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EARLY CRETACEOUS TRIGONIID BIVALVES OF MANNING PROVINCIAL PARK, SOUTHWESTERN BRITISH COLUMBIA

T.P. POULTON

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EARLY CRETACEOUS TRIGONIID BIVALVES OF MANNING PROVINCIAL PARK, SOUTHWESTERN BRITISH COLUMBIA

Abstract

The lower Cretaceous (Hauterivian to Albian) Jackass Mountain Group of Manning Provincial Park, southwestern British Columbia, contains 10 species of trigoniid bivalves. One species, *Columbitrigonia jackassensis*, is new; 7 are not specifically identified. *Columbitrigonia* is described as a new genus, based on *Trigonia columbiana* Packard. *Quoiecchia* Crickmay is shown to be a valid genus although it has been questioned in the literature. *Steinmanella* Crickmay is considered to include *Yaadia* Crickmay, and to be a subgenus of *Myophorella* Bayle.

Two distinct trigoniid faunas are recognized. The older, Hauterivian and Barremian fauna contains *Columbitrigonia jackassensis* n. sp., *Quoiecchia aliciae* Crickmay, *Myophorella* (*?Steinmanella*) sp. A, as well as poorly preserved *Apiotrigonia* sp. cf. *A. kayana* (Anderson), *A.* sp. and *Quoiecchia* sp. The younger, Albian fauna contains *Myophorella* (*Steinmanella*) sp. B., *Columbitrigonia columbiana* (Packard), *C.*? sp. cf. *C. condoni* (Packard), and probably also *Pterotrigonia* (*Pterotrigonia*) sp.

The best preserved, and apparently the only remaining, specimen of the syntypes of *Trigonia whiteavesi* (Packard) is redescribed in order to demonstrate the reality of the specimen, which has been considered previously as a partial restoration or complete reconstruction.

The restricted ranges of the trigoniid bivalves of Manning Park indicate their considerable potential for biostratigraphic zonation of the Lower Cretaceous rocks of western Canada and United States, but further study is required.

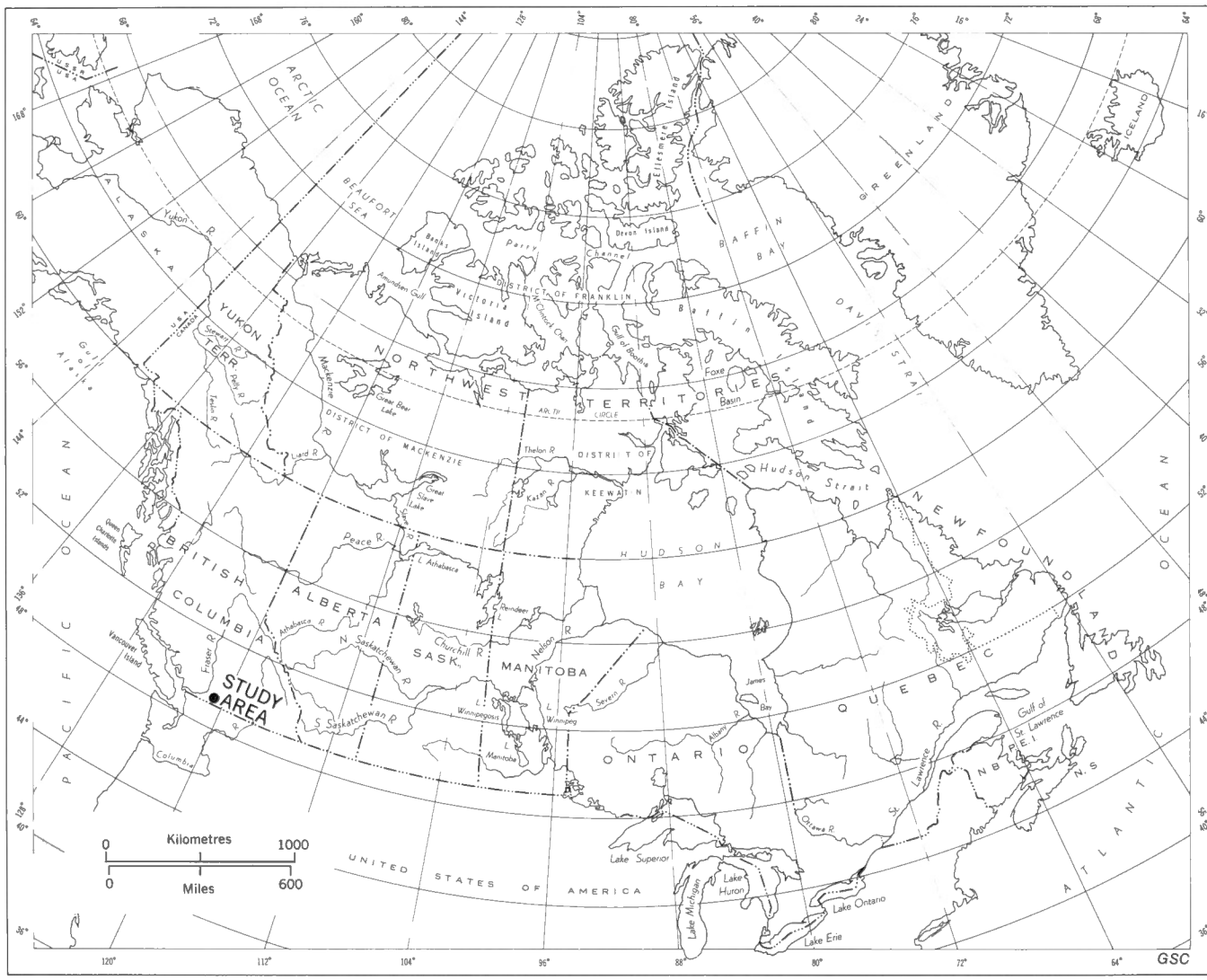
Résumé

Le groupe de Jackass Mountain du parc provincial Manning, au sud-ouest de la Colombie-Britannique, date du Crétacé inférieur (Hauterivien et Albien). Il comprend 10 espèces de trigoniidés bivalves. Une de ces espèces, le *Columbitrigonia jackassensis*, est nouvelle et sept autres n'ont pas été identifiées. Le *Columbitrigonia* est décrit comme un genre nouveau basé sur le *Trigonia columbiana* Packard. L'auteur montre que le *Quoiecchia* Crickmay est un véritable genre même si certains ouvrages l'ont remis en question. Le *Steinmanella* Crickmay qui comprend le *Yaadia* Crickmay est considéré comme un sous-genre de *Myophorella* Bayle.

L'auteur distingue deux faunes de trigoniidés. La plus ancienne, qui est hauterivienne et barrémienne, comprend *Columbitrigonia jackassensis* n. sp., *Quoiecchia aliciae* Crickmay, *Myophorella* (*?Steinmanella*) sp. A, de même que les espèces suivantes qui sont mal conservées: *Apiotrigonia* sp. cf. *A. kayana* (Anderson), *A.* sp., et *Quoiecchia* sp. La faune la plus récente, qui est albienne, comprend *Myophorella* (*Steinmanella*) sp. B, *Columbitrigonia columbiana* (Packard), *C.*? cf. *C. condoni* (Packard) et probablement aussi *Pterotrigonia* (*Pterotrigonia*) sp.

L'échantillon du cotype *Trigonia whiteavesi* (Packard), celui qui est le mieux conservé et apparemment le seul qui reste, est décrit de nouveau; l'auteur désire ainsi démontrer la réalité de cet échantillon qui était auparavant considéré comme une reconstitution partielle ou complète.

Les séries restreintes de trigoniidés bivalves du parc Manning montrent l'importance que pourraient avoir ces fossiles dans la détermination des zones paléontologiques des roches du Crétacé inférieur de l'ouest du Canada et des Etats-Unis. Une étude plus poussée est cependant requise.



TEXTFIGURE 1. Index map showing location of study-area

EARLY CRETACEOUS TRIGONIID BIVALVES OF MANNING PROVINCIAL PARK, SOUTHWESTERN BRITISH COLUMBIA

INTRODUCTION

Trigoniid bivalves are a quantitatively and biostratigraphically significant element in fossil collections from the Lower Cretaceous rocks of southwestern British Columbia. Those that occur in Hauterivian to Albian beds of the Jackass Mountain Group of Manning Provincial Park (*see* Textfigs. 1, 2, 3) are described and illustrated in this report. Many of the trigoniids previously were identified tentatively by F.H. McLearn (*in* Rice, 1947) and J.A. Jeletzky (1971a, and *in* Coates, 1974), who recognized their biostratigraphic utility in these ammonite-poor and lithologically monotonous rocks. The present study, which is based on all material available in the collections of the Geological Survey of Canada, supports Jeletzky's (*op. cit.*) age determinations for the most part, although the trigoniid identifications are revised substantially. The biostratigraphic results of this study are expected to prove useful to workers engaged in the Cretaceous stratigraphy of western Canada and the United States. In particular, Barremian and Albian faunas, which are the most abundant in the area, can be distinguished easily on the basis of the trigoniids.

ACKNOWLEDGMENTS

Most of the fossils described were collected by J.A. Coates in 1965 and 1966 and by J.A. Jeletzky in 1969. Other material studied was collected by J.L. Usher in 1946 and by H.M.A. Rice in 1941; the latter collections were studied by F.H. McLearn (*in* Rice, 1947, p. 18, 19). Supplementary material from Lower Cretaceous rocks elsewhere in British Columbia and casts of American and Japanese type material generously made available by Mrs. LouElla Saul and M. Tashiro, respectively, also were studied, as were type and accessory material at the United States National Museum, through the courtesy of E.G. Kauffman and R.W. Imlay. M. Nakano gave helpful advice and criticism.

J.A. Jeletzky assisted by discussing the stratigraphy and providing access to unpublished information. The technical assistance of J. Callahan, and photography of J. White is gratefully acknowledged. The manuscript was critically read by J.A. Jeletzky and E.T. Tozer.

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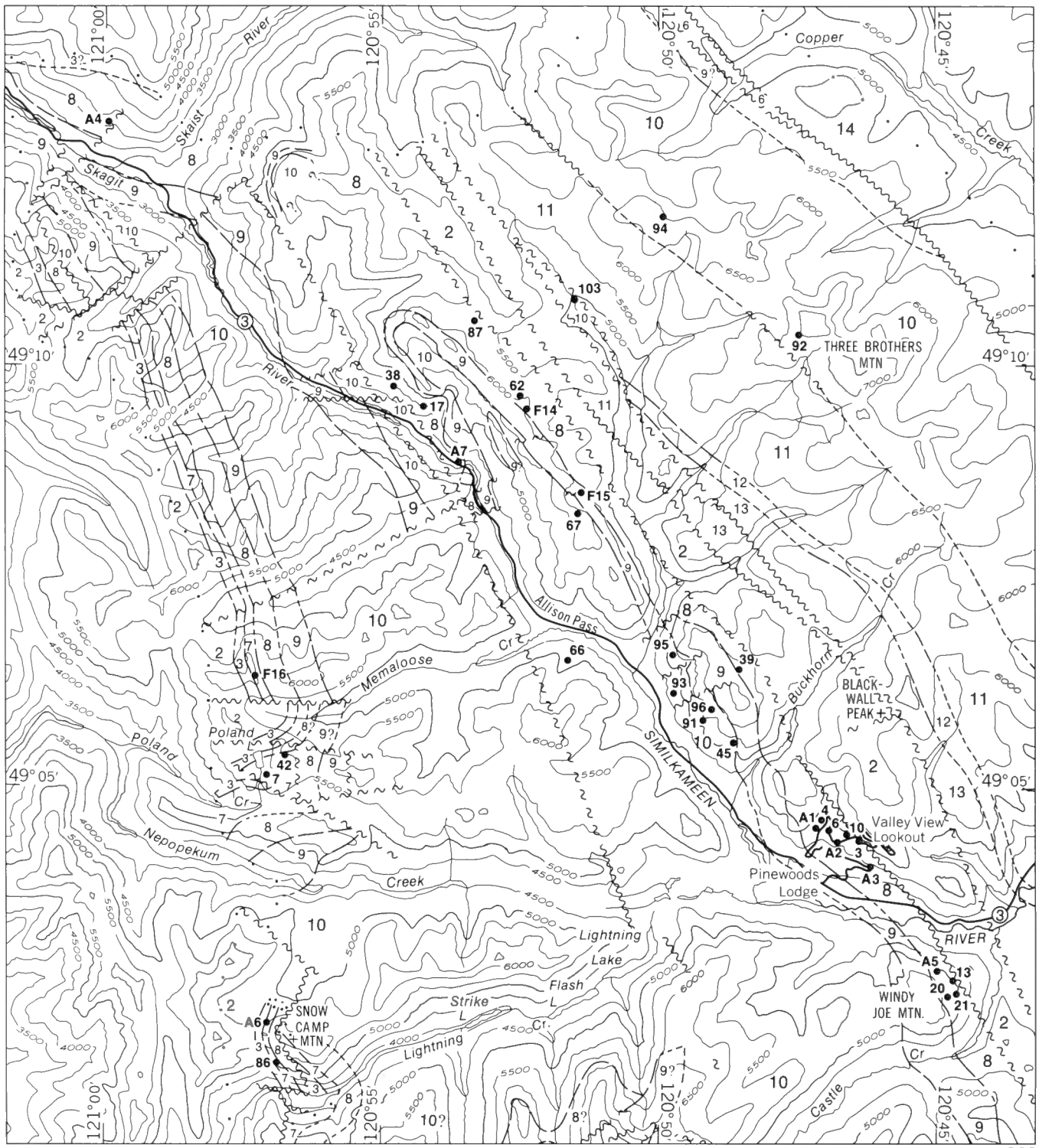
STRATIGRAPHY AND AGES OF FOSSILS

The stratigraphic subdivision and terminology adopted in this report is essentially that of Coates (1970, 1974; Textfigs. 2, 3, 4) with modifications and refinements provided by the detailed work of Jeletzky (1971a, 1972a, b). All the trigoniids were collected from map-units 7, 8, 9, and 10 of the Jackass Mountain Group (Textfigs. 2, 3, Tables 1, 2) which comprise the Hauterivian to Albian parts of the volcanogenic succession in the syntectonic Tyaughton Trough of southwestern British Columbia (*see* Jeletzky and Tipper, 1968; Monger, 1970; Douglas *et al.*, 1970, p. 445-448; Monger *et al.*, 1972; Wheeler and Gabrielse, 1972, p. 25-27). These rocks occur in a fault-bounded, north-northwest-south-southeast-trending synclinal structure (Textfig. 2) in Manning Park. Map-units 8, 9, and 10 in the eastern facies belt of Coates (1974) appear to correspond to Jeletzky's (1971a, 1972a, b) units, in terms of the gross stratigraphic distribution of major lithological units (Textfig. 4), as follows: map-unit 8 with the lower greywacke member through the Albian and (?)Aptian siltstone unit; map-unit 9 with the Lower Albian conglomerate unit; and map-unit 10 with the variegated marine clastic unit. Jeletzky (1971a, 1972a, b) included Coates' (1974) map-unit 7 within his lower greywacke member as a western facies equivalent, which is also older, in part, than that unit in its eastern facies. Map-units 8, 9, and 10 also appear to correspond respectively with Rice's (1947, p. 15-19) Divisions A and B, C, and D, of the Dewdney Creek Group, although Rice's descriptions are not adequate for precise correlation of his units with those of Coates.

MAP-UNIT 7

Map-unit 7, comprising the *Inoceramus colonicus* beds, is exposed only in the western facies belt of Coates (1974). Ammonites indicate a late Hauterivian to (?)early Barremian age (Jeletzky, 1971a, p. 221; *in* Coates, 1974, p. 82, 83). Small and poorly preserved *Apiotrigonia* sp. cf. *A. kayana* (Anderson), *A.* sp., *Quoiecchia* sp., and possibly *Columbitrigonia jackassensis* n. sp. were collected from this unit near Poland Lake and near Snow Camp Mountain. These and other bivalve faunas in map-unit 7 are neither well enough known nor sufficiently well preserved to be considered biostratigraphically diagnostic in their own right. However, similar forms to these occur in the lower part of map-unit 8, which is Barremian and possibly, in part, Hauterivian (*see* below). The trigoniids, therefore, indicate that map-unit 7 and the lower part of map-unit 8 probably are of nearly the same age.



Geological contact (defined, approximate, assumed) .....

Fault (defined, approximate, assumed) .....

Limit of mapping (see Coates, 1974, Fig. 2 for geology of western part of area) .....

Fossil locality cited in Coates (1974) ..... **67** ●

Fossil locality cited in Rice (1974, p. 18) ..... **F16** ●

Other fossil localities ..... **A7** ●

Kilometres 0 6

Miles 0 3

TEXTFIGURE 2. Geological map, simplified and with minor modifications, after Coates (1974), showing Early Cretaceous trigoniid bivalve occurrences, Manning Provincial Park, southwestern British Columbia.

Note: Map-units as in Textfigure 3. The '*Yaadia* beds' of Coates (1974, p. 29, 151, Fig. 2) are assigned to map-unit 10 rather than map-unit 8 where Coates (*ibid.*) placed them (Loc. 103 of Textfig. 2), on the basis of the trigoniid faunas. The '*Ptyophyllum* beds' are assigned to the Pasayten Group following Jeletzky (1972a, p. 36) rather than to the Neocomian where Coates (1974, p. 25, 26) questionably placed them

MAP-UNIT 8

Map-unit 8, in the eastern facies belt, contains well-dated ammonite faunas that range from Barremian to Early Albian (Jeletzky, 1971a; *in* Coates, 1974, p. 41, 42). Certain collections from low in the unit may be Hauterivian (Jeletzky *in* Coates, 1974, p. 143) although no diagnostic Hauterivian fossils have been found. These include GSC localities 73595, which contains *Quoiecchia* sp., and 64806, which contains *Apiotrigonia* sp. cf. *A. kayana* (Anderson). The latter species also may occur higher in map-unit 8, judging by a questionable identification in the collection from GSC locality 14909. Characteristic trigoniids from reliably dated Barremian beds include *Myophorella* (*?Steinmanella*) sp. A, *Quoiecchia aliciae* Crickmay, and *Columbitrigonia jackassensis* n. sp. At present, the Barremian trigoniid faunas cannot be subdivided satisfactorily because they are not commonly associated with diagnostic ammonites in the collections studied. Well-dated Aptian beds of this map-unit have yielded only rare unidentifiable trigoniids from one locality (GSC loc. 83966), and Lower Albian beds have yielded none to date. Most of the collections from map-unit 8 made by Coates cannot be confidently assigned to any particular lithostratigraphic subdivision erected by Jeletzky (1971a). Therefore, their precise biostratigraphic positions are not known.

MAP-UNIT 9

Biostratigraphically diagnostic fossils have not been found in map-unit 9, which was dated as Early Albian on the basis of faunas in overlying and underlying rocks (Jeletzky, 1972b; *in* Coates, 1974). A small collection of bivalves, including forms identified by the present writer as *Columbitrigonia*? sp. aff. *C. jackassensis* n. sp., was reported to come from the upper part of the unit by Rice (1947, p. 19; GSC loc. 14907, Loc. F15 of Textfigs. 2, 3).

MAP-UNIT 10

Map-unit 10 spans the Albian, according to Jeletzky (*in* Coates, 1974, p. 42). The upper age limit of the unit is uncertain; however, it is overlain by unfossiliferous rocks. Jeletzky's (*in* Coates, 1974, p. 146) suggestion, based on his interpretation of the trigoniids, that Cenomanian rocks also may be present is not warranted in the present writer's opinion (*see* also Jeletzky, 1972a, p. 8-11).

The characteristic trigoniid fauna includes *Myophorella* (*Steinmanella*) sp. B and *Columbitrigonia columbiana* (Packard). *Pterotrigonia* (*Pterotrigonia*) sp. occurs in a loose boulder at GSC locality 69412 which is considered by the present writer to represent map-unit 10 because *M.* (*Steinmanella*) sp. B occurs also in the boulder. The '*Yaadia* beds' of Coates (1974) (Loc. 103 of Textfig. 2) also are interpreted herein to represent a fault slice of map-unit 10 because of the presence of *M.* (*Steinmanella*) sp. B, whereas Jeletzky (*in* Coates, 1974, p. 29) considered them to be correlative with map-unit 8.

BIOSTRATIGRAPHIC VALUE OF THE TRIGONIID BIVALVES

The Early Cretaceous trigoniid bivalves of Manning Park fall into two reasonably well defined biostratigraphic assemblages (*see* Table 2).

The older assemblage is characterized by *Myophorella* (*?Steinmanella*) sp. A, *Quoiecchia aliciae* Crickmay, and *Columbitrigonia jackassensis* n. sp., all of which occur in Barremian beds of map-unit 8 of the Jackass Mountain Group. Other trigoniids, mainly juvenile or poorly preserved, that occur in map-unit 7 (in part Hauterivian) and the lower part of map-unit 8 also are included in this older assemblage, although future study of better material may indicate that they can be differentiated as an older distinct fauna. These trigoniids are *Apiotrigonia* sp. cf. *A. kayana* (Anderson), *A.* sp., and *Quoiecchia* sp. The younger assemblage, characterizing Albian map-unit 10, consists of *Myophorella* (*Steinmanella*) sp. B, *Pterotrigonia* (*Pterotrigonia*) sp., *Columbitrigonia columbiana* (Packard), and *Columbitrigonia*? sp. cf. *C. condoni* (Packard).

The restricted biostratigraphic distributions of trigoniid species outlined above and on Table 2 conform, for the most part, with previously published occurrences of identical or similar Early Cretaceous trigoniids in western North America.

The age of *Columbitrigonia columbiana* (Packard) in Albian map-unit 10 of Manning Park is the same as that of its holotype in the Albian Haida Formation of Queen Charlotte Islands (Packard, 1921). The Albian ages of both *C.* sp. cf. *C. condoni* (Packard) in Manning Park and *C. condoni* (Packard) in Oregon (Jones, 1960) indicate biostratigraphic potential for this species although the Canadian specimens are not well enough preserved to establish specific identity.

Myophorella (*Steinmanella*) sp. B of the Albian of Manning Park is similar to Albian *M.* (*Steinmanella*) *whiteavesi* (Packard) of Anderson (1958, p. 111) from Queen Charlotte Islands (*see* Pl. 2, fig. 45) and to undescribed specimens from the Albian of west-central British Columbia, but further study of this group is

PERIOD	EPOCH	GROUP OR FORMATION	MAP-UNIT	LITHOLOGY
CRETACEOUS	LATE CRETACEOUS	*EAGLE TONALITE (in part)*	14	Tonalite and granodiorite
	Unconformity?			
	MIDDLE ALBIAN AND YOUNGER	*PASAYTEN GROUP*	13	Nonmarine lithic sandstone and conglomerate
			12	Nonmarine red beds; conglomerate, arkose and siltstone
	EARLY TO LATE ALBIAN	*JACKASS MOUNTAIN GROUP*	11	Nonmarine conglomerate, arkose, sandstone and siltstone
			10	Marine sandstone, shale, siltstone and conglomerate
	EARLY ALBIAN		9	Polymict conglomerate, sandstone and argillite
	BARREMIAN-EARLY ALBIAN		8	Sandstone, argillite and minor conglomerate
	HAUTERIVIAN TO EARLY BARREMIAN		7	Marine sandstone
	NEOCOMIAN (EARLY CRETACEOUS)	*COPPER CREEK ASSEMBLAGE*	6	Volcanic sandstone, conglomerate and red argillite
	Unconformity			
LATE JURASSIC TO CRETACEOUS?		*EAGLE GRANODIORITE (in part)*	14	Tonalite and granodiorite, gneissic to foliated
JURASSIC	LATE JURASSIC	*DEWDNEY CREEK GROUP*	3	Volcanic sandstone, conglomerate and argillite
	Unconformity			
	TOARCIAN TO BAJOCIAN	*LADNER GROUP*	2	Volcanic sandstone, argillite, conglomerate, tuff, breccia, flows

GSC

TEXTFIGURE 3. Table of formations, Manning Provincial Park, and legend for Textfigure 2 (modified after Coates, 1974).

Note: *See* Textfigure 4 for relationships between the Jackass Mountain and Pasayten Groups

required to fully document its biostratigraphic potential. Trigoniids from the Queen Charlotte Islands, identified as *Trigonia* (*Yaadia*) *leana* var. *whiteavesi* (Packard), and *Trigonia* (*Pterotrigonia*) cf. *columbiana* (Packard) by D.L. Jones and F.H. McLearn (*in* Sutherland Brown, 1968, p. 92), were considered (*ibid.*) to occur in the upper Lower Albian *Brewericeras hulenense* zone. These determinations are the best for indicating the ages of the type specimens of *Columbitrigonia columbiana* and *Myophorella* (*Steinmanella*) *whiteavesi*, earlier reports being much less precise in their locality and stratigraphic data.

Quoiecchia appears to be restricted to Hauterivian and Barremian rocks of southwestern British Columbia as does *Inoceramus colonicus* (Jeletzky, 1971a, p. 271; Jeletzky and Tipper, 1968, p. 9).

The biostratigraphic value of the other species cannot be evaluated fully at present. Further study of Canadian and American material is required before anything approaching even a local zonation can be proposed.

FACIES CONTROL OF DISTRIBUTIONS

All the trigoniids described occur in 'greywackes' of shallow-marine aspect (Coates, 1974, p. 29-41, 50-53; Jeletzky, 1971a) judging by sedimentary structures (Coates, *ibid.*) and the generally moderately rich and varied faunal assemblages. No further data are available to suggest that the restricted stratigraphic occurrences (Table 2) are facies-related rather than indicating restricted biostratigraphic ranges.

AFFINITIES OF THE TRIGONIID FAUNAS

Many of the Cretaceous trigoniid bivalves exhibit a well-defined faunal provincialism (Steinmann, 1882; Kitchin, 1913; Kobayashi and Amano, 1955; Fleming, 1963, 1964; Nakano, 1968, 1970, 1974a, b; Kauffman, 1973). The forms described in this report, which are either endemic or show close circum-Pacific affinities, represent the North Pacific Province of the Tethyan Realm as interpreted by Jeletzky (1971b, p. 10, 11) on the basis of Canadian ammonite faunas. Of the

GEOLOGIC UNIT	GSC LOCALITY	LOCALITY Textfigure 2	*Myophorella (? Steinmanella)* sp. A	*Myophorella (Steinmanella)* sp. B	*Myophorella (Steinmanella)* sp. indet.	*Quoiecchia aliciae* Crickmay	*Quoiecchia* sp.	*Pterotrigonia (Pterotrigonia)* sp. indet	*Columbitrigonia columbiana* (Packard)	*Columbitrigonia jackassensis* n. sp.	*Columbitrigonia? C. condoni* (Packard)	*Columbitrigonia?* sp. indet.	*Apiotrigonia* sp. cf. *A. kayana* (Anderson)	*Apiotrigonia* sp.	*trigoniids. gen. et sp. undet.*
			NAME OF SPECIES												GSC
10	75148	103A		×											×
	75144	103		×								×			
	74792	92													×
	74795	94													×
	68150	45							×		×				
	74812	96							×						
	74791	91							×						
	74794	93		×					×						
	74801	95B			×				×						
	74799	95		×					×		×				
	69413	67							?						?
	69412	66		×				×							
9	14907	F15								?					
8	66982	21													×
	69141	20A								×					
	14905	(20)								?					
	69410				×					?					×
	83961									×					
	66981	20								×					
	64806	13			×								×		
	15167	A5													×
	83956	A3								×					
	62323	3								×					×
	83944	A2								×					
	83945	(10)													×
	62515	6A										×			
	86987	(6)	×							×					
	83948									×					×
	83946									×					×
	83947		×							×					
	62514	6								×					
	62325	4A			×	×									
	62324A														×
	83935	(4)								×					
	83933									×					
	62324	4				×				×					
	83934	A1								×					
	68144	39				×				×					
	14909	F14								?			?		
	69346	62			×	×				×					
	73595	87					×								
	83966	A7													×
	64810	17								×					
	68143	38					×			×					
	83960	A4								×					
7	73572	86										×			
	14914	(A6)								?			×		
	14913						×			?					
	20504	A6												×	
	74793	7A													×
	62516	7											×		
	68147	42					×								
	14906	F16						•		?					

TABLE 1. List of species and distribution chart of described trigoniid bivalves and accessory material from the Lower Cretaceous Jackass Mountain Group, Manning Provincial Park, southwestern British Columbia

Manning Park forms, *Quoiecchia* Crickmay is a unique representative of Myophorellinae, endemic to southwestern British Columbia. *Columbitrigonia* n. gen. also is apparently endemic to western North America, but may have representatives in South America (*Trigonia eximia* Philippi; *see* Lambert, 1944). It is similar to Japanese *Apiotrigonia* species to which the specimens of *A.* sp. cf. *A. kayana* (Anderson) and *A.* sp. described here are allied (*see* Nakano, 1957; Tashiro, 1972; Maeda and Kawabe, 1966). The species of *Myophorella* (*Steinmanella*) and *M.* (*?Steinmanella*) described in this report belong to a widespread group of coarsely tuberculate, diagonally costate Myophorellinae ('Pseudoquadratae' of Steinmann, 1882) but they are most similar to other western North American species and thus may form an endemic group. The general affinities of our poorly known *Pterotrigonia* (*Pterotrigonia*) sp. are worldwide.

LIST OF GSC FOSSIL LOCALITIES

Many of the localities were described previously by Jeletzky (*in* Coates, 1974), to which work the reader is referred for complete faunal listings. Numbers in brackets following each GSC locality number correspond to locality numbers shown on Textfigure 2 (*see* also Table 1). Numbers alone correspond to those of Coates (1974); the prefix A indicates newly plotted collections of J.L. Usher and J.A. Jeletzky; numbers with the prefix F correspond to localities of Rice (1947, p. 18).

14905 (F 13, near 20). H.M.A. Rice, 1941. Nose between Similkameen River and Castle Creek. About 90 m (300 ft) stratigraphically above beds at an elevation of 1579 m (5180 ft). Massive greenish, arkosic sandstone or greywacke.

14906 (F 16). H.M.A. Rice, 1941. Near 1949 m (6390 ft) peak about 6.4 km (4 miles) west of Allison Pass. Massive green greywacke or arkose.

14907 (F 15). H.M.A. Rice, 1941. Ridge north of Allison Pass.

14909 (F 14). H.M.A. Rice, 1941. Ridge due north of Allison Pass. Below the massive conglomerate.

14913 (F 18, near A6). H.M.A. Rice, 1941. The ridge west of north of the most westerly lake at head of Lightning Creek,

14914 (F 18A, near A6). H.M.A. Rice, 1941. "A little east of loc. 14913, but probably the same horizon."

15167 (A 5). J.L. Usher, 1946. Northeast side of big knoll between Castle Creek and Similkameen River, elevation 1585 m (5200 ft), talus.

20504 (A 6). J.L. Usher, 1946. Skyline Trail, approximately 1 km (0.6 mile) west-northwest of peak of Snow Camp Mountain. North side of ridge.

TABLE 2. Stratigraphic distribution of Early Cretaceous trigoniid bivalves, Manning Park, southwestern British Columbia

AGE	MAP-UNIT (Jackass Mountain Group) (see Textfigure 2 and 3)	*Apiotrigonia* sp. cf. *A. kayana* (Anderson)	*Apiotrigonia* sp.	*Quoiecchia* sp.	*Columbitrigonia jackassensis* n. sp.	*Quoiecchia aliciae* Crickmay	*Myophorella* (? *Steinmanella*) sp. A	*Myophorella* (*Steinmanella*) sp. B	*Pterotrigonia* (*Pterotrigonia*) sp.	*Columbitrigonia columbiana* (Packard)	*Columbitrigonia* ? sp. cf. *C. condoni* (Packard)
MIDDLE AND LATE ALBIAN	10	ALBIAN ASSEMBLAGE →						×	×	×	×
EARLY ALBIAN	9				?						
APTIAN	8										
BARREMIAN		?			×	×	×	BARREMIAN AND HAUTERIVIAN ASSEMBLAGE			
HAUTERIVIAN OR BARREMIAN		×		×							
HAUTERIVIAN	7	×	×	×	?						

GSC

62323 (3). J.A. Coates, 1964. Roadcut on lookout road above Pinewoods Lodge. Basal Cretaceous fine-grained sandstone.

62324 (4). J.A. Coates, 1964. Elevation 1432 m (4700 ft) on Lookout Road above Pinewoods Lodge. Approximately same as GSC locality 83933.

62324a (4A). J.A. Coates, 1964. Elevation 1432 m (4700 ft) on Lookout Road above Pinewoods Lodge.

62325 (4A). J.A. Coates, 1964. Road cut on Lookout Road above Pinewoods Lodge.

62514 (6). J.A. Coates, 1964. Road cut on Lookout Road above Pinewoods Lodge.

62515 (6A). J.A. Coates, 1964. Road cut on Lookout Road above Pinewoods Lodge.

62516 (7). J.A. Coates, 1964. Road cut on Poland Lake Road about 150 m (500 ft) east of Poland Creek.

64806 (13). J.A. Coates, 1964. Elevation 1435 m (4710 ft) on spur between Castle Creek and Similkameen River, east side of spur. From a 15 cm (6 in) thick, richly fossiliferous bed.

64810 (17). J.A. Coates, 1964. At 1371 m (4500 ft) elevation on hillside north of Hope-Princeton Highway in centre of big burn northwest of Allison Pass. About 450 m (500 yds) northwest of small creek which has cut a deep cleft in the conglomerate ridge above.

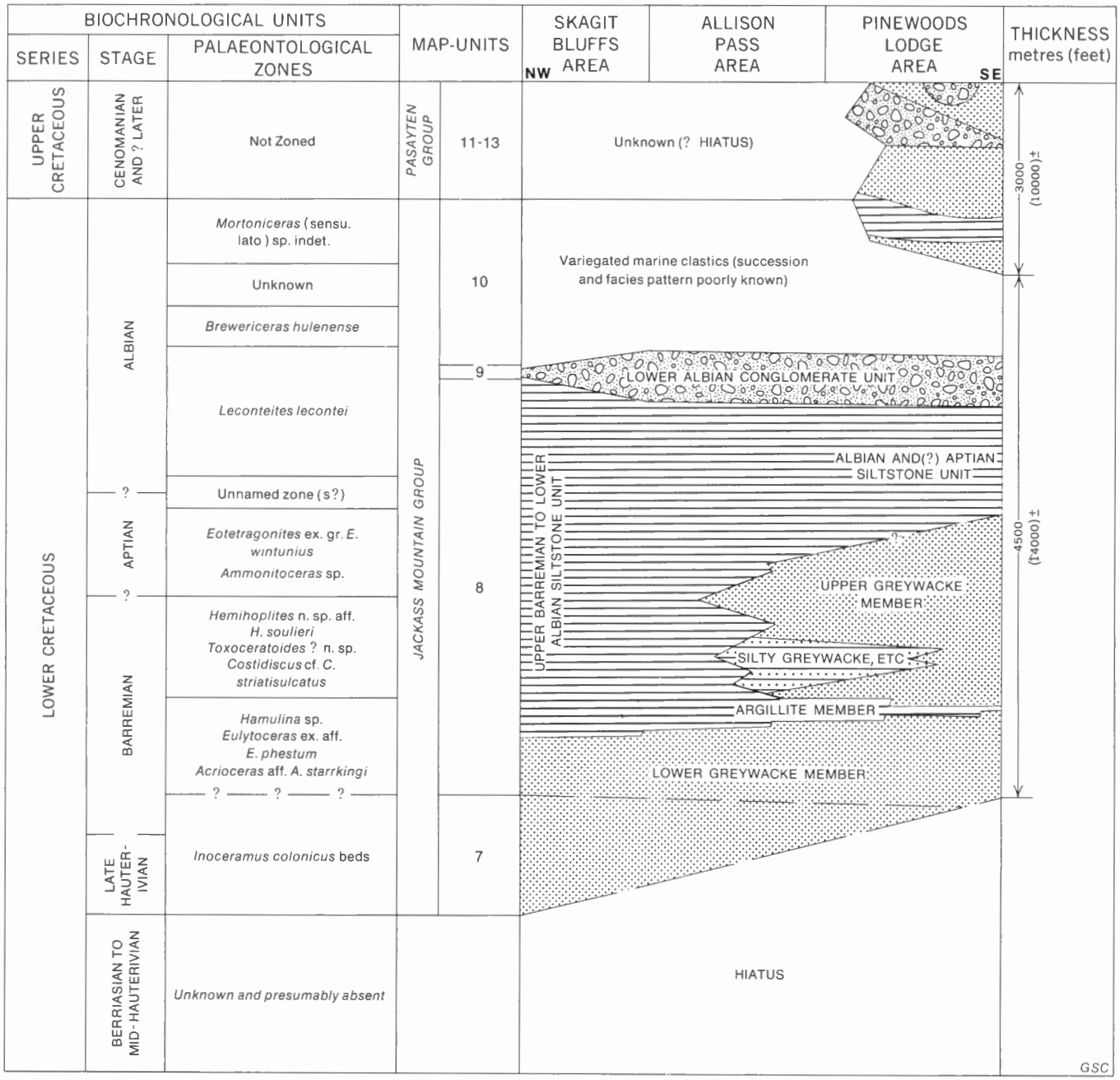
66981 (20). J.A. Coates, 1964. Elevation 1631 m (5350 ft) on spur between Castle Creek and Similkameen River at north rim of dry gully. East side of Windy Joe Mountain.

66982 (21). J.A. Coates, 1964. At approximate elevation of 1524 m (5000 ft) on spur between Castle Creek and Similkameen River, east side of Windy Joe Mountain.

68143 (38). J.A. Coates, 1965. Elevation 1362 m (4470 ft) on north slope of Hope-Princeton Highway between two intermittent streams crossing large burn northwest of Allison Pass. Southwest of 6120 survey control point on Map 92-H2W. From section of siltstone and fine sandstone underlying the thick conglomerate.

68144 (39). J.A. Coates, 1965. Most westerly of two cirques on north side of 2048 m (6720 ft) mountain between Buckhorn Creek and Hope-Princeton Highway near base of headwall on west side of the basin. From two zones, each 30 cm (12 in) thick, and 9 m (30 ft) apart. Most fossils collected from talus. Fossils occur at the base of a very thick conglomerate section, in pebbly horizon interbedded with fine- to medium-grained feldspathic arenites.

68147 (42). J.A. Coates, 1965. On east side of summit ridge of 1898 m (6227 ft) peak due east of Poland Lake. Elevation 1859 m (6100 ft). At top bluffs on north side of peak. A 10 cm (4.0 in) thick fossiliferous zone in massive to thick-bedded subgreywackes.



TEXTFIGURE 4. Ages and facies relationships, Lower Cretaceous rocks, Manning Provincial Park [adapted from Jeletzky (1972b) to show correlation with Coates' (1974) map-units that are used in this paper].

Note: The stratigraphic profile extends diagonally across the area shown in Textfigure 2, from the northwestern corner to the southeastern corner of that map

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68150 (45). J.A. Coates, 1965. Elevation 1625 m (5330 ft) on crest of spur trending due south from 2048 m (6720 ft) peak between Buckhorn Creek and Hope-Princeton Highway. Poorly exposed pebbly horizon in siltstone and fine sandstone. A zone 30 cm (12 in) thick contains abundant fossils.

69141 (20A). J.A. Coates, 1965. From float at a point a "few hundred feet" (100 m approx.?) along strike from GSC locality 66981, same zone.

69346 (62). J.A. Coates, 1965. Elevation about 1874 m (6150 ft) on northeast-trending spur

on northeast side of a long ridge parallel to, and northeast of, Hope-Princeton Highway. Approximately 0.62 km (0.4 mile) north-northeast of 1826 m (5990 ft) survey control point. Latitude 49°09'30"N, Longitude 120°52'30"W. About 120 m (400 ft) stratigraphically below the thick conglomerate.

69410 (20). J.A. Coates, 1965. Same as GSC locality 66981.

69412 (66). J.A. Coates, 1965. At approximately 1432 m (4700 ft) elevation in bottom of a creek entering Memaloose Creek from the south, 0.8 km (0.5 mile) east of Allison Pass summit. From a single boulder in creek's bottom, in a rock similar to that of nearby bedrock.

69413 (67). J.A. Coates, 1965. About 60 m (200 ft) east-southeast of 1910 m (6265 ft) triangulation station on ridge 2.4 km (1.5 miles) north of Allison Pass on Hope-Princeton Highway. All from outcrop at a horizon about 90 m (300 ft) above the thick conglomerate section corresponding to Division C of Rice (1947).

73572 (86). J.A. Coates, 1966. Approximately 1478 m (4850 ft) elevation on slope north of Lightning Creek about 600 m (2000 ft) northwest of west end of Thunder Lake. From 4.5 m (15 ft) of soft, sheared greywacke at base of very thick *Inoceramus*-bearing greywacke section that forms vertical bluffs here. Latitude 49°01'45"N, Longitude 120°57'00"W.

73595 (87). J.A. Coates, 1966. Almost at summit of divide, north-northwest of Allison Pass. A "few hundred feet" (100 m approx.?) west of Jurassic-Cretaceous contact. Latitude 49°10'30"N, Longitude 120°53'30"W.

74791 (91). J.A. Coates, 1966. Elevation of 1646 m (5400 ft) on spur trending 240° from 2048 m (6720 ft) summit between Blackwall Peak and Hope-Princeton Highway.

74792 (92). J.A. Coates, 1966. Elevation of 2134 m (7000 ft) on west side of southwest-trending spur south of 2246 m (7367 ft) peak of Three Brothers Mountain.

74793 (7A). J.A. Coates, 1966. Road cut at terminus of Poland Lake road, 75 m (250 ft) from Poland Creek.

74794 (93). J.A. Coates, 1966. Elevation of 1451 m (4760 ft) on spur above Hope-Princeton Highway. Latitude 49°06'10"N, Longitude 120°49'45"W.

74795 (94). J.A. Coates, 1966. At top of steep northeast-facing slope a "few hundred feet" (100 m approx.?) southeast of 2048 m (6718 ft) survey control point. Latitude 49°11'45"N, Longitude 120°49'50"W.

74799 (95). J.A. Coates, 1966. Elevation of 1625 m (5330 ft) on ridge northeast of Hope-Princeton Highway between Buckhorn Creek and Cambie Creek (Similkameen River). Most northerly of the spurs facing highway. Latitude 49°06'30"N, Longitude 120°49'30"W. From middle of 90 m (300 ft) thick fossiliferous sandstone section.

74801 (95B). Same as GSC locality 74799, J.A. Coates, 1966. Float near top of 90 m (300 ft) thick fossiliferous section.

74812 (96). J.A. Coates, 1966. Elevation of 1730 m (5675 ft) on southeast side of a spur on mountain between Buckhorn Creek and Cambie Creek (Similkameen River). Latitude 49°05'50"N, Longitude 120°49'00"W.

75144 (103). J.A. Coates, 1966. Approximately at the 1524 m (5000 ft) contour on Cambie Creek (Similkameen River).

75148 (103A), J.A. Coates, 1966. Approximately at the 1524 m (5000 ft) contour on Cambie Creek (Similkameen River).

83933 (4). J.A. Jeletzky, 1969. Lookout Road above Pinewoods Lodge. The stretch immediately below the third switchback below the lookout, about 145 m (475 ft) south of the switchback. Approximately same as GSC locality 62324.

83934 (A1). J.A. Jeletzky, 1969. Lookout Road above Pinewoods Lodge. About 230 m (760 ft) south from third switchback below the lookout.

83935 (near 4). J.A. Jeletzky, 1969. Lookout Road above Pinewoods Lodge. The stretch immediately below the third switchback below the lookout, about 175 m (575 ft) south from the switchback. About 56 m (185 ft) north from GSC locality 83934, and about 56 m (185 ft) stratigraphically below it.

83944 (A2). J.A. Jeletzky, 1969. Road cut on Lookout Road above Pinewoods Lodge. About 620 m (2125 ft) below second switchback below lookout, just before the turn of a gentle S-shaped loop of the road.

83945 (10). J.A. Jeletzky, 1969. Road cut on north side of Lookout Road, 0.8 km (0.5 mile) northwest of second switchback below lookout.

83946 (6). J.A. Jeletzky, 1969. Lookout road above Pinewoods Lodge. Road cut on the northwest side of, and 165 m (540 ft) northwest from, the S-shaped curve about 0.8 km (0.5 mile) northwest of second switchback below the lookout. Probably equivalent or nearly equivalent with GSC locality 62514.

83947 (6). J.A. Jeletzky, 1969. Nearly same as GSC locality 83946. Collected from approximately 23 m (75-76.5 ft) below top of section.

83948 (near 6). J.A. Jeletzky, 1969. Nearly same as GSC locality 83947, but 90 m (300 ft) northwest of it and 71 to 71.5 m (238-239 ft) stratigraphically below it. From northwest side of S-shaped curve of road.

83956 (A3). J.A. Jeletzky, 1969. Lookout road above Pinewoods Lodge. Just above first switchback on the way up, from road cut on northeast corner of switchback. Collected 6 m (20 ft) below top of outcrop.

83960 (A4). J.A. Jeletzky, 1969. North side of Skagit River valley at a point about 1.6 km (1 mile) east of Skagit Bluffs. Collected near the top of the west slope of a small stream which falls into Skagit River about 0.16 km (0.1 mile) south of Skagit River campsite. Collected from scree, altitude 1097 m (3600 ft).

83961 (20). J.A. Jeletzky, 1969. Same as GSC locality 66981.

83966 (A7). J.A. Jeletzky, 1969. Roadcut on northeast side of Hope-Princeton Highway, about 10.4 km (6.5 miles) southeast of the bridge over Skaist Creek and about 70 m (235 ft) northeast of the culvert across Skagit River at east end of the big burn northwest of Allison Pass. Approximately same locality as 16A of Coates (1974, p. 99).

86987 (6). J.A. Jeletzky, 1970. About 5.5 to 6 m (18-19 ft) stratigraphically below GSC locality 83947.

SYSTEMATIC PALEONTOLOGY

All specimens are deposited in type collection of the Geological Survey of Canada, Ottawa. Question marks preceding locality references indicate uncertain fossil identifications.

Class BIVALVIA Linné 1758 (Buonanni 1681)

Subclass PALAEOHETERODONTA Newell 1965

Order TRIGONIOIDA Dall 1889

Superfamily TRIGONIACEA Lamarck 1819

Family TRIGONIIDAE Lamarck 1819

Subfamily MYOPHORELLINAE Kobayashi 1954

Genus *Myophorella* Bayle 1878

Myophorella Bayle. Cox, 1969.

Steinmanella Crickmay, 1930.

Yaadia Crickmay, 1930; Cox, 1952 (part); Savel'ev, 1958.

Transitrigonia Dietrich, 1933.

Myophorella (*Myophorella*) Cox, 1952; Savel'ev, 1958; Skwarko, 1963.

Packardella Kobayashi and Amano, 1955.

Steinmanella (*Yeharella*) Kobayashi and Amano, 1955; Cox, 1969.

Steinmannella Kobayashi and Amano, 1955; Levy, 1969.

Quadratotrigonia (*Transitrigonia*) Savel'ev, 1958.

Quadratotrigonia (*Yeharella*) Savel'ev, 1958.

Steinmanaea Crickmay, 1962.

Steinmanella (*Steinmanella*) Cox, 1969.

Yaadia (*Yaadia*) Cox, 1969.

Type species. *Myophorella nodulosa* Bayle 1878. Oxfordian, France (*see* discussions by Crickmay, 1932; Cox, 1969).

Diagnosis. Flank of adult with costae which may be lines of tubercles, curved or straight, cutting growth lines ventrally in the anterior direction; and with a more complex pattern of intersecting rows of tubercles in the anteroventral region of the flank of some species. Costae or segments of costae meet anterior margin at high angles in most species. Area with concentric costellae or growth lines, occasionally with superimposed oblique costellae. Escutcheon with concentric growth lines, occasionally with oblique or transverse costellae that may consist of aligned elongate tubercles. Marginal and escutcheon carinae generally distinct.

Discussion. *Myophorella* is interpreted more broadly in this report than it was by previous authors. Only those taxonomic names are listed as synonyms that are directly relevant to the inclusion of the presently described species within the genus. They are intended mainly to unite morphologically similar forms that previously have been separated artifically according to whether they are Jurassic or Cretaceous in age.

Most Cretaceous representatives of *Myophorella* (as interpreted by the writer) have been previously grouped into the Pseudoquadratae Section of "*Trigonia*" of Steinmann (1882). They are either entirely undifferentiable from Jurassic *Myophorella* species (e.g. *Yeharella*), or are different in having weak or incipient oblique or transverse costellation of the area or escutcheon, at least in the umbonal stages. They are, furthermore, commonly larger and more coarsely and more irregularly costate and tuberculate than most Jurassic *Myophorella* species. They commonly lack a well-defined marginal carina, the position of which is marked by either an irregular row of tubercles or, simply, terminations of the costae of the flank. These characteristics occur in some Jurassic species and are not considered to be valid criteria for distinction at the genus level. They indicate the transitional nature of Cretaceous *Myophorella* species with the contemporaneous mainly European Quadratae Section, referred to *Quadratotrigonia* Dietrich (1933) and *Mediterraneotrigonia* Nakano (1974a). Nevertheless, these features (*see* also discussion by Kitchin, 1913, p. 106, 107), and their potential for diagnosing Cretaceous rather than Jurassic forms, justify the separation of some forms as a distinct subgenus, to which the name *Myophorella* (*Steinmanella*) [with type species *M.* (*S.*) *holubi* (Kitchin)] can be applied. The Pseudoquadrate Section was subdivided by Crickmay (1930) into the genera

Steinmanella and *Yaadia*, the latter distinguished by an independent row of nodes along the anterior side of the shell. Crickmay (1962) subsequently unnecessarily proposed *Steinmanaea* to replace *Steinmanella* for nomenclatorial reasons. The presence or absence of the independent anterior row of nodes is not significant above the species level in many Jurassic representatives of *Myophorella*, and does not appear to be so in most Cretaceous forms seen by the writer. Exceptions include the very distinctive *Scaphotrigonia navis* (Lamarck) and *S. naviformis* (Hyatt). *Steinmanella* and *Yaadia*, therefore, are considered to be synonymous (*see* also discussions by Kobayashi and Amano, 1955; Levy 1969; and their treatment by Cox, 1952, 1969). The name *Steinmanella* is preferred to *Yaadia*, because of its wide acceptance by trigoniid workers, particularly those in South America and Japan, and because of the extremely poor quality of preservation of the type material of the type species *Yaadia lewisagassizi* (Crickmay, 1930, p. 50, Pl. XIII, figs. 1, 2).

The other Cretaceous genera or subgenera *Yeharella* Kobayashi and Amano (1955), *Transitrigonia* Dietrich (1933), and *Packardella* Kobayashi and Amano (1955) are accommodated easily as junior synonyms of *Myophorella* as here diagnosed (*see* also Cox, 1969).

Setotrigonia Kobayashi and Amano (1955) is considered to be a distinct genus from *Myophorella*, characterized by coincidence of costae of the flank with concentric features on the area, indicating a trend toward simplified concentric ornamentation. *Quadratotrigonia* Dietrich (1933) and *Mediterraneotrigonia* Nakano (1974a) are distinguished by the strongly oblique sculpture of their area and escutcheon. *Litschkovitrigonia* Savel'ev (1958) and *Korobkovitrigonia* Savel'ev (1958), as well as *Quadratotrigonia*, exhibit a change in direction of costation in the umbonal region of the flank. *Scaphotrigonia* Dietrich (1933) has a very distinct anterior row of nodes.

The Manning Park specimens

At least two distinct species, one Early Albian and possibly with a longer range, and the other probably late Barremian, are described below. Although they are sufficiently well preserved to be formally named, open nomenclature is used until American workers are able to correct the sorry state of the present taxonomy of similar or identical species in the United States, which results from the previous designation of many species based on poorly preserved type material and poorly documented stratigraphy (e.g. Anderson, 1958). The Manning Park species are both similar to *Trigonia whiteavesi* (Packard) [=*Trigonia* sp. undt. Whiteaves, 1876, p. 70-72, Pl. X, figs. 2, 2a; =*T. leana* var. *whiteavesi* Packard, 1921, p. 21-23, Pl. 5, fig. 4(?), Pl. 6, fig. 2].

Trigonia whiteavesi was elevated to specific rank by Anderson (1958, p. 111), who regarded Whiteaves' (1876) figure 2 of Plate X to represent the holotype. Anderson (*op. cit.*) thought that Whiteaves' other figured specimen (Whiteaves, *op. cit.*, Fig. 2a) was a "partial reconstruction (possibly a composite reconstruction)". This latter specimen is re-figured in this report (Pl. 2, fig. 45); it is not reconstructed in any way in Whiteaves' figure. Furthermore, it now appears to be the only specimen remaining from the original syntypes studied by Whiteaves and used by Packard (1921) in his erection of *Trigonia leana* var. *whiteavesi*.

Other similar species include *Trigonia leana* Gabb (1876, p. 312; Packard, 1921, p. 20, 21, Pl. 5, figs. 1, 2, 3, 5, 6, Pl. 6, fig. 1, Pl. 7, fig. 1; Anderson, 1958, p. 113) [=*Trigonia gibboniana* Lea; Gabb, 1864, p. 190, Pl. 25, fig. 178, Pl. 31, fig. 262], *Trigonia wheelerensis* Anderson (1958, p. 116, 117), *T. colusaensis* Anderson (1958, p. 110, Pl. 1, fig. 6), *T. perrinsmithi* Anderson (1958, p. 110, Pl. 2, fig. 7), *T. hemphilli* Anderson (1958, p. 115, Pl. 52, figs. 9a, b) and those similar species described by Stoyanow (1949). Although the writer places considerable emphasis on the restricted ranges of the Manning Park specimens, the complete biostratigraphic potential of the coarsely nodose, obliquely costate Cretaceous trigoniids will not be known until the above-mentioned taxonomic problems are resolved by further study of topotypic material.

Myophorella (?*Steinmanella*) sp. A

Plate 1, figures 1, 2, 16, 17

Of the reasonably well preserved specimens from Manning Park, those from GSC localities 83947 and 86987 (hypotypes GSC 45471, 45479; Loc. 6 of Textfig. 2) are certainly from map-unit 8 of Coates (1974), but they were not associated with diagnostic ammonites. Hauterivian or Barremian and well-dated late Barremian ammonites were collected southeast of these localities (Jeletzky *in* Coates, 1974, p. 83-85, Loc. 3, p. 95, Loc. 19; *see* Textfig. 2), ammonites of the same age were collected northwest of localities 83947 and 86987 more or less along strike (*op. cit.*, p. 90, Loc. 4), and poorly preserved, possibly Early Albian ammonites were collected southwest from, and stratigraphically above them (*op. cit.*, p. 154, 155, Loc. 112). A late Barremian age, therefore, is favoured for these specimens.

Myophorella (*Steinmanella*) sp. B

Plate 1, figures 3-15, 18

Hypotypes GSC 45478 and 45480 (Pl. 1, figs. 14, 15, 18) from GSC localities 74794 and 74799 (Locs. 93, 95 of Textfig. 2) occur in the Albian map-unit 10 of Coates (1974). No ammonites are directly associated, but immediately adjacent rocks along strike to the southeast contain Early Albian *Brewericeras* (*Leconteites*) *lecontei* (Anderson) identified by J.A. Jeletzky (in Coates, 1974, p. 144, Loc. 89, p. 153, Loc. 109). The two trigoniid specimens, although fragmentary, are similar to other probably Albian specimens described below (hypotypes GSC 45473, 45477) and they appear to show the same differences as do those from the probably late Barremian forms (hypotypes GSC 45471, 45479). Furthermore, they differ from these last specimens in the

development of a distinct set of tuberculate transverse costellae on the escutcheon (Pl. 1, figs. 14, 15, 18). This last characteristic is preserved also on an undescribed Albian *M.* (*Steinmanella*) species from Smithers map-area of west-central British Columbia. A feature more closely related to the Barremian than the other ?Albian specimens noted below, however, is the presence of an apparently distinct row of nodes on the marginal carina in hypotype GSC 45478 (Pl. 1, fig. 14), at least in intermediate growth stages.

Hypotypes GSC 45473 and 45477 (from GSC locs. 75144 and 75148; Pl. 1, figs. 6-9, 13; Loc. 103 of Textfig. 2) are from the '*Yaadia* beds' which occur in a fault slice within rocks of the Albian Pasayten Group (Textfig. 2). The costae of these specimens are straighter, more obviously posterodorsally tapering, slightly more dorsoventrally oriented, and more coarsely tuberculate than those of specimens from map-unit 8 (contrast figs. 1 and 6 of Pl. 1). The costae stand higher in the presently described specimens and the anterior dorsoventral row of nodes is heavier. The umbonal portions of the area may be more distinctly obliquely costellate (Pl. 1, figs. 8, 9, 13) than in the Barremian forms. A further difference is the continuity of the costae of the flank to the marginal carina which is the locus joining their posterodorsal ends in the present form, whereas a row of tubercles distinct from the costae of the flank characterizes the Barremian specimens. Because of these differences from the Barremian forms, and the similarities with other probably Albian specimens, *M.* (*Steinmanella*) sp. B from the '*Yaadia* beds' is considered to be of probable Albian age and to so date the '*Yaadia* beds' (Loc. 103 of Textfig. 2).

Specimens (hypotypes GSC 45472, 45474, 45475, 45476; Pl. 1, figs. 3-5, 10-12) collected from a loose boulder in Albian (map-unit 10a; Loc. 66 of Textfig. 2) terrain conform with the above-described specimens from GSC localities 74794, 74799, 75144, and 75148, and Jeletzky's (*in* Coates, 1974, p. 131, Loc. 66) suggestion that they were derived from an older (Hauterivian or Barremian) unit is rejected on that basis. These specimens exhibit somewhat coarser tubercles on the area than any of the others described (*see* Pl. 1, figs. 4, 12).

Genus *Quoiecchia* Crickmay, 1930

Quoiecchia Crickmay, 1930.

Type species. *Quoiecchia aliciae* Crickmay, 1930. Hauterivian or Barremian, British Columbia.

Diagnosis. Shell small, subcircular or dorsoventrally elongated, gryphaeiform. Flank, area, and escutcheon indistinctly separated by rows of tubercles near umbos. Flank near umbo with anteroventrally sloping, oblique costae that extend onto area. These costae on the flank become subradial within a short distance, and die out on anterior part of shell. Late growth stages with concentric growth lines or rugae only.

Discussion. This unusual, monotypic genus is valid despite the questioning it received from Cox (1952, 1969). It is apparently endemic to British Columbia, where it is a useful Hauterivian-Barremian guide fossil, albeit localized and commonly poorly preserved.

Quoiecchia appears to be a 'simplified' derivative of obliquely costate representatives of Myophorellinae. Its early growth stages preserve the oblique costae characteristic of *Myophorella* species and, less clearly, continuous tuberculation or oblique costellation of the area. These latter characteristics suggest derivation from a possible *M.* (*Steinmanella*)-like ancestor, which involved simplification of sculpture, as well as change in shape and reduction in size of the shell.

Savel'ev's (1958) inclusion of *Quoiecchia* in his subfamily Laevitrigoniinae superficially unites morphologically similar but only distantly related concentrically costate genera.

Quoiecchia aliciae Crickmay

Plate 2, figures 1-11

Quoiecchia aliciae Crickmay, 1930, p. 51, Pl. XIII, figs. 3-8.

Description. Shell small to medium in size, reaching approximately 4 cm in height. Subtrigonal outline, higher than wide, gryphaeiform. Strongly convex. Beaks central, orthogyrous, pointed. Rounded anteroventral and posteroventral corners.

Shell surface divided into flank and area by a rounded edge that becomes indistinct ventrally.

Area with growth lines and rugae that are continuous with those of flank. Within 15 mm of umbo, there are subdued degenerate relics of an escutcheon carina, which appears as a row of indistinct broad elongated nodes on each ruga, and a median groove which is a broad, slightly concave furrow. Within 5 to 10 mm of umbo, there also are relatively sharp oblique costellae that appear to be continuous with costae of the flank. Escutcheon narrow, with continuations of growth rugae.

Main part of flank with sharp, narrow, concentric grooves that separate high, rounded rugae. These rugae or costae are widely and nearly evenly spaced in centre of shell, and are of constant strength. They become indistinct near umbo, and become finer spaced and less regular near ventral margin.

A set of smoothly curved, anteroventrally sloping, oblique costae occupy flank in the umbonal 1 cm (Pl. 2, fig. 7). They are rounded, broad, strong, and either weakly and irregularly corrugated or smooth. They appear to coincide with oblique costellae of the area but may be interrupted at the marginal carina. They are enlarged near their anterior ends so that a row of weak, node-like varices runs along the anterior end of the shell (Pl. 2, fig. 9).

After the shell is 1 cm high, these oblique costae become nearly dorsoventrally oriented (pseudoradial), broad, rounded ridges standing between sharp narrow grooves. The posterior portion of the flank therefore has a reticulate appearance, marked by intersecting concentric and pseudoradial sets of grooves.

The pseudoradial grooves are added along the indistinct edge that is the marginal carina, and die out ventrally before reaching the ventral margin. They do not occur on the anteroventral part of the shell. They meet the marginal carina at angles decreasing from about 45° near the umbo to 10-20° near the ventral margin. In some specimens, they are too faint to be seen.

In the earliest 2 cm of the shell, the anterior row of varices is continued ventrally by weak varices near the anterior ends of the concentric rugae.

Discussion. With the exception of one specimen (Pl. 2, fig. 5), the characteristics of the Manning Park specimens agree well with those of Crickmay's (1930, p. 51, Pl. VIII, figs. 3-8) type material of *Quoiecchia aliciae*. The exceptional specimen bears finer and smoother radial costae than either of the type specimens.

Material and occurrence. All specifically identifiable specimens occur in Barremian beds of map-unit 8 of the Jackass Mountain Group of Manning Park (Coates, 1974). The largest well-preserved specimens (hypotypes GSC 45481-45484 from GSC locs. 62324, 68144) are either late (or probably late) Barremian (Jeletzky *in* Coates, 1974, p. 85, 114, 115). Others (including hypotypes GSC 45485 and 45486 from GSC loc. 69346 and those from GSC loc. 62325) are also probably of similar age judging by their stratigraphic position, although diagnostic ammonites were not found with them.

Quoiecchia sp.

Plate 2, figures 12, 13, 14

Several poorly preserved or fragmentary specimens of *Quoiecchia* sp. occur in the probably Hauterivian-Barremian map-unit 7 of Coates (1974) (e.g. hypotype GSC 45487 from GSC loc. 68147) and at a poorly dated locality that is probably the same age in the lower part of map-unit 8 to the east (e.g. hypotypes GSC 45488, 45582 from GSC loc. 73595).

Subfamily MEGATRIGONIINAE van Hoepen, 1929

Members of the subfamily Megatrigoniinae, taken to include Rutitrigoniinae van Hoepen (1929) and Iotrigoniinae Savel'ev (1958), are united and distinguished from other Trigoniidae by the reduction in the size and distinctness of the area. In this characteristic, they are morphologically gradational with probably ancestral Myophorellinae, from which they are arbitrarily distinguished (*see* also Nakano, 1965; Levy, 1967). The variation in style of flank ornamentation is approximately equivalent to that of the Myophorellinae, but is sufficiently different in the lesser degree of tuberculation, narrowness and, to some extent, orientation of costae, as well as the common tendency of oblique or subradial costae to develop from concentric juvenile costae which they appear to truncate, to indicate possible homeomorphic radiation within the subfamily after its origin. Nevertheless, it is possible that the subfamily is not strictly monophyletic and that future study may necessitate taxonomic revision.

Genus *Columbitrigonia* new genus

Type species. *Trigonia columbiana* Packard, 1921. Albian, British Columbia.

Diagnosis. Flank subdivided into inflated anterior and central part with coarse oblique costae, and smooth, rostrate posterior part, on anterior slope of marginal carina. Umbonal part of flank with concentric or subconcentric costae that are replaced ventrally by the oblique costae of the adult growth stages.

Discussion. *Columbitrigonia* n. gen. is based on *Trigonia columbiana* Packard (1921). *Trigonia condoni* Packard (1921, p. 28, Pl. 8, fig. 2) is included in *Columbitrigonia*, judging from material described by Jones (1960, p. 158, Pl. 29, figs. 8-10, 17, 18), as is *C. jackassensis* n. sp. from Manning Park. *Trigonia eximia* Philippi (1899; Lambert, 1944) is possibly a species of *Columbitrigonia*. South American species of *Anditrigonia* Levy (1967) and certain Japanese *Apiotrigonia* species (Nakano, 1957; Tashiro, 1972), as well as *A. newcombei* (Packard, 1921), show either incipient development of the smooth rostrate space anterior to the marginal carina or domination of the flank by oblique costae. However, only in those species assigned to *Columbitrigonia* do both features occur together and well developed. The new genus, nevertheless, is closely allied to both *Anditrigonia* and *Apiotrigonia*.

In its general form, *Columbitrigonia* resembles *Pterotrigonia* (*Rinetrigonia*) van Hoepen which, however, bears costae on the posterior part of the flank. Also, in contrast to *P.* (*Rinetrigonia*), the umbonal concentric or subconcentric costae of species of *Columbitrigonia* are replaced ventrally by, and give the appearance of being truncated by, the oblique costae of the adult flank. This last feature is particularly well seen in *C. columbiana* (Packard) (Pl. 3, figs. 7, 16, 20, 21, 25) and *C. jackassensis* n. sp. (Pl. 2, figs. 18, 30). *Columbitrigonia* also differs from *P.* (*Rinetrigonia*) and other representatives of the subfamily Pterotrigoniinae in its almost total lack of distinct area, the posterior end of the shell being a rounded point. The smooth posterior part of *Columbitrigonia* allies it morphologically with *Nototrigonia* Cox and related genera, which, however, have different ornamentation on the main part of the flank (*see* for example Cox, 1952; Skwarko, 1963).

Columbitrigonia columbiana (Packard)

Plate 3, figures 1-30

Trigonia columbiana Packard, 1921, p. 23, 24, Pl. 11, figs. 1, 3.

Description (based on the Manning Park specimens). Shell medium to large, rarely exceeding 10 cm in length. Subtrigonal outline with strongly rostrate posterior. Smoothly rounded anterior and anteroventral margins; straight or gently curved posteroventral

and dorsal margins. Posterior end either very short or pointed. Main part of flank very strongly convex, subglobose; posterior part of flank flat; area apparently absent; escutcheon long, narrow, strongly concave.

Posterior part of flank and escutcheon are separated by a relatively sharp edge. There is no structure similar to the escutcheon carina or area of other trigoniids, although homologous features may be present within the region herein referred to the escutcheon. Escutcheon is smooth except for fine growth lines which are continuous with those of the posterior part of the flank. Some specimens exhibit a very faint suggestion of fine oblique striation on umbonal parts of the escutcheon.

Posterior one quarter or one third of flank smooth and flat, with fine growth lines. It is separated from the remainder of the flank by an entirely or nearly straight imaginary line which is the locus of terminations of costae of the major part of the flank.

Major part of flank bears oblique costae which are mainly smoothly curved, sweeping ventrally and anteriorward from the above-mentioned imaginary line. The earliest of these costae are not preserved on the material available, but they are apparently fine, smooth, and distinctly oblique, sloping anteroventrally, when the shell is 3 or 4 mm long. In later growth stages, they become coarse, widely spaced, high standing, and bear more or less irregular, rounded, pustule-like tubercles which are aligned, from one rib to the next, along widely spaced but evenly spaced growth rugae. When the shell is between 5 and 15 cm long, approximately, there is a more or less distinct V-flexure of the costae, their posterior portions being oriented nearly dorsoventrally. Increase in importance of these posterior portions of the costae with growth, together with gradually increased rotation of the main portions of the costae to a more strongly oblique orientation, results in the appearance of truncation of the posterior ends of many of the oblique costae by a more posterior set of costae which are more nearly dorsoventrally oriented. Some of the early costae, therefore, do not extend to the locus which forms the posterior limit of most of the costae of the flank.

On the main part of the flank, the costae are strongly diverging anteroventrally. They also become noticeably stronger in this direction to about the middle, highest, part of the shell, beyond which they taper to the anterior and anteroventral margins which they meet nearly at right angles. A few exceptional specimens exhibit intercalations of fine secondary costae in the anteroventral region (Pl. 3, fig. 9). The ventral part of the flank, just anterior to the posterior smooth part, is covered with dorsoventrally oriented or steeply posteroventrally sloping costae which are fine, closely spaced, and mainly nearly smooth. They are equivalent structures with the postero-umbonal segments of all of the other costae of the flank. Their postero-umbonal terminations form the locus separating the flank into two distinct parts. These costae meet this locus at increasingly acute angles with succeeding growth stages. They increase in thickness and width of spacing ventrally. The actual spacing and width of these costae, as well as the angles which they form with the locus joining their terminations, is somewhat variable from one specimen to another. Some of these costae are gently and sinuously curved rather than being straight.

Discussion. The writer's concept of *C. columbiana* (Packard) is based on a cast of the specimen of *Trigonia columbiana* figured by Packard (1921, Pl. 11, fig. 1) which is considered by the present writer to be the holotype of the species. It was supplied by LouElla Saul. The characteristic smooth posterior part of the flank is costate in the only other original figure, which is a composite drawing based on several specimens (Packard, 1921, Pl. 11, fig. 3). This portion of the holotype is not well preserved but appears to be smooth (*see* Packard, 1921, Pl. 11, fig. 1), and costation in the composite drawing is assumed to be either an error by the artist, or to be an unusual development of the species in specimens other than the holotype.

The early ontogenetic development of the coarse oblique costae of the flank and the more strongly diverging posterior costae separate this species from *C. condoni* (Packard) and *C. jackassensis* n. sp. (*see* also discussion of *C. jackassensis*).

Material and occurrence. Abundant external and internal moulds (including hypotypes GSC 45507 to 45522) from Albian map-unit 10 of the Jackass Mountain Group in central Manning Park (GSC locs. 68150, ?69413, 74791, 74794, 74799, 74801, 74812). The holotype of this species occurs in the Albian Haida Formation of Queen Charlotte Islands (Packard, 1921), where the species was identified in the upper Lower Albian *Brewericeras hulenense* Zone by D.L. Jones and F.H. McLearn (*in* Sutherland Brown, 1968).

Columbitrigonia jackassensis new species

Plate 2, figures 18-43

Description. Shell small to medium in size, not exceeding 5 cm in length. Outline subtriangular, rostrate to posterior. Anterior and anteroventral margins form smooth semicircle; posterior part of ventral margin and dorsal margin straight. Shell gently convex. Area apparently absent. Escutcheon long, narrow.

Flank and escutcheon separated by an edge which is very sharp near the umbos but which becomes rounded to posterior. Escutcheon is covered, in its umbonal part at least and throughout in some specimens, with fine, weak, regular, transverse, striae, and with growth lines. A weak groove runs the length of the edge corresponding to the marginal carina just dorsal to that edge. Just dorsal to this groove, very faint, fine, radial striae are suggested.

The posterior one fifth or one sixth of the flank is flat and smooth except for fine growth lines. The anteroventral boundary of this smooth space is a straight to gently curved line that is the locus of posterodorsal ends of the posterior costae of the flank. There is a suggestion of a slight posterior gape.

The umbonal few millimetres of the flank have not been seen, but sculpture appears to be concentric, or nearly so, in the earliest 5 mm of growth. These costae are weak, finely spaced, and apparently smooth. When shell is 5 to 15 mm high approximately, a change of orientation of the (major) central and anterior portions of the costae occurs, so they become more strongly oblique, sloping anteroventrally. Posterior portions of costae are replaced progressively by smooth, dorsoventrally oriented costal segments which give the appearance of truncating the central portions of the costae. The anterior and central portions of the costae become strong, coarsely spaced, strongly and irregularly tuberculate. When the shell is about 15 mm high, the posterior and central portions of costae become aligned to form smoothly sweeping costae over the major portion of the adult shell. They meet the anterior and ventral margins at high angles. In some specimens there is a slight tendency to irregularity of the ventral parts of these costae or to intercalation of secondary costae near the anteroventral margin. In some specimens the costae weaken in the anteroventral parts of the flank, so that this part of the shell bears only growth lines, or less commonly, growth rugae.

The posteroventral part of the flank is occupied by sharply defined, straight or nearly straight, mainly parallel, dorsoventrally oriented, nearly smooth costae of constant and regular strength and spacing. They form a plicate surface of commissure.

Discussion. This species is differentiated from *C. columbiana* (Packard) by the greater regularity of the spacing and strength of the dorsoventrally oriented costae of the posteroventral part of the flank and by the greater angle which these costae form with the locus that joins their dorsal terminations. It also differs from *C. columbiana* in the smaller proportion of the flank occupied by the posterior smooth space, in the presence of the groove following the position of the marginal carina, in the lesser convexity of the shell as a whole, and in the stronger, but still weak, fine transverse striation of the escutcheon. The replacement, with progressive growth stages of the shell, of concentric by dorsoventral costae is somewhat more clearly exhibited in the present species than in *C. columbiana*, and the earlier mode of sculpture persists longer in the present species. The ribbing of the main part of the flank is weaker and more finely spaced than on *C. columbiana*. There is commonly a distinct flexure between the posterior and central portions of the costae that is absent on the smoothly curved costae of *C. columbiana*.

The new species is similar to *C. condoni* (Packard), the interpretation of which species is based on Jones' (1960) study of fossils from Oregon. Packard's (1921, p. 28, Pl. 8, fig. 2) holotype of *C. condoni* is more distinctly tuberculate than most of Jones' specimens which Jones (1960, p. 158, 159) nevertheless considered to be conspecific, and possibly topotypic, with *C. condoni*. The status of Anderson's (1958, p. 108, Pl. 1, fig. 5) *Trigonia packardi* (not *Haidaia packardi* Crickmay, 1930) is unclear because of its poor preservation, and it may be synonymous with *C. condoni* as Jones (1960) suggested. *Columbitrigonia jackassensis* n. sp. differs from *C. condoni* in the much earlier replacement of concentric costae of the flank by subradial and oblique costae. The juvenile concentric costae of *C. condoni* appear to extend to the marginal carina, and succeeding subradial costae develop ventrally from them. In *C. jackassensis*, however, even the early growth stages exhibit a well-defined, smooth posterior part of the flank, and the subradial costae develop anteroventral to it, posterior to the main oblique costae. The appearance in *C. condoni* is one of truncation of subradial by concentric costae; in *C. jackassensis*, it is the reverse.

'*Trigonia*' *kitchini* Stoyanow (1949, p. 82, Pl. 14, figs. 4-10) resembles *C. jackassensis* but the sharp change from subradial to subconcentric costae remains until the latest growth stages in the former species.

Derivation of name. Jackass Mountain Group.

Material and occurrence. Several dozen moderately to poorly preserved or fragmentary external moulds from many localities in Barremian or probably Barremian beds of map-unit 8 of the eastern belt of the Jackass Mountain Group (*see* Table 1; Coates, 1974), including holotype GSC 45491 and paratype GSC 45502 from GSC locality 83961; paratypes GSC 45492 and 45583 from GSC locality 83948; GSC 45493 and 45495 from GSC locality 86987; GSC 45494, 45497, and 45505, from GSC locality 83944; GSC 45496 from GSC locality 62514; GSC 45498 from GSC locality 83956; GSC 45499 and 45500 from GSC locality 83934; GSC 45501 from GSC locality 68143; GSC 45503 from GSC locality 83960; and GSC 45504 from locality 68143. A few poorly preserved and specifically unidentifiable specimens (not figured) in Lower Albian map-unit 9 (GSC loc. 14907) and Hauterivian-Barremian map-unit 7 (GSC locs. 14906, 14913, 19414) may be younger and older representatives of this species. Alternatively, those specimens from map-unit 7 possibly may be adult specimens of *Apiotrigonia* sp. cf. *A. kayana* (Anderson) (*see* below).

Columbitrigonia? sp. cf. *C. condoni* (Packard)

Plate 2, figure 44

cf. *Trigonia condoni* Packard, 1921, p. 28, Pl. 8, fig. 2; Jones, 1960.

?cf. *Trigonia packardi* Anderson, 1958, p. 108, Pl. 1, fig. 5.

Two specifically undeterminable fragments of external moulds (including hypotypes GSC 45506 and 45507 from GSC loc. 68150; other specimens from GSC loc. 74799) were found in Albian map-unit 10 of the Jackass Mountain Group of Coates (1974). The posterior subradial costae are slightly coarser spaced than in *Columbitrigonia jackassensis* n. sp. which, together with their Albian age, allies them with *C. condoni* (Packard).

Genus *Apiotrigonia* Cox, 1952

Megatrigonia (*Apiotrigonia*) Cox, 1952.

Apiotrigonia (*Apiotrigonia*) Cox, 1969.

Type species. *Trigonia sulcataria* Lamarck, 1819. Cenomanian, Europe.

Diagnosis. Small to medium size, pyriform, gently concave. Umbonal and anterior parts of flank with costae that are either gently oblique or are nearly concentric except at their anterior ends; on posterior part of flank, early concentric costae are replaced, with growth, by subradial costae approximately perpendicular to ventral margin.

Discussion. The specific content of *Apiotrigonia* and its relationship with *Heterotrigonia* Cox (1952) and *Microtrigonia* Nakano (1957) require further study, which is beyond the scope of this paper. The writer's present concept is that of Nakano (1957; *see* also Tashiro, 1972), who raised it to generic rank from its original status as a subgenus of *Megatrigonia* (Cox, 1952).

The resemblance of *Apiotrigonia* with species of *Vaugonia* Crickmay is superficial and probably homeomorphic as Maeda and Kawabe (1966) and others have suggested.

Apiotrigonia sp. cf. *A. kayana* (Anderson)

Plate 3, figures 34-40

cf. *Trigonia kayana* Anderson, 1938, p. 108, Pl. 7, fig. 4.

Description. Shell small, rarely exceeding 2 cm in length. Outline subtriangular with rostrate posterior. Anterior and anteroventral margins form smooth semicircle; posterior part of ventral margin, and dorsal margin, straight. Shell gently convex. Escutcheon long, narrow.

Flank and escutcheon are separated by a rounded edge that is sharp in the few millimetres near the umbo. One or more fine, faint grooves extend along the dorsal side of this edge in some specimens. Escutcheon with fine, oblique or transverse costellae throughout, or only on the umbonal few millimetres, otherwise smooth or with fine growth lines, gently concave.

Costae of umbonal 5 mm of flank regular, sharp, and concentric, except near anterior margin which they meet nearly at right angles. They are curved upward along a locus that extends ventrally in later growth stages as the anterior boundary of the posterior smooth part of the flank. Thus, there is, near the umbo, a very narrow and short-lived, obliquely costate region between the escutcheon and the flank. The oblique costae of this small region die out, after the shell is about 5 mm long, in the posterior smooth part of the flank. This narrow part of the flank bears rare growth lines.

The major (anterior and central) part of the flank has sharp, fine, subconcentric costae that are evenly spaced. In some specimens these costae are stepped ventrally toward the anterior and, thus, exhibit incipient, slightly anteroventrally oblique orientation. They cut sharply across the growth lines in the anterior region of the shell, and meet the anterior margin nearly at right angles.

A set of dorsoventrally oriented, strong, smooth costae develop immediately anterior to the posterior smooth part of the flank, after the shell is about 5 mm long. They originate as upturned posterior ends of the concentric costae but this appearance is soon lost, and they become independent, and dominate the central portion of the flank.

Discussion. Because the Manning Park specimens are few and possibly all juvenile, no specific assignment is made. They are very close to *Apiotrigonia kayana* (Anderson) [=*Trigonia aequicostata* Gabb of Diller and Kay, 1924, p. 3, Fig. 3], as well as Aptian '*Trigonia*' *kitchini* Stoyanow (1949, p. 82, Pl. 14, figs. 4-10) and '*T.*' *cragini* Stoyanow (*ibid.*, p. 80, Pl. 13, figs. 6-10, Pl. 14, fig. 3). The horizon which yielded the type of *A. kayana* is questionable (Anderson, 1938, p. 108) but *A. kayana* also occurs in Aptian (Popenoe *et al.*, 1960) beds of the 'Horsetown Group' near Ono, California (Anderson, 1938, p. 108; Murphy, 1956, p. 2116).

The Manning Park specimens are smaller than the otherwise similar *A. crassoradiata* Nakano and *A. minor* (Yabe and Negao) (*see* Nakano, 1957; Maeda and Kawabe, 1966; Tashiro, 1972). However, future studies of these closely related forms may necessitate taxonomic revision.

Apiotrigonia newcombei (Packard) is larger and more inflated than *A.* sp. cf. *A. kayana*. In the umbonal 5 to 7 mm of *A. newcombei*, the fine concentric costae of the flank extend to the marginal carina and the smooth narrow posterior region of the flank develops at later growth stages. In *A.* sp. cf. *A. kayana*, however, the triangular posterior region of the flank is smooth or obliquely costate in even the earliest growth stages and the concentric costae of the flank commonly end sharply, in some specimens with a slight enlargement, anterior to it. *A.* sp. cf. *A. kayana* of Manning Park could be confused with juvenile specimens of *Columbitrigonia columbiana* (Packard), *C. condoni* (Packard), and *C. jackassensis* n. sp., but the concentric costae on the flank persist into later growth stages and remain independent of the dorsoventrally oriented costae throughout the extent of the flank, distinguishing them from those of *Columbitrigonia* species. The posterior smooth space is narrower than in *C. columbiana* and the fine oblique or transverse costellation of the escutcheon is more pronounced. Certain poorly preserved trigoniids associated with *A.* sp. cf. *A. kayana* are fragmentary unidentifiable adults which resemble *Columbitrigonia jackassensis* n. sp. Although they differ in their juvenile characteristics, the two species may be similar as adults. Therefore, those poorly preserved fragmentary specimens resembling *C. jackassensis* have been identified as possibly *C. jackassensis* n. sp. in map-unit 8 and are questionably designated as such in Tables 1 and 2. However, the two forms may be found to be synonymous following future study.

Material and occurrence. A few small, possibly juvenile, external moulds occur at GSC locality 62516 in the Hauterivian to Barremian map-unit 7 of Coates (1974) (hypotype GSC 45525) and at GSC locality 64806 in the lower [Hauterivian(?) or Barremian] part of map-unit 8 (hypotypes GSC 45523, 45524, 45526, 45527, 45528). The species is questionably identified at GSC locality 14909 well within map-unit 8.

Apiotrigonia sp.

Plate 3, figures 31, 32, 33

A few small, possibly juvenile, specifically unidentifiable specimens (including hypotypes GSC 45584, 45585 from GSC loc. 20504) in Hauterivian to Barremian map-unit 7 exhibit unusually strong transverse to oblique costae on the posterior, otherwise smooth part of the flank in the early growth stages (Pl. 3, fig. 32). These costae are continuous with the concentric costae of the flank. These specimens also have, in the early growth stages, a rudimentary area that is clearly separated in its orientation and in the direction of its oblique costellation from both the flank and the escutcheon (Pl. 3, fig. 33). The costellae of the escutcheon are coarser than in *A.* sp. cf. *A. kayana* (Anderson).

Subfamily PTEROTRIGONIINAE van Hoepen, 1929

The present writer tentatively follows the classification of Nakano (1974b) for Pterotrigoniinae and also includes *Linotrigonia* van Hoepen within the subfamily, although Kobayashi and Nakano (1957) suggested that *Linotrigonia* is similar only morphologically to other members of Pterotrigoniinae and properly belongs to the Clavellatae Group of Agassiz (1840) (included in subfamily Myophorellinae of this paper). Further discussion is not undertaken herein because of the inability of the Manning Park material to contribute to resolution of the problems of the complicated taxonomy of the Pterotrigoniinae.

Genus *Pterotrigonia* van Hoepen, 1929

Pterotrigonia van Hoepen, 1929; Cox, 1969; Nakano, 1974b.

Type species. *Pterotrigonia cristata* van Hoepen, 1929. Cretaceous, Zululand.

Diagnosis. Escutcheon depressed, with transverse costellae. Area narrow, with median groove, smooth, with growth lines, or with minor transverse costellae in early growth stages.

Discussion. Nakano's (1974b; *see* also Kobayashi and Nakano, 1957) classification and diagnoses are followed by the present writer.

Pterotrigonia (*Pterotrigonia*) sp.

Plate 2, figures 15, 16, 17

Description. Flank apparently with strongly crescentric form typical of *Pterotrigonia*. Strongly convex region along anterior end of shell, less convex to posterior.

Costae on main part of flank sharp, high-standing, sigmoidal, smooth, continuous from approximate position of marginal carina to anterior margin which they meet nearly at right angles. Their strength is increased greatly along the strongly convex anterior part of the shell. Costae are separated by broader intercostal spaces that bear growth lines. There is a suggestion of tuberculation on ribs in the anteroventral part of the flank.

Area, if any is present, very narrow and smooth, at least in umbonal region. Escutcheon long, broad, strongly recessed below beak, strongly and regularly transversely costellate.

Discussion. The Manning Park specimens represent *P.* (*Pterotrigonia*) van Hoepen, but are too rare and poorly preserved to contribute to our knowledge of that group, or to identify specifically.

Material and occurrence. Three partial external moulds (including hypotypes GSC 45489 and 45490) were found in a loose boulder in an area surrounded by rocks of Albian subdivision 10a of Jackass Mountain Group (Coates, 1974) (GSC loc. 69412). An Albian age is proposed for the boulder because of the association with *Myophorella* (*Steinmanella*) sp. B.

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PLATES

PLATE 1

(All figures natural size; all figures of latex casts from external moulds; all specimens from Jackass Mountain Group, Manning Park)

Myophorella (*?Steinmanella*) sp. A

Figures 1, 2. Lateral and dorsal views of incomplete left valve; hypotype GSC 45471 from GSC locality 83947. Probably late Barremian.

Figures 16, 17. Lateral views of right valve and incomplete left valve of hypotype GSC 45479 from GSC locality 86987. Probably late Barremian.

Myophorella (*Steinmanella*) sp. B

Figures 3, 4, 5. Lateral, dorsal, and umbonal views of incomplete left valve and part of right valve; hypotype GSC 45472 from GSC locality 69412. Albian.

Figures 6, 7, 8, 9. Lateral, oblique umbonal, umbonal, and oblique dorsal views of left valve, hypotype GSC 45473 from GSC locality 75148. Possibly Albian.

Figure 10. Lateral views of articulated posterodorsal parts of valves of hypotype GSC 45474 from GSC locality 69412. Albian.

Figure 11. Lateral view of anteroventral portion of right valve of hypotype GSC 45475 from GSC locality 69412. Albian.

Figure 12. Lateral view of incomplete right valve of hypotype GSC 45476 from GSC locality 69412. Albian.

Figure 13. Lateral view of articulated umbonal portions of (?juvenile) valves, hypotype GSC 45477 from GSC locality 75148. Possibly Albian.

Figures 14, 15. Lateral and dorsal views of articulated partial valves of hypotype GSC 45478 from GSC locality 74799. Probably Early Albian.

Figure 18. Dorsal view of fragment of posterior area of right valve, hypotype GSC 45480 from GSC locality 74794. Probably Early Albian.

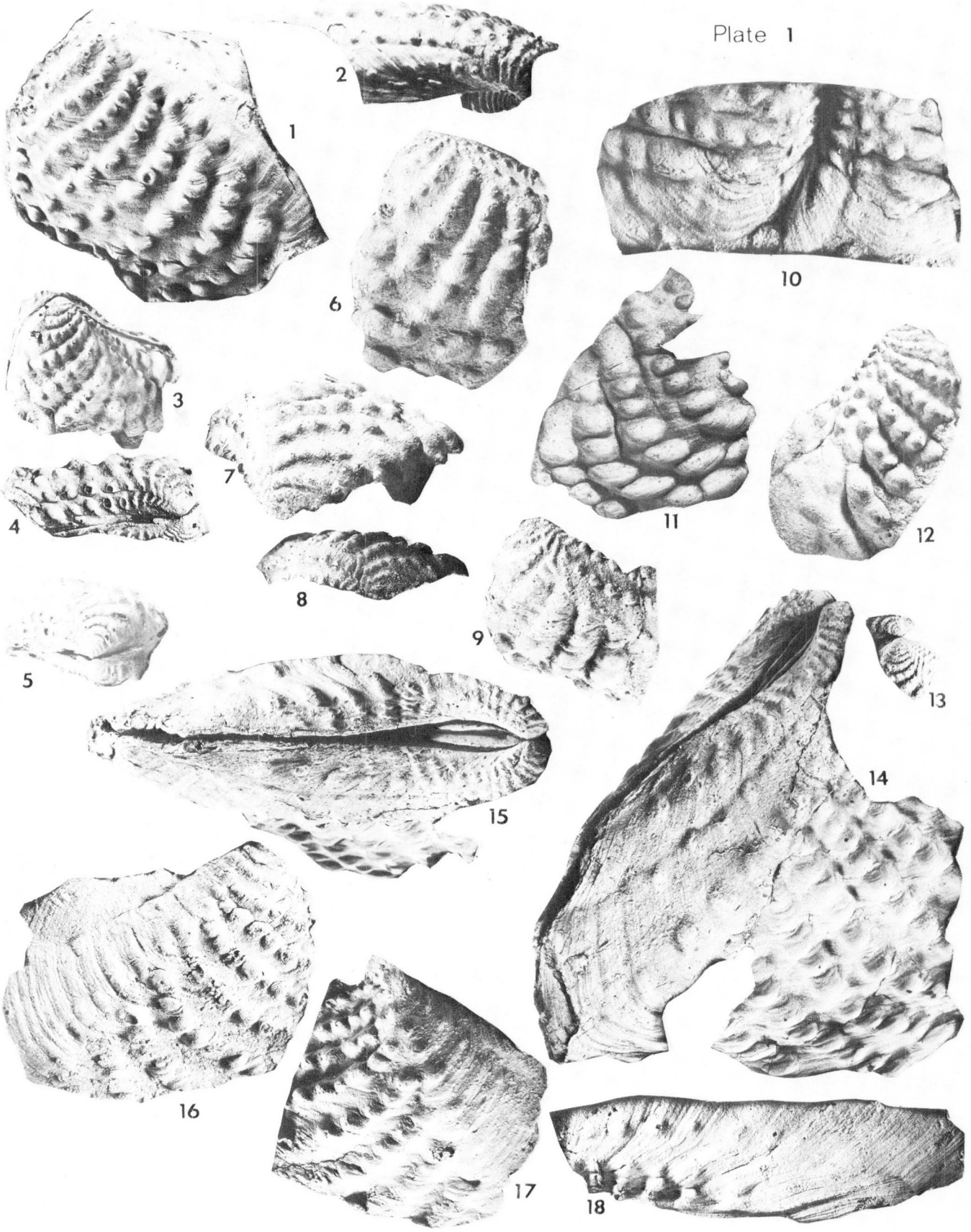
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PLATE 2

(All figures natural size except 42, 43; all figures of latex casts except 1-5, 12, 39, 45; all specimens from Jackass Mountain Group, Manning Park, except Figure 45).

Quoiecchia alicíae Crickmay

Figures 1, 2. Lateral and posterodorsal views of right valve, hypotype GSC 45481 from GSC locality 68144. Probably late Barremian.

Figure 3. Lateral view of right valve, hypotype GSC 45482 from GSC locality 68144. Probably late Barremian.

Figure 4. Lateral view of left valve, hypotype GSC 45483 from GSC locality 68144. Probably late Barremian.

Figures 5, 6. Lateral and posterodorsal views of partial right valve, hypotype GSC 45484 from GSC locality 62324. Late Barremian.

Figures 7, 8, 9, 10. Lateral, posterodorsal, anterior and umbonal views of left valve, hypotype GSC 45485 from GSC locality 69346. Barremian(?).

Figure 11. Lateral view of partial right valve, hypotype GSC 45486 from GSC locality 69346. Barremian(?).

Quoiecchia sp.

Figure 12. Posterodorsal view of fragment of left valve, hypotype GSC 45488 from GSC locality 73595. Hauterivian or Barremian.

Figure 13. Lateral view of fragmentary left valve, hypotype GSC 44582 from same locality as Figure 12.

Figure 14. Lateral view of juvenile right valve, hypotype GSC 45487 from GSC locality 68147, emphasizing the diagonal orientation of costae near the umbo. Hauterivian or Barremian.

Pterotrigonia (*Pterotrigonia*) sp.

Figure 15. Lateral view of partial left valve, hypotype GSC 45489 from GSC locality 69412. Albian.

Figures 16, 17. Dorsal and anterior views of fragmentary left valve, hypotype GSC 45490 from same locality as Figure 15.

Columbitrigonia jackassensis new species

Figure 18. Lateral view of broken right valve, holotype GSC 45491 from GSC locality 83961. Probably Barremian.

Figure 19. Lateral view of right valve, paratype GSC 45492 from GSC locality 83948. Probably Barremian.

Figures 20, 21. Lateral and dorsal views of right valve, paratype GSC 45493 from GSC locality 86987. Probably Barremian.

Figure 22. Lateral view of juvenile left valve, paratype GSC 45494 from GSC locality 83944. Probably Barremian.

Figures 23, 24. Lateral and dorsal views of partial left valve, paratype GSC 45495 from GSC locality 86987. Probably Barremian.

Figures 25, 26, 27. Lateral (right valve), posterodorsal, and ventral views of fragmentary paratype GSC 45496 from GSC locality 62514. Probably Barremian.

Figures 28, 29. Lateral views (different lighting) of partial right valve, paratype GSC 45497 from GSC locality 83944. Probably Barremian.

Figure 30. Lateral view of right valve, paratype GSC 45498 from GSC locality 83956. Probably Barremian.

Figure 31. Lateral view of partial right valve, paratype GSC 45499 from GSC locality 83934. Probably Barremian.

Figure 32. Lateral view of partial right valve, paratype GSC 45500 from GSC locality 83934. Probably Barremian.

Figures 33, 34, 35. Lateral (left valve), anterior, and umbonal views of fragmentary paratype GSC 45501 from GSC locality 68143. Hauterivian or Barremian.

Figures 36, 37. Lateral views (different lighting) of partial left valve, paratype GSC 45502 from GSC locality 83691. Probably Barremian.

Figure 38. Dorsal view of partial paratype GSC 45503 from GSC locality 83960. Probably Barremian.

Figure 39. Lateral view of left valve with shell partially preserved, paratype GSC 45504 from GSC locality 68143. Probably Barremian.

Figure 40. Lateral view of right valve, paratype GSC 45583 from GSC locality 83948. Probably Barremian.

Figures 41, 42, 43. Lateral (x1, x2) and oblique umbonal (x2) views of juvenile right valve, paratype GSC 45505 from GSC locality 83944. Probably Barremian.

Columbitrigonia? sp. cf. *C. condoni* (Packard)

Figure 44. Lateral and oblique anteroventral views of fragmentary left valves, hypotypes 45506, 45507 from GSC locality 68150. Albian.

Myophorella (*Steinmanella*) *whiteavesi* (Packard)

Figure 45. Lateral view of left valve, hypotype GSC 4997 figured by Whiteaves (1876, Pl. 10, fig. 2a) and Packard (1921, Pl. 6, fig. 2) and subsequently erroneously interpreted as a partial restoration, or possibly a complete reconstruction, by Anderson (1958, p. 111). Probably Albian, Haida Formation, Queen Charlotte Islands.

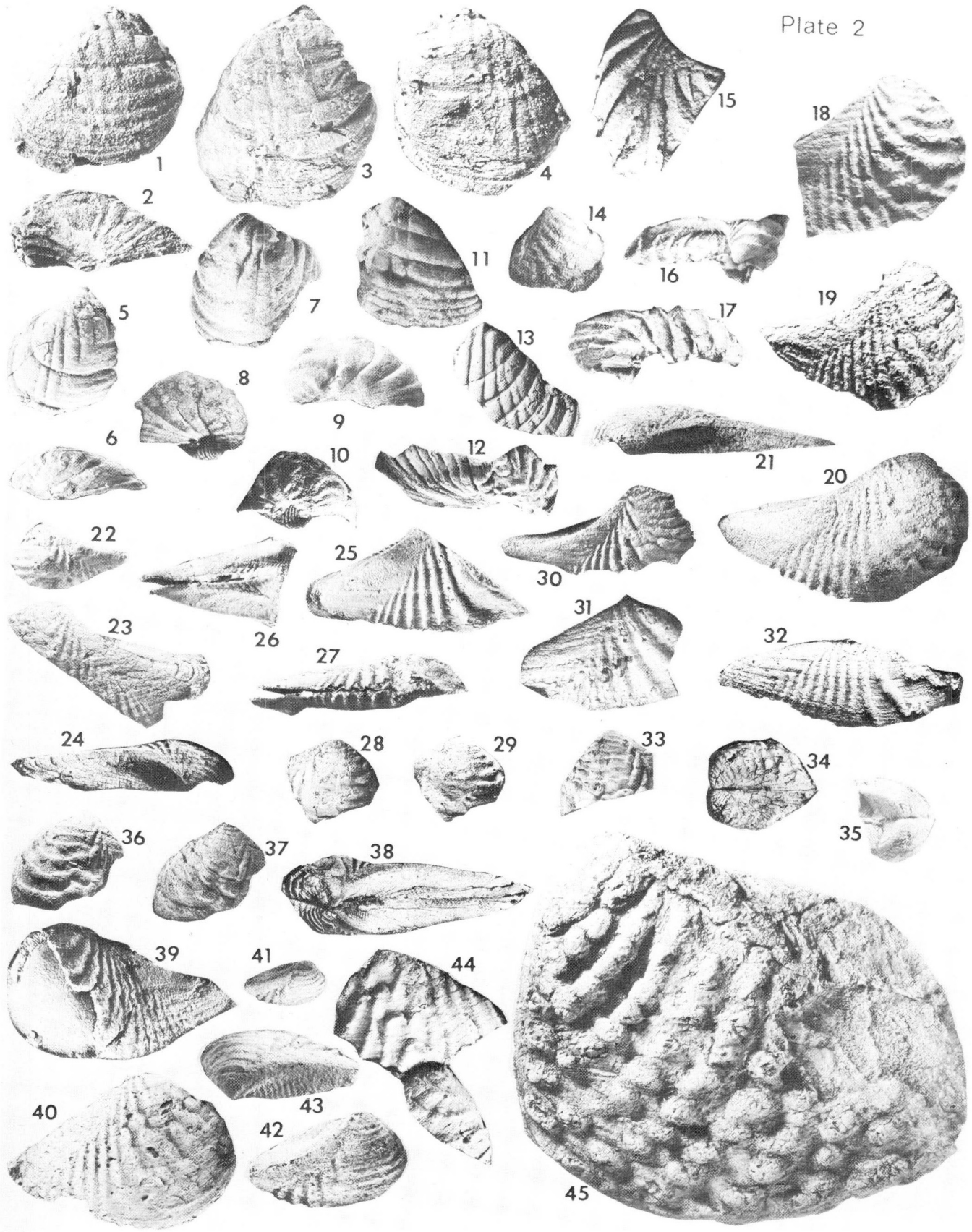
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PLATE 3

(All figures natural size except 31, 32, 33; all figures of latex casts except 29, 30; all specimens from Jackass Mountain Group, Manning Park).

Columbitrigonia columbiana (Packard)

Figures 1, 2, 3. Lateral, oblique dorsal, and dorsal views of left valve, and lateral view of a fragmentary left valve, hypotypes GSC 45507, 45508 from GSC locality 74794. Albian.

Figure 4. Lateral view of left valve, hypotype GSC 45509 from GSC locality 74794. Albian.

Figures 5, 6. Lateral and posterodorsal views of partial left valve, hypotype GSC 45510 from GSC locality 68150. Albian.

Figure 7. Lateral view of left valve, hypotype GSC 45511 from GSC locality 74794. Albian.

Figure 8. Lateral view of partial left valve, hypotype GSC 45512 from GSC locality 68150. Albian.

Figure 9. Lateral view of partial left valve, hypotype GSC 45513 from GSC locality 74791. Albian.

Figure 10. Lateral view of partial right valve, hypotype GSC 45514 from GSC locality 74791. Albian.

Figures 11, 12. Lateral and anterior views of broken left valve, hypotype GSC 45515 from GSC locality 74791. Albian.

Figures 13, 14. Lateral and umbonal views of partial right valve, hypotype GSC 45516 from GSC locality 68160. Albian.

Figures 15, 16, 17, 18. Oblique umbonal, lateral, anterior and ventral views of right valve, hypotype GSC 45517 from GSC locality 74801. Albian.

Figure 19. Lateral view of right valve, hypotype GSC 45518 from GSC locality 74791. Albian.

Figures 20, 21, 22, 23. Lateral, oblique lateral, oblique umbonal, and umbonal views of broken left valve, hypotypes GSC 45519 from GSC locality 74794. Albian.

Figures 24, 25, 26, 27. Lateral (different lighting), oblique umbonal, and posterodorsal views of partial left valve, hypotype GSC 45520 from GSC locality 69346. Albian.

Figure 28. Lateral view of right valve, hypotype GSC 45522 from GSC locality 74794. Albian.

Figures 29, 30. Anterior and lateral views of broken right valve, hypotype GSC 45521 from GSC locality 68150. Albian.

Apiotrigonia sp.

Figure 31. Umbonal view of right valve, hypotype GSC 45584 from GSC locality 20504 (x3). Hauterivian or Barremian.

Figures 32, 33. Lateral and umbonal views of right valve, hypotype GSC 45585 from same locality as Figure 31 (x3).

Apiotrigonia sp. cf. *A. kayana* (Anderson)

Figures 34, 35. Lateral and dorsal views of left valve, hypotype GSC 45524 from GSC locality 64806. Hauterivian(?) or Barremian.

Figure 36. Lateral view of partial right valve, hypotype GSC 45525 from GSC locality 62516. Hauterivian or Barremian.

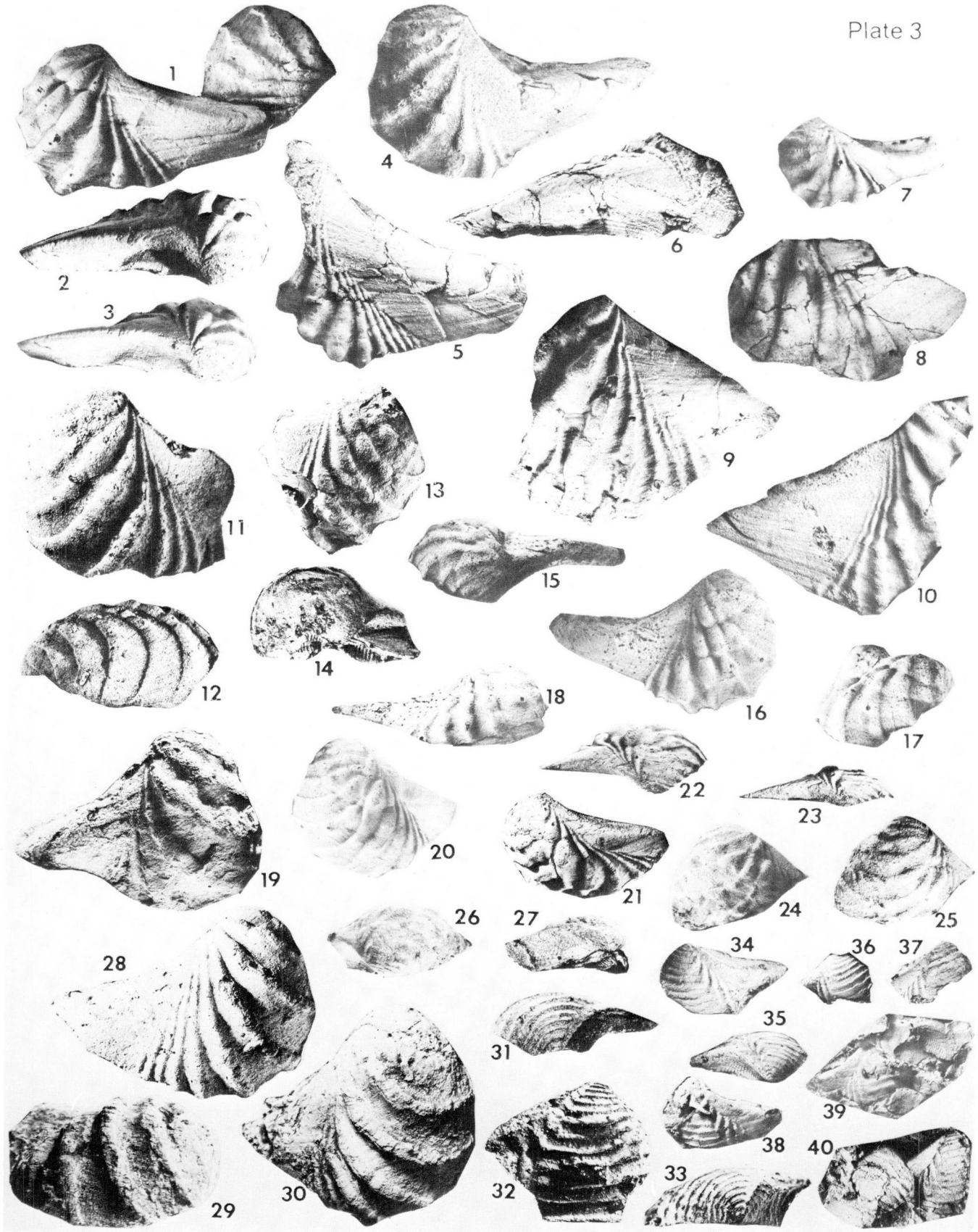
Figure 37. Lateral view of partial right valve, hypotype GSC 45526 from same locality as Figure 34.

Figure 38. Lateral view of left valve, hypotype GSC 45523 from same locality as Figure 34.

Figure 39. Lateral view (partial right valve) and oblique posterodorsal view (fragment of right valve), hypotypes GSC 45527, 45527a from same locality as Figure 34.

Figure 40. Lateral view of partial right valve, hypotype GSC 45528 from same locality as Figure 34.

Plate 3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