A-B. *Tollia (Tollia) mutabilis* (Stanton, 1895) var. *tehamaensis* (Anderson, 1938). Same locality, etc., as for the specimen shown in fig. 2. GSC No. 16637.

Partly flattened medium-sized specimen with part of living chamber preserved. 6A, Lateral view; 6B, Cross-section of the whorl and the venter of its earlier part. The but little deformed end of the living chamber has obtuse venter and subparallel flanks typical of the species.

Figures 7A,B. *Buchia tolmatschowi* (Sokolov, 1908) var. *americana* (Sokolov, 1908). Same locality, etc., as for the speciment shown in Pl. XIV, fig. 3. CAS No. 12378.

Mostly shell-covered, medium-sized left valve. 7A, Lateral view of exterior; 7B, Anterior view. The shell layer is well preserved over most part of valve. A representative of *T. (T.) mutabilis* var. *mutabilis* is preserved in the same piece of rock.

Figures 8A-D. *Tollia (Tollia) mutabilis* (Stanton, 1895) s. lato. The same locality, etc., as for the specimen shown in fig. 2. GSC No. 16638.

8A, Lateral view; 8B, Cross-section; 8C, Lateral view of other side; 8D, Same view as in fig. 8A, X2. A juvenile specimen. Note the extremely dense and fine ribbing diagnostic of the species.

Figure 9. *Tollia (Tollia) mutabilis* (Stanton, 1895) var. *burgeri* (Anderson, 1938). Same locality, etc., as for specimen shown in fig. 2. GSC No. 16639.

Lateral view of a flattened specimen with characteristic ribbing habit.

Figures 10A-D. *Buchia tolmatschowi* (Sokolov, 1908) var. *americana* (Sokolov, 1908). Same locality, etc., as for the ammonite shown in fig. 2. GSC No. 16640.

Internal cast of large left valve with considerable patches of the shell layer. This specimen is transitional to *Buchia pacifica* n. sp. in its fairly regular and heavy ribbing.

10A, Lateral view of exterior; 10B, Anterior view; 10C, Oblique posterior view; 10D, Hinge margin and beak viewed obliquely from above. Hinge margin is on left.

Figures 11A-C. *Buchia tolmatschowi* (Sokolov, 1908) var. *americana* (Sokolov, 1908). Same locality, etc., as for the ammonite shown in fig. 2. GSC No. 16641.

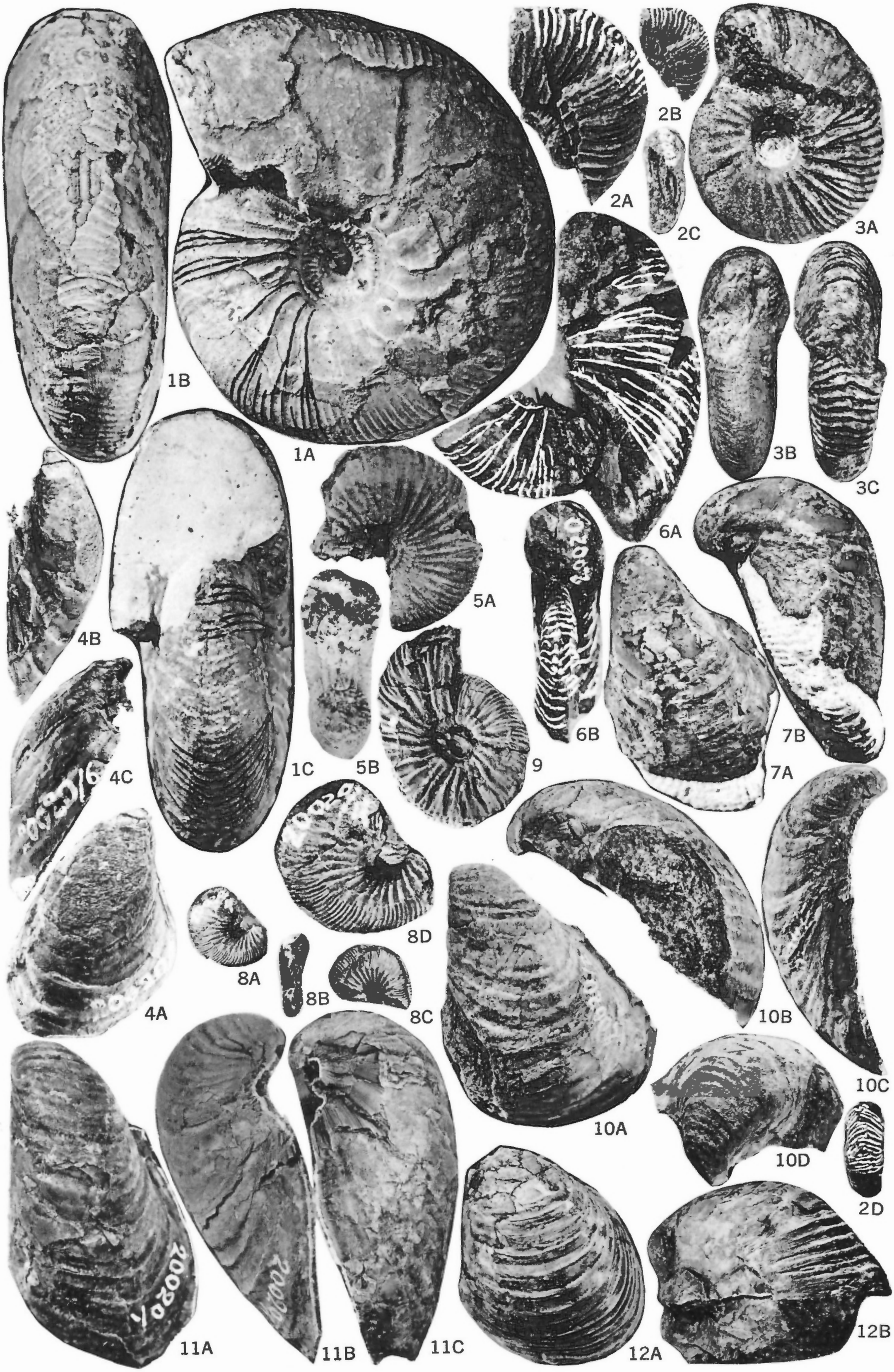
Well-preserved and complete left valve. The anterior part of the valve completely covered with the shell layer. The posterior part is an internal cast. This specimen is typical of the late forms of the variant.

11A, Lateral view of the exterior; 11B, Oblique posterior view; 11C, Anterior view.

Figures 12A,B. *Buchia pacifica* n. sp. The same locality, etc., as for the specimen figured in Pl. XIV, fig. 3. CAS No. 12379. Well-preserved, shell-covered but incomplete left valve. The badly squashed right valve is visible beneath the well-preserved left valve. Note the truncation of both valves towards the lower margin in anterior-posterior aspect.

12A, Lateral view of the exterior. Most of the beak part is broken off; 12B, Anterior view of the same.

PLATE XV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12B

PLATE XVI

Figures 1A,B. *Buchia pacifica* n. sp. Holotype. Bridge River District, B.C., Tyaughton Lake area. In the valley of Mud Creek, a northern tributary of Tyaughton Creek; about 1½ miles above the mouth of Mud Creek, and 200 feet above its right bank. Some 200 yards NE of fos. loc. 249-F. Eldorado Group (lower part). Mid-Valanginian. Coll. C. E. Cairnes, 1937. GSC No. 16642.

Internal cast of typical left valve with small patches of shell layer preserved near hinge margin (*see* fig. 1A). This specimen is also shown on Pl. XXII, fig. 3.

1A, Lateral view of exterior; 1B, Anterior view.

Figures 2A-D. *Buchia pacifica* n. sp. West coast of Vancouver Island, B.C. Southern end of the southern rocky fringe of Grassy Island. One Tree Formation, 1,103-1,104 feet above the base of the section and 597-8 feet above Jurassic/Cretaceous contact. Mid-Valanginian. GSC No. 16643.

An internal cast of typical left valve with considerable patches of shell layer preserved in the anterior part of the valve. 2A, Lateral view of exterior; 2B, Anterior view; 2C, Oblique posterior view; 2D, Hinge margin and beak viewed from above.

Figures 3A-C. *Buchia pacifica* n. sp. West coast of Vancouver Island. Southern end of the southern rocky fringe of Grassy Island (about 40 feet N from the sea). One Tree Formation, 1,112-1,113 feet above the base of the section and 606-7 feet above the Jurassic/Cretaceous contact. Mid-Valanginian. GSC No. 16644.

Internal cast of medium-sized left valve with considerable patches of shell layer on the anterior part. This specimen is much like *B. tolmatschowi* var. *americana* in its outline but differs in its heavy, regular ribbing habit. This specimen almost duplicates that figured by Sokolov (1908b, Pl. I, fig. 14) from McCarty Creek, California, and wrongly identified as *Aucella uncitoides* Pavlow. 3A, Lateral view of exterior; 3B, Anterior view; 3C, Hinge margin and beak viewed from above. Hinge margin is on the left.

Figures 4A-C. *Buchia pacifica* n. sp. var. The same locality, etc., as for the specimen shown in fig. 2. GSC No. 16645. Internal cast of an almost complete, medium-sized left valve. This extreme morphological variant resembles strongly *Buchia keyserlingi* f. typ.; it differs from it, however, in the angular shape and very coarse and widely spaced ribbing. 4A, Lateral view of exterior; 4B, Anterior view; 4C, Hinge margin and beak viewed from above.

Figures 5A,B. *Neocomites (Parandiceras)* cf. *rota* (Spath, 1925). West coast of Vancouver Island, B.C. Southern end of the southern rocky fringe of Grassy Island. One Tree Formation, 1,057-59 feet above the base of the section and 551-553 feet above the Jurassic/Cretaceous contact. Mid-Valanginian. About 7 to 9 feet above base of *Buchia pacifica* zone. GSC No. 16646. 5A, Lateral view; 5B, Ventral view.

Figures 6A-C. *Buchia sublaevis* (Keyserling, 1846) var. *majuscula* (Lahusen, 1888). Canadian Arctic Archipelago, District of Franklin, N.W.T., Ellef Ringnes Island, Delta River, locality FH-101. Coll. H. Heywood, 1953. Mid-Valanginian? GSC No. 16647. Internal cast of a complete specimen with considerable patches of shell layer.

6A, Lateral view of exterior of left valve; 6B, Lateral view of exterior of right valve and that of underside of beak part of left valve; 6C, Anterior view of exterior of both valves.

Figures 7A,B. *Buchia pacifica* n. sp. The same locality, etc., as for the specimen shown in fig. 3. GSC No. 16648. Medium-sized right valve. This specimen belongs to the same extreme variant of the species as that shown in fig. 4. The specimen is completely covered by the inner shell layer.

7A, Lateral view of exterior; 7B, Anterior view. Byssal notch is at extreme right of photo.

Figures 8A-C. *Buchia pacifica* n. sp. f. typ. West coast of Vancouver Island. The southernmost end of the southern rocky fringe of Grassy Island. One Tree Formation. Top bed of the section overlooking the sea. 1,146 to 1,148 feet above the base of the section and 640 to 642 feet above the Jurassic/Cretaceous contact. Mid-Valanginian. GSC No. 16649.

Internal cast of an almost complete left valve with remnants of the inner shell layer. A half grown, typical specimen corresponding to the top part of the holotype only (*see* fig. 1B).

8A, Lateral view of exterior; 8B, Anterior view; 8C, Hinge margin and beak part viewed from above.

Figures 9A-D. *Buchia pacifica* n. sp. var. The same locality, etc., as for the specimen shown in fig. 2. GSC No. 16650. An internal cast with considerable patches of the shell layer on the left side (*see* figs. 9A,B). Almost complete left valve of extremely short, widely, and coarsely ribbed variant of the species superficially resembling *B. okensis* s. lato.

9A, Lateral view of exterior; 9B, Anterior view; 9C, Oblique posterior view; 9D, Hinge margin and beak part viewed from above.

Figures 10A-C. *Buchia pacifica* n. sp. var. The same locality, etc., as for the specimen shown in fig. 2. GSC No. 16651. Internal cast of a fragmentary but large left valve. This morphological variant of *B. pacifica* n. sp. was commonly confused with *B. crassicollis* s. str. by North American workers.

10A, Lateral view of exterior; 10B, Oblique posterior view; 10C, Hinge margin and fragmentary beak part viewed from above.

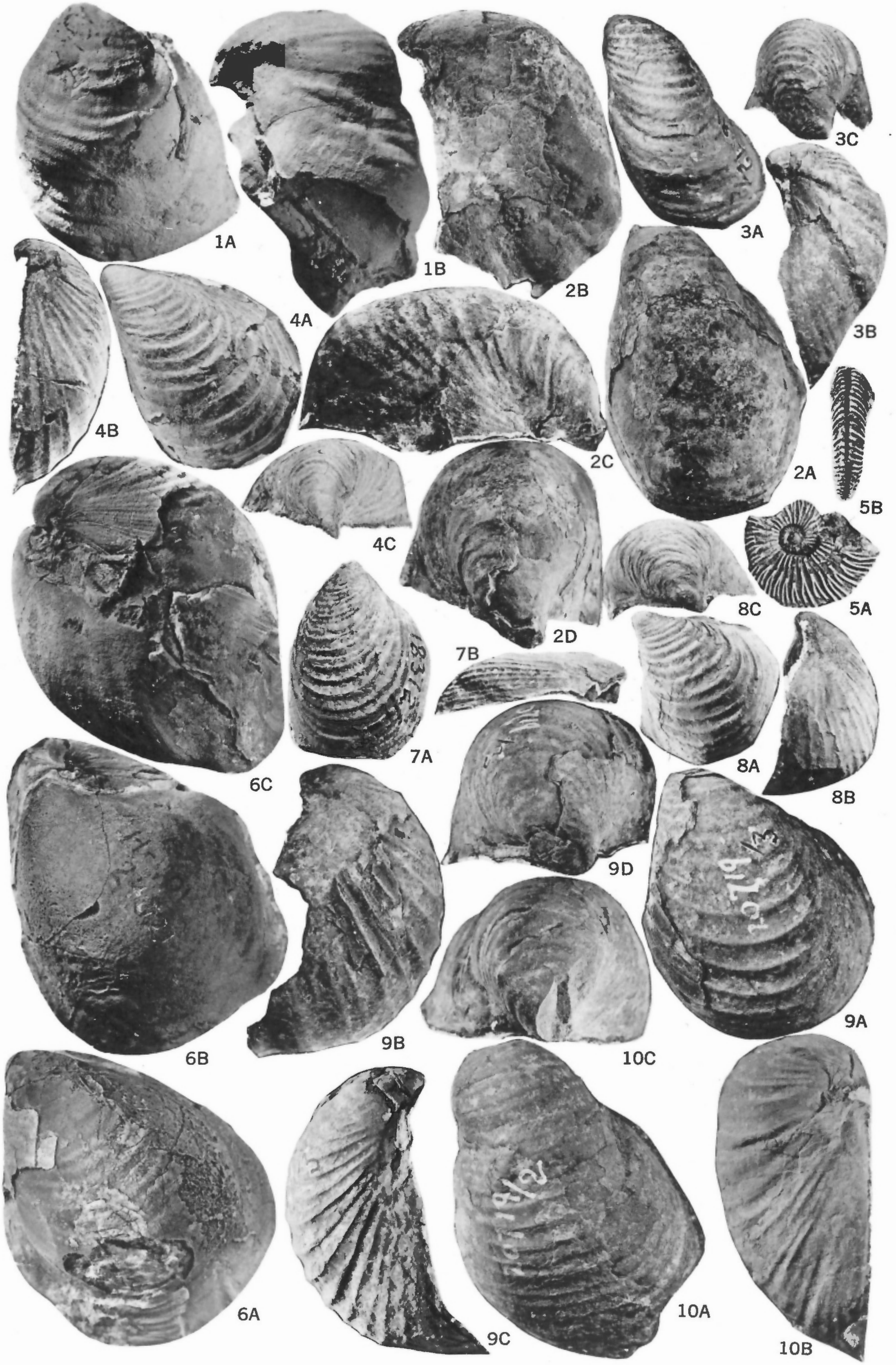

1A
1B
2B
3A
3C
3B
4A
4B
2C
2A
5B
4C
5A
8C
2D
7B
7A
6C
8A
8B
9D
9A
6B
9B
10C
6A
9C
10A
10B

PLATE XVII

Figures 1A-D. *Buchia sublaevis* (Keyserling, 1846) var. *majuscula* (Lahusen, 1888). Bridge River District, B.C., Tyaughton Lake area. Along the N. bank of Tyaughton Creek a few yards east of GSC loc. No. 9447 (Field No. M-69-F) and apparently lower stratigraphically. Eldorado Group (lower part). Mid-Valanginian. Collection by C. E. Cairnes, 1937. GSC No. 17330.

An internal cast of a complete, large specimen. 1A, Lateral view of exterior of left valve; 1B, Lateral view of exterior of right valve and protruding beak of left valve; 1C, Anterior view of both valves; 1D, Hinge margins and beaks of both valves viewed from above.

Figures 2A-D. *Buchia inflata* (Toula, 1874) var. *crassa* (Pavlow, 1907). Bridge River District, B.C., Tyaughton Lake area. Along N. bank of Tyaughton Creek, a few hundred feet west of the mouth of Camp Creek. Eldorado Group (lower part). Mid-Valanginian. Collected by C. E. Cairnes, 1937. GSC No. 17331.

Internal cast of a complete, large specimen typical of the species and variant. Associated with the predominant *Buchia pacifica* n. sp. 2A, Lateral view of exterior of left valve; 2B, Lateral view of exterior of right valve and projecting beak of the left valve; 2C, Anterior view of both valves; 2D, Hinge margins and beaks of both valves seen from above.

Figures 3A-E. *Buchia* aff. *inflata* (Toula, 1874) s. lato. Same locality, etc., as for specimen shown in fig. 1. GSC No. 17332. A complete, large specimen apparently transitional? between *B. inflata* s. lato and *B. pacifica* n. sp. An internal cast with considerable patches of the shell layer on its lower part (fig. 3D).

3A, Lateral view of exterior of left valve; 3B, Lateral view of exterior of right valve; 3C, Anterior view of both valves; 3D, Oblique view of hinge and posterior margins of both valves; 3E, Hinge margins and beaks of both valves seen from above.

Figures 4A-D. *Buchia inflata* (Toula, 1874) var. *crassa* (Pavlow, 1907). Same locality, etc., as for specimen shown in fig. 1. GSC No. 17333. Medium-sized, complete specimen typical of the species and the variant. An internal cast.

4A, Lateral view of exterior of left valve; 4B, Lateral view of exterior of right valve and protruding beak of left valve; 4C, Anterior view of both valves; 4D, Hinge margins and beaks of both valves viewed from above.

Figures 5A-D. *Buchia* cf. *sublaevis* (Keyserling, 1846) s. lato. Bridge River District. Tyaughton Lake area. Just north of Tyaughton Creek (1,000 feet plus), 17,400 feet towards 280° from junction of Tyaughton Creek and Spruce Lake. Eldorado Group (lower part). Mid-Valanginian. Collected by V. Dolmage, 1928. GSC No. 17334. A complete specimen, apparently transitional between *B. keyserlingi* f. typ. and *B. sublaevis* f. typ. but closer to the latter in its shape. An internal cast. Associated with fairly numerous *B. pacifica* n. sp., *B. tolmatschowi* s. lato and *Dichotomites* cf. *giganteus* (Imlay, 1960).

5A, Lateral view of exterior of left valve; 5B, Lateral view of exterior of right valve; 5C, Anterior view of both valves; 5D, Hinge margins and beaks of both valves seen from above.

Figures 6A-E. *Buchia inflata* (Toula, 1874) f. typ. Bridge River District. Tyaughton Lake area, 300 yards NW of the north end of Spruce Lake. Eldorado Group (lower part). Mid-Valanginian. Collected by C. H. Crickmay, 1939. GSC No. 17335.

Internal cast of a complete but somewhat deformed (compressed laterally), medium-sized specimen typical of the species. Associated with rare *B. pacifica* n. sp.

6A, Lateral view of exterior of left valve; 6B, Lateral view of exterior of right valve; 6C, Oblique view of hinge and posterior margins of both valves; 6D, Anterior view of both valves. Right valve is squeezed into interior of left valve thus reducing considerably the thickness of the specimen and making it similar to *B. keyserlingi* f. typ.; 6E, Hinge margins and beaks of both valves seen from above.

PLATE XVII


1A
2C
2A
2B
3A
3C
2D
1C
3E
3D
3B
1B
1D
4B
4D
4A
4C
5A
5C
6A
6C
5D
5B
6E
6D
6B

PLATE XVIII

Figure 1. *Dichotomites* cf. *giganteus* (Imlay, 1960). Bridge River District, B.C., Tyaughton Lake area. Along N. bank of Tyaughton Creek, a few hundred feet west of the mouth of Camp Creek. A few yards east of GSC loc. No. 9447 (Field No. M-69-F) and apparently lower stratigraphically. Eldorado Group (lower part). Mid-Valanginian. Collected by C. E. Cairnes, 1937. GSC No. 17323.

Medium-sized, partly flattened specimen septate to the end. Lateral view. Associated with *B. pacifica* n. sp.

Figures 2A-D. *Buchia pacifica* n. sp. var. Bridge River District, B.C., Tyaughton map area, ¼ mile west of Spruce Lake. Eldorado Group (lower part). Mid-Valanginian. Collected by H. Frebold, 1958. GSC No. 17324.

Internal cast of left valve of a large, *B. crassicollis*-like variant of the species. The concentric ribbing is subdued over most part of the valve but the pronounced left-handed curvature of the beak, large size and the posteriorly oblique shape of the valve distinguish it from *B. crassicollis* s. str. 2A, Lateral view of exterior; 2B, Anterior view; 2C, Hinge margin and beak viewed obliquely from above. Beak is raised in order to show the ligamental plate preserved as an internal cast; 2D, Same view as last but viewed directly from above to show the overhang of left beak over right valve.

Figures 3A-D. *Buchia pacifica* n. sp. var. Same locality, age, etc., as for specimen shown in fig. 2. GSC No. 17325.

Internal cast of a large right valve possibly belonging to the same individual as the left valve shown in fig. 2.

3A, Lateral view of exterior; 3B, Anterior view; 3C, Oblique view of the hinge and posterior margins of the same; 3D, View of the hinge margin, beak, and byssus ear from above.

Figures 4A-C. *Acroteuthis* n. sp. A. Bridge River District, B.C. Same locality, age, etc., as for specimen of *Dichotomites* cf. *giganteus* (Imlay, 1960) shown in fig. 1. GSC No. 17326.

A fragmentary grown-up guard of an unusually slender, *Cylindroteuthis*-like *Acroteuthis* form, which is common in *Buchia pacifica* zone of the Canadian western Cordillera. It differs from true Upper Jurassic representatives of *Cylindroteuthis* (*see* Pl. II, fig. 8) in its marked dorso-ventral flattening and compression (*see* figs. 4C, 5C). All true *Cylindroteuthis* forms show, on the contrary, a more or less marked lateral flattening and compression.

4A, Ventral view. Apical (lower) end of fragmentary guard shows a pronounced median furrow, which disappears on stem part of guard; 4B, Lateral view. Ventral side of guard is on left side of photograph. Although most of apical part of guard is broken off, displacement of apical region towards dorsal side is apparent; 4C, Cross-section of upper part of stem region (just below the apex of the alveolus) at level of middle of three cracks visible in figs. 4A,B.

Figures 5A-C. *Acroteuthis* n. sp. A. Same locality, age, etc., as for specimen of *Dichotomites* cf. *giganteus* (Imlay, 1960) shown in fig. 1. GSC No. 17327.

A fragmentary guard of a half-grown representative of the *Acroteuthis* form shown in fig. 4. This guard shows the same generically diagnostic dorso-ventral flattening and compression as the grown-up guard.

5A, Ventral view. Preserved upper part of apical region of the guard is broadly and shallowly depressed rather than clearly furrowed. This feature seems to be diagnostic of the early growth-stages of the species; 5B, Lateral view. Ventral side of the guard is on left side of photograph. Guard shows same displacement of apical region towards its dorsal side as its grown-up representative (*see* fig. 4B); 5C, Cross-section of the middle part of the stem region at the level of lower (of two) crack visible in figs. 5A,B.

Figures 6A-D. *Dichotomites* cf. *giganteus* (Imlay, 1960). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17328.

An undistorted but fragmentary early whorl showing the suture line and the characteristically flexed and polyptychoidally bundled ribbing habit. The latter lacks the bidichotomous branching of primaries diagnostic of the corresponding growth-stages of *D. quatsinoensis.* Note that the suture line is much simpler than that of *D. quatsinoensis.*

6A, Left lateral view; 6B, Cross-section of end of whorl and venter of its earliest visible part; 6C, Two cross-sections of the fragmentary early part of whorl (*see* left side of fig. 6A); 6D, Ventral view of the end part of whorl (*see* upper right side of fig. 6A).

Figures 7A-C. *Dichotomites* cf. *giganteus* (Imlay, 1960). Same locality, age, etc., as for specimen shown in fig. 1. GSC No. 17329. Fragment of an older whorl septate to the end but showing a definite weakening of the ornament in the middle of the flanks. Markedly swollen lower parts of primaries are visible in fig. 7A.

7A, Lateral view of the mostly shell-covered side; 7B, Lateral view of other side mostly preserved as an internal cast. The imperfectly preserved suture line is visible. Even at this later growth-stage it is much simpler than that of *D. quatsinoensis;* 7C, Cross-section (somewhat deformed laterally).

PLATE XVIII

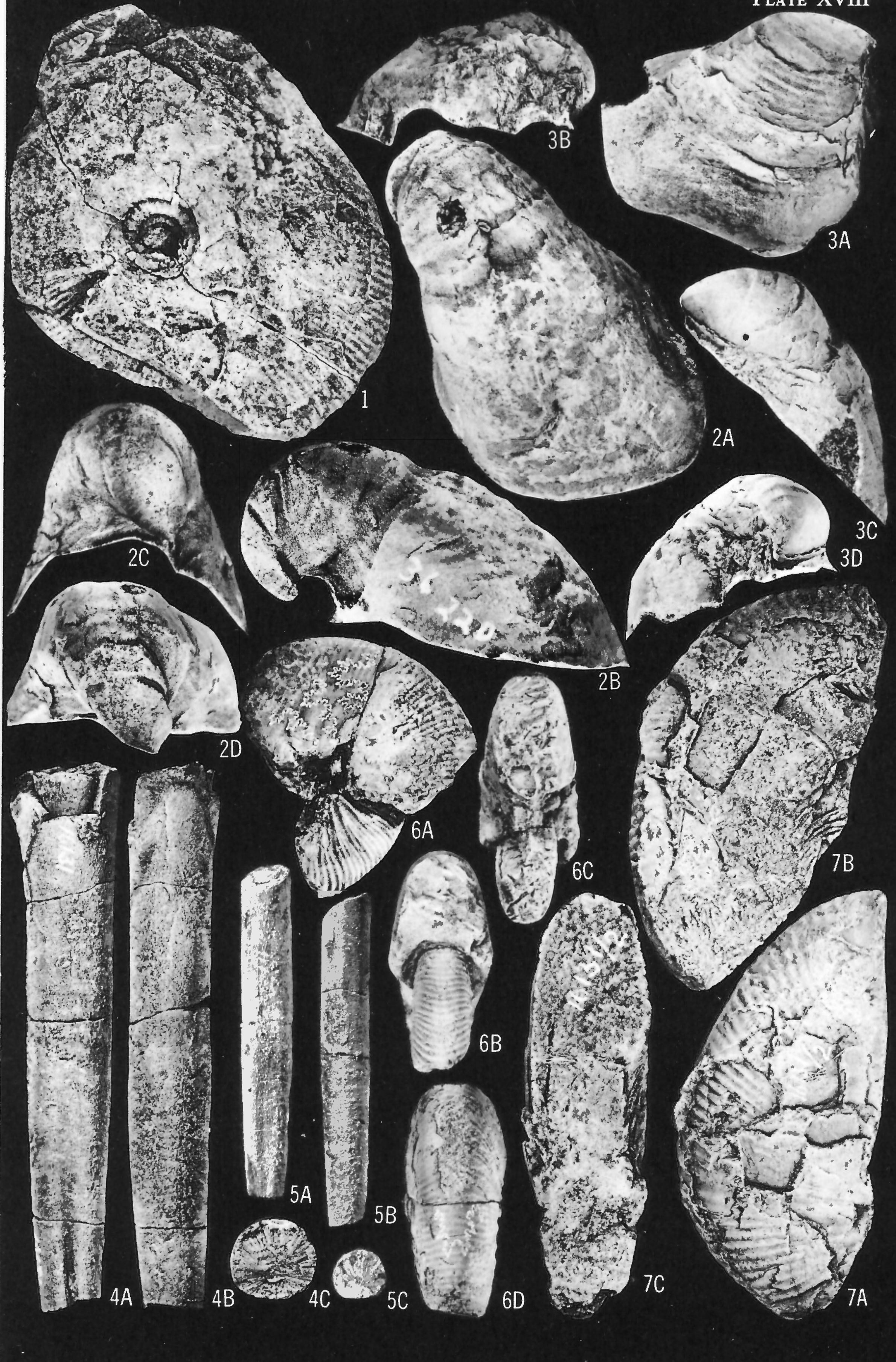


PLATE XIX

Figures 1A-C. *Buchia keyserlingi* (Lahusen, 1888) var. *gigas* (Crickmay, 1930). East Greenland, Wollaston foreland. Mount Niesen section, No. 12. Collected at 443-foot level. Mid-Valanginian. *Min. og. Geol. Mus.* No. 9001.

Internal cast of an incomplete left valve. 1A, Lateral view of the exterior; 1B, Oblique posterior view; 1C, Hinge margin and fragmentary beak part viewed from above. Most of the beak part is broken off.

Figures 2A-C. *Buchia keyserlingi* (Lahusen, 1888) f. typ. East Greenland, Trail Island. Locality 92 of Donovan (1953, pp. 51-52). Middle or (?) late Lower Valanginian. *Min. og. Geol. Mus.* No. 9002.

Complete and large left valve with perfectly preserved shell layer. 2A, Lateral view of the exterior; 2B, Anterior view; 2C, Hinge margin and beak part viewed from above.

Figures 3A-C. *Buchia pacifica* n. sp. var. Same locality, etc., as for specimen figured in Pl. XVI, fig. 2. GSC No. 16652.

Medium-sized left valve partly covered by remnants of the inner shell layer. This extreme morphological variant strongly resembles *B. keyserlingi* f. typ. et var. (*see* figs. 1-2, 5, 7); it differs from it, however, in the angular shape as well as in generally coarser and more widely spaced ribs.

3A, Lateral view of exterior; 3B, Anterior view; 3C, Hinge margin and beak viewed from above.

Figures 4A-C. *Buchia pacifica* n. sp. f. typ. Same locality, etc., as for specimen figured in Pl. XVI, fig. 2. GSC No. 16653.

Internal cast of a medium-sized right valve. This right valve is typical of the species. Note its swollen appearance and abrupt truncation of the lower part.

4A, Lateral view of the exterior; 4B, Hinge margin and the beak viewed from above; 4C, Anterior view of the exterior. Byssal notch is on the extreme right of the photo (painted white).

Figures 5A-C. *Buchia keyserlingi* (Lahusen, 1888) var. East Greenland, Wollaston foreland. Mount Niesen section, No. 20. Collected at 520-530-foot level. Upper Valanginian (equivalent of *Buchia crassicollis* s. str. zone?)? *Min. og Geol. Mus.* No. 9003.

Internal cast of large and almost complete left valve. This morphological variant (or evolutionary stage?) of the species is similar to *B. pacifica* n. sp. in its coarse and distant ribbing. It differs from it, however, in its low and broad shape and the gradually tapering lower part of the valve.

5A, Lateral view of exterior; 5B, Anterior view; 5C, Hinge margin and beak part viewed from above.

Figures 6A-C. *Buchia pacifica* n. sp. var. West coast of Vancouver Island. Southernmost end of the southern rocky fringe of Grassy Island. One Tree Formation. Top part of a hogsback overlooking the sea, 1,129-1,133 feet above the base of the section and 623-27 feet above the Jurassic/Cretaceous contact. Mid-Valanginian. GSC No. 16654.

Internal cast of almost complete, medium-sized left valve with considerable patches of well-preserved shell layer. Same morphological variant of the species as that shown in Pl. XVI, fig. 9.

6A, Lateral view of the exterior; 6B, Anterior view; 6C, Hinge margin and beak part viewed from above.

Figures 7A,B. *Buchia keyserlingi* (Lahusen, 1888) f. typ. Same locality, etc., as for the specimen shown in fig. 2. *Min. og Geol. Mus.* No. 9004.

Almost complete left valve of a juvenile representative with the shell layer perfectly preserved throughout.

7A, Lateral view of the exterior; 7B, Anterior view.

Figures 8A,B. *Buchia pacifica* n. sp. var. Same locality, etc., as for the specimen figured in Pl. XVI, fig. 2. GSC No. 16655.

Internal cast of a large and complete left valve with patches of well-preserved shell layer in its middle part. Like the left valves shown in Pl. XVI, fig. 9 and Pl. XIX, fig. 6, this valve is *B. okensis*-like in the coarseness and spacing of its concentric ornament; its beak has, however, pronounced left-handed incurvature and the flanks slope steeply.

8A, Lateral view of the exterior; 8B, Oblique posterior view.


2B
4C
3B
3C
1B
2A
3A
4B
4A
2C
5B
1A
1C
Niesen
20, 520-530
m
5A
5C
6B
7A
8A
7B
6A
6C
8B

PLATE XX

Figures 1A-B. *Buchia crassicollis* (Keyserling, 1846) s. str. Vancouver Island, B.C. Quatsino Sound, Forward Inlet. Northeastern shore of Winter Harbour. 1,550 yards N. of the mouth of a nameless creek that falls into the inlet opposite the village of Winter Harbour. Some 15-20 feet above the base of the Cretaceous section (an unconformity; *see* fig. 4). Upper Valanginian. GSC No. 16656.

Internal cast of a typical left valve of the species (a small patch of shell layer is preserved in the beak part of the valve; *see* fig. 1B). 1A, Lateral view of the exterior; 1B, Anterior view.

Figures 2A-C. *Dichotomites quatsinoensis* (Whiteaves, 1882). San Juan Islands, Washington, U.S.A., north shore of Spieden Island. Sandstone and shale member near the base of Spieden Island Formation. At the foot of Spieden Bluff. Upper Valanginian. U. of Wash., Pal. Coll. No. 6959.

2A, Lateral view; 2B, Cross-section showing globose inner whorl; 2C, Ventral view of younger part of the shell. Note the change from *Tollia*-like to bidichotomous ribbing habit near the end of whorl.

Figures 3A-B. *Dichotomites quatsinoensis* (Whiteaves, 1882). Vancouver Island, B.C. Quatsino Sound, Forward Inlet. Southeast end of a small wooded islet inside of Winter Harbour and about 2,200 yards N. of Greenwood Point. Some 40-50 feet above the visible base of Cretaceous section. Upper Valanginian. GSC No. 16657.

3A, Lateral view; 3B, Ventral view. Juvenile specimen characterized by the *Tollia*-like dichotomous to trichotomous ribbing habit.

Figures 4A-B. *Dichotomites* aff. *quatsinoensis* (Whiteaves, 1882). Unfigured topotype of Whiteaves (1882). Vancouver Island, B.C. Quatsino Sound, Forward Inlet. East side of Winter Harbour. Coll. by G. M. Dawson, 1885. Upper Valanginian. GSC No. 4799a.

4A, Lateral view; 4B, Cross-section and ventral view of early part of whorl. This specimen differs from the typical representatives of the species in retaining the *Tollia*-like ribbing habit to a later growth stage and in being more heavily ribbed; it resembles *D.* cf. *giganteus* in marked flexuosity of ribs.

Figures 5A-C. *Dichotomites quatsinoensis* (Whiteaves, 1882). Same locality, etc., as for the specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6960.

5A, Lateral view; 5B, Ventral view; 5C, Cross-section. A juvenile specimen characterized by the *Tollia*-like ribbing habit throughout.

Figures 6A-C. *Dichotomites quatsinoensis* (Whiteaves, 1882). Same locality, etc., as for specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6961.

6A, Lateral view; 6B, Ventral view of end part of whorl; 6C, Ventral view of early part of whorl. Intermediate growth stage of the species showing transition from *Tollia*-like to bidichotomous ribbing habit. This specimen retains *Tollia*-like ribbing habit to a later stage than most other representatives of the species.

Figures 7A-C. *Dichotomites quatsinoensis* (Whiteaves, 1882). Same locality, etc., as for specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6962.

7A, Lateral view; 7B, Cross-section and ventral view of earlier parts of the whorl; 7C, Cross-section of end of whorl, and the ventral view of the middle part of whorl.

Figures 8A-C. *Buchia crassicollis* (Keyserling, 1846) var. *solida* (Lahusen, 1888). Same locality, etc., as for ammonite specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6963.

Well-preserved and complete representative of the variant covered with the perfectly preserved shell layer throughout. Only very fine and closely spaced ribs or striae cover the surface of the shell layer. Specimen is believed to be only homoeomorphically similar to *Buchia pacifica* n. sp. figured in Pl. XXI, fig. 3.

8A, Lateral view of exterior of left valve; 8B, Same view of right valve and that of underside of beak part of left valve; 8C, Oblique posterior view of exterior of both valves.

Figures 9A-B. *Buchia crassicollis* (Keyserling, 1846) var. *solida* (Lahusen, 1888). Vancouver Island, B.C., Quatsino Sound, Forward Inlet. West end of a small wooded islet inside of Winter Harbour and about 2,200 yards N. of Greenwood Point. Collected some 300 feet higher in the succession than the specimen shown in fig. 1. GSC No. 16658.

A complete, partly shell-covered left valve. 9A, Lateral view of the exterior; 9B, Oblique posterior view.

Figures 10A-D. *Buchia crassicollis* (Keyserling, 1846) f. typ. Harrison Lake, B.C., Lonetree Island, off the south tip of peninsula. Crickmay's (1930a, p. 41) foss. loc. No. 40. Collected by J. A. Roddick, 1954. Upper Valanginian. GSC No. 16659.

Smooth internal cast of a typical and complete left valve of the species.

10A, Lateral view of exterior; 10B, Anterior view; 10C, Oblique posterior view; 10D, Hinge margin and beak viewed from above.

Figures 11A-B. *Buchia crassicollis* (Keyserling, 1846) f. typ. Same locality, etc., as for the specimen shown in fig. 1. GSC No. 16660.

Internal cast of a typical right valve with considerable patches of well-preserved shell layer. The cast's surface is smooth while that of the shell layer is densely and finely ribbed.

11A, Lateral view of the exterior; 11B, Oblique posterior view. Hinge margin (oblique view) is on left side of photo.

Figures 12A-B. *Buchia crassicollis* (Keyserling, 1846) var. *solida* (Lahusen, 1888). Same locality as for ammonite shown in fig. 3. Collected some 150 feet above the visible base of the section. Upper Valanginian. GSC No. 16661.

Internal cast of an unusually wide left valve with some well-preserved shell layer around the beak. The beak has marked left-handed incurvature.

12A, Lateral view of exterior; 12B, Anterior view.

Figure 13. *Dichotomites quatsinoensis* (Whiteaves, 1882). Harrison Lake, B.C. East shore of the peninsula, 200 yards N. of Lonetree Island. Upper Valanginian. This is a reproduction of one of Crickmay's (1930a, Pl. XXI, fig. 4) paratypes of *Homolsomites poecilochotomus* introduced for the purpose of comparison with the types of *Olcostephanus quatsinoensis* Whiteaves, 1882. Lateral view, X2. GSC No. 9696.

Juvenile specimen. Note change from *Tollia*-like to bidichotomous ribbing habit near end of whorl.

Figures 14A-C. *Dichotomites quatsinoensis* (Whiteaves, 1882). Holotype. The same locality, etc., as for the unfigured topotype of the species shown in fig. 4. Upper Valanginian. GSC No. 4799.

14A, Lateral view. The parallel flanks and relatively wide umbilicus of this specimen are due to its strong distortion and partial flattening. 14B, Same as 14A, X2 to show the detail of characteristic bidichotomous ribbing of the species; 14C, Cross-section.

Figures 15A-B. *Dichotomites quatsinoensis* (Whiteaves, 1882). Same locality, etc., as for *Buchia* specimen shown in fig. 12. GSC No. 16662.

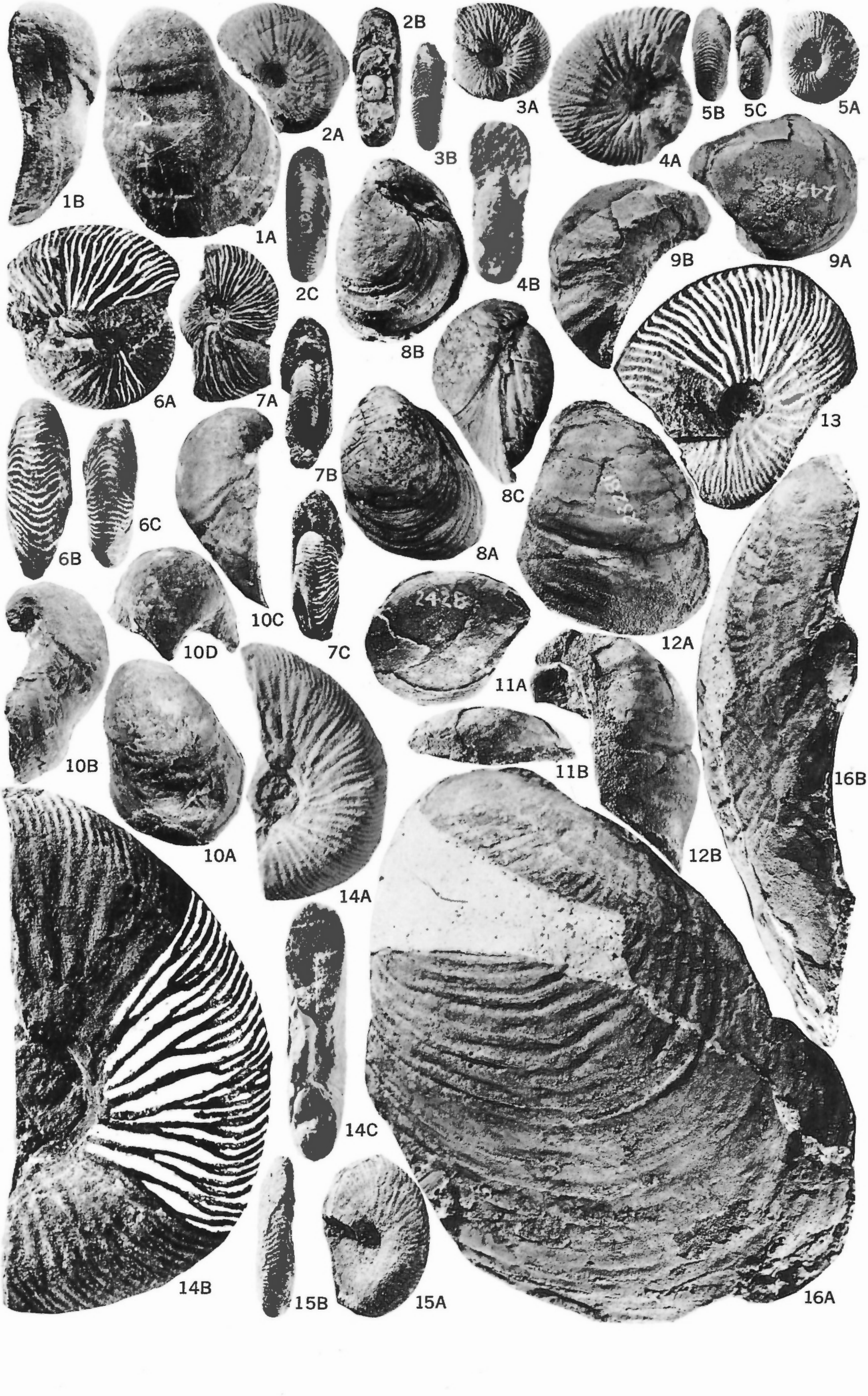
15A, Lateral view; 15B, Ventral view. A juvenile specimen distorted and flattened in exactly the same fashion as the holotype of the species (*see* fig. 14).

Figures 16A-B. *Buchia keyserlingi* (Lahusen, 1888) var. *gigas* (Crickmay, 1930). Same locality, etc., as for the specimen shown in fig. 10. GSC No. 16663.

Plaster cast of a rock mould (internal cast) of a fragmentary but undistorted left valve of the variant. Compare with the East Greenland representative of the variant, figured in Pl. XIX, fig. 1.

16A, Lateral view of the exterior; 16B, Oblique posterior view.

PLATE XX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Figures 1A-C. *Buchia keyserlingi* (Lahusen, 1888) var. *gigas* (Crickmay, 1930). Holotype of the variant. Harrison Lake, B.C. The same locality, etc., as for specimen of *D. quatsinoensis* shown in Pl. XX, fig. 13. GSC No. 9664.

Left valve is an internal cast while right valve is mostly covered with the shell layer. Specimen is distorted and flattened in such a fashion as to simulate a large *Buchia volgensis* (Lahusen, 1888); its comparison with better-preserved topotypes (e.g. Pl. XX, fig. 16) reveals, however, its true affinities.

1A, Lateral view of exterior of left valve; 1B, Same view of right valve and view of underside of protruding beak part of left valve; 1C, Anterior view of exterior of both valves.

Figures 2A-C. *Buchia crassicollis* (Keyserling, 1846) var. *gracilis* (Lahusen, 1888). Nooksack area, Washington, U.S.A. North shore of the North Fork of Nooksack River, 1¾ miles WSW of the top of Church Mountain. Nooksack Group. Fossil loc. 8.11.55.1. Upper Valanginian. U. of Wash., Pal. Coll. No. 6964.

Internal cast of small but complete left valve with considerable patches of poorly preserved shell layer. 2A, Lateral view of exterior; 2B, Anterior view; 2C, Hinge margin and beak viewed from above.

Figures 3A-D. *Buchia pacifica* n. sp. var. Same locality, etc., as for specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6965.

An internal cast of a large and complete left valve. This peculiar form is only tentatively assigned to *Buchia pacifica* n. sp.; it could also be an extreme form of *B. crassicollis* Keys, var. *solida* and a homoeomorph of *B. pacifica* n. sp.

3A, Lateral view of the exterior; 3B, Anterior view; 3C, Oblique posterior view; 3D, Hinge margin and beak viewed from above.

Figures 4A,B. *Dichotomites quatsinoensis* (Whiteaves, 1882). Same locality, etc., as for specimen shown in Pl. XX, fig. 2, U. of Wash., Pal. Coll. No. 6966.

4A, Lateral view; 4B, Cross-section. Fragment of the living chamber with characteristic sculpture. Compare with the specimen shown in fig. 11.

Figures 5A-C. *Buchia crassicollis* (Keyserling, 1846) var. Same locality, etc., as for specimen figured in fig. 2, U. of Wash., Pal. Coll. No. 6967.

A complete left valve of a broad *B. keyserlingi*-like variant. About one half of the valve is an internal cast. Another half is covered with well-preserved shell layer. Note the contrast between the smooth surface of the internal cast and the finely and closely ribbed surface of shell layer.

5A, Lateral view of the exterior; 5B, Anterior view; 5C, Hinge margin and beak viewed from above.

Figures 6A,B. *Buchia crassicollis* (Keyserling, 1846) s. str. Same locality, etc., as for specimen shown in fig. 2, U. of Wash., Pal. Coll. No. 6968.

A large and almost complete, typical right valve. Most of the valve is covered by well-preserved, thinly and densely ribbed shell layer. Note same contrast between the surface of shell layer and that of the internal cast as for specimen shown in fig. 5.

6A, Lateral view of the exterior; 6B, Anterior view. Byssal notch and byssus ear are in the extreme right of the photo.

Figures 7A-C. *Buchia crassicollis* (Keyserling, 1846) var. Same locality, etc., as for specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6969.

Medium-sized and complete left valve, which is almost completely covered by shell layer. An extremely low and broad variant of the species resembling *Buchia keyserlingi* (Lahusen) in its proportions and thickness; the lower part of the shell is, however, truncated as that of *B. pacifica* n. sp. and *B.* aff. *pacifica* n. sp. from north-eastern British Columbia.

7A, Lateral view of the exterior; 7B, Anterior view; 7C, Hinge margin and the beak viewed from above.

Figures 8A-D. *Polyptychites* s. lato sp. indet. juven. The same locality, etc., as for the *Buchia* specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6970.

8A-B, Two lateral views; 8C, Cross-section and the ventral view of the earlier part of the whorl; 8D, Ventral view of the later part of the whorl.

Figure 9. *Dichotomites quatsinoensis* (Whiteaves, 1892). Same locality, etc., as for *Buchia* specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 6971.

Lateral view of a fragmentary juvenile specimen showing transition from the *Tollia*-like to bidichotomous ribbing habit.

Figures 10A-C. *Dichotomites quatsinoensis* (Whiteaves, 1892). Same locality, etc., as for the *Buchia* specimen shown in fig. 2. U. of Wash., Pal. Coll. No. 7011.

10A, Lateral view; 10B, Ventral view; 10C, Cross-section. A somewhat fragmentary juvenile specimen that exhibits the *Tollia*-like sculpture to the very end.

Figure 11. *Dichotomites quatsinoensis* (Whiteaves, 1892). The same locality, etc., as for specimen shown in Pl. XX, fig. 13. GSC No. 9697. This is the reproduction of the holotype of *Homolsomites poecilochotomus* Crickmay 1930a (Pl. XXI, fig. 2). Lateral view of the flattened and fragmentary living chamber. Note the feebly developed but broad and distinctly swollen basal parts of two primaries at the umbilical margin.

PLATE XXI

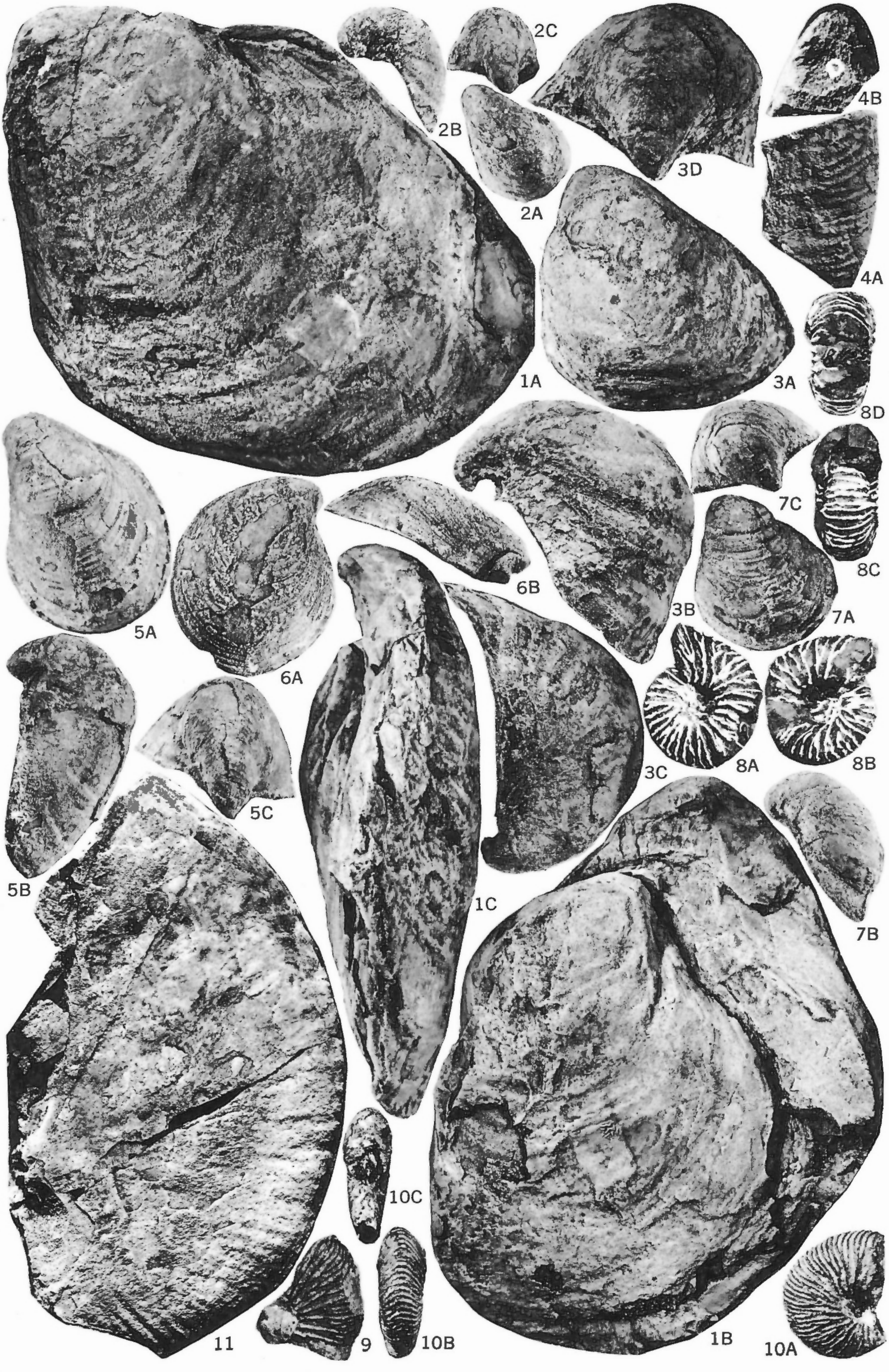

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PLATE XXII

Figures 1A-E. *Buchia* aff. *crassicollis* (Keyserling, 1846) var. *solida* (Lahusen, 1888). Bridge River District, B.C., Tyaughton Lake area, south side of the ridge between Gun and Leckie Creeks, 6,300 feet elevation. Eldorado Group (lower part). Upper Valanginian. Associated with *B. crassicollis* f. typ. and advanced forms of *B. keyserlingi*. Collected by C. H. Crickmay, 1939. GSC No. 17336.

An internal cast of a complete specimen morphologically transitional between *B. sublaevis* var. *majuscula* (Lahusen, 1888) (*see* Pl. XVI, fig. 6 and Pl. XVII, fig. 1) and *B. crassicollis* var. *solida* (Lahusen, 1888) (Pl. XX, figs. 8, 9, 12).

1A, Lateral view of the exterior of the left valve; 1B, Anterior view of the exterior of both valves; 1C, Oblique posterior view of the same; 1D, Lateral view of the exterior of the right valve and the projecting part of the beak of the left valve; 1E, Hinge margins and the beak parts of both valves viewed from above. The beak of the left valve has only a feeble left-handed curvature similar to that of *B. crassicollis* var. *solida* or *B. sublaevis* s. lato.

Figures 2A-E. *Buchia* cf. *blanfordiana* (Stoliczka, 1866). West coast of Vancouver Island, B.C., west side (tidal shelf) of the main body of Grassy Island. Upper shale member of Division B, 501-503 feet above the base of the section and 3 to 5 feet below the Jurassic-Cretaceous boundary. Uppermost Portlandian s. str.? GSC No. 17517.

Well-preserved but incomplete internal cast of a large right valve with an excellently preserved and complete byssus ear. 2A, Lateral view of the exterior; 2B, Lateral view of the interior. The inner surface of the byssus ear is only shallowly excavated, clearly grooved and contracted at its posterior end; it is furthermore, distinctly 'spoon-like' (i.e. partly anteriorly closed by the ridge-like anterior surface of the obliquely directed byssus ear; compare Pl. I, figs. 3-5). The overall evolutionary grade of the inner surface of byssus ear is comparable to that of the late *B. mosquensis* s. lato—*B. piochii* s. lato species group (Pl. I, fig. 5) rather than to that of *B. concentrica* — early *B. mosquensis* s. lato species group (Pl. I, fig. 1). 2C, Lateral view of interior of beak part, X3. Oriented exactly as in fig. 2B; 2D, Anterior view of exterior. Anterior surface of the byssus ear is only moderately high in this aspect and its lower margin is markedly concave, as the anterior end of the groove occurring on the inner side of the ear (*see* figs. 2B,C) is only partly blocked; 2E, Oblique posterior view of the exterior. The flat-topped nature of the valve is clearly visible.

Figures 3A-C. *Buchia pacifica* n. sp. Holotype. Bridge River District, B.C., Tyaughton Lake area, in the valley of Mud Creek, a northern tributary of Tyaughton Creek, about 1½ miles above the mouth of Mud Creek and 200 feet above its right bank, some 200 yards northeast of the fossil loc. 249-F Eldorado Group (lower part). Mid-Valanginian. Collected by C. E. Cairnes, 1937. GSC No. 16642.

An internal cast of the left valve with small patches of the shell layer preserved near the hinge margin. 3A, Posterior view of the exterior; 3B, Oblique lateral view of the exterior. The valve is tilted so as to bring the earlier growth-stages and the beak into the foreground. The other lateral view of the same valve (*see* Pl. XVI, fig. 1A) is tilted so as to bring the later growth-stages in the foreground; 3C, Hinge margin and the beak viewed from above. For the anterior view of the exterior see Pl. XVI, fig. 1B.

Figures 4A-D. *Buchia okensis* (Pavlow, 1907) s. lato var. West coast of Vancouver Island, B.C., west side of the main body of Grassy Island. One Tree Formation, 607 to 607⅓ feet above the base of the section and 101 to 101⅓ feet above the Jurassic-Cretaceous contact. Lower Berriasian. GSC No. 17519.

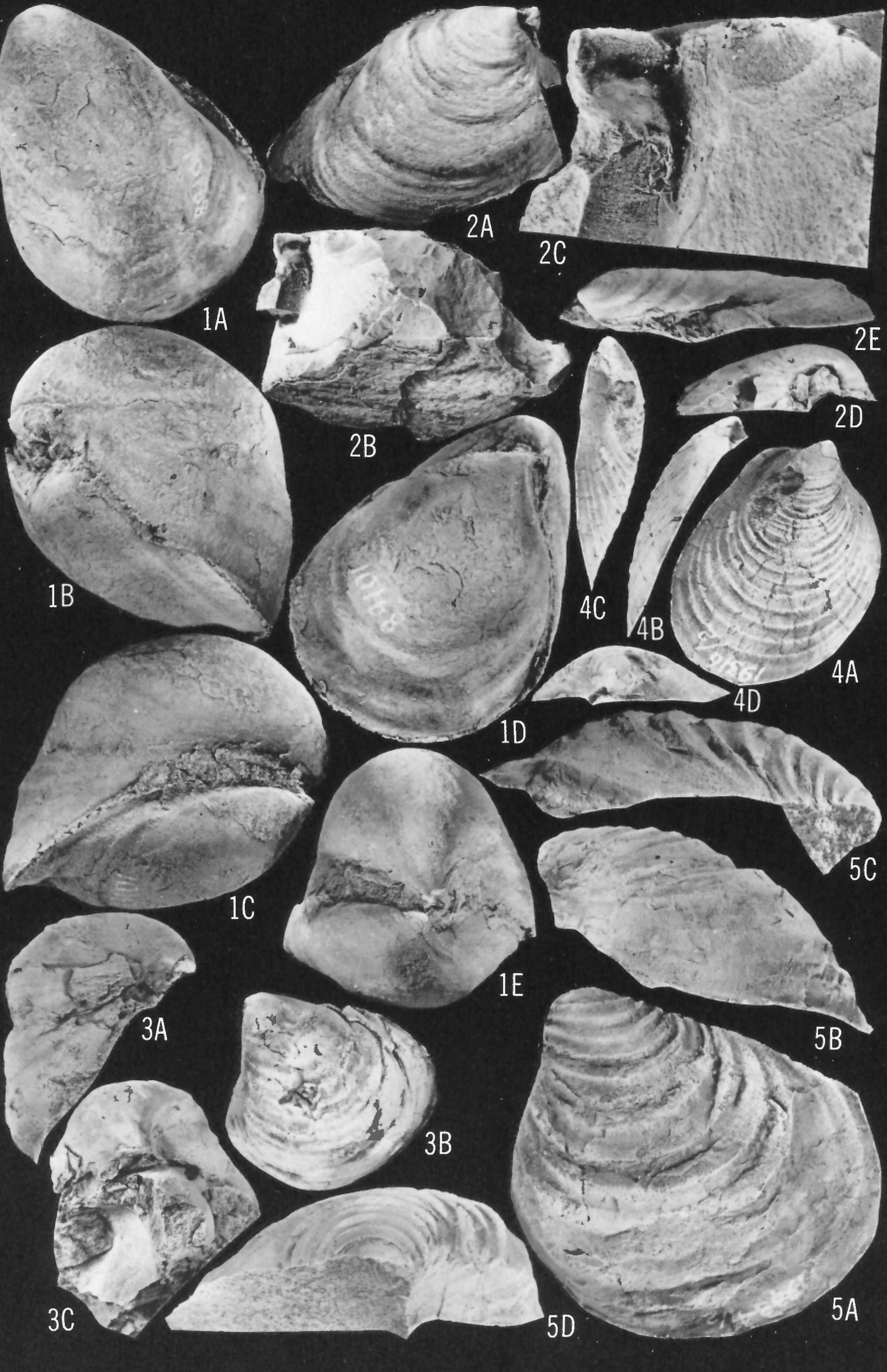
Internal cast of an almost complete, fairly large right valve with considerable patch of poorly preserved shell layer around the beak. This specimen matches closely that shown in Pl. VII, fig. 4, except that it has an exceptionally large and angular posterior ear and is more broadly rounded in outline.

4A, Lateral view of exterior; 4B, Anterior view; 4C, Oblique posterior view; 4D, Hinge margin and the beak viewed from above. Byssus ear is completely broken off.

Figures 5A-D. *Buchia okensis* (Pavlow, 1907) var. *canadiana* (Crickmay, 1930). West coast of Vancouver Island, B.C., west side of the main body of Grassy Island, 533 feet above the base of the section and 47 feet above the Jurassic-Cretaceous contact. Lower (but not the basal) Berriasian. Top part of *Buchia okensis* zone proper. GSC No. 17518.

Internal cast of incomplete (lacks all of the hinge part and most of the beak) but undeformed left valve of the same giant form of the variant as that shown in Pl. VI, fig. 1.

5A, Lateral view of the exterior; 5B, Anterior view; 5C, Oblique posterior view; 5D, Incomplete upper side viewed from above.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