NEW MOLLUSCAN FAUNAS FROM THE LATE JURASSIC (KIMMERIDGIAN AND EARLY TITHONIAN) OF WESTERN CANADA

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Abstract

Kimmeridgian and Lower Tithonian molluscan faunas recently discovered in Manning Provincial Park, southwestern British Columbia, contain a mixture of Boreal [Buchia concentrica], intermediate [Ochetoceras (Suboxydiscites) manningense subgen. nov., sp. nov.], and Tethyan/East Pacific species [Discosphinctoides(?) aff. D. neohispanicum (Burckhardt), Lithacoceras(?) sp., L.(?) (Subplanites?) sp., Physodoceras sp., Phylloceras cf. P. mazenoti Joly]. This association results from a mixing of Boreal and southern faunas with a broad range of overlap along the west coast of North America.

Résumé

Des faunes de mollusques d'âge kimméridgien et tithonien inférieur, récemment découvertes dans le parc Provincial de Manning, dans le sud-ouest de la Colombie-Britannique, contiennent un mélange d'espèces boréales [Buchia concentrica], d'espèces intermédiaires [Ochetoceras (Suboxydiscites) manningense subgen. nov., sp., nov.] et d'espèces originaires de la mer Téthys et de l'Est du Pacifique [Discosphinctoides(?) aff. D. neohispanicum (Burckhardt), Lithacoceras(?) sp., L.(?) (Subplanites?) sp., Physodoceras sp., Phylloceras cf. P. mazenoti Joly]. Cette association résulte d'un mélange de faunes boréales et de faunes du sud, qui se recouvrent amplement le long de la côte ouest de l'Amérique du Nord.

INTRODUCTION

Kimmeridgian and Lower Tithonian molluscan faunas new to Canada were discovered in southwestern British Columbia in 1985 by the authors and Jennifer O'Brien. The faunas are unusual and significant because they include ammonites characteristic of the East Pacific and Tethyan faunal realms together with the bivalve Buchia, which characterizes the Boreal Realm. The Manning Park fauna thus has significance for interprovincial correlation. The Buchia zones (Imlay, 1980; Jeletzky, 1965, 1984) of the Upper Jurassic and Lower Cretaceous of the Boreal Realm generally contain few ammonites that permit them to be correlated in detail with the Tethyan ammonite zones. Hence any fauna, such as that described in this report, contributes to resolving some of the long-standing problems of inter-provincial faunal correlation.

The fossils described in this report were collected from talus derived from bluffs directly above the talus slopes, on the north side of Thunder Lake at its west end, in southwestern Manning Provincial Park (GSC localities 68706, C-128986; lat. $49^{\circ}01'30"N$, long. $120^{\circ}57'30"W$; Fig. A, loc. 6; Fig. 5.1). The fossils come from black, rusty weathering, medium grained greywacke beds that were assigned to the Dewdney Creek Group by Coates (1974, p. 126) and to the "Thunder Lake Sequence" by O'Brien (1986). Although found in talus, the fossils collected by the authors (GSC locality C-128986) appear to represent two assemblages from a narrow stratigraphic interval, which could not be examined in outcrop, because the bluffs are inaccessible without climbing equipment. Although the Upper Oxfordian to Tithonian

Thunder Lake Sequence may be as thick as 350 m in the western Thunder Lake area (O'Brien, 1986), and about 150 m of Upper Jurassic and Cretaceous rocks are exposed in the bluffs in the immediate area (Coates, 1974), the Jurassic fossils described here are from an interval within 50 m of the base of the disconformably overlying Lower Cretaceous (Hauterivian or Barremian) Jackass Mountain strata, They are the sole contributors to the uppermost, and westernmost parts of the talus. The fossils collected earlier by Coates (1974, p. 126; GSC loc. 68706) include an admixture of Hauterivian-Barremian (e.g., Inocemmus colonicus, indet., Adlacoteuthis? cf. Hoplocrioceras? sp. and A. impressa) and probably Upper Tithonian (Buchia fischeriana trigonoides of Jeletzky, 1984) fossils. These younger fossils were derived from the overlying strata that are present in the same bluffs and appear low on the talus slope near the lake. If Upper Tithonian beds are indeed present, they must be thin, because the probable source beds for the Kimmeridgian and Lower Tithonian fossils are separated from the Hauterivian-Barremian strata by less than 50 m. The various strata are not sufficiently distinct to permit recognition of the units on lithological criteria.

AGE AND CORRELATION

Although the fossils described in this report are from rocks of uniform lithology and a narrow stratigraphic interval, they appear to give conflicting evidence regarding their age, and are now thought to come from beds of at least two different ages.

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Figure 5.1. J.A. Jeletzky and A. Zeiss collecting the fossils described in this report from talus below bluffs of the Dewdney Creek Group and Cretaceous greywackes, Thunder Lake, Manning Park, southwestern British Columbia. Photograph no. ISPG 2564-4.

The Buchia specimens figured are in part diagnostic of Late Oxfordian to Mid-Kimmeridgian ages, as indicated by B. concentrica. Its variety, erringtoni, also figured, is probably Early to Mid-Kimmeridgian in age, which is the most likely age for all members of the species at this locality. The Canadian Ochetoceras (Suboxydiscites) species appear to be closer to Middle Kimmeridgian, or possibly uppermost Lower Kimmeridgian, species of Ochetoceras s.s. than to other species. The presence of both the Phylloceras and Physodoceras specimens also suggests a Kimmeridgian age, but a more precise date cannot be determined.

The Discosphinctoides neohispanicus fauna of Mexico is clearly of Early Tithonian age (e.g., Imlay, 1980) and the various perisphinctids described in this report are consistent with that, and can be correlated with the Hybonotum, and perhaps the Subplanitoides fauna of southern Germany as well.

PALEOBIOGEOGRAPHIC COMMENTS

The overall distribution of Buchia is Boreal. The Buchia-bearing seas in western North America extended as far south as California.

All the ammonites described in this report are of Tethyan/East Pacific affinity, and represent the northernmost well developed Kimmeridgian/Tithonian Tethyan faunas known so far in North America. Tethyan/East Pacific ammonites of these ages are otherwise sparsely represented by a few individual fragments in Buchia-rich beds in northern Manning Park (unpublished data), Taseko Lakes (Jeletzky, 1965; Jeletzky and Tipper, 1968), and perhaps Spatsizi areas of British Columbia. Some specimens of Phylloceras and Lytoceras from Alaska were mentioned by Imlay (1961, p. D11) and Imlay and Detterman (1973, p. 21). The "Dichotomosphinctes/Buchia concentrica" fauna of Alaska is apparently somewhat older (see Imlay, 1980, p. 30). This is also evident from the specimen figured as "Perisphinctes (Dichotomosphinctes) sp. cf. P. (D.) muehlbachi Hyatt" (Imlay, 1961, pl. 4, fig. 6), which is a representative of the genus Orthosphinctes, of latest Oxfordian/earliest Kimmeridgian age.

In general, the mixed Boreal and Tethyan/East Pacific faunas of western North America reflect a broad zone of faunal mixing. This was perhaps due to several short-lived northerly and southerly shifts of the interface between opposing water masses. Additionally, and perhaps more importantly, they may be a result of the effects of northsouth oriented coastal currents along a geographically complicated, tectonically active, continental margin.

The western North American margin appears, at present, to have been the most likely migration route for Ochetoceras into Boreal seas, where they were considerably modified from Tethyan Ochetoceras s.s. species. Middle American Upper Oxfordian species are likely ancestors for O. (Suboxydiscites) manningense, and O. (S.) elgense and O. (S.) taimyrense may be its Middle and Upper Kimmeridgian Boreal descendants, respectively.

SYSTEMATIC PALEONTOLOGY

All figured specimens are stored in the type collection of the Geological Survey of Canada, Ottawa, Canada.

Class CEPHALOPODA Leach, 1817

Order AMMONOIDEA Zittel, 1884

Superfamily HAPLOCERATACEAE Zittel, 1884

Family OPPELIIDAE Bonarelli, 1894

Genus Ochetoceras Haug, 1885

Subgenus Suboxydiscites subgen. nov.

Type species. Ochetoceras (Suboxydiscites) manningense sp. nov.

Diagnosis. A subgenus of Ochetoceras with a very narrow umbilicus, normal coiling, a serrated, non-undulating keel, very weak internal ribs, and retrocostate, single, external ribs. In microconchs, a lateral channel may be present, as well as a short protrusion of the mouth border at the end of the channel, which perhaps marks the beginning of a lateral lappet, and somewhat denser ribbing at the mouth border.

Remarks. Oxydiscites has an undulating keel and more distinct internal ribs. The ribs are denser, mostly bifurcating, and continuous on the flanks; they may weaken somewhat in the middle of the flanks (see Geyer, 1960). Ochetoceras s.s. has a wider umbilicus and more falcoid, often bifurcating, external ribs. Hildoglochiceras and Salinites also have a notably wider umbilicus, more falcoid ribs, and a broader, more rounded venter like that of Glochiceras, but with a median, partly serrated, keel. Streblites has secondary (auxiliary) ribs between the primary external ribs. Neochetoceras also exhibits this character, but has no distinct median keel. Other species of the new subgenus are O. (S.) taimyrensis (Mesezhnikov) and O. (S.) elgense (Sej and Kalacheva).

Ochetoceras (Suborvdiscites) manningense sp. nov.

Plate 5.1, figures 1-14; Plate 5.3, figure 10

? Strebittes? (Oxydiscites?) cf. taimyrensis Mesezhnikov. Callomon and Birkelund, 1980, Pl. 3, figs. 5a, b.

Oppeliid ammonites closely resembling Sanmartinoceras (Theganoceras?) sp. Jeletzky, in Coates, 1974, p. 126.

Holotype. GSC 83491 (Pl. 5.1, figs. 1-4).

Description. The largest specimen is 5.2 cm in diameter, and another fragment was probably septate to a diameter of about 6 cm; most specimens are smaller.

The shell is oxycone, strongly compressed. The flanks are very gently convex. The venter is acute with a finely serrated keel. The ventrolateral edge is broadly rounded and indistinct (Pl. 5.1, figs. 1, 5, 7, 8, 11, 14).

The umbilicus is small but not minute, with low, steep, smooth walls. The umbilical edge is sharp.

A spiral groove or channel located halfway up the flank can be observed in some specimens (Pl. 5.1, figs. 7, 14; Pl. 5.3, fig. 10). In one specimen (Pl. 5.1, fig. 1) it is restricted to the end of the body chamber. There is no spiral ridge.

The ribs are falcate. The internal half of the flank is smooth, or has very fine, prorsiradiate growth lines, which on the adoral portions of only three specimens are widely enough spaced to be called weak primary ribs. On the external half of the flank, the ribs are stronger. They are rursiradiate, i.e. curving backward over most of their length, becoming stronger, more widely spaced and adorally gently concave toward the venter. Approaching the venter they curve sharply forward at their tips in some specimens, or more commonly they fade rapidly so that a narrow smooth space stronger in larger growth stages.

The adult mouth border of macroconchs is not known; at intermediate growth stages or in microconchs, the growth lines follow the ribs, or replace them adorally. In those stages the mouth border is best seen (PI. 5.1, fig. 1; PI. 5.3, fig. 10) and it is also falcoid, like the ribs and growth lines. There is a short prolongation at the end of the radial groove.

No sutures can be seen.

Discussion. None of the specimens from Manning Park is as large as the macroconchs from the U.S.S.R. figured as "Oxydiscites" taimyrensis (Mesezhnikov, 1984, Pl. VI, VII, LVII), and all of them are assumed to be microconchs. Only two smaller specimens from there (*ibid.* Pl. VII, figs. 3-4) are directly comparable. The one shown in figure 3 is somewhat similar to the supposed microconchs from Thunder Lake, while the other (fig. 4) is more densely ribbed, as on small macroconchs. The main difference is that O. taimyrensis has less falcoid ribs; also the microconchs have higher whorl sections, are more densely ribbed, and there appear to be no channels present. Another similar form, in shape and size of ribbing, is Ochetoceras elgense from the far eastern U.S.S.R. (Sej and Kalacheva, 1983, Pl. 3), but its ribs are less numerous and more coarse. The microconchs of that species are not as densely ribbed as in O. manningense. Sej and Kalacheva (1983, p. 68) have made detailed comparisons of O. elgense with other somewhat similar species of Ochetoceras.

Some European and Cuban species of Ochetoceras are similar, such as O. canaliculatum (d'Orbigny) and O. semifalcatum. Although the mouth border is the same, the ribbing is concave, sometimes bifurcating in these species. Also, the umbilicus is not as narrow as in the Canadian species (see also Sej and Kalacheva, 1983, p. 64).

The coarse spacing of the ribs, their strength, and the general form of the shell of the Manning Park specimens are similar to one specimen from the lower Mutabilis beds of East Greenland (Callomon and Birkelund, 1980, Pl. III, figs. 5a, b) but for the most part, the Greenland specimens are not sufficiently well preserved to be definitively compared.

Ochetoceras (S.) manningense sp. nov. seems to be an intermediate form, preserving some characteristics of the more typical Tethyan Ochetoceras that do not appear in those species from the mainly Boreal fauna in Greenland and Siberia. This may indicate a northward migration of Suboxydiscites from Cuba or Mexico via western North America, giving rise to the somewhat modified Boreal species of East Greenland, northern Siberia, and perhaps also the far eastern U.S.S.R.

Superfamily PHYLLOCERATACEAE Zittel, 1884

Family PHYLLOCERATIDAE Zittel, 1884

Genus Phylloceras Suess, 1865

Phylloceras cf. P. mazenoti Joly

Plate 5.1, figures 15-19

cf. Phylloceras mazenoti Joly, 1976, Pl. 6, fig. 1.

Description. The largest specimen has a whorl height of 6 cm, at which size it is non-septate; other small fragments have coarser ribbing, suggesting that they represent specimens that attained a larger size, if in fact they belong to the same species. The specimens available have differing whorl cross-sections, due at least partly to crushing, and the original cross-section of the shell cannot be confidently determined. Nevertheless, the venter is clearly rounded.

The ribs are gently flexed forward over the venter. Very faint, irregularly spaced folds occur on the lower half of the flank. No mouth border, constrictions, flares, or suture line can be seen.

Discussion. Besides P. mazenoti Joly, 1976, of Kimmeridgian age, the Manning Park specimens are similar to Phylloceras subplicatius Burckhardt, 1912 from Mexico, also Kimmeridgian, and to Tithonian specimens described as Phylloceras cf. P. consanguinum Gemmellaro, 1876 by Rossi (1984, Pl. 30, fig. 1).

Family ASPIDOCERATIDAE Zittel, 1895

Genus Physodoceras Hyatt, 1900

Physodoceras sp.

Plate 5.1, figures 20, 21

Description. The single specimen is strongly distorted. Approximate reconstruction of its original shape indicates that it reached a diameter of about 6 to 7 cm. No sutures can be seen and the entire outer whorl preserved may well be the body chamber, although it is possible that a ventral groove or break in the shell, even in its most adoral parts, represents the siphuncle in the phragmocone of a considerably larger specimen than that preserved. There is a suggestion of uncoiling of the last few centimetres. The shell was probably fairly depressed, with rounded whorl cross-section. The umbilicus is tiny. Faint, fine ribbing over the venter can be seen on the oralmost 2 cm. A single row of inward-facing spines, spaced about 0.5 to 1 cm apart, occurs around the umbilicus. On the internal mould they are preserved only as subtle rounded protuberances and therefore are not well shown in the photograph (Pl. 5.1, fig. 21). No sutures can be seen.

Discussion. The most similar described species include Aspidoceras acanthophalotum Zittel (Canavari, 1903, Pl. I [XXVI], figs. 3a-c) from the Middle Kimmeridgian Acanthicus beds throughout Southern Europe and A. (Physodoceras) cf. A. altenense (d'Orbigny) (Quenstedt, 1887-8, Pl. 116, fig. 4) of the southern German Weisser Jura Gamma beds (middle and upper Tenuilobatus Zone; Mutabilis and Cymodoce Zones). A smaller species (3-5 cm diameter) with a ventral furrow has been assigned to A. hermanni Berckhemer from the Upper Kimmeridgian of central Europe (see Hölder and Ziegler, 1959, Pl. 19, fig. 4).

Family ATAXIOCERATIDAE Buckman, 1921

Subfamily LITHACOCERATINAE Zeiss, 1968

Discussion. Small specimens with lateral lappets (microconchs), intermediate sized specimens (e.g., Pl. 5.3, fig. 3) and large specimens are present. They may be microand macroconchs of the same species, but this would need to be verified by collecting from a single horizon. The inner whorls of the large specimens cannot be observed sufficiently well to prove their morphological similarity to the small specimens. Because of these difficulties, the different morphotypes are treated here as different morphospecies, belonging to different morphological genera.

The assignment of the specimens collected, especially the microconchs, to existing genera is difficult. They exhibit characteristics that are represented to varying degrees in several existing genera and subgenera, in particular, Subplanitoides, Discosphinctoides, Pseudodiscosphinctes and Torquatisphinctes. However, the characteristics fit none of these taxa completely. Considering that the macroconchs resemble Lithacoceras quite well in shape and style of ribbing, it would be reasonable to assign the smaller microconchs to Subplanites, which is thought generally to be the microconch counterpart of Lithacoceras (including

Virgatolithacoceras). The trouble is that the microconchs corresponding to the true Lithacoceras (L. ulmense Group) of the lower and middle Hybonotum Zone have not been described in detail, except for a few specimens (e.g., in Berckhemer and Hölder, 1959; Ohmert and Zeiss, 1980; Schairer and Barthel, 1981). All those specimens were treated informally, e.g.: "Lithacoceras? (Subplanites?) sp.," "Perisphinctidae sp. et gen. indet.", "Perisphinctes". Only a monographic study could show the variety of those forms. It would be possible to describe the Manning Park microconchs as a new, dichotomous, rather densely ribbed group of Subplanites, but this would lead to an undesirable enlargement of the original diagnosis of this genus. Alternatively, it may well be that the recently established genus Discosphinctoides includes these forms (see Oloriz, 1978, p. 482-484). Therefore, at the present status of our knowledge, it seems appropriate to assign the Manning Park microconchs to Discosphinctoides(?), especially as we can only assume that the micro- and macroconchs come from the same horizon.

The generic names used in this section are those of morphotaxa. Their true relationships will only be deciphered after a monographic study of the contemporaneous micro-and macro-conchs in Europe and America.

Genus Discosphinctoides Oloriz

Discophinctoides (?) aff. D. neohispanicum Burckhardt

Plate 5.3, figures 1, 2, 4-9

- Pectinatites (Paraberriasella) ex gr. blondeti (Donzé). Jeletzky in Coates (1974, p. 126).
- ?Pectinatites (Paraberriasella) ex gr. blondeti (Donzé). Jeletzky, 1984, p. 188, Pl. IV, figs. 14a, b.
- aff. Idoceras neohispanicus Burckhardt, 1912, Pl. XXIX.
- aff. Perisphinctes (Aulacosphinctes) neohispanicus (Burckhardt), 1919, Pl. 10, figs. 1-7.
- aff. Perisphinctes (Dichotomosphinctes) neohispanicus. Muñoz, 1964, p. 11, Pl. 3, figs. 3,4.
- aff. Perisphinctes (Dichotomosphinctes) neohispanicus guadalupensis Muñoz, 1964, p. 12, Pl. 3, figs. 1, 2, Pl. 4, figs. 3, 4.

Description. The microconchs reach a diameter of 8 cm. They are moderately evolute. The cross-section appears to vary from subcircular, at a diameter of 5 mm, to compressed subquadrate, at a diameter of 8 cm, but it cannot be seen clearly because all the specimens are crushed to some degree. The venter is rounded and simple. The umbilical edge is rounded and the umbilical wall is low, steep, and smooth, or with fine, wiry extensions of the ribs.

The smallest size at which ribs can be described confidently is at a whorl height of 1 cm, where nearly all the ribs bifurcate about halfway up the flank. From this stage, to the largest size of the microconch (whorl height 2.3 cm), there is a gradual admixture of simple ribs until about every third to fifth one is simple; trifurcating ribs are rare. The ribs are straight and radial, passing straight over the venter, except in the adoralmost 3 cm, where they become slightly prorsiradiate. No sutures can be seen.

On one fragmentary small specimen (Pl. 5.3, fig. 8), the ribs are more finely spaced than on the other perisphinctids described above, and they are perhaps more sinuous and certainly more irregular. There is not enough material available to attach great taxonomic or biostratigraphic significance to these attributes. Similar differences in Mexican collections led Muñoz (1964) to create a new subspecies of "Perisphinctes" neohispanicus (Burckhardt): "P." neohispanicus guadalupensis.

The body chamber appears to occupy about seveneighths of a whorl. Two constrictions, which are very weakly developed, are seen on one specimen only. A well developed constriction on the internal mould, a flare adoral to it, and prominent lateral lappets form the mouth border. On the external shell surface, the ribbing is unchanged at the mouth border, except for being slightly inclined forward.

Discussion. The specimen collected by J.A. Coates and illustrated by Jeletzky (1984, p. 188, Pl. IV, fig. 14a, b) drew the writers' attention to the Manning Park locality, where further specimens, those described here, were collected. The original identification of Coates' specimen as *Pectinatites* is questionable because of the complete lack of well defined virgatotome ribbing in any of the specimens. The original specimen compares well with the variety of forms from the later collection. In *Pectinatites* Buckman, as in the Manning Park specimens, the ribbing is entirely bifurcating in small intermediate growth stages, but in the larger intermediate growth stages, the secondaries appear to develop additionally by intercalation of simple ribs, and by bidichotomous splitting. The polygyrate ribbing also distinguishes *Subplanites* Spath (1925), another similar genus, from the Manning Park specimens. One of the specimens is similar to certain forms of *Subplanitoides* Zeiss, 1968.

"Idoceras" neohispanicus Burckhardt (1912, Pl. XXIX) from the Kimmeridgian of Mexico is very similar to the Manning Park specimens. It was subsequently assigned to "Aulacosphinctes" by Burckhardt (1919), and to "Perisphinctes (Dichotomosphinctes)" by Muñoz (1964), who illustrated an assemblage that includes more finely ribbed varieties (his var. guadalupensis) that more closely resemble the more finely ribbed component of the Manning Park fauna (Pl. 5.3, fig. 8). Discosphinctoides neohispanicus guadalupensis differs from most of the Manning Park specimens by its finer, more flexuous, and more prorsiradiate ribs and by the slightly smaller whorl height. Most of the Mexican specimens are slightly more involute than the Canadian species, and have differently shaped ribs. Other small species from Mexico described and illustrated by Imlay (1939, p. 34, 35, Pl. 9, figs. 1, 2) as "Torquatisphinctes?" sp. and "T.?" aff. bangei (Burckhardt) are apparently also indistinguishable from the Manning Park species.

Genus Lithacoceras Hyatt

Lithacoceras (?) sp.

Plate 5.2, figures 1-5

Description. On two specimens, the primary ribs at a whorl height of 6 to 7 cm are subdued, represented by vague swellings relatively finely spaced on one (Pl. 5.2, figs. 3, 4), more distantly spaced on another (Pl. 5.2, fig. 5). Multiple,

finely, and evenly spaced secondaries cover the outer part of the flank. At intermediate growth stages, constrictions remain insignificant.

The largest growth stage seen is represented by a small fragment with a whorl height of 11 cm (Pl. 5.2, figs. 1, 2). At this size, the umbilical wall is high, vertical, and smooth. The flanks converge toward the venter, which is broadly rounded. Strong radial bullae around the umbilicus fade ventrally, and the ventral half of the flank is smooth. The oralmost part of the shell is possibly represented on one fragment (unfigured, whorl height 9.5 cm; preserved length 15.5 cm), indicated by gentle forward inclination, weakening, and irregular spacing of the primary ribs on the oralmost preserved 10 cm. No secondaries are visible. No sutures can be seen.

Discussion. Systematic attribution of these large forms is particularly difficult because of the fragmentary preservation. The style of ribbing and shell shape are similar to representatives of *Lithacoceras*, especially *L. ulmensis* (Oppel) (see Berckhemer and Hölder, 1969; Ohmert and Zeiss, 1980). *Lithacosphinctes* is also somewhat similar, but the locus of bifurcation of the ribs in this genus is generally halfway up the whorl, while it is much lower on the outer whorls of *Lithacoceras*.

Subgenus Subplanites Spath

Lithacoceras(?) (Subplanites?) sp.

Plate 5.3, figure 3

One specimen, represented by part of a whorl from an intermediate growth stage of a macroconch may be distinguished from the other perisphinctids from Thunder Lake by its irregular polygyrate and bidichotomous style of ribbing. The primary ribs are swollen and bent slightly forward along the umbilical edge. Just below halfway up the flank some of the ribs subdivide into two or three secondaries and some intercalated secondaries are present. Just above halfway up the flank, many of the ribs split again, so that there are variably three or four secondaries to each primary. A similar specimen has been figured from Europe, as *S. rueppellianus* (Quenstedt) by Schairer and Barthel (1981). The ribbing style is also similar to certain forms of the contemporaneous genus *Rowaiskya*.

Class BIVALVIA Linné, 1758

Family BUCHIIDA E Cox, 1953

Genus Buchia Rouillier, 1845

(=Aucella Keyserling, 1846; suppressed by Opinion 492 of the International Commission on Zoological Nomenclature, 1957).

Subgenus Anaucella Pchelintseva, 1955

Discussion. This subgenus is characterized by an essentially Meleagrinella-like structure of its byssus ear combined with either a strong development of the radial ornament or its prevalence over the concentric ornament. Jeletzky (1965, p. 4, 8) discussed the morphology and status of Anaucella.

Buchia (Anaucella) concentrica (Sowerby)

Plate 5.3, figures 13-20

See Zakharov (1981, p. 64, 65) for the Eurasian synonymy and Imlay (1959, p. 157) for the North American synonymy.

Description. Seven specimens are available. They are complete to fragmentary internal casts of individual valves including six left and one right (PI. 5.3, figs. 19, 20).

The shell is moderately to pronouncedly oblique posteriorly in relation to the short hinge line. The posterior wing varies from prominent and angular (Pl. 5.3, fig. 17) to being a barely visible, rounded protuberance (Pl. 5.3, fig. 15). The anterior wing does not exist in the left valve and is transformed into a characteristic *Meleagrinella*-like ear in the right valve. Both valves are either equally feebly convex or nearly flat, except for the beak part of the left valve, which is considerably more convex, more elevated, and distinctly to markedly elongated. Consequently, the left beak overhangs the slightly elevated, very small right beak. The left beak is slightly (Pl. 5.3, fig. 13) to markedly (Pl. 5.3, fig. 17) incurved to the right (i.e., opisthogyrous).

The right valve is an elongated oval, pronouncedly oblique posteriorly (Pl. 5.3, fig. 19). The outline of the left valve is extremely variable. One morphological extreme is characterized by a short beak part that widens posteriorly and curves in markedly to the right. The rest of the valve is a widened, elongated oval shape, pronouncedly oblique posteriorly (Pl. 5.3, fig. 17). This extreme variant is only represented by one valve in our material. However, it appears to be dominant in the central Russian and north Siberian population samples of B. (A.) concentrica (e.g., Zakharov, 1981, Pl. III, IV). The other morphological extreme is characterized by a much longer and a much more slender left beak that expands gradually and more or less evenly in the posterior direction. This results in a fairly strongly elongated, posteriorly oblique pear-like shape of the left The flanks of this pear-shaped variant are only valve. slightly to feebly convex, while its lower posterior, and posterior, margins are more or less regularly and broadly rounded. The maximum width of the left valve is situated near the lower margin in this variant (Pl. 5.3, figs. 13, 15). This extreme variant is prevalent in our material. It was designated "Aucella" erringtoni by Meek (1865, p. 479, Appendix B, Pl. 1, figs. 1-3, 5). The specimen reproduced in Plate 1, figure 2a of that publication is typical of this taxon, which is treated here as a mere morphological variant of Buchia (Anaucella) concentrica, because the two occur together and intergrade in all North American collections However, typical representatives of B. (A.) studied. concentrico var. erringtoni appear to be extremely rare among the hitherto figured Eurasian representatives of the species (e.g., Sokolov, 1902, Pl. XIV, fig. 6). If it is found that this variety is largely or perhaps entirely restricted to North American populations of B. (A.) concentrica, its varietal status proposed here would have to be reconsidered.

The shell surface of both valves is covered by thin and sharp-topped, closely to moderately closely spaced concentric ribs that are mostly fairly regularly spaced (e.g., Pl. 5.3, fig. 13). Five to eight such ribs occur per centimetre in most of the specimens available (e.g., Pl. 5.3, figs. 13, 15). However, the concentric ribs may be considerably less regular and more closely spaced in some other specimens (e.g., Pl. 5.3, fig. 17). The normally prominent, fine and closely spaced radial striation is either invisible or only locally visible (e.g., Pl. 5.3, fig. 13) in our specimens because of their internal cast preservation. Study of shell-covered specimens of B. (A.) concentrica from other localities indicates that their radial ornamentation is much more strongly developed on the shell surface than on the internal cast. However, even in specimens with the shell preserved, this ornamentation is considerably less prominent than the concentric ribbing.

No parts of the hinge are preserved in any of the left valves studied. However, the poorly preserved hinge of the only available right valve (Pl. 5.3, fig. 19) appears to have a *Meleagrinella*-like, simply furrowed byssus ear of the type described and figured by Jeletzky (1965, p. 4, 8; Pl. I, figs. 1, 2, 10).

Family ENTOLIIDAE Korobkov, 1960

Genus Comptonectes Agassiz, 1864

Camptonectes sp.

Plate 5.3, figure 12

The single available fragment is not well enough preserved, nor are the taxonomy and distribution of the many named species well enough known, for it to be assigned to a particular species with any confidence.

Subgenus Mclearnia Crickmay, 1930

Camptonectes (Mclearnia) sp.

Plate 5.3, figure 11

The single specimen available is not sufficiently well preserved to allow assignment to any of the several closely similar species known.

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PLATE 5.1

All specimens from GSC locality C-128986, southwestern British Columbia; x1, except figure 4 (x3).

Figures 1-14. Ochetoceras (Suboxydiscites) manningense sp. nov.

- 1-4. Right lateral, ventral, left lateral and enlarged (x3) views, holotype GSC 83491.
- 5-14. Lateral views of figured specimens GSC 83492-83501.

Figures 15-19. Phylloceras cf. P. mazenoti Joly

- 15, 17. Lateral views of small fragments, figured specimens GSC 83502 and 83503.
 - 16. Ventral view of small fragment, figured specimen GSC 83504.
- 18, 19. Lateral and ventral views of figured specimen GSC 83505.

Figures 20, 21. Physodoceras sp.

Ventral and lateral views of crushed figured specimen GSC 83506. The umbilical spines are not well shown because of exfoliation of the shell away from the internal mould.



PLATE 5.2

All specimens are from GSC locality C-128986, southwestern British Columbia; x1.

Figures 1-5. Lithacoceras (?) sp.

- 1, 2. Lateral and ventral views of fragment, figured specimen GSC 83507. Large growth stage, macroconch.
- 3, 4. Ventral and lateral views of fragment, figured specimen GSC 83508. Large intermediate growth stage, macroconch.
 - 5. Lateral view, crushed figured specimen GSC 83509. Larger intermediate growth stage, macroconch.



All specimens are from GSC locality C-128986, southwestern British Columbia; x1.

Figures 1, 2, 4-9. Discosphinctoides (?) aff. D. neohispanicum (Burckhardt)

- 1, 2. Lateral and ventral views, figured specimen GSC 83510, adult microconch with lateral lappet (impression of reverse side).
 - 4. Lateral view, figured specimen GSC 83512, small intermediate growth stage.
 - 6. Lateral view, figured specimen GSC 83513, adult microconch with lateral lappet.
- 5, 7, 9. Lateral views, figured specimens GSC 83514-83516, small to small intermediate growth stages.

8. Lateral view, figured specimen GSC 83517.

Figure 3. Lithacoceras (?) (Subplanites?) sp.

Lateral view, figured specimen GSC 83511, smaller intermediate growth stage of macroconch, showing incipient ataxioceratan ribbing habit.

Figure 10. Ochetoceras (Suboxydiscites) manningense sp. nov.

Lateral view, figured specimen GSC 83524, showing well developed radial groove.

Figure 11. Camptonectes (Mclearnia) sp.

Figured specimen GSC 83518.

Figure 12. Camptonectes sp.

Figured specimen GSC 83519.

- Figures 13-16. Buchia concentrica (Sowerby) var. erringtoni (Meek)
 - 13. Figured specimen GSC 83520, left lateral (outside) view of left valve.
 - 14. Same specimen as in figure 13, anterior view of left valve.
 - 15. Figured specimen GSC 83521, left lateral (outside) view of left valve.
 - 16. Same specimen as in figure 14, beak part and hinge margin of left valve viewed from above.
- Figures 17-20. Buchia concentrica (Sowerby) f. typ.
 - 17. Figured specimen GSC 83522, half grown, left lateral (outside) view of left valve.
 - Same specimen as in figure 17, half grown, left lateral (outside) view of left valve.
 - 19. Figured specimen GSC 83523, half grown, right lateral (outside) view of right valve.
 - 20. Same specimen as in figure 19, dorsal view of right valve (x2); byssus ear extends down and left from beak.

