GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

GEOLOGICAL SURVEY
BULLETIN 282

JURASSIC TRIGONIID BIVALVES FROM CANADA AND WESTERN UNITED STATES OF AMERICA

T. P. Poulton

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

1979

GEOLOGICAL SURVEY
BULLETIN 282

JURASSIC TRIGONIID BIVALVES FROM CANADA AND WESTERN UNITED STATES OF AMERICA

T. P. Poulton

Available in Canada through

authorized bookstore agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Québec, Canada K1A 0S9

and from

Geological Survey of Canada
601 Booth Street
Ottawa, Canada K1A 0E8

A deposit copy of this publication is also available
for reference in public libraries across Canada

Catalogue No. M42-282 — Canada: $8.25
ISBN 0-660-01535-8 — Other countries: $9.90

Price subject to change without notice

Scientific Editor
E.J.W. IRISH

Critical Readers
J.A. JELETZKY
E.T. TOZER

Editor
VALERIE DONNELLY

Text printed on Kelmscott offset, smooth (brilliant white)
Set in Times Roman with Permanent captions
by PIERRE DES MARAIS INC., Saint-Laurent, Quebec

1300-1978-6792-3

Preface

This study was undertaken to evaluate the potential of trigoniid bivalves for biostratigraphic use in Canada. The usefulness of these fossils for subdivision and correlation of Jurassic rocks has already been well established in other parts of the world. The study involved examination of extensive collections, some of them made by the author. Thirty-nine of the approximately eighty known species are described in detail and the patterns of stratigraphic and geographic distribution of the Trigoniidae in Jurassic rocks of North America are given in this report.

Trigoniidae prove to be scarce in the Arctic regions in contrast to their abundance in western Canada. This may be a key to the influence of climate on animal distribution patterns in Jurassic time.

This report presents information and interpretations that will assist in our better understanding of the geology of western Canada — an understanding essential to reliable estimation of the abundance and distribution of fuel and mineral resources in this part of the country.

D. J. McLaren,
Director General
Geological Survey of Canada

Ottawa, 13 March, 1978

Contents

Abstract/Résumé 1

Introduction 2
- Importance of present study 2
- Previous studies of Jurassic Trigoniidae in North America 2
- Previously described and new species of North American Jurassic Trigoniidae 2
- Relationships between North American and other Jurassic Trigoniidae 3
- Acknowledgments 3

Biostratigraphy of trigoniid bivalves in North America 3
- General features of the biostratigraphic distribution and significance of North American Trigoniidae 3
- Facies control of distributions 5
- Biostratigraphic occurrences of North American Jurassic trigoniid bivalves 6
  - Hettangian 6
  - Sinemurian 6
  - Pliensbachian 8
  - Toarcian 8
  - Other Lower Jurassic occurrences 8
  - Bajocian 9
  - Bathonian 10
  - Callovian 10
  - Other Middle Jurassic occurrences 11
  - Lower Oxfordian 11
  - Late Jurassic occurrences younger than Early Oxfordian 12

Essential features of trigoniid morphology 12
- General features of the external shell surface 12
- Maturity of specimens 14
- Quantitative techniques 14

Systematic paleontology 14
- Family Trigoniidae 14
  - Subfamily Trigoniinae 14
    - Genus *Trigonia* 15
  - Subfamily Myophorellinae 15
    - Genus *Frenguelliella* 17
    - Genus *Jaworskiella* 19
    - Genus *Vaugonia* 21
    - Genus *Myophorella* 27
    - Genus *Scaphotrigonia* 40
    - Genus *Orthotrigonia* 41
  - Subfamily Megatrigoniinae 42
    - Genus *Anditrigonia* 43

References 44

Appendix — Fossil localities
Geological Survey of Canada 50
United States Geological Survey 55
United States Geological Survey, field numbers 58
California Academy of Sciences 58
Department of Geology, Stanford University 58

Plates 1 – 11. Illustrations of fossils 59–81

Table 1. Checklist and distribution chart, North American Jurassic Trigoniidae in pocket

Textfigures
1. Approximate ages of Jurassic rocks in key areas referred to in this report in pocket
2. Index map, western Canada and United States 6
3. Index map, British Columbia 7
4. Generalized sketches of representative right valves of *Vaugonia* Crickmay, showing external morphological terms used 12
5. Some major styles of trigoniid ornamentation 12
6. Schematic drawings of representatives of *Vaugonia* Crickmay 16
7. Schematic generalized representative of *Vaugonia*(?) *yukonensis* n. sp. 17
8. Schematic drawings of representatives of *Orthotrigonia* Cox 17

JURASSIC TRIGONIID BIVALVES FROM CANADA AND WESTERN UNITED STATES OF AMERICA

Abstract

The bivalve family Trigoniidae, previously well known only outside North America, now is known to be a quantitatively important and biostratigraphically significant element of the Jurassic fauna of North America.

Approximately eighty species of Trigoniidae are known from Jurassic rocks of North America. The following ten species are described as new in this report: *Jaworskiella supleiensis, J. siemonmulleri, Vaugonia imlayi, V. oregonensis, V.(?) yukonensis, Myophorella alaskaensis, M. freboldi, M. tipperi, M. tuxedniensis,* and *Orthotrigonia(?) sohli.* Another 29 species are treated in some detail.

The subfamily Myophorellinae Kobayashi is emended to encompass several genera of trigoniids with concentrically costellate areas, including *Myophorella* Bayle, *Vaugonia* Crickmay, *Jaworskiella* Leanza, *Frenguelliella* Leanza, *Orthotrigonia* Cox, and *Scaphotrigonia* Dietrich. The genus *Myophorella* is emended to include several previously named Jurassic and Cretaceous genera with obliquely costate shells.

The Jurassic Trigoniidae in North America are divisible into an early group of species older than Middle Toarcian, and a younger group that ranges from Middle Toarcian through Late Jurassic. The oldest, Hettangian, trigoniid is *Prosogyrotrigonia*(?) sp. from the northern Yukon Territory. Sinemurian through Early Toarcian forms include species of *Trigonia, Frenguelliella, Jaworskiella, Psilotrigonia* and *Vaugonia.* Middle Toarcian and younger Jurassic trigoniids are dominated by *Myophorella, Trigonia* and *Vaugonia* species with, locally, abundant occurrences of species of *Orthotrigonia(?), Scaphotrigonia,* and *Anditrigonia.*

Representatives of the Trigoniidae are rare in the Early Jurassic Arctic faunas and apparently absent in the boreal Middle Jurassic faunas of the Arctic. They are most abundant in the pre–Upper Oxfordian Jurassic rocks of western North America and in younger Jurassic rocks of the southern United States and Mexico. Trigoniids are rare in post–Lower Oxfordian rocks that are characterized by *Buchia* species.

Résumé

La famille Trigoniidae (bivalves), auparavant bien connue seulement à l'extérieur de l'Amérique du Nord, est maintenant reconnue comme élément d'importance quantitative et biostratigraphique de la faune jurassique d'Amérique du Nord.

On connaît environ quatre-vingts espèces de Trigoniidae, qui proviennent des roches jurassiques d'Amérique du Nord. Les dix espèces suivantes, décrites dans le rapport, sont considérées comme nouvelles: *Jaworskiella supleiensis, J. siemonmulleri, Vaugonia imlayi, V. oregonensis, V.(?) yukonensis, Myophorella alaskaensis, M. freboldi, M. tipperi, M. tuxedniensis,* et *Orthotrigonia(?) sohli.* On traite aussi d'une façon assez détaillée de 29 autres espèces.

Des modifications sont apportées à la sous-famille Myophorellinae Kobayashi afin d'englober plusieurs genres de trigoniidés avec les aréas ornées de côtes fines concentriques, notamment *Myophorella* Bayle, *Vaugonia* Crickmay, *Jaworskiella* Leanza, *Frenguelliella* Leanza, *Orthotrigonia* Cox, et *Scaphotrigonia* Dietrich. Le genre *Myophorella* a été modifié afin de comprendre plusieurs genres déjà nommés du Jurassique et du Crétacé, qui possèdent des coquilles à côtes obliques.

Les Trigoniidae jurassiques d'Amérique du Nord peuvent être divisés en deux groupes: le premier réunit des espèces anciennes antérieures au Toarcien moyen, et le second, plus jeune, oscille entre le Toarcien moyen et le Jurassique supérieur. La plus ancienne espèce trigoniidé, qui provient de l'Hettangien, appartient au genre *Prosogyrotrigonia*(?) et on la trouve dans le nord du Yukon. Les formes qui vont du Sinémurien au Toarcien inférieur comprennent les genres suivants: *Trigonia, Frenguelliella, Jaworskiella, Psilotrigonia* et *Vaugonia.* Les trigoniidés du Toarcien moyen et du Jurassique plus jeune sont dominés par des espèces appartenant aux genres *Myophorella, Trigonia,* et *Vaugonia* et, par endroits, on trouve en abondance des espèces appartenant aux genres *Orthotrigonia(?), Scaphotrigonia,* et *Anditrigonia.*

Les représentants de la famille Trigoniidae ne se trouvent que rarement dans les faunes arctiques du Jurassique inférieur et, dans l'Arctique, ils semblent absents des faunes boréales du Jurassique moyen. En revanche, l'ouest de l'Amérique du Nord en possède en abondance dans ses roches jurassiques du pré–Oxfordien supérieur, et dans ses roches jurassiques plus jeunes du Mexique et du sud des États-Unis. Les trigoniidés se font toutefois rares dans les roches postérieures à l'Oxfordien inférieur, caractérisés par les espèces du genre *Buchia.*

Original manuscript submitted 15 October 1975
Approved for publication 28 January 1977

Introduction

Importance of present study

Trigoniid bivalves are a quantitatively significant and biostratigraphically useful element of Mesozoic faunas throughout the world. They are abundant and varied in the Mesozoic rocks of western Canada and United States, although relatively little detailed study has been done on them by North American workers. As a result of this lack of study, many, if not most, of the North American Jurassic species have not yet been described and general reviews of the family Trigoniidae are misleading to the extent that they ignore these rich faunas. This report summarizes the available data concerning North American Jurassic trigoniids and contributes to the description of the species present.

An understanding of the distribution of the Trigoniidae is believed to be useful for biostratigraphic work in rocks that do not yield diagnostic ammonites, but which commonly contain abundant bivalve faunas.

Eighty-one new or previously known but inadequately described or illustrated species of Jurassic North American Trigoniidae are described and illustrated, or listed in this report. Their biostratigraphic and geographic distribution patterns are described and summarized. The report is not a complete monograph of North American Jurassic Trigoniidae, however, since more new species await description, and the ranges of certain species that are already known probably will be changed as our knowledge increases.

The family Trigoniidae is a large and complicated group, many members of which are thought to possess the properties of good index fossils: distinctive and easily recognized morphology, wide geographic distribution and short time-stratigraphic range. The family is so complex, however, that phylogenies are poorly understood as yet, and its biostratigraphic potential still is not well known. External morphology of some short-lived groups of trigoniids is exceptionally complex, whereas other more generalized forms are relatively long lived. Most species are distinguished readily, although large collections of well preserved adult material are necessary for accurate identification of some of them.

The earliest representatives of the Trigoniidae occur in the Middle Triassic of South America (Barthel, 1958). Trigoniids are particularly abundant in marine Jurassic and Cretaceous rocks throughout the world and have survived since Cretaceous time in small populations around the Australian continent. The family is defined and recognized by the peculiar dentition of its members, which is remarkably consistent within the family except in some short-lived Triassic members (Fleming, 1962, 1963, 1964) and markedly distinct from all other bivalves.

Much of the material available for study was collected by H.W. Tipper (Geological Survey of Canada) in 1970 and 1971 and by the author in 1971 in Smithers and adjacent map areas of central British Columbia; by the author in southern British Columbia, Alberta, central Oregon and California in 1972; and by the author and T. Richards (Geological Survey of Canada) in Hazelton and adjacent map areas in British Columbia in 1973. Other major sources of specimens were collections accumulated up to the present by the Geological Survey of Canada, the United States Geological Survey, Stanford University, and the California Academy of Sciences. Recent collections by several workers in British Columbia, Yukon Territory and Alaska have been incorporated into the study. Wherever possible, original type material was restudied.

Previous studies of Jurassic Trigoniidae in North America

The only comprehensive, exclusively North American, review of Trigoniidae to date is that of Packard (1921). Until that time, descriptions of individual species, under the all-inclusive generic name *Trigonia*, were published by Eichwald (1871), Meek (1864, 1873), Whiteaves (1878a), Hyatt (1892), Hall and Whitfield (1877), Meek and Hayden (1860), Whitfield and Hovey (1906), and Cragin (1893, 1897, 1905). Some of the five species of trigoniids described as Cretaceous by Burwash in 1913 may, in fact, be Jurassic in view of the confusion between these two systems on Queen Charlotte Islands at that time (McLearn, 1949). Most of them are based on material too poorly preserved to warrant retention as valid species, however, and none can be compared closely with Jurassic species. Hyatt (1892) did not publish adequate descriptions or illustrations of his species but was credited with their authorship by Packard (1921), who described and figured them. Subsequent descriptions of individual species were published by McLearn (1926), Crickmay (1930a, b), Frebold (1959), Alencaster (1963), Imlay (1964a) and Poulton (1976). The brief summary of trigoniid occurrences by Poulton (1973) is superseded by the present report. Other works which contributed to our knowledge of the distribution of North American Jurassic Trigoniidae are by Meek and Hayden (1865), White (1883), Whiteaves (1884), Stanton (1899), Stanton and Martin (1905), Veatch (1907), Butler et al. (1920), Mansfield (1927), Jaworski (1929), Lees (1934), Imlay (1940, 1945), Stoyanow (1949), Sanborn (1960), Alencaster and Buitron (1965) and Paterson (1968).

Previously described and new species of North American Jurassic Trigoniidae

The Jurassic species of Trigoniidae presently recognized in North America, their authors and their distributions are shown in Table 1. Undocumented identifications of trigoniids in reports dealing mainly with stratigraphy or regional geology are not included in Table 1, nor in the citations listed in the section on previous studies.

Of four species described by Eichwald (1871), *Trigonia nana* and *T. consobrina* are regarded as being *nomina dubia* since they are based on very poor material, as Packard (1921) recognized. Other suppressed specific names are *Trigonia ferrieri* McLearn [= *Myophorella montanaensis* (Meek)], *Trigonia charlottensis* Packard [?= *Myophorella devexa* (Eichwald)], *Vaugonia mariajosephinae* Crickmay (= *Vaugonia veronica* Crickmay), and *Haidaia statluensis* Crickmay [?= *Myophorella packardi* (Crickmay)]. Confirmation of the validity of *Trigonia trafalgarensis* Warren, *T. pandicosta* Meek and *T. obliqua* Hyatt requires further collecting of topotypic material.

Relationships between North American and other Jurassic Trigoniidae

The Early Jurassic trigoniid faunas of North America are similar to those of other areas bordering the Pacific Ocean. Species of *Frenguelliella* similar to *F. inexspectata* (Jaworski), for example, as well as other species of *Frenguelliella* as redefined herein, occur in Yukon Territory, British Columbia, Mexico, South America and Japan. The affinities of Early Jurassic *Vaugonia* species with those of South America (Leanza, 1942; Möricke, 1895) and Japan (Kobayashi and Mori, 1955) have been described by Poulton (1976). The affinities of other North American Lower Jurassic forms cannot be evaluated meaningfully as yet.

Most of the Middle Toarcian to Early Oxfordian species of *Trigonia*, *Myophorella* and *Vaugonia*, well represented in North America, are similar to those of Europe (see for example Lycett, 1872–1879; Agassiz, 1840; Lebküchner, 1932; Choffat, 1885), central Asia (Savel'ev, 1960), Japan (see for example Kobayashi and Mori, 1955; Kobayashi et al., 1959; Kobayashi and Tamura, 1955) and New Zealand (Fleming, 1964). The general similarity of these faunas only rarely extends to specific identity. The same comments hold true for forms less well represented in North America, such as *Scaphotrigonia* and *Orthotrigonia* species.

Acknowledgments

This report constitutes part of a Ph.D. thesis submitted to Queen's University, Kingston, Ontario, in 1974. The Geological Survey of Canada sponsored and supported the work at all stages of progress.

J.A. Jeletzky (Geological Survey of Canada) suggested the project, and the work was supervised by both J.L. Usher (Queen's University) and J.A. Jeletzky.

H. Frebold (GSC) provided most of the identifications and age determinations of Canadian ammonites upon which the ages of trigoniid-bearing collections are based, and assisted with some stratigraphic problems. J.A. Jeletzky and R.W. Imlay (United States Geological Survey) gave valuable advice concerning the study of bivalves, and trigoniids particularly. H. Frebold, H.W. Tipper, T. Richards, J.A. Jeletzky (all GSC), R.W. Imlay, R.L. Detterman, D.L. Jones (USGS), V. McMath (Chico State University, California), M. Brookfield (University of Guelph) and R. Hall (McMaster University) gave useful information concerning Jurassic stratigraphy of particular areas, and R. Hall is thanked for the loan of specimens he collected. J.L. Usher, R.G. Greggs, D.L. Smith, and G.A. Bartlett (Queen's University) provided advice and discussion of stratigraphic and paleontological problems. S.M. Stanley (Johns Hopkins University), R.M. Carter (University of Otago) and E.G. Kauffman (United States National Museum) provided useful ideas and unpublished information related to functions and growth, as well as morphological characterization of the bivalve shell. An incomplete manuscript of the late F.H. McLearn concerning trigoniids was made available by the Geological Survey of Canada.

The author is particularly grateful to Drs. Jeletzky, Frebold, Tipper, and W.T. Dean (GSC), R.W. Imlay (USGS), N.J. Silberling (Stanford University), and P. Rodda (California Academy of Sciences) for the loan of specimens. N.J. Morris (British Museum, Natural History) is thanked for generous assistance, encouragement and discussion of ideas, and for permission to study specimens at the museum. H.C. Ivimey-Cook (Institute of Geological Sciences, London), C.L. Forbes (Sedgwick Museum, Cambridge University), J.M. Edmonds (Oxford University Museum), E.T. Tozer (GSC) and K. Duff (University of Leicester) are thanked also for permission to study specimens in their care, and for general discussion and assistance.

The Geological Survey of Canada provided logistical and financial support for field work in the summers of 1971, 1972 and 1973. Queen's University provided financial support and laboratory and office facilities for the project. H.W. Tipper, T. Richards and B.S. Norford (GSC) are thanked especially for logistical support. E. Fernando, J. Keenan (Queen's) and Jeanne White (GSC) are thanked for photographic assistance, and B.J. Botte, J. Callahan and E. Corey (GSC) for preparatory and cataloguing assistance.

The manuscript was improved greatly by critical comments from J.A. Jeletzky, E.T. Tozer and R.W. Imlay, but the author is responsible for all ideas stated, errors and omissions.

Biostratigraphy of trigoniid bivalves in North America

General features of the biostratigraphic distribution and significance of North American Trigoniidae

The usefulness of trigoniids for providing relative age determinations and local correlations has been discussed by Kitchin (1926), Kobayashi (1954), Kobayashi et al. (1959), Nakano (1960), Hayami (1962) and others, and the restricted ranges of European, particularly English, species have long been recognized (see for example Lycett, 1872–1879). Certain of the subfamilies and genera of Trigoniidae also are biostratigraphically restricted and gross morphological features are potentially useful tools for crude correlation without specific identification.

Only a brief review of the biostratigraphic significance of North American Trigoniidae is given in this section; the range of each individual Jurassic species is provided under 'Systematic Paleontology' (see also Table 1).

Some species are distinctive and apparently are markedly restricted biostratigraphically, and are therefore potentially useful for relative age determinations; others are less so. Some species are represented by only one or a small number of specimens and the assessment of their biostratigraphic significance is difficult; the ranges of others, represented by large numbers of specimens from many localities over a considerable area, are better known. The widespread infraspecific variation in some species and the recurrent development of certain features within lineages necessitate large collections of well preserved specimens for reliable age determinations of most forms.

Triassic Trigoniidae in North America are mainly *Minetrigonia* and *Myophorigonia* species; a few other poorly understood forms occur rarely. These genera have not been found in Jurassic rocks, in North America or elsewhere. Most Jurassic genera have not been found in Triassic rocks. Therefore the most common Jurassic and Triassic Trigoniidae are, for the most part, distinctly different in North America and throughout the world, and these bivalves provide a useful means for quickly distinguishing the two systems in rocks where they occur. Although some species of *Trigonia* and *Frenguelliella*—i.e., *F.* (*Kumatrigonia*)—occur in both Triassic and Jurassic rocks on the global scale, they have not been found in the Triassic in North America. The generic assignment of the Yukon Triassic species *Trigonia textilis* Lees (1934) is in doubt. Although its flank and area are dominated by concentric ornament similar to that of *Frenguelliella* species, it nevertheless exhibits radial costae, particularly on the antecarinal part of the flank, that are characteristic of Triassic *Minetrigonia* and *Costatoria* species.

The Trigoniidae are well represented, if often poorly preserved, in the Jurassic rocks of western North America. The most prolific and representative collections come from the volcaniclastic Hazelton and Bowser Lake groups (Tipper and Richards, 1976) of north-central British Columbia, and from the volcaniclastic Jurassic rocks of southern Alaska (Textfig. 1). Study of trigoniids from these regions has resulted in the delimitation of most of the biostratigraphic ranges of Toarcian through Early Oxfordian forms, and the description of many species. Other regions of importance for biostratigraphic interpretations are Nevada (Sinemurian and Pliensbachian), Mount Jura area of central California (Toarcian, Bajocian, Callovian; Hyatt, 1892), Pit River area of northern California (Bajocian; Sanborn, 1960), central Oregon (Pliensbachian, Middle Bajocian) and western Vancouver Island (Pliensbachian; Poulton, 1976). Trigoniid faunas from other regions (Table 1, Textfig. 1) provide further useful data for biostratigraphy, as well as providing further documentation of the specific character of the faunas.

The North American Jurassic trigoniid faunas are biostratigraphically divisible into two major assemblages, respectively older and younger than Middle Toarcian, which appear to have worldwide significance. The more detailed biostratigraphic distribution described below appears to conform with East Asian and European data for the most part, but certain ranges are known to be local. The writer concurs with Kitchin's (1926) hesitation in correlating over long distances on grounds of similar morphology only; either specific identity or near identity should be established for detailed correlations. For crude correlation, the general character of a fauna consisting of several species can be used.

The lower, approximately Hettangian to Lower Toarcian, trigoniid assemblage is characterized by *Frenguelliella* species, mainly small and finely sculptured *Trigonia* species, and *Vaugonia* species of the character of *V. vancouverensis, V. coatesi, V. jeletzkyi* and *V. oregonensis*. *Frenguelliella* is characteristic of the Lower Jurassic in South America and Mexico (Jaworski, 1916, 1929; Leanza, 1942) and therefore appears to be a valuable, widespread, Early Jurassic index fossil.

The *Vaugonia* species mentioned above are similar morphologically to those species in Lower Jurassic successions of Japan (Kobayashi and Mori, 1955) and South America (Möricke, 1895). The significance of the ranges of the individual species of *Vaugonia, Frenguelliella* and *Trigonia* are not yet known, nor is the significance of *Psilotrigonia canadensis* Poulton, which occurs in Canadian rocks of Pliensbachian age. *Jaworskiella* species occur in Sinemurian and Pliensbachian rocks of the United States and Canada and the genus appears to be restricted to these stages in North America.

The oldest reliably dated (Early Hettangian) North American bivalve that is probably trigoniid, *Prosogyrotrigonia*(?) sp. cf. *P. inouyei* (Yehara) from northern Yukon Territory (Frebold and Poulton, 1977), closely resembles Japanese species of similar age and indicates probable worldwide biostratigraphic significance for this group of species.

The Middle Toarcian to Early Oxfordian trigoniid faunas of western North America are well known because they are relatively prolific in many areas, particularly in western and northwestern British Columbia and southern Alaska. In these areas, trigoniids are most abundant in certain facies of the Lower and Middle Bajocian and in the Lower Callovian. However, forms that are represented less abundantly in other intervals in these areas, and at various levels in other areas, permit a reasonably confident biostratigraphic interpretation of many, if not most, of the Middle Toarcian to Early Oxfordian trigoniid species. No zonation will be presented, however, until more species are described. The trigoniids of this interval comprise several closely knit groups. They are dominated by *Myophorella* species, *Vaugonia* species, and by large and coarsely sculptured *Trigonia* species of the same general form as those in Middle Jurassic rocks of Europe (see for example Lycett, 1872–1879; Lebküchner, 1932) and eastern Asia (Kobayashi, 1954; Kobayashi and Tamura, 1955). The stratigraphic ranges of most species in the Middle Toarcian to Lower Oxfordian interval of western North America vary considerably. *Myophorella montanaensis* (Meek), for example, spans that entire interval. The more restricted ranges of most other species are shown in Table 1. Certain of these ranges have been used successfully by the writer to date beds that are otherwise sparsely fossiliferous, in his field studies in British Columbia and in the identification of collections submitted by other field geologists.

The Middle Toarcian to Lower Oxfordian succession of west-central British Columbia is lithologically almost uniform, and is not easily divisible by means of bivalve faunas because most forms from different parts of that interval are similar. Frebold (1957) and Imlay (1964a) have remarked on the similarity of most bivalves in the Bajocian through Callovian rocks in west-central North America. Certain trigoniid species, however, are biostratigraphically short lived and have proven to be useful for dating particular beds where ammonites are not abundant. Characteristic Middle Bajocian trigoniids are *Myophorella tipperi* n. sp., *M. freboldi* n. sp., *M. tuxedniensis* n. sp., *M. dawsoni* (Whiteaves), *M. argo* (Crickmay) and others, some of which do appear, however, to range into Callovian rocks locally. They are morphologically gradational with the mainly Callovian species *M. packardi* (Crickmay), *M. devexa* (Eichwald) and *M. orientalis* (Kobayashi and Tamura). Species such as *Vaugonia*(?) *yukonensis* n. sp., with a reticulate costation pattern, as well as *Myophorella* species such as *M. yellowstonensis* Imlay, with finely and sharply tuberculate ribs and clearly defined umbonal radial striae, are mainly Middle Bajocian. *Myophorella tipperi* n. sp. also is common in Lower Bajocian rocks. It is expected that the ranges of some of these species will require revision following more detailed stratigraphic work.

The long ranges of certain species, such as *M. montanaensis* (Meek) are taken, with other criteria, to indicate their unusually great environmental tolerance and adaptive potential; other species that are short lived may have been less adaptable. The ranges of certain species, such as the Bajocian or Callovian species listed above, are determined by evolutionary gradation from one to the other. In contrast, the younger age limits of *Anditrigonia plumasensis* (Hyatt), *Scaphotrigonia naviformis* (Hyatt), *Myophorella devexa* (Eichwald), *Vaugonia doroschini* (Eichwald) and North American representatives of *M. orientalis* Kobayashi and Tamura, for example, are associated with a facies change to a *Buchia*-dominated fauna, in which trigoniids are rare. In post–Lower Oxfordian rocks, trigoniids are rare except in the southern United States (Stoyanow, 1949; Imlay, 1945) and Mexico (Imlay, 1940). The general morphological character of Callovian *Myophorella* species extends higher than Callovian in the Jurassic of Europe, and *M. orientalis* Kobayashi and Tamura, while restricted to the Callovian in Alaska, ranges up to Berriasian in Japan.

The present writer emphasizes the different natures of Jurassic and Cretaceous trigoniid faunas less than other authors (for example, Kitchin, 1926) have done. The two faunas clearly are different at specific and generic levels in many areas but subfamilies and major morphological characters generally do not serve to differentiate them. Uhlig (1910; see discussion by Stoyanow, 1949) suggested the continuity of Late Jurassic–Early Cretaceous trigoniid fauna. An extensive discussion of the question with respect to the controversial Malone Formation of Texas is given by Stoyanow (1949, p. 41–50) and other writers he referred to. The Jurassic age (Early Kimmeridgian to Tithonian; see Cragin, 1905; Kitchin, 1926; Stoyanow, 1949, p. 41; Albritton, 1937, 1938; Imlay, 1943, p. 1472–1474, 1492; 1945) of the ammonite faunas of the Malone Formation seems to be well established. Their direct association with trigoniids that are considered to be of Cretaceous aspect (Kitchin, 1926) is uncertain but appears to be likely (see Albritton, 1938; Stoyanow, 1949). The present writer sees no reason to exclude *'Trigonia' vyschetzkii* Cragin and the other Malone trigoniids from the Jurassic on morphological grounds, since an adequate trigoniid biostratigraphy for the Upper Jurassic–Lower Cretaceous boundary interval is not yet established. Nevertheless, it must be pointed out that those Texan species assigned a Late Jurassic age in Table 1 are of Cretaceous aspect and that there is some question regarding their age. Some Bajocian *Myophorella* species in Canada have developed complexly costellate areas and escutcheons as well as quadrate outlines, features generally associated with Cretaceous trigoniids.

Apiotrigonia Cox, *Pterotrigonia* van Hoepen, *Quoiecchia* Crickmay, *Myophorella* (*Steinmanella*) Crickmay, *Heterotrigonia* Cox and *Columbitrigonia* Poulton are good indicators of Cretaceous rocks in North America and some are useful, at the genus or subgenus level, for diagnosing particular Cretaceous stages. Individual species of many Cretaceous trigoniids have been shown to be biostratigraphically useful by Stoyanow (1949), Jones (1960) and Poulton (1977), for example.

Facies control of distributions

Trigoniids occur alone in some places, but more often are associated with a rich and varied fauna and with sedimentary structures that characterize and indicate shoreline or shallow marine environments. Forms that commonly accompany trigoniids include the bivalves *Astarte, Pleuromya, Pinna, Gervillia, Ostrea* and *Inoceramus,* small solitary corals, rhynchonellid brachiopods, belemnites and ammonites. Rare occurrences in apparently deeper water rocks can be attributed, in each case known to the writer, to transport from shallower environments.

The degree to which lithological facies (i.e., bottom sediment) affect the distributions of trigoniids is not yet well known and may vary from species to species. In North America, most trigoniids have been found in argillaceous sandstone or sandy mudstone. Clastic rocks as coarse as grit grade (up to approximately 4 mm in diameter) contain *Vaugonia* and *Myophorella* species, some of which occur with equal or greater abundance in fine-grained rocks. Some forms, such as *Frenguelliella* species, occur in medium- to coarse-grained clastic rocks as well as in coquinoid lenses within dominantly volcanic successions. British Jurassic species and many from western United States (Imlay, 1964a) apparently are distributed throughout both carbonate and clastic successions. Tentatively, it seems that most trigoniids were very tolerant of facies as regards grain size and composition of the bottom sediments (see also Stanley, 1977).

The Trigoniidae of the Middle and Upper Jurassic are extremely rare in rocks characterized by 'boreal'[1] ammonites and they are, therefore, a further and a rather striking example of the Mesozoic worldwide marine faunal differentiation (see reviews by Arkell, 1956 and Imlay, 1965). They were sensitive to whatever factors, as yet undetermined, caused the pattern of faunal differentiation. Only Bathonian *Vaugonia athena* Poulton and Callomon and Late Jurassic *Laevitrigonia* spp., both from East Greenland, have been identified to date in the Boreal Realm (Poulton and Callomon, 1977). The same type of environmental

[1]The term 'boreal' is used throughout this paper to indicate the Boreal Realm of the Jurassic, as used by Arkell (1956) and Imlay (1965). Trigoniids are rare in boreal regions, but are widespread in the more southerly faunal regimes, which were grouped together in two broad realms, the Tethyan and the Pacific, by Arkell and by Imlay.

sensitivity also may explain the rarity of Trigoniidae in Arctic regions in the Lower Jurassic, when other faunas such as ammonites were little differentiated. The Arctic Lower Jurassic occurrences comprise only *Vaugonia* spp. from the Toarcian of the Canadian Arctic Islands, Richardson Mountains of the District of Mackenzie, Siberia, East Greenland and Spitzbergen, and *Prosogyrotrigonia*(?) sp. from the Hettangian of the northern Yukon (Frebold and Poulton, 1977). A further example of similar biogeographic restriction may be the rarity of Trigoniidae in seas dominated by *Buchia* species in the post–Lower Oxfordian Upper Jurassic of North America north of Texas.

Biostratigraphic occurrences of North American Jurassic trigoniid bivalves

The stratigraphic and geographic occurrences of trigoniid-bearing rocks in western Canada and the United States are discussed briefly in this section (see also Textfigs. 1–3). Age assignments for units that have provided trigoniids are documented briefly if they are new. References are given to previous authors' assignments either below or in the pertinent columns in Textfigure 1. However, it is not the purpose of this essentially paleontological report to discuss detailed stratigraphy and correlation of particular regions; such discussions are available in the literature cited for each region. Unless otherwise mentioned, the fossils from Canadian localities were identified and dated by H. Frebold, except trigoniids, which were identified by the writer. The ages and biostratigraphic ranges of most of the trigoniids are based primarily on collections that either contain diagnostic ammonites in direct association or are correlated with reasonable confidence with ammonite-bearing beds. Ages for certain units otherwise undated, or isolated localities are proposed on the basis of the trigoniids they contain. Detailed locality data are given in the appendix.

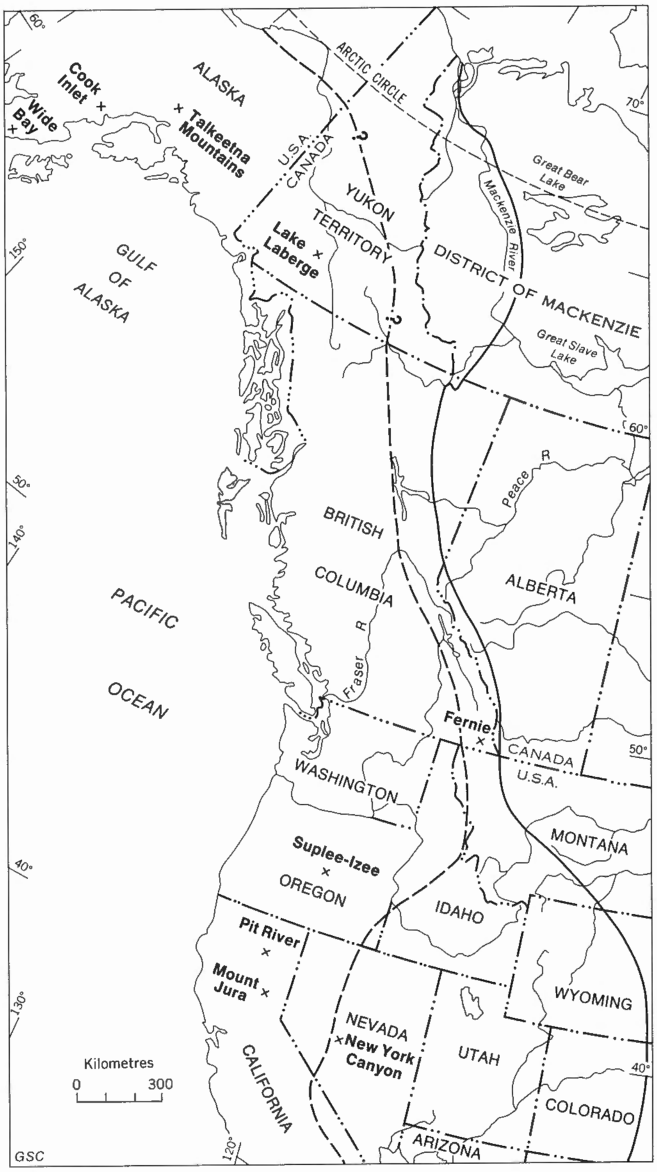
Hettangian

Trigoniid bivalves are known in the Hettangian from only a few localities and either the familial identification or the age determination is questionable in each case. Bivalves that resemble *Prosogyrotrigonia inouyei* (Yehara) occur with *Psiloceras (Caloceras)* sp. cf. *P. (C.) johnstoni* (Sowerby) in Lower Hettangian beds of northern Yukon Territory (Frebold and Poulton, 1977). Several other, as yet undescribed, occurrences of *Frenguelliella* spp. in the lower parts of the Hazelton Group of north-central British Columbia are questionably dated because ammonites are absent or of poor quality, but may be Hettangian.

Sinemurian

The Sunrise Formation of New York Canyon, Gabbs Valley Range, Nevada, has yielded several trigoniid specimens, which were located in the collections of the late S. Wm. Muller of Stanford University. The stratigraphic occurrences of the trigoniids, which represent several species, were interpreted by the writer from labels bearing field locality numbers. A juvenile specimen of *Frenguelliella*? sp. D was found with basal Sinemurian ammonites in Unit 6 of Muller and Ferguson (1939, p. 1611, 1612; label bears field no. 714-B). *Vaugonia* sp. cf. *V. vancouverensis* Poulton, *Frenguelliella* sp. C and *Jaworskiella siemonmulleri* n. sp. are associated with *Eoderoceras* Spath of Late Sinemurian age (map-unit 8 of Muller and Ferguson, 1939, p. 1612; also Imlay, 1968). *Trigonia* sp. A. aff. *T. hemisphaerica* Lycett occurs either in the same bed or in the slate unit below it (Stanford label bears field no. 714C-D).

Crickmay (1930b) mentioned '*Trigonia*' sp. in the Lower Jurassic, possibly Sinemurian (see Frebold and Tipper, 1969) Ntlakapamux Formation of the Ashcroft area, British Columbia, but this occurrence has not been subsequently documented. *Trigonia littlei* Frebold has been described



Major area (mentioned in text) .... ×

Eastern limit of Cordilleran tectonic belt .... ——

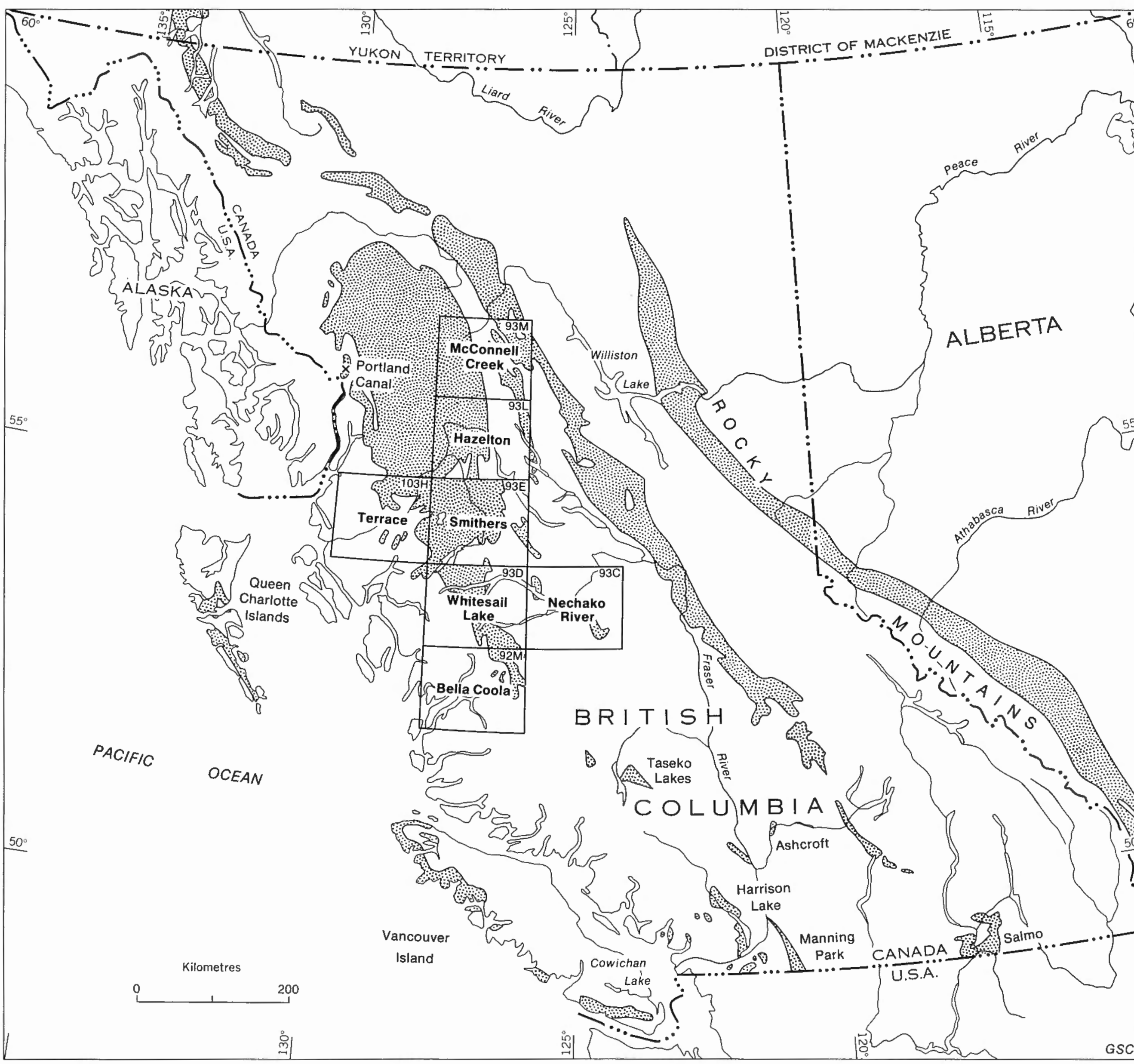
Approximate eastern limit of Jurassic sediments characterized by abundant associated volcanic rocks .... — —

Textfigure 2. Index map of western Canada and United States showing major areas mentioned in text. Areas in British Columbia are shown on Textfigure 3.

from Lower Sinemurian beds of Salmo map area (Frebold, 1959; Frebold and Little, 1962). Beds with the Early Sinemurian ammonite *Coroniceras* in Taseko Lakes map area (Frebold and Tipper, 1969 and references therein) contain *Frenguelliella* sp., which is as yet undescribed.

Poorly preserved and undeterminable ammonites that may be Sinemurian have been identified recently by H. Frebold from Lower Jurassic beds in the Cowichan Lake area of southern Vancouver Island. The same beds also yielded *Frenguelliella* sp. A described in this report and *Vaugonia* sp. cf. *V. coatesi* Poulton (1976). The tentative Toarcian dating by Poulton (1976) for the *Vaugonia* species therefore must be further questioned and the precise age of these beds remains undetermined. This reiterates the possibility that *Vaugonia coatesi* Poulton and associated faunas in Manning Park of southwestern British Columbia may be Sinemurian rather than Toarcian. Both ages have been proposed on the basis of poorly preserved ammonites and the general association (see discussion by Poulton, 1976).

Poorly dated, but probably Sinemurian, beds of the Hazelton Group in Telkwa Range of Smithers map area (GSC loc. 85424) have yielded *Frenguelliella* sp., which is undescribed as yet. Other beds in the lower part of the Hazelton Group of north-central British Columbia have yielded *Frenguelliella* spp. and *Vaugonia*(?) sp., and may



Textfigure 3. Index map of British Columbia. Stippled parts indicate areas totally or partly underlain by Jurassic sedimentary or volcanic rocks. (Modified from GSC Map 1250A.)

be Sinemurian, but most of these are not well dated because diagnostic ammonites are absent. One of these localities, however, contains Late Sinemurian *Arctoasteroceras* sp. These trigoniid specimens are not yet described. The Nilkitkwa Formation of the Hazelton Group (=lower volcanic division of Poulton, 1974) on Frypan Peak, Bait Range in Hazelton map area (GSC loc. 90981) yielded *Vaugonia* sp. aff. *V. oregonensis* n. sp. (Pl. 10, figs. 20–22) associated with *Weyla* spp. and indeterminate ammonites that are possibly *Leptechioceras* and tentatively dated as Late Sinemurian (identified by H. Frebold). Lower Jurassic beds of Nechako River area at GSC locality 20117 are dated tentatively as Late Sinemurian because of the presence of *Jaworskiella siemonmulleri* n. sp. These specimens await description.

Lower Sinemurian beds with *Arnioceras* sp. (Lees, 1934, p. 46, Pl. VI, figs. 5–8) in the Laberge area of southern Yukon have yielded *Frenguelliella* sp. B., which is refigured in this report (Pl. 1, fig. 10).

Pliensbachian

Upper Pliensbachian beds of the Suplee Formation of Oregon (Imlay, 1968; GSC loc. 89405, USGS locs. 26732, 27359, 27361, 28372) have yielded a few specimens of *Vaugonia oregonensis* n. sp. The lithology associated with *Myophorella supleiensis* n. sp. (Calif. Acad. Sciences loc. 300) suggests that this species occurs in the same Upper Pliensbachian beds of the Suplee Formation. Both species are described in this report.

The so-called Pliensbachian-Toarcian Greywacke Unit of northwestern Vancouver Island (Jeletzky, 1954, 1970) contains *Vaugonia jeletzkyi* Poulton, *V. vancouverensis* Poulton, *Trigonia* sp. and *Psilotrigonia canadensis* Poulton (Poulton, 1976). This unit also contains the Early Pliensbachian ammonite *Fanninoceras* McLearn as well as poorly preserved *Protogrammoceras* and *Fuciniceras*, identified by H. Frebold and dated by him as Late Pliensbachian. The earlier determinations of these ammonites as *Grammoceras*? were discussed by Jeletzky (1970, p. 15).

Pliensbachian beds of southern Alaska recently have yielded a few specimens, as yet undescribed and unfigured, similar to *Vaugonia jeletzkyi* Poulton.

Toarcian

Several poorly preserved and still unstudied trigoniid species occur in the Hardgrave Formation of Mount Jura area, central California (Hyatt, 1892; Crickmay, 1933; McMath, 1966). The Toarcian (i.e., Late Lias) dating of this formation accepted in the present report is that of Hyatt (1894; see also Imlay, 1952).[1]

Vaugonia coatesi Poulton (1976) is common in a unit in the eastern Jurassic facies belt of the Ladner Group of Manning Park, British Columbia (see Frebold et al., 1969; Coates, 1974; Poulton, 1976). The unit was dated by the association of belemnites and *Weyla* sp., both identified by the writer, and it also contains *Grammoceras*? sp., which H. Frebold identified and dated as probably Toarcian (Poulton, 1976). An earlier Sinemurian dating based on a poorly preserved arietitid ammonite (Coates, 1974, p. 22) for one collection (GSC loc. 69415) from this unit was assumed by the writer (Poulton, 1976) to be erroneous. It now must be reconsidered, however, in view of the recent discovery of probable Sinemurian ammonites with *V.* sp. cf. *V. coatesi* in Vancouver Island (see section on Sinemurian). Undescribed, poorly preserved juvenile *Myophorella*? sp. indet. that are associated with *Grammoceras*? along Lookout Road of Manning Park (Jeletzky, 1972, 1973) may be Toarcian, according to H. Frebold's dating of the ammonites.

Probable Middle and Upper Toarcian rocks of the Ankwill[2] and Bait members of the Hazelton Group of Bait Range in Hazelton map area of British Columbia (upper volcanic and sedimentary divisions of Poulton, 1974) contain undescribed *Trigonia* sp. and *Myophorella* sp. Associated ammonites include *Phymatoceras* and *Peronoceras*, identified by H. Frebold. Trigoniid bivalves occur in other Toarcian localities of the Hazelton Group in Smithers and adjacent map areas, but these are as yet unstudied.

Vaugonia sp. cf. *V. coatesi* Poulton occurs in Cowichan Lake map area (GSC loc. 89090) of southern Vancouver Island and was tentatively assigned a Toarcian age because of its similarity with *V. coatesi* of Manning Park (Poulton, 1976). Associated species include *Frenguelliella* sp. aff. *F. inexspectata* (Jaworski) and *Weyla* sp. Recently discovered poorly preserved ammonites indicate that these rocks may be Sinemurian.

The Kialagvik Formation of the Wide Bay area, southern Alaska contains *M. alaskaensis* n. sp., *M. tuxedniensis* n. sp. and other undescribed trigoniid species in the Upper Toarcian *Hammatoceras* beds.

Single specimens of *Vaugonia* sp. aff. *V. literata* (Young and Bird) have been found in Middle Toarcian beds of the Jaeger Formation of Ellesmere Island and in probable Toarcian or Lower Bajocian beds of the Bug Creek Formation in the northern Richardson Mountains of Northwest Territories.

Other Lower Jurassic occurrences

Poorly preserved specimens possibly referrable to either *Frenguelliella* or *Trigonia* occur in imprecisely dated, probably Lower Jurassic, rocks near Sproat Lake, Vancouver Island (see Muller and Carson, 1969), but are not yet described.

Several poorly preserved and still unstudied trigoniids from Manning Park, British Columbia occur, without associated ammonites, in a 1.5 m thick bed of conglomerate between an undated volcaniclastic unit of the Ladner Group near the Naturalist Hut on Lookout Road and nearby argillaceous rocks to the north. These argillaceous rocks were dated tentatively as (?)Sinemurian (Jeletzky, 1972). Jeletzky (1973) suggested that the trigoniids are Early

[1]If the Hardgrave Formation is no older than Toarcian, neither is it late in the Toarcian because Batten and Taylor (1978, J. Paleontol., v. 52, p. 208, 209) report the Lower Jurassic bivalve *Plicatostylus* in the probably younger Thompson Formation from the same area (see Textfig. 1).

[2]Spelling corrected from 'Ankwell' (Tipper and Richards, 1976) to coincide with geographic feature 'Ankwill Creek'.

Pliensbachian in age. In the present writer's opinion, the trigoniids, including *Vaugonia* sp., *Scaphotrigonia*(?) sp. and *Myophorella* sp. cf. *M. yellowstonensis* Imlay, show close affinities with Middle Jurassic faunas (see 'Other Middle Jurassic occurrences').

Bajocian

Myophorella argo (Crickmay), *M. yellowstonensis* Imlay, *M.* sp. aff. *M. dawsoni* (Whiteaves), *Orthotrigonia*(?) sp., and *Trigonia* sp. B. aff. *T. hemisphaerica* Lycett occur in the Bajocian Mormon Formation (USGS locs. 525, 2423, 2425a) of Mount Jura, central California. The unit was dated by Hyatt (1894; see also Imlay, 1952).

The Potem Formation of Pit River area, Big Bend map sheet, northern California, studied by Sanborn (1960), contains *Vaugonia* sp. cf. *V. kobayashii* Alencaster, *V.*(?) sp. cf. *V.*(?) *yukonensis* n. sp., *Myophorella yellowstonensis* Imlay, other poorly known species of *Myophorella*, possibly *Orthotrigonia*(?) sp. and *Trigonia* sp. (i.e., *Trigonia* sp. cf. *T. denticulata* Agassiz of Sanborn, 1960). The trigoniids, as well as the other bivalves and brachiopods, were dated, probably correctly, by Sanborn (1960) as Bajocian on the basis of their similarity with British forms. A collection from USGS locality 1013, labelled 'probably Lower Jurassic, Sinemurian', is thought to be Bajocian by the present writer.

The Middle Bajocian Weberg Formation of Oregon (Lupher, 1941; Dickinson and Vigrass, 1965; Imlay, 1973) contains abundant specimens of *Trigonia* sp. and *Myophorella* sp., both forms unstudied, as well as rare specimens of *M. freboldi* n. sp., *M.* sp. cf. *M. argo* (Crickmay) and *Vaugonia* sp. cf. *V*(?) *yukonensis* n. sp., which are described in this paper.

Trigoniids are abundant in the Bajocian through Callovian (undifferentiated) Carmel Formation and equivalent units of Montana, Wyoming, South Dakota and Idaho (Crickmay, 1936; Imlay 1964a; Wright, 1973). They include *Trigonia americana* Meek, *T. elegantissima* Meek, *T.* sp. indet., *Vaugonia conradi* (Meek and Hayden), *V.* sp. aff. *V. conradi*, *V. utahensis* Imlay, *Myophorella montanaensis* (Meek) and *M. yellowstonensis* Imlay; the last species apparently is restricted to Bajocian rocks in the United States (Imlay, 1964a).

The Lower to Middle Bajocian Gypsum Springs Formation of Wyoming (Imlay, 1952) contains *Orthotrigonia*(?) *sohli* n. sp. (USGS loc. 19357).

Vaugonia utahensis Imlay and *Myophorella montanaensis* (Meek) are known from the poorly dated, but probably Bajocian Lower Member of the Shaunavon Formation of southwestern Saskatchewan (Paterson, 1968).

The Middle Bajocian Rock Creek Member of the Fernie Group in southwestern Alberta and southeastern British Columbia has yielded several unstudied trigoniid species as well as *Myophorella trafalgarensis* (Warren, 1932), which is represented by poorly preserved and specifically unidentifiable specimens. Middle Bajocian beds of the Lodgepole area, southeastern British Columbia (see Frebold, 1976) contain *M. argo* (Crickmay) and *M.* sp. aff. *M. dawsoni* (Whiteaves).

Juvenile and poorly preserved specimens of *Myophorella* sp. occur in the probably Bajocian Harrison Lake Formation of Harrison Lake area, British Columbia (Crickmay, 1930a, 1962).

Several specimens representing a new, as yet unstudied, species of *Vaugonia* occur with Late Bajocian *Spiroceras* sp. (identified by H. Frebold) in the Nicola Lake area of southern British Columbia.

Middle Bajocian rocks of Lookout Road area, Manning Park, British Columbia (Jeletzky, 1972, 1973; Coates, 1974) yield *Myophorella* sp. aff. *M. montanaensis* (Meek).

Myophorella argo (Crickmay) is common in the Middle Bajocian Opuntia Formation of the Ashcroft area, British Columbia (Crickmay, 1930b; GSC loc. 89468) where Crickmay also recorded *Vaugonia* sp. This last form has not been observed by the present writer.

Lower Bajocian rocks of Smithers and nearby map areas that contain *Tmetoceras* and *Erycites* have yielded *Myophorella tipperi* n. sp. and undescribed species of *Myophorella* and *Trigonia.* Middle Bajocian rocks of Smithers, Whitesail Lake and Hazelton map areas contain rich trigoniid faunas, including *Trigonia guhsani* McLearn, *T.* spp., *Myophorella dawsoni* (Whiteaves), *M. argo* (Crickmay), *M. freboldi* n. sp., *M. yellowstonensis* Imlay, *M. tipperi* n. sp., *M. tuxedniensis* n. sp., *M.* sp. C, *Orthotrigonia*(?) sp. and *Vaugonia* spp. The Middle Bajocian rocks are crudely divisible into three zones characterized by the ammonites *Sonninia, Sonninia* with *Stephanoceras* and *Witchellia*, and *Stephanoceras,* in upward succession. The trigoniid faunas in each of these zones are not distinguishable at present.

Probable Bajocian beds, which, however, are not certainly dated (Frebold and Tipper, 1973) at Tenas Creek have a basal unit with abundant small specimens of *Vaugonia*(?) sp.

Whiteaves' (1878a) original description of *Trigonia* (i.e. *Myophorella*) *dawsoni* was based on collections by G.M. Dawson from Bella Coola map area, British Columbia. These trigoniids apparently were not associated with diagnostic ammonites. However, *Myophorella dawsoni* (Whiteaves) is known now to be characteristic mainly of Middle Bajocian rocks of the Hazelton Group. Furthermore, only the Middle Bajocian ammonite *Stephanoceras* has been found in Jurassic rocks of the Iltasyuko River area, which yielded Whiteaves' (1878a, b) original specimens of *M. dawsoni* (see also Baer, 1966).

Vaugonia(?) *yukonensis* n. sp., *V.* sp. cf. *V.*(?) *yukonensis, Myophorella* sp. aff. *M. freboldi* n. sp. and *Trigonia* sp. occur in the upper part of the Laberge Group of southern Yukon Territory (GSC locs. C-18178, C-18179; Tempelman-Kluit, 1974). Their similarity with British Middle Bajocian species probably indicates a similar age for the unit which contains them (Poulton, in Tempelman-Kluit, 1974). *Myophorella* sp. B occurs in Upper Toarcian or Lower Bajocian (Aalenian) beds of the Laberge Group (GSC loc. 83477). These beds were dated by J.A. Jeletzky based on the presence of the belemnite *Pseudodicoelites* sp.

Middle Bajocian beds of the Yakoun Formation of Queen Charlotte Islands (Sutherland Brown, 1968) have yielded a few poorly preserved, as yet unidentified, specimens of *Myophorella.*

Lower and Middle Bajocian beds of the Tuxedni Group of Cook Inlet, southern Alaska (i.e., Red Glacier through Twist Creek formations; Detterman and Hartsock, 1966; Imlay, 1964b) contain *Myophorella tipperi* n. sp. and *M. tuxedniensis* n. sp. The Red Glacier Formation contains *Myophorella alaskaensis* n. sp. and *M. argo* (Crickmay). This formation has yielded ammonites indicating Late Toarcian through Middle Bajocian ages (Detterman and Hartsock, 1966). *Myophorella tipperi* n. sp. and *M. montanaensis* (Meek) occur in Middle Bajocian beds of the formation. The Gaikema Sandstone contains *M. argo* (Crickmay), *M. dawsoni* (Whiteaves) and *Vaugonia imlayi* n. sp. as well as Middle Bajocian ammonites, including *Sonninia, Stephanoceras* and *Chondroceras* species. The following USGS trigoniid-bearing localities occur in eastward succession on the south shore of Tuxedni Bay in a section that was described by Stanton and Martin (1905), Martin and Katz (1912) and Martin (1926, p. 142), and subsequently restudied by Imlay (1964b) who redescribed certain of the localities: 3002, 2999, 2996, 10512, 2994. The numbers of beds designated in the detailed locality descriptions in the appendix refer to positions in the section of Martin (1926). The base of the section is about 3.2 km (2 mi) west of Fossil Point; the top is at Fossil Point. The ammonite determinations from this section are taken from Imlay (1964b) and indicate a Middle Bajocian age. Martin (1926) referred the whole section to the Tuxedni Sandstone; it can now be subdivided apparently into Cynthia Falls and Fitz Creek formations faulted against Red Glacier Formation (Detterman and Hartsock, 1966; Detterman, 1963). The formation designations and the eastward succession of localities designated above are taken from Imlay (1964b). They do not agree entirely with the stratigraphic succession indicated by Martin (1926, p. 142).

Myophorella sp. cf. *M. argo* (Crickmay) occurs in the Middle Bajocian *Parabigotites* beds of the Kialagvik Formation of Wide Bay area, southern Alaska (Westermann, 1969).

Bathonian

Some of the trigoniids in the Carmel Formation of Utah and equivalent rock units elsewhere in the western interior of the United States may be Bathonian (see section on 'Bajocian'; Wright, 1973). The Carmel Formation, however, is not readily divisible biostratigraphically (Imlay, 1964a) and definite Bathonian fossils have not been identified. Upper Bathonian or Callovian beds of the Fernie Group of the southern Canadian Rocky Mountains (Frebold, 1957) contain *Myophorella montanaensis* (Meek) (see section on 'Callovian').

Bathonian rocks of Smithers map area, British Columbia, described by Frebold and Tipper (1973; GSC locs. 85409, 85444), contain *Myophorella montanaensis* (Meek).

Recent restudy of certain ammonites from middle and upper parts of the Bowser Formation of southern Alaska by R.W. Imlay (pers. com., 1977) has led him to reinterpret their ages as Bathonian rather than Callovian, as they were formerly dated (see following section). These Bathonian or probably Bathonian beds of Iniskin Bay area and equivalent beds in Talkeetna Mountains (USGS locs. 2919, 3034, 3038, 20764, 24118) contain abundant *Vaugonia doroschini* (Eichwald) and *Myophorella devexa* (Eichwald), and less commonly *Myophorella* sp. cf. *M. orientalis* Kobayashi and Tamura. However, some confusion still exists concerning the precise biostratigraphic distribution of these species, because the locality data of many of the older collections are imprecise and there are no ammonites associated with them in the collections.

Callovian

The Callovian Foreman Formation of Mount Jura, California (USGS loc. 3143) contains *Myophorella* sp. and *Scaphotrigonia* sp. aff. *S. naviformis* (Hyatt). *Vaugonia obliqua* (Hyatt), *Anditrigonia plumasensis* (Hyatt) and *Scaphotrigonia naviformis* (Hyatt) occur in the Mount Jura area in the Callovian Bicknell Sandstone (USGS loc. 9258) which McMath (1966) included within the Hinchman Formation. The ages of the formations were established by Hyatt (1894; and in Diller, 1908), Crickmay (1933) and Imlay (1952, 1961a), and were reviewed by Imlay (1961a).

Vaugonia sturgisensis (Whitfield and Hovey) occurs in Callovian to Oxfordian beds of the Sundance Formation in Wyoming and South Dakota (Whitfield and Hovey, 1906; Imlay, 1964a; Wright, 1973). Other Callovian trigoniids from the western interior of the United States are listed separately in the section on 'Bajocian'. The present writer has identified *Scaphotrigonia*(?) sp. in Callovian beds of the Ellis Group in Montana (Imlay, 1962a).

Trigonia americana Meek and *Myophorella montanaensis* (Meek) occur in the Callovian Lower Member of the Vanguard Formation of southern Saskatchewan; *M. montanaensis* (Meek) occurs also in the Callovian(?) Upper Member of the Shaunavon Formation (Paterson, 1968).

The Upper Bathonian or Lower Callovian *Corbula munda* beds and the Lower Callovian *Gryphaea* bed of the Fernie Group in southwestern Alberta (Frebold, 1957) contain abundant *M. montanaensis* (Meek) (which is interpreted to include '*Trigonia ferrieri*' McLearn) and other less well preserved *Myophorella* species. Localities yielding these faunas are already well known (Frebold, 1957, 1963; McLearn, 1929b) and also include GSC localities 6586 and 89471–89501 described in the appendix of this paper.

The Billhook Formation of Harrison Lake area, British Columbia, probably Middle or Upper Callovian to Lower Oxfordian (Crickmay, 1930a, 1962; Frebold and Tipper, 1967; Brookfield, 1973), has yielded *Myophorella billhookensis* (Crickmay), *M. packardi* (Crickmay) (taken to include '*Haidaia*' *statluensis* Crickmay), *Anditrigonia plumasensis* (Hyatt) and *Vaugonia* sp. aff. *V. doroschini* (Eichwald). Ammonites in the Billhook Creek section of Crickmay (1930a, 1962) are indeterminate 'cadoceratoids'; those submitted by the writer to H. Frebold were similarly indeterminate, as were those mentioned by Frebold and Tipper (1967). Poorly preserved *M.* sp. cf. *M. packardi* also occurs in the uppermost (Callovian) part of the immediately underlying Mysterious Creek Formation.

Myophorella packardi (Crickmay) occurs in Middle Callovian beds near Lorna Lake, Taseko Lakes map area, southwestern British Columbia. The associated ammonites were described by Frebold and Tipper (1967).

The Callovian stage is well represented in Smithers and nearby areas of west-central and northwestern British Columbia. Only the Lower Callovian rocks, containing *Kepplerites* and other ammonites, have a rich shelly fauna, which includes *Myophorella devexa* (Eichwald), *Anditrigonia plumasensis* (Hyatt) and *Scaphotrigonia naviformis* (Hyatt) as well as other trigoniids not yet studied. Succeeding beds have yielded *Pseudocadoceras, Cadoceras, Lilloettia* and other ammonites, and the youngest (Upper) Callovian beds are characterized by *Quenstedtoceras (Lamberticeras)* and other ammonites described by Frebold and Tipper (1975). Probable, but not definitely dated, Callovian rocks on Grouse Mountain south of Smithers contain *Myophorella* sp. aff. *M. dawsoni* (Whiteaves) and *M. yellowstonensis* Imlay. Beds without diagnostic fossils, but in an area of Whitesail Lake map area yielding only the Callovian ammonite *Kepplerites,* contain *Myophorella* sp. A (GSC 13756). Ammonites in this area had been wrongly identified previously as *Stephanoceras* (McLearn, in Duffell, 1959, p. 52) according to H. Frebold (pers. com., 1974).

Some of the beds of the Bowser Formation[1] and equivalent rocks of southern Alaska, previously thought to be Callovian (see Imlay, 1953, 1962a; Detterman, 1963; Detterman and Hartsock, 1966), are now assigned to the Bathonian Stage (R.W. Imlay, pers. com., 1977; see preceding section). Those beds of the upper part of the Bowser Formation and the Chinitna Formation of the same area that are Callovian or probably Callovian contain *Vaugonia doroschini* (Eichwald), *Myophorella packardi* (Crickmay), *M. orientalis* Kobayashi and Tamura, *M. devexa* (Eichwald) and *M.* sp. aff. *M. dawsoni* (Whiteaves). Designation of zones in the detailed locality descriptions referring to these occurrences refers to the section of Martin and Katz (1912, p. 61, 62), Martin (1926, p. 145) and Moffit (1927, p. 13).

Lower and possibly Middle Callovian beds of the Yakoun Formation in Queen Charlotte Islands (McLearn, 1949; Sutherland Brown, 1968) contain *M. devexa* (Eichwald)—taken to include *M. charlottensis* (Packard)—and *M. packardi* (Crickmay).

Other Middle Jurassic occurrences

Crickmay (1930b) described *Vaugonia veronica* and *V. mariajosephinae*, which are considered herein to be synonymous, from Middle Jurassic beds of the Salmon River district, near the head of Portland Canal, northwestern British Columbia. Crickmay's age determination appears to have been based on the trigoniids and has not been otherwise substantiated (see McLearn, in Hanson, 1935). The fossils occur in the basal part of the Hazelton Group at Divide Lake.

Lower Oxfordian

Vaugonia sturgisensis (Whitfield and Hovey) occurs in Callovian to Oxfordian beds of the Sundance Formation in Wyoming and South Dakota (Whitfield and Hovey, 1906; Imlay, 1964a; Wright, 1973).

Several species of trigoniid bivalves occur in the Billhook Formation of Harrison Lake area, southwestern British Columbia, which includes Lower Oxfordian as well as Callovian beds, according to Brookfield (1973). They are listed in the section on 'Callovian'.

Lower Oxfordian rocks of the Bowser Lake Group in Smithers, Terrace, and Hazelton map areas, characterized by species of the ammonite *Cardioceras* (Frebold and Tipper, 1975), contain *Myophorella devexa* (Eichwald) and *Anditrigonia plumasensis* (Hyatt) (GSC locs. 23485, 85395). Lithologically distinctive beds in the Bowser Lake Group (i.e., 'Trout Creek beds' of Richards and Jeletzky, 1975) in Smithers map area are rich in *Myophorella devexa* (Eichwald) and *Vaugonia doroschini* (Eichwald) and have yielded *Cardioceras* at one locality (T. Richards, pers. com., 1974).

Late Jurassic occurrences younger than Early Oxfordian

Myophorella sp. aff. *M. devexa* (Eichwald) occurs rarely with Late Oxfordian or Early Kimmeridgian *Buchia concentrica* (Sowerby) in the Relay Mountain Group of Taseko Lakes area of southwestern British Columbia. Unstudied specimens of trigoniids occur with mid-Kimmeridgian to Early Portlandian *Buchia mosquensis* (Buch) and with Late Oxfordian to Early Kimmeridgian *B. concentrica* in the Dewdney Creek Group of Manning Provincial Park, southwestern British Columbia (see Jeletzky, in Coates, 1974, p. 139, 150). *Vaugonia doroschini* (Eichwald) is described in this report from Oxfordian or Kimmeridgian *Buchia*-bearing beds of the Naknek Formation of southern Alaska. No other trigoniids have been reliably documented, to the writer's knowledge, in post–Lower Oxfordian Jurassic beds in Canada or in the United States north of Texas. The Lower Kimmeridgian to Upper Tithonian Malone Formation and equivalent beds in Texas and Mexico have yielded several trigoniid species, however, which have been described by Cragin (1897, 1905), Stoyanow (1949), Imlay (1940, 1945) and Alencaster and Buitron (1965).

Essential features of trigoniid morphology

The most important characteristics of the trigoniid shell for taxonomic and biostratigraphic purposes are the general size, shape and convexity of the shell, the direction of coiling of the umbo, and the nature of the ornamentation of the outer surface. These last features include mainly the strength, spacing, orientation, degree of curvature, ornamentation and ontogenetic change in the nature of the costae. The nature of the shell structure, the hinge

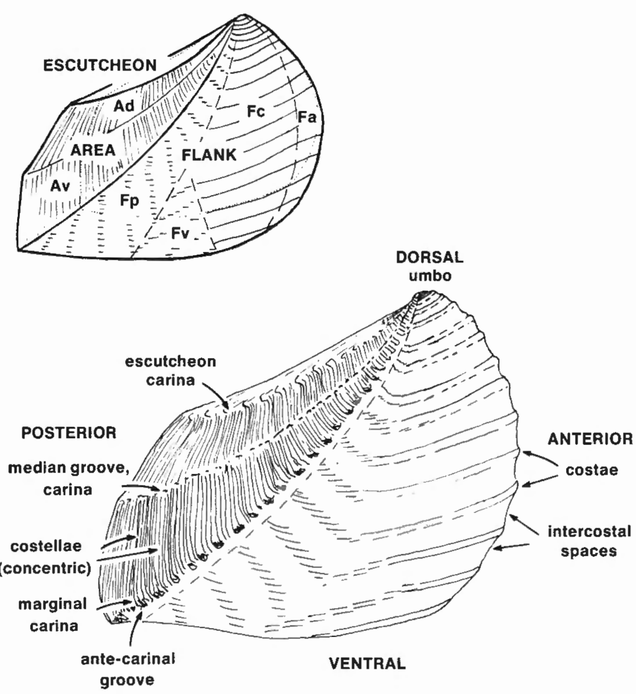
[1]The reader is cautioned not to confuse the Bowser Formation (Bathonian and Callovian) of Cook Inlet region, southern Alaska, with the entirely different unit of similar name (Bajocian through Lower Kimmeridgian) in northwestern British Columbia. The former unit was named the Bowser Member by Kirschner and Minard (1949) and raised to formation rank by Detterman (1963). For the latter unit, the name Bowser Group was first used in print by Duffell and Souther (1964, p. 24, 27). The name has been revised to Bowser Lake Group, and its boundaries defined, by Tipper and Richards (1976; see Textfig. 1 of this paper).

structure and the internal muscular impressions are of little value for taxonomy or biostratigraphy at present because they appear to be identical or similar in most forms, their variation in different groups is not well known, and insufficient well preserved material is available for representative study.

Trigonia, Recent *Neotrigonia,* the Triassic radially costate forms such as *Minetrigonia* and a few other genera are unusual among trigoniids in having differently sculptured left and right valves. The left valve of *Trigonia* has a strongly marked antecarinal groove and the right valve has a postcarinal groove of similar aspect. Thus, the two valves, at the plane of commissure, interlock with the posteroventral small extension of the marginal carina fitting the groove of the other shell.

General features of the external shell surface

The following description concerns only those features that are necessary for understanding the relatively complex terminology that has developed for trigoniid shells, and that are used in the descriptions of species and diagnoses of genera and subfamilies. The present writer has adopted the terminology used by Cox (1969), except where it is inadequate for his purpose.

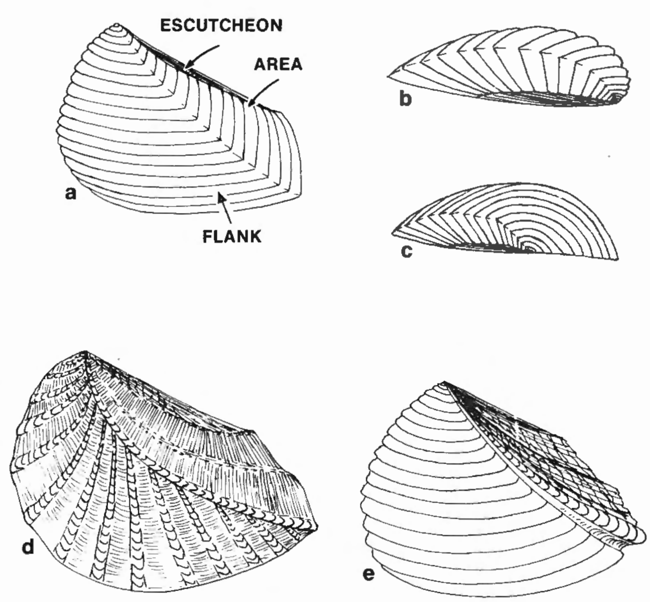


Textfigure 4. Generalized sketches of representative right valves of the genus *Vaugonia* Crickmay, showing external morphological terms used. Regions of shell: Ad, dorsal half of area; Av, ventral half of area; Fp, posterior part of flank with costal segments oblique and sloping anteroventrally relative to the radial direction; Fc, central part of flank with costal segments concentric with growth lines; Fv, ventral part of central region of flank, where costal segments are broken up and are realigned obliquely, sloping posteroventrally; Fa, anterior part of flank with costal segments that cut across growth lines and meet anterior margin at high angles (the costae are 'pseudoconcentric'); a representative growth line is shown by fine dotted line.

The external surface of the shell of most trigoniids is divided along radial loci into three regions: the escutcheon, the area and the flank (see Textfigs. 4, 5 for all morphological terms). The flank is further subdivided into an anterior part (Fa of Textfig. 4) and the remainder of the flank. These various regions may be separated only indistinctly, or they may be separated by distinct edges, or by other features such as ridges (carinae), rows of tubercles, or grooves. A 'median carina' also may occur in the centre of the area. A groove may be anterior to the marginal carina, posterior to it (in the right valve of *Trigonia*), or in the centre of the area. Grooves generally accompany sinuses on the ventral margin of the shell; carinae may or may not accompany small protuberances of the shell margin.

The proportion of the shell surface occupied by the different regions varies considerably among major taxa. *Psilotrigonia,* for example, has no structure that can be termed a distinct escutcheon. Representatives of the subfamilies Megatrigoniinae and Pterotrigoniinae exhibit narrow and, in some cases, indistinctly defined areas. The differentiation of the shell surface is obscure in forms where the same style of ornament covers the entire shell and where the carinae are not well developed, as for example in the Cretaceous genera *Quoiecchia* and *Setotrigonia.*

The area shows considerable variation in ornamentation, and this is used herein for differentiation of the major



Textfigure 5. Some major styles of trigoniid ornamentation, shown in generalized sketches of representative genera. (a, b, c) Simple concentric style as in primitive species of *Frenguelliella* Leanza. The costae abut the anterior margin: (a) lateral view of left valve showing the three major regions of the shell; (b) posterodorsal view of left valve; (c) dorsal view of left valve; (d) obliquely costate flank and concentrically costate area, as in genus *Myophorella* Bayle, left valve; (e) concentrically costate flank and cancellate area, as in genus *Trigonia* Bruguière, left valve. The antecarinal groove of the left valve corresponds to the marginal carina of the right valve, interlocking with it at the plane of commissure.

taxa of Trigoniidae. The simplest ornamentation consists solely of fine growth lines. These commonly are somewhat irregular and in some forms are rugose. The area of many forms, particularly in early growth stages, is covered with concentric[1] costellae, which are fine ridges, regular in their form and spacing. Most concentrically costellate trigoniids have some sort of median ornament running lengthwise down the centre of the area. It may be simply a median groove which interrupts the costellae or growth lines only slightly or not at all, or it may be a slight ridge (median carina) or row of small nodes. Where they are interrupted by a median carina, the ends of costellae commonly enlarge and sometimes unite to form two rows or irregularly shaped varices, one on either side of the median groove. In many cases these rows of varices are nearly identical with those on the escutcheon carina.

The concentrically costellate pattern of the area, which characterizes the subfamily Myophorellinae, exhibits superimposed transverse or oblique costellae in Cretaceous representatives and in other groups inferred to be derived from them.

In primitive forms, such as some *Frenguelliella* species, the nodes on the marginal carina, as well as the costellae of the area, are simple continuations of costae of the flank.

Other ornamentation of the area, believed to indicate fundamentally different stocks, are regular oblique costellae as in *Psilotrigonia* (Poulton, 1976); a cancellate pattern of small nodes which represent the intersection of concentric and radial costellae, as in *Trigonia;* and a faint radial striation superimposed on an otherwise nearly smooth surface, as in *Pacitrigonia* (Cox, 1969).

Increased strength or complexity of the ornament of the carinae commonly, but not invariably, accompanies complex ornamentation of the area. In forms where nodes occur on the marginal carina, the nodes commonly are the enlarged ends of certain costellae of the area, and small costellae may extend from the nodes across the escutcheon either perpendicular to, or oblique to, the growth lines.

[1]The term 'concentric' is used in the sense of Thompson (1942) for structures that correspond in orientation to the growth lines. Concentric ornament, for example, is produced by periodic variation, along a uniform mantle edge, in the rate of shell secretion. It generally can be differentiated from growth lines or rugae by its regularity of spacing and strength, which supports the interpretation of an internally controlled physiological, rather than environmental, variation in rate of secretion of shell material. 'Radial' features radiate from the umbo. They are produced by regular or irregular secretion of shell material by a mantle edge that is differentiated along its length into portions with differing secretory rates. 'Oblique' features are oblique with respect to the radial direction. Oblique costae on the flank of trigoniids can cut ventrally across the growth lines toward either the anterior or posterior directions relative to the marginal carina, and thus are termed either 'anteroventrally sloping' or 'posteroventrally sloping', respectively. Anteroventrally sloping costae of *Myophorella packardi* (Crickmay), for example (see also Textfig. 5d), and of the posterior region of the flanks of certain *Vaugonia* species (Textfig. 4) may also become so rotated with increasing growth stages of the shell as to become consistently radial or nearly radial in orientation in late growth stages or, in extreme cases, to slope posteroventrally. Mechanisms for production of oblique structures of the shell are poorly understood. Structures that are 'transverse' to the escutcheon, area, or carinae, cross them nearly at right angles, and are either concentric or oblique in relation to the growth co-ordinates.

The flank, which is the major part of the trigoniid shell and that part most often preserved, shows great variation in the pattern of sculpture. It is nearly smooth or ornamented with growth lines in some groups. Growth rugae are developed in only a few stocks. The major styles of ornament are concentric, radial or oblique costation, or tuberculation, in which case the tubercles are commonly aligned to form oblique costae.

Radial costation is best developed in the Triassic genera *Minetrigonia* and *Myophorigonia* and in Recent *Neotrigonia.* Radially oriented costae can arise ontogenetically on a shell, the juvenile portion of which was occupied by differently oriented costae, as in *Orthotrigonia* (Textfig. 8).

Ontogenetic changes in the style of ornamentation of the flank are commonplace in the Trigoniidae, and provide a useful descriptive tool, coupled with the tendency for the flank to become differentiated along radial loci, into regions that are ornamented differently. These characteristics are emphasized in the specific descriptions in this paper. The significance and descriptive usefulness of ontogenetic changes in sculpture of the flank were appreciated by Crickmay (1930b) in his description of the type species of *Vaugonia;* in this genus these changes are readily apparent (Pl. 10, figs. 1–6). This genus is useful also to illustrate the differentiation of the flank mainly along radial loci, into regions of different sculptural styles (Textfig. 4). There are three major regions, and a fourth subregion in late growth stages of most *Vaugonia* species: posterior region (Fp), central region (Fc), anterior region (Fa), and ventral subregion of mature stage of central region (Fv). These characteristics are described in greater detail in the discussion of the subfamily Myophorellinae.

The earliest recognizable (biostratigraphically) and most long lived example of differentiation of the flank is in the separation of the anterior part of the flank (Fa of Textfig. 4) from the remainder of the flank. Costae which are otherwise concentric follow a straight path over the curve at the anterior end of the shell to the anterior margin, which they meet at nearly right angles. There may be a distinct flexure or a node at the point where they depart from the mainly concentric orientation. The anterior parts of nearly all Trigoniidae representatives exhibit this phyletically early developed and conservative style, although the costation style of the remainder of the flank is extremely varied. This suggests the high taxonomic rank of this characteristic. Radial differentiation of the shell sculpture is much less common in non-trigoniid bivalves, and the style of secretion required to produce each type of ornament is inferred to be physiologically very different, further illustrating its significance.

The anterior portions of costae in many forms are independent features that extend as short costal segments from a row of radially located nodes. These portions of costae are continuous ribs, which are aligned either with oblique costae on the flank or separated from them as dictated by selective pressure for continuity of ribbing. Either of these features is structurally equally simple when these anterior costae are viewed as independent of the costae of the central part of the flank. Thus, the phylogenetic and taxonomic significance of their alignment or nonalignment with oblique costae of the main part of the flank is markedly reduced. It is considered to achieve major taxonomic rank only in its extreme development in *Scaphotrigonia;* it is mainly only a specific, or in some cases an infraspecific, feature. The anterior costal segments are separated from the main oblique costae most commonly in those forms where the latter ribs have rotated extremely from the concentric orientation, in the same way that extreme rotation of the posterior costal segments requires their separation from concentric segments. In most forms, in fact, the primitive constant spacing and style are maintained conservatively in the anterior ornament regardless of the many variations in costation of the main part of the flank.

Maturity of specimens

Many of the large species of tuberculate, obliquely costate Myophorellinae exhibit a striking morphological change in their latest preserved growth stages. Usually, as seen in *M. devexa* (Eichwald), the oblique costae of the flank weaken and swing abruptly anteriorly, becoming concentric or nearly so. In other species, such as *Vaugonia*(?) *yukonensis* n. sp., a style of ornament different from that of the main part of the flank appears in the anteroventral corner at a certain relatively late stage of growth. These features, together with a relative uniformity of maximum sizes in a population, have been taken to indicate maturity of the individual specimens. Stanley (1977, p. 890–892) demonstrated that at least some ontogenetic changes such as these are related to differing rates of burrowing and prevention of sediment scour required as the size and weight of the shell increased with growth. In some of the large, obliquely costate or nodose species, the nearly concentric orientation of costae in the anterior part of the adult shell appears to be a natural and necessary consequence of the radial-concentric geometry of the shell growth (March, 1911, figs. 4, 5, 8a) and may not require a functional explanation.

Quantitative techniques

Because western Canadian and American trigoniids generally are not sufficiently well preserved and undistorted to provide representative quantitative data, comparisons and contrasts of species on a numerical basis were not done routinely; indeed, no problems of taxonomic subdivision or groupings of species were encountered that appeared to require such treatment. Nevertheless, many parameters of trigoniid shells have been quantified by previous authors (see for example Savel'ev, 1958), who have indicated that they are useful descriptive tools.

Systematic paleontology

This section presents descriptions of new and already known North American Jurassic species of Trigoniidae.

Abbreviations are explained on page 59. Question marks preceding locality references indicate that the fossil identification is uncertain. Generic diagnoses are those of the present writer and some are modified considerably from those of previous authors. The descriptive terminology is that used in the Treatise on Invertebrate Paleontology.

Class Bivalvia Linné, 1758 (Buonanni, 1681)
Subclass Palaeoheterodonta Newell, 1965
Order Trigonioida Dall, 1889
Superfamily Trigoniacea Lamarck, 1819
Family Trigoniidae Lamarck, 1819

Diagnosis. The family is characterized and distinguished by its peculiar dentition, which mainly is uniform within the family. A large massive, triangular tooth in the left valve has ventrally diverging sockets on either side. The tooth is split on its ventral side more or less markedly in different groups. The sockets bear even and regular, slightly curved striae which are approximately perpendicular to the plane of commissure. Subordinate elongate teeth occur anterior and posterior to the sockets. Two grooved teeth in the right valve match the sockets of the left.

Discussion. Similar dentition in ancestral Myophoriidae lacks the regularly developed striation of the large teeth and sockets, and has less distinctly and uniformly developed layout of the teeth.

The present writer agrees with the widely held opinion that bivalve hinge structures are conservative evolutionary features of highest taxonomic rank and that external morphology, relatively labile because of its highly adaptive nature, is of lesser importance. Therefore, the proposal of Newell and Boyd (1975) that the complicated trigonian dentition developed by parallel evolution in three different families is not followed in this report. As interpreted here and by Cox (1969), the family Trigoniidae is considered to be defined by its dentition, to be monophyletic, and to include those members of Myophoriidae and Costatoriidae (Newell and Boyd, 1975) that have trigonian dentition.

The conceptual content of the family is essentially that of the genus *Trigonia* as it was used by early writers before a generic classification was achieved.

Subfamily Trigoniinae Kobayashi, 1954

Diagnosis. Radial or intersecting radial and concentric costellae on area. Concentric costae on main part of flank, but they meet anterior margin at high angles in most specimens. If *Pseudomyophorella* Nakano is truly a member of this subfamily, costae of flank vary to oblique.

Distribution. Middle Triassic (Anisian) to Upper Cretaceous, cosmopolitan except for boreal regions.

Discussion. The nature of costellation of the area distinguishes representatives of subfamily Trigoniinae from other mainly concentrically costate genera, such as *Frenguelliella* Leanza. This interpretation is in contrast with those of Cox (1952, 1969) and Savel'ev (1958) but in agreement with that of Nakano (1961, 1970).

Genus *Trigonia* Bruguière, 1789

Trigonia Bruguière, 1789 (in Lebküchner, 1932); Nakano, 1961, 1970; Poulton, 1976.
Trigonia (Trigonia) Cox, 1952, 1969; Savel'ev, 1958.
Lyridon Sowerby, 1823.
Lyriodon Bronn, 1834; Lebküchner, 1932.
Lyrodon Goldfuss, 1837.

Type species. *Venus sulcata* Hermann, 1781 (Crickmay, 1932; Cox, 1952, 1969; Savel'ev, 1958). Upper Lias, Alsace.

Diagnosis. Area with reticulate ornament due to intersecting radial and concentric costellae. Costae concentric on main part of flank but meeting anterior margin at high angles. More or less inequivalve; distinct antecarinal groove in left valve matching marginal carina of right valve where they meet at the plane of commissure; postcarinal groove in right valve. Area, flank and escutcheon distinctly separated. Marginal carina prominent.

Distribution. Middle Triassic (Anisian) to Upper Cretaceous, cosmopolitan except for boreal regions.

Discussion. As defined above, the genus *Trigonia* is a well defined, relatively homogeneous, old and apparently early differentiated group. It includes those species earlier referred to Agassiz's (1840) Costatae Section of Trigoniidae.

Trigonia is relatively well represented in Jurassic collections of North America. The genus has not yet been studied extensively, however, and several species remain undescribed. Generally, the known and undescribed species are uncommon, small and relatively finely ribbed in Lower Jurassic rocks older than Middle Toarcian, but are common, large and more coarsely ornamented in Middle Toarcian through Middle Jurassic rocks. The same appears to be true of English species with which the North American forms are closely allied.

Trigonia sp. A aff. *T. hemisphaerica* Lycett

Plate 1, figures 1, 2

aff. *Trigonia hemisphaerica* Lycett, 1872–1879, p. 174, Pl. 31, figs. 4–8, Pl. 33, figs. 4–6.

Material and occurrence. This species is represented by the single hypotype USNM 219927 from the Sunrise Formation of Nevada. The field number 714C-D (collected by S.W. Muller, Stanford University) indicates that it was obtained from division 8 of Muller and Ferguson (1939, p. 1611, 1612), which also contains *Eoderoceras* Spath. This ammonite genus is Late Sinemurian (Imlay, 1968).

Description. Shell of medium size, subtriangular, with pointed posterior end. Anterior and ventral margins form smooth subovoid curve. Dorsal margin very short. Posterior end strongly reclined umbonally, long, forming acute angle with ventral margin. Shell gently convex.

Marginal carina a sharp, strongly raised ridge. Area depressed relative to it. Area with concentric and radial costellae of equal strength producing reticulate appearance on anteroventral half, but with concentric costellae dominant on dorsal half. Concentric costellae run up onto dorsal side of marginal carina slightly irregularly, suggesting that the smoothness of the marginal carina on the specimen is due to abrasion. Median carina is only a slightly stronger than average radial stria; dorsal to it is a very weak radial groove. Escutcheon carina similar to median carina. Very small, slightly depressed escutcheon.

Flank with distinct but not strong antecarinal groove (left valve). Many very fine but ventrally coarsening concentric costae, which run directly to anterior margin and end abruptly at edge of antecarinal groove.

Discussion. The fine costation of the flank, the low profile and very small escutcheon of this species, together separate it from most other *Trigonia* species. It is similar to the English Bajocian *T. hemisphaerica* Lycett in these characters, which are each slightly more strongly developed in the American form. It is larger than *T. elegantissima* Meek, and has a stronger marginal carina.

Trigonia sp. B aff. *T. hemisphaerica* Lycett

Plate 1, figure 3

aff. *Trigonia hemisphaerica* Lycett, 1872–1879, p. 174, Pl. 31, figs. 4–8, Pl. 33, figs. 4–6.
Trigonia n. sp. aff *T. hemisphaerica.* Hyatt, 1892, p. 305.
Trigonia aff. *hemisphaerica.* Packard, 1921, p. 33.

Material and occurrence. This species is represented by the single, poorly preserved hypotype USGS 103485, from the Bajocian Mormon Formation of Mount Jura, California.

Discussion. This shell was described briefly but not illustrated by Hyatt (1892) and Packard (1921). It is a gently convex, finely and densely ribbed form, closely resembling *T. hemisphaerica* Lycett. It is somewhat coarser ribbed than the similar *T.* sp. A aff. *T. hemisphaerica* from Nevada and *T. elegantissima* Meek, but is finer ribbed than most Middle Jurassic *Trigonia* species, such as *Trigonia americana* Meek and *Trigonia poststriata* Whitfield and Hovey.

Subfamily Myophorellinae Kobayashi, 1954

Diagnosis. Fine concentric costellae or growth lines on area, with subordinate nodes or transverse to oblique costellae in some forms. Escutcheon smooth, with growth lines, or with subordinate transverse or oblique costellae. Flank with concentric costae that meet the anterior margin at high angles or with oblique, generally tuberculate costae. Distinct marginal and inner carinae in most but not all forms. Antecarinal groove absent or narrow.

Distribution. Upper Triassic to Upper Cretaceous, cosmopolitan.

Discussion. The content of this subfamily is expanded considerably as compared with its usage by previous authors, to indicate the phyletic relationship inferred to exist among its members and their obvious distinction from other major groups. In this report, the subfamily Myophorellinae is considered to be a long-ranging group that is morphologically distinguished from other contemporaneous groups by the mainly concentrically costellate and moderately well defined area, and the narrowness or absence of the antecarinal groove. Subfamilies of other authors including Myophorellinae Kobayashi, 1954; Vaugoniinae Kobayashi, 1954; Frenguelliellinae Nakano, 1960 (in part); Prosogyrotrigoniinae Kobayashi, 1954; and Quadratotrigoniinae Savel'ev, 1958 (see also Kobayashi and Amano, 1955; Kobayashi and Tamura, 1955; Kobayashi and Mori, 1955; Nakano, 1961, 1968) are incorporated in the writer's broadly reinterpreted concept of the subfamily. The inferred phylogenetic trends within the subfamily as interpreted here are mainly the progressively greater differentiation and complication of the ornament on different regions of the shell and, to a lesser degree, complication of the ornament of the area. Triassic and Early Jurassic (Kobayashi and Mori, 1954) *Prosogyrotrigonia* Krumbeck, 1924 is a probable ancestor to *Frenguelliella* Leanza, 1942. It is sculptured relatively simply, lacks a distinct marginal carina and has a simple ovate to subcircular outline with prosogyrous umbos.

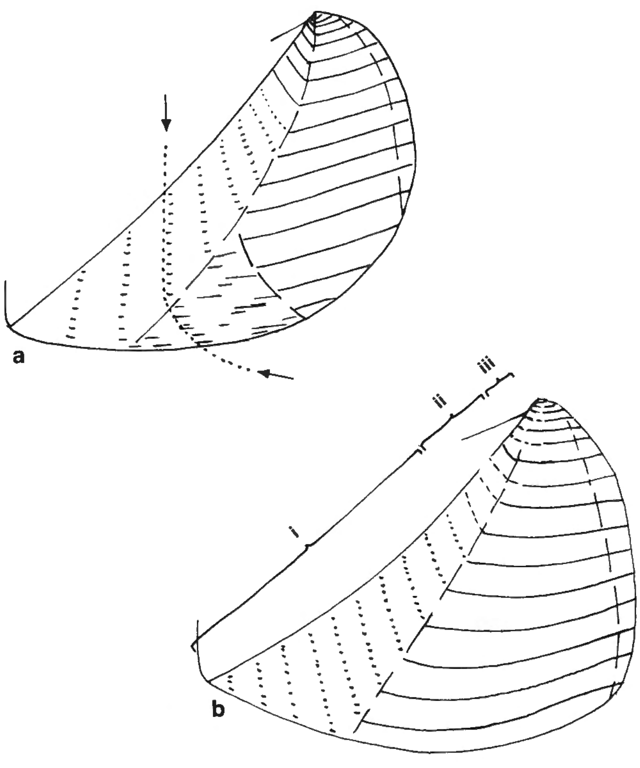
Strong and regular oblique costellation of the area and escutcheon is considered to be the basis for taxonomic separation of another subfamily Pterotrigoniinae van Hoepen as a derivative of Myophorellinae. Reduction in the size of the area is the basis for separation of Megatrigoniinae van Hoepen from Myophorellinae. Although all of the above-mentioned authors recognized the general trends toward complication of the shell ornament, they failed to unite those forms with similarly sculptured areas into a single major taxon as the present author has done and, thus, they underestimated the taxonomic importance of that highly conservative element of the shell. The incorporation of forms with basically differently sculptured areas into the same subfamilies [for example *Psilotrigonia* Cox in Frenguelliellinae (Nakano, 1961)] further exemplifies the underestimation of the taxonomic role of the nature of the area. In addition to placing too great an emphasis on the taxonomic significance of the sculpture of the flank, which now appears to be a highly labile character, Savel'ev's (1958) classification also overemphasized the morphological differences between Jurassic and Cretaceous trigoniids. The transitional relationships of many of these forms thus were obscured by their separation into different subfamilies by Savel'ev (ibid.).

Choffat (1885), Lebküchner (1932) and others have emphasized the transitional relationships between the forms herein assigned to *Myophorella*, *Vaugonia* and *Scaphotrigonia*. Lebküchner (1932) considered them all to be one group and proposed recurring iterative evolution to derive *Vaugonia* species from *Myophorella*. The evolution within this subfamily now is known to be more complex, however, as outlined below. It cannot be decided yet whether *Myophorella* is a polyphyletic genus or not. Further study may necessitate revision of the classification accepted in this report, either by subdivision of *Myophorella* and *Vaugonia* into smaller monophyletic taxa, or by inclusion of them, together with *Scaphotrigonia* and *Orthotrigonia*, in a single large genus *Myophorella*.

The flank of the shell of most *Vaugonia* species is divided into the following regions which are ornamented differently (Textfig. 4), and which are significant for interpreting phyletic relationships of the various genera of the subfamily Myophorellinae.

Posterior region (Fp)

The costae, or segments of costae, of the posterior region (Fp) are oblique, sloping anteroventrally, and are smooth, nodose, or corrugated. These costae arise ontogenetically early and appear to be basic to the *Vaugonia-Myophorella* stock. Where the posterior oblique costae radiate (Textfig. 6a) rather than being parallel (Textfig. 6b), continued differential retardation of their anterior ends with respect to time of secretion during shell growth is indicated. The earlier ontogenetic appearance of this feature suggests that it is more primitive than later developing parallel costae. It also explains why radially diverging oblique costae must even-



Textfigure 6. Sketches of representative specimens of species of the genus *Vaugonia* Crickmay. (a) Holotype of *V. veronica* Crickmay (see Pl. 10, fig. 1) showing breakup of concentric costae in ventral subregion of flank and orientation of the small segments into a curve approximately continuous with the posterior set of oblique costae (dotted line). The posterior set of costae radiate throughout the growth of the shell. (b) *Vaugonia coatesi* Poulton showing: (i) parallel posterior segments of costae in adult stage, (ii) radiating and (iii) subconcentric costae in juvenile stages.

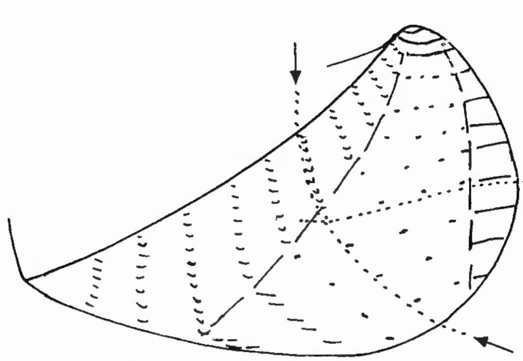
tually become separated from the concentric costae anterior to them (compare Textfig. 6a and b) whereas the two may be continuous in *Vaugonia* species with parallel oblique costae.

Anterior region (Fa)
The costae of the anterior end of the shell (Fa of Textfig. 4) commonly cut ventrally across growth lines and meet the anterior margin at nearly right angles, as they do in many other trigoniids, such as the genus *Trigonia*.

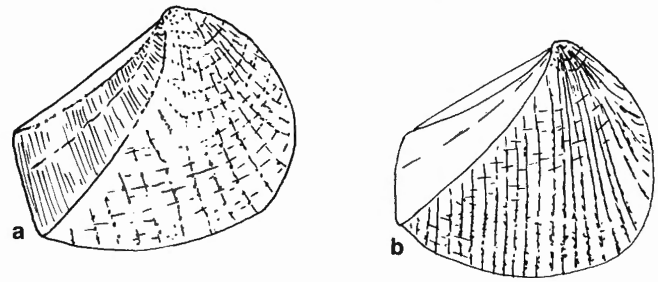
Central region (Fc)
The central region (Fc of Textfig. 4) of shells of *Vaugonia* species exhibits concentric costal segments (concentric in the sense of Thompson, 1942).

Ventral subregion (Fv)
The concentric costae of the central region (Fc) of *Vaugonia* commonly break up within the ventral subregion (Fv), generally not irregularly, but in steplike fashion, with the short segments aligned with the posterior set of costal segments (Textfig. 4). This ontogenetically late development produces a pattern homeomorphically similar, in part, to that of many species of *Myophorella*. The breakup of concentric costal segments into nodes and realignment of the nodes into costae continuous with the posterior oblique set of costae are clearly seen in *Vaugonia*(?) *yukonensis* n. sp. (Textfig. 7). In *Vaugonia veronica* Crickmay, *V. coatesi* Poulton and *V.*(?) *yukonensis* n. sp., the reorientation of costae effectively serves to enlarge the area of the flank that is obliquely costate, at the expense of concentric costation of the central region. A more extreme case, where the realignment of nodes occurs very early in the growth of the shell, is exemplified by *Orthotrigonia* species (Textfig. 8).

In these examples, radial alignment of the nodes in the umbonal area is well developed and, modified, produced the secondary set of oblique ('pseudoradial') costae. Certain other species, such as the English *'Trigonia' griesbachi* Lycett may have developed in the same way. In terms of the timing in ontogenetic development, the breakup of the concentric portions of costae and realignment of the resulting small segments is late in *Vaugonia coatesi* and *V. veronica*, intermediate in *V.*(?) *yukonensis*, and early in *Orthotrigonia*. This more 'primitive' nature of the first-named species suggests the earlier phyletic appearance of *Vaugonia* compared with *Myophorella*, and its probable ancestry with respect to *Orthotrigonia*. The phyletic significance of the similar reorientation of costae by secondary alignment of tubercles seen on the flank of the Cretaceous genera *Korobkovitrigonia* Savel'ev and *Quadratotrigonia* Dietrich is not known, but this may be an independent development.



Textfigure 7. Schematic generalized representative of *Vaugonia*(?) *yukonensis* n. sp. showing ontogenetically early breakup of concentric costae into nodes (horizontal dotted line), and their incorporation into oblique costae continuous with posterior oblique segments of costae (oblique curved dotted line).



Textfigure 8. Schematic drawings of representative specimens of genus *Orthotrigonia* Cox. (a) Specimen from Middle Bajocian beds of England, showing modification of umbonal radial-concentric ornament to oblique or radial ornament. (b) Specimen from Cornbrash beds (Upper Bathonian or Lower Callovian) of France, showing extreme development of secondary radial costae.

A subregion of posteroventrally sloping costal segments may occur where the short costal segments or nodes are aligned with the anterior set of segments. The extreme development of this style of costation produces the form known as '*Hijitrigonia*', with very sharp V-costation of the flank.

In most *Myophorella* species and similar obliquely costate forms, the posterior region can be considered as occupying the whole of the flank, except for the anterior end, and the central concentrically ornamented region is missing or confined to early growth stages. In some forms, such as *Scaphotrigonia* species, a smooth region occurs between the posterior and anterior regions of the flank.

Genus *Frenguelliella* Leanza, 1942

Trigonia (Frenguelliella) Leanza, 1942; Cox, 1952, 1969; Savel'ev, 1958.
Frenguelliella (Kumatrigonia) Tamura, 1959.
Trigonia (*Kumatrigonia*) Cox, 1969.

Type species. *Trigonia inexspectata* Jaworski, 1915. Lower Jurassic, Argentina.

Diagnosis. Flank with concentric costae that meet the anterior margin at high angles and that may be somewhat irregular. Area with concentric costellae or growth lines.

Distribution. Upper Triassic to Upper Cretaceous, according to Cox (1969); apparently restricted to Upper Triassic and Lower Jurassic in North and South America, and Japan. Cosmopolitan(?) except for boreal regions.

Discussion. The absence of any trace of radial costellae on the area is considered by the present writer to be sufficiently important to separate *Frenguelliella* from *Trigonia* Bruguière. It is allied with other concentrically costellate genera that are included within the subfamily Myophorellinae Kobayashi for reasons given briefly in the discussion of that subfamily. The genus *Frenguelliella* is interpreted broadly in this paper to include Triassic and Early Jurassic species with concentric ornament on both flank and area.

Progressive differentiation of the area, flank, marginal carina and antecarinal groove appears to have characterized the evolution of *Frenguelliella,* as did development of finer concentric ornament on the area than on the flank. The morphological and taxonomic separation of *Frenguelliella* from similar and probably ancestral Late Triassic and Early Jurassic *Prosogyrotrigonia* Krumbeck is arbitrary, and is based on the prosogyrous umbos, the simple ovate or subcircular outline and the absence of a distinct marginal carina (or edge at the same position) in the type species of *Prosogyrotrigonia.*

The subgeneric name *Kumatrigonia* Tamura is available, potentially, for forms in this paper included in *Frenguelliella* that have a distinct marginal carina and costellae of the area that correspond with costae of the flank.

Frenguelliella sp. A

Plate 1, figures 4–8, 22

Material and occurrence. This species is represented by hypotype GSC 43240 from GSC locality 89090 and hypotypes GSC 43238, 43239, 48731 from GSC locality 93587. These are from Cowichan Lake map area, southern Vancouver Island. The beds at GSC locality 89090 were dated tentatively as Toarcian by Poulton (1976) on the basis of associated *Vaugonia* sp. cf. *V. coatesi* Poulton. A Sinemurian age was considered possible by H. Frebold (unpubl. report) for GSC locality 93587 based on the presence of poorly preserved and indeterminate ammonites of Sinemurian aspect (see discussion in 'Biostratigraphic occurrences—Sinemurian'). The precise age of both localities remains uncertain.

Description. Shell large, strongly convex. Outline subtrigonal with rostrate posterior. Umbos sharp, prosogyrous, near anterior end of shell.

Marginal carina narrow, raised slightly above level of area; ornamented with closely spaced, small, sharp tubercles near umbos, with more widely spaced transverse, lozenge-like nodes near posterior end. Area with faint growth lines. Median carina a narrow ridge with small sharp tubercles; offset posterodorsally from median position. Posterodorsal part of area slightly depressed relative to anteroventral part. Escutcheon carina a narrow ridge with small sharp tubercles. Escutcheon small, depressed, with fine growth lines.

Flank with broad and distinct antecarinal groove at same level as intercostal spaces and strongly depressed relative to marginal carina. Flank with widely and evenly spaced, mostly regular, strong, rounded costae that essentially are concentric but which become wavy and irregular at their anterior ends, descending directly to anterior margin of shell, which they meet at high angles. Costae terminate abruptly against antecarinal groove. There is some suggestion that the costae cut dorsally, at a small angle, across growth lines near their posterior ends, in the posterior direction (Pl. 1, figs. 6, 22).

Discussion. This species differs from all other described species of *Frenguelliella* known to the writer in its lack of well defined costellae on the area, which is ornamented with growth lines and prominent carinae.

Frenguelliella sp. B

Plate 1, figure 10

Trigonia aff. *costatula* Lycett. Lees, 1934, p. 42, Pl. IV, fig. 6.
Trigonia aff. *T. costatula.* Frebold, 1964a, Pl. V, fig. 6.

Material and occurrence. Hypotype GSC 9635 (from GSC loc. 93556) from a bed which also yielded *Arnioceras* sp. of Early Sinemurian age, Laberge Group, Yukon Territory. The collection is lot 77 of Lees (1934).

Description. Shell small, subrectangular, about twice as long as high, gently convex, umbo one quarter distance from anterior. Posterior end long.

Marginal carina a fine sharp ridge. Area broad, with fine regular concentric costellae in first 4 mm, remainder with very fine growth lines. Escutcheon carina poorly defined except near umbo, where costellae enlarge to slight nodes. Escutcheon poorly known, apparently with very faint growth lines. Flank with very regular, evenly spaced concentric costae that meet anterior margin at high angles. The earliest are aligned with, and apparently continuous with, the costellae of area.

Discussion. This species is known from a single external mould of a juvenile right valve. It differs from '*Trigonia*' *costatula* Lycett (1872–1879, Pl. 12, figs. 6, 6a) in being elongate and in having a more flaring area. It lacks the upturning (ibid., Pl. 15, fig. 10) of the posterior ends of the costae and the breakup of the costae into nodes (ibid., Pl. 15, fig. 8) of that species. The Yukon specimen is more finely sculptured and more nearly rectangular in outline than any other *Frenguelliella* species known to the writer.

Frenguelliella sp. C

Plate 1, figure 9

Material and occurrence. Hypotype USNM 219928 from the Sunrise Formation of Nevada. The specimen is unlabelled but was in a drawer marked '714D A–E' which contained other specimens of Early to Late Sinemurian age, collected by S. Wm. Muller (Stanford University) from the New York Canyon Section (Muller and Ferguson, 1939, p. 1611–1613). The designation 714D is thought to indicate its origin in Unit 8 (Upper Sinemurian) of Muller and Ferguson.

Description. Shell small, subtriangular. Posterior end short, inclined umbonally. Dorsal margin about two thirds length of shell. Umbo about one quarter length of shell from anterior end. Shell gently convex.

Flank and area meet at a simple edge at which there are very slightly expanded varices at the ends of the costae of the flank. Area with regularly spaced concentric costellae that are continuations of costae of flank. Escutcheon carina a simple edge. Escutcheon slightly depressed, nearly smooth.

Flank with finely spaced, sharp concentric costae, which meet the anterior margin at high angles.

Discussion. The specimen is a primitive form judging by its simple marginal carina, and conformity of the costae of the flank and costellae of the area. These characters, the fine spacing of the ribs and the absence of posterior rostration and an antecarinal groove separate it from other *Frenguelliella* species.

Frenguelliella(?) sp. D

Plate 1, figure 11

Material. This species is known from the single hypotype USNM 219929 from the Lower Jurassic Sunrise Formation of Nevada. Stanford University label bears field no. 714B, associated with a note saying 'Zone 6', suggesting it was collected from division 6 of Muller and Ferguson (1939, p. 1611, 1612), which yielded, in part, basal Sinemurian fossils (ibid., p. 1612). The specimen is in limestone which could be termed 'oolitic', as Muller and Ferguson (1939) described Unit 6.

Description. Shell small, slightly longer than high. Posterior end broad. Dorsal margin long. Ventral and anterior margins form semicircular curve, with a posteroventral sinus.

Marginal carina a fine sharp ridge. Area with fine, regular concentric costellae, at least one pair of which unites posterodorsally. Escutcheon carina simply a line of slight varices at end of costellae. Escutcheon apparently smooth. Flank with strong regular and evenly spaced concentric costae. Anterior end unknown. Incipient antecarinal groove.

Discussion. The shell is too small to warrant a detailed comparison with any other species of *Frenguelliella*, or to assign it positively to that genus. It possesses a strong marginal carina and finely costellate area, unlike the other *Frenguelliella* species from the Sunrise Formation.

Genus *Jaworskiella* Leanza, 1942

Jaworskiella Leanza, 1942; Cox, 1969.
Trigonia (Jaworskiella) Cox, 1952; Savel'ev, 1958.

Type species. *Trigonia burckhardti* Jaworski, 1916. Lower Jurassic, Argentina.[1]

Diagnosis. Flank with gently oblique, anteroventrally sloping costae that are either continuous or lines of tubercles. The costae maintain their full strength to a well developed antecarinal groove across which faint extensions of the costae may extend, to join corresponding nodes of the marginal carina and costellae of the area. Each costella of the area may correspond with a flank costa, or there may be a larger number of finer spaced costellae.

Distribution. Lower Jurassic and Upper(?) Jurassic, North and South America, Portugal(?).

Discussion. Leanza's (1942) original description of *Trigonia (Jaworskiella)* was based on *Trigonia burckhardti* Jaworski. Leanza's (1942, Pl. VI, figs. 2, 3) figured type specimen for *Jaworskiella* is slightly different from that figured by Jaworski (1916, Pl. V, fig. 3), having slightly tuberculate rather than smooth costae, and clearly oblique rather than apparently mainly concentric costae. Other characters being nearly identical, Jaworski's drawing is presumed to be in error. The present author's concept of *Jaworskiella* is modified slightly from that of Leanza (1942) to include *J. supleiensis* n. sp. and *J. siemonmulleri* n. sp. The addition of the costae at the anterior end of the shell and the marked antecarinal furrow, cited by Leanza (1942) in his diagnosis of *T. (Jaworskiella)*, are dropped, therefore, from the list of diagnostic features in the present writer's use of the name.

Jaworskiella is interpreted to be a homeomorph of *Myophorella* Bayle by development of oblique costae on the flank of a concentrically costate *Frenguelliella*-like ancestor. Gradual rotation of the costae over the major part of the flank appears to have taken place in the phyletic development of *Jaworskiella*, in contrast with rotation of only the posteriormost segments of costae, or breakup of costae and realignment of nodes, which characterize *Myophorella* species.

The distinction between *Jaworskiella* species and some *Myophorella* species is obscure since some of the latter species (e.g., *M. freboldi* n. sp.) have subparallel, smoothly curving costae which do not curve up sharply at the marginal carina. The more distinct differentiation of the styles of ornament of the flank and area generally serves to distinguish members of *Myophorella* from those of *Jaworskiella*.

Portuguese Late Jurassic *Trigonia freixialensis* Choffat (1885, p. 35, Pl. X, figs. 1–7) is similar to other species referred to *Jaworskiella* and may represent that genus, as

[1]A valuable paper discussing *Jaworskiella* in Chile, and other forms relevant to this bulletin, appeared after it went to press: Perez and Reyes, 1977, Instituto de Investigaciones Geologicas — Chile, Bol. 30.

Cox (1969) thought. Unlike North American species assigned to *Jaworskiella*, it has no well developed antecarinal groove.

Jaworskiella siemonmulleri n. sp.

Plate 7, figures 1–4

?*Trigonia* aff. *T. clavellata* Sowerby; Muller and Ferguson, 1939, p. 1612.

Material and occurrence. This species is known from holotype USNM 219930 and paratypes USNM 219931–219933, all from the Sunrise Formation of Nevada. Stanford University label with designation '725-10, 714-D, 0-10 feet' indicates they were collected in division 8 of the New York Canyon Section (Muller and Ferguson, 1939, p. 1611, 1612). This unit also yielded the ammonite *Eoderoceras* Spath which is of Late Sinemurian age according to Imlay (1968). The species has also been identified by the writer in Lower Jurassic beds of the Nechako River area, British Columbia (GSC loc. 20117).

Description. Shell of medium size, ovate in outline. Anterior, ventral and posterior margins form smooth rounded curve. Dorsal margin straight, long. Shell uniformly gently convex. Umbos near anterior, orthogyrous. Escutcheon poorly known, apparently small, nearly smooth, slightly depressed. Escutcheon carina a simple sharp edge. Area with fine, slightly irregular costellae that may or may not be interrupted by faint median groove. Marginal carina a narrow sharp ridge near umbos; to posterior becoming a rounded ridge with transverse semicircular tubercles, the flat side of each facing umbos. Faint projections of tubercles extend laterally to form some of the costellae of area, and across the broad antecarinal groove, which is smooth except for these faint markings, to join costae of flank.

Flank with subparallel costae that intersect growth lines at small angles. Costae with poorly defined irregular tubercles, best developed in costae of later growth stages and near marginal carina, elongated along growth lines.

Discussion. Jaworskiella siemonmulleri is morphologically intermediate between species similar to *F. inexspectata* (Jaworski), and younger *Myophorella* species and it may be a phylogenetically intermediate form. It is smaller, more finely and more regularly ornamented than *J. burckhardti* (Jaworski). *Jaworskiella siemonmulleri* is distinguished from *J. supleiensis* n. sp. in having less well defined tubercles on the costae, a less convex shell, and a smaller angle of intersection of costae and growth lines. The area is less coarsely costellate in *J. siemonmulleri* than in *J. supleiensis*.

Derivation of name. Dr. Siemon W. Muller.

Jaworskiella supleiensis n. sp.

Plate 7, figures 5–8

Material and occurrence. This species is known from holotype CAS 55838 and paratypes CAS 55835–55837, all from CAS locality 300, from the Suplee Formation of Oregon (no more detailed information is available). The lithology indicates the probable origin of the collection to be in the richly fossiliferous Upper Pliensbachian beds of the Suplee Formation.

Description. Shell of medium size, elongate. Ventral and anterior margins form smooth semicircular curve. Posterior end straight, meeting ventral margin in a rounded 65 degree angle. Umbos very near anterior, slightly opisthogyrous. Shell strongly convex.

Escutcheon apparently small and strongly depressed, but poorly preserved. Area with fine growth lines or slightly irregular costellae in umbonal region. Distinct coarse costellae near posterior end, standing up as sharp ridges. Faint median groove down centre of area rarely interrupts costellae. Costellae in places broken up into discontinuous segments, generally stronger in that half of area nearest marginal carina.

Marginal carina is a rounded ridge with a row of transversely elongated, rounded strong nodes, except near umbos where ridge is sharper and narrower, and tubercles fine and sharp. Tubercles generally aligned with costae of flank but somewhat displaced in some cases. Costellae of area meet some tubercles of marginal carina, but lie between others. Narrow antecarinal smooth space.

Costae of flank subparallel, gently curved to anterior, extending regularly from antecarinal smooth space to anterior margin. Costae near umbos cut growth lines at smaller angle than later costae but preservation is not sufficiently good to detect the earliest concentric ornament that is inferred to have been present. Early costae are fine, raised ridges with fine, irregular tubercles. Later costae mainly consist of closely spaced tubercles aligned along faint rounded ridges, except near anterior ends where they are smooth, sharp, narrow raised ridges. Tubercles larger, more widely spaced in later costae. Tubercles aligned not only along costae but in less well defined lines parallel to marginal carina. Every second tubercle is aligned along growth lines, which also connect the tubercles with those tubercles of the marginal carina.

Discussion. Jaworskiella supleiensis is distinguished from *J. siemonmulleri* n. sp. in being generally more coarsely tuberculate. Furthermore, costellae are developed on the area of *J. supleiensis,* as are nodes on the marginal carina.

Derivation of name. Suplee Formation of Oregon.

Genus *Vaugonia* Crickmay, 1930

Vaugonia Crickmay, 1930b; Imlay, 1964a; Poulton, 1976.
Vaugonia (Vaugonia) Cox, 1969; Alencaster, 1963.
Myophorella (Vaugonia) Cox, 1952; Savel'ev, 1958.
?*Geratrigonia* Kobayashi, in Kobayashi and Mori, 1954; Cox, 1969.
Vaugonia (Hiiitrigonia) Kobayashi, in Kobayashi and Mori, 1955.
Latitrigonia Kobayashi, in Kobayashi and Tamura, 1957.
Trigonia (Latitrigonia) Cox, 1969.

Type species. *Vaugonia veronica* Crickmay, 1930b. Middle Jurassic, British Columbia.

Diagnosis. Flank of adult subdivided into regions based on style of costae as follows: posterior region with oblique costae sloping anteroventrally from marginal carina; central region with concentric costae; anterior region where the concentric costae meet anterior margin at high angles. Costae commonly disrupted in ventral part of central region, or with posteroventrally sloping segments of costae in this portion. Area with concentric costellae. Area, escutcheon and flank distinctly separated by carinae in most representatives.

Distribution. Lower to Upper Jurassic, cosmopolitan.

Discussion. The general content of *Vaugonia* Crickmay is approximately that of the old Undulatae Section of Agassiz (1840). Lebküchner (1932) pointed out the difficulty and apparent artificiality of separating taxonomically those forms with V-shaped costae (i.e., *Vaugonia* species) from those with simply oblique costae, and he grouped forms with both these characters into a large genus *Clavotrigonia* Lebküchner, which now is thought generally to be a junior synonym of *Myophorella,* being based on *Trigonia clavellata* J. Sowerby. At present, the writer differentiates *Vaugonia* from *Myophorella* on the basis of the ornament of the central region of the flank (Textfig. 4), which is concentric in the former genus. Some species, however, such as '*Trigonia*' *sharpiana* Lycett (1872–1879, Pl. 15, fig. 11, Pl. 16, figs. 3–6) and '*T.*' *literata* (ibid., Pl. 14, figs. 1–4) cannot be referred satisfactorily to either genus because the central and anterior regions of their flanks bear costae that are concentric in some specimens and only slightly oblique in others. These morphologically and presumably phylogenetically intermediate forms are referred arbitrarily to one or the other genus on other grounds, such as the presence of an acute V-pattern in some specimens, produced by a region of posteroventrally sloping costal segments, or the presence of tubercles on the costae. The close relationship of *Myophorella* and *Vaugonia* is emphasized by the abundance of intermediate forms, but the presence of these forms does not invalidate the taxonomic separation of the genera.

The main characters of *Geratrigonia* Kobayashi (in Kobayashi and Mori, 1954), based on *Trigonia hosourensis* Yokoyama, conform with those that are considered to be diagnostic of *Vaugonia,* and therefore it is probably a junior synonym of *Vaugonia.* Absolute suppression of the name *Geratrigonia* requires reassessment of the taxonomic significance of the smooth area of that genus, however.

Latitrigonia Kobayashi (in Kobayashi and Tamura, 1957) is taken to be a junior synonym of *Vaugonia* because the small, probably juvenile, specimens of *L. pyramidalis* Kobayashi and Tamura, on which it is based, exhibit nodes at the posterior ends of the costae of the flank that are similar to those of certain *Vaugonia* species, such as *V.* sp. cf. *V. kobayashii* Alencaster.

The extreme development of continuous posteroventrally sloping costal segments in the ventral part of the central region of the flank in some species induced Kobayashi (in Kobayashi and Mori, 1955) to erect the subgenus *Hijitrigonia,* which name was rejected by Cox (1969). Its characteristic feature, mentioned above, appears to be an extreme but not uncommon morphological character developed in the ontogeny of certain *Vaugonia* species, and not yet demonstrated to form a distinct phylogenetic stock. The character is well shown in *V. imlayi* n. sp. (Pl. 10, figs. 7–13), which is assigned to *Vaugonia* on the basis of its general similarity with *V. veronica. Hijitrigonia,* therefore, is rejected tentatively as a junior synonym of *Vaugonia.*

Orthotrigonia Cox is excluded from *Vaugonia* because a region with concentric costation is absent and the ontogenetic change from V-shaped to oblique costation of the flank (Textfig. 8) is unusually early.

Vaugonia veronica Crickmay

Plate 10, figures 1–6

Vaugonia veronica Crickmay, 1930b, p. 53, Pl. 7, fig. f.
Vaugonia mariajosephinae Crickmay, 1930b, p. 54, Pl. 7, fig. g.

Material and occurrence. This species is known from holotype GSC 27715 designated by Crickmay (1930b), hypotypes GSC 43303, 43304, and the holotype (GSC 27716) of *Vaugonia mariajosephinae* (Crickmay, 1930b). All these specimens occur in probable Middle Jurassic rocks ('Salmon River Formation' of Crickmay, 1930b) east of Divide Lake near its north end in the vicinity of the head of Cascade River, tributary of Salmon River, near the head of Portland Canal, British Columbia, according to Crickmay (1930b). He appears to have assigned the age of the original collection on the basis of the similarity of the *Vaugonia* specimens with Middle Jurassic English species (see McLearn, in Hanson, 1935). The present writer concurs with the Middle Jurassic determination although a Middle or Late Toarcian age cannot be dismissed.

Description. Shells moderate to large in size, subovate. Dorsal margin straight. Posterior margin broken by small offset at median carina. Ventral and anterior margins form smooth curve becoming straight in posteroventral region. Distinct but rounded corners at umbo and at intersection of posterior end with dorsal and ventral margins. Shell gently convex.

Marginal carina a rounded narrow ridge with finely and regularly spaced small tubercles which are enlarged ends of each costella of area, or with tubercles which are varices at the united ends of several costellae. Area with finely and regularly spaced concentric costellae that become coarser and irregular with growth. They are interrupted at medium carina, which is bordered by rows of tubercles in late growth stages. Median line is line of offset of surface of area so that dorsal half is at lower level than anteroventral half. Costellae on dorsal half are offset from, and slant umbonally relative to, those of other half. Escutcheon carina a distinct edge with continuations of costellae of area, or with varices joining certain costellae. Escutcheon small, with dorsally fading faint, irregular, oblique, wavy costellae, which are continuous with costellae or varices on escutcheon carina.

Umbonal 8 mm of flank with at least seven (preserved) costae, which are approximately concentric (but meeting anterior end of shell at high angles) at umbos, but with posterior ends curved umbonally in latest ones so that a V-pattern results. Next 1 cm of flank with costae sharply flexed or broken into two segments. Anterior segments concentric, tapering toward anterior margin, which they meet at right angles. Posterior segments maintain constant strength, or taper dorsally, and extend almost, but not quite, to marginal carina, leaving a very narrow antecarinal groove. They meet marginal carina at angles of 40 to 50 degrees, decreasing to posterior. Costae in latest growth stages similar but posterior segments of costae nearly parallel with marginal carina. Also, posterior ends of anterior costal segments become slightly curved toward ventral margin and then are broken into shorter segments, which are secondarily aligned in anteroventrally sloping direction. The early costae and anterior segments of later costae are very fine and rounded, separated by much broader intercostal spaces. Posterior costal segments broader, rounded, about as wide as their intercostal spaces, very slightly and irregularly crenulated and of approximately constant strength throughout their length.

Discussion. The holotype of *V. veronica* (Pl. 10, figs. 1, 2) has a narrower area than the holotype of *V. mariajosephinae* Crickmay, has less distinct costellae on the escutcheon, and lacks the abundant large varices on the marginal carina. The two species are considered to be synonymous by the present writer because of the relatively low taxonomic value ascribed to these differences of morphology, particularly as this sort of variation is exhibited on all the specimens available from the area which yielded the type specimens. Variation of similar magnitudes also characterizes other Canadian species of subfamily Myophorellinae. Furthermore, according to Crickmay (1930b), his two species were collected in the same area and from the same unit ('Salmon River Formation') and the similarity of lithologies containing them suggests that they are from the same bed.

Vaugonia veronica is clearly distinguished from *V. imlayi* n. sp. by its less intricate ornamentation and less convex profile at the same size of specimen. *Vaugonia veronica* is larger than *V. vancouverensis* Poulton and *V. coatesi* Poulton, and the ornament is coarser and slightly more irregular although of the same general style. The V-shaped costation is much more advanced than in *V. oregonensis* n. sp. The species *Vaugonia veronica* does not closely resemble any other species known to the writer.

Vaugonia imlayi n. sp.

Plate 10, figures 7–13

Material and occurrence. The species is known from holotype USNM 219907 and paratypes USNM 219908–219910 and several other well preserved specimens from the Middle Bajocian Gaikema Formation of Alaska (USGS loc. 19962).

Description. Shell of medium size, subtrigonal to subtrapezoidal in outline, mainly posteroanteriorly elongated, less commonly subequant or dorsoventrally elongated. Anterior and ventral margins form smooth curve. Posterior margin long and straight except for offset and change of orientation at median carina. Dorsal margin short, straight. Shell moderately convex with moderately to strongly incurved umbos.

Marginal carina a strong narrow ridge with relatively coarse, rounded, evenly spaced tubercles, which are aligned with posterior segments of costae of flank. Area broad, with very fine concentric costellae or growth lines and a 'median' carina which is very slightly offset to dorsal of centre of area. Median carina is a simple edge at which dorsal half of area is recessed relative to anteroventral half. Median carina with tubercles similar to those of escutcheon carina in some specimens. Escutcheon carina an edge with fine but distinct tubercles, which are extended as concentric costellae partly across dorsal part of area. Escutcheon small, depressed, with fine growth lines.

Umbonal 5 mm of flank with approximately seven fine, sharp concentric costae that meet the anterior margin at high angles, the latest of which show incipient V-pattern near the marginal carina. Remainder of flank with three distinct sets of costal segments. Anterior third of flank with fine, sharp, evenly spaced costal segments that meet the anterior margin at high angles. Central third with posteroventrally sloping continuations of the anterior segments, somewhat irregular and, in later stages, partly independent of anterior costal segments and broken up into discrete nodes. Posterior third of flank with anteroventrally sloping costal segments, independent in late growth stages. They are coarser and more widely spaced than the other costal segments, and are finely and irregularly crenulated. They taper abruptly toward a very narrow, sharp, antecarinal groove.

Discussion. The species *Vaugonia imlayi* is distinguished from all other North American *Vaugonia* species by the early development and dominance of the central region of the flank, where costal segments slope posteroventrally, and the resulting acutely V-shaped sculpture. The sculpture of the central region of the flank is much more regularly developed than in otherwise similar specimens of *V. literata* (Young and Bird). *Vaugonia v-costata* (Lycett) *mexicana* Alencaster has concentric costae over a greater proportion of the flank than *V. imlayi,* apparently has coarser costae in the umbonal region, and has a smooth rather than tuberculate marginal carina. None of the Japanese species known to the writer closely resembles *V. imlayi.*

Derivation of name. Dr. R.W. Imlay.

Vaugonia oregonensis n. sp.

Plate 10, figures 14–19

Material and occurrence. The species is known from holotype USNM 219913, paratypes USNM 219911, 219912, 219915 (all from USGS Mesozoic loc. 27359), paratype USNM 219914 (USGS loc. 26732) and other well preserved specimens (USGS locs. 27361, 28372; GSC loc. 89405). All these occur in the Upper Pliensbachian upper part of the Suplee Formation of Oregon.

Description. Small to medium shell, largest specimen 3.8 cm long, 2.5 cm high. Rounded subtrigonal outline, elongate to posterior. Anterior and ventral margins gently curved, meeting either in distinct rounded right angle, or in smooth paraboloid curve. Posterior margin straight or slightly curved, meeting ventral margin in obtuse angle which becomes acute in large specimens so that it is distinctly inclined to the anterior. Shell gently convex except near umbo.

Marginal carina a fine, sharp edge standing above very narrow, smooth antecarinal space, coplanar with area, ornamented by ends of costellae of area which may be enlarged to slight varices. Area with fine concentric costellae that are regular and even near umbo, becoming more irregular and slightly wavy toward posterior margin. Costellae interrupted in late growth stages by weak median groove, which is absent in some specimens. Escutcheon carina, known from one specimen only, is sharp but simple edge between area and escutcheon. Escutcheon relatively broad, about two thirds length of adult shell, gently concave, with fine concentric growth lines.

Flank with costae that are divided into three differently oriented segments, visible even in earliest preserved stage of paratype USNM 219914 (Pl. 10, figs. 17, 18), where they form a relatively smooth, nearly concentric curve, but meet the anterior margin at high angles. In later growth stages, that half of the flank adjacent to the marginal carina bears relatively straight or umbonally slightly concave costae, which form angles of about 90 degrees with marginal carina, at intervals of about 3 mm. They are broad and rounded, with growth lines. They meet costae of anterior half of shell at a rounded angle, which becomes sharper with progressive growth stages in most specimens but remains rounded in others. Costae of main part of anterior half of flank apparently subconcentric but growth lines generally are not well preserved. In progressive growth stages, costae cut more and more ventrally to posterior, eventually becoming broken into en echelon segments near their junction with posterior segments of costae. Anterior ends of costae perpendicular to plane of commissure in umbonal 5 to 10 mm, more closely aligned with growth stages, becoming nearly concentric.

Discussion. Generally *Vaugonia oregonensis* is slightly larger than *V. vancouverensis* Poulton and the sculpture is coarser. The umbos are less pointed, are more anteriorly positioned and are orthogyrous. The ontogenetically early ribbing patterns last into larger growth stages in *V. oregonensis* and are more consistent. Young specimens of both species may be identical.

Vaugonia oregonensis closely resembles Bajocian forms of *Vaugonia* identified as *Trigonia (Indotrigonia) impressa* Sowerby by Alencaster (1963), but it differs from them by being more variably sculptured from specimen to specimen, and by generally, but not always, showing a greater differentiation of posterior and anterior costal segments.

Derivation of name. The state of Oregon.

Vaugonia sp. aff. *V. oregonensis* n. sp.

Plate 10, figures 20–22

Material and occurrence. Two specimens (hypotypes GSC 43305–43307) occur in the Hazelton Group at Frypan Peak, Hazelton map area (GSC loc. 90981). Associated poorly preserved ammonites, which are possibly *Leptechioceras* of Late Sinemurian age, were identified by H. Frebold.

Description. Shell of medium size, outline apparently subtrigonal. Umbo near anterior. Well developed anteroventral corner. Gently convex profile.

Marginal carina a narrow sharp ridge at same level as area. Area narrow; ornament poorly known, appears to be very fine concentric costellae with very weak medium groove. Detailed character of escutcheon carina and depressed escutcheon unknown.

Flank with posterior set of widely spaced, relatively strong, narrow costal segments, approximately perpendicular to marginal carina, separated from it by very narrow antecarinal groove. These costal segments thicken to anterior and meet anterior set of finely spaced, gently posteroventrally sloping, weak but distinct set of costal segments. Posterior and anterior segments mutually continuous. Anterior costae appear to end where shell curves sharply and descends, without apparent ornament, to anterior margin. The V-pattern of the ribs increases ventrally because of gradual rotation of posterior costal segments away from near-concentric orientation in umbonal region.

Discussion. The only species similar to *V. oregonensis* is *V. niranohamensis* Kobayashi and Mori (1955) of Japan. The smooth area and finely nodose nature of the posterior costal segments distinguish that species, however.

Vaugonia sp. cf. *V. vancouverensis* Poulton

Plate 10, figures 23, 24

cf. *Vaugonia vancouverensis* Poulton, 1976, p. 48, Pl. 8, figs. 13–20.

Material and occurrence. Two specimens (hypotypes USNM 219934, 219935) occur in the Sunrise Formation of Nevada.

The label reads "714-D" and "1½ miles from the mouth [of the canyon presumably], along the western ridge . . . , west side of Flat Iron Knob". They occur in medium-grained, grey to pink 'greywacke'. These data indicate that the specimens were collected by S.W. Muller (Stanford University) in division 8 of the New York Canyon Section (Muller and Ferguson, 1939, p. 1611, 1612). Associated *Eoderoceras* Spath indicates a late Sinemurian age according to Imlay (1968). One specimen from Nevada (Pl. 10, fig. 24) appears to be identical with certain specimens of *V. vancouverensis*. The other fragmentary specimen (Pl. 10, fig. 23) is similar but has slightly coarser ribs than is typical of the Canadian specimens of that species.

Vaugonia doroschini (Eichwald)

Plate 10, figures 25–28; Plate 11, figures 1–5

Trigonia doroschini Eichwald, 1871, p. 180, 181, Pl. 14, figs. 12–14, Pl. 14, figs. 1–4; Packard, 1921, p. 15, Pl. 3, figs. 2, 3.

Material and occurrence. The species was described originally from southern Alaska by Eichwald (1871). Other specimens from southern Alaska occur in Bathonian or probably Bathonian beds of the Bowser Formation (hypotype USNM 219919 from USGS loc. 20764; other specimens from USGS locs. 2919, 3034, 3038, 20764), from Bathonian or Callovian beds (USGS loc. 3035), from Callovian or probably Callovian beds of the Bowser and Chinitna formations (hypotype USNM 219916 from USGS loc. 20765; other specimens from USGS locs. 20728, 20734, 20765 and 22550), and from Oxfordian or Kimmeridgian beds of the Naknek Formation (hypotype USNM 219920 from USGS loc. 3096). This species is common also in the lower part of the Bowser Lake Group of northwestern British Columbia where it often forms a coquina (GSC locs. 7206, 57177, 81923, 81924, 81930, 85425, 85426, 87309, 87397). These beds have yielded the Early Oxfordian ammonite *Cardioceras* (identified by H. Frebold) at one locality (T. Richards, pers. com.).

Description. Shell medium to large, reaching 8.25 cm long. Suboval outline, with somewhat elongated posterior end. Umbos orthogyrous, variably located, usually about one quarter of shell's length from anterior. Escutcheon one half length of shell. Shell strongly convex.

Marginal carina in the 1.3 to 3.2 cm nearest the umbo (varying from specimen to specimen) a sharp edge, with small but regularly spaced conical nodes. In this interval are a faint median groove and escutcheon carina, the latter marked by finely spaced, strong, transversely elongate tubercles. From these, attenuating but distinct transverse costellae extend across the escutcheon, which is otherwise unornamented (Pl. 10, fig. 3). This early part of area bears straight to slightly wavy transverse costellae. In some specimens they are grouped to form small but distinct transverse ridges, which are continuous with nodes of marginal carina and varices of escutcheon carina (Pl. 10, fig. 28).

In the later growth stages of most specimens, after shell becomes about 2.5 cm long, marginal and escutcheon carinae and median groove become indistinct. In these later growth stages, the area is covered only by very fine to rugose growth lines that pass over the position of the marginal carina, which is here a rounded angle, and are continuous with growth lines of flank (Pl. 11, fig. 4). In some specimens, distinct tuberculate carinae and median groove occur throughout length of area (Pl. 10 figs. 25, 27, 28).

Ornament of flank variable. In some specimens (e.g., Pl. 11, fig. 1), particularly those collected from limestone or very fine grained rocks, concentric, fine, slightly irregular growth lines are the dominant ornament. Others have irregular growth rugae (Pl. 11, fig. 4) and in some cases these concentric markings are so evenly spaced that they might be termed concentric costae. In the 1.3 to 1.9 cm nearest the umbo of most specimens, the fine concentric costae vary in the anterior direction in such a way that they descend directly to anterior margin (Pl. 10, fig. 26). In Eichwald's (1871) figures, this feature persists throughout most of the shell's growth. In some specimens in the author's collections, these anterior portions of costae cannot be detected or are confined to only the very earliest growth stages. The anterior portions of the otherwise subconcentric costae in many specimens are gradually replaced ventrally by purely concentric ornament; in others there is a sharp boundary, the concentric pattern truncating the other style to produce a narrow biconvex eyelike appearance (Pl. 10, fig. 26). Faint, short ridges perpendicular to the plane of commissure commonly are superimposed on the concentric ornament at the anterior end of the shell (Pl. 10, fig. 26, Pl. 11, fig. 2). Posterior part of flank has more or less well developed subradial grooves tapering dorsally into a very slight narrow antecarinal groove which disappears posteriorly. The rounded ridges separating the radial grooves widen and become fainter with growth; only the posterior few reach the ventral margin. In some specimens (e.g., Pl. 11, fig. 1) these subradial ribs are weak, and in some others they cannot be seen. In general, the subradial ornament is less well developed than in Eichwald's (1871) figures, and is more independent of the concentric ornament.

Discussion. Eichwald's (1871, Pl. XIII, figs. 12–14, Pl. XIV, figs. 1–4) figures of *Trigonia doroschini*, if accurately drawn, suggest that he was dealing with slightly different forms from those described here. There is little doubt, however, that they are conspecific because of the characteristic unusual shape and sculpture of the shell, and because of their common occurrence in the Jurassic strata in the same vicinity in which Eichwald collected his specimens. The species shows considerable variation in morphology and Eichwald's (1871) figures suggest that he was dealing with only one variety, a variety which is not the most common in either the Alaskan or British Columbia collections. One specimen figured in this report (Pl. 10, figs. 25–28) is close to Eichwald's (1871) specimens but lacks the smoothly draped appearance of the costae. In most specimens, the posterior subradial costae are less closely coincident with the concentric costae shown by Eichwald (1871, Pl. XIV, figs. 1, 3), and there is much more variation in the relative lengths of the costae than Eichwald indicated. Further study of *V. doroschini,* based on material collected with better stratigraphic control than the specimens presently available, may lead to a biostratigraphically useful subdivision of the species.

Vaugonia athena Poulton and Callomon (1977) from the Bathonian of central East Greenland is similar to *V. doroschini,* but differs primarily in the spacing of the dorsoventrally oriented costae and the position of the umbos. Further differences are described by those authors.

Vaugonia doroschini is similar to less posteriorly elongate *V. obliqua* (Hyatt) of California, with which it may be synonymous (see below).

Vaugonia obliqua (Hyatt)

Trigonia obliqua Hyatt, 1892, p. 407; Packard, 1921, p. 16, Pl. 3, figs. 5, 6.

This species was erected, poorly described and not figured, by Hyatt (1892) but was satisfactorily described by Packard (1921) from the original type material (lectotype USNM 32479). It came from the Callovian Bicknell Sandstone (Hinchman Formation) of Mount Jura, California. The type material is similar to Alaskan and Canadian specimens of *Vaugonia doroschini* (Eichwald), but appears to be less elongate to the posterior. More and better preserved specimens will be required before the validity of the species, or its synonymy with *V. doroschini,* can be confirmed. Both these Callovian and Oxfordian species are larger than otherwise similar *V. utahensis* Imlay, *V. conradi* (Meek and Hayden), *V. quadrangularis* (Hall and Whitfield) and *V. sturgisensis* (Whitfield and Hovey).

Vaugonia sp. cf. *V. kobayashii* Alencaster

Plate 10, figures 29–31

Trigonia cf. *T. v-costata* Lycett. Sanborn, 1960, p. 26, Pl. 2, figs. 15, 20.
cf. *Vaugonia kobayashii* Alencaster, 1963, p. 27, Pl. 2, fig. 9, Pl. 3, figs. 1–6.

Material and occurrence. The species is known only from hypotypes figured by Sanborn (1960; from LSJU loc. 2966) and USNM 219917 and 219918 (both from USGS loc. 1013). These are all from the Potem Formation of the Big Bend area of northern California. This formation was dated as Bajocian by Sanborn (1960) because the trigoniid faunas are similar to Bajocian species of England. Collections from USGS locality 1013 are thought to be of the same age because of the similar lithology and the presence of *V.* sp. cf. *V. kobayashii.*

Description. Shell of medium size, 6 cm long, 3.8 cm high. Subtriangular outline with strongly extended posterior. Posterior end strongly inclined to umbo, about as long as dorsal margin. Shell gently convex, with steep anterior and dorsal margins near umbo.

Marginal carina a broadly rounded edge, smooth or with growth lines. Narrow anterior side of marginal carina slopes down to level of costae of flank. Area nearly smooth. Marginal carina and area poorly preserved in specimens available. Escutcheon small, ornamentation unknown.

Flank with coarse costae that are continuously curved and concentric, or nearly so, near umbo but that become more and more strongly V-shaped with progressive growth stages until they distinctly divide into posterior segments that are nearly perpendicular to ventral margin, and anterior segments that are mainly concentric but meet the anterior margin at high angles. Costae in umbonal 1 cm finer toward umbo; the remainder approximately equally strong and equidistant. Those very near umbo approximately concentric. In intermediate growth stages, posterior ends of costae turn upward sharply near marginal carina, the greater part of the costae remaining subconcentric, meeting growth lines at a very small angle. Costae markedly enlarged along locus of flexure near marginal carina. In late growth stages, posterior segments of costae nearly perpendicular to ventral margin; they are weak, crenulated by fine growth lines and meet anterior segments of costae, which weaken adventrally, at right angles. The otherwise concentric portions of costae appear to become concave ventrally but they are poorly preserved.

Discussion. The three specimens referred to this species differ in ornamentation of the flank. The two specimens from USGS locality 1013 have a smaller, less clearly defined region of concentric costae than does the third specimen, so that the costae are more or less continuously curved in all growth stages. One of them also has less well developed nodes on the posterior ends of the costae than do the specimens from LSJU locality 2966.

The California specimens are more strongly rostrate posteriorly than *V. kobayashii* Alencaster from Mexico and appear to have a narrower area, more strongly developed nodes on the costae, finer spaced costae and more posteroventrally directed costae in the posteroventral corner. The presently described species is similar to certain specimens of *V. fukuiensis* Maeda of Japan but is more strongly and sharply rostrate and has more uniform and less undulatory ornament. These characters also distinguish it from British *V. painei* (Lycett), *V. angulata* (Sowerby), *V. flecta* (Lycett) and *V. v-costata* (Lycett), which are similar in general morphology. *Vaugonia* sp. cf. *V. kobayashii,* unlike English *V. spinulosa* (Young and Bird), has no fine tubercles on the flank and area, and has developed large nodes at the point of flexure of costae of the flank.

Vaugonia(?) *yukonensis* n. sp.

Plate 8, figures 6–11

Material and occurrence. This species is represented by the holotype GSC 43284 and paratypes GSC 43283, 43285 and

43286 (all from GSC loc. C-18179) from the Laberge Group of southern Yukon Territory; by paratypes GSC 43287 (GSC loc. 89374), USNM 219899 (USGS loc. 2570) and possibly other specimens (GSC loc. 89344) from the Potem Formation of northern California; and possibly by other specimens (GSC loc. 89382) from the Middle Bajocian Weberg Formation of Oregon. The Potem Formation is probably Bajocian (Sanborn, 1960) as are the relevant beds in the Laberge Group (Poulton, in Tempelman-Kluit, 1974).

Description. Shell of medium size, rounded subtrigonal in outline. Anterior margin straight or slightly curved, meeting gently curved ventral margin with rounded angle. Posterior margin slightly curved, meeting ventral and dorsal margins with rounded 120 to 130 degree angles. Dorsal margin three quarters length of shell. Umbos orthogyrous, near anterior. Most of shell gently convex but the escutcheon, area and anterior part of flank are steep.

Marginal carina a fine sharply raised ridge near umbos, with small rounded tubercles if the shell is smaller than 1.3 cm long. To posterior, it becomes a broad ridge consisting of closely spaced varices where costellae of area cross it. Area with evenly and relatively coarsely spaced costellae, generally straight and regular, but which form varices across marginal carina, and which become slightly irregular in older specimens. Slight median groove that does not interrupt costellae except near umbos. Escutcheon carina a row of fine sharp tubercles, independently distributed with respect to costellae of area. Escutcheon small, depressed, with fine growth lines.

First three costae of flank, in 3 mm nearest umbo, strong fine ridges, concentric. Next three with very fine nodes, V-shaped, with apex of V's very near marginal carina. Ventrally, flank with three distinct sets of ornament: (1) posterior finely tuberculate costae which taper toward marginal carina, meeting it at posteriorly decreasing acute angles; (2) anterior set of sharp and fine nontuberculate ridges that are straight and parallel, and mainly perpendicular to anterior margin; (3) central region of discrete tubercles that are organized in reticulate pattern, aligned in one direction with the anterior set of costae, and in the other, with an offset or an angle, with the posterior set. Alignment with anterior set of costae results from synchronous growth of the various tubercles along growth lines. Anteroventrally, the tubercles of this central set become flattened parallel to growth lines.

Discussion. This species resembles one specimen of Toarcian *'Trigonia' literata* Young and Bird figured by Lycett (1872–1879, Pl. 14, fig. 3). Typically, however, that species is ornamented with much better defined V's on the flank and the costae in the centre of the flank may slope posteroventrally (Young and Bird, 1828, p. 225, Pl. 8, fig. 23; Lycett, 1872–1879, Pl. 14, figs. 1, 2, 4).

Vaugonia(?) *yukonensis* also is similar to *V. kodaijimensis* Kobayashi and Mori (1955) of the Middle Bajocian of Japan, which is, however, smaller, more finely ribbed, and apparently has a smooth area. In *V. namigashira* Kobayashi and Mori (1955) of the Hettangian of Japan the concentric orientation of aligned nodes in the centre of the flank persists longer during the growth of the shell, resulting in a much more distinct V-pattern.

The most closely similar species to *V.*(?) *yukonensis* is *V. krommelbeini* (Torre, 1960; Krommelbein, 1956), which occurs in the San Cayetano Formation of western Cuba. This species is older than Middle Oxfordian (Haczewski, 1976) and is probably Middle Jurassic (Torre, 1960).[1] The V-pattern of the costae on the flank extends into later growth stages in the Cuban species than in the Yukon species, and the costae of the posterior part of the flank have finer nodes.

The domination of the flank by anteroventrally sloping costae in *V.*(?) *yukonensis* possibly could justify its placement in the genus *Myophorella* Bayle. Such an assignment is rejected, however, because of the manner in which the costae in the centre of the flank appear to have developed by secondary alignment of nodes which were first, in the ontogeny of the shell, concentrically aligned.

Derivation of name. Yukon Territory.

Vaugonia sp. cf. *V.*(?) *yukonensis* n. sp.

Plate 8, figure 12

Material and occurrence. This species is known from a single specimen (hypotype GSC 43288; GSC loc. C-18178) from the Laberge Group, southern Yukon Territory. It was found in a bed close to, and probably the same age as, that which yielded another collection with a rich assemblage of bivalves (GSC loc. C-18179), dated as probably Middle Bajocian by Poulton (in Tempelman-Kluit, 1974) on the basis of their general similarity with European species.

Description. Shell small, rounded triangular in outline. Ventral and anterior margins form smooth curve. Shell very gently convex. Umbos sharp, orthogyrous near anterior end of shell.

Marginal carina a fine, sharp ridge near umbo, becoming very finely tuberculate to posterior. Its anterior side is a very narrow smooth space. Area with very fine growth lines and faint median groove. In earliest 1 cm, flank with very fine tuberculate costae which leave marginal carina at very close intervals, diverging and curving rapidly to meet anterior margin at right angles. In next stages, central parts of costae are extended to form V-shape, tubercles in central region become coarse and ultimately slightly irregular, and the posterior portions of costae become more widely separated. Intercostal spaces smooth and wider than the costae.

---

[1]More recently, Wierzbowski (1976, Acta Geol. Pol., v. 26, no. 2, p. 137–260) considered the fauna in which this species occurs to be Oxfordian.

Discussion. The specimen exhibits more finely tuberculate costae than *V.*(?) *yukonensis* n. sp. and a less pronounced breakup of the ribs into tubercles at an equivalent growth stage. The incipient breakup of costae into nodes that are secondarily obliquely aligned distinguish this species from the rather similar *Myophorella sharpiana* (Lycett).

Genus *Myophorella* Bayle, 1878

Myophorella Bayle, 1878.
Myophorella (Myophorella) Cox, 1952; 1969; Savel'ev, 1958; Skwarko, 1963.
Clavotrigonia Lebküchner, 1932.
Trigonia (Clavitrigonia) Leanza, 1942.
Myophorella (Promyophorella) Kobayashi and Tamura, 1955.
Haidaia Crickmay, 1930b, 1930a, 1932.
Myophorella (Haidaia) Kobayashi and Tamura, 1955; Nakano, 1970.
Scaphogonia Crickmay, 1930b.
Scaphitrigon Crickmay, 1930a.
Yaadia Crickmay, 1930a.
Yaadia (Yaadia) Cox, 1969.
Steinmanella Crickmay, 1930a.
Steinmanella (Steinmanella) Cox, 1969.
Steinmannella. Levy, 1969; Kobayashi and Amano, 1955.
Steinmanaea Crickmay, 1962.
Steinmannella (Yeharella) Kobayashi and Amano, 1955.
Steinmanella (Yeharella) Cox, 1969.
Transitrigonia Dietrich, 1933.
Quadratotrigonia (Transitrigonia) Savel'ev, 1958.
Quadratotrigonia (Yeharella) Savel'ev, 1958.
Packardella Kobayashi and Amano, 1955.
?*Ibotrigonia* Kobayashi, in Kobayashi and Tamura, 1957.
?non *Myophorella (Pseudomyophorella)* Nakano, 1961; Cox, 1969.

Type species. *Myophorella nodulosa* Bayle, 1878. Oxfordian, France (see discussions by Crickmay, 1932; Cox, 1952, 1969).

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

Distribution. Lower Jurassic (Middle Liassic) to Upper Cretaceous. Cosmopolitan, except for boreal regions.

Discussion. Myophorella is distinguished from its pseudomorph *Jaworskiella* Leanza by the taper of the costae toward the marginal carina in most representatives of the former genus and by the distinctly different ornament of the flank and area. *Vaugonia* Crickmay is distinguished from *Myophorella* by the presence of a central region of the flank with concentric costal segments. *Scaphotrigonia* Dietrich has a more markedly developed row of nodes and costal segments along the anterior margin of the shell, and a broader, more distinct smooth space posterior to this row of nodes. The criteria for distinguishing *Myophorella* from other Cretaceous genera of the subfamily Myophorellinae are given by Poulton (1977). Subsequent to release of that publication, and while the present one was in final editorial stages, Mrs. LouElla R. Saul kindly provided the writer with a manuscript copy of a paper entitled "The North Pacific Cretaceous Trigoniid Genus *Yaadia*", soon to be published by the University of California Press. The separation of *Yaadia* Crickmay from *Steinmanella* Crickmay on morphological grounds and their distinction from *Myophorella* Bayle on morphological and implicitly on biostratigraphic grounds by Mrs. Saul are points of contrast with the taxonomy of the present writer. Of further relevance to the present report is her discussion of the Upper Jurassic fauna from the Malone Formation of Texas, and her comments regarding possible evolutionary relationships between some Jurassic and Cretaceous North American trigoniid species.

Trigonia clavellata J. Sowerby, which served as the type species for *Clavotrigonia* Lebküchner [and *Trigonia (Clavitrigonia)* Leanza], is not different in its essential characters from *T. nodulosa* Bayle which Crickmay (1932) designated as the genotype for *Myophorella.* Cox (1952, 1969) has already rejected *Clavotrigonia* and *Clavitrigonia* as junior synonyms of *Myophorella.* Crickmay (1930b) divided North American Jurassic trigoniids exhibiting the general form of *Myophorella* into *Haidaia* and *Scaphogonia,* the latter distinguished by a row of nodes and costal segments along the anterior margin of the shell that do not meet the costae of the remainder of the flank. *Trigonia dawsoni* Whiteaves, which served as the type for *Haidaia,* also bears this discrepant anterior ornament, judging by recently collected, apparently conspecific material which is better preserved than that available to previous authors (Pl. 1, figs. 12–21). The name *Scaphitrigon* was substituted, apparently unintentionally, for *Scaphogonia* by Crickmay (1930a; see Crickmay, 1962). The presence of a distinct row of nodes along the anterior margin of the shell is interpreted herein to be simply one manifestation, in some species, of the ornament of the anterior region of the shell that was differentiated early in the history of the Trigoniidae (see section on morphology). It occurs in some forms, but not others, that can be assigned to *Myophorella* on all other grounds. This character therefore is taken to be of no more than specific and, in some cases, infraspecific rank, except where it is extremely developed, as in *Scaphotrigonia* Dietrich. For these reasons, the names *Haidaia, Scaphogonia* and *Scaphitrigon* are rejected as being junior synonyms of *Myophorella* Bayle, as they were also by Cox (1952, 1969).

Although the presence of an anterior row of nodes that are distinct from the costae of the main part of the flank is not accorded high taxonomic rank by the present writer, it is nevertheless a useful paleobiogeographic character. This feature commonly is developed in North American species, notably *Myophorella dawsoni* (Whiteaves), *M. montanaensis* (Meek), *M. devexa* (Eichwald), *M. argo* (Crickmay), *M. freboldi* n. sp. and *M. tipperi* n. sp. This peculiar morphological characteristic serves to distinguish these species from nearly all otherwise similar Middle and Late Jurassic European *Myophorella* species, on whose shells the oblique costae of the flank extend entirely to the anterior end. These species include *M. clavellata* (J. Sowerby), *M. signata* (Agassiz), *M. moretoni* (Morris and Lycett), *M. perlata* (Agassiz), *M. corallina* (d'Orbigny), *M. juddiana* (Lycett), *M. bronni* (Agassiz), *M. pellati* (Munier-Chalmas), *M. voltzii* (Agassiz), *M. suevica* (Quenstedt), and other species that also differ in other characteristics from the North American species.

Kobayashi and Tamura (1955, p. 93, 99) emended the diagnosis of *Haidaia* and used the name for a subgenus of *Myophorella* with "distinctly crenulate ventral slopes of the costae which are generally roof-shaped, steep on their dorsal side". This diagnosis, unintelligible in itself, was intended to distinguish a particular style of ornamentation of the costae from that of two other subgenera, *M. (Myophorella)* and *M. (Promyophorella)* (see Kobayashi and Tamura, 1955, p. 91–93). Although the present writer considers the nature of the nodes to be a significant character for differentiation of some *Myophorella* species, he does not consider that the distinction between those forms divided between *M. (Myophorella)* and *M. (Haidaia)* by Kobayashi and Tamura (1955) can be made on that basis.

The subgenus *Myophorella (Promyophorella)* Kobayashi and Tamura (1955) was erected to distinguish *Myophorella* species with costae that are "nearly plain, or more frequently with small tubercles on the top" (Kobayashi and Tamura, 1955, p. 92). This diagnosis is supported by the ornament of its type species, *M. (P.) sigmoidalis* Kobayashi and Tamura (1955, p. 96, 97, Pl. 5, figs. 1–3) and by the inclusion of *Trigonia formosa* Lycett. The subgeneric name, therefore, is available for some *Myophorella* species should future work indicate the need for formal taxonomic subdivision of North American species of *Myophorella*.

The validity of the genus *Ibotrigonia* Kobayashi (in Kobayashi and Tamura, 1957) is questioned, because the small size of the type species, *I. masatanii* Kobayashi and Tamura, and the irregularity of nodes that are developed on its costae suggest that it is a juvenile specimen of a *Myophorella* species. At any rate, the absence of radial ornament on the area clearly separates it from the subfamily Trigoniinae, as restricted herein, where Kobayashi and Tamura (1957) placed it.

The taxonomic placement of the rare and atypical trigoniid genus *Pseudomyophorella*, based on *P. savelievi* Nakano (1961), remains difficult because of the presence of radial striae on the area of a form otherwise typical of Myophorellinae. This character separates it from the genus *Myophorella* as realized by Nakano (1961) but not by Cox (1969), if not from the subfamily Myophorellinae, in which group it possibly could be an unusual development, as Savel'ev (1958) and Nakano (1961) thought.

The remainder of the synonyms listed are mainly Cretaceous and detailed discussion is beyond the scope of the present report. They are treated elsewhere by the writer (Poulton, 1977), who interprets the genus *Myophorella* to incorporate representatives of the Pseudoquadratae Group of Trigoniids, designated by Steinmann (1882).

Myophorella packardi (Crickmay)

Plate 3, figures 1–16

Haidaia packardi Crickmay, 1930a, p. 50, Pl. XII, figs. 2, 3.
non *Trigonia packardi* Anderson, 1958, p. 109, Pl. 1, fig. 5.
Haidaia statluensis Crickmay, 1930a, p. 50, Pl. XII, figs. 4–6.
Trigonia dawsoni Whiteaves, 1884, p. 231, Pl. 31, fig. 1a; Packard, 1921, p. 13, 14, Pl. 4, fig. 2.
non *Trigonia dawsoni* Whiteaves, 1878a, p. 405; 1878b, p. 154; 1884, Pl. 31, fig. 1.

Material and occurrence. This species was described originally (Crickmay, 1930a) from the Callovian Billhook Formation of Harrison Lake area, southern British Columbia (holotype GSC 9682 and its internal mould-paratype GSC 9686; elev. 1050 m, 3400 ft, Billhook Creek). It is considered now to include *Haidaia statluensis* (Crickmay, 1930a) from the same area (types GSC 9673a–d; elev. 1100 m, 3600 ft, Billhook Creek). The species is well represented in this area (hypotypes GSC 43264–43266 from GSC loc. 89433; also specimens from GSC locs. 89456, 89457 and possibly 89458 and 89461, which may be in the Mysterious Creek Formation immediately below the Billhook Formation). Other material is from the Lower and possibly Middle Callovian beds of the Yakoun Formation of Queen Charlotte Islands (including hypotype GSC 4927 of *Trigonia dawsoni* Whiteaves, 1884; hypotypes 4916, 4916a and 4916b; as well as specimens from GSC locs. 13618, 13619, 13626, 44707 and possibly 6363, 13621) and the Callovian Chinitna Formation of southern Alaska (USGS loc. 24151).

Description. Shell of moderate size, holotype measuring 7 cm long and 4.5 cm high, rounded subtrapezoidal to subtriangular in outline. Ventral and anterior margins form smooth curve; posterior end relatively broad, slightly rounded, bent at median groove. It meets ventral margin at 90 to 110 degree angles. Dorsal margin about three quarters length of shell, straight, meeting dorsal part of posterior margin at obtuse angle. Escutcheon broad. Umbos slightly posterior of anterior margin. Shell gently convex except near umbos.

Marginal carina a sharp narrow ridge near umbo; to posterior it remains strong but is less clearly defined and rounded, crossed by growth lines and with irregular, transversely elongated, strong, rounded tubercles that become larger with growth. The most posterior tubercles are continuous with growth rugae. Marginal carina stands above flank, but is coplanar with area. Area with concentric costellae or fine slightly irregular growth lines that become rugose to posterior. Weak but distinct median groove with weak or relatively strong irregular, round or teardrop-shaped tubercles that may form a herringbone pattern. The escutcheon carina is a rounded but distinct edge, with a few weak irregular tubercles, or is of the same strength and character as the marginal carina. Escutcheon concave, with fine growth lines.

Flank with coarsely and somewhat irregularly tuberculate curved costae, which number 22 in the largest (unfigured) specimen available, superimposed on background with fine growth lines and coarser growth rugae. Coarsest tubercles of costae aligned along coarsest concentric rugae. Costae of specimens referred to *'Haidaia statluensis'* by Crickmay (1930a) appear to be straight when viewed perpendicular to main part of shell surface (Pl. 3, fig. 2); in most other specimens costae are smoothly curved toward anterior. Costae relatively weak, rounded ridges except for the tubercles. Costae taper and weaken toward marginal carina, and may weaken ventrally and anteriorly, but they extend to ventral and anterior margins in most specimens. Costae meet marginal carina at angles of 60 to 80 degrees near umbo and, in posterior region, about 30 to 40 degrees or even 10 degrees in large specimens. Costae diverge at nearly constant rates. They weaken and die out just short of marginal carina, or extend onto narrow antecarinal smooth slope. Costae about same width as intercostal spaces, which have fine growth lines. Tubercles round or transversely elongated, beadlike or platelike.

Discussion. The present interpretation of *M. packardi* (Crickmay) includes three forms that may require formal taxonomic separation in the future, or may be variants due to local environmental adaptations. They are: (1) the holotype of *Haidaia packardi* Crickmay with coarser tubercles, more smoothly curved costae and less posteriorly elongate outline than other specimens herein referred to *M. packardi;* (2) type and accessory material of *Haidaia statluensis* Crickmay, with costae that are straight or slightly sinuous and more nearly dorsoventrally oriented than usual; and (3) material from Queen Charlotte Islands and Alaska that is virtually identical with the holotype except for the more regular and finer tuberculation. These last forms were included in *Trigonia dawsoni* by Whiteaves (1884), from which species they are separated for reasons given under the discussion of that species, and below. Whiteaves' (1884, 1889) criteria for differentiating these specimens from the Queen Charlotte Islands from *M. intermedia* (Fahrenkhol) and *M. montanaensis* (Meek) are confirmed herein.

Myophorella packardi is more elongated posteriorly, and more irregularly tuberculate than Japanese Callovian to Berriasian *M. orientalis* Kobayashi and Tamura (Maeda and Kawabe, 1966), which also occurs in Callovian rocks of Alaska. The radial alignment of tubercles on costae near the umbos seen in *M. orientalis* is not apparent in *M. packardi.*

This species is distinguished from *M. dawsoni* (Whiteaves) in being more elongated posteriorly, usually larger, and in having tubercles that stand higher above their background than those of *M. dawsoni*. In *M. dawsoni,* the tubercles are like small plates dipping dorsally, whereas in the present species they have the appearance of small plates standing on end. *Myophorella dawsoni* has a row of discrepant anterior nodes, which is absent in the present species. *Myophorella packardi* (Crickmay) has consistently coarser nodes than *M. dawsoni.*

Myophorella packardi lacks the discrepant or irregular anterior nodes and costal segments of *M. devexa* (Eichwald). Also, in many of the specimens available, the costae of *M. devexa* radiate more strongly and have platelike tubercles similar to those of *M. dawsoni* (Whiteaves), the costellae are more sinuous or irregular and coarser spaced, and there are irregular transversely elongate tubercles on the escutcheon and median carinae. *Myophorella devexa* also is larger generally than *M. packardi.*

Myophorella orientalis Kobayashi and Tamura

Plate 4, figures 1–6

Myophorella (Promyophorella) orientalis Kobayashi and Tamura, 1955, p. 98, Pl. 5, figs. 6a–b; Maeda and Kawabe, 1966, p. 51–56, Pls. I, II.

Material and occurrence. This species is represented by hypotypes USNM 219872–219875 (USGS loc. 20726) and other specimens (USGS loc. 24184) from the Lower-Middle Callovian Chinitna Formation; hypotype USNM 219876 (USGS loc. 11057) from Callovian beds of Cook Inlet area which have not been assigned to a particular formation; and possibly by specimens in Callovian beds of the upper part of the Bowser Formation (USGS loc. 20764); all in southern Alaska. The last locality was recently assigned to the Bathonian stage (Imlay, pers. com., 1977). In Japan the species ranges from Callovian through Berriasian in age.

Description. Shell of moderate size, subtriangular in outline, about as high as long. Anterior and ventral margins form smooth lunate curve. Posterior end straight and short, meeting dorsal and ventral margins at sharp 110 to 125 degree angles. Umbos about one quarter length of shell from anterior, slightly opisthogyrous. Shell thick, gently convex except for steep escutcheon and umbonal regions of flank and area.

Area relatively narrow with very fine and regularly transverse costellae, which vary to growth lines with increased size of shell. Slight but distinct median groove slightly dorsal of centre of area. Escutcheon relatively broad, gently concave, with fine growth lines. Marginal and escutcheon carinae strong sharp ridges of about equal strength, with small sharp tubercles near umbos that become larger and transversely elongate to posterior.

Flank with single set of costae. In 2 cm nearest umbos, they diverge rapidly and become wider away from marginal carina. Later costae thin less toward marginal carina, fading into its relatively smooth anterior slope. Costae curve smoothly anteriorly, taper to meet anterior margin nearly at right angles. Earliest parts of costae are sharp narrow ridges, with growth becoming finely, then coarsely tuberculate; the tubercles fade near anterior end. In anteroventral region of large specimens, costae swing strongly to anterior and nodes may become irregular. Tubercles subcircular to transversely elongate, beadlike. Spaces between costae about same width as costae, with fine growth lines.

Discussion. This species has finer and more closely spaced ribs, and is less posteriorly elongated than *M. packardi* (Crickmay). The anterior parts of the ribs are more strongly curved than in *M. packardi.*

The Alaskan specimens apparently are identical to the Japanese specimens of *M. orientalis* described by Maeda and Kawabe (1966) except that they lack the fine transverse costellae of the escutcheon of the Japanese forms. In Canadian *Myophorella* species this feature does not appear to be of specific significance in many cases.

Myophorella devexa (Eichwald)

Plate 5, figures 6–15; Plate 6, figures 1–7

Trigonia devexa Eichwald, 1871, p. 183, Pl. 17, figs. 5, 6; Stanton and Martin, 1905, p. 398; Packard, 1921, p. 14.
?*Trigonia charlottensis* Packard, 1921, p. 12, 13, Pl. 3, fig. 1.

Material and occurrence. Eichwald (1871) originally described the species from southern Alaska. Additional specimens from southern Alaska occur in Bathonian or probably Bathonian beds of the Bowser and equivalent formations (hypotypes USNM 219886 and 219889 from USGS loc. 2919; 219887 from USGS loc. 3034; 219888 and 219890 from USGS loc. 3038; 219892–219894 from USGS loc. 24118), in Bathonian or Callovian beds (USNM 219891 from USGS loc. 26955), in the Callovian Chinitna Formation (USGS loc. 20765) and in Callovian beds not assigned to a particular formation, in the vicinity of Chisik Lake (CAS loc. 33378). The species is well represented in the Lower or Middle Callovian beds of the Yakoun Formation of Queen Charlotte Islands (GSC locs. 6363, 13616, 13617, 13619, 13624, 14920, 14923, 44738 and possibly 13621 and 44706), in probable Lower Oxfordian beds of the Bowser Lake Group of Smithers and adjacent map areas of British Columbia (hypotypes 43273–43275 from GSC loc. 57177; specimens from GSC locs. 10077, 80295, 81924, 81925, 85425, 85426, 87308–87310, 87383, 87391 and possibly 80296, 81926, 81930 and 83371) and in Callovian or Lower Oxfordian beds of the Bowser Lake Group of Spatsizi area (hypotype 48730 from GSC loc. 91765) and Smithers area (GSC loc. 81927).

Description. Shell large, elongate suboval to subtrigonal. Anterior and ventral margins form rounded curve. Posterior end slightly curved and inclined umbonally, meeting ventral margin at angle of 125 to 130 degrees. Dorsal margin long and straight. Shell gently convex, with umbonal-dorsal and anterior regions forming steep sides. Umbos at or near anterior end; slightly opisthogyrous.

Marginal carina a fine sharp ridge near umbo, becoming first finely, then coarsely tuberculate, more indistinct, and the spacing of the tubercles increases to about 8 to 9 mm at posterior end.

Broad area lies at small angle with flank, the angle increasing umbonally to almost a right angle. Area with irregular growth lines or occasionally concentric costellae, and with median groove or row of small tubercles. Median groove may be bordered by two rows of indistinct teardrop-shaped varices. A few wavy costellae cross it, particularly in late growth stages. Escutcheon carina a strong sharp ridge, with tubercles and growth lines. Escutcheon large, depressed, concave, smooth, or with fine growth lines, and some specimens have fine, irregular, poorly developed tubercles or transverse to oblique wavy costellae, which leave escutcheon carina in a regular fashion, becoming discontinuous and irregular toward dorsal margin.

Flank with nodose costae, numbering 13 in a specimen 9 cm long. There is considerable variation in strength, spacing and curvature of ribs. They are straight in young growth stages and perpendicular to growth lines, but ventrally they become curved toward anterior end, and in extreme cases are more concentric than radial. The stage at which the curvature begins varies considerably from one specimen to another. Most of the ribs bear large irregularly arranged tubercles. These costae near the umbo are very finely tuberculate. Ventrally on each rib of some specimens, the tubercles become faint and merge together, and the ribs weaken. Toward the marginal carina the tubercles are finer and the ribs taper into a narrow antecarinal smooth space in most specimens. The latest (posterior) few ribs are very weakly tuberculate. They are nearly straight and are inclined posteriorly.

A distinct dorsoventrally oriented row of nodes runs down anterior end of shell. In some specimens the nodes are strong and form the angular edge of the main portion of the flank. Posterior to this row of nodes is a narrow, ventrally broadening space with growth lines only. The anterior nodes are joined to the anterior margin by short, tapering, sharp and finely tuberculate ribs, either perpendicular to the plane of commissure or inclined very slightly umbonally. Within 4 cm of the umbo, these short anterior costae are aligned with, although they are discontinuous from, the costae of the main part of the flank. Later ones are independent of them. In some specimens the anterior nodes are weak and more closely related to the costae of the main part of the flank; in still others they are not recognized.

Discussion. Eichwald's (1871) figures and descriptions are insufficient for positive identification of any specimens with his species. Furthermore, his locality and stratigraphic data are poorly documented. However, the specimens illustrated here, from Alaska, are of the only similar form known in the area (Tuxedni Bay) from which Eichwald described his species and so are confidently taken to be the same species, as they were by Stanton (in Stanton and Martin, 1905; Martin, 1926) and by Imlay (in Detterman and Hartsock, 1966).

Packard's (1921) original description of *Trigonia charlottensis* was based on several specimens collected by C.F. Newcombe and by Packard himself from the north shore of Maude Island, Skidegate Inlet, Queen Charlotte Islands. Packard (1921) considered them to be Cretaceous, but noted that they are "the only Cretaceous representative of this group [i.e. Clavellatae Group of Agassiz, 1840] from this province". McLearn (1949) has discussed clearly the confusion of Jurassic and Cretaceous rocks and faunas by early workers, and has largely remedied the stratigraphic problems. The exact locations of many older collections, including those on which *M. charlottensis* was based, are not known with sufficient accuracy to determine their age. However, on the basis of external morphology and general area of occurrence on the north shore of Maude Island, the specimens originally described as *T. charlottensis* by Packard (1921) are believed by the present writer to be from Callovian beds and to be synonymous with the other specimens herein assigned to *M. devexa.*

The present concept of *M. devexa* is one of considerable morphological diversity, which may justify further study, but which is taken to be of infraspecific significance. In particular, certain outcrops, such as those of probable Lower Oxfordian beds of Smithers map area, yield specimens that are morphologically consistently alike, but contrast somewhat with the Callovian collections of Alaska and Smithers. The probable Oxfordian specimens from Smithers (Pl. 5, fig. 14, 15, Pl. 6, fig. 1) are less elongated, and have straighter costae than the others (Pl. 5, figs. 8, 11, 13, Pl. 6, figs. 2, 5–7, for example). The variation of ornamentation within one collection from the Lower Oxfordian beds of Smithers area (compare Pl. 5, fig. 15 and Pl. 6, fig. 1), together with the variation in outline of the Alaskan specimens (compare Pl. 6, figs. 4 and 5 for example), support the interpretation that the variations between the regions and between collections of different ages are not taxonomically significant, at least at the specific level.

Myophorella devexa is distinguished from *M. packardi* (Crickmay) by the presence of anterior nodes and costal segments that are separated from the costae of the main part of the flank, the generally coarser and more widely spaced costae, and the generally larger size. Also ribs on late growth stages are more nearly subparallel, converging less strongly toward the marginal carina. *Myophorella devexa* is distinguished from probably ancestral *M. dawsoni* (Whiteaves) by being generally larger and more elongate posteriorly, although some individual specimens are indistinguishable. The growth lines of the area recline backward more strongly than in *M. dawsoni.* Except on a few specimens the ribs of *M. devexa* are more widely spaced than in *M. dawsoni.* Although *Myophorella devexa* is very similar to *M. freboldi* n. sp., it is generally larger and has ribs that radiate more strongly rather than being subparallel.

Some juvenile specimens resemble *M. argo* (Crickmay) but generally they are more elongate and more coarsely ribbed; also, some have a more complexly ornamented area and escutcheon. The less sinuous ribs of *Myophorella devexa* are coarser and more widely spaced than in the superficially similar *M. tipperi* n. sp., its shell outline is more rounded, the posterior end is less rostrate, and the area and escutcheon are less complexly ornamented.

Certain specimens tentatively identified as *M. devexa* from north-central British Columbia (e.g., Pl. 5, fig. 13) have a strongly developed row of nodes along the anterior margin and develop a line, down the centre of the shell, where costae are unusually thickened, and they thus resemble *Scaphotrigonia naviformis* (Hyatt) from which they are distinguished by their greater posterior elongation and their close association with, as well as general similarity with, more typical specimens of *M. devexa.*

Myophorella sp. aff. *M. devexa* (Eichwald)

Plate 8, figures 4, 5

aff. *Trigonia devexa* Eichwald, 1871, p. 183, Pl. XIV, figs. 5, 6.

Material and occurrence. One specimen (Pl. 8, fig. 4; hypotype GSC 43281 from GSC loc. 23485), from Lower Oxfordian rocks of the Bowser Lake Group of Terrace map area, British Columbia, resembles *M. devexa* (Eichwald). The anterior row of nodes on this specimen is irregular, however, and poorly developed, and it may be pathological. Other characters ally the specimen with *M. packardi* (Crickmay) but that species generally is smaller and totally lacks the distinct anterior row of nodes. A poorly preserved internal mould (Pl. 8, fig. 5; hypotype GSC 43282 from GSC loc. 85323) from Callovian beds of the Hazelton Group of Smithers area resembles the specimen described above in general outline, size, and costation.

Myophorella argo (Crickmay)

Plate 4, figures 9–17

Material and occurrence. This species is known from the holotype GSC 27714 (Crickmay, 1930b) and numerous other well preserved specimens (GSC loc. 89468) from the Middle Bajocian Opuntia Formation of Ashcroft area, British Columbia; from hypotypes USNM 219878, 219881, 219882 (USGS loc. 19962), 219880 (USGS loc. 19948) and possibly by other specimens (USGS loc. 19936) from the Middle Bajocian Gaikema Formation of southern Alaska; from hypotype USNM 219879 (USGS loc. 10521) and other specimens (USGS loc. 3002) from the Middle Bajocian Cynthia Falls Formation; from specimens in Bajocian beds of the Red Glacier Formation of southern Alaska (USGS locs. 19951, 19986) and the Bajocian Mormon Formation of Mount Jura, California (USGS loc. 2425a).

Description. Shell of medium size, subtrapezoidal to gibbous in outline. Posterior end shorter than anterior end; shell distinctly elongate, particularly in young stages. Shell gently convex but, in umbonal region, sides descend steeply to plane of commissure. Umbos near anterior, slightly opisthogyrous.

Marginal carina a sharply raised fine ridge of closely and regularly spaced transversely elongate tubercles. Area relatively broad, more than one third of area of shell, with growth lines and median row of very fine tubercles or with median groove bordered on both sides by fine tubercles. Escutcheon carina a raised ridge of fine, transversely elongate tubercles of equal strength to those of marginal carina. Escutcheon long, narrow, depressed, concave, with very fine growth lines.

Flank depressed relative to marginal carina, the anterior side of which is smooth except for growth lines. Costae of flank taper onto this smooth area. Earliest costae meet it at nearly 90 degrees; the angle decreasing with growth to about 40 degrees. Costae leave marginal carina at intervals of 1 to 1.5 mm near umbo, increasing to 3 mm in posterior end of large specimens. Each rib tapers toward marginal carina. Costae with closely spaced transversely elongate tubercles. Narrow smooth space along vertical locus about one third of width of flank from anterior end of shell. A row of nodes lies anterior to the smooth space, from which nontuberculate sharply raised ribs descend, tapering, directly to anterior margin. Nodes and short anterior costae continuous with costae of flank in early growth stages, independent from them in later growth stages. Some variation in length of anterior set of costae and width of smooth space posterior to them. Except in anteroventral region and near umbo, costae generally perpendicular to growth lines. In extreme anteroventral region of larger shells, tubercles and costae may become extremely irregular.

Discussion. Crickmay's (1930b) diagnosis of *Scaphogonia* based on *S. argo* overemphasized the importance of the smooth space separating the anterior row of nodes from the costae of the main part of the flank. The writer's collections of *M. argo* and other species indicate that this feature develops in various forms referrable to *Myophorella,* that this feature is variable to a small extent within a single species, but that generally it is consistent within a single population. *Myophorella argo* is very close to *M. dawsoni* (Whiteaves) but its anterior row of nodes and costae are more clearly distinct, its nodes are less platelike and its anteroventral corner is more distinct. *Myophorella argo* is distinguished from the closely related *M.* sp. cf. *argo* in having a more rounded anteroventral outline and curved radiating ribs over a longer growth period. *Myophorella argo* differs from *M. montanaensis* (Meek) in having more strongly beadlike tubercles on the costae of the flank, a generally more distinct anteroventral corner, less well developed posterior rostration and an evenly convex flank surface, rather than the median line of relative shell height of *M. montanaensis.*

Myophorella sp. cf. *M. argo* Crickmay 1930

Plate 4, figures 18–22

cf. *Scaphogonia argo* Crickmay, 1930b, p. 52, Pl. 5, figs. a, b.

Material and occurrence. This species is known only from the poorly preserved hypotypes USNM 219883 and 219884 (USGS loc. 19844) from the Middle Bajocian *Parabigotites* beds of the Kialagvik Formation of southern Alaska, and hypotype USNM 219885 (USGS field no. 56-120) from the Middle Bajocian Weberg Formation of Oregon.

Description. Shell of medium size, subtriangular in outline, height approximately same as length. Anterior and ventral margins very gently curved, meeting in rounded angle of approximately 90 degrees. Posterior end very gently curved, nearly perpendicular to ventral margin; meeting posterior and ventral margins at relatively sharp angles. Dorsal margin long, straight. Umbos near anterior, slightly opisthogyrous. Shell gently convex.

Carinae, area, escutcheon poorly known, probably same as in *M. argo* (Crickmay).

Flank with two sets of costae. Costae of young growth stages not known. Costae of main portion of shell radiate from marginal carina, which is raised above them, expanding and becoming more strongly tuberculate anteroventrally. Tubercles small, transversely elongate beads. Costae in centre of shell radiate strongly and curve anteriorly; those more ventral become nearly subparallel and straight. Line of short costae near anterior end of shell, separated from costae of main portion of flank by narrow smooth space and descending directly to plane of commissure. At all growth stages, costae nearly perpendicular to growth lines.

Discussion. Myophorella sp. cf. *M. argo* is distinguished from the closely related *M. argo* (Crickmay) by its generally more upright and more triangular outline and its costae of the flank which become straight, subparallel and nearly dorsoventrally oriented at an earlier growth stage. These same characters ally *M.* sp. cf. *M. argo* with *M. leanzai* (Lambert), with which it may be conspecific. The poor preservation of the American specimens does not warrant identification with that species, which occurs in the Callovian of Argentina, however. *Myophorella tuxedniensis* n. sp. has less regular anterior nodes, is more nearly circular in outline, grows to a larger size when adult, and has fine, intercalated tuberculate costae in the anteroventral corner of large growth stages.

Myophorella alaskaensis n. sp.

Plate 4, figures 7, 8

Material and occurrence. This species is known from the holotype USNM 219877 (USGS loc. 24113) and other specimens (USGS loc. 8951) from Bajocian beds of the Tuxedni Group of Talkeetna Mountains, southern Alaska; and from Toarcian and Lower Bajocian beds of the Kialagvik Formation, southern Alaska (USGS loc. 19785; CAS loc. 29017).

Description. Shell of medium size, rounded subtrigonal in outline with distinctly elongate posterior end. Anterior margin forms smooth curve with ventral margin, which becomes straight in its posterior end. Posterior end short, straight. Dorsal margin long, straight. Umbos near anterior very slightly opisthogyrous. Main portion of shell strongly convex but elongate posterior end flattened, except for marginal carina.

Marginal carina a sharp ridge, the area forming one side, a smooth antecarinal slope forming the other. Marginal carina with fine growth lines, very finely tuberculate near umbos. Area narrow, nearly smooth, with very fine growth lines and faint medium groove. Escutcheon nearly smooth or with fine growth lines, and with fine tubercles near umbos. Escutcheon long, narrow, depressed, smooth or with very fine growth lines.

Earliest 3 mm with 4 fine concentric sharp costae.

Main, central and anterior portions of flank with 6 or 7 strongly radiating tuberculate costae with much wider intercostal spaces. Costae taper sharply to marginal carina and toward anterior margin, which they meet at high angles. Costae and spaces between them with fine growth lines. Elongate posterior end with 6 to 7 nontuberculate costae, subparallel, nontapering, running up onto smooth antecarinal surface or meeting it at slight node, maintaining strength to ventral margin, which they meet directly.

Discussion. This species is distinguished from all others by the sinuous curvature and wide spacing of the ribs of the main part of the flank, and by its intermediate size.

Derivation of name. The state of Alaska.

Myophorella dawsoni (Whiteaves)

Plate 1, figures 12–21; Plate 2, figures 1–4

Trigonia dawsoni Whiteaves, 1878a, p. 405; 1878b, p. 154; 1884, Pl. 31, fig. 1.
non *Trigonia dawsoni* Whiteaves, 1884, Pl. 31, fig. 1a.
?*Trigonia dawsoni* Whiteaves, 1889, p. 167.

Material and occurrence. This species was described originally by Whiteaves (1878a) from the vicinities of Iltasyuko River and Sigutlat Lake, Bella Coola map area, British Columbia (GSC syntypes 4781 and 4781a, b, c). The sedimentary rocks in this area are Middle Bajocian (Baer, 1966) and are equivalent to part of the Hazelton Group to the northeast. Other material includes hypotypes GSC 43241–43243, 43245, 43249 and 43250 (GSC loc. 87311), GSC 43244 (GSC loc. 83262), GSC 43246 (GSC loc. 85398), GSC 43247 (GSC loc. 87543) and GSC 43248 (GSC loc. 85427), as well as numerous other well preserved specimens from Middle Bajocian beds of the Hazelton Group, in Smithers map area of British Columbia (GSC locs. 81919, 83994, 85405, 87312, 87317, 87318, 87388, 87541, 87550, 87554 and possibly 82358, 85332, 85385, 85412, 87386, 87389, 87537 and 87553) and from Middle Bajocian beds of the Tuxedni Group of southern Alaska (USGS locs. 8567 and 20008).

Description. Shell of medium size, reaching 6.35 cm in length, rounded subtrigonal in outline. Anterior and ventral margins smoothly rounded, dorsal margin straight; end of area slightly rounded and meeting ventral margin at obtuse angle in most specimens. Umbos very near anterior, orthogyrous or very slightly opisthogyrous. Shell gently convex.

Marginal carina slightly curved, slightly raised, with fine growth lines and with tubercles that are more or less regularly spaced at intervals of about 2 to 3 mm apart when the shell is 3.2 cm long, and which are lozengelike, elongated transverse to the carina. The umbonal 1 cm of the carina is a smooth ridge, fairly sharp; in this region the area and flank lie at an angle of about 45 degrees, decreasing to about 15 degrees in shells 3.8 cm long.

Area broad, about one third of surface of shell, with faint median groove, which is scarcely noticeable in most specimens but is quite distinct in some and may have a row of very faint tubercles spaced approximately 1 mm. Area with very fine growth lines; but in umbonal 1.3 cm of most specimens, and throughout the whole area of some specimens, the area exhibits two rows (separated by median groove or simply a line of juncture) of evenly spaced costellae of a constant density in a single specimen, but varying slightly from specimen to specimen. On some specimens these riblets are straight and continuous, in others they are discontinuous, finely wavy, or anastomosing. In some of the type material from Iltasyuko River, the costellae are coarse and irregular, and on syntype GSC 4781c (Pl. 1, fig. 15), varices occur at their end to form the escutcheon carina, and in two rows bordering the median carina. Escutcheon carina variable but commonly it is finely tuberculate and essentially identical with marginal carina, especially in small shells. Escutcheon nearly smooth, with very fine growth lines.

Flank with growth lines and with 10 (when shell is 3.8 cm long) costae that are crenulate, the crenulae being spaced regularly at about 1 mm or 2 mm intervals, although they may be slightly irregular. They have the appearance of being a lot of small plates dipping toward the umbo or toward the dorsal margin at a shallow angle. The first 4 (to 7 in some specimens) costae are acutely pointed at their dorsal ends and leave the carina at an acute angle of as much as 75 degrees; later costae are not pointed and leave the marginal carina at an angle of about 45 degrees. The earliest ones mainly radiate strongly from each other so that intercostal spaces widen anteroventrally, and curve upward slightly. The obliquity of costae in the early growth stages is very variable. Certain collections show some infraspecific variation, such as finer or weaker than usual tubercles on the costae, finer spaced costae and somewhat less curvature of the costae with shell growth. Most of these variants are smaller overall than usual. Costae terminate along dorsoventral line near anterior end of shell. Along this line, which appears to directly overlie the anterior tooth (in the left valve), is a single more or less strongly to weakly developed row of nodes, regularly spaced at approximately 5 mm intervals, quite independent of the crenulate costae posterior to them. Faintly to moderately well developed set of costal segments join these nodes directly to the anterior margin. This region, anterior to the row of nodes, lies at a very slight angle to the remainder of the flank. The costae, which leave the marginal carina at about 45 degrees, are straight and are subparallel or radiate slightly. Most costae are approximately perpendicular to growth lines.

Discussion. Whiteaves' (1878a) original description of *M. dawsoni* and the specimens designated by him as types (GSC 4781 and 4781a, b, c) correspond well with the above description, which is based on specimens from GSC locality 87311 of Smithers map area, although the original type material is distorted, less well preserved, and does not clearly show a distinct anterior row of nodes.

Myophorella dawsoni generally is smaller and more nearly subequant in outline than specimens of *M. packardi*

(Crickmay) from Queen Charlotte Islands that Whiteaves (1884) considered to be synonymous with *M. dawsoni*, and is similarly distinguished from *M. devexa* (Eichwald). *Myophorella packardi* lacks the distinct row of nodes along the anterior end, has more beadlike tubercles on the costae and a less compressed cross-section. The separation of the anterior row of nodes from costae of the main part of the flank is more strongly developed than in *M. argo* (Crickmay) and *M. montanaensis* (Meek). The beadlike nature of the tubercles of *M. argo*, and commonly smoother, less distinctly tuberculate nature of the costae of *M. montanaensis* also distinguish those species. *Myophorella montanaensis* commonly has an indistinct ridge down the centre of the shell. The posterior rostration of *M. montanaensis* and more semicircular outline of *M. argo* further distinguish those species. There are, nevertheless, a few specimens identified as *M. dawsoni* by the writer, which approach *M. argo* and *M. montanaensis* in their general outline or nature of tuberculation. Occasional specimens (such as those from GSC locs. 83262, 85405, 87317), otherwise typical of *M. dawsoni*, bear an incipient ridge down the centre of the shell, approaching *M. montanaensis*, have slightly wider spaced ribs than normal, and have an anterior row of nodes, which are aligned with the costae of the main part of the flank, all features more strongly developed in *M. freboldi* n. sp. These intermediate forms indicate the close relationship of members of this group of species, each of which is nevertheless sufficiently distinct to require its specific separation.

Myophorella sp. aff. *M. dawsoni* (Whiteaves)

Plate 9, figures 12–20

Many Middle Jurassic specimens of *Myophorella* cannot be specifically identified at present, but are similar in their essential features to *M. dawsoni* (Whiteaves), *M. montanaensis* (Meek) and *M. argo* (Crickmay). They mainly are generalized forms, which are more finely sculptured than the more easily recognizable species. *Trigonia trafalgarensis* Warren (1932) was based on poorly preserved specimens that are specifically unidentifiable representatives of *Myophorella*. Better preserved topotypes are required to render that species valid.

Other typical examples are hypotypes GSC 43301 (GSC loc. 88485), GSC 43302 (GSC loc. 80301) and other specimens (GSC locs. 16071, 24780, 82395, 88585) from Bajocian and younger beds of the Hazelton Group of Smithers and adjacent areas, British Columbia; hypotypes USNM 219900, 219901, 219903 and 219906 (all USGS loc. 10512), USNM 219902, 219904, 219905 (USGS loc. 1495) and other specimens from Middle Bajocian beds of southern Alaska (USGS locs. 2994, 2996, 2999, 19796; CAS loc. 32712); specimens from the Bajocian Mormon Formation of Mount Jura, California (GSC loc. 89351, USGS loc. 525), from the Bajocian Potem Formation of northern California (GSC loc. 89375), from Bathonian or Lower Callovian beds of the Fernie Group, southern Alberta (GSC locs. 89471 and 89487), and from the Callovian Chinitna Formation of southern Alaska (USGS loc. 20765).

Myophorella montanaensis (Meek)

Plate 4, figures 23–27; Plate 5, figures 1–5

Trigonia montanaensis Meek, 1873, p. 472; White, 1883, p. 147, 148, Pl. 38, fig. 2a; Stanton, 1899, p. 619, 620.
Trigonia ferrieri McLearn, 1924, p. 45, 46, Pl. 5, figs. 2, 10.
Myophorella (Promyophorella) montanaensis (Meek) Imlay, 1964a, p. 31–33, Pl. 3, figs. 33–36, 38–41.

Material and occurrence. The species was figured originally by White (1883, Pl. 38, fig. 2a; USNM type 7817) from Montana, and Imlay (1964a) subsequently described numerous specimens from Middle Jurassic rocks of the western interior of the United States. The species is well represented in the Bathonian or Lower Callovian beds of the Fernie Group of southern Alberta (holotype GSC 6064 and paratype GSC 6065 of *Trigonia ferrieri* McLearn; also specimens from GSC locs. 6586, 89471, 89476, 89486–89488, 89491, 89496–89498, 89500 and possibly 89482, 89501) and in Bajocian through Callovian beds of the Hazelton Group of Smithers area, British Columbia (hypotypes GSC 43267, 43269 from GSC loc. 88565; 43268 from GSC loc. 85456; 43270, 43271 from GSC loc. 88567; 43272 from GSC loc. 88485; and other specimens from GSC locs. 85407, 85409, 85444, 85450, 85465, 88482 and possibly 87406).

Description. Shell medium to large. Adult shell with rounded subtrigonal to subtrapezoidal outline, distinctly posteriorly rostrate in most specimens, but varying to subequant. Shell thin and gently convex. Dorsal margin and posterior part of ventral margin straight or gently concave. Anterior and anteroventral margins form smooth curve. Umbos near anterior varying to a point one sixth length of shell therefrom, orthogyrous or slightly opisthogyrous.

Area with very fine growth lines, or very fine, regular and evenly spaced to somewhat coarser and slightly irregular wavy to anastamosing costellae, disrupted by a distinct median groove, on each side of which the costellae may enlarge to form slight varices. Where costellae are present, they generally give way to finer growth lines posteriorly.

Marginal carina a weak edge, coplanar with area but raised slightly above flank, with very small indistinct slope in its anteroventral side to which the costae of the flank extend. Marginal carina of some specimens ornamented with weak transverse lozengelike or irregularly ovoid tubercles at regular 2 to 3 mm intervals. In specimens on which the area bears coarser wavy costellae, the tubercles of the marginal carina may represent enlarged ends of the costellae or of every second costellae, or may alternate with them. Where costellae are very fine or absent, the tubercles apparently are unrelated to them.

Escutcheon carina a curved edge, sharp and smooth or finely to coarsely tuberculate, dorsal to which is a narrow, concave escutcheon that apparently is smooth or with fine growth lines.

Main part of flank with up to 12 oblique costae, which leave marginal carina at intervals of about 2 mm near umbo, gradually increasing to about 5 mm near posterior end. They form an angle with the marginal carina of 75 to 80 degrees near umbo, decreasing to about 45 degrees when shell is about 2.5 cm long, and increasing again to about 75 degrees near posterior end. Costae diverge relatively rapidly on main part of flank, but those near posterior end run parallel to each other and meet the ventral margin at right angles. Costae of main part of flank thicken and stand high to form a row of nodes resulting in a slightly curved line of maximum height more or less strongly developed down centre of shell. Costae taper gradually from this line of maximum height to marginal carina. Specimens in which this line of maximum height is relatively weak, though still distinct, also bear stronger tubercles or crenulae on the costae and marginal carina and coarser costellae of the area, than other specimens. A second, dorsoventral, straight row of nodes along the anterior margin corresponds with position of anterior tooth of left valve approximately. These circular nodes are either continuous with costae of the flank or, more commonly, are offset from them to varying degrees. Their strength is variable. The costae anterior to the previously described line of maximum shell height either extend to this row of nodes, weakening somewhat, or there is a narrow smooth area between them. Weak costae extend perpendicular to the anterior margin from anterior row of nodes in some specimens; the anterior edge is smooth in other specimens.

Certain rare, unfigured specimens exhibit incipient development of a second line of relative height of costae, which arises near the ventral margin midway between the anterior row of nodes and the previously described central line of maximum shell height that is subparallel with the marginal carina.

Posterior costae are fine, subparallel, approximately perpendicular to the ventral margin, finely and evenly spaced; this spacing apparently varies with the degree of posterior rostration. Large specimens commonly lose the median line of maximum height and the strength of their costae decreases. Costae are nearly smooth in some specimens and are crenulated or finely to moderately tuberculated in others, or they bear fine growth lines that also cover the intercostal spaces.

Discussion. Although a few specimens assigned to this species show certain similarities to *M. dawsoni* (Whiteaves) and indicate their relationship in the same species group, the following differences warrant its specific separation: *Myophorella montanaensis* has the median dorsoventral moderately prominent line of relative height of costae, anterior to which the costae weaken; *M. montanaensis* is more rostrate, posterior costae leaving the marginal carina at increased angles because of the stronger curvature of the marginal carina; crenulation of the costae and marginal carina generally is stronger and more regular in *M. dawsoni*; the area of *M. montanaensis* is a relatively smaller proportion of the total shell surface than in *M. dawsoni* and is less richly ornamented in most specimens; the cross-section of articulated shell of *M. montanaensis* is more strongly convex.

Young forms resemble those of *Scaphotrigonia naviformis* (Hyatt) but adult shells are clearly distinguishable by their smaller size and less extreme separation and strength of the nodes along the anterior end of the shell; the last feature characterizes the genus *Scaphotrigonia.*

Certains forms, with a relatively strongly developed anterior set of nodes and smooth space posterior to them, resemble *M. argo* (Crickmay), which is distinguished by its more strongly beadlike tubercles on the costae, its generally more distinct anteroventral corner, its lack of posterior rostration, and its lack of the median line of height.

Topotypes and other specimens of *T. ferrieri* McLearn, collected by the present writer, support its synonymy with *M. montanaensis* as suggested by Imlay (1964a). Warren's (1932) figured specimens of *Trigonia trafalgarensis* are not sufficiently different from *M. montanaensis* to warrant their specific separation but they are too poorly preserved to be positively identified.

Certain Callovian forms are more strongly posteriorly rostrate than the average but are not specifically distinct. In this characteristic they (for example, specimens from USGS locs. 19170, 19183, 19195) resemble certain specimens of *M. devexa* (Eichwald) (such as those from USGS loc. 26955) from which they differ in possessing the median dorsoventral line of relative height of costae, in being generally smaller, and mostly differently tuberculate.

Myophorella freboldi n. sp.

Plate 2, figures 5–12

Material and occurrence. This species is represented by the holotype USNM 219867 (USGS field no. 56-153F) from the Middle Bajocian Weberg Formation of Oregon; by paratypes GSC 43251, 43253–43255 (GSC loc. 87541), GSC 43252, 43256 (GSC loc. 87554) and GSC 43257 (GSC loc. 64796), as well as by numerous other specimens from Middle Bajocian beds of the Hazelton Group, Smithers map area, British Columbia (GSC locs. 81919, 81922, 82358, 87319, 87388, 87538, 87556 and possibly 87306).

Description. Shell moderately large; outline subquadrate or with rostrate posterior. Anteroventral corner sharp or a rounded curve. Shell gently convex.

Area with growth lines or fine concentric costellae. Area with median groove that may be bordered by small tubercles. Marginal carina is a narrow edge near umbo but bears regular transverse, lozengelike or crescentic tubercles in later growth stages, which are increasingly stronger and more widely spaced toward the posterior. Escutcheon carina similar to marginal carina but tubercles are weaker. Escutcheon nearly smooth but some specimens (Pl. 2, fig. 12) bear fine, irregular, transverse costellae that extend from fine nodes on escutcheon carina.

Flank with gently curved oblique, regularly spaced costae that leave a narrow antecarinal groove at angles varying from 52 to 80 degrees. Costae taper toward the groove in some specimens (Pl. 2, fig. 10) in which they also swing markedly umbonally at their posterior ends, but they maintain constant strength in others (e.g., Pl. 2, fig. 7).

The spacing of the costae is constant throughout most of the shell's growth, except in young specimens, which generally show finer ribbing than larger ones. After the shells are 2 cm long, the interval at which costae leave the marginal carina is relatively constant, approximately 7 mm. The costae of the main part of the flank bear fine but distinct tubercles that are elongated along the growth lines. A row of nodes, distinct from the costae of the remainder of the flank, occurs along the anterior end of the shell (e.g., Pl. 2, fig. 8). Short costal segments extend from these nodes directly to the anterior margin.

Discussion. Certain forms of *M. freboldi* are similar to *M. dawsoni* (Whiteaves), in particular slightly rostrate members of that species, but these are distinguished by the greater angle and interval at which costae leave the marginal carina, and the somewhat more angular anteroventral corner, as well as by the coarser tuberculation of the costae. *Myophorella freboldi* is smaller than *M. devexa* (Eichwald) and has straighter and more nearly parallel costae.

Derivation of name. Dr. Hans Frebold.

Myophorella sp. aff. *M. freboldi* n. sp.

Plate 8, figure 3

Material and occurrence. This species is represented by the single hypotype GSC 43280 (GSC loc. C-18178) from the Laberge Group of southern Yukon Territory. The associated bivalve fauna was tentatively dated as Middle Bajocian by Poulton (in Tempelman-Kluit, 1974).

Description. Shell large, semicircular to rounded trigonal in outline. Ventral and anterior margins form broad curve, posterior margin inclined toward umbo, dorsal margin short. Shell mainly gently convex but escutcheon, umbonal parts of area and anterior part of flank are steep. Umbo near anterior.

Marginal carina a fine sharp ridge in the 2.5 cm nearest umbo, becoming increasingly coarsely tuberculate with growth. Area broad, forming slight angle with flank, except near umbo, with very fine growth lines and indistinct medial depression. Escutcheon carina strong, coarsely tuberculate. Escutcheon very small, with very faint growth lines.

Earliest part of flank not preserved. Even at early growth stages, costae coarsely tuberculate, widely spaced, leaving marginal carina at constant angle of about 40 degrees then bending sharply anteriorly. Costae in the 3.8 cm nearest umbo taper toward marginal carina, producing sinuous appearance. Later costae more simply curved approaching growth lines, tapering toward anterior. Vertical row of strong nodes near anterior margin with sharp nontuberculate costae tapering from them to the anterior margin. In posteroventral region, costae and tubercles irregular in late growth stages.

Discussion. This species differs from *M. devexa* (Eichwald) in the closer spacing and curvature of costae. It may be synonymous with *M. freboldi* n. sp., but differs in the sinuosity of the costae and in the umbonal upturning and taper of the costae of the central part of the flank.

Myophorella yellowstonensis Imlay

Plate 2, figures 17–22

Myophorella (Haidaia) yellowstonensis Imlay, 1964a, p. 33, Pl. 3, figs. 27–32.

Material and occurrence. This species, originally described by Imlay (1964a) from Middle Bajocian rocks of the western interior of United States, occurs commonly in Middle Bajocian beds of the Hazelton Group of Smithers map area, British Columbia (hypotypes GSC 43258–43262 from GSC loc. 87541, GSC 43263 from GSC loc. 87554, and specimens from GSC locs. 87536, 87538, 87556). It also has been identified in the Middle Bajocian Harrison Lake Formation of southern British Columbia (GSC loc. 25781), the Bajocian Mormon Formation of Mount Jura, California (USGS loc. 2423) and Callovian beds of the Hazelton Group of Smithers area (GSC loc. 85456 and possibly 85451 and 87542).

Description. Small shell, reaching a maximum length of 3.2 cm, strongly convex. Anterior margin subcircular, ventral margin straight; posterior end rostrate and truncate. Umbos nearly orthogyrous, about one quarter to one fifth length of shell from anterior end.

Marginal carina is a very fine, slightly raised, smooth ridge. Flank and area commonly form only a very slight angle at the marginal carina, but in some specimens the angle may reach 60 degrees so that the shell's convexity is increased considerably. Area with regular, evenly spaced, concentric costellae, without a median ornament or with a very faint median groove that becomes strong near posterior margin. Escutcheon carina a fine raised ridge. Escutcheon depressed, with very fine growth lines. In some specimens, transverse costellae cross the escutcheon, the marginal carina is finely tuberculate, and the area has raised varices near the escutcheon carina.

Flank with sharp, narrow, finely spaced costae, which arise at the marginal carina at a regular spacing of about 1 to 1.5 mm. The first five or six costae diverge rapidly and curve anteriorly. In some specimens, the locus of points at which these costae curve forms an inclined line down the shell, anterior of which fine tubercles become obvious upon the costae. They are elongated transverse to the costae so that the costae appear to broaden. Fine radial striae are superimposed on the costae in the umbonal region and gradually merge with the marginal carina ventrally. A nearly dorsoventrally oriented line, along the anterior margin of the shell, is marked by alignment of very faint to quite distinct nodes on the costae. From each of these nodes the respective costae reach directly for the anterior margin, commonly on a somewhat steeper plane than is the main body of the flank, and they are commonly narrow, without tubercles. These anterior nodes are not recognized in many specimens. The remainder of the costae (posterior) are straight and parallel, leaving the marginal carina at a relatively constant angle of about 60 degrees and joining the ventral margin almost perpendicularly although in some specimens they curve gently anteriorly at their ventral margins.

Discussion. Its small size and fine ornamentation distinguish *Myophorella yellowstonensis* from all other *Myophorella* species in North America. The Canadian specimens occur in Callovian as well as Bajocian rocks, whereas, according to Imlay (1964a), the American specimens are restricted to the Bajocian. Many Canadian specimens have a faint but distinct anterior row of nodes as seen in many larger species of *Myophorella* but this apparently does not occur in the American specimens figured by Imlay.

Myophorella tipperi n. sp.

Plate 8, figures 13–15; Plate 9, figures 1–9

Material and occurrence. This species is known from the holotype GSC 43289 (GSC loc. 87386), paratypes GSC 43290 (GSC loc. 87381), 43291 (GSC loc. 87326), 43292 (GSC loc. 87319), 43293, 43295, 43296 (GSC loc. 87324), 43294 (GSC loc. 87541) and 43297 (GSC loc. 85398), as well as from numerous other specimens from Middle Bajocian beds of the Hazelton Group of Smithers area, British Columbia (GSC locs. 80298, 87322, 87387, 87393, 87409, 87554 and possibly 87307, 87320). It has been identified also in Bajocian beds of the Hazelton Group in Nechako River area (GSC loc. 21886) and in Middle Bajocian beds of the Tuxedni Group in southern Alaska (USGS loc. 24113 and possibly 21295).

Description. Shell is large, triangular, with relatively straight dorsal and ventral sides, smoothly curved anterior end and rostrate posterior, the end of which is straight and inclined back toward the umbos. Umbos sharply pointed near anterior, opisthogyrous. Flank flat or very slightly convex. Two specimens which have not been flattened have area and anterior part of flank nearly at right angles to plane of commissure (e.g., Pl. 8, figs. 13–15). Marginal carina and anterior row of nodes form sharp edges.

Marginal carina is a sharp, raised ridge near the umbos. To posterior, it grades to a row of tubercles, which are small, pointed, close together at first, then larger, more rounded, with spacing of 4 mm in largest specimen. Largest tubercles semicircular, transverse to marginal carina, with their straight sides toward umbos. Growth lines cross these tubercles and spaces between them.

Area relatively narrow, with very fine growth lines and median groove. Most specimens with moderately well developed transverse to oblique wavy costellae, except in the 2.5 cm nearest the umbos. These costellae occur in two sets, separated by a sharp but fine median groove. The upper set of costellae are, in part, continuous with nodes of the marginal carina, and in part intercalated between them. Costellae of the lower set are much more closely spaced; they unite and form teardrop-shaped varices which constitute the escutcheon carina.

Escutcheon long and broad, flat or slightly concave, either with fine growth lines, or with transverse to oblique or concentric finely tuberculate costellae. Spacing and size of these costellae and of varices of inner carina increase with size of shell.

Flank with oblique, tuberculate, costae numbering 27 when shell is 9 cm long. There is some variation in density of ribs; Lower Bajocian forms are commonly but not always finer ribbed. Earliest 4 or 5 costae are sinuous, curving umbonally at posterior ends, ventrally at anterior ends. Later costae are straight except for small degree of dorsal curvature at posterior ends in some specimens. Costae taper, with finer, more closely spaced tubercles toward marginal carina. Costae leave the marginal carina at a constant angle of about 60 degrees, and interval increases from 1.5 mm near umbo to 2.5 mm near posterior end of largest specimen. Tubercles of posterior part of shell are transversely elongate, platelike, 'dipping' dorsally, very closely spaced. Tubercles in centre of shell are subcircular, relatively widely and evenly spaced. In large shells ornamentation in anteroventral corner is irregular. Rows of tubercles in this region are curved anteriorly; some are discontinuous. A few isolated tubercles are interspersed randomly with them. In distal parts of costae, tubercles are subcircular to irregularly shaped, large and relatively flat. Anterior of flank bears a row of strong nodes at constant intervals of 4 to 5 mm, which are joined perpendicularly to the anterior margin by short tapering costae. Narrow, ventrally widening, smooth space separates anterior row of nodes from remainder of flank.

Costae or rows of tubercles are perpendicular to growth lines, except in anteroventral corner.

Tubercles and spaces between them bear very fine growth lines on well preserved surfaces.

Discussion. This species is not similar to any other North American trigoniid. Young or broken specimens resemble *Scaphotrigonia naviformis* (Hyatt) but have finer ribbing, a wider smooth region posterior to the anterior vertical row of nodes, are more clearly posteriorly elongated, and differ in the ornament of the area and escutcheon. Small specimens may resemble *M. argo* (Crickmay) but differ in having sinuous rather than simply curved ribs. Small specimens of *M. tipperi* resemble *M. aculeata* (d'Orbigny), which, however, are smaller as adults and not as posteriorly elongated. *Myophorella snaintonensis* (Lycett) is similar to juvenile specimens of *M. tipperi* but, as far as is known, is smaller as an adult and does not have the complex ornamentation of *M. tipperi*. In the sinuous shape of the ribs on the main part of the flank and the strong anterior discrepant row of nodes, *M. tipperi* differs from British *M. ramsayi* (Wright), *M. leckenbyi* (Lycett), *M. incurva* (Bennett) [including *M. heberti* (Munier-Chalmas)] and *M. carrei* (Munier-Chalmas).

Derivation of name. Dr. H.W. Tipper.

Myophorella tuxedniensis n. sp.

Plate 7, figures 9–17

Material and occurrence. The species is represented by the holotype USNM 219895 and paratypes USNM 219896–219898 (USGS loc. 24113) from Middle Bajocian beds of the Tuxedni Group, Talkeetna Mountains, southern Alaska; by paratypes GSC 43277 (GSC loc. 85398) and 43278 (GSC loc. 82358) and other specimens (GSC loc. 81936) from Middle Bajocian beds of the Hazelton Group of Smithers area, British Columbia; and it has been identified from the Toarcian *Hammatoceras* beds of the Kialagvik Formation, southern Alaska.

Description. Shell subovate in outline. Ventral and anterior margins form semicircular curve. Posterior end meets ventral margin in rounded 135 degree corner. Posterior end gently rounded, about equal to length of dorsal margin. Shell gently convex. Umbos near anterior margin, orthogyrous.

In umbonal 3 cm, the marginal carina is poorly developed and bears tubercles spaced at about 3 mm. To posterior, growth lines of area meet ornament of the flank with only faint varices, slightly raised, following locus of marginal carina in the British Columbia specimen (Pl. 7, fig. 12). The transversely elongate tubercles maintain their strength on the large Alaska specimen (Pl. 7, fig. 9). Area is broad, with slightly irregular growth lines and median set of transversely elongated tubercles. Set of strong transversely elongate tubercles follows locus of escutcheon carina and these tubercles continue across escutcheon as strongly raised ridges that are slightly irregular and parallel with growth lines.

Most of flank within 2 cm of the marginal carina has tuberculate costae that are perpendicular to ventral margin, nearly parallel and leave the marginal carina at a constant angle of about 40 to 45 degrees; nearly constant in thickness. The tubercles are of constant density. Costae are rounded ridges above flat intercostal spaces that are of approximately the same width. Intercostal spaces with distinct growth lines. Tubercles are closely spaced, transversely elongate and lozengelike. Costae in umbonal region are somewhat oblique, diverging and widening anteroventrally.

In anteroventral region of shell, the density of costation is increased sharply along a locus about 2 cm from marginal carina. There costae are perpendicular to marginal carina. These more densely arranged costae show a narrowing of the transverse tubercles and an increase in their density in the anteroventral direction. Some of these costae are continuous with vertical costae of rest of flank; others are intercalated between them, or arise irregularly. Since tubercles of each costa are aligned along growth lines, the ornament of this part of the shell is distinctly reticulate. Costae of flank nearly perpendicular to direction of shell growth, but this character varies slightly in anterior region. Distinct set of very finely tuberculate costae along anterior portion of shell, perpendicular to anterior margin.

Discussion. This species is differentiated from *M. billhookensis* (Crickmay) in that the costae of the flank are nearly perpendicular to the growth lines, leaving the marginal carina at angles of 40 to 50 degrees. The ornament of the anteroventral corner of the flank of *M. tuxedniensis* results from addition of tuberculate costae, whereas no new costae are added in this region in *M. billhookensis*. No other species is similar.

Derivation of name. Tuxedni Group of Alaska.

Myophorella billhookensis (Crickmay)

Plate 8, figure 1

Haidaia billhookensis Crickmay, 1930a, p. 49, Pl. XII, fig. 1.

Material and occurrence. This species is known only from the holotype GSC 9681, which was collected from Callovian beds of the Billhook Formation, Harrison Lake area, southwestern British Columbia (Crickmay, 1930a).

Description. Shell large. Only lower portions of flank and a small part of the area are preserved. Shell gently convex. Area with fine irregular growth lines and weak median groove. Marginal carina an indistinct row of irregular nodes that die out near posteroventral end.

Main portion of flank convex with straight, parallel, evenly spaced costae, which leave marginal carina at constant angle of 50 to 60 degrees, broken into irregular tubercles that are continuous along growth lines. In ventral region costae are fainter; growth lines are the dominant ornament. Spaces between costae are narrow. Each costa tapers toward marginal carina. Near ventral and anteroventral edges, costae curve slightly anteriorly. They are continuous, apparently broken only because of environmental or pathological causes.

Discussion. This species is easily distinguished from the only similar form, *M. tuxedniensis* n. sp., because its ribs are oblique in the main portion of the flank and are disturbed, rather than added, in the anteroventral region.

Myophorella sp. A

Plate 8, figure 2

Material and occurrence. This species is known only from hypotype 43279 (GSC loc. 13756) from Whitesail Lake map area, British Columbia. It was not found directly associated with diagnostic ammonites but all Jurassic sedimentary rocks in the immediate vicinity are uniformly Lower Callovian and contain *Kepplerites*.

Description. Shell is not complete but the outline is inferred by tracing concentrically aligned elongate tubercles across the flank. Growth lines are not preserved everywhere. Shell elongate with rostrate posterior region. Ventral and anterior margins appear to form a smooth curve but there may be a slight rounded corner where they meet. End of area meets ventral margin at rounded 135 degree corner, and probably has a similar relationship with the dorsal margin. Shell gently convex.

Only those portions of marginal carina and area posterior to the posterior adductor muscle scar are preserved. Marginal carina appears straight over most of its length, marked by slightly raised, transversely elongate, lozengelike tubercles of constant size and spacing, about 2 to 2.5 mm apart. Between them very fine growth lines cross that carina. Area with fine growth lines and median line of transversely elongate tubercles, which are of same dimensions and spacing as those of the marginal carina, and aligned with them along growth lines. Escutcheon carina and escutcheon not preserved.

Flank, within 2 cm of marginal carina, with tuberculate costae. The 8 costae nearest umbo diverge from the marginal carina at constant intervals of about 4 mm and at angles that vary from nearly 90 degrees at umbo to 60 degrees where marginal carina is 3 cm long. Latest of these costae diverge relatively rapidly, anteriorly curved; the earliest are nearly straight and parallel. Remainder of costae of flank leave marginal carina at angle decreasing posteriorly from 45 to 30 degrees, very slightly diverging, nearly subparallel, tapering to marginal carina. Costae nearest umbo apparently sharp, very finely tuberculate ridges, but this appearance may be due to poor preservation. Those near centre of specimen bear very closely spaced indistinct tubercles near marginal carina but anteriorly become more widely spaced, strong, transversely elongate tubercles. Most posterior costae are weaker and bear fine, closely spaced tubercles.

In anteroventral region of specimen, beyond 2 cm from marginal carina, there is a sharp change to a distinct set of rows of tubercles that is nearly perpendicular to marginal carina. These rows of tubercles are subparallel, at intervals of 3 mm. The tubercles are rounded or sharply pointed, and triangular to subcircular in outline.

In all parts of shell, the costae are nearly perpendicular to growth lines.

Discussion. The single specimen available is broken and somewhat deformed but the nature of the ribbing on most of the flank can be seen and the outline of the shell can be judged to have been nearly subequant in dimensions. *Myophorella* sp. A is distinguished from *M. tipperi* n. sp. by its apparently subequant rather than posteriorly elongated outline, the gentle convexity of its shell and the more numerous ribs on the anteroventral part of the flank. The coarse spacing of the costae, the large size and the gentle convexity of the shell separate it from other North American species except *M. devexa* (Eichwald) and *M. dawsoni* (Whiteaves), which do not have the fine costation in the anteroventral corner. The outline and detailed costation pattern in the adult shell distinguish it from similar British and European species *M. leckenbyi* (Lycett), *M. ramsayi* (Wright), *M. incurva* (Bennett) [including *M. heberti* (Munier-Chalmas)] and typical *M. carrei* (Munier-Chalmas).

Myophorella sp. B

Plate 9, figures 10, 11

Material and occurrence. This species is known from hypotypes GSC 43298 and 43299 as well as several other fragmentary specimens (all from GSC loc. 83477) from the Laberge Group of southern Yukon Territory. This collection was dated as probably Early Bajocian or possibly Late Toarcian by J.A. Jeletzky on the basis of the presence of the belemnite *Pseudodicoelites*.

Description. The complete left valve is 2.8 cm long and 2 cm high. Fragments with coarser ornamentation and internal moulds indicate that the species reached a larger maximum size. Shell approximately semicircular in outline. Anterior and ventral margins form smooth curve. Dorsal margin slightly concave. Umbos very near anterior, slightly recurved posteriorly. Posterior end nearly straight, forming angles of about 120 degrees with both ventral and dorsal margins. Shell gently convex except near umbos where dorsal and anterior sides are nearly perpendicular to plane of commissure. Area narrow, strongly curved near umbo but flaring rapidly to posterior. Distinct 'median' groove located nearer escutcheon carina than marginal carina. Area with very fine costellae which become slightly coarser to posterior. They are slightly wavy and irregular. Their continuation across median groove cannot be judged. Escutcheon carina a sharp edge. It has distinct but fine tubercles which result from joining of two or more costellae of area. Escutcheon relatively broad, strongly concave. Near its dorsal side, it is covered only with very fine growth lines. Near umbo, relatively coarse costellae cross it transversely, originating at each tubercle of escutcheon carina and dying out dorsally. Similar costellae nearer posterior are slightly oblique, extend farther across escutcheon, and are corrugated with very fine growth lines. Very near posterior, a second set of costellae, oblique in the opposite direction, cross the first set, giving a somewhat reticulate appearance. In this region the tubercles of the escutcheon carina are somewhat irregular.

Marginal carina near umbo is simply the anteroventral edge of the area. To posterior, it becomes ornamented with fine, transversely elongated tubercles which occur at junctions of two or more costellae of the area and which are comparable in size with tubercles of escutcheon carina. Very fine antecarinal groove separates marginal carina from ornament of flank. Very faint suggestion of postcarinal groove.

Flank with radiating curved tuberculate costae, 13 on the left valve available. They are about 2 mm apart near marginal carina, which they meet at nearly right angles near umbo and at an angle of about 20 degrees at posterior end of shell. Each costa tapers strongly toward marginal carina but is truncated by antecarinal groove.

Costae are sharp narrow ridges separated by relatively broader intercostal spaces, which are covered with fine growth lines. Tubercles on the costae are small sharp points, which increase in size and become transversely elongated away from marginal carina. They are aligned along growth lines on the major part of flank. In the 1 cm near the beak, however, there is a diagonal alignment of tubercles and lineation on intercostal spaces.

Relatively sharp angle in shell near anterior margin, between the gently convex or nearly flat major portion of the flank and the small anterior region, which is nearly perpendicular to the plane of commissure. Costae continue across this angle, extending directly to the plane of commissure, which they meet at right angles and with only slight loss of strength, but with a distinct decrease in the strength of tuberculation. Slight tendency to form nodes at the angle between the two subplanar surfaces.

Discussion. The incipient reticulate ornamentation of the area, the transverse costellation of the escutcheon, the dorsal offset of the median groove and the posterior elongation ally this species, which may be represented by juvenile specimens only, with *M. tipperi* n. sp. It lacks, however, the independent anterior row of tubercles of that species and the sinuous curvature of the costae.

Myophorella sp. C

Plate 6, figures 8, 9

Material and occurrence. This species is represented by the single hypotype GSC 43276 (GSC loc. 85398), from Middle Bajocian beds of the Hazelton Group, Smithers map area, British Columbia.

Description. Shell large. Ventral and anterior margins gently curved. Posterior margin straight, strongly inclined toward umbo. Dorsal margin relatively short. Convexity and general outline of shell not known, possibly subquadrate.

Escutcheon large, prominent, with very fine growth lines. Marginal carina a row of tubercles of moderate size, which dies out near posterior end.

Flank with 11 widely spaced subparallel rows of large and uniformly rounded tubercles, apparently abraded, leaving marginal carina at angle of about 90 degrees at 2.5 cm from umbo, decreasing to about 65 degrees near posterior. The rows of tubercles have varying relationships with growth lines but constantly slope anteroventrally.

Discussion. This species is superficially similar to large Cretaceous forms such as those referred to *Steinmanella* Crickmay. The specimen is not sufficiently well preserved to compare it with that species, or any other species. Its appearance in the Middle Jurassic is unusual in view of the mainly Cretaceous occurrence of forms that are so coarsely costate and so nearly quadrate in outline.

Genus *Scaphotrigonia* Dietrich 1933

Type species. *Trigonia navis* Lamarck, 1819. Lower Bajocian (Aalenian), Germany.

Diagnosis. Costae of flank coarse, nearly straight, perpendicular to ventral margin. A discrete row of nodes occurs along anterior edge of shell, with short costae leading from the nodes to the anterior margin. Smooth space between this row of nodes and the main costae of the flank. Area with growth lines but with concentric costellae near umbo. Adult marginal carina becoming obscure.

Distribution. Middle to ?Upper Jurassic [Lower Bajocian (Aalenian) to Callovian, and (?)Lower Oxfordian]. North America, Europe, ?India.

Discussion. Scaphotrigonia Dietrich (1933; Deecke, 1925 nom. nud.; Cox, 1969) [=*Myophorella (Scaphotrigonia)* Cox, 1952] contains *Scaphotrigonia navis* (Lamarck) and *S. naviformis* (Hyatt), which are morphological end members of the Myophorellinae. They are separated arbitrarily from *Myophorella* mainly by the strong separation of anterior nodes from costae of the main portion of the flank. The similarity of certain *Myophorella* species, such as *M. montanaensis* (Meek), *M. devexa* (Eichwald) (GSC loc. 91765) and *M. tipperi* n. sp. to *Scaphotrigonia* species may indicate their derivation from the same stock in or prior to earliest Bajocian (Aalenian) time.

Scaphotrigonia naviformis (Hyatt)

Plate 11, figures 8–13

Trigonia naviformis Hyatt, 1892, p. 407; Packard, 1921, p. 11, Pl. 2, fig. 1.

Material and occurrence. This species is represented by the lectotype USNM 32478 selected by Packard (1921), hypotypes USNM 32478a, b (all USGS loc. 9258) from the Callovian Bicknell Sandstone (Hinchman Formation) of Mount Jura, California; by hypotype GSC 43308 (GSC loc. 85450) and other specimens from Lower Callovian beds of the Bowser Lake Group of Smithers map area, British Columbia (GSC loc. 85456 and possibly 87542); and possibly by juvenile specimens in the Callovian Foreman Formation of Mount Jura, California (USGS loc. 3143) and in probable Callovian beds of the Ellis Group (?Rierdon Formation) of Montana (USGS loc. 10729).

Description. Shell large, triangular in outline. Anterior margin straight, ventral margin gently curved; they meet at rounded but distinct angle. Dorsal margin long, straight. Posterior end extended but detailed form poorly known. Umbos in extreme anterodorsal corner of large specimens, markedly in-curved. Flank gently convex but with steep sides in umbonal region and along anterior edge.

Marginal carina a sharp raised curved ridge. Area and flank meet at sharp angles that decrease posteriorly. Area narrow, apparently smooth but with some suggestion of occasional growth lines and a fine median groove. Escutcheon very narrow, about three quarters length of shell, smooth, slightly depressed.

Flank in 1.3 cm nearest umbo with 3 or 4 narrow, sharp, raised costae (Pl. 11, fig. 10). Their spacing is variable from one specimen to another. Each costa consists of three elements: long central portions, approximately concentric; short posterior segment tapering dorsally, approximately radial; and weak, short anterior segment, weakening toward anterior margin, to which it is perpendicular. These segments meet at angles that also carry strongly raised varices, giving each costa a binodose appearance (Pl. 11, fig. 10). Growth lines not preserved in umbonal regions. After shell becomes about 1.3 cm long, central segment of each costa disappears, resulting in long, relatively wide, smooth space close to anterior end of shell. Posterior portion of costae becomes long sweeping ribs, leaving marginal carina at angles decreasing from 40 degrees near umbos to 20 degrees near posterior end of large specimens and spaced at nearly constant interval of 3 mm. Ribs nearly straight or feebly curved, with dorsal ends curved slightly umbonally. Within 1.9 cm of umbo these ribs do not meet marginal carina but are separated from it by very slightly depressed, smooth antecarinal space. Ribs strongest and most coarsely nodose along a line down centre of flank, tapering and becoming finely and less distinctly tuberculate in both directions therefrom. Anterior edge of flank with row of strong nodes at nearly constant 1 cm spacing. From each node, a tapering rib descends directly to plane of commissure. Ribs oriented nearly perpendicular to growth lines except in earliest, umbonal growth stages. Spaces between ribs with fine growth lines, except in early growth stages.

Discussion. This species was inadequately described by Hyatt (1892) but was redescribed and figured by Packard (1921). The original type material is still the best available.

Scaphotrigonia naviformis is easily distinguished from any other hitherto described form. Young specimens resemble young *Myophorella montanaensis* (Meek) but have more clearly binodose costae, which are subparallel to each other rather than diverging adventrally. *Scaphotrigonia naviformis* has similarities with certain specimens (unfigured) referred to *M. devexa* (Eichwald), but it is larger and more coarsely ribbed and the anterior row of nodes is more strongly developed. These nodes and the anterior parts of costae are more clearly separated from the costae of the main portion of the flank and the costae become much stronger in the centre of the flank. The overall outline of the shell also separates *S. naviformis* from these two species. *Scaphotrigonia naviformis* is larger and has stronger and more coarsely spaced costae than *S. navis* (Lamarck).

The flank of an unfigured juvenile specimen from probable Callovian beds of Montana (USGS loc. 10729) is similar to that of *S. naviformis.* This specimen has transverse costellae on the area, a character not seen, possibly because of nonpreservation, in *S. naviformis* from the type area.

Genus *Orthotrigonia* Cox, 1952

Type species. *Trigonia duplicata* Sowerby, 1819. Bajocian, England.

Diagnosis. Flank with V-shaped costae in juvenile growth stages. Adult part of shell with fine subradial or anteroventrally sloping oblique costae that abut or intersect the juvenile costae.

Distribution. Lower to Upper Jurassic, Upper Cretaceous. Cosmopolitan, except for boreal regions.

Discussion. Orthotrigonia Cox [=*Myophorella (Orthotrigonia)* Cox 1952, Savel'ev, 1958; = *Vaugonia (Orthotrigonia)* Cox, 1969] is separated as an extreme form of the *Myophorella-Vaugonia* group by its ontogenetically early change of ornament of the style less perfectly developed by *Vaugonia*(?) *yukonensis* n. sp. The nodes of the curved oblique costae in the early growth stages are radially aligned and become modified slightly so that they parallel the posterior oblique portions of costae. The addition or dichotomy of costae in the anteroventral region, and the fine corrugation of the costae, also separate many *Orthotrigonia* species from those of *Myophorella.*

The Cretaceous extension of the range from that cited by Cox (1969) is intended to include *Trigonia gilleti* Basse, which may, however, require erection of a new genus in the future.

Orthotrigonia(?) sp.

Plate 11, figures 14–17

Material and occurrence. This species is known from hypotypes GSC 43309 (GSC loc. 81937), 43310 (GSC loc. 87387) and 43300 (GSC loc. 87324) and numerous other specimens (GSC locs. 10073, 87321, 87323, 87325, 87541 and possibly 87378 and 87406) from Middle Bajocian beds of the Hazelton Group, Smithers map area, British Columbia; and it has been identified questionably from the probably Bajocian Potem Formation of northern California (GSC loc. 89344) and the Bajocian Mormon Formation of Mount Jura, California (USGS loc. 525).

Description. Shell small, subtriangular. Anterior and ventral margins form smooth U-shaped curve, meeting posterior end at right angles. Dorsal margin straight. Umbos straight, midway along shell. Shell gently convex.

Marginal and escutcheon carinae are sharp ridges with very fine transversely elongate tubercles. Area with very fine costellae; median groove absent or very weak. Escutcheon not known.

Umbonal part of flank with fine, sharp subconcentric or curved, gently oblique costae with superimposed very fine radial striae. Posterior portions of costae remain the same with later growth stages, meeting a very narrow antecarinal groove at constant 1.5 mm intervals, radiating at first, then becoming subparallel. In intermediate growth stages, costae are added in the anteroventral part of the flank. They appear to arise as extensions of the radial striae of the umbonal growth stages. These newly added costae become oriented parallel to the posterior costal segments and fuse with them, so that continuous, more or less straight, very finely tuberculate costae cover the adult part of the flank. The anterior costal segments meet the anterior margin at right angles, descending to it from a very slight node. Large specimens exhibit the development of abundant closely spaced ribs in the anteroventral region of the shell. There is considerable variation in the orientation of the juvenile costae and in the spacing of costae.

Discussion. This species does not closely resemble any other, being much more finely sculptured. The addition of oblique ribs by modification of radial umbonal striae, characteristic of the genus *Orthotrigonia,* is not well developed in the Canadian species and occurs only near the anterior end of the shell. It is, thus, transitional with *Myophorella* species such as *M. yellowstonensis* Imlay, which does not show this character at all, and has curved rather than straight ribs in the adult.

Orthotrigonia(?) *sohli* n. sp.

Plate 2, figures 13–16

Material and occurrence. This species is known from the holotype USNM 219869 and paratypes USNM 219868, 219870 and 219871 and a few other fragmentary specimens (all from USGS loc. 19357) from probable Bajocian beds of the Gypsum Springs Formation of Wyoming.

Description. Small shell, subtrigonal in outline. Ventral and anterior margins form smooth curve. Posterior and dorsal margins short. Shell moderately convex.

Marginal carina a very fine sharp ridge near umbos, rounded and indistinct at posterior, bearing small nodes which are ends of costellae of area. Area with simple fine concentric costellae becoming somewhat irregular with growth. Simple median groove, slightly dorsal of middle of area, does not offset costellae significantly. Escutcheon carina a simple edge, with fine nodes that are the ends of costellae, or are weak varices at junctions of every two costellae. Small escutcheon, only slightly depressed, smooth or with very faint growth lines.

Umbonal 5 mm of flank with about 7 fine, sharp costae, concentric at umbo but meeting anterior margin at high angles, becoming somewhat V-shaped with increasing growth stages, as posterior ends curve umbonally. Each costa aligned or continuous with costellae across marginal carina. Radial striae cross costae. Remainder of flank with three distinct sets of ornament. Narrow anterior region with short costal segments approximately perpendicular to anterior margin. Central region with fine pointed tubercles, somewhat irregular in some specimens but more or less well aligned to form conjugate (a) anteroventrally sloping oblique 'costae' and (b) concentric 'costae' continuous with anterior costal segments. Radially directed 'tails' can be seen extending ventrally from some tubercles. The earliest oblique 'costae', so formed by the tubercles, are not continuous with the posterior set of costal segments; later ones are. Posterior costal segments leave either the marginal carina or the very narrow antecarinal groove at angles of 70 degrees at 5 mm from umbo, changing to about 20 degrees at posterior end.

Discussion. The delicate and complex ornament of this species and its small size distinguish it from any other North American species known to the writer. It appears to be closely allied with New Zealand Middle Jurassic to Oxfordian *Trigonia kawhiana* Trechmann (1923, p. 277, Pl. XIII, figs. 6–9) but lacks the acute V-sculpture on the umbonal region of the flank.

Derivation of name. Dr. N.F. Sohl.

Subfamily Megatrigoniinae van Hoepen 1929

Diagnosis. Pyriform to ovate outline. Marginal and escutcheon carinae poorly defined except near umbos. Area narrow, smooth or with concentric costellae near umbos. Flank with smooth or slightly tuberculate, rather thin, subconcentric to oblique costae, which may be broken in centre of flank.

Distribution. Middle Jurassic (Callovian) to Upper Cretaceous. Cosmopolitan except for boreal regions.

Discussion. Representative members of the subfamily Megatrigoniinae, taken herein to include Rutitrigoniinae van Hoepen, 1929 and Iotrigoniinae Savel'ev, 1958, are united and distinguished from other Trigoniidae by their smooth and narrow area. Nevertheless, certain of the species of Stoyanow (1949) probably referrable to Megatrigoniinae, have a well defined area and marginal carina and are therefore gradational with probably ancestral Myophorellinae, with which they are closely linked. Megatrigoniinae are presumed to be descended from Myophorellinae (Nakano, 1965; Levy, 1967) by reduction in the distinctness and relative size of the area and escutcheon. The variation in style of flank ornamentation is approximately equivalent to that of the Myophorellinae (see also Levy, 1967) but is sufficiently different in the lesser degree of tuberculation, narrowness and, to some extent, orientation of costae, to suggest homeomorphic radiation within the subfamily after its origin. Nevertheless, the relatively early occurrence of the most complexly sculptured form, that is *Anditrigonia* *plumasensis* (Hyatt), suggests that the family may not be strictly monophyletic. This question and the exact relationships of Megatrigoniinae with Pterotrigoniinae and Myophorellinae, are not yet resolved satisfactorily. The various morphotypes of Megatrigoniinae are ornamented concentrically or nearly concentrically (*Rutitrigonia*), obliquely (*Megatrigonia*), with V's (*Anditrigonia*), or more complexly (*Iotrigonia*). The complex sculpture of early *Anditrigonia* may indicate its generalized nature, where selection pressures did not yet define a particularly strong orientation of costae.

Genus *Anditrigonia* Levy, 1967

Type species. *Trigonia carrincurensis* Leanza, 1942. Tithonian, Argentina.

Diagnosis. Flank, area and escutcheon distinct but carinae indistinct. Flank with smooth or slightly tuberculate costae, concentric near umbos and on anterior. Posterior part of flank with oblique costae, mainly perpendicular to ventral margin, or curved and broken up. Area narrow, with concentric costae near umbos, smooth to posterior. Escutcheon narrow, smooth.

Distribution. Middle Jurassic (Callovian) to Cretaceous (Neocomian). North and South America.

Discussion. The author's interpretation of *Anditrigonia* is based on Levy's (1967) inclusion of both simple L-sculptured forms and irregularly nodose forms, as well as her placement of the genus in Megatrigoniinae. The character of its area is thus considered to be taxonomically significant; the ornament of the flank is of the same variable style as that of homeomorphic *Vaugonia* Crickmay. Superficially similar *Apiotrigonia* Cox is different from *Anditrigonia* in the common oblique costellation of its escutcheon, a character well developed in the type species *Trigonia sulcataria* Lamarck.

Although Skwarko (1970) considered *Trigonia calderoni* (Castillo and Aguilera) to be a species of *Apiotrigonia* Cox, it is placed questionably in this report in *Anditrigonia* Levy, because oblique or transverse costellae are absent from the escutcheon of this species.

Anditrigonia plumasensis (Hyatt)

Plate 11, figures 6, 7

Trigonia plumasensis Hyatt, 1892, p. 407; Packard, 1921, p. 32, Pl. 10, fig. 5.

Material and occurrence. This species is represented by the lectotype USNM 32480 (selected by Packard, 1921) from the Callovian Bicknell Sandstone (Hinchman Formation) of Mount Jura, California; and by numerous poorly preserved specimens in Callovian (GSC locs. 85388, 85450, 85451, 85456, 87542 and 88506) and Lower Oxfordian (GSC locs. 23485, 85395) rocks of the Hazelton and Bowser Lake groups in Smithers and Terrace map areas; as well as by rare specimens in the Callovian Billhook Formation of Harrison Lake area, southern British Columbia (GSC loc. 89457).

Description. Large elongated shell. Dimensions of lectotype: length 7 cm, height 4 cm, thickness right valve 1 cm. Anterior margin and anterior part of ventral margin rounded, meeting at a distinct but rounded corner. Near posterior, ventral margin is straight or gently concave. Dorsal margin straight. Posterior end narrow, almost forming a point. Umbos one third to one half length of shell from anterior, slightly opisthogyrous. Flank gently convex. Anterior region of flank, area and escutcheon nearly perpendicular to plane of commissure.

Marginal carina unornamented, a relatively sharp angle between area and flank, decreasing to posterior. Area on holotype absent or extremely narrow and unornamented, poorly known on accessory material. Escutcheon larger, but small relative to size of shell, smooth or with very fine growth lines.

Flank with as many as 6 very fine sharp concentric costae in 6 mm nearest umbo. Rest of flank with 3 distinct sets of ornament. Triangular region adjacent to ventral margin, tapering toward umbo, with numerous fine costae perpendicular to marginal carina. These costae are subparallel, leaving marginal carina at angles decreasing gradually from 80 degrees near umbos to 65 degrees near posterior, nearly evenly spaced, but becoming slightly farther apart to posterior. There is some variation from one specimen to another in the spacing of these costae and in the degree of taper of posterior end. Costae tapering slightly toward marginal carina, meeting it without interruption. Very fine indistinct transverse crenulations cross these costae. Centre of flank with large rounded nodes that are irregularly aligned in oblique 'costae' that vary from subconcentric near umbo to subradial ventrally. Nodes become larger and more irregularly spaced ventrally. Anterior quarter of flank has sharp ridges that meet anterior margin at 90 degrees. They are continuous with early concentric costae near umbo, meeting them at a slight angle. With growth, anterior set of costae are more widely spaced. Some of these costae are continuous with lines of coarse nodes of central part of shell, others are independent of them.

Growth lines are not preserved on most specimens available.

Discussion. This species was inadequately described by Hyatt (1892) but has been described and illustrated by Packard (1921). The lectotype USNM 32480 (Pl. 11, figs. 6, 7) remains the best preserved specimen available, although poorly preserved specimens interpreted to be conspecific are not uncommon in western Canada. *Anditrigonia plumasensis* is not easily confused with any other form.

References

Agassiz, L.
1840: Études critiques sur les mollusques fossiles; Mémoire sur les Trigonies, Petitpierre, Neuchâtel.

Albritton, C.C., Jr.
1937: Upper Jurassic and Lower Cretaceous ammonites of the Malone Mountains, Trans-Pecos, Texas; Bull. Mus. Comp. Zool. Harvard Coll., v. 80, no. 10, p. 391–412.
1938: Stratigraphy and structure of the Malone Mountains, Texas; Bull. Geol. Soc. Am., v. 49, p. 1747–1806.

Alencaster, G.
1963: Pelecipodos del Jurásico Medio del Noroeste de Oaxaca y Noreste de Guerrero; Pal. Mex., No. 15.

Alencaster, G. and Buitron, B.E.
1965: Fauna del Jurásico superior de la region de Petlalcingo, Estado de Puebla; Pal. Mex., No. 21, pt. II, p. 1–53.

Anderson, F.M.
1958: Upper Cretaceous of the Pacific Coast; Geol. Soc. Am., Mem. 71.

Arkell, W.J.
1956: Jurassic geology of the World; Oliver and Boyd, Ltd., Edinburgh.

Baer, A.J.
1966: Bella Coola and Laredo Sound map-areas, British Columbia; Geol. Surv. Can., Paper 66-25.

Barthel, K.W.
1958: Eine marine faunula aus der mittleren Trias von Chile; N. Jahrb. Geol. Palaeontol. Abh., v. 106, p. 352–382.

Bayle, E.
1878: Fossiles principaux des terrains. Explication de la carte géologique de la France, Vol. 4, pt. 1 (Atlas); Imprimerie royale, Paris.

Brooke, M.M. and Braun, W.K.
1972: Biostratigraphy and microfauna of the Jurassic System of Saskatchewan; Sask. Dept. Min. Res., Rept. 161.

Brookfield, M.E.
1973: Lower Oxfordian (Upper Jurassic) sediments at Harrison Lake, British Columbia, and the age of the 'Agassiz Orogeny', Can. J. Earth Sci., v. 10, p. 1688–1692.

Burwash, E.M.
1913: On some new species of marine invertebrates from the Cretaceous of the Queen Charlotte Islands; Trans. Roy. Soc. Can., 3rd ser., v. 7, sect. 4, p. 77–90.

Butler, B.S., Loughlin, G.F. and Heikes, V.C.
1920: The ore deposits of Utah; U.S. Geol. Surv., Prof. Paper 111.

Castillo, A.D. and Aguilera, J.G.
1895: Fauna fósil de la Sierra de Catorce, San Luis Potosí; Com. Geol. México, Bol. 1.

Choffat, P.
1885: Description de la faune jurassique du Portugal. Mollusques lamellibranches, 2-e ordre Asiphonidae. Livr. 2; Commission travaux géologiques du Portugal, Lisbon.

Coates, J.A.
1967: Manning Park area (92H), Cascade Mountains; Geol. Surv. Can., Paper 67-1A, p. 56, 57.
1974: Geology of the Manning Park area, British Columbia; Geol. Surv. Can., Bull. 238.

Cox, L.R.
1952: Notes on the Trigoniidae, with outlines of a classification of the family; Proc. Malac. Soc. London, v. 29, p. 45–70.
1959: Superfamily Trigoniacea Lamarck, 1819; in Treatise on Invertebrate Paleontology, R.C. Moore, ed.; Part N, v. 1, p. N471–N489.

Cragin, F.W.
1893: A contribution to the invertebrate paleontology of the Texas Cretaceous; Geol. Surv. Texas, 4th Ann. Rept., p. 139–246.
1897: Discovery of marine Jurassic rocks in southwestern Texas; J. Geol., v. 5, p. 813–820.
1905: Paleontology of the Malone Jurassic Formation of Texas; U.S. Geol. Surv., Bull. 265.

Crickmay, C.H.
1930a: Fossils from Harrison Lake area, British Columbia; Nat. Mus. Can., Bull. 63, p. 33–66.
1930b: The Jurassic rocks of Ashcroft, British Columbia; Univ. Calif. Geol. Publ. v. 19.
1932: Contributions toward a monograph of the Trigoniidae; Am. J. Sci., v. 24, p. 443–464.
1933: Mount Jura investigation; Bull. Geol. Soc. Am., v. 44, p. 895–926.
1936: Study in the Jurassic of Wyoming; Bull. Geol. Soc. Am., v. 47, p. 541–564.
1962: Gross stratigraphy of Harrison Lake area, British Columbia; published by the author, Calgary, Art. 8, p. 1–12.

Deecke, W.
1925: Uber die Trigonien; Pal. Zeitschr., Bd. 7, p. 65–101.

Detterman, R.L.
1963: Revised stratigraphic nomenclature and age of the Tuxedni Group in the Cook Inlet region, Alaska; U.S. Geol. Surv., Prof. Paper 475-C, p. C30–C34.

Detterman, R.L. and Hartsock, J.K.
1966: Geology of the Iniskin-Tuxedni region, Alaska; U.S. Geol. Surv., Prof. Paper 512.

Dickinson, W.R. and Vigrass, L.W.
1965: Geology of the Suplee-Izee area, Crook, Grant, and Harney Countries, Oregon; State of Oregon Dept. Geol. Min. Industries, Bull. 58.

Dietrich, W.O.
1933: Das Muster der Gattung *Trigonia* (Moll. Lam.); Sitzungsber. Ges. naturforsch, Freunde, Berlin, p. 325–332.

Diller, J.S.
1908: Geology of the Taylorsville region, California; U.S. Geol. Surv., Bull. 353.

Duffell, S.
1959: Whitesail Lake map-area, British Columbia; Geol. Surv. Can., Mem. 299.

Duffell, S. and McTaggart, K.C.
1952: Ashcroft map-area, British Columbia; Geol. Surv. Can., Mem. 262.

Duffell, S. and Souther, J.G.
1964: Geology of Terrace map-area, British Columbia; Geol. Surv. Can., Mem. 329.

Eichwald, C.E. von
1871: Geognostich-Palaeontologische Bemerkungen über die Halbinsel Mangischlak und die Aleutischen Inseln, von dr. Eduard von Eichwald; Buckdruckerei der Kaiserlichen akademie der wissenschaften, St. Petersburg.

Felix, J.
1891: Versteinerungen aus der mexicanischen Jura und Kreide Formation; Palaeontographica, v. 37, p. 140–194, Pl. 22–30.

Fleming, C.A.
1962: Two new genera of Triassic Trigoniidae from New Zealand; Proc. Malac. Soc. London, v. 35, p. 1–4, Pl. 1.
1963: A new genus and species of Trigoniidae from the Middle Triassic of New Zealand; New Zealand J. Geol. Geophys., v. 6, p. 843–846.
1964: History of the bivalve family Trigoniidae in the southwest Pacific; Aust. J. Sci., v. 26, no. 7, p. 196–204.

Frebold, H.
1951: Contributions to the palaeontology and stratigraphy of the Jurassic System in Canada; Geol. Surv. Can., Bull. 18, p. 1–54.
1953: Correlation of the Jurassic formations of Canada; Bull. Geol. Soc. Am., v. 64, p. 1229–1246.
1957: The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills; Geol. Surv. Can., Mem. 287.
1959: Marine Jurassic rocks in Nelson and Salmo areas, southern British Columbia; Geol. Surv. Can., Bull. 49.
1963: Ammonite faunas of the upper Middle Jurassic beds of the Fernie Group in western Canada; Geol. Surv. Can., Bull. 93.
1964a: Illustrations of Canadian fossils. Jurassic of western and Arctic Canada; Geol. Surv. Can., Paper 63-4.
1964b: Lower Jurassic and Bajocian ammonoid faunas of northwestern British Columbia and southern Yukon; Geol. Surv. Can., Bull. 116.
1966: Upper Pliensbachian beds in the Fernie Group of Alberta; Geol. Surv. Can., Paper 66-27.
1967: Position of the Lower Jurassic genus *Fanninoceras* McLearn and the age of the Maude Formation on Queen Charlotte Islands; Can. J. Earth Sci., v. 4, p. 1145–1149.
1969: Subdivision and facies of Lower Jurassic rocks in the southern Canadian Rocky Mountains and Foothills; Proc. Geol. Assoc. Can., v. 20, p. 76–89.
1970: Pliensbachian ammonoids from British Columbia and southern Yukon; Can. J. Earth Sci., v. 7, p. 435–456.
1976: The Toarcian and lower Middle Bajocian beds and ammonites in the Fernie Group of southeastern British Columbia and parts of Alberta; Geol. Surv. Can., Paper 75-39.

Frebold, H. and Little, H.W.
1962: Palaeontology, stratigraphy, and structure of the Jurassic rocks in Salmo map-area, British Columbia; Geol. Surv. Can., Bull. 81.

Frebold, H., Mountjoy, E.W. and Reed, R.
1959: The Oxfordian beds of the Jurassic Fernie Group, Alberta and British Columbia; Geol. Surv. Can., Bull. 53.

Frebold, H. and Poulton, T.P.
1977: Hettangian (Lower Jurassic) rocks and faunas, northern Yukon Territory; Can. J. Earth Sci., v. 14, p. 89–101.

Frebold, H. and Tipper, H.W.
1967: Middle Callovian sedimentary rocks and guide ammonites from southwestern British Columbia; Geol. Surv. Can., Paper 67-21.
1969: Lower Jurassic rocks and fauna near Ashcroft, British Columbia and their relation to some granitic plutons (92-I); Geol. Surv. Can., Paper 69-23.
1970: Status of the Jurassic in the Canadian Cordillera of British Columbia, Alberta and southern Yukon; Can. J. Earth Sci., v. 7, p. 1–21.
1973: Upper Bajocian–Lower Bathonian ammonite fauna and stratigraphy of Smithers area, British Columbia; Can. J. Earth Sci., v. 10, p. 1109–1131.
1975: Upper Callovian and Lower Oxfordian ammonites from southeastern Bowser Basin, British Columbia; Can. J. Earth Sci., v. 12, no. 2, p. 145–157.

Frebold, H., Tipper, H.W. and Coates, J.A.
1969: Toarcian and Bajocian rocks and guide ammonites from southwestern British Columbia; Geol. Surv. Can., Paper 67-10.

Haczewski, G.
1976: Sedimentological reconnaissance of the San Cayetano Formation: an accumulative continental margin in the Jurassic of western Cuba; Acta Geol. Polonica, v. 26, pt. 2, p. 331–353.

Hall, J. and Whitfield, R.P.
1877: Paleontology; U.S. Geol. Explor. 40th Parallel (King), v. 4, pt. 2, p. 199–302, Pls. 1–7.

Hanson, G.
1935: Portland Canal area, British Columbia; Geol. Surv. Can., Mem. 175.

Hayami, I.
1962: Jurassic pelecypod faunas in Japan with special reference to their stratigraphical distribution and biogeographical provinces; J. Geol. Soc. Japan, v. 48, p. 96–108.

Hoepen, E.C.N. van
1929: Die Krytfauna von Soeloeland, 1. Trigoniidae; Pal. Navorsing Nat. Museum. Bloemfontein, v. 1, pt. 1.

Hyatt, A.
1892: Jura and Trias at Taylorville, California; Bull. Geol. Soc. Am., v. 3, p. 395–412.
1894: Trias and Jura in the western states; Bull. Geol. Soc. Am., v. 5, p. 395–434.

Imlay, R.W.
1940: Upper Jurassic pelecypods from Mexico; J. Paleontol., v. 14, p. 393–411.

1943: Jurassic formations of Gulf Region; Bull. Am. Assoc. Petrol. Geol., v. 27, p. 1407–1533.
1945: Jurassic fossils from the southern states, no. 2; J. Paleontol., v. 19, p. 243–276.
1952: Correlation of the Jurassic formations of North America, exclusive of Canada; Bull. Geol. Soc. Am., v. 63, p. 953–992.
1953: Callovian (Jurassic) ammonites from the United States and Alaska. Part 2. Alaska Peninsula and Cook Inlet regions; U.S. Geol. Surv., Prof. Paper 249-B, p. 41–108, Pls. 25–55.
1961a: Late Jurassic ammonites from the western Sierra Nevada, California; U.S. Geol. Surv., Prof. Paper 374-D.
1961b: New genera and subgenera of Jurassic (Bajocian) ammonites from Alaska; J. Paleontol., v. 35, p. 467–474.
1962a: Jurassic (Bathonian or early Callovian) ammonites from Alaska and Montana; U.S. Geol. Surv., Prof. Paper 374-C.
1962b: Late Bajocian ammonites from the Cook Inlet region, Alaska; U.S. Geol. Surv., Prof. Paper 418-A, p. A1–A14, Pls. 1–5.
1964a: Marine Jurassic pelecypods from central and southern Utah; U.S. Geol. Surv., Prof. Paper 483-C.
1964b: Middle Bajocian ammonites from the Cook Inlet region, Alaska; U.S. Geol. Surv., Prof. Paper 418-B.
1965: Jurassic marine faunal differentiation in North America; J. Paleontol., v. 39, p. 1023–1038.
1968: Lower Jurassic (Pliensbachian and Toarcian) ammonites from eastern Oregon and California; U.S. Geol. Surv., Prof. Paper 593-C.
1973: Middle Jurassic (Bajocian) ammonites from eastern Oregon; U.S. Geol. Surv., Prof. Paper 756.
1975: Stratigraphic distribution and zonation of Jurassic (Callovian) ammonites in southern Alaska; U.S. Geol. Surv., Prof. Paper 836.

Imlay, R.W. and Detterman, R.L.
1973: Jurassic paleobiogeography of Alaska; U.S. Geol. Surv., Prof. Paper 801.

Jaworski, E.
1916: Beitrage zur Kenntnis des Jura in Süd-Amerika. Teil II. Spezieller, paläontologischer Teil; N. Jahrb. Min., Geol. Palaeontol., Beil. – Bd. XL, Stuttgart.
1929: Eine Lias-fauna aus Nordwest-Mexiko; Abhandlungen der schweizerischen Palaeontologischen Gesellschaft, Bd. XLVIII.

Jeletzky, J.A.
1954: Tertiary rocks of the Hesquiat-Nootka area, west coast of Vancouver Island, British Columbia; Geol. Surv. Can., Paper 53-17.
1970: Some salient features of early Mesozoic history of insular tectonic belt, western British Columbia; Geol. Surv. Can., Paper 69-14.
1972: Jurassic and Cretaceous rocks along the Hope-Princeton Highway and Lookout Road, Manning Park, British Columbia (supplement to Section 10 of 24th Int. Geol. Congr. Guidebook A03-C03); Geol. Surv. Can., Open File 114.
1973: Cretaceous and Jurassic stratigraphy of northern Vancouver Island (102I) and Manning Park area (92H, E/2 and W/2), British Columbia; Geol. Surv. Can., Paper 73-1A, p. 259–262.

Jones, D.L.
1960: Pelecypods of the genus *Pterotrigonia* from the west coast of North America; J. Paleontology, v. 34, p. 433–439.

Kirschner, C.E. and Minard, D.L.
1949: Geology of the Iniskin Peninsula, Alaska; U.S. Geol. Surv., Oil and Gas Investigations, Prelim. Map OM-95.

Kitchin, F.L.
1926: The so-called Malone Jurassic Formation in Texas; Geol. Mag., v. 63, p. 454–469.

Kobayashi, T.
1954: Studies on the Jurassic trigonians in Japan, Part I, preliminary notes; Jap. J. Geol. Geog., v. 25, p. 61–80.

Kobayashi, T. and Amano, M.
1955: On the Pseudoquadratae trigonians, *Steinmanella,* in the Indo-Pacific Province; Jap. J. Geol. Geog., v. 25, p. 193–208.

Kobayashi, T. and Mori, K.
1954: Studies on the Jurassic trigonians in Japan, Part II, *Prosogyrotrigonia* and the Trigoniinae; Jap. J. Geol. Georg., v. 25, p. 155–175, Pl. 15/6.
1955: The Vaugoniinae from the Kitakami Mountains in North Japan. On the Jurassic trigonians in Japan, Part III; Jap. J. Geol. Geog., v. 26, p. 73–88.

Kobayashi, T. and Tamura, M.
1959: The bearing of trigoniids on the Jurassic stratigraphy of Japan. Studies on the Jurassic trigonians in Japan, Part VII; Jap. J. Geol. Geog., v. 30, p. 273–292.

Kobayashi, T. and Tamura, M.
1955: The Myophorellinae from North Japan. Studies on the Jurassic trigonians in Japan, Part IV; Jap. J. Geol. Geog., v. 26, p. 89–104.
1957: Additional new genera and species of trigonians from the Jurassic of Soma, North Japan; Jap. J. Geol. Geog., v. 28, p. 35–42.

Krommelbein, K.
1956: Die ersten marinen fossilien (Trigoniidae, Lamellibr.) aus der Cayetano-Formation West Cubas; Senckenberg. Leth., v. 37, p. 331–335.

Leanza, A.F.
1942: Los pelecipodos del Lias de Piedra Pintada en el Neuquen. Inst. del Museo de la Universidad Nacional de la Plata. Revista del Museo de la Plata (N.S.); Tomo II Palaeontologia, No. 10, p. 145–206.

Lebküchner, R.
1932: Die Trigonien des Suddeutchen Jura; Paleontographica, v. 77, p. 1–119.

Lees, E.J.
1934: Geology of the Laberge area, Yukon; Trans. Roy. Inst. Can., v. 20.

Levy, R.
1967: Revision de las Trigonias de Argentina, Parte IV: Los Megatrigoniinae de Argentina y su relacion con *Anditrigonia* gen. nov.; Ameghiniana, T.V, no. 4, p. 135–144.
1969: Revision de las Trigonias de la Argentina, Parte V: El grupo de las Pseudoquadratae; Ameghiniana, T. VI, p. 65–68.

Lupher, R.L.
1941: Jurassic stratigraphy of central Oregon; Bull. Geol. Soc. Am., v. 52, p. 219–270.

Lycett, J.
1872–1879: A monograph of the British fossil Trigoniae; Palaeontograph. Soc. London.

Maeda, S. and Kawabe, T.
1966: Note on the ontogenetic change of *Myophorella (Promyophorella) orientalis;* Ann. Rept. Foreign Students' College of Chiba Univ., no 1, p. 51–56, Pls. I, II.

Mansfield, G.R.
1927: Geography, geology, and mineral resources of southeastern Idaho; U.S. Geol. Surv., Prof. Paper 152.

March, M.C.
1911: Studies in the morphogenesis of certain Pelecypoda. (3) The ornament of *Trigonia clavellata* and some of its derivatives; Mem. Proc. Manchester Lit. Phil. Soc., v. 55, No. 15, p. 1–13.

Martin, G.C.
1926: The Mesozoic stratigraphy of Alaska; U.S. Geol. Surv., Bull. 776.

Martin, G.C. and Katz, F.J.
1912: A geological reconnaissance of the Iliamna region, Alaska; U.S. Geol. Surv., Bull. 485.

McLearn, F.H.
1924: New pelecypods from the Fernie Formation of the Alberta Jurassic; Trans. Roy. Soc. Can., sec. IV, p. 39–61.
1926: New Jurassic species from the Hazelton Group of British Columbia; Nat. Mus. Can., Bull. 44, p. 89–99, Pls. XIX, XXV.
1929a: Contributions to the stratigraphy and palaeontology of Skidegate Inlet, Queen Charlotte Islands, British Columbia; Nat. Mus. Can., Bull. 54.
1929b: Stratigraphy, palaeontology, Blairmore region, Alberta; Nat. Mus. Can., Bull. 58, Geol. Ser., no. 50, p. 80–107.
1949: Jurassic formations of Maude Island and Alliford Bay, Skidegate Inlet, Queen Charlotte Islands, British Columbia; Geol. Surv. Can., Bull. 12.

McMath, V.
1966: Geology of the Taylorsville area, northern Sierra Nevada; Calif. Div. Mines and Geology, Bull. 190, p. 173–183.

Meek, F.B.
1864: Description of the Jurassic fossils. Palaeontology of California; Geol. Surv. Calif., v. 1, sec. III, p. 37–54, Pl. 8.
1873: Paleontological report; U.S. Geol. Surv. Terr., 6th Ann. Rept. 1872, p. 429–518.

Meek, F.B. and Hayden, F.V.
1860: Descriptions of new organic remains from the Tertiary, Cretaceous and Jurassic rocks of Nebraska; Acad. Nat. Sci. Philadelphia Proc. 1860, p. 175–185.
1865: Palaeontology of the upper Missouri; invertebrates; Smithsonian Inst., Smithsonian Contr. Knowledge, v. 14, no. 172, p. 1–35.

Moffit, F.H.
1922a: Geology of the vicinity of Tuxedni Bay, Cook Inlet, Alaska; U.S. Geol. Surv., Bull. 722-D, p. 141–147.
1922b: The Iniskin Bay district (Alaska); U.S. Geol. Surv., Bull. 739-C, p. 117–132.
1927: The Iniskin-Chinitna Peninsula and the Snug Harbour district, Alaska; U.S. Geol. Surv., Bull. 789.

Monger, J.W.H.
1970: Hope map-area, west half, British Columbia; Geol. Surv. Can., Paper 69-47.

Möricke, W.
1895: Versteinerungen des Lias und Unteroolith von Chile; N. Jahrb. Min., Geol. Palaeontol., Beil. – Bd. 9, p. 1–100.

Muller, J.E.
1967: Kluane Lake map-area, Yukon Territory (115G, 115F E½); Geol. Surv. Can., Mem. 340

Muller, J.E. and Carson, D.J.T.
1969: Geology and mineral deposits of Alberni map-area, British Columbia (92F); Geol. Surv. Can., Paper 68-50.

Muller, S.W. and Ferguson, H.G.
1939: Mesozoic stratigraphy of the Hawthorne and Tonopah Quadrangles, Nevada; Bull. Geol. Soc. Am., v. 50, p. 1573–1624.

Nakano, M.
1960: Stratigraphic occurrences of the Cretaceous trigoniids in the Japanese Islands and their faunal significances; J. Sci. Hiroshima Univ., ser. C, v. 3, p. 215–280.
1961: On the Trigoniinae; J. Sci. Hiroshima Univ., ser. C, v. 4, p. 71–94.
1965: On the Megatrigoniinae; J. Sci. Hiroshima Univ., ser. C, v. 5, p. 13–20.
1968: On the Quadratotrigoniinae; Jap. J. Geol. Geog., v. 39, p. 27–41.
1970: Notes on the Trigoniinae and the Nototrigoniinae; Res. Bull. Hiroshima Inst. Technology, v. 4, p. 91–108.

Newell, N.D. and Boyd, D.W.
1975: Parallel evolution in early Trigoniacean bivalves; Bull. Am. Mus. Nat. Hist., v. 154, Art. 2, p. 55–162.

Packard, E.L.
1921: The Trigoniae of the Pacific Coast of North America; Univ. of Oregon Publ., v. 1, no. 9.

Paterson, D.F.
1968: Jurassic megafossils of Saskatchewan with a note on charophytes; Sask. Dept. Min. Res., Geol. Sci. Branch, Sed. Geol. Div., Rept. no. 120.

Poulton, T.P.
1972: Jurassic studies, British Columbia (93E, K, L); Geol, Surv. Can., Paper 72-1A, p. 115, 116.
1973: Jurassic Trigoniidae of western British Columbia; Geol. Surv. Can., Paper 73-1A, p. 268.
1974: Lower Jurassic sedimentary and volcanic rocks, Bait Range, Hazelton map-area (93M E½); Geol. Surv. Can., Paper 74-1A, p. 31–33.
1976: Some Lower Jurassic trigoniid bivalves from southwestern British Columbia; Geol. Surv. Can., Bull. 256, p. 41–53.
1977: Early Cretaceous trigoniid bivalves of Manning Provincial Park, southwestern British Columbia; Geol. Surv. Can., Paper 76-9.

Poulton, T.P. and Callomon, J.H.
1977: A new species of trigoniid bivalve from the Boreal Bathonian (Jurassic) of central East Greenland; Bull. Geol. Soc. Denmark, v.26, p. 155–159.

Richards, T.
1974: Hazelton east-half (93M east half); Geol. Surv. Can., Paper 74-1A, p. 35–37.

Richards, T. and Dodds, C.J.
1973: Hazelton (east-half) map-area, British Columbia; Geol. Surv. Can., Paper 73-1A, p. 38–42.

Richards, T. and Jeletzky, O.L.
1975: Preliminary study of the Upper Jurassic Bowser Assemblage in the Hazelton west half map-area, British Columbia (93M-W½); Geol. Surv. Can., Paper 75-1A, p. 31–36.

Sanborn, A.F.
1960: Geology and paleontology of the southwest quarter of the Big Bend Quadrangle, Shasta County, California; Calif. Div. Mines, Spec. Rept. 63.

Savel'ev, A.A.
1958: Lower Cretaceous Trigoniidae from Mangyschlak and western Turkmenia; Trudy VNIGRI, v. 125 (in Russian).
1960: Jurassic Trigoniidae from Mangyschlak and western Turkmenia; Trudy VNIGRI, v. 148 (in Russian).

Skwarko, S.K.
1963: Australian Mesozoic trigoniids; Bur. Min. Resources Geol. Geophys., Australia, Bull. 67, p. 1–42.
1970: An Upper Jurassic *Apiotrigonia* from Mexico; Bol. Soc. Geol. Mexicana, v. 31, p. 75–78.

Sowerby, J. de C.
1823: The mineral conchology of Great Britain; Meredith, London.

Stanley, S.M.
1977: Coadaptation in the Trigoniidae, a remarkable family of burrowing bivalves; Palaeontology, v. 20, p. 869–899.

Stanton, T.W.
1899: Mesozoic fossils of the Yellowstone National Park; U.S. Geol. Surv., Monogr. 32, pt. 2, p. 600–650, Pls. 62–76.

Stanton, T.W. and Martin, G.C.
1905: Mesozoic section in Cook Inlet and Alaska Peninsula; Bull. Geol. Soc. Am., v. 15, p. 391–410.

Steinmann, G.
1882: Die Gruppe der Trigoniae pseudoquadratae; N. Jahrbuch Min., Geol. Palaeontol., Beil. I, p. 219–228, Pls. VII–IX.

Stoyanow, A.
1949: Lower Cretaceous stratigraphy in southeastern Arizona; Geol. Soc. Am., Mem. 38.

Sutherland Brown, A.
1968: Geology of the Queen Charlotte Islands, British Columbia; B.C. Dept. Mines Petrol. Res., Bull. 54.

Taliaferro, N.L.
1942: Geologic history and correlation of the Jurassic of southwestern Oregon and California; Bull. Geol. Soc. Am., v. 53, p. 71–112.

Tamura, M.
1959: On *Kumatrigonia,* a subgenus of *Frenguelliella,* and a *Tosapecten* from the Carnic Tanoura Formation in Kyushu, Japan; Mem. Fac. Educ., Kumamoto Univ., v. 7.

Tempelman-Kluit, D.
1974: Reconnaissance geology of Aishihik Lake, Snag and part of Stewart River map-areas, west-central Yukon (115H, 115J and 115N–O); Geol. Surv. Can., Paper 73-41.

Thompson, d'A.W.
1942: On Growth and Form, 2nd ed.; MacMillan, New York.

Tipper, H.W.
1972: Smithers map-area; Geol. Surv. Can., Paper 72-1A, p. 39–41.

Tipper, H.W. and Richards, T.A.
1976: Jurassic stratigraphy and history of north-central British Columbia; Geol. Surv. Can., Bull. 270.

Torre, A. de la
1960: Fauna de la formacion Cayetano del Jurasico Medio de Pinar del Rio; Soc. Cubana Historia Nat. Mem., v. 25, no. 1, p. 65–72.

Trechmann, C.T.
1923: The Jurassic rocks of New Zealand. With an appendix on ammonites from New Zealand by L.F. Spath; Quart. J. Geol. Soc., v. 79, p. 246–312, Pls. 12–18.

Uhlig, V.
1910: Die Fauna des Spiti-Scheefer des Himalaya, ihr geologisches Alter und ihre Weltstellung; K. Akad. Wiss.. Math.-Naturw., Kl., Denkschr., Bd. 85, p. 597–609.

Veatch, A.C.
1907: Geography and geology of a portion of southwestern Wyoming; U.S. Geol. Surv., Prof. Paper 56.

Warren, P.S.
1932: A new pelecypod fauna from the Fernie Formation, Alberta; Roy. Soc. Can. Proc. and Trans., 3rd Ser., v. 26, sec. 4, p. 1–36, Pls. 1–5.

Westermann, G.E.G.
1964: The ammonite fauna of the Kialagvik Formation at Wide Bay, Alaska Peninsula. Part 1. Lower Bajocian (Aalenian); Bull. Am. Paleontol., v. 47, no. 216, p. 329–503.
1969: The ammonite fauna of the Kialagvik Formation at Wide Bay, Alaska Peninsula. Part 2. *Sonninia sowerbyi* Zone (Bajocian); Bull. Am. Paleont., v. 57, no. 255.

Wheeler, J.O.
1961: Whitehorse map-area, Yukon Territory; Geol. Surv. Can., Mem. 312.

White, C.A.
1883: Contributions to invertebrate paleontology no. 7; Jurassic fossils from the western territories; U.S. Geol. Surv. Terr., 12th Ann. Rept., pt. 1, p. 143–154.

Whiteaves, J.F.
1878a: On some Jurassic fossils from the Coast Range of British Columbia; Can. Naturalist and Quart. J. Sci., new ser., v. 8, p. 400–410.

1878b: Notes on some Jurassic fossils, collected by Mr. G.M. Dawson, in the Coast Range of British Columbia; Geol. Surv. Can., Rept. Prog. 1876-1877, p. 150–159.

1884: On the fossils of the coal-bearing deposits of the Queen Charlotte Islands collected by G.M. Dawson in 1878; Geol. Surv. Can., Mesozoic Fossils, v. 1, pt. III, p. 192–262.

1889: On some Cretaceous fossils from British Columbia, the North West Territory and Manitoba; Geol. Surv. Can., Contrib. Canadian Palaeontol., v. 1, pt. 2, p. 151–196.

Whitfield, R.P. and Hovey, E.O.
1906: Remarks on and descriptions of Jurassic fossils of the Black Hills; Bull. Am. Mus. Nat. Hist., v. 22, Art. 23, p. 389–402.

Wright, R.P.
1973: Marine Jurassic of Wyoming and South Dakota: Its paleoenvironments and paleobiogeography; Univ. Michigan Mus. Paleontol., Papers on Paleontology, no. 2.

Young, C.M. and Bird, J.
1828: A geological survey of the Yorkshire coast, 2nd ed.; Whitby.

Appendix

Fossil localities

Localities of the Geological Survey of Canada (GSC)

6363. D.M. Kean for H.I. Smith 1919. Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Probably Lower or Middle Callovian, Yakoun Formation.

6586. F.H. McLearn 1915. Railway cut, south slopes of Grassy Mountain, near Lille, Fernie Group, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

7206. Leach 1910. Bulkley River, north of Smithers, Smithers map area, British Columbia (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

10073. A.H. Lang 1939. Ridge 3 km (2 mi) north of Hubert, Smithers map area, British Columbia (NTS 93L). Middle Bajocian, Hazelton Group.

10077 (=57177, ?80295, 87308, 87309, 87310). A.H. Lang 1939. Roadcut, Highway 16, approximately 0.4 km (0.25 mi) north of Trout (Sheedy) Creek, Smithers map area, British Columbia. Loc. 80295 may be on the west side of the Bulkley River (NTS 93L). Lower Oxfordian, Bowser Lake Group.

13616. F.H. McLearn 1921. Newcombe Bay, Maude Island, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Lower or Middle Callovian, Yakoun Formation.

13617. F.H. McLearn 1921. Robber Point, Maude Island, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Lower or Middle Callovian, Yakoun Formation.

13618. F.H. McLearn 1921. On island, northeast shore of Alliford Bay, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Lower or Middle Callovian, Yakoun Formation.

13619. F.H. McLearn 1921. South side of Alliford Bay, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Lower or Middle Callovian, Yakoun Formation.

13621. F.H. McLearn 1921. Newcombe Bay, Maude Island, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Float from Lower or Middle Callovian beds, Yakoun Formation.

13624. F.H. McLearn 1921. Talus, on island, northeast side of Alliford Bay, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Probably Lower or Middle Callovian, Yakoun Formation.

13626. F.H. McLearn 1921. South side of Alliford Bay, Skidegate Inlet, Queen Charlottte Islands (NTS 103F). Talus from Lower or Middle Callovian beds, Yakoun Formation.

13756. S. Duffell 1947. 30.5 km (19 mi) up Tahtsa River, 3 km (2 mi) inland on north shore, 8 km (5 mi) east of Sibola Creek, Whitesail Lake map area, British Columbia (NTS 93E). Probably Lower Callovian, Hazelton Group.

14920. G.M. Dawson 1878. Alliford Bay, Skidegate Inlet, Queen Charlotte Islands (NTS 103F). Probably Lower or Middle Callovian, Yakoun Formation.

14923. V.C. Brink 1944. East coast of Alliford Bay, Queen Charlotte Islands (NTS 103F). Probably Lower or Middle Callovian, Yakoun Formation.

16071. S. Duffell 1947. Chikamin Mountain just above adit on Garner No. 1 and Marie claim, 880 m (2900 ft) above the upper cabin, Whitesail Lake map area, British Columbia (NTS 93E). Middle Bajocian, Hazelton Group.

20117. H.W. Tipper 1951. 3.2 km (2 mi) northwest of east end of Chelaslie Lake, Nechako River map area (NTS 93F). Late Sinemurian (?), Hazelton Group.

21886. H.W. Tipper 1952. Kyakuz Mountain 2.4 km (1.5 mi) south of peak, Nechako River map area (NTS 93F). Bajocian, Hazelton Group.

23485. S. Duffell 1953. 6.2 to 8 km (4–5 mi) north of Oliver Creek on Hazelton-Terrace highway, Terrace map area (NTS 103I). Lower Oxfordian, Bowser Lake Group.

24780. H.W. Tipper 1954. On wagon trail 5 km (3 mi) northeast of Tango Lake, Anahim Lake map area (NTS 93C). Probably Middle Bajocian, Hazelton Group.

25781. H. Frebold 1955. West side of Harrison Lake, 18 km (11 mi) from Agassiz-Mission highway, Harrison Lake area, British Columbia (NTS 92H). Middle Bajocian, Harrison Lake Formation.

44706. A. Sutherland Brown 1960. Alliford Bay at bomb shelter, Queen Charlotte Islands (NTS 103F). Probably Lower or Middle Callovian, Yakoun Formation.

44707. A. Sutherland Brown 1960. South shore of Alliford Bay, Queen Charlotte Islands (NTS 103F). Lower or Middle Callovian, Yakoun Formation.

44738. A. Sutherland Brown 1960. South of Alliford Bay, Queen Charlotte Islands (NTS 103F). Probably Lower or Middle Callovian, Yakoun Formation.

57177. Same as 10077.

64796. R.V. Kirkham 1964. Approximately same as 87536. Talus slope approximately 1.6 km (1 mi) southeast of Silvern Lake, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

80295. R.V. Kirkham 1967. Same as 10077 or 81925.

80296. R.V. Kirkham 1967. East side of Bulkley River, approximately opposite mouth of Trout (Sheedy) Creek, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

80298. R.V. Kirkham 1967. Elevation approximately 980 m (3250 ft) on north side of Mt. Evelyn, approximately 3.2 km (2 mi) south of Trout (Sheedy) Creek, Smithers map area (NTS 93L). Probably Middle Bajocian, Hazelton Group.

80301. R.V. Kirkham 1967. Elevation approximately 600 m (2000 ft) in Owens Creek, Mt. Evelyn, Smithers map area (NTS 93L). Probably Middle Bajocian, Hazelton Group.

81919 (=81936). G. Hanson 1924. Between Silvern Lake and Schufer's mining property, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

81922. G. Hanson 1924. Between Silvern Lake and Schufer's mining property, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

81923 (=87397). E.J. Lees. Railway cut, north end of railway tunnel across Trout (Sheedy) Creek, 54°56′25″N, 127°19′55″W, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

81924. E.J. Lees. 30 m (100 ft) north of canyon, Bulkley River, 0.4 km (0.25 mi) north of Trout (Sheedy) Creek, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

81925 (=?80295, 81926, 81930). E.J. Lees. West side of Bulkley River, 0.4 km (0.25 mi) north of Trout (Sheedy) Creek, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

81926. E.J. Lees. Same as 81925.

81927. E.J. Lees. Black sandstone, probably nearly in place near andesite contact, side of high glacier-covered mountain (presumed to be the mountain about 51°30′N, 127°54′30″W). Smithers map area (NTS 93L). Callovian or Lower Oxfordian, Hazelton or Bowser Lake Group.

81930. E.J. Lees. Same as 81925.

81936. G. Hanson 1925. Same as 81919.

81937. A.H. Lang 1938. Hill 6.4 km (4 mi) north of Lacroix (Round) Lake, elevation 940 m (3100 ft), Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

82358. E.D. Kindle. East of lower Silvern Lake, elevation 1650 to 1800 m (5500–6000 ft), west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, lower 4.5 m (15 ft) of sediments above volcanic unit, Hazelton Group.

82395. A.H. Lang 1938. Northwest slope of Dome Mountain. Smithers map area (NTS 93L). Middle Jurassic, Hazelton Group.

83262. R.V. Kirkham 1967. "Elev. 1560 m (5150 ft) . . . green and grey sandstone and siltstone at a contact with a major volcanic unit." (This must be approximately the same locality as 85385 and 85412.) Ashman Ridge, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

83371. R.H.B. Jones 1925. Mouth of Coal Creek, west of Hudson Bay Mountain, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

83477. D.D. Cairnes 1906. Toric Mountain, 11.3 km (7 mi) west of Robinson, Yukon Territory (NTS 105D). Upper Toarcian or Lower Bajocian, Laberge Group.

83994. H.W. Tipper 1970. Same as 87311.

85315. H.W. Tipper 1970. Same as 97389.

85323. H.W. Tipper 1970. Near head of Ganokwa Creek, 54°52′N, 126°53′W, Smithers map area (NTS 93L). Callovian, Hazelton Group.

85328. H.W. Tipper 1970. Same as 87409.

85332. H.W. Tipper 1970. Small ravine at south end of ridge west of small lake, 54°45′N, 126°43′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

85336. H.W. Tipper 1970. Same as 87388.

85385. H.W. Tipper 1970. Talus on south slope of small peak, Ashman Ridge, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

85388. H.W. Tipper 1970. Probably same as 85465.

85395. H.W. Tipper 1970. Shale bed on south side of second northernmost peak of Ashman Ridge, where ridge goes off to east, Smithers map area (NTS 93L). Lower Oxfordian, Bowser Lake Group.

85398. H.W. Tipper 1970. Ashman Ridge, 46.7 km (29 mi) on bearing 282° from Smithers, 54°45′N, 127°47′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

85405. H.W. Tipper 1970. High on southeast and south sides of small peak of loc. 85385, Ashman Ridge, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

85407. H.W. Tipper 1970. Same as 88565.

85409. H.W. Tipper 1970. About 86 m (300 ft) up creek from waterfall on loc. 88565, and about 20 to 27 m (65–90 ft) stratigraphically above Lower Jurassic red tuffs (see Frebold and Tipper, 1973), Telkwa Mountains, Smithers map area (NTS 93L). Bathonian, Hazelton Group.

85412. H.W. Tipper 1970. Talus on southeast slope of same small peak as in loc. 85385, Ashman Ridge, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

85424. H.W. Tipper 1970. Telkwa Mountains, near head of Houston Tommy Creek, 54°23.5′N, 127°27′W, Smithers map area (NTS 93L). Probably Sinemurian, Hazelton Group.

85425. H.W. Tipper 1970. Shale bed high on south side of small peak of loc. 85395, Smithers map area (NTS 93L). Lower Oxfordian, Bowser Lake Group.

85426. H.W. Tipper 1970. Stratigraphically above loc. 85425, Smithers map area (NTS 93L). Lower Oxfordian, Bowser Lake Group.

85427. H.W. Tipper 1970. Ashman Ridge, 46.7 km (29 mi) on bearing 282° from Smithers, 54°47′N, 127°47′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

85444. H.W. Tipper 1970. Boulders of green sandstone in creek, probably derived from stratigraphic interval 27.5 to 36 m (90–121 ft) stratigraphically above Lower Jurassic red tuffs (see Frebold and Tipper, 1973), Telkwa Mountains, Smithers map area (NTS 93L). Bathonian, Hazelton Group.

85450, 85451, 85456. H.W. Tipper 1970. Probably same as 85465.

85465 (probably = 85388, 85450, 85451, 85456). H.W. Tipper 1970. Richly fossiliferous sandstone lenses, probably a single horizon near top of hill of Tenas Creek section. Stratigraphic interval 4.5 to 6.8 m (15–25 ft) stratigraphically below dark red tuff at top of hill, 88 to 94 m (285–310 ft) above Lower Jurassic red tuffs, Telkwa Mountains, Smithers map area (NTS 93L). Lower Callovian, Hazelton Group.

87306. H.W. Tipper 1970. 3.2 km (2 mi) south of television transmitter, 54°43.5′N, 126°58.5′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87307. H.W. Tipper 1970. Approximately same as loc. 87306.

87308–87310. T.P. Poulton 1971. Same as 10077.

87311 (=83994). T.P. Poulton 1971. Road from Smithers to Smithers Landing, Babine Lake, about 4.8 km (3 mi) north of Doris Lake, 55°N, 126°31.5′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87312. T.P. Poulton 1971. Road outcrop on small side road leading to west of Smithers Landing road, about 2.8 to 3.2 km (1.7–2 mi) north of Doris Lake, 54°59′N, 126°32′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87317. T.P. Poulton 1971. Hill about 1.2 km (0.75 mi) northwest of Lacroix (Round) Lake, south nose of hill, 54°40′17″N, 126°56′50″W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87318. T.P. Poulton 1971. Hill 4.5 km (2.75 mi) north-northwest of Lacroix (Round) Lake, 0.3 m (1 ft) exposure, 54°42′08″N, 126°59′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87319. T.P. Poulton 1971. Near brow of southeast-facing barren slope 3.6 km (2.25 mi) east of Maclure Lake, 1.1 km (0.68 mi) east-southeast of sawmill at end of Hislop Road, 54°43′10″N, 126°58′W, 0.6 m (2 ft) exposed rock, elevation 1800 m (5950 ft), Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87320. T.P. Poulton 1971. Near top of small slope facing south-southwest, 3.6 km (2.25 mi) east of Maclure Lake, 1.2 km (0.68 mi) due east of small sawmill and end of Hislop Road, from bottom of 12 m (40 ft) exposure, 54°43′20″N, 126°57′45″W. Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87321. T.P. Poulton 1971. Same as loc. 87320. Top of 12 m (40 ft) exposure. Middle Bajocian, Hazelton Group.

87322. T.P. Poulton 1971. 3.2 km (2 mi) east of centre of Maclure Lake, 0.8 km (0.5 mi) southeast of sawmill and end of Hislop Road, 54°43′04″N, 126°58′10″W. Loose rubble, probably nearly in place, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87323. T.P. Poulton 1971. 3.2 km (2 mi) east of constriction in Maclure Lake, 1 km (0.6 mi) east-southeast of sawmill and end of Hislop Road, loose boulders, probably nearly in place, 54°43′10″N, 126°58′W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87324. T.P. Poulton 1971. 3.2 km (2 mi) east of constriction in Maclure Lake, 1.6 km (1 mi) east-southeast of sawmill and end of Hislop Road, brow of hill, 54°43'10"N, 126°58'W. Probably about 24.5 m (80 ft) stratigraphically above loc. 87323, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87325. T.P. Poulton 1971. Same as loc. 87324. Just west of it on brow of hill, probably 7.6 to 12 m (25–40 ft) stratigraphically above it, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87326. T.P. Poulton 1971. Same as loc. 87324. About 12 m (40 ft) stratigraphically below loc. 87325, at lowest exposure, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87378. H.W. Tipper 1971. 6.4 km (4 mi) due east of north end of Maclure Lake, 54°43.5'N, 126°56.6'W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87381. H.W. Tipper 1971. Approximately same as loc. 87378.

87383. H.W. Tipper 1971. Between Bulkley River and old road 1.6 km (1 mi) southeast of Doughty, 54°57'N, 127°20'W, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

87386. H.W. Tipper 1971. 6.4 km (4 mi) due east of north end of Maclure Lake, 54°43'N, 127°56.5'W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87387. H.W. Tipper 1971. 6.4 km (4 mi) due east of north end of Maclure Lake, 54°43.5'N, 127°56.5'W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87388 (=85336). T.P. Poulton 1971, West end of ridge extending 2.5 km (1.5 mi) west of Dome Mountain, 54°44'28"N, 126°41'25"W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87389 (=85315). T.P. Poulton 1971. Same as loc. 87388. About 30 m (100 ft) stratigraphically above it. Middle Bajocian, Hazelton Group.

87391. T.P. Poulton 1971. Small outcrop on Kitseguecla Lake Road, about 1.6 km (1 mi) from Highway 16, west of Doughty, northwest of Smithers, 54°57'30"N, 127°21'40"W, Smithers map area (NTS 93L). Probably Lower Oxfordian, Bowser Lake Group.

87393. T.P. Poulton 1971. Approximately same as 87409.

87397. T.P. Poulton 1971, 1973. Same as 81923.

87406. T.P. Poulton 1971. Mt. Cronin fire lookout, 54°56'N, 126°47'30"W, Smithers map area (NTS 93L). Middle Jurassic, Hazelton Group.

87409 (=85328, 87393). T.P. Poulton 1971. Small ridge trending north-south, west of small lake, 4 km (2.5 mi) west of peak of Dome Mountain, 54°45'N, 126°42'30"W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87536. T.P. Poulton 1971. Talus, derived entirely from beds of loc. 87554, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87537. T.P. Poulton 1971. About 1 km (0.6 mi) south of Silvern Lake, about 90 m (295 ft) above Lower Jurassic volcanic unit, west side of Hudson Bay Mountain, 54°49'40"N, 127°22'40"W, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87538. T.P. Poulton 1971. Outcrop from stratigraphic interval about 27 to 36 m (90–120 ft) above contact with Lower Jurassic volcanic unit, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87541. T.P. Poulton 1971. Talus derived from lowest 36 m (120 ft) of Middle Bajocian rocks, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87542. T.P. Poulton 1971. Terrace about 0.16 km (0.09 mi) north of centre of Coppermine Lake, west of Grouse Mountain, 54°33'35"N, 126°43'30"W, Smithers map area (NTS 93L). Probably Callovian, Hazelton Group.

87543. T.P. Poulton 1971. Outcrop about 34.5 m (115 ft) stratigraphically above contact with Lower Jurassic volcanic unit, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87550. T.P. Poulton 1971. Outcrop and talus from about 42 to 44 m (140–145 ft) stratigraphically above contact with Lower Jurassic volcanic unit, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87553. T.P. Poulton 1971. South side of Mt. Astlais, about 75 to 90 m (250–300 ft) south of mining road, 54°49'06"N, 126°52'00"W, Smithers map area (NTS 93L). Probably Middle Bajocian, Hazelton Group.

87554. T.P. Poulton 1971. Outcrop from stratigraphic interval 10.5 to 29 m (35–95 ft) above underlying Lower Jurassic volcanic unit, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

87556. T.P. Poulton 1971. Talus derived from interval 21 to 43 m (70–145 ft) stratigraphically above contact with Lower Jurassic volcanic unit, west side of Hudson Bay Mountain, Smithers map area (NTS 93L). Middle Bajocian, Hazelton Group.

88482. T.P. Poulton 1971. Road following Zymoetz River about 1.1 km (0.68 mi) northwest of west end of McDonnell Lake, about 54°47′17″N, 127°38′55″W, Smithers map area (NTS 93L). Middle Jurassic, Hazelton Group.

88485. T.P. Poulton 1971. Approximately same locality as 88482, Smithers map area (NTS 93L). Upper Bathonian, Hazelton Group.

88505. T.P. Poulton 1971. Zymoetz River, 1.6 km (1 mi) north of junction with Nilah Creek, talus slope and outcrop on road, immediately overlying red tuffs, 54°30′N, 127°55′30″W, Smithers map area (NTS 93L). Lower Callovian, Hazelton Group.

88506. T.P. Poulton 1971. Same area as loc. 88505. Outcrop and near outcrop on terrace within 23 m (75 ft) above top of talus slope of loc. 88505, Smithers map area (NTS 93L). Lower Callovian, Hazelton Group.

88565 (=85407). T.P. Poulton 1971. Talus slope beside waterfall, derived from lowest 20 m (65 ft) of green sandstone which overlies Lower Jurassic red/maroon tuffs (see Frebold and Tipper, 1973), Telkwa Mountains, Smithers map area (NTS 93L). Bajocian(?), Hazelton Group.

88567. T.P. Poulton 1971. Stratigraphic interval 9 to 13.5 m (30–45 ft) above contact with Lower Jurassic red tuffs (Frebold and Tipper, 1973), Smithers map area (NTS 93L). Bajocian(?), Hazelton Group.

88585. T.P. Poulton 1971. Rubble on terraced north-facing slope west of small creek of main Tenas Creek section of Frebold and Tipper (1973), equivalent with rocks of interval 70 to 90 m (235–295 ft) stratigraphically above contact with Lower Jurassic red tuffs, Smithers map area (NTS 93L). Middle Jurassic, Hazelton Group.

89090. J.E. Muller 1970. F.P. logging road C5, 11.3 km (7 mi) east of Nitinat Lake, 48°49′55″N, 124°31′25″W, Cowichan Lake map area (NTS 92C). Lower Jurassic (?Sinemurian or ?Toarcian), Bonanza Subgroup.

89344. T.P. Poulton 1972. Sandstone outcrop on small road that leads to Little Joe Flat, near small creek, about 0.64 km (0.4 mi) south of north boundary of Section 3, 1.3 km (0.8 mi) west of east boundary, R. 1 W., T. 36 N., Big Bend Quadrangle, California. Probably Middle Bajocian, Potem Formation.

89351. T.P. Poulton 1972. Nose of ridge on north side of Mount Jura, southwest corner of Foreman Ravine, elevation 1090 to 1100 m (3600–3640 ft), about 0.3 km (0.19 mi) west of east boundary of Section 23, 0.96 km (0.6 mi) north of south boundary, R. 10 E., T. 26 N., Taylorsville area, California. Bajocian, Mormon Formation, 7.6 to 9 m (25–30 ft) of strata near base, collected from rubble.

89374. T.P. Poulton 1972. Section of purple sandstone exposed on nose of hill just north of road which runs into Little Joe Flat; lowest 3 m (10 ft) of outcrop, west boundary of Section 3, 0.64 km (0.4 mi) south of north boundary, R. 1 W., T. 36 N., Big Bend Quadrangle, California, Probably Middle Bajocian, Potem Formation.

89375. T.P. Poulton 1972. Same as loc. 89374. 3 to 5 m (10–17 ft) above base, to top of resistant ledge. Probably Middle Bajocian, Potem Formation.

89382. T.P. Poulton 1972. Road outcrop north of Boundary Spring. 7.6 m (25 ft) of sandstone at north end of outcrop, 0.8 km (0.5 mi) west of east boundary of Section 29, 1.3 km (0.8 mi) south of north boundary, R. 26 E., T. 18 S. Middle Bajocian, Weberg Formation, Oregon.

89405. T.P. Poulton 1972. Roadcut near head of Rosebud Creek, T. 17 S., R. 28 E., Section 1, 0.08 km (0.05 mi) south of north boundary, 0.16 km (0.1 mi) east of west boundary, Izee Quadrangle. Upper Pliensbachian, Suplee Formation, Oregon.

89433. T.P. Poulton 1972. Logging road outcrop and talus slope above it, just west of small lake, about elevation 640 m (2100 ft), 49°29′54″N, 121°54′50″W, Harrison Lake area, British Columbia (NTS 92H). Callovian, Billhook Formation.

89456. T.P. Poulton 1972. Logged-off mountainside north of Mystery Creek, southwest end of small hanging valley near top of hill, elevation 900 m (3000 ft), 49°31′02″N, 121°57′25″W. Talus slope above and to northeast of end of eastward-climbing old logging road, Harrison Lake area, British Columbia (NTS 92H). Callovian, Billhook Formation.

89457. T.P. Poulton 1972. Same as loc. 89456. From boulders across small gully, 45 m (150 ft) to west, 49°31′03″N, 121°57′30″W, Harrison Lake area, British Columbia (NTS 92H). Callovian, Billhook Formation.

89458. T.P. Poulton 1972. Logged-off hillside north of Mystery Creek, roadcut, old logging road, about elevation 830 m (2750 ft), 49°30′49″W, 121°57′31″W, Harrison Lake area, British Columbia (NTS 92H). Callovian, upper part of Mysterious Creek Formation.

89461. T.P. Poulton 1972. South of Mystery Creek, boulders in talus slope from regolith nearly in place, old logging road, elevation 700 m (2320 ft), 49°30′09″N, 121°55′28″W. 90 m (300 ft) east of, and about 30 m (100 ft) above, gradational contact with Mysterious Creek Formation, Harrison Lake area, British Columbia (NTS 92H). Callovian, Billhook Formation.

89468. T.P. Poulton 1972 (=Loc. 6 of Crickmay, 1930b). 7.6 m (25 ft) of siltstone about 24 to 31.5 m (80–105 ft) below the top of Opuntia Formation, about elevation 530 to 540 m (1760–1780 ft), 5.2 km (3.25 mi) from Ashcroft Bridge on bearing N35°E. In small ravine on east slope of Semlin Hill, 50°45'48"N, 121°14'04"W, Ashcroft map area, British Columbia (NTS 92I). Middle Bajocian, Opuntia Formation.

89471. T.P. Poulton 1972. South slope of Grassy Mountain, grassy hillside just below old mine road cut, about half way between Sections C and F of Frebold (1963), Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89476. T.P. Poulton 1972. South slope of Grassy Mountain, Section C of Frebold (1963), Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89482. T.P. Poulton 1972. Road cut, Gold Creek road, south side of Grassy Mountain, Section E of Frebold (1963), stratigraphically 2.1 m (7 ft) above loc. 89481, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89486. T.P. Poulton 1972. Road cut, Gold Creek road, south side of Grassy Mountain, easternmost fossiliferous rock, about 66 m (220 ft) west of Blairmore conglomerate outcrop; probably part of Section E of Frebold (1963), Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89487. T.P. Poulton 1972. Road cut, south side of Grassy Mountain, Section A of Frebold (1963), Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89488. T.P. Poulton 1972. Old road cut, south side of Grassy Mountain, Section B of Frebold (1963), just down hill from loc. 89487, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89491. T.P. Poulton 1972. Hastings Ridge, road to Adanac strip mine, about 5.5 m (18 ft) stratigraphically below loc. 89490, elevation 1850 m (6100 ft), 49°29'32"N, 114°24'41"W, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89496. T.P. Poulton 1972. Hastings Ridge, small quarry on road leading to second northernmost of the Adanac mines, just up hill from loc. 89495, on a parallel short hauling road, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89497. T.P. Poulton 1972. Hastings Ridge, loose boulders in floor of same quarry as loc. 89496, probably a concretionary lithology from just below *Gryphaea* bed, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89498. T.P. Poulton 1972. Hastings Ridge, northernmost of two prominent gullies on east slope of hill bearing roads climbing to northwesternmost of the Adanac mines, about 12 to 18 m (40–60 ft) above lowest road level, loose debris from *Corbula munda* bed, and from *Gryphaea* bed, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89500. T.P. Poulton 1972. Hastings Ridge, northernmost of two prominent gullies on east side of hill bearing roads climbing to northwesternmost of the Adanac mines, about 1.8 m (6 ft) below lowest *Gryphaea* beds, Alberta (NTS 82G). Upper Bathonian or Lower Callovian, Fernie Group.

89501. T.P. Poulton 1972. Hastings Ridge, northernmost of two prominent gullies on east side of hill with roads climbing to northwesternmost of the Adanac mines, from the lowest of two *Gryphaea* beds, Alberta (NTS 82G). Lower Callovian, Fernie Group.

90981. T. Richards 1972, 1973; T.P. Poulton 1973. Frypan Peak, 55°28'N, 126°15'W, Hazelton map area (NTS 93M). Late Sinemurian(?), Hazelton Group.

91765. H.W. Tipper 1974. Klastline Plateau, 15.2 km (9.5 mi) southeast of Eddontenajon (Iskut), approximately 57°41'20"N, 129°48'10"W, Spatsizi map area, British Columbia (NTS 104H). Probably Callovian or Lower Oxfordian, Hazelton or Bowser Lake Group.

93556. E.J. Lees 1929. Eastern side of western branch of Mandanna Valley, from 0.3 to 1.5 m (1–5 ft) below massive conglomerate, Laberge area, southern Yukon Territory (NTS 105D). Early Sinemurian, Laberge Group.

93587. H.W. Tipper 1975. Block 1216 of Pacific Logging Co, north of head of Harris Creek, southern Vancouver Island, British Columbia, 48°44'45"N, 124°10'50"W. Lower Jurassic (?Sinemurian or ?Toarcian), Bonanza Subgroup.

C-18178 (and C-18179). D. Tempelman-Kluit 1972. 61°27'N, 136°10'30"W, Aishihik Lake map area, Yukon Territory (NTS 115H). Probably Middle Bajocian, Laberge Group.

Mesozoic localities of the United States Geological Survey (USGS)

525. I.C. Russell 1888. 3.2 km (2 mi) southeast of Taylorsville, Mount Jura, California, probably Sec. 1, T. 25 N., R. 10 E. Bajocian, Mormon Formation.

1013. J. Storrs and T.W. Stanton 1893. East side of Pit River, Shasta County, California, about 4 km (2.5 mi) below Great Bend, mostly loose fragments in bed of small creek. Probably Bajocian, Potem Formation.

1495. W.H. Dall 1895. Northwest of head of Chisik Harbor, Cook Inlet area, Alaska. Middle Bajocian, Fitz Creek Siltstone.

2423. J.S. Diller and A. Hyatt 1891(?). Elev. 1500 m (4925 ft), Spur 8 (approx. 1.4 km bearing 225° from peak) of Mount Jura, California. Bajocian, Mormon Formation.

2425a. J.S. Diller and A. Hyatt 1891. Elev. 1400 m (4650 ft), Ravine 2 of Mount Jura, California, northeast corner of Sec. 26, T. 26 N., R. 10 E. Bajocian, Mormon Formation.

2570. T.W. Stanton, J. Storrs 1902. West side of Pit River, about 4.8 km (3 mi) below Big Bend, Big Bend Quadrangle, California. Probably Middle Bajocian, Potem Formation.

2919. G.C. Martin 1903. East shore of Iniskin Bay, Alaska, mixed collection from USGS locs. 3035 and 3038, zones A and B of section of Martin (1926, p. 145). Probably Bathonian.

2994. T.W. Stanton, G.C. Martin, A. Brown 1904. South side of Fossil Point, Cook Inlet, Alaska. Middle Bajocian, from sandstone whose base is about 15 m (50 ft) above base of Cynthia Falls Sandstone (Imlay, 1964b, p. B24, loc. 31).

2996. T.W. Stanton, G.C. Martin, A. Brown 1904. South shore of Tuxedni Bay, about 390 m (1300 ft) west of Fossil Point, Alaska. Middle Bajocian, Fitz Creek Siltstone, 7.6 m (25 ft) below top; base of bed 7 of Martin (1926, p. 142; see also Imlay, 1964b, p. B23, loc. 24).

2999. T.W. Stanton, G.C. Martin, A. Brown 1904. South shore of Tuxedni Bay, 760 m (2500 ft) west of Fossil Point, Alaska. Middle Bajocian, Fitz Creek Siltstone 30 to 45 m (100–150 ft) below top; talus, probably mostly from beds 11 to 14 of Martin (1926, p. 142; see also Imlay, 1964b, p. B23, loc. 22).

3002 (=10521). T.W. Stanton 1904. South shore of Tuxedni Bay, southern Alaska. Bajocian, Cynthia Falls Sandstone; bed 25 of section of Martin (1926, p. 142).

3034. T.W. Stanton 1904. East shore of Iniskin Bay, 1.6 km (1 mi) above lower cabin, Alaska. Probably Bathonian, Bowser Formation.

3035. T.W. Stanton and L. Martin 1904. East shore of Iniskin Bay, 1.9 km (1.25 mi) above lower cabin, Alaska, zone B of section of Martin (1926, p. 145). Bathonian or Callovian.

3038. T.W. Stanton, G.C. Martin, L. Martin 1904. East shore of Iniskin Bay, near point at entrance to Right Arm. 8.4 km (5.25 mi) on bearing N74°W from Front Mountain, Alaska. Callovian, Bowser Formation according to Imlay (1962a); revised to Bathonian (Imlay, pers. com., 1977); zone A of section of Martin (1926, p. 145).

3096. T.W. Stanton, G.C. Martin, L. Martin 1904. Kamishak Bay, west bank of Douglass River, 1.6 km (1 mi) above its mouth, Cook Inlet region, Alaska. Oxfordian or Kimmeridgian, Upper Naknek Formation.

3143. J. Storrs 1904. South Fork of Foreman Ravine, 2.8 km (1.75 mi) southeast of Foreman's House, 4.8 km (3 mi) northeast of Taylorsville, Mount Jura area, California. NW¼ Sec. 30, T. 26 N., R. 11 E. Callovian, Foreman Formation.

8567. G.C. Martin, R.M. Overbeck, J.B. Mertie, Jr. 1913. Second creek entering Boulder Creek from the north, above the canyon (creek north of extreme end of Anthracite Ridge), 5 km (3.2 mi) up the creek, Matanuska Valley, Talkeetna Mountains, Alaska. Middle Bajocian, Tuxedni Formation (Martin, 1926, p. 225; Imlay, 1964b, p. B22, loc. 12).

8951. T. Chapin 1914. Small gulch tributary to Crooked Creek just north of Albert Creek, Matanuska Valley, Talkeetna Mountains, Alaska. Bajocian according to Stanton (in Martin, 1926, p. 226).

9258. Mount Jura, Taylorsville area, California (no more detailed information available). Callovian, Bicknell Sandstone (Hinchman Formation).

10512. F.H. Moffit 1920. South shore of Tuxedni Bay, on south side of Fossil Point, Alaska. Middle Bajocian, Cynthia Falls Sandstone (see Imlay, 1964b, p. B24, loc. 30).

10521. F.H. Moffit 1920. Same as locality 3002 (see there).

10729. C. Cathcart, T.W. Stanton 1921. 1.6 km (1 mi) a little north of east of St. Paul Mission, Little Rocky Mountains, Fort Belknap Indian Reservation, Montana. Probably Callovian, Ellis Group.

10808. S.R. Capps 1921. Shore cliffs on point 3.2 km (2 mi) from southwest end of Kialagvik Bay, Alaska. Toarcian, *Hammatoceras* beds of Kialagvik Formation (see Martin, 1926, p. 190).

11057. A.A. Baker 1921. East shore of Iniskin Bay about 76 m (250 ft) south from end of trail at lower cabin, peninsula between Chinitna Bay and Iniskin Bay, Alaska. Probably Callovian, Tuxedni Group.

19357. J.B. Reeside, Jr., D. Love 1944. 0.8 km (0.5 mi) south of Mill Creek, Fremont Co., Sec. 5, T. 2 S., R. 1 W., Wind River Basin, Wyoming. Probably Bajocian, Gypsum Springs Formation.

19785. L.B. Kellum 1944. Sea cliffs about 1.6 km (1 mi) west of mouth of short creek, 7.5 km (4.8 mi) on bearing N75.5°W from west end of Hartman Island, bluff at top of sea cliff escarpment, Wide Bay area, Kanatak District, Alaska. Toarcian, *Hammatoceras* beds, Kialagvik Formation.

19796. S.N. Daviess 1966. Float from bluff along the southeast shore of Wide Bay, 6.4 km (4 mi) on bearing S74.5°E from Mt. Alai, Wide Bay area, Kanatak District, Alaska. Bajocian, *Parabigotites* beds, Kialagvik Formation (Imlay, 1961b).

19844. L.B. Kellum 1945. About 12.8 km (8 mi) on bearing S56°W from west end of Hartman Island, elev. 235 m (689 ft), Wide Bay area, Kanatak District, Alaska. Bajocian, *Parabigotites* beds, Kialagvik Formation.

19936. H. Wedow 1944. Right side of Tonnie Creek about 270 m (900 ft) upstream from the trail crossing the mouth of Fitz Canyon, Alaska. Bajocian, 48 to 54 km (160–180 ft) above base of Gaikema Sandstone (Detterman and Hartsock, 1966).

19948. H. Wedow and L.B. Kellum 1944. North side of Gaikema Creek about 850 m (2800 ft) upstream from Chinitna Bay and 1.1 km (0.7 mi) on bearing N65°W from mouth of Fitz Creek, Alaska. Bajocian, 30 to 45 m (100–150 ft) above base of Gaikema Sandstone (Detterman and Hartsock, 1966).

19951. H. Wedow and L.B. Kellum 1944. South side of Gaikema Creek about 360 m (1200 ft) upstream from mouth, 1.88 km (1.18 mi) on bearing N82°E from mouth of Fitz Creek, Alaska. Middle Bajocian, 15 m (50 ft) below top of Red Glacier Formation (Detterman and Hartsock, 1966; Imlay, 1964b).

19962. H. Wedow and L.B. Kellum 1944. Sea cliffs, about 575 m (1900 ft) west of mouth of Gaikema Creek, 1 km (0.65 mi) on bearing 42.5°W from mouth of Fitz Creek, south shore of Chinitna Bay, Alaska. Bajocian, base of Gaikema Sandstone (Detterman and Hartsock, 1966).

19986. H. Wedow and L.B. Kellum 1944. Northeast side of Tonnie Creek about 135 m (450 ft) upstream from trail crossing at mouth of canyon and 2.5 km (1.59 mi) on bearing S63°E from Tonnie Peak, Tonnie Creek area, Alaska. Bajocian, 0 to 3 m (0–10 ft) below top of Red Glacier Formation (Detterman and Hartsock, 1966).

20008. H. Wedow and L.B. Kellum 1944. Northeast side of Forty Creek about 45 m (150 ft) upstream from trail crossing at mouth of canyon and 2.8 km (1.75 mi) on bearing N78.4°W from Tonnie Peak, Tonnie Creek area, Alaska. Bajocian, base of Gaikema Sandstone (Detterman and Hartsock, 1966).

20726. C.E. Kirschner 1946. 8.5 km (5.3 mi) on bearing S69°W from Front Mountain, east shore of Iniskin Bay, Alaska. Callovian, Chinitna Formation, 150 to 180 m (500–600 ft) above base of Tonnie Siltstone (loc. 240 of Detterman and Hartsock, 1966).

20728. C.E. Kirschner 1946. 7.8 km (4.9 mi) on bearing N56°W from Front Mountain, Alaska, 59°44.5′N, 153°14.5′W. Probably Lower Callovian, near top of Bowser Formation (loc. 177 of Detterman and Hartsock, 1966).

20734. D.L. Minard 1946. 0.88 km (0.55 mi) on bearing N58°W from Front Mountain, Bowser Creek area, Alaska. Callovian, 260 to 290 m (850–950 ft) above base of Tonnie Siltstone member of Chinitna Formation.

20764. C.E. Kirschner 1946. 8 km (5 mi) on bearing N83°W from Front Mountain, Alaska. Bathonian (Imlay, pers. com., 1977), Bowser Formation (loc. 193 of Detterman and Hartsock, 1966).

20765. C.E. Kirschner 1946. 8.5 km (5.3 mi) on bearing S84°W from Front Mountain, Cook Inlet, Alaska. Callovian, Chinitna Formation.

21295. R.W. Imlay 1948. In gulch 2.6 km (1.62 mi) on bearing N60°W from dock at mouth of Fitz Creek, south shore of Chinitna Bay, Alaska. Middle Bajocian, 90 to 96 m (300–320 ft) below top of Red Glacier Formation (Detterman and Hartsock, 1966; Imlay, 1964b).

22550. D. Hill 1950. 45 m (50 yd) southeast from alluvial fan, Right Arm, Iniskin Bay, Alaska. Probably Callovian, 515 to 545 m (1700–1800 ft) above base of Bowser Formation (loc. 188 of Detterman and Hartsock, 1966).

24113. A. Grantz, R.D. Hoare, R.W. Imlay 1952. From a landslide scar 2.6 km (1.63 mi) north of mouth of Albert Creek, Talkeetna Mountains (A-1) Quadrangle, Alaska. Middle Bajocian, Tuxedni Group, 15 to 75 m (50–250 ft) above base (see Imlay, 1961b; 1964b, p. B22, loc. 2).

24118. A. Grantz 1952. North side of north branch of upper part of Little Nelchina River, 3.63 km (2.27 mi) from main fork in headwaters, 62°07′15″N, 147°42′02″W. Talkeetna Mountains (A-2) Quadrangle, Alaska. Bathonian, upper part of Tuxedni Group, 23 m (75 ft) below base of Chinitna Formation (Imlay, 1962a, pers. com., 1977).

24151. R.D. Hoare 1952. North bank of Little Nelchina River, 3.95 km (2.47 mi) on bearing S27°W from 1400 m (4610 ft) benchmark, southeastern Talkeetna Mountains, Alaska. Callovian, Chinitna Formation.

24184. A. Grantz, R.D. Hoare, R.W. Imlay 1952. On north tributary of Little Nelchina River entering 1.6 km (1 mi) above Flat Creek, 1.73 km (1.08 mi), on bearing S10°E from 1400 m (4610 ft) VABM Wal., Talkeetna Mountains, Alaska, reworked concretions in Cretaceous shales containing fossils from Chinitna and Naknek formations and the overlying Nelchina Limestone. Fossils from Callovian, Chinitna Formation.

26732. R.W. Imlay, W.R. Dickinson 1957. Western spur on west side of divide at head of main fork of Rosebud Creek, on slope north of Rosebud Creek, just above road shown on 1961 ed. of Izee Quadrangle, in NE¼ NW¼, NW¼ of Sec. 1, T. 17 S., R. 28 E., Grant County, Oregon. Apparently nearly the same as GSC loc. 89405. Upper Pliensbachian, upper 3 m (10 ft) of Suplee Formation (Imlay, 1968).

26955. E.R. Orwig 1957. Ridge south of north fork of Little Nelchina River, 360 m (1200 ft) north and 60 m (200 ft) east of benchmark 5160 ft (1570 m), Talkeetna Mountains (A-2) Quadrangle, Alaska. Bathonian or Callovian, equivalent of middle member of Bowser Formation.

27359. R.W. Imlay, R. Christner 1958. On west side of Rosebud Creek in north-central part of SW¼ of Sec. 2, T. 17 S., R. 28 E., Oregon. Upper Pliensbachian, upper 9 m (30 ft) of Suplee Formation (Imlay, 1968).

27361. R.W. Imlay and R. Christner 1958. On crest of spur south of Caps Creek, SE¼, NW¼ of Sec. 16, T. 17 S., R. 28 E., Oregon. Upper Pliensbachian, upper 3 m (10 ft) of Suplee Formation (Imlay, 1968).

28372. R.W. Imlay 1961. On logging road in northeast corner of Sec. 2, T. 17 S., R. 28 E., Izee Quadrangle, Grant County, Oregon. Upper Pliensbachian, 4.5 to 7.5 m (15–25 ft) below top of Suplee Formation (Imlay, 1968).

Field numbers of uncatalogued U.S. Geological Survey collections

56-120. J.H. Beeson, W.R. Dickinson, S.W. Muller, L.W. Vigrass 1956. Crest of nose trending north-south 60 m (200 ft) southwest of Swamp Creek. SW¼ SW¼, Section 34, T. 17 S., R. 26 E., Grant County, Oregon. Middle Bajocian, near middle of Weberg Formation.

56-153F. J.H. Beeson, W.R. Dickinson, S.W. Muller, L.W. Vigrass 1956. On westerly slope about 300 m (1000 ft) northeast of Old Harris Place, 166 m (550 ft) east of creek and 166 m (550 ft) north of gully, NW¼ SE¼, Section 26, T. 17 S., R. 26 E., Grant County, Oregon. Middle Bajocian, float from Weberg Formation.

Localities of the California Academy of Sciences (CAS)

300. Oregon. Probably Upper Pliensbachian, Suplee Formation.

29017. Alaska. Lower Bajocian, Kialagvik Formation.

32712. Fossil Point area, Tuxedni Bay, Alaska. Middle Bajocian.

33378. Chisik Lake, Alaska. Probably Callovian beds below the Naknek Formation.

Locality of the Department of Geology, Stanford University (LSJU)

2966. Southeast side of Pit River, 2.41 km (1.5 mi) on bearing 147.5° from peak of Oak Mountain (from Sanborn, 1960, Pl. 1), Big Bend Quadrangle, northern California. Probably Bajocian, Potem Formation.

Plates

Prefixes for figured specimens and localities are:

GSC	Geological Survey of Canada
USGS	United States Geological Survey
USNM	United States National Museum
CAS	California Academy of Sciences
LSJU	Stanford University

Prefixes for figured specimens indicate location of storage. Figures are natural size unless otherwise indicated. Lighting and exposure values are not constant from specimen to specimen. Measurements of inflation apply to the single valve illustrated, unless otherwise indicated.

Plate 1

Trigonia sp. A aff. *T. hemisphaerica* Lycett (page 15)

Figures 1, 2. Lateral and dorsal view of left valve of hypotype USNM 219927 from loc. 714D-C of S.W. Muller (Stanford University). Upper Sinemurian, Sunrise Formation, Nevada. Inflation – 9.6 mm.

Trigonia sp. B aff. *T. hemisphaerica* Lycett (page 15)

Figure 3. Lateral view of hypotype USGS 103485. Bajocian Mormon Formation, Mount Jura, California. Inflation – 8.5 mm (est.).

Frenguelliella sp. A (page 18)

Figure 4. Lateral view of partial right valve of hypotype GSC 43238 from GSC loc. 93587; latex cast. Lower Jurassic (Sinemurian or Toarcian) beds of southern Vancouver Island, British Columbia. Maximum inflation of fragment – 6 mm (approx.).

Figure 5. Lateral view of juvenile right valve of hypotype GSC 43239 from same locality as in fig. 4; latex cast. Maximum inflation of fragment – 3.5 mm (approx.).

Figure 22. Lateral view of fragmentary left valve of hypotype 48731 from same locality as in fig. 4; latex cast. Maximum inflation of fragment – 6.5 mm (approx.).

Figures 6, 7, 8. Lateral, dorsal, and anterior views of right valve of fragmentary hypotype GSC 43240 from GSC loc. 89090; latex cast. Most of shell missing. Lower Jurassic (Sinemurian or Toarcian) beds of Cowichan Lake area, Vancouver Island, British Columbia. Inflation – 19.5 mm.

Frenguelliella sp. B (page 18)

Figure 10. Lateral view of right valve, hypotype GSC 9635 from GSC loc. 93556. Lower Sinemurian, Laberge Group, Yukon Territory. Inflation – 2 mm.

Frenguelliella sp. C (page 18)

Figure 9. Lateral view of left valve of hypotype USNM 219928 from loc. 714D A–E of S.W. Muller (Stanford University). Sinemurian, Sunrise Formation, Nevada. Inflation – 8 mm.

Frenguelliella(?) sp. D (page 19)

Figure 11. Lateral view of left valve of hypotype USNM 219929 from loc. 714B of S.W. Muller (Stanford University). Sinemurian, Sunrise Formation, Nevada. Inflation – 2 mm (approx.).

Myophorella dawsoni (Whiteaves) (page 33)

Figures 12 to 15 do not show the distinct separation of costae from anterior row of nodes characteristic of the typical form of the species.

Figure 12. Lateral view of right valve of syntype GSC 4781b. Probably Middle Bajocian, Bella Coola area, British Columbia. Inflation – 4.5 mm (approx.).

Figure 13. Lateral view of right valve of syntype GSC 4781. Probably Middle Bajocian, Bella Coola area, British Columbia. Inflation – 4 mm (approx.).

Figure 14. Lateral view of left valve of syntype GSC 4781a. Probably Middle Bajocian, Bella Coola area, British Columbia. Inflation – 7 mm (approx.).

Figure 15. Lateral view of right and left valves of syntype GSC 4781c. Probably Middle Bajocian, Bella Coola area, British Columbia. Inflation (right valve) – 4 mm (approx.).

Figure 16. Lateral view of left valve of hypotype GSC 43241 from GSC loc. 87311. Middle Bajocian, Smithers area, British Columbia. Inflation – 7 mm.

Figure 17. Lateral view of right valve of hypotype GSC 43242 from GSC loc. 87311. Middle Bajocian, Smithers area, British Columbia. Inflation – 7.5 mm.

Figure 18. Lateral view of left valve of hypotype GSC 43243 from GSC loc. 87311. Middle Bajocian, Smithers area, British Columbia. Inflation – 7 mm (approx.).

Figure 19. Lateral view of left valve of hypotype GSC 43244 from GSC loc. 83262. Middle Bajocian, Smithers area, British Columbia. Inflation – 7 mm.

Figure 20. Lateral view of right valve of hypotype GSC 43245 from GSC loc. 87311. Middle Bajocian, Smithers area, British Columbia. Inflation – 9 mm (approx.).

Figure 21. Lateral view of right valve of hypotype GSC 43246 from GSC loc. 85398. Middle Bajocian, Smithers area, British Columbia. Inflation – 10 mm (approx.).

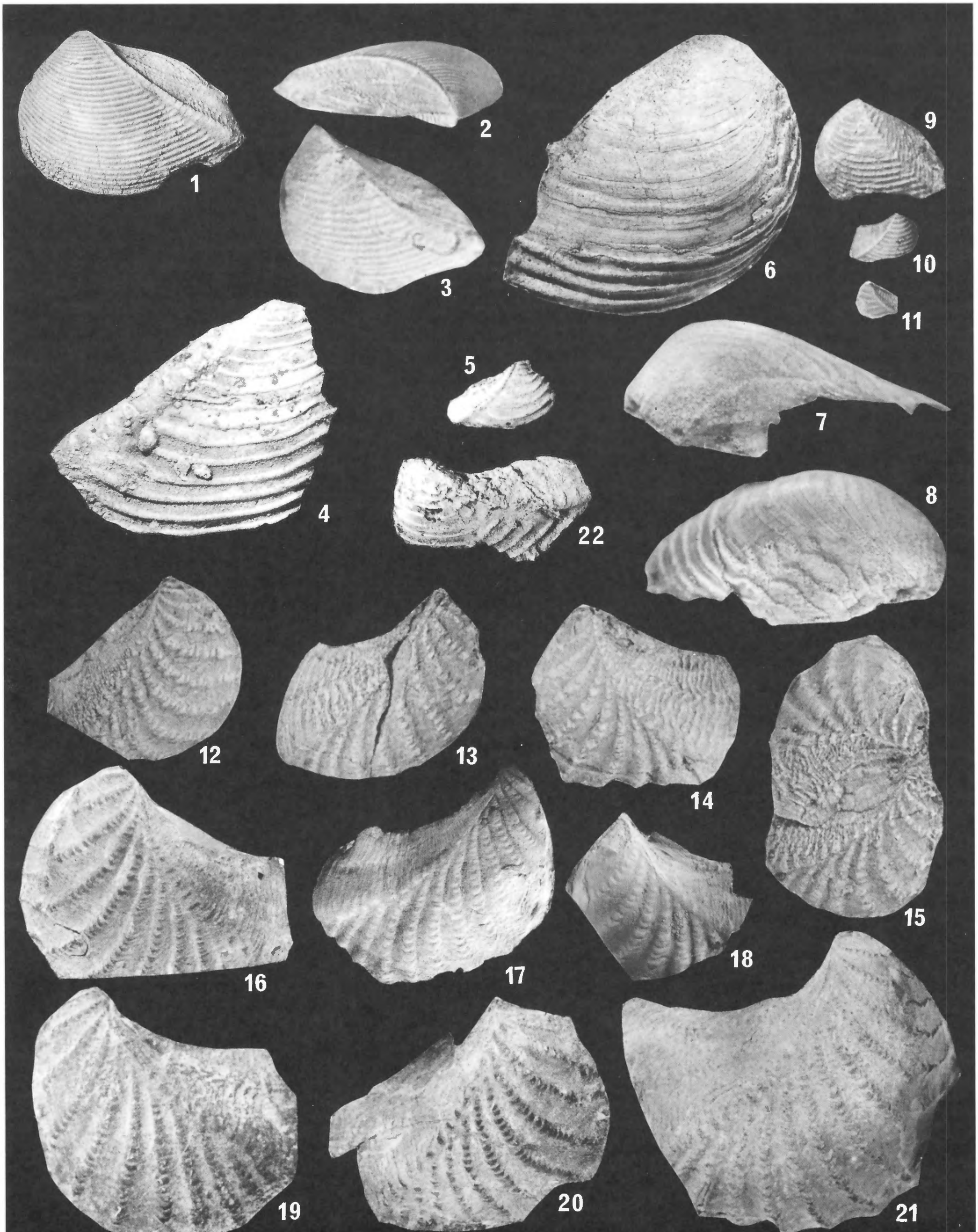

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Plate 2

Myophorella dawsoni (Whiteaves) (page 33)

Figure 1. Lateral view of broken right valve of hypotype GSC 43247 from GSC loc. 87543. Middle Bajocian, Smithers area, British Columbia. Inflation – 7 mm.

Figure 2. Lateral view of fragmentary left valve of hypotype GSC 43248 from GSC loc. 85427. Middle Bajocian, Hazelton Group, Smithers area, British Columbia. Maximum inflation of fragment – 8.5 mm.

Figure 3. Associated right and left juvenile valves of hypotype GSC 43249 from GSC loc. 87311. Middle Bajocian, Smithers area, British Columbia. Inflation – 4 mm (approx.).

Figure 4. Lateral view of juvenile right valve of hypotype GSC 43250 from GSC loc. 87311. Middle Bajocian, Smithers area, British Columbia. Inflation – 5 mm.

Myophorella freboldi n. sp. (page 35)

Figure 5. Lateral view of partial right valve of paratype GSC 43251 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 5 mm (est.; flattened).

Figure 6. Lateral view of external mould of right valve of paratype GSC 43252 from GSC loc. 87554. Middle Bajocian, Smithers area, British Columbia. Inflation – 7 mm (est.).

Figure 7. Lateral view of partial right valve of paratype GSC 43253 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 4 mm (flattened).

Figure 8. Lateral view of partial left valve of paratype GSC 43254 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 8 mm.

Figure 9. Lateral view of partial left valve of paratype GSC 43255 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Maximum inflation of fragment – 9 mm.

Figure 10. Lateral view of partial right valve of paratype GSC 43256 from GSC loc. 87554. Middle Bajocian, Smithers area, British Columbia. Inflation – 10 mm (est.).

Figure 11. Lateral view of articulated valves of holotype USNM 219867 from locality bearing USGS field no. 56-153F, Middle Bajocian Weberg Formation, Oregon. Inflation (left valve) – 14 mm.

Figure 12. Lateral view of articulated valves of paratype GSC 43257 from GSC loc. 64796. Middle Bajocian, Smithers area, British Columbia. Inflation (right valve) – 4 mm.

Orthotrigonia(?) *sohli* n. sp. (page 42)

Figure 13. Anterior views of right and left valves of paratype USNM 219868 from USGS loc. 19357; latex cast. Probably Bajocian, Gypsum Springs Formation, Wyoming. Maximum inflation of fragmentary right valve – 6 mm. (approx.).

Figure 14. Lateral view of right valve and fragmentary left valve of holotype USNM 219869 from same locality as in fig. 13, latex cast. Inflation (right valve) – 6.5 mm (approx.).

Figure 15. Lateral view of left valve of paratype USNM 219870 from same locality as fig. 13, latex cast. Inflation – 5 mm (approx.).

Figure 16. Lateral view of fragmentary left valve of paratype USNM 219871 from same locality as fig. 13, latex cast. Inflation – 5 mm.

Myophorella yellowstonensis Imlay (page 36)

Figure 17. Lateral view of right valve of hypotype GSC 43258 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 2.5 mm (approx.).

Figure 18. Lateral view of right valve of hypotype GSC 43259 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation (est.) – 3.5 mm.

Figure 19. Lateral view of right valve of hypotype GSC 43260 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 3 mm (approx.).

Figure 20. Lateral view of right valve of hypotype GSC 43261 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 2 mm (approx.).

Figure 21. Lateral view of left valve of hypotype GSC 43262 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Inflation – 2.2 mm (approx.).

Figure 22. Lateral view of left valve of hypotype GSC 43263 from GSC loc. 87554. Middle Bajocian, Smithers area, British Columbia. Inflation – 2.5 mm (approx.).

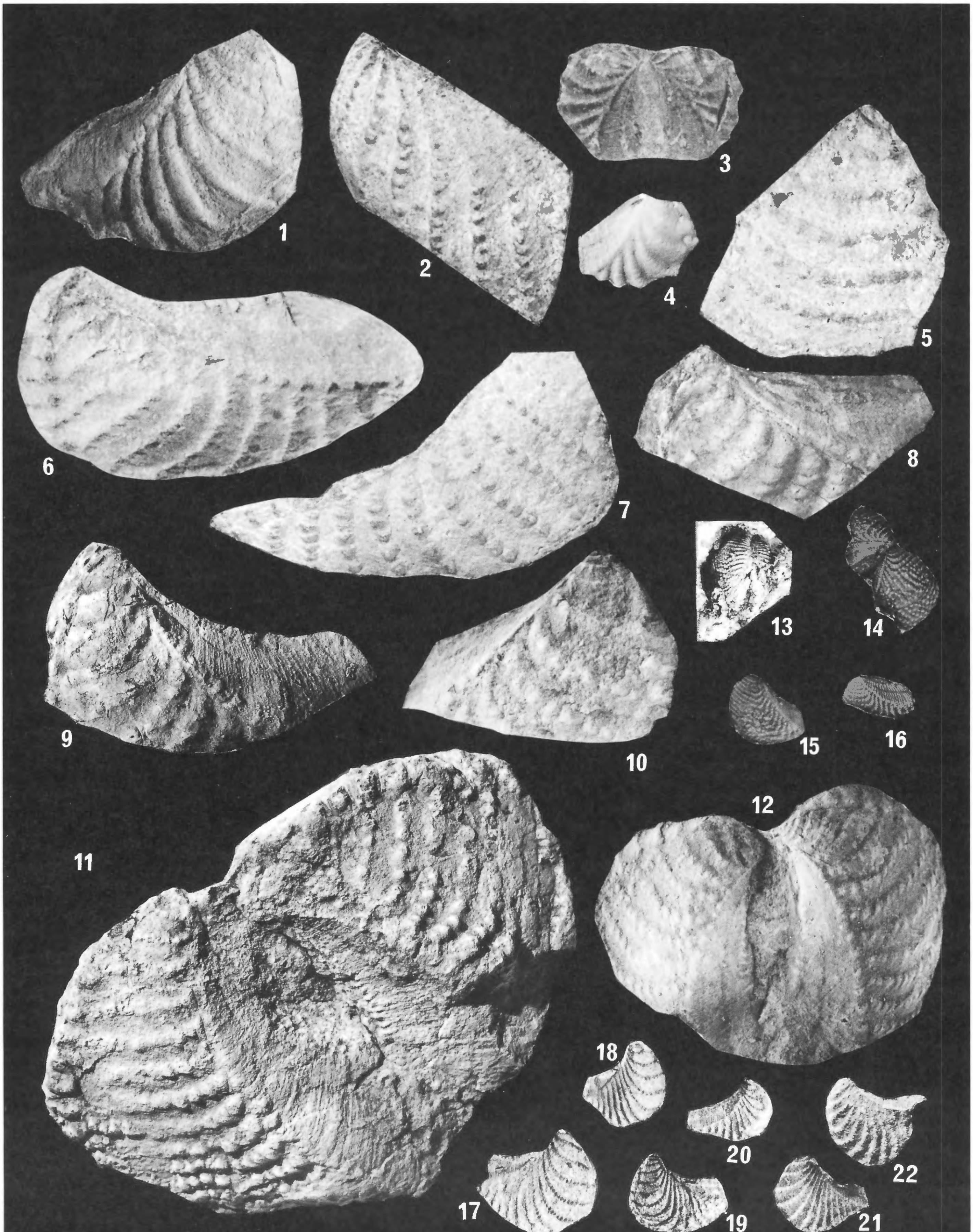

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Plate 3

Myophorella packardi (Crickmay) (page 28)

Figure 1. Lateral view of right valve of holotype GSC 9682 figured by Crickmay (1930a, Pl. XII, figs. 2, 3); latex cast. Callovian, Billhook Formation, Harrison Lake area, British Columbia.

Figure 2. Lateral view of fragment of left valve of paratype GSC 9673 of *Haidaia statluensis* figured by Crickmay (1930a, Pl. XII, fig. 6). Callovian, Billhook Formation, Harrison Lake area, British Columbia.

Figure 3. Lateral view of broken left valve of hypotype GSC 43264 from GSC loc. 89433; latex cast. Callovian, Billhook Formation, Harrison Lake area, British Columbia, Inflation – 11 mm.

Figures 4, 5. Lateral and dorsal views of right valve of hypotype GSC 43265 from GSC loc. 89433; latex cast. Callovian, Billhook Formation, Harrison Lake area, British Columbia. Inflation – 14 mm.

Figures 6, 7. Umbonal and lateral views of right valve of hypotype GSC 43266 from GSC loc. 89433; latex cast. Callovian, Billhook Formation, Harrison Lake area, British Columbia. Inflation – 13 mm.

Figures 8, 9, 10. Lateral, dorsal and anterior views of left valve of hypotype GSC 4916a. Callovian, Yakoun Formation, Queen Charlotte Islands, British Columbia. Inflation (left valve) – 13 mm (deformed).

Figure 11. Lateral view of right valve of hypotype GSC 4927 of *Trigonia dawsoni* figured by Whiteaves (1884, Pl. XXXI, fig. 1a). Callovian, Yakoun Formation, Queen Charlotte Islands, British Columbia. Inflation (each valve) – 15 mm.

Figures 12, 13, 14, 15. Lateral (right valve), dorsal, lateral (left valve) and anterior views of hypotype GSC 4916b. Callovian, Yakoun Formation, Queen Charlotte Islands, British Columbia. Inflation (each valve) – 14.5 mm.

Figure 16. Lateral view of right valve of hypotype GSC 4916. Callovian, Yakoun Formation, Queen Charlotte Islands, British Columbia. Inflation – 17 mm (flattened).

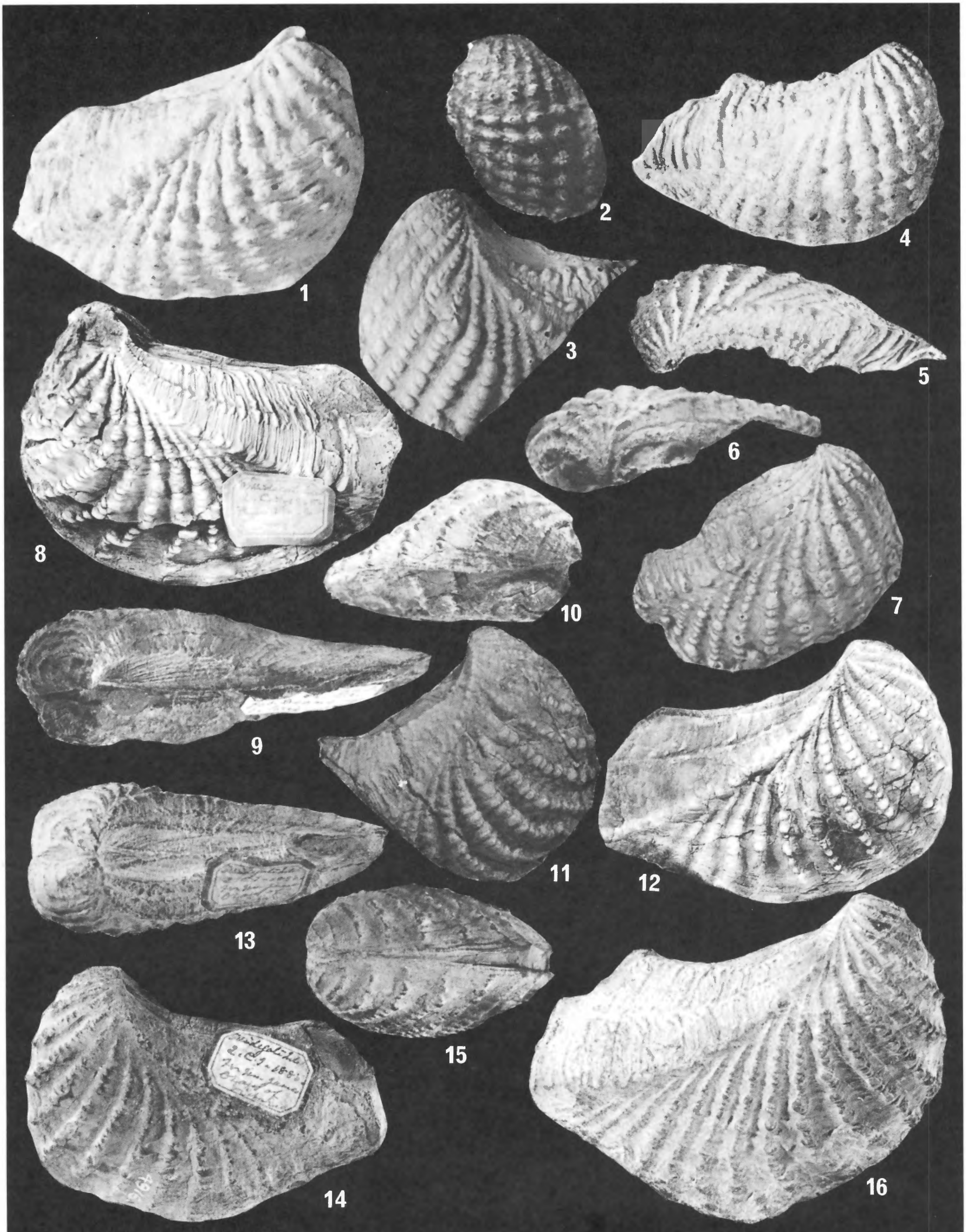

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Plate 4

Myophorella orientalis Kobayashi and Tamura (page 29)

Figures 1, 2. Lateral and dorsal views of left valve of hypotype USNM 219872 from USGS loc. 20726. Callovian, Chinitna Formation, Iniskin Bay, Alaska. Inflation (left valve) – 10 mm.

Figure 3. Lateral view of left valve of hypotype USNM 219873 from USGS loc. 20726. Callovian, Chinitna Formation, Iniskin Bay, Alaska. Inflation – 12 mm.

Figure 4. Lateral view of right valve of hypotype USNM 219874 from USGS loc. 20726. Callovian, Chinitna Formation, Iniskin Bay, Alaska. Inflation – 12 mm.

Figure 5. Lateral view of left valve of hypotype USNM 219875 from USGS loc. 20726. Callovian, Chinitna Formation, Iniskin Bay, Alaska. Inflation – 11 mm (approx.).

Figure 6. Lateral view of right valve of hypotype USNM 219876 from USGS loc. 11057. Probably Callovian beds, Iniskin Bay, Alaska. Inflation – 11 mm (approx.).

Myophorella alaskaensis n. sp. (page 32)

Figures 7, 8. Lateral and posterodorsal views of right valve of holotype USNM 219877 from USGS loc. 24113. Bajocian beds, Tuxedni Formation, Talkeetna Mountains, Alaska. Inflation (right valve) – 12 mm.

Myophorella argo (Crickmay) (page 31)

Figure 9. Lateral view of right valve of holotype GSC 27714, figured by Crickmay (1930b, Pl. 5, figs. a, b). Middle Bajocian, Opuntia Formation, Ashcroft area, British Columbia. Inflation (each valve) – 10 mm.

Figure 10. Lateral view of left valve of hypotype USNM 219878 from USGS loc. 19962. Middle Bajocian, Gaikema Sandstone, Chinitna Bay, Alaska. Inflation – 12 mm (approx.).

Figures 11, 12, 13. Lateral, posterodorsal and anterior views of hypotype USNM 219879 from USGS loc. 10521. Middle Bajocian, Cynthia Falls Sandstone, Tuxedni Bay, Alaska. Inflation – 12.5 mm.

Figure 14. Lateral view of fragmentary left valve of hypotype USNM 219880 from USGS loc. 19948. Middle Bajocian, Gaikema Sandstone, Chinitna Bay, Alaska. Maximum inflation of fragment – 11 mm.

Figures 15, 16. Lateral and umbonal views of fragmentary right valve of hypotype USNM 219881 from USGS loc. 19962. Middle Bajocian, Gaikema Sandstone, Chinitna Bay, Alaska. Inflation – 12.5 mm.

Figure 17. Lateral view of juvenile right valve of hypotype USNM 219882 from USGS loc. 19962. Middle Bajocian, Gaikema Sandstone, Chinitna Bay, Alaska. Inflation – 5 mm.

Myophorella sp. cf. *M. argo* (Crickmay) (page 32)

Figure 18. Lateral view of right valve of hypotype USNM 219883 from USGS loc. 19844. Middle Bajocian, Kialagvik Formation, Wide Bay, Alaska. Inflation – 13 mm (approx.).

Figure 19. Same view of same specimen as in fig. 18. Specimen only partly cleaned, showing nature of tuberculation of costae.

Figure 20. Lateral view of left valve of hypotype USNM 219884 from USGS loc. 19844. Middle Bajocian, Kialagvik Formation, Wide Bay, Alaska. Inflation – 12 mm (approx.).

Figure 21. Same view of same specimen as in fig. 20. Specimen only partly cleaned, showing nature of tuberculation of costae.

Figure 22. Lateral view of fragmentary and poorly preserved left valve of hypotype USNM 219885 from USGS loc. 56-120 (field number). Middle Bajocian, Weberg Formation. Maximum inflation of fragment – 11 mm (approx.).

Myophorella montanaensis (Meek) (page 34)

Figure 23. Lateral view of right valve of syntype USNM 7817 figured by White (1883, Pl. 38, fig. 2a). Bajocian, Yellowstone Canyon, Montana. Inflation – 8 mm (approx.).

Figure 24. Lateral view of broken left valve of hypotype GSC 43267 from GSC loc. 88565. Probably Bajocian, Hazelton Group, Smithers area, British Columbia. Maximum inflation of fragment – 7 mm.

Figure 25. Lateral view of right valve of hypotype GSC 43268 from GSC loc. 85456. Lower Callovian, Hazelton Group, Smithers area, British Columbia. Inflation – 5 mm (approx.).

Figure 26. Lateral view of broken left valve of holotype GSC 6064 of *Trigonia ferrieri*, figured by McLearn (1924, Pl. 5, fig. 2). Lower Callovian, Fernie Group, Blairmore area, Alberta. Inflation – 13 mm (est.).

Figure 27. Lateral view of juvenile poorly preserved left valve of hypotype GSC 43269 from GSC loc. 88565. Probably Bajocian, Hazelton Group, Smithers area, British Columbia. Inflation – 5.5 mm.

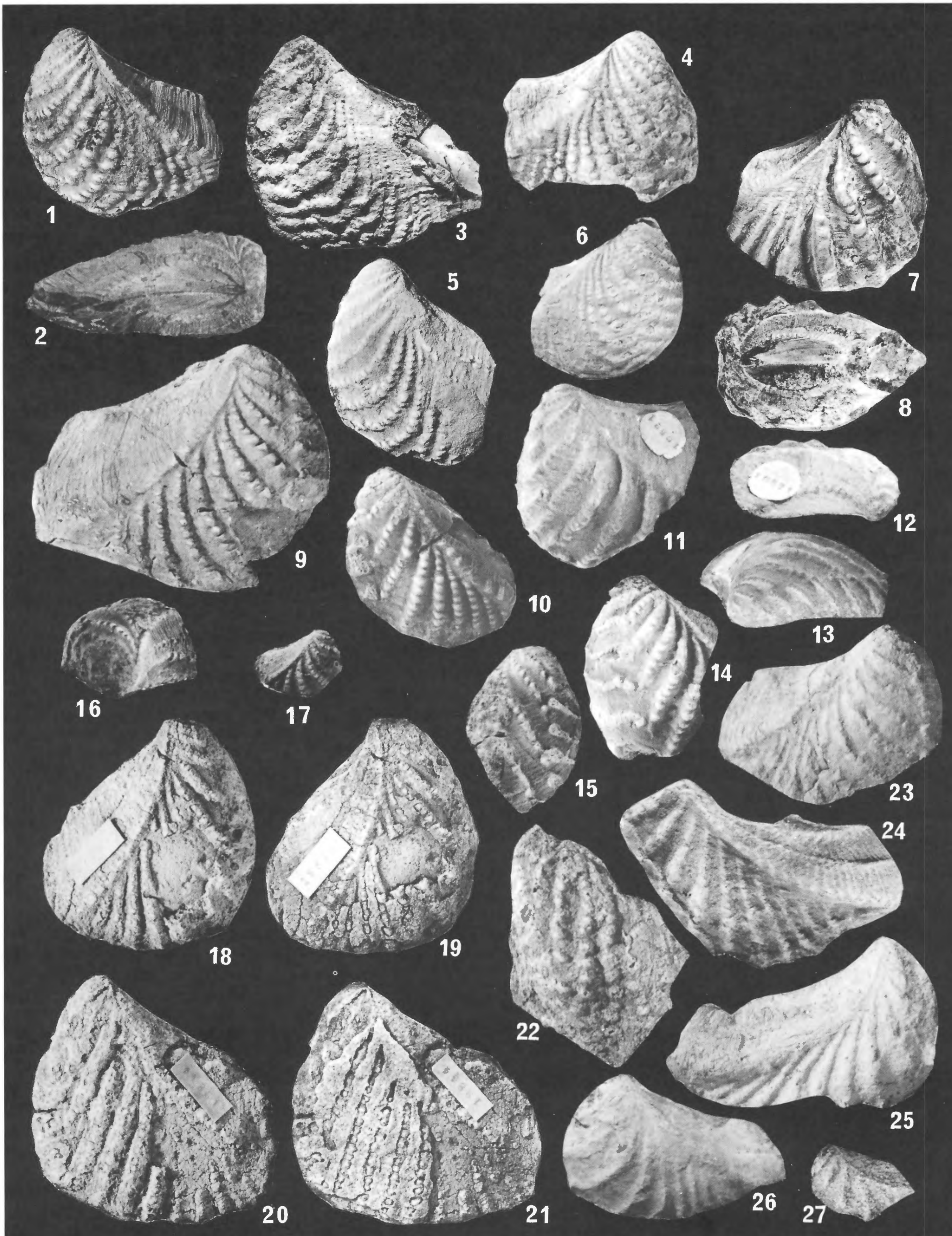

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

Plate 5

Myophorella montanaensis (Meek) (page 34)

Figure 1. Lateral view of left valve of hypotype GSC 43270 from GSC loc. 88567. Probably Bajocian, Hazelton Group, Smithers area, British Columbia. Inflation – 6 mm.

Figure 2. Lateral view of broken right valve of hypotype GSC 43271 from GSC loc. 88567. Probably Bajocian, Hazelton Group, Smithers area, British Columbia. Inflation – 11 mm (approx.).

Figure 3. Lateral view of juvenile right valve of paratype GSC 6065 of *Trigonia ferrieri,* figured by McLearn (1924, Pl. 5, fig. 10). Lower Callovian, Fernie Group, Blairmore area, Alberta. Inflation – 4 mm.

Figures 4, 5. Lateral views (different lighting) of left valve of hypotype GSC 43272 from GSC loc. 88485. Upper Bathonian, Hazelton Group, Smithers area, British Columbia. Inflation – 6.5 mm.

Myophorella devexa (Eichwald) (page 30)

Figures 6, 7. Lateral and dorsal views of fragmentary right valve of hypotype USNM 219886 from USGS loc. 2919. Probably Bathonian, Iniskin Bay, Alaska. Maximum inflation of fragment – 18 mm.

Figures 8, 9, 10. Lateral, anterior and dorsal views of right valve of hypotype USNM 219887 from USGS loc. 3034. Probably Bathonian, Iniskin Bay, Alaska. Inflation – 21 mm.

Figure 11. Lateral view of partial right valve of hypotype USNM 219888 from USGS loc. 3038. Bathonian, Bowser Formation, Alaska. Maximum inflation of fragment – 27 mm.

Figure 12. Lateral view of fragmentary left valve of hypotype USNM 219889 from USGS loc. 2919. Probably Bathonian, Iniskin Bay, Alaska. Maximum inflation of fragment – 18 mm.

Figure 13. Lateral view of right valve of hypotype GSC 48730 from GSC loc. 91765; latex cast. Probable Callovian or Lower Oxfordian beds, Spatsizi map area, British Columbia. Inflation – 15 mm (approx.).

Figure 14. Lateral view of partial right valve of hypotype GSC 43273 from GSC loc. 57177; latex cast. Probably Lower Oxfordian, Bowser Lake Group, Smithers area, British Columbia. Maximum inflation of fragment – 15 mm.

Figure 15. Lateral view of small, possibly juvenile, right valve of hypotype GSC 43274 from same locality as fig. 14; latex cast. Inflation – 10.5 mm.

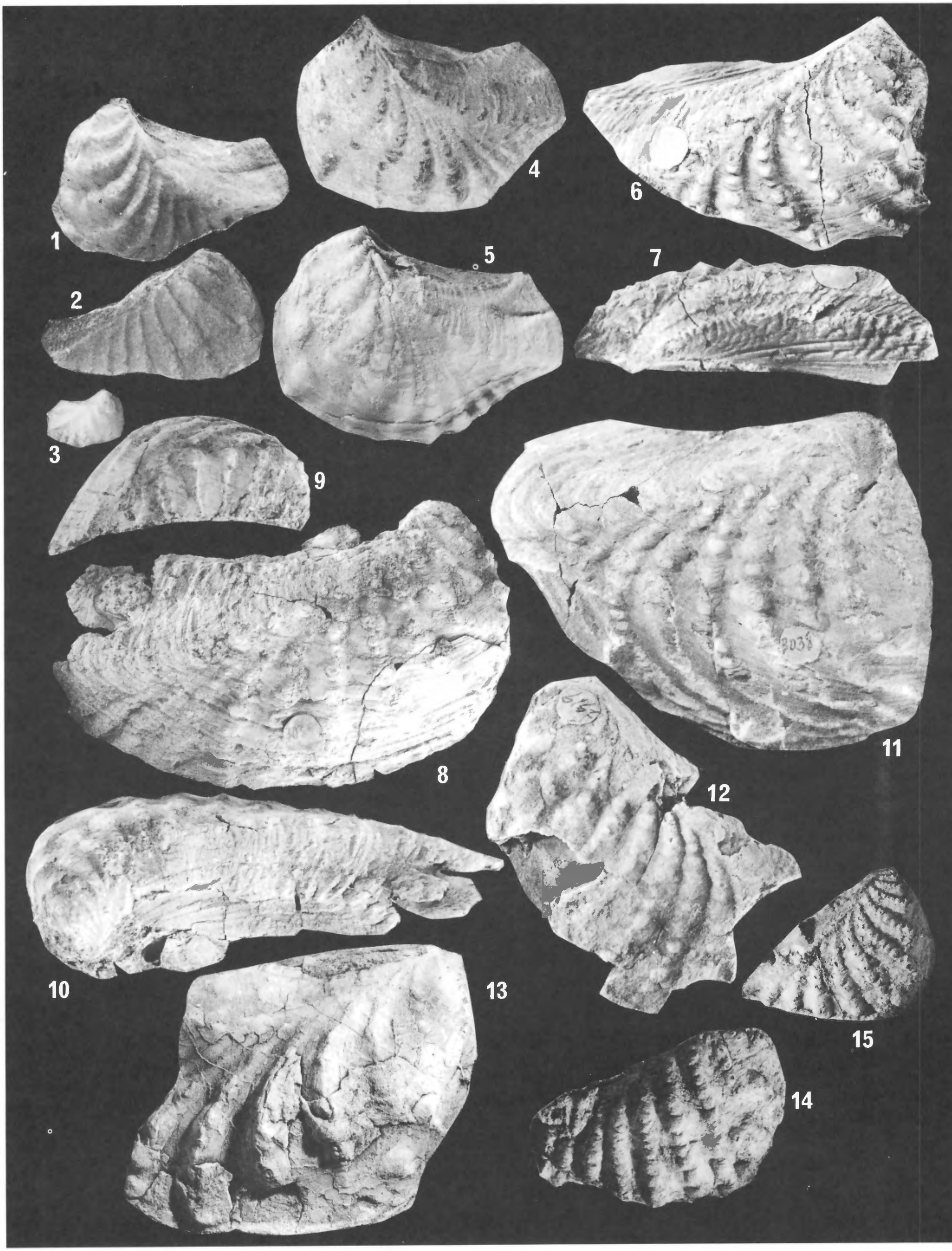

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Plate 6

Myophorella devexa (Eichwald) (page 30)

Figure 1. Lateral view of left valve of hypotype GSC 43275 from GSC loc. 57177; latex cast. Probably Lower Oxfordian, Bowser Lake Group, Smithers area, British Columbia. Inflation – 15 mm.

Figures 2, 3. Lateral and dorsal views of left valve of hypotype USNM 219890 from USGS loc. 3038. Bathonian, Bowser Formation, Alaska. Inflation – 21 mm.

Figure 4. Lateral view of abnormally short left valve of hypotype USNM 219891 from USGS loc. 26955. Bathonian or Lower Callovian, Talkeetna Mountains, Alaska. Inflation – 11.5 mm (est.).

Figure 5. Lateral view of left valve of hypotype USNM 219892 from USGS loc. 24118. Bathonian, Talkeetna Mountains, Alaska. Inflation – 14 mm (est.).

Figure 6. Lateral view of right valve of hypotype USNM 219893 from USGS loc. 24118. Bathonian, Talkeetna Mountains, Alaska. Inflation – 10.5 mm (approx.).

Figure 7. Lateral view of broken right valve of hypotype USNM 219894 from USGS loc. 24118. Bathonian, Talkeetna Mountains, Alaska. Inflation – 10 mm (approx.).

Myophorella sp. C (page 40)

Figures 8, 9. Lateral views (different lighting) of poorly preserved left valve of hypotype GSC 43276 from GSC loc. 85398. Middle Bajocian, Smithers area, British Columbia. Inflation – 7.5 mm (flattened).

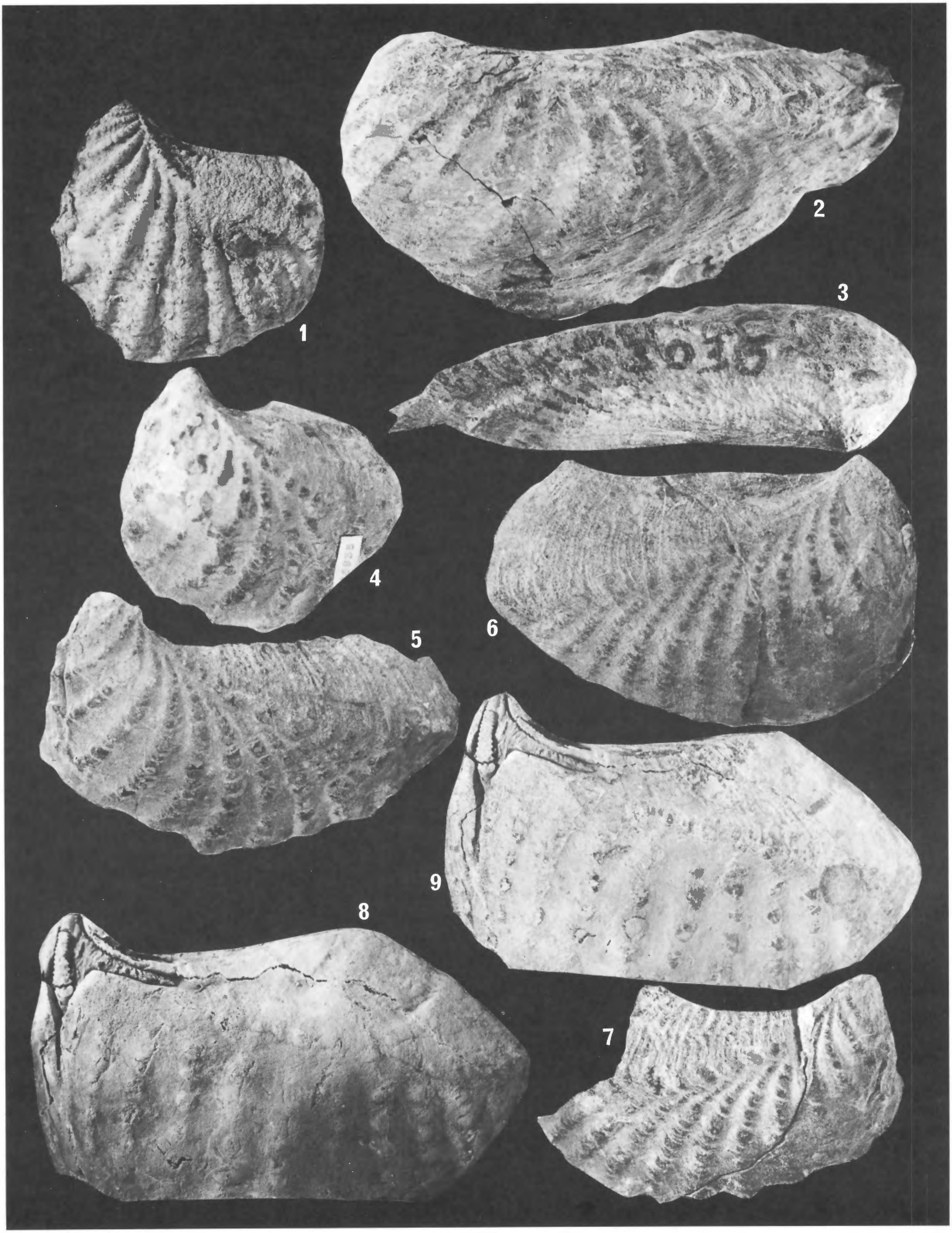

1
2
3
4
5
6
7
8
9

Plate 7

Jaworskiella siemonmulleri n. sp. (page 20)

Figure 1. Lateral view of right valve of holotype USNM 219930 from locality 714-D of S.W. Muller (Stanford University). Upper Sinemurian, Nevada. Inflation – 14 mm (approx.).

Figure 2. Lateral view of external mould of right valve of paratype USNM 219931 from same locality as fig. 1. Maximum inflation of fragment – 11 mm.

Figure 3. Lateral view of left valve of paratype USNM 219932 from same locality as fig. 1. Inflation – 17 mm.

Figure 4. Lateral view of right valve of paratype USNM 219933 from same locality as fig. 1. Inflation – 8 mm.

Jaworskiella supleiensis n. sp. (page 20)

Figure 5. Lateral view of right valve and umbonal view of attached left valve of paratype CAS 55835 from CAS loc. 300. Probably Upper Pliensbachian, Suplee Formation, Oregon. Inflation – 19 mm.

Figure 6. Lateral view of left valve of paratype CAS 55836 from same locality as fig. 5. Inflation – 17 mm.

Figure 7. Lateral view of right valve of paratype CAS 55837 from same locality as fig. 5. Inflation – 7 mm (est.).

Figure 8. Lateral view of fragmentary external mould of right valve of holotype CAS 55838 from same locality as fig. 5. Inflation (each valve) – 14 mm (est.).

Myophorella tuxedniensis n. sp. (page 38)

Figures 9, 10, 11. Lateral, umbonal and posterodorsal views of right valve of holotype USNM 219895 from USGS loc. 24113. Middle Bajocian, Talkeetna Mountains, Alaska. Inflation – 23 mm (approx.).

Figures 12, 13. Lateral views (different lighting) of incomplete left valve of paratype GSC 43277 from GSC loc. 85398. Middle Bajocian, Smithers area, British Columbia. Maximum inflation of fragment – 8 mm (approx.).

Figure 14. Lateral view of juvenile left valve of paratype USNM 219896 from USGS loc. 24113. Middle Bajocian, Talkeetna Mountains, Alaska. Inflation – 6.5 mm.

Figure 15. Lateral view of fragmentary juvenile right valve of paratype USNM 219897 from USGS loc. 24113. Middle Bajocian, Talkeetna Mountains, Alaska. Maximum inflation of fragment – 10 mm.

Figure 16. Lateral view of fragmentary juvenile right valve of paratype USNM 219898 from USGS loc. 24113. Middle Bajocian, Talkeetna Mountains, Alaska. Maximum inflation of fragment – 6 mm (est.).

Figure 17. Lateral view of fragment of left valve of paratype GSC 43278 from GSC loc. 82358. Middle Bajocian, Smithers area, British Columbia. Maximum inflation of fragment – 6.5 mm.

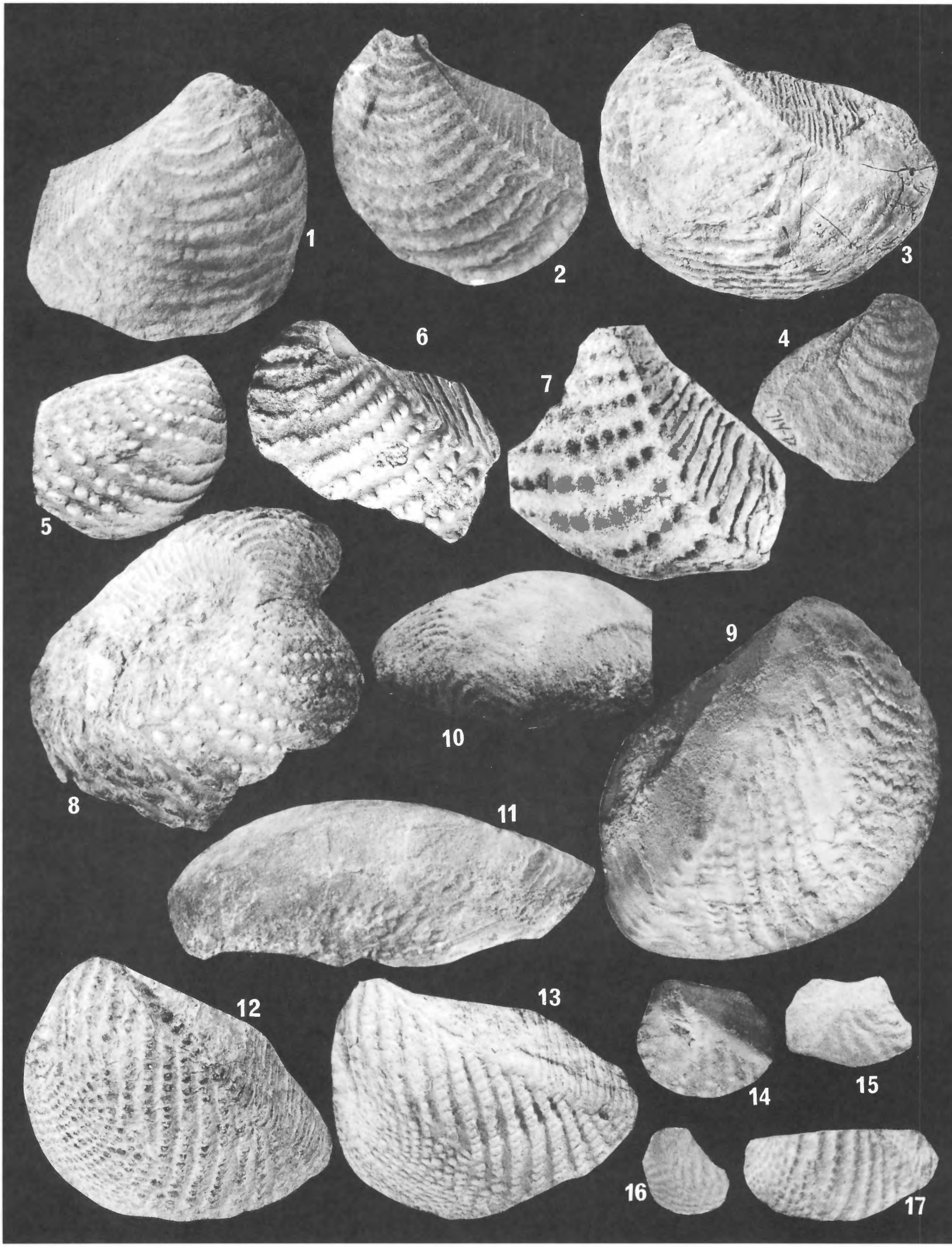

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Plate 8

Myophorella billhookensis (Crickmay) (page 38)

Figure 1. Lateral view of latex cast of fragmentary left valve of holotype GSC 9681. Callovian, Billhook Formation, Harrison Lake area, British Columbia. Maximum inflation of fragment – 20.5 mm.

Myophorella sp. A (page 38)

Figure 2. Lateral view of broken left valve of hypotype GSC 43279 from GSC loc. 13756. Probably Lower Callovian, Whitesail Lake area, British Columbia. Maximum inflation of fragment – 10 mm.

Myophorella sp. aff. *M. freboldi* n. sp. (page 36)

Figure 3. Lateral view of right valve of hypotype GSC 43280 from GSC loc. C-18178; latex cast. Probably Middle Bajocian, Laberge Group, Yukon Territory. Inflation – 10 mm.

Myophorella sp. aff. *M. devexa* (Eichwald) (page 31)

Figure 4. Lateral view of right valve and partial left valve of hypotype GSC 43281 from GSC loc. 23485; latex cast. Lower Oxfordian, Terrace area, British Columbia. Inflation (right valve) – 13 mm.

Figure 5. Lateral view of poorly preserved right valve, with most of shell missing; hypotype GSC 43282 from GSC loc. 85323. Callovian, Smithers area, British Columbia. Inflation (distorted) – 18 mm.

Vaugonia(?) *yukonensis* n. sp. (page 25)

Figure 6. Lateral view of fragmentary left valve of paratype GSC 43283 from GSC loc. C-18179; latex cast. Probably Middle Bajocian, Laberge Group, Yukon Territory. Maximum inflation of fragment – 11 mm.

Figure 7. Lateral view of fragmentary right valve of holotype GSC 43284 from GSC loc. C-18179; latex cast. Probably Middle Bajocian, Laberge Group, Yukon Territory. Inflation – 6.5 mm (approx.).

Figure 8. Lateral view of fragmentary right valve of paratype GSC 43285 from GSC loc. C-18179; latex cast. Probably Middle Bajocian, Laberge Group, Yukon Territory. Inflation – 7 mm (approx.).

Figure 9. Lateral view of left valve of paratype GSC 43286 from GSC loc. C-18179; latex cast. Probably Middle Bajocian, Laberge Group, Yukon Territory. Maximum inflation of fragment – 4 mm.

Figure 10. Lateral view of partial left valve of paratype USNM 219899 from USGS loc. 2570. Probably Middle Bajocian, Potem Formation, California. Inflation – 15 mm (est.).

Figure 11. Lateral view of fragmentary external mould of right valve of paratype GSC 43287 from GSC loc. 89374. Probably Middle Bajocian, Potem Formation, Big Bend Quadrangle, California. Inflation – 5 mm.

Vaugonia sp. cf. *V.*(?) *yukonensis* n. sp. (page 26)

Figure 12. Lateral view of partial left valve of hypotype GSC 43288 from GSC loc. C-18178; latex cast. Probably Middle Bajocian, Laberge Group, Yukon Territory. Inflation – 5.5 mm (est.).

Myophorella tipperi n. sp. (page 37)

Figures 13, 14, 15. Lateral, anterior and oblique umbonal views of fragment of left valve of holotype GSC 43289 from GSC 87386; latex cast. Middle Bajocian, Smithers area, British Columbia. Inflation – 11.5 mm.

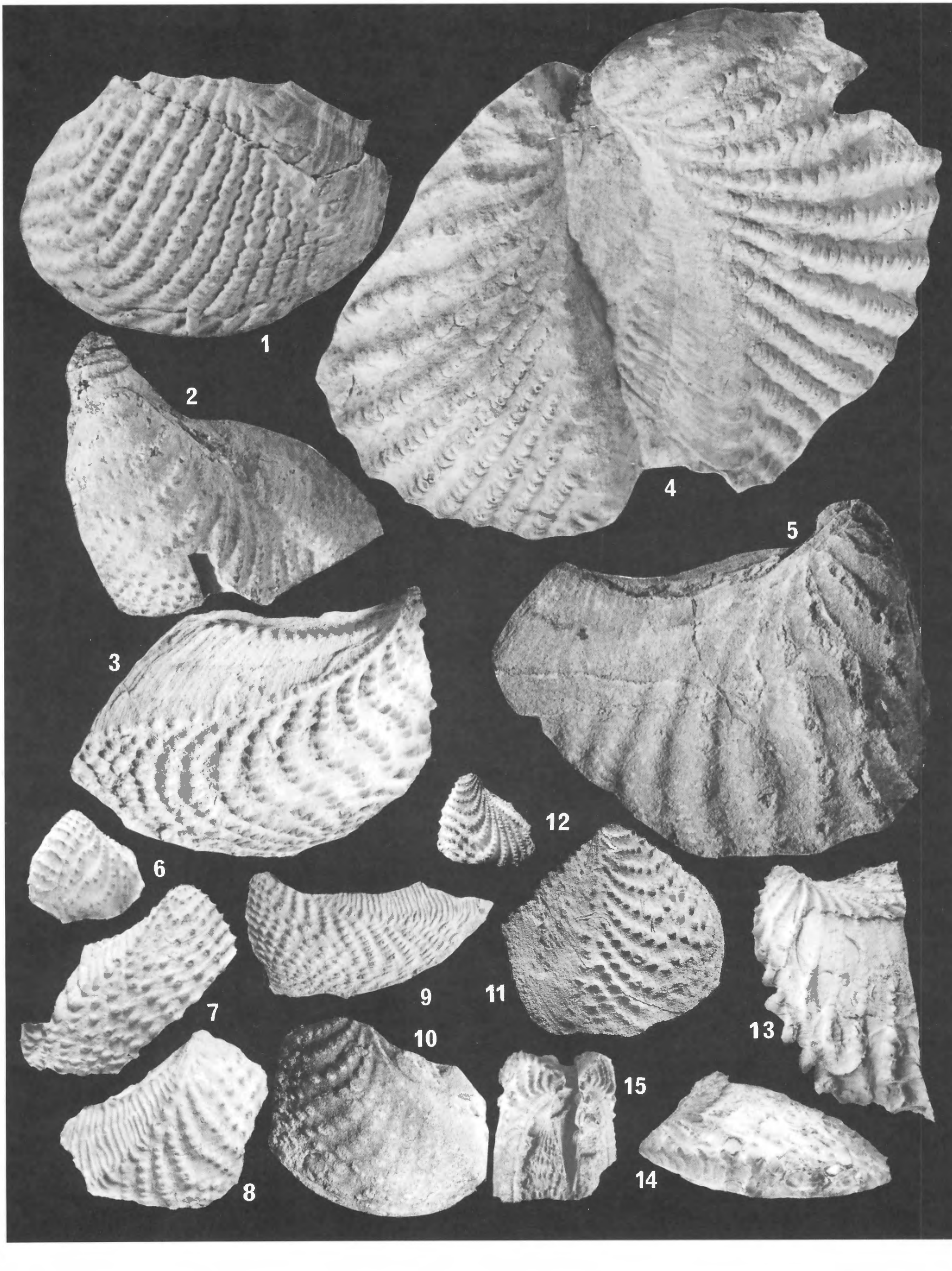

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Plate 9

Myophorella tipperi n. sp. (page 37)

Figure 1. Lateral view of left valve of paratype GSC 43290 from GSC loc. 87381. Middle Bajocian, Smithers area, British Columbia. Inflation – 4 mm (flattened).

Figure 2. Lateral view of juvenile right valve of paratype GSC 43291 from GSC loc. 87326. Middle Bajocian, Smithers area, British Columbia. Inflation – 2 mm (approx.).

Figure 3. Lateral view of juvenile right valve of paratype GSC 43292 from GSC loc. 87319. Middle Bajocian, Smithers area, British Columbia. Inflation – 1.5 mm (approx.; flattened).

Figure 4. Lateral view of right valve of paratype GSC 43293 from GSC loc. 87324. Middle Bajocian, Smithers area, British Columbia. Inflation – 5 mm (flattened).

Figure 5. Lateral view of anteroventral fragment of right valve of paratype GSC 43294 from GSC loc. 87541. Middle Bajocian, Smithers area, British Columbia. Maximum inflation of fragment (flattened) – 6 mm.

Figure 6. Lateral view of right valve of paratype GSC 43295 from GSC loc. 87324; latex cast. Middle Bajocian, Smithers area, British Columbia. Inflation – 4 mm (flattened).

Figure 7. Lateral view of anteroventral fragment of left valve of paratype GSC 43296 from GSC loc. 87324. Middle Bajocian, Smithers area, British Columbia. Inflation – 0 mm (flattened).

Figures 8, 9. Lateral views (different lighting) of right valve of paratype GSC 43297 from GSC loc. 85398. Middle Bajocian, Smithers area, British Columbia. Inflation – 9 mm (distorted; est.).

Myophorella sp. B (page 39)

Figure 10. Lateral view of left valve of hypotype GSC 43298 from GSC loc. 83477; latex cast. Early Bajocian or Late Toarcian, Laberge Group, Yukon Territory. Inflation – 4 mm (approx.).

Figure 11. Oblique anterior view of fragment of right valve of hypotype GSC 43299 from same locality as fig. 10. Maximum inflation of fragment – 7.5 mm.

Myophorella sp. aff. *M. dawsoni* (Whiteaves) (page 34)

Figure 12. Lateral view of right valve of hypotype USNM 219900 from USGS loc. 10512. Middle Bajocian Cynthia Falls Sandstone, Tuxedni Bay, Alaska. Inflation – 5 mm.

Figure 13. Lateral view of right valve of hypotype USNM 219901 from USGS loc. 10512. Middle Bajocian, Cynthia Falls Sandstone, Tuxedni Bay, Alaska. Inflation – 6 mm (approx.).

Figure 14. Lateral view of left valve of hypotype USNM 219902 from USGS loc. 1495. Middle Bajocian, Fitz Creek Siltstone, Cook Inlet, Alaska.

Figure 15. Lateral view of right valve of hypotype USNM 219903 from USGS loc. 10512. Middle Bajocian, Cynthia Falls Sandstone, Tuxedni Bay, Alaska. Inflation – 6 mm (approx.).

Figure 16. Lateral view of left valve of hypotype USNM 219904 from USGS loc. 1495. Middle Bajocian, Fitz Creek Siltstone, Cook Inlet, Alaska. Inflation – 5 mm (approx.).

Figure 17. Lateral view of right valve of hypotype USNM 219905 from USGS loc. 1495. Middle Bajocian, Fitz Creek Siltstone, Cook Inlet, Alaska. Inflation – 7.5 mm.

Figure 18. Lateral view of left valve of hypotype GSC 43301 from GSC loc. 88485. Upper Bathonian, Smithers area, British Columbia. Inflation – 4 mm (approx.).

Figure 19. Lateral view of left valve of hypotype GSC 43302 from GSC loc. 80301. Middle Jurassic, Smithers area, British Columbia. Inflation – 3.5 mm.

Figure 20. Lateral view of left valve of hypotype USNM 219906 from USGS loc. 10512. Middle Bajocian, Cynthia Falls Sandstone, Tuxedni Bay, Alaska. Inflation – 3.5 mm (approx.).

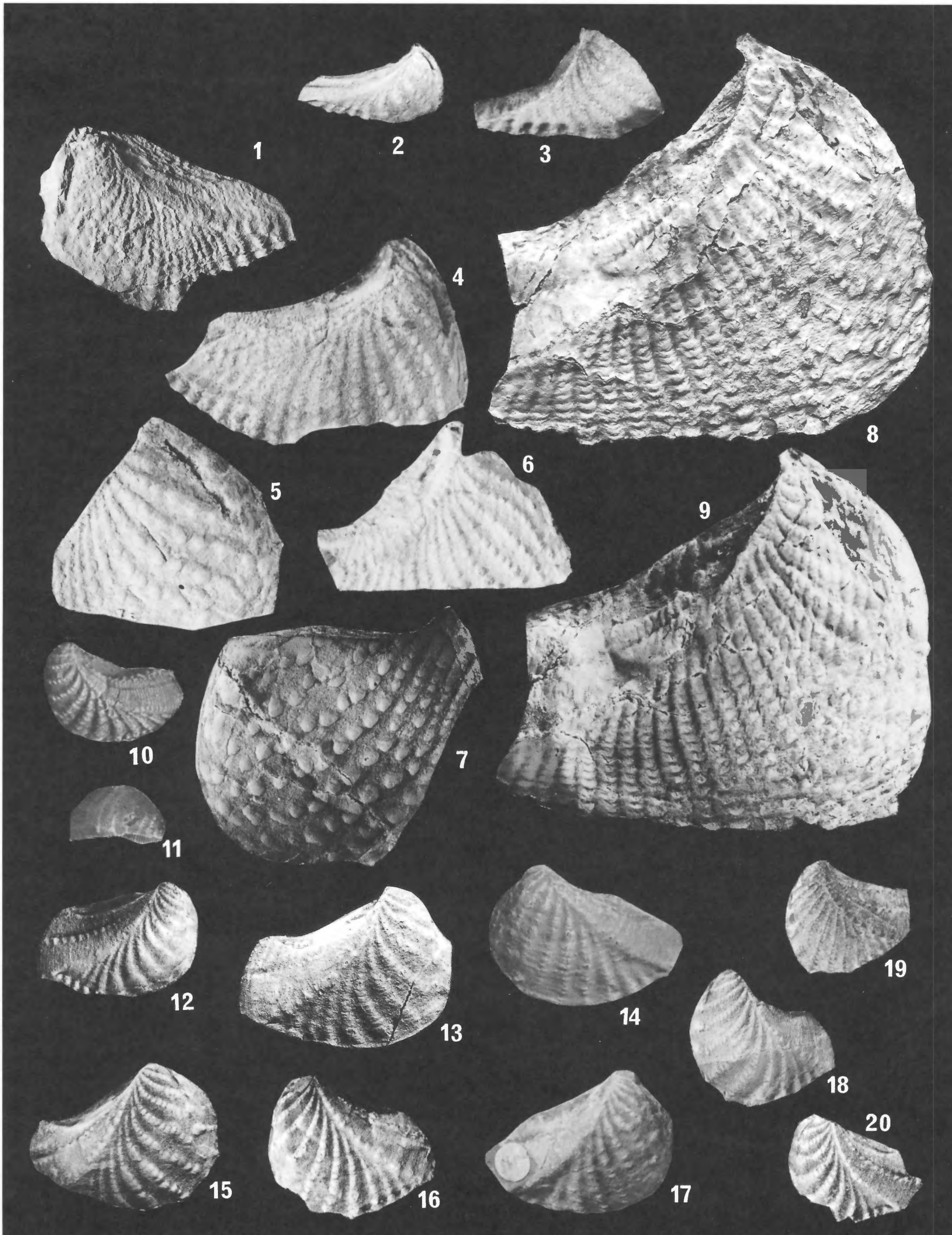

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Plate 10

Vaugonia veronica Crickmay (page 21)

Figures 1, 2. Lateral and dorsal views of holotype GSC 27715, figured by Crickmay (1930b, Pl. 7, fig. f). Middle Jurassic, head of Portland Canal, British Columbia. Inflation – 8.5 mm.

Figure 3. Lateral view of broken right valve of hypotype GSC 43303 from unnumbered locality, probably nearly the same as for figs. 1, 2, 4. Inflation – 3 mm (est.).

Figure 4. Lateral view of broken holotype GSC 27716 of *Vaugonia mariajosephinae* Crickmay (1930b, Pl. 7, fig. g). Middle Jurassic, head of Portland Canal, British Columbia. Inflation – 10 mm.

Figures 5, 6. Lateral and dorsal views of left valve of hypotype GSC 43304, from same locality as fig. 3. Inflation – 13 mm.

Vaugonia imlayi n. sp. (page 22)

Figures 7, 12. Lateral and anterior views of left valve of holotype USNM 219907 from USGS loc. 19962. Middle Bajocian, Gaikema Formation, Alaska. Inflation – 8 mm.

Figure 8. Lateral view of left valve of paratype USNM 219908 from same locality as fig. 7. Inflation – 11 mm.

Figures 9, 11. Lateral and umbonal views of left valve of paratype USNM 219909 from same locality as fig. 7. Inflation – 8 mm.

Figures 10, 13. Lateral and anterior views of left valve of paratype USNM 219910 from same locality as fig. 7. Inflation – 10 mm.

Vaugonia oregonensis n. sp. (page 23)

Figure 14. Lateral view of left valve of paratype USNM 219911 from USGS loc. 27359. Upper Pliensbachian, Suplee Formation, Oregon. Inflation – 9 mm.

Figure 15. Lateral view of left valve of paratype USNM 219912 from USGS loc. 27359. Upper Pliensbachian, Suplee Formation, Oregon. Inflation – 11 mm.

Figure 16. Lateral view of left valve of holotype USNM 219913 from USGS loc. 27359. Upper Pliensbachian, Suplee Formation, Oregon. Inflation – 7 mm.

Figures 17, 18. Lateral views (fig. 18 ×2) of right valve of paratype USNM 219914 from USGS loc. 26732. Upper Pliensbachian, Suplee Formation, Oregon. Inflation – 10.5 mm (est.).

Figure 19. Lateral view of right valve of paratype USNM 219915 from USGS loc. 27359. Upper Pliensbachian, Suplee Formation, Oregon. Inflation – 8 mm.

Vaugonia sp. aff. *V. oregonensis* n. sp. (page 23)

Figure 20. Lateral view of broken left valve of hypotype GSC 43305 from GSC loc. 90981; latex cast. Probably Upper Sinemurian, Hazelton area, British Columbia. Maximum inflation of fragment – 7 mm.

Figure 21. Lateral view of poorly preserved broken right valve of hypotype GSC 43306 from same locality as fig. 20. Inflation – 6 mm.

Figure 22. Lateral view of fragment of left valve of hypotype GSC 43307 from same locality as fig. 20. Maximum inflation of fragment – 2 mm (approx.).

Vaugonia sp. cf. *V. vancouverensis* Poulton (page 23)

Figure 23. Lateral view of fragmentary left valve of hypotype USNM 219934 from locality 714-D of S.W. Muller (Stanford University); ×2. Upper Sinemurian, Sunrise Formation, Nevada. Maximum inflation of fragment – 8 mm (est.).

Figure 24. Lateral view of poorly preserved right valve of hypotype USNM 219935 from locality 714-D of S.W. Muller (Stanford University). Upper Sinemurian, Sunrise Formation, Nevada. Inflation – 5 mm (approx.).

Vaugonia doroschini (Eichwald) (page 24)

Figures 25, 26, 27, 28. Lateral (left valve), anterior, lateral (right valve) and dorsal views of hypotype USNM 219916 from USGS loc. 20765. Probably Callovian, Chinitna Formation, Alaska. Inflation (right valve) – 20 mm, (left valve) – 15 mm.

Vaugonia sp. cf. *V. kobayashii* Alencaster (page 25)

Figure 29. Lateral view of right valve of hypotype USNM 219917 from USGS loc. 1013. Probably Middle Bajocian, Big Bend Quadrangle, California. Inflation – 10.5 mm (approx.).

Figure 30. Lateral view of left valve of hypotype figured by Sanborn (1960, Fig. 20); locality LSJU 2966. Probably Middle Bajocian, Big Bend Quadrangle, California. Inflation – 12 mm (est.).

Figure 31. Lateral view of left valve of hypotype USNM 219918 from USGS loc. 1013; latex cast. Probably Middle Bajocian, Big Bend Quadrangle, California. Inflation – 7 mm (est.).

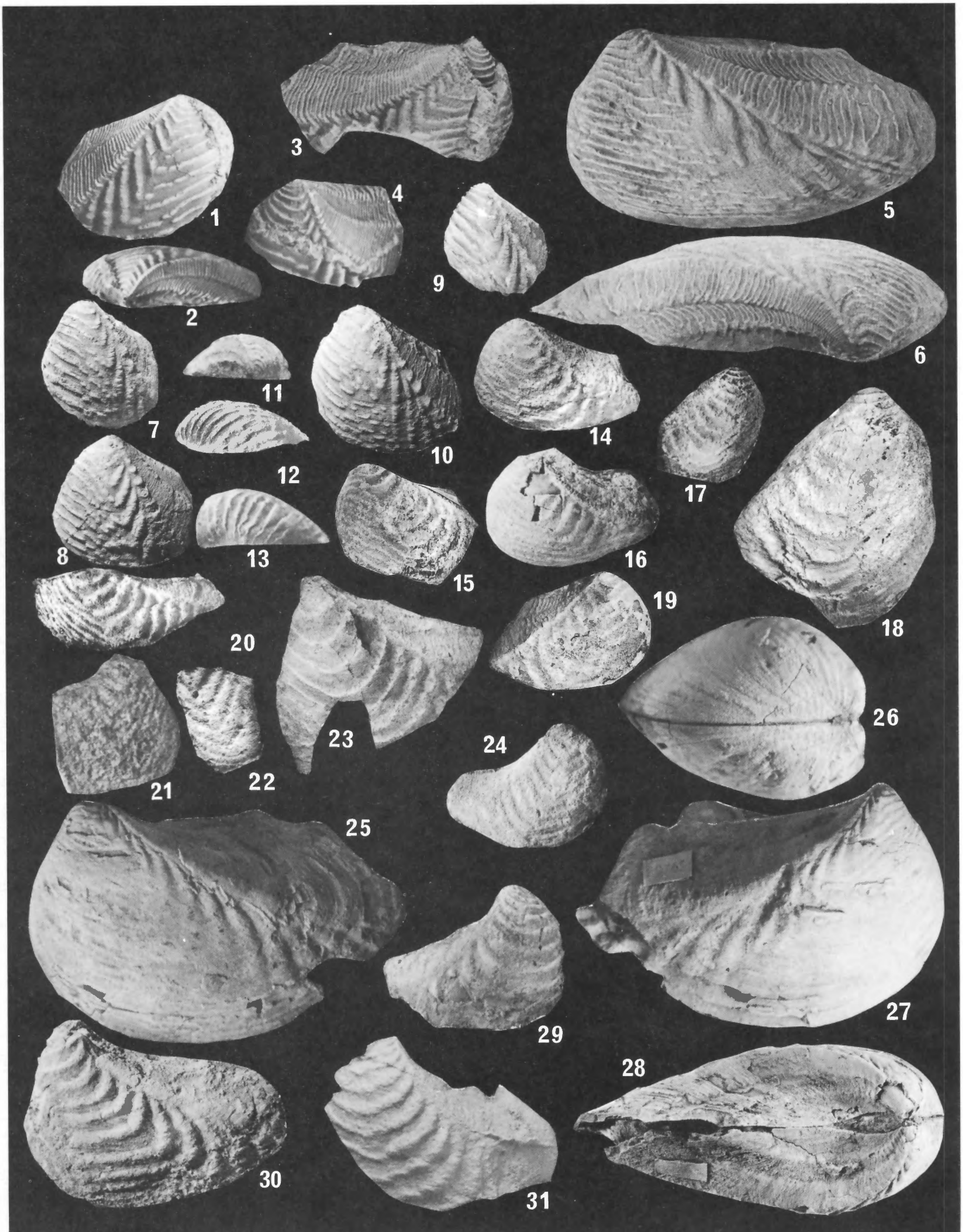

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

Plate 11

Vaugonia doroschini (Eichwald) (page 24)

Figures 1, 2, 3. Lateral, anterior and dorsal views of right valve of hypotype USNM 219919 from USGS loc. 20764. Bathonian, Bowser Formation, Alaska. Inflation – 17.5 mm.

Figures 4, 5. Lateral and dorsal views of right valve of hypotype USNM 219920 from USGS loc. 3096. Oxfordian or Kimmeridgian, Naknek Formation, Alaska. Inflation – 18 mm (est.).

Anditrigonia plumasensis (Hyatt) (page 43)

Figures 6, 7. Lateral and dorsal views of right valve of USNM lectotype 32480, figured by Packard (1921, Pl. 10, fig. 5); latex cast. Callovian, Bicknell Sandstone, Mount Jura, California. Inflation (right valve) – 19.5 mm.

Scaphotrigonia naviformis (Hyatt) (page 40)

Figures 8, 9, 10. Lateral, anterior and umbonal views of left valve of USNM lectotype 32478, figured by Packard (1921, Pl. 2, fig. 1); latex cast. Callovian, Bicknell Sandstone, Mount Jura, California. Inflation – 25 mm (est. minimum).

Figure 11. Lateral view of juvenile left valve of hypotype GSC 43308 from GSC loc. 85450. Lower Callovian, Smithers area, British Columbia. Inflation – 5.5 mm.

Figure 12. Lateral view of posteroventral fragment of right valve of hypotype USNM 32478a from USGS loc. 9258; latex cast. Callovian Bicknell Sandstone, Mount Jura, California. Maximum inflation of fragment – 5 mm.

Figure 13. Lateral view of right valve of hypotype USNM 32478b from same locality as fig. 12; latex cast. Maximum inflation of fragment – 28 mm.

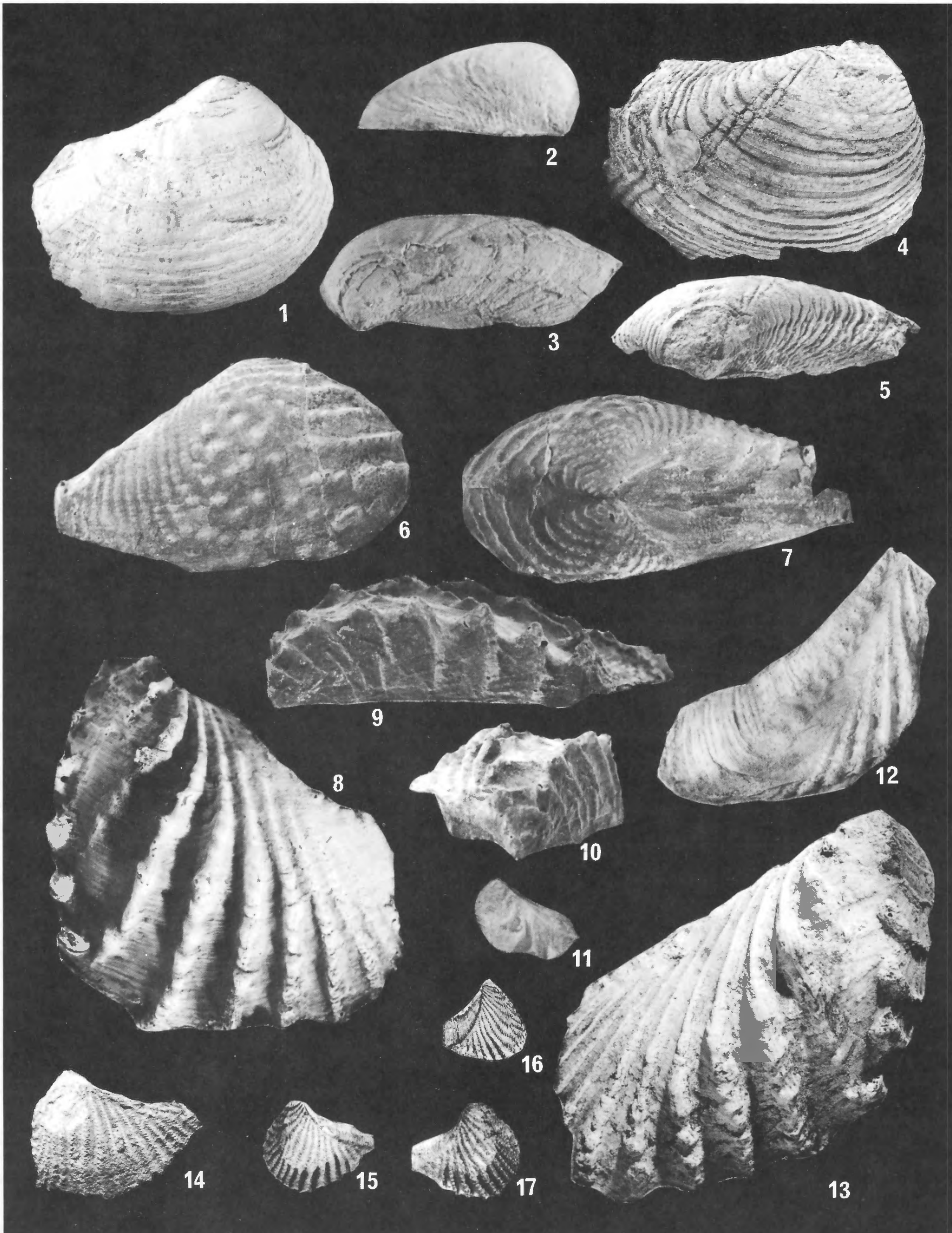
Orthotrigonia(?) sp. (page 41)

Figure 14. Lateral view of left valve of hypotype GSC 43309 from GSC loc. 81937. Middle Bajocian, Hazelton Group, Smithers area, British Columbia. Maximum inflation of fragment – 5.5 mm (approx.).

Figure 15. Lateral view of right valve of hypotype GSC 43310 from GSC loc. 87387; latex cast. Middle Bajocian, Hazelton Group, Smithers area, British Columbia. Inflation – 3.5 mm (approx.).

Figure 16. Lateral view of right valve of hypotype GSC 43300 from GSC loc. 87324. Middle Bajocian, Hazelton Group, Smithers area, British Columbia. Inflation – 3.5 mm (approx.).

Figure 17. External mould of same specimen as in fig. 15.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Errata

Table 1
In column 1:
Prosogyrotrigonia(?) sp. aff. *P. inouyei* should be *Prosogyrotrigonia*(?) sp. cf. *P. inouyei.*
?*Orthotrigonia*(?) sp. – Remove the first question mark.

In column 2:
Frebold, 1964 should be Frebold 1964a.

In column 3:
Opposite *M.* sp. A, Plate 9 should be Plate 8.
Opposite *M.* sp. B, Plate 8 should be Plate 9.
Opposite *V. doroschini,* Plate 10 should be Plates 10, 11.

In column 4:
Opposite *F.* sp. A, replace Toarcian(?) with Sinumerian or Toarcian.

In column 5:
Opposite ?*Orthotrigonia*(?) sp., replace West-central British Columbia with Western Canada and U.S.
Opposite *V. utahensis,* insert Saskatchewan after Western interior, U.S.
Opposite *M. dawsoni,* replace Western British Columbia, Alaska with Western Canada and U.S.

Textfigure 1
In column 6, Dickinson and Vigrass (1966) should be (1965).
In column 11, Frebold, Tipper and Coates (1967) should be (1969); and Jeletzky (1973a, b) should be (1972, 1973).
In column 15, Imlay (1953, 1962a, b, 1964b, 1967) – Change 1967 to 1975.
In column 13, Nilkitwa should be Nilkitkwa.
In column 7, Gypsum Spring should be Gypsum Springs.