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TERTIARY MOLLUSCAN FAUNA FROM THE YAKATAGA DISTRICT AND ADJACENT AREAS OF SOUTHERN ALASKA

By

Saburo KANNO

Geological and Mineralogical Institute, Faculty of Sciences,
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ABSTRACT

The Tertiary system developed in the Yakataga District is subdivided into three formations named Yakataga, Poul Creek, and Kulthieth in descending order. These three formations are apparently conformable in the Yakataga Reef area, but the Yakataga overlaps the Poul Creek and Kulthieth with unconformity in the eastern part of the Yakataga District and in the adjacent Malaspina District.

The three formations yield abundant molluscan fossils of 62 genera and 104 species, of which 9 species are new. Each formation yields its own characteristic molluscan fauna. The Kulthieth fauna consists of a few marine and fresh water mollusks suggestive of warm water conditions. The Poul Creek fauna, which includes marine mollusks of 46 genera and 70 species, is characterized by inhabitants of the upper neritic zone of subtropical to temperate marine waters. The Yakataga fauna, which includes marine mollusks of 22 genera and 34 species, is characterized by a shallow and cold water fauna comparable with that which now occupies the littoral to neritic zone in the Gulf of Alaska. However, the Yakataga fauna is represented by rather deeper water dwellers in the western part of the Yakataga District, whereas the littoral fauna is dominant in the eastern part of this district.

Yakataga and Poul Creek faunas consist of 1) Alaskan species, 2) Washington and Oregon species, 3) Asian species, and 4) living species in the northern Pacific region. The percentage of Alaskan, Washington and Oregon, Asian, and living species in the northern Pacific regions in the Yakataga fauna is 38.7/3.3/25.8/32.2, whereas in the Poul Creek fauna it is 34.0/35.8/26.4/3.8. The Kulthieth fauna represents a fresh water to littoral environment with water temperatures of 15° to 25°C. The Poul Creek fauna represents a subtropical (no month cooler than 10°C) fauna that inhabited waters 200 to 20 meters in depth. The Yakataga fauna consists of boreal species that lived mostly in the littoral zone in waters less than 60 meters deep, excepting in the western part of the mapped area.

The Kulthieth formation is of late Paleocene to Eocene age, the Poul Creek formation is possibly Oligocene to early Miocene age, and the Yakataga formation is middle to late Miocene to probably Pliocene age. The Kulthieth formation correlates with the Eocene formations developed around Puget Sound in Washington, the Tigiri group of Kamchatka, and the Ishikari group in Hokkaido of northern Japan. The Poul Creek formation correlates mostly with the Blakeley and Twin River formations in Washington, the Kobatin and Animan formations in Kamchatka and the Poronai and Momijiyama as well as Horomui formations in Hokkaido of Japan. The Yakataga formation correlates with the upper part of the Astoria and Clallam formations in Washington and Oregon, the Bayampoli group in Kamchtka, the Kawabata group (Takinoue, Kawabata, and Oiwake formotions) and possibly the Takikawa formation in Hokkaido of Japan.

Manuscript received June 10, 1971.

I. INTRODUCTION

PRESENT STUDY

The writer has studied the Tertiary molluscan fauna from the western Pacific regions, mainly the districts of northern Japan, and has been interested in the Oligocene to Pliocene mollusks from the standpoint of faunal changes and migration. In 1968 the writer had an opportunity to study the molluscan fauna of the west coast of North America including the Gulf of Alaska region during a one-year visit to the United States sponsored by the Ministry of Education of Japanese Government. Field work in the Yakataga District was carried out in August of 1968, during which time a fairly large number of molluscan fossils were collected from the Yakataga, Poul Creek, and Kulthieth formations.

Since the summer of 1968, the writer studied the molluscan fauna that he collected from the Tertiary sequence exposed along the coast of the Gulf of Alaska as well as the extensive collections of the U. S. Geological Survey, the California Academy of Sciences, the Pan American Petroleum Corporation, the Standard Oil Company of California, and the Phillips Petroleum Company. Most of the writer's work on the Gulf of Alaska faunas was done at the U. S. Geological Survey in Menlo Park, California, but part of it was completed at the Tokyo University of Education, Japan.

The specimens treated in this report are mostly from the area between Duktoth Mountain in the Yakataga District to Samovar Hills in the Malaspina District, but in part they include those collected elswhere in the Gulf of Alaska region. Namely they are from: 1) Samovar Hills, 2) Chaix Hills, 3) Kaar Hills, 4) Beare Glacier, 5) Big River, 6) Lare Glacier, 7) Little River, 8) Johnston Creek, 9) Munday Creek, 10) Poul Creek, 11) Shokum Creek, 12) White River, 13) Yakataga Reef, 14) Yakataga Glacier, 15) Brower Ridge, 16) Ductoth Mountain, 17) Kayak and Wingham Islands (Text-fig. 1).

The purpose of this report is primarily to describe and illustrate the mollsks from the Yakataga, Poul Creek, and Kulthieth formations of the Yakataga District and adjacent areas along the Gulf of Alaska, and to reconsider their geologic ages, biologic affinities, and stratigraphic implications. The present work is also concerned with the problem of middle Tertiary faunal migration and climatic changes in the northern Pacific region. The writer has furthermore attempted to correlate the middle Tertiary faunal sequence of the Yakataga District with that of Kamchatka, Japan, and Washington and Oregon.

In addition, the type specimens studied by CLARK (1932) and mollusks from the Tertiary formations in Washington, Oregon, and California were restudied, and new materials were obtained from the type localities of those formations.

The molluscan fossils from the Yakataga District deposited at the U. S. Geological Survey and some oil companies were also restudied by the writer.

Specific names proposed by CLARK in 1932 have been used by many authors despite the fact that some types were represented by deformed specimens or their descriptions were very brief. In the present work specific names follows CLARK's 1932 usage as far as possible, but new names are proposed for some specimens.

ACKNOWLEDGMENTS

The writer is indebted to Prof. Wataru HASHIMOTO and the colleagues of the Geological and Mineralogical Institute, Tokyo University of Education, and Prof. Kotora HATAI, Tohoku University, for their encouragement. Much of this work was suggested by Drs. David M. HOPKINS, Warren O. ADDICOTT, and George PLAFKER of U.S. Geological Survey, to whom the writer owes thanks for their valuable help and encouragement. Especially, the writer is indebted to Drs. Warren O. ADDICOTT and George PLAFKER for their much significant advice on the paleontology and stratigraphy of the west coast of North America as well as their careful reading and criticism of the manuscript. The writer wishes to express his gratitude to Dr. F. Stearns MACNEIL, formerly of the U.S. Geological Survey at Menlo Park, for his invaluable advice and assistance. Many people with the U.S. Geological Survey at Menlo Park, including Drs. D.L. JONES, Charles W. MERRIAM, Jack A. WOLFE, K.A. ARMSTRONG, Richard L. PIERCE, Charles A. REPENING, Patsy B. SMITH, and E. BRABB helped and encouraged the writer during this work. The writer also wishes to express his hearty thanks to Prof. J. Wyatt DURHAM and Mr. C.M. NELSON of the University of California at Berkeley, Profs. A. Myra KEEN of Stanford University, Richard C. ALLISON of the University of Alaska, and Dr. Leo G. HERTLEIN of the Academy of Sciences of California, for their encouragement and grant of access to the collection. The writer is especially indebted to Dr. Richard C. ALLISON for detailed information on the correlation of Alaskan Tertiary strata. It is a pleasure to acknowledge the assistance of numerous persons who supported the field work and made valuable suggestions. Among them are Messrs. R.L. JONES of Standard Oil Company of California, John F. ROGERS of Sinclair Oil & Gas Co., Alexander SISSON of Union Oil Co. of California, K.W. CIRIACKS and A.R. ORMISTON of Pan American Petroleum Corp. Research Center, and Scott MCCOY Jr., Phillips Petroleum Co.. Photographs used were prepared by Mr. Kenji SAKAMOTO of the U.S. Geological Survey, to whom the writer expresses his sincere thanks.

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Finally the writer is grateful to the U.S. Geological Survey for permission to carry out his work at the Survey, and the Japanese Ministry of Education for the grant to study abroad and also the grant to publish the results as a Special Paper, Palaeontological Society of Japan.

HISTORICAL REVIEW

The first systematic geologic investigation of the present area was made by MADDREN in 1913 to study the placer gold deposits and possibilities of petroleum and coal. His results were published by the U.S. Geological Survey in 1914.

During the summer of 1920 TALIAFERRO engaged in a geological survey of the Controller Bay to Icy Bay region, the results of which were published in 1932. He recognized two formations, the Yakataga and Poul Creek (in descending order), in Tertiary sediments of the area. He pointed out that no unconformity occurs in the sequence, though the Tertiary strata totalled around 2400 to 3000 meters in thickness. Moreover, he emphasized the presence of glacial debris in the sediments, and concluded that the climatic conditions during upper Oligocene time were the same as those at the present time.

CLARK's result of study (1932) of the fossils collected by TALIAFERRO in 1920 from the Poul Creek and Yakataga formations is the first published systematic description of the mollusks from the area. He recognized 42 taxa, including 24 newly described species or subspecies, and concluded that the mollusks indicated a late Oligocene age. Faunas from both the Poul Creek and Yakataga formations were correlated with faunas from the Blakeley "horizon" of western Washington and the Sooke formation of Vancouver Island. According to CLARK there was little faunal change between the Poul Creek and Yakataga formations, moreover, he estimated that the water temperatures were presumed to have been cool, with conditions similar to the present conditions in the Gulf of Alaska.

SCHENCK (1931) described a new subspecies of Cephalopoda, *Aturia angustata alaskensis*, from the upper part of the Poul Creek formation in the Gulf of Alaska. He pointed out that the genus *Aturia* has not been found in rocks younger than middle Miocene on the Pacific coast of North America. He (1936) also described nuculid bivalves of the genus *Acila*, and reviewed three middle Tertiary species from the Gulf of Alaska described by CLARK (1932), one of which he renamed *Acila taliaferroi* instead of *Nucula* (*Acila*) *hamiltonensis* CLARK (1932, p. 806, pl. 14, figs. 11, 14).

MERRIAM (1941) described fossil *Turritella* from the Pacific coast of North America, including *Turritella hamiltonensis* CLARK from the Yakataga District.

A field party representing a group of oil companies made a geologic investigation of the southern part of the Robinson Mountains in the Yakataga District during 1938 and intensive field mapping, geophysical work, and exploratory drilling have been carried out by a number of oil companies since 1951. Except for a report on the regional structural development of the Gulf of Alaska sedimentary rocks by STONELY (1967), the results of the investigations have not been published.

Field studies also have been intermittently conducted by the U. S. Geological Survey between 1944 and 1970 to obtain basic geologic information required to appraise the petroleum possibilities of the Gulf of Alaska Tertiary province. MILLER (1951) reported the preliminary report on the geology and oil possiblities of the Yakataga District. He described the occurrence of a few mollusks of late Eocene age from the Kulthieth formation. He considered the Poul Creek formation to be of middle and late Oligocene age and the Yakataga formation to be Miocene. The former contains mollusks indicative of correlation with the Lincoln and Blakeley formations of Washington. He also pointed out that many of the species listed by CLARK (1932) from the Yakataga formation are actually from the underlying Poul Creek formation. Moreover, he indicated the stratigraphic ranges of some diagnostic mollusks in the Poul Creek and Yakataga formations on a correlation chart.

In 1957, MILLER published a geologic map of the southeastern part of the Robinson Mountains, Yakataga District. According to F. S. MACNEIL's study of the molluscan fauna collected by MILLER and previous workers from the Kulthieth, Poul

Creek, and Yakataga formations in the Yakataga District is of late Eocene, middle(?) and late Oligocene to early Miocene, and of middle to late Miocene and early Pliocene(?) age respectively. MILLER plotted the stratigraphic ranges of 69 significant mollusks from the Poul Creek and Yakataga formations together with taxonomic notes, and he showed the number of collections in a range chart. He also emphasized the environmental characteristics of the respective fauna, e. g., the Poul Creek fauna indicates warm temperate or subtropical water temperatures, and the Yakataga fauna shows much cooler conditions. This interpretation differs markedly from CLARK's (1932), who saw little environmental difference between the Poul Creek and Yakataga faunas.

PLAFKER and MILLER (1957) published the reconnaissance geology of the Malaspina District, just east of the Yakataga District. The sequence of Tertiary and probable Tertiary age is subdivided into an unnamed siltstone sequence of early Tertiary age, the Kulthieth formation of Paleocene and Eocene age, and the Yakataga formation of Miocene and Pliocene(?) age. The authors' early Tertiary siltstone sequence and the Kulthieth formations were correlated by L. G. HERTLEIN with the upper Eocene Cowlitz formation of Washington. They reported the occurrence of *Turritella uvasana sargeanti* ANDERSON and HANNA from the Kulthieth formation in the Samovar Hills which suggests a late Eocene age. *Ostrea iridaensis fettkei* WEAVER also occurs in this bed. More recent work by ADDICOTT and PLAFKER (1971) indicates that the "*Turritella*" is actually the middle Eocene *Cristispira pugetensis* ALLISON and that the Kulthieth formation contains the late Paleocene species *Turritella merriami brevitabulata*. These mollusks, in combination with an abundant flora and sparse microfauna, suggest that the Kulthieth formation ranges in age from late Paleocene through late Eocene and that the unnamed siltstone units is of Paleocene through middle Eocene age. *Mytilus* and *Mya* are abundant in the Yakataga formation of the Malaspina District, which, together with abundant marine tillite deposits, suggest cool climatic conditions.

MILLER, PAYNE, and GRYC (1959) reported the geology of possible petroleum provinces in Alaska. They pointed out that local glaciation started in the middle or late Miocene in the Gulf of Alaska region on the basis of the presence of marine glacial deposits and characteristic mollusks in strata of this age.

MACNEIL (1961) described *Lituyapecten*, a new subgenus of *Patinopecten*, from Alaska, which included three species of *P.* (*L.*) *yakatagensis*, *P.* (*L.*) *lituyaensis*, and *P.* (*L.*) *poulcreekensis*, all from the Gulf of Alaska Tertiary province. In the same publication MILLER (1961b) also reported the stratigraphic occurrence of *Lituyapecten* in southern Alaska, describing the stratigraphic relations of eight Miocene and Pliocene species of *Lituyapecten* and *Patinopecten*. He divided the Tertiary sequence of the Gulf of Alaska into three parts, i. e., the lower Tertiary represented by nonmarine sediment intercalated with marine strata which include marine invertebrates indicative of tropical or subtropical conditions; the middle Tertiary consisting of more marine strata of somewhat deeper conditions, and the upper Tertiary of pure marine of shallow water aspect, including marine tillites.

PLAFKER (1967) published a compilation geologic map of the Gulf of Alaskan Tertiary province with the explanation, in which the occurrence of marine fossils was indicated. On the basis of molluscan faunas identified by F. S. MACNEIL, he concluded that the Yakataga formation is of middle Miocene to lower Pleistocene age and the Poul Creek formation and its equivalents are of middle(?) and late Oligocene and early Miocene age.

STONELEY (1967) reported the occurrence of a few oyster coquinas in the Kulthieth formation (Eocene) near the head of Malaspina Glacier, interpreting that this coquina-bearing formation may become more marine toward the northern part of its outcrop area.

DENTON and ARMSTRONG (1969) described the Miocene-Pliocene glaciations in southern Alaska, and reviewed the published data on molluscan assemblages from the Yakataga formation. They emphasized the cool conditions during Yakataga time based on the molluscan fauna and the marine tillites which occur stratigraphically well below mollusks of late Miocene age. However, they also pointed out that the molluscan assemblages underlying the Miocene marine tillites suggested subtropical and temperate marine conditions.

TAKEDA (1953) published the Poronai formation of Hokkaido and south Sakhalin and its fossil fauna, mentioning that the Poronai fauna was quite different from the Yakataga and Poul Creek faunas. Namely, there is no occurrence of such genera as *Colus*, *Cancellaria*, and *Echinophoria* in the Poronai formation, whereas these genera are abundant in the Alaskan Tertiary. The first appearance of *Echinophoria* and *Chione* in Hokkaido is the next younger stage above strata of Poronai age.

DURHAM and SASA (1961) compared the fauna of the Poronai formation of Japan with west American middle Tertiary faunas. They pointed out twenty-three mollusks from the Poronai formation of Hokkaido that were very similar to species of "Blakeley stage" of Oregon, Washington, and Alaska and they correlated the Poronai with the Poul Creek of Alaska, and the Blakeley and Yaquina formations of Washington and Oregon.

MACNEIL, WOLFE, MILLER, and HOPKINS (1961) correlated Tertiary formations of Alaska, emphasizing that many Alaskan species were more closely related to Asian stocks.

The only published foraminiferal studies of the Tertiary formations in Alaska are those of RAU (1963) and BANDY et al. (1969). RAU (1963) described the foraminifers from the upper part of the Poul Creek formation of southeastern Alaska. He described and illustrated nineteen species of Foraminifera from the upper part of the Poul Creek formation exposed in the Yakataga District. The assemblage was referred to the Saucesian stage of the Miocene sequence of the Pacific coast. He pointed out that the Poul Creek foraminiferal fauna inhabited moderately shallow and warm marine water, based upon comparison of the assemblage with modern faunas.

BANDY, BUTLER, and WRIGHT (1969) described Foraminifera from the late Tertiary marine glacial deposits in the Yakataga Reef area. They pointed out that the Poul Creek formation of Oligocene and Miocene age contained a fauna of temperate or subtropical aspect and that the overlying Yakataga formation (Miocene to Pliocene) yielded a mostly cool or cold water molluscan fauna. The appearence of the sinistral planktonic foraminifer *Turborotalia pachyderma* in the Yakataga formation is taken by them as suggestive of the existence of glaciation during the late Miocene.

WOLFE (1969) described the Paleogene floras from the Gulf of Alaska region, in which he noted that the climate during late Eocene time was characterized by a lack of frost, and a mean annual temperature of 22° to 25°C.

ADDICOTT, KANNO, et al. (1971) revised CLARK's type specimens which are deposited in the University of California at Berkeley.

In 1971 MILLER's map of the Yakataga District was published on a scale of 1: 125.000 with accompanying text and tables showing the stratigraphic range of selected mollusks, foraminifers, and fossil plants collected in the district.

II. BRIEF NOTE ON THE GEOLOGY OF THE YAKATAGA DISTRICT AND ADJACENT AREAS

The bedrock exposed in the Gulf of Alaska has been broadly divided into four units (PLAFKER and MILLER, 1957; PLAFKER, 1967) as Mesozoic and older(?) rocks, Jurassic(?) and Cretaceous rocks, Cretaceous or Tertiary rocks, and Tertiary rocks. The oldest rocks consist chiefly of a crystalline complex that includes granitic rocks, schist, gneiss, amphibolite, and marble which are deformed and moderately to intensely metamorphosed. The second unit, the Yakutat group, consists of graywacke, argillite, and slate with minor conglomerate which are strongly deformed and locally metamorphosed; it locally contains sparse megafossils of *Inoceramus* and *Buchia* indicating a late Jurassic(?) and early Cretaceous age, and one foraminifer of probable late Cretaceous or Paleocene age (BRABB and MILLER, 1962). The third unit consists of intrusive igneous rocks mainly quarts diorite and granodiorite with minor quartz monzonite and mafic intrusive rocks, which are believed to be of Cretaceous or earliest Tertiary age. The fourth unit consists mainly of bedded clastic and volcanic rocks ranging from Paleocene to Pliocene, or possibly Pleistocene, in age.

These rock units trend WNW to ESE almost parallel with the sea coast. In general, the older rocks are inland and the younger strata are arranged towards the south (on the outer side, or sea side). The actual relationship between them are commonly obscured by structural complications but there are unconformities at certain places.

The Tertiary rocks exposed in the area of this report are thick sedimentary strata ranging in age from early Tertiary to late Tertiary or in some part of the Pleistocene. The sequence developed along the coast of the Gulf of Alaska has been subdivided by previous workers into Yakataga, Poul Creek, and Kulthieth formations in descending order. In some areas these formations are separated by unconformities, but elswhere they are conformable or are separated by faults.

KULTHIETH FORMATION

The oldest rocks in the Tertiary sequence of the area are represented by the Kulthieth formation which is restricted in a narrow belt on the northern side of Miller Creek Fault and in the Samovar Hills (Text-fig. 1).

The type locality of the Kulthieth formation was designated in the vicinity of the small lake at the head of the northeasternmost branch of the Kulthieth River (MILLER, 1957), where it characteristically has a distinctive banded or striped appearance and consists largely of a yellowish-orange colored coal-bearing sandstone sequence.

In a small area of the Samovar Hills arkosic sandstone and siltstone intercalated with black coal and carbonaceous shale similar to those of the type Kulthieth formation crop out. This rock sequence was correlated with the Kulthieth formation by PLAFKER and MILLER (1957). According to their study, the Kulthieth formation in the Samovar Hills is subdivided into an upper and a lower units separated by an unconformity. Although the lower part of the Kulthieth consists mainly of leaf-bearing terrestrial deposits, it is intercalated with marine strata which yields the marine mollusks *Cristispira pugetensis* ALLISON and *Ostrea* sp., as well as with non-marine *Corbicula* bearing beds.

POUL CREEK FORMATION

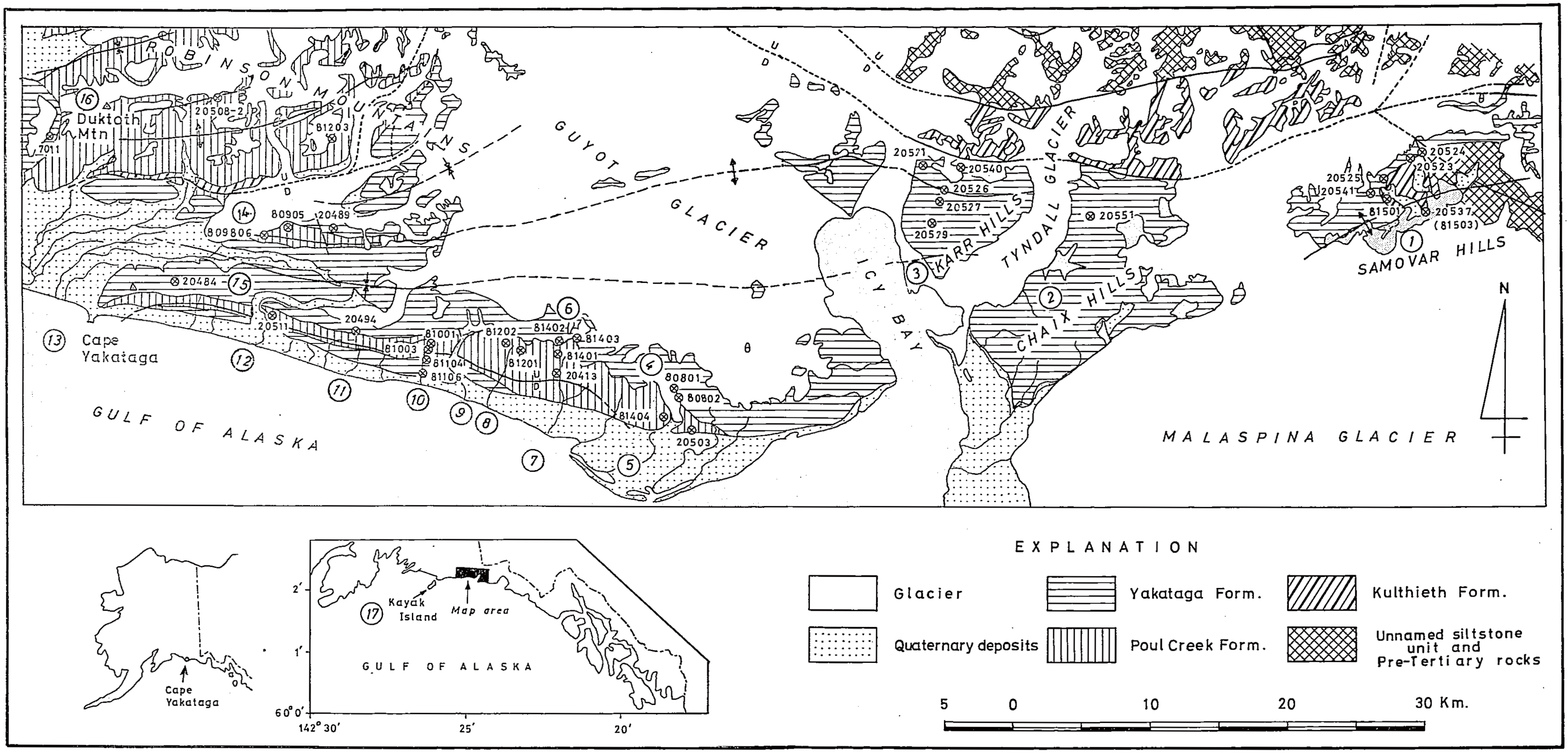
TALIAFERRO (1932, p. 754-756) proposed the name Poul Creek formation for the strata exposed along the Poul Creek in the coastal area of the Robinson Mountains. According to his designation of the formation, the Poul Creek is " fully 3000 feet of dark hard platy shales, in part calcareous and in part sandy, thin-bedded sandstones, conglomerates, occasional thin limestones, and a few beds of glauconitic sandstone. The shales greatly predominated, especially in the lower part, and make up fully 75 percent of the formation. They occur as thin, rather platey beds in the lower part, becoming thicker and more massive toward the top ". Moreover, he described the Poul Creek formation is overlain conformable by the Yakataga formation and that the base of the formation was not exposed in the coastal area.

MILLER (1957) redefined the Poul Creek as follows; " the Poul Creek consists of approximately 6100 feet of marine interbedded siltstone and sandstone strata that lie with apparent conformity on the Kulthieth formation. As thus defined, the formation includes in its upper part most of the strata originally assigned to it as the type sequence of the Poul Creek by TALIAFERRO, but it also includes the lower part of the Yakataga Reef section, which he assigned entirely to the overlying Yakataga formation, and excludes the beds he described as glacio-fluvial conglomerates, here assigned to the Yakataga formation ".

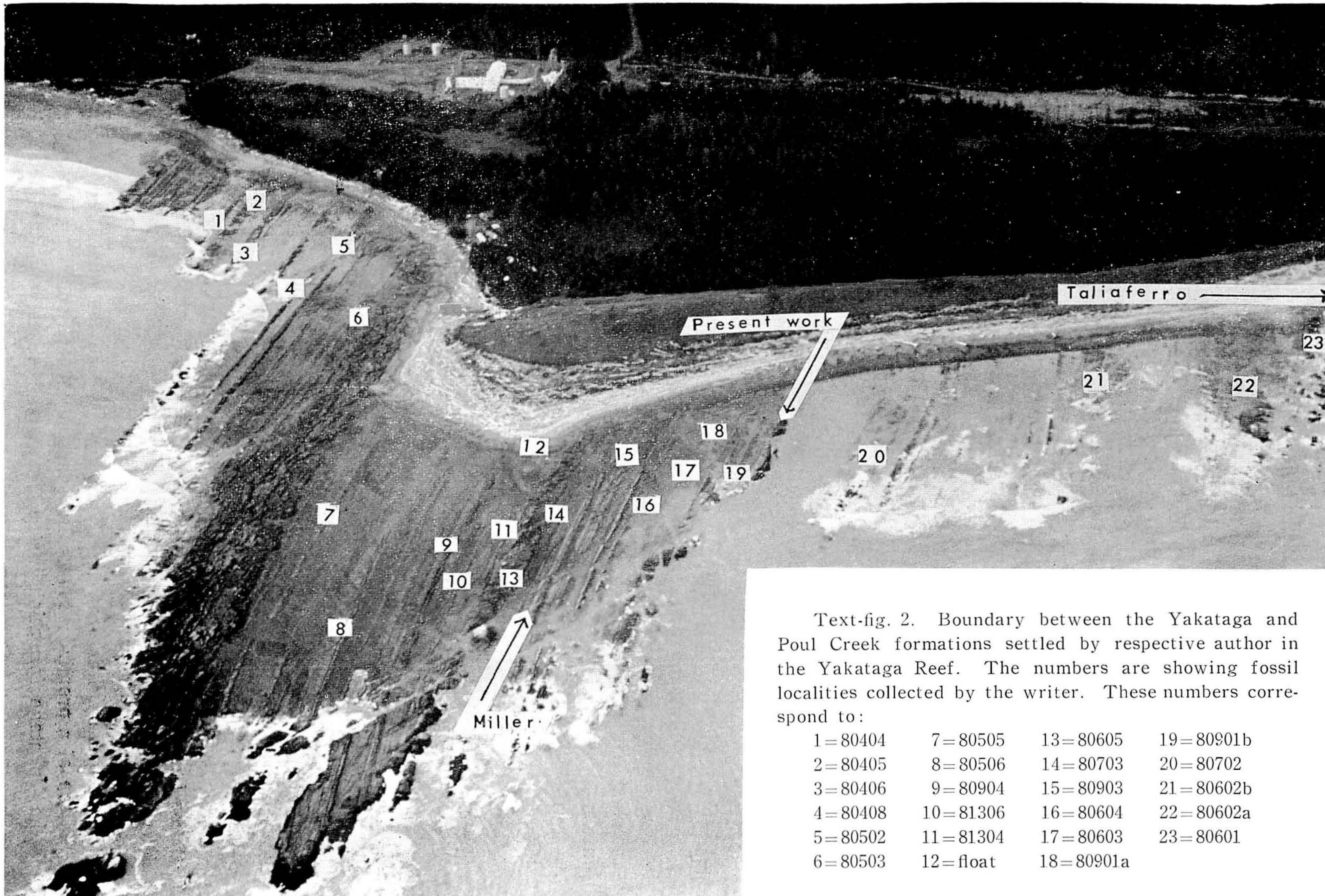
The Poul Creek formation is fairly well exposed in the type locality, where it is characterized by slabby, greenish gray, or olive-gray fine-grained sandstone. Hard, calcareous siltstone and silty very fine-grained sandstone showing slight stratification predominate at the top of the formation. These rocks are also characterized by a reddish brown weathered color and fossiliferous pebble- to cobble-sized calcareous concretions.

The upper part of this formation consists mainly of massive, fine- to medium-grained, olive-gray sandstone. The middle part is interbedded with arkosic granule to pebble bearing conglomerate (about 10 to 20 meters in thickness) in the type locality.

The lower part of the formation, which is mainly exposed in the southern face



Text-fig. 1. Geologic map and fossil localities of the Yakataga and eastern Malaspina Districts (compiled from MILLER, 1957 and 1971, PLAFKER and MILLER, 1957). 1. Samovar Hills 2. Chaix Hills 3. Karr Hills 4. Beare Glacier 5. Big River 6. Lare Glacier 7. Little River 8. Johnston Creek 9. Munday Creek 10. Poul Creek 11. Shokum Creek 12. White River 13. Yakataga Reef 14. Yakataga Glacier 15. Brower Ridge 16. Ductoth Mountain 17. Kayak and Wingham Islands



Text-fig. 2. Boundary between the Yakataga and Poul Creek formations settled by respective author in the Yakataga Reef. The numbers are showing fossil localities collected by the writer. These numbers correspond to:

1=80404	7=80505	13=80605	19=80901b
2=80405	8=80506	14=80703	20=80702
3=80406	9=80904	15=80903	21=80602b
4=80408	10=81306	16=80604	22=80602a
5=80502	11=81304	17=80603	23=80601
6=80503	12=float	18=80901a	

of the Robinson Mountains (MILLER, 1957), is represented chiefly by dark-gray, fine grained silty sandstone intercalated with 30 to 100 cm bed of dark-green sandstone consisting of fresh and angular clastic fragments in a glauconitic matrix. Although the Poul Creek formation is characterized by greenish gray, glauconitic sandstone throughout the whole sequence, the typical glauconitic sandstone beds are predominant mainly in the upper part of the formation.

The boundary between the Poul Creek and the overlying Yakataga at Yakataga Reef is rather vague, because that boundary has been placed by authors in different stratigraphic positions as shown in Text-fig. 2.

The uppermost part of the Poul Creek at Yakataga Reef consists mostly of dark gray massive mudstone intercalated with two distinct beds of glauconitic sandstone. This part, except for the glauconitic sandstone, is usually inaccessible because it lies under the sea level except at the time of the maximum low tide. However, this black shale is fairly well exposed in the area between the White River and the Beare Glacier, where this unit makes a characteristic topography of subsequent streams owing to less resistance to erosion than the adjacent beds of the main part of Poul Creek and the Yakataga as pointed out by MILLER. In the upper most part of this unit there is another rather thick, distinct sandstone bed which consists of rather black glauconitic sandstone. The top of the sandstone is designated as the upper limit of the Poul Creek formation (Text-fig. 3).

On the south side of the Robinson Mountains, this formation seems to be underlain conformably by the Kulthieth formation (MILLER, 1957).

Marine molluscan fossils occur commonly through the whole sequence, and especially in the upper part of the formation, in which *Crassatella*, *Cyclocardia*, *Spisula*, *Turritella*, *Liracassis*, *Cancellaria*, and *Aturia* are characterisitically collected.

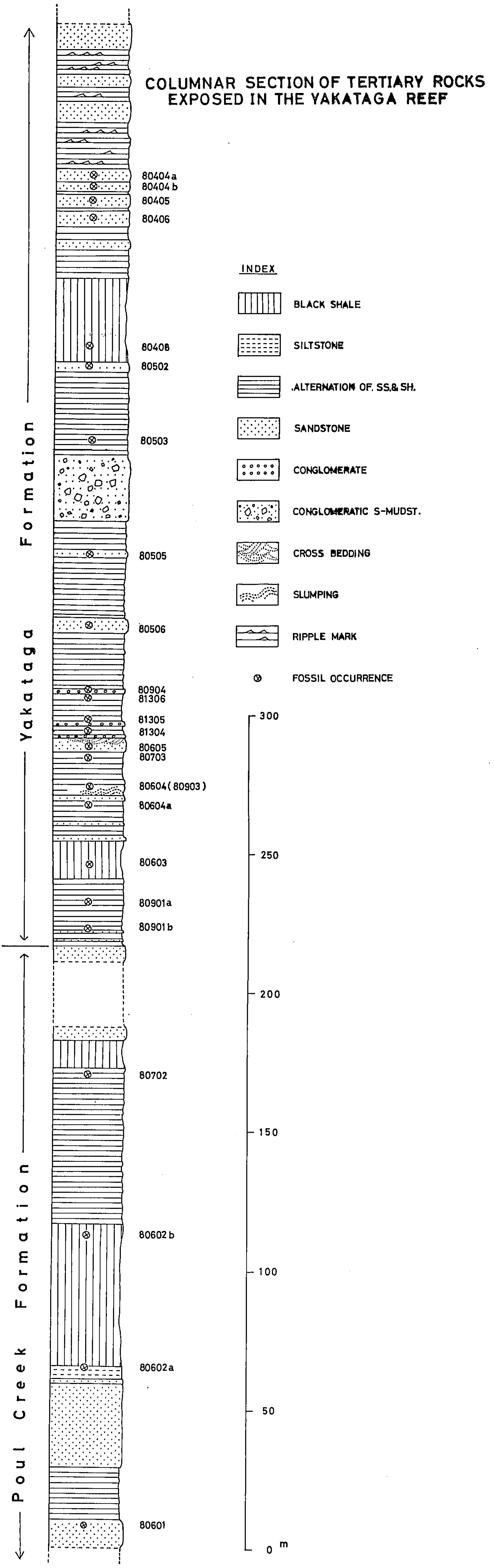
YAKATAGA FORMATION

The Yakataga formation was named by TALIAFERRO (1932, p. 756-772) for the marine sedimentary rocks lying conformably on the Poul Creek formation in the coastal area of the Robinson Mountains, although he did not designate its type locality. However, he stated that "the Yakataga formation is well exposed at Yakataga Reef and on the north and south flanks of Yakataga anticline". This anticline is almost equivalent to the Sullivan Fault as mapped by MILLER (1957), since the fault was formed along the axial plane of the anticline.

In 1957, MILLER redefined the Yakataga formation; i.e., the lower part of the Yakataga Reef section, which was entirely assigned to the Yakataga by TALIAFERRO (1932), was included in the Poul Creek formation. MILLER recognized "a 50-foot-thick transitional unit" between the Poul Creek and Yakataga formations, and their contact was drawn arbitararily above the Pecten-bearing siltstone and silty sandstone.

The present writer draws the boundary between the Poul Creek and Yakataga on the top of a prominent glauconitic sandstone bed, as shown in Text-figs. 2 and 3.

The Yakataga formation in the Yakataga District comprises more than 5000



Text-fig. 3. Columnar section of Tertiary rocks exposed in the Yakataga Reef

Text-fig. 4. Out crop of the Yakataga formation, a distant view of Munday Peak (ca. 1460 m).

meters of sedimentary rocks which are mainly siltstone, sandstone, and tillite-like conglomeratic sandy mudstone.

The Yakataga formation is widely distributed in the area to the south and southeast of the Miller Creek fault. The lower part of the Yakataga formation is especially well exposed at Yakataga Reef, where it is about 330 meters in thickness. The upper part of the Yakataga formation in the reef area is predominantly medium-grained, pale brown, massive sandstone which is interbedded with dark gray or black shale, showing an alternation of sandstone and siltstone in part, but locally intercalated with thin beds of shale. The characteristic ripple marks are well developed on the bedding palenes of most sandstone beds in the upper part of the section in the reef area.

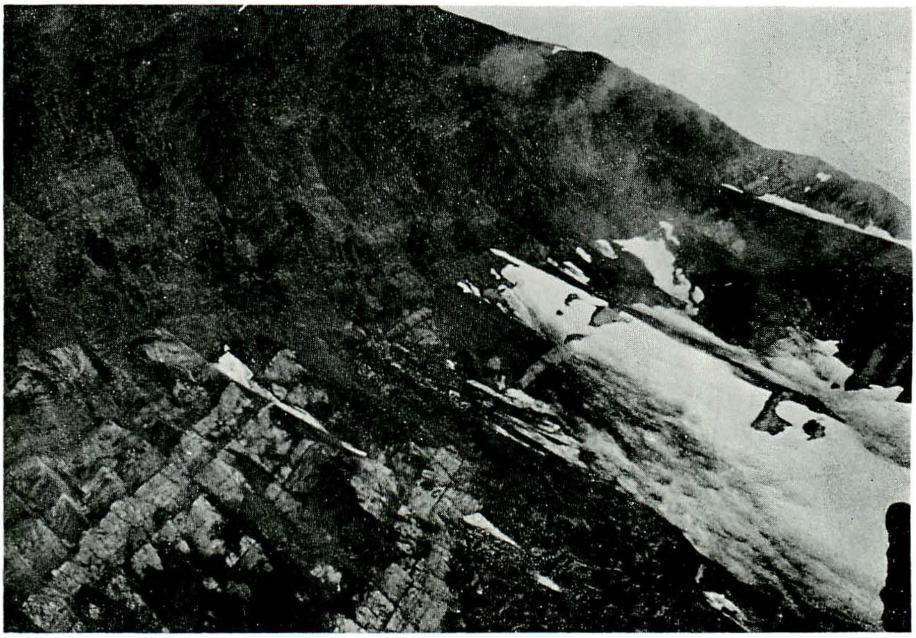
A rather thick black shale (ca. 30 meters in thickness) and a thick conglomeratic sandy mudstone are developed in the upper part of the section. This conglomerate is characterized by various sized rounded or subangular pebbles and a large number of angular blocks in the matrix of black mudstone with some sandy parts. Moreover, glacial striae are found on some pebbles in the conglomerate (MILLER, 1957; PLAFKER and MILLER, 1957). Generally speaking, the pebbles and blocks are not closely-spaced as in the usual stream or beach conglomerate but are scattered through a massive matrix of sandy mudstone or very fine-grained silty sandstone.

Several rather thick sandstone beds and three thin beds of granule and pebble-sized conglomerate are developed in a thick alternation of sandstone and shale immediately beneath the conglomeratic sandy mudstone (Text-fig. 3). The lowest thick sandstone is medium-grained, cross-bedded, pale-brown in weathered color, and greenish blue in the fresh part. This sandstone marks the highest point in the

Yakataga Reef area (MILLER, p. 246 in MACNEIL, 1961).

The black shale-rich alternation of sandstone and shale underlies the thick sandstone described above and the alternation is "a 50-foot-thick transitional unit between the Poul Creek and Yakataga formation" recognized by MILLER (in MACNEIL, 1961) in which small-scale slumping is slightly developed.

Yakataga formation exposed at Yakataga Reef is underlain conformably by the Poul Creek formation, but overlies unconformably the Poul Creek in the eastern part of the mapped area. Namely, in the right side cliff of the head of a glacier, an eastern tributary of the Little River, an irregular erosion surface of the unconformity is rather distinct. The relationship of the Yakataga and the Poul Creek becomes obscure in the area between the Little River and Big River. However, the Yakataga is directly underlain by the Kulthieth with angular unconformity in the Samovar Hills. Judging from the relations among these three formations, the Yakataga seems to be overlapping the underlying formations from west to east or from southwest to northeast (Text-fig. 5). The upper limit of this formation is not clear at the present in the Yakataga District and adjacent areas.



Text-fig. 5. The unconformity between the Yakataga and the Kulthieth formations in the Samovar Hills.

The Yakataga formation is quite fossiliferous. Large sized pectinids such as *Patinopecten* (*Lituyapecten*) *poulcreekensis* MACNEIL, *P.* (*L.*) *lituyaensis* MACNEIL, and *P.* (*L.*) *yakatagensis* (CLARK) occur in sandstone beds at various levels of the formation in this area associated with *Panomya arctata* (LAMARCK) and *Neptunea* cf. *N. tabulata* (BAIRD). *Yoldia* (*Cnesterium*) *ensifera* DALL, *Nuculana* (*Borissia*) *alferovi sakhalinensis* KRISHTOFOVICH, *Acila* (*Truncacila*) *taliaferroi* SCHENCK, and *Turritella hamiltonensis* CLARK are abundant in the black shale of the same formation.

III. FAUNAL ANALYSIS

The molluscan fauna of the Tertiary system of the Yakataga District and adjacent areas contains 104 species including 67 species of bivalves, 1 species of scaphopod, 35 species of gastropods, and 1 species of cephalopod. Most of the specimens were collected in the Yakataga area, but some of them came from the Samovar Hills, and Kayak and Wingham Island (Text-fig. 1).

Of the total fauna, the Yakataga formation yields 34 species, the Poul Creek 70 species, and Kulthieth only 3 species (including specifically undertermined ones) (Table 1). Eight joint genera of bivalves are found in the Yakataga and the Poul Creek faunas, but no joint genus is found between the Kulthieth and other two faunas. However, only two joint species of bivalves, *Conchocele disjuncta* and *Periploma besshoense*, are found from the Yakataga and Poul Creek faunas. On the other hand, there are two joint genera of gastropod between the Yakataga and Poul Creek faunas. It should be noteworthy that each fauna is represented by its own characteristic elements. Accordingly, each fauna is hereafter referred to as the Yakataga, the Poul Creek, and the Kulthieth faunas.

Table 1. Composition of molluscan fauna from the Yakataga, Poul Creek, and Kulthieth formations.

	Number of genera and species								Total	
	Bivalvia		Scaphopoda		Gastropoda		Cephalopoda			
	Genera	Species	Genera	Species	Genera	Species	Genera	Species	Genera	Species
Yakataga	17	27(3)*	—	—	5	7(2)	—	—	22	34(5)
Poul Creek	26	40(9)	1	1	18	28(11)	1	1	46	70(20)
Kulthieth	2	2(2)	—	—	1	1	—	—	3	3(2)
Total	38	67(14)	1	1	22	35(13)	1	1	62	104(27)

* The numbers in brackets are that of unidentified species.

KULTHIETH FAUNA

The Kulthieth formation yields marine and fresh water or brackish water mollusks, though its faunal composition is simple. The available molluscan species from the Kulthieth are very sparse, e. g., *Ostrea* sp., *Corbicula* (*Corbicula*) sp., and *Cristispira pugetensis* ALLISON. These mollusks were all collected from the Samovar Hills where *Corbicula* makes several shell beds and *Ostrea* is also rather abundant in the arkosic sandstone, but *Cristispira* occurs very rarely from the same sandstone.

POUL CREEK FAUNA

The Poul Creek fauna consists of 46 genera and 70 species. It includes 26 genera and 40 species of bivalves, 1 genus and 1 species of scaphopod, 18 genera and 28 species of gastropods, and 1 genus and 1 species of cephalopod, of which 2 bivalves and 5 gastropods are described as new species.

So far as the writer's observation around the Yakataga District is concerned, the Poul Creek fauna may be subdivided into lower* and upper ones. The upper part of the Poul Creek consists chiefly of olive-green, fine- to medium-grained sandstone in which molluscan fossils occur very abundantly. *Acila* (*Acila*) *gettysburgensis*, *Crassatella*, *Cyclocardia*, *Clinocardium*, *Pitar* (*Katherinella*), *Spisula*, *Thracia*, *Liracassis*, *Cancellaria*, *Turritella* aff. *T. diversilineata blakeleyensis*, *Polinices*, *Scaphander*, and *Aturia* are characteristic of this part.

The lower part of the Poul Creek consists chiefly of rather dark-gray black shale or silty sandstone, which usually includes calcareous concretions of pebble- or cobble-size. Well-preserved fossil specimens commonly occur within the concretions. The lower part of the Poul Creek is characterized by genera such as *Solemya*, *Conchocele*, *Nemocardium*, *Pteropurpura*, and *Ancistrolepis*, which are rather deep water dwellers compared to genera in the upper part.

YAKATAGA FAUNA

The Yakataga fauna consists of 22 genera and 34 species, of which 3 pelecypods and 2 gastropods are specifically undetermined, and 2 bivalves are described as new species. Some specimens from the Yakataga formation are rather well preserved, especially those collected from the calacreous concretions in the dark gray mudstone or sandy siltstone. Hower, specimens from sandstone and black shale are usually somewhat deformed and decorticated.

So far as the exposure on Yakataga Reef is concerned, the faunal sequence is rather clear. *Neptunea*, *Panomya*, and *Turrittella hamiltonensis* occur in the lowest part of the Yakataga formation, though the number of individuals are rather few. Above these small-sized *Nuculana* and *Acila* (*Truncacila*) occur in the dark-gray or black mudstone. Immediately above this assemblage, *Patinopecten* (*Lituyapecten*) *poulcreekensis* occurs in the medium-grained sandstone. This seems to be the lowest stratigraphic occurrence of large-sized pectinids in the mapped area (Text-figs. 2, 8).

There is a thick sandstone bed which makes the highest point on the Reef, with *Macoma arctata* and *Siliqua* sp. in the basal part.

From the two distinct sandstone beds between the above-mentioned thick sandstone and the thick conglomeratic sandy mudstone, the writer collected abundant *Patinopecten* (*Lituyapecten*) *lituyaensis* associated with *Clinocardium* and *Neptunea*. This may mark the lowest occurrence of *P.* (*L.*) *lituyaensis* in the area studied (no. 3 in Text-fig. 8). *Turritella hamiltonensis* and *Neptunea* cf. *N. tabulata* occur immediately above the thick conglomeratic sandy mudstone.

In the uppermost part of the Reef area, a sandy facies becomes dominant, and *Patinopecten* (*L.*) *lituyaensis*, *P.* (*L.*) *yakatagensis*, *Mya truncata*, *Panomya arctata*, and *Turritella hamiltonensis* are abundant.

The faunal sequence obtained from Yakataga Reef provides useful control as a

* The writer did not collect any molluscan fossils from the lowest part of the formation in this area. "The lower part" as used here does not comprise the actual basal part of the formation, but rather signifies the lower part of the Poul Creek formation treated in this report.

horizon marker in the Yakataga area.

The Yakataga developed in the upper reaches of the Leare Glacier and Bare Glacier yields abundant *Clinocardium*, *Swiftopecten*, *Yoldia* (*Cnesterium*), and *Turritella hamiltonensis*. However, *Mytilus* sp., *Pododesmus* (*Monia*) *macroschisma*, and *Neptunea* cf. *N. tabulata* occur in the lowest part of the Yakataga exposed in the Samovar Hills.

On the west side of Kayak Island and at the southern point of Wingham Island, *Calyptogena chitanii* and *Delectopecten peckhami* occur in dark-gray or black shale of the lower part of the Yakataga formation.

FAUNAL CHARACTERISTICS

1. **Kulthieth fauna:** Although this fauna is very small, it includes very significant species, e. g., *Cristispira pugetensis* which has been reported by ALLISON (1965) from the Eocene formation of Puget Sound, Washington. Another common species is *Ostrea* sp. which probably lived in tropical to temperate waters for the reason that recent species of *Ostrea* of west coast of North America occur south of Puget Sound except for one species, *Ostrea lurida* CARPENTER, which is distributed from Sitka, Alaska, to Cape San Lucas, Lower California. Besides these marine mollusks, this fauna includes fresh water or brackish water mollusks as shown in Plate 17, Figs. 13–15.

2. **Poul Creek fauna:** The molluscan fauna from the Poul Creek formation consists of 46 genera and 70 species, of which 50 species are determined specifically and 20 species are unidentified, though they are generically distinct. Of the present fauna the living species comprise 3.8 percent, the species reported also from the Asian Tertiary system 26.4 percent, the endemic Alaskan species 34.0 percent, and the species reported from the Tertiary system of Oregon and Washington are 35.8 percent. It is noteworthy that the Poul Creek fauna includes a fairly large number of Oregon and Washington species and distinctly smaller number of living species which are mostly widely distributed in the Pacific region.

The living species from the Poul Creek fauna are *Conchocele disjuncta* GABB and *Macoma incongrua* v. MARTENS. *Conchocele disjuncta* is geographically widely distributed in the Pacific region, but its bathymetric occurrence is highly variable, e. g., this species lives in a shallow part less than 10 meters in the Gulf of Alaska, but it occurs in the depth from 60 to 200 meters or more off Japan (KANNO, 1971). The ecological distribution of this species seems to be controlled by sea-water temperature. *Macoma incongrua* is distributed along the Pacific coast of Japan, ranging from lat. 31°N to lat. 44°N. However, a fossil species is reported from the Crag formation (Pleistocene) in England.

The following species seem to be restricted in geographic occurrence to Alaska: *Cyclocardia yakatagensis* (CLARK), *C. hamiltonensis* (CLARK), *Papyridea hamiltonensis* (CLARK), *Clinocardium hopkinsi* KANNO, n. sp., *Nemocardium alaskense* (CLARK), *Spisula addicotti* KANNO, n. sp., *Mya* (*Mya*) *salmonensis* CLARK, *Bathybembix turbonata* (CLARK), *B. jonesi* KANNO, n. sp., *Euspira ramonensis* (CLARK), *Liracassis durhami*

KANNO, n. sp., *Pteropurpura* n. sp., *Ancistrolepis macneili* KANNO, n. sp., *A. rearensis* CLARK, *Priscofusus clarki* KANNO, n. sp., *Musashia* (*Neopsephaea*) *corrugata* (CLARK), *Cancellaria* (*Crawfordina*) *alaskensis* CLARK, and *Scaphander alaskensis* CLARK.

Among the genera of the above listed species, the living species of *Bathybembix* and *Scanphander* distribute in the northern Pacific region north of Puget Sound (KEEN, 1963, p. 99), ranging from 60 to 1600 meters in depth. However, *Pteropurpura* and *Cancellaria* are essentially restricted in occurrence to temperate to tropical regions.

The following species are reported from the East Asian Tertiary system: *Acila* (*Acila*) *submirabilis* MAKIYAMA, *A.* (*Truncacila*) cf. *A.* (*T.*) *kamtschatica* ILYINA, *Yoldia* (*Yoldia*) *takaradaiensis* KRISHTOFOVICH, *Y.* (*Y.*) *biremis* UOZUMI, *Solemya* (*Acharax*) *dalli* CLARK, *Acesta* cf. *A. yagenensis* (OTUKA), *Lucinoma* cf. *L. tomitensis* KANNO, *Nemocardium* aff. *yokoyamai* TAKEDA, *Spisula equilateralis* (CLARK) [=*S. onnechiuria* (OTUKA, 1937)], *Mya* (*Mya*) *salmonensis* CLARK, *Panomya elongata* KANNO, *Periploma besshoense* (YOKOYAMA), *Dentalium* (*Coccodentalium*) cf. *D.* (*C.*) *nunomae* TAKEDA, and *Aturia alaskensis* SCHENCK [=*A. minoensis* KOBAYASHI, 1954].

The species listed above are mostly from the Tertiary system of the Pacific coast of Japan and Kamchatka, except for those of *Acila* (*Truncacila*) and *Panomya*, which are Recent species in the northern Pacific region. *Solemya* has a geographically wide distribution from the boreal to tropical regions, as already discussed by previous workers (DALL, 1908; KANNO, 1960). *Aturia alaskensis* [=*A. minoensis*] occurs from several lower to middle Miocene localities in Japan associated with subtropical faunal element. *Spisula equilateralis* [=*S. onnechiuria*] is one of the characteristic species in northern Japan, especially in Hokkaido, where it occurs in strata of early to middle Miocene ages; it is not known to occur south of Hokkaido. *Acesta yagenensis* and *Lucinoma tomitensis* are known from the lower to middle Miocene strata of several areas in Japan.

The following species are reported from the Tertiary system of Oregon and Washington, and parts of California: *Acila* (*Acila*) *gettysburgensis* (REAGAN), *Crenella porterensis* WEAVER, *Vertipecten* sp., *Crassatella* cf. *C. washingtoniana* (WEAVER), *Crassatina carmanahensis* (CLARK), *Tellina* cf. *T. cowlitzensis* WEAVER, *Pitar* (*Katherinella*) *arnoldi* (WEAVER), *P.* (*K.*) *arnoldi etheringtoni* (TEGLAND), *P.* (*K.*) sp., *Macrocallista weaveri* CLARK, *Panope snohomishensis* CLARK, *Thracia schencki* CLARK, *T.* cf. *T. condoni* CONRAD, *Epitonium* (*Cirsotrema*) *clallamense* DURHAM, *Turritella* aff. *T. diversilineata blakeleyensis* WEAVER, *Crepidula* cf. *C. praerupta* CONRAD, *Liracassis apta* (TEGLAND), *Colus* aff. *C. jordani* DALL, and *Turricula* cf. *T. washingtoniana* (WEAVER).

3. **Yakataga fauna:** Of the molluscan fauna from the Yakataga formation, 29 species are determined specifically and 5 undetermined species are identified generically. Of these, the living species in the boreal province of the northern Pacific region constitute 32.2 percent, the species reported also from the Asian Tertiary system 25.8 percent, the Alaskan proper species 38.7 percent, and the species reported from the Tertiary system of Oregon and Washington only 3.3 percent (Table 2). It follows that the total of the living boreal species and the Alaskan Tertiary proper

species occupies about 71 percent of the Yakataga fauna, whereas the Oregon and Washington species constitute only about 3 percent. Thus, the Yakataga mollusks may represent a cold water fauna.

The living species of the Yakataga fauna are; *Yoldia* (*Cnesterium*) *ensifera* DALL, *Conchocele disjuncta* GABB, *Pododesmus* (*Monia*) *macroschisma* (DESHAYES), *Mya* (*Mya*) *truncata* LINNÉ, *Panomya arctica* (LAMARCK), *Hiatella arctica* (LINNÉ), *Beringius* cf. *B. crebricostatus* (GMELIN), and *Neptunea* (*Salcosipho*) cf. *N.* (*S.*) *tabulata* (BAIRD). Besides the above listed species, *Siliqua* sp. and *Antiplanes* sp. are included in this fauna. Although these two are specifically undeterminable, the living species of these genera are usually found in temperate to cold waters.

The following species seem to occur exclusively in the Tertiary of Alaska: *Acila* (*Truncacila*) *taliaferroi* SCHENCK, *Yoldia* (*Cnesterium*) *yakatagensis* KANNO, n. sp., *Swiftopecten donmilleri* (MACNEIL), *Patinopecten* (*Lituyapecten*) *lituyaensis* MACNEIL, *P.* (*L.*) *poulcreekensis* MACNEIL, *P.* (*L.*) *yakatagensis* (CLARK), *P. jonesi* KANNO, n. sp., *Clinocardium yakatagense* CLARK, *C. brooksi* (CLARK), *Securella alaskensis* (CLARK), *Neptunea* (*Neptunea*) *plafkeri* KANNO, n. sp., and *N.* (*N.*) sp..

According to SCHENCK (1936, p. 33), *Acila* (*Truncacila*) prefers a cool temperate habitat, but is not restricted to that environment. *Yoldia* (*Cnesterium*) generally distributes in rather cold waters. *Patinopecten* (*Lituyapecten*) is a typical pectinid of boreal waters. Recent species allied to the fossil species of *Clinocardium* and *Securella* of the Yakataga are also distributed in the northern Pacific regions.

The following species are reported from the Asian Tertiary system, namely: *Nuculana* (*Borissia*) *alferovi sakhalinensis* KRISHTOFOVICH, *Miyagipecten* sp., *Delectopecten peckhami* (GABB), *Calyptogena chitanii* (KANEHARA), *Macoma* cf. *M. incongrua* v. MARTENS, *Mya cuneiformis* (BÖHM), *Periploma besshoense* (YOKOYAMA), and *Turritella* (*Neohaustator*) *hamiltonensis* CLARK [=*T.* (*N.*) *chikubetsuensis* KOTAKA, 1959]. It does not necessarily mean that these species are all originated from Asia, but these are rather common species in the East Asian Tertiary system. Except for *Delectopceten peckhami*, *Calyptogena chitanii*, and *Periploma besshoense*, these Asian species are known mostly from north of central Japan. *Dlectopecten peckhami*, *Calyptogena chitanii*, and *Periploma besshoense* are typical muddy bottom dwellers and the allied living species are mostly reported from rather deep waters.

The following species are also reported from Oregon and Washington: *Macoma arctata* (CONRAD).

Table 2. Faunal composition of Tertiary mollusks of the Yakataga District.

Faunal elements	Yakataga fauna	Poul Creek fauna	Kulthieth fauna
Alaskan species	12(38.7)	18(34.0)	—
Washington-Oregon species	1(3.3)	19(35.8)	—
Asian species	8(25.8)	14(26.4)	—
Living species	10(32.2)	2(3.8)	—

The number shows that of species of each element, and the percentage is shown in brackets.

It is noteworthy that the Yakataga fauna includes far less species from Oregon and Washington than the Poul Creek fauna.

To sum up, the compositions of the respective faunas are distinct from one another (Table 2).

It is clear that the Yakataga fauna is characterized by a rapid increase in living species of cold water regions and also by a rapid decrease in the Washington and Oregon species, which are generally indicative of rather warm water conditions. Moreover, it is very interesting that the Alaskan proper species and Asian species occupy almost the same percentage in both the Poul Creek and the Yakataga faunas.

IV. PALEOECOLOGY

The molluscan fossils collected from the Tertiary system of the Yakataga District and adjacent area consist of 62 genera and 104 species. Of the 62 genera, 51 are stil living along the Pacific coast of North America as well as the Asian side. The generic and specific compositions of the Tertiary molluscan faunas are shown in Table 1 and 2.

Although these species do not represent all of the actually contained mollusks in the respective formation, the species indentified by this study seem to be sufficient for the estimation of the paleoecological condition of the respective fauna.

KULTHIETH FAUNA

Although the available Kulthieth fauna has too few species to discuss their ecological condition, it includes a very important species. Namely, the Kulthieth fauna includes *Ostrea* sp. and *Cristispira pugetensis*, as well as non-marine mollusks of *Corbicula* sp.. These marine mollusks seem to indicate warm water conditions. Moreover, the Kulthieth contains several coal measures which yield plants fossils. According to floral study by WOLFE (1969), the climatic condition of the early Ravenian (early late Eocene) vegetation of the Yakataga District and adjacent areas is stated as "this was the warmest known period in the Alaskan Tertiary; comparisons can not be made, however, to the early and middle Eocene, because assemblages of that age are not yet known in Alaska. The climate during the early Ravenian is indicated to have been paratropical, that is, it was characterized by a lack of frost, mean annual temperature of 22°C to 25°C and abundant precipitation throughout the year," and "the mean temperature of the coldest month could have been as low as about 15°C" (WOLFE, 1969, p. 61).

POUL CREEK FAUNA

The molluscan fauna from the Poul Creek includes 46 genera and 70 species, of which most genera are still living along the Pacific coast of North America as well as the Asian side of the Pacific. Only 5 genera, *Vertipecten, Liracassis, Eosiphonalia, Priscofusus*, and *Aturia*, are extinct.

Vertipecten is known only from the west coast of North America in Oligocene to Miocene age, *Liracassis* is restricted to the northern Pacific regions north of Oregon in the west coast of North America and north of Japan ranging from Oligocene to Pliocene, mostly Oligocene to Miocene age. *Eosiphonalia* is known only from the Oligocene and Miocene of California, Washington, and Oregon in addition to the Yakataga District. *Priscofusus* is also known only from the west coast of North America from Kodiak Island, Gulf of Alaska, to California, in strata of Oligocene and Miocene age, but there are no records from the Asian side. *Aturia* is a cosmopolitan genus essentially distributes in tropical and subtropical regions and ranging from Paleocene to Miocene, except for a few problematical occurrences in the Chico formation (upper Cretaceous) and Pliocene strata of Australia.

As already stated in the preceding chapter, the living species included in the Poul Creek fauna are only two, which are characterized by having wide distributions. However, generically speaking, the Poul Creek fauna includes a large number of warm water genera such as *Anadara* (*Anadara*), *Vertipecten*, *Crassatella*, *Pitar* (*Katherinella*), *Eosiphonalia*, *Priscofusus*, *Cancellaria* (*Crawfordina*), and *Aturia*. Although, *Aturia* floats after death and could be transported for a significant distance by current, the mode of occurrence of this species in the Poul Creek shows an endemic specimens as is remarked in the systematic description.

The living species of genus *Anadara* are shallow water dwellers and do not range north of Gulf of California along the west coast of North America, and moreover, the living species of subgenus *Anadara* (*Anadara*) is distributed south of the southern point of Kyushu Island (lat. 31°N) in the west Pacific region. Tertiary species of the genus are also restricted south of Oregon (SCHENCK and REINHART, 1938; REINHART, 1943). Fossil species of subgenus *Anadara* (*Anadara*) seems to have flourished in great number of species and individuals in Miocene epoch and they were distributed up to the north of Hokkaido (lat. 45°N) in that age.

Vertipecten is restricted along the west coast of North America where it is usually associated with warm water dwellers in strata of Oligocene to Miocene ages.

Recent species of genus *Crassatella* shows world-wide distribution in tropical to subtropical regions in waters 20 to 80 meters in depth. It is found only south of Point Conception, California, in the eastern Pacific and ranging south of lat. 35°N along the Pacific coast of Japan. *Crassatella carmanahensis* (CLARK) has been reported south of Vancouver Island prior to the present paper.

Pitar is one of the warm water dwellers in the world. The living species of the genus are mostly distributed in the regions south of lat. 35°N along the Pacific coast of Japan, and it also seems to be restricted south of the Gulf of California along the coast of the eastern Pacific Ocean.

Eosiphonalia and *Priscofusus* are restricted mostly south of Oregon where they are associated with rather warm water dwellers.

It is noteworthy that a large number of specimens of *Aturia* occur in the upper part of the Poul Creek formation, and that specimens of various growth stages are found there. Although the nautiloid mollusks are said to be distributed far from their original habitat by floating after death, the occurrence in the Poul Creek seems to be autochthonous. SCHENCK (1931, p. 447) inferred that "these cepalopods were vagile benthonic organisms, that they inhabited the nertic zone of the oceans, and were more apt to be sublittoral than littoral".

The species belonging to the above-mentioned genera are generally typical of the neritic zone less than 100 meters in depth. It may be very significant that the Poul Creek fauna which is represented by more than sixty species includes a fairly large number of tropical and subtropical forms that lived in rather shallow waters. Moreover, these mollusks are represented not only by adult specimens but also by younger ones.

As already discussed by DURHAM (1950, 1960), the presence of thermophilic (warm-limited) organisms seems to be much more important than the presence of cool water elements.

From the above discussion, the marine climate during late Poul Creek time may be fairly warm compared with that of the present day.

This interpretation, which is based on the molluscan fauna, is also supported by RAU (1963) with his study of foraminifers. According to his results, the upper Poul Creek yields shallow and warm water dwellers such as *Siphogenerina*, *Cancris*, *Uvigerina*, *Sphaeroidina*, *Bolivina*, *Cibicides*, *Buliminella*, and *Cassidulina*. Based on these foraminifers he concluded that those in the upper part of the Poul Creek formation, would, as a group, prefer moderately warm water temperatures at rather shallow depths. Probably they would thrive in temperatures between 7.2° and 12.8°C at depths between 60 and 250 meters (RAU, 1963, p. 137).

In connection with the ecological conditions inferred from the fauna, reference data may be available from the recent studies on the glauconite. As previously described, the upper part of the Poul Creek formation is characterized by glauconitic sandstone. According to the review given by CLOUD (1955) and recent data by EHLMANN et al. (1963) and new data based on offshore southern California by PRATT (1963), galuconite is commonest at depths ranging from 30-700 meters. Moreover, it should not occur in tropical waters shallower than 50 meters and may be more abundant at about 250 meters. It is noteworthy that temperatures lower than about 15°C would favour the generation of glauconite.

A molluscan fauna which consists of *Conchocele*, *Solemya*, *Nemocardium*, *Bathybembix*, *Liracassis*, *Pteropurpura*, *Ancistrolepis*, and *Musashia* (*Neopsephaea*), characterized by muddy bottom dwellers, occurs from somewhat lower part of the Poul Creek compared with the section discussed above. Moreover, these genera are associated in some places with *Aturia*, although *Aturia* occurs more abundantly in the upper part of the Poul Creek. As described in the preceding line, *Aturia* is considered as one of vagile benthonic mollusks lived in the tropical and subtropical regions. Accordingly, the fauna in question may have lived in waters affected by warm surface water currents. Judging from the ecological evidence of living species of *Conchocele disjuncta*, (KANNO, 1971), and *Solemya* (*Acharax*), (DALL, 1908; KANNO, 1960) these mollusks may have lived in a muddy bottom in a somewhat deeper part of the neritic zone.

YAKATAGA FAUNA

The Yakataga fauna includes 22 genera and 34 species, of which 20 genera are still living along the Pacific and Asian coasts. Two genera, *Miyagipecten* and *Securella,* are extinct one, of which *Miyagipecten* is known only from the middle Miocene and *Securella* is restricted to the Miocene and Pliocene.

The species collected from the Yakataga formation are characterized by distinct cold water dwellers now living in the northern Pacific region. They include the following species:

Yoldia (*Cnesterium*) *ensifera*, which lives in silty bottoms of the littoral zone to 50 meters depth and ranges from north of California through Alaska.

Pododesmus (*Monia*) *macroschisma*, which lives very commonly in the northern Pacific region where it is found attached to rocks and wharf piling from low-tide mark to about 20 meters in depth.

Conchocele disjuncta, which lives in the silty bottom of the littoral zone to more than several hundreds of meters, but the shallow bottom dweller of this species is known only from the boreal region.

Mya truncata, which lives on the silty and fine-grained sandy bottom of the littoral zone in the circumpolar region including the Bering Sea, Alaska, Kamchatka, and the Pacific coast north of Hokkaido and California.

Panomya arctica [=*P. trugida* DALL, 1916], which usually lives in muddy bottoms in cold offshore waters and distributes in the north of Hokkaido, Kamchatka, Bering Sea, Canada, and north of California.

Hiatella arctica, which lives in borings in clay or limestone of the littoral zone of Arctic seas to deep waters off Panama, and north of Honshu (main island of Japan).

Siliqua sp. is large and is similar to recent species of *S. patula* DIXON and *S. alta* (BRODERIP and SOWERBY) which distribute from northern Japan to Kamchatka and from Alaska down to Monterey, California. Such large-sized species of *Siliqua* seem to be restricted to temperate to cold waters.

Beringius crebricostatus, which distributes in Unalaska, Alaska, to British Columbia, and has been collected from 160 to 200 meters in depth.

Neptunea (*Sulcosipho*) *tabulata*, which distributes in British Columbia to San Diego, California, and has been reported from 60 to 400 meters in depth.

Antiplanes (*Antiplanes*) has been reported from the Pacific coast of Japan north of lat. 35°N in water 30 to 250 meters in depth.

Alaskan proper elements of the Yakataga fauna include *Yoldia* (*Cnesterium*), *Swiftopecten*, *Patinopecten* (*Lituyapecten*), *Clinocardium*, *Securella*, *Neptunea* (*Sulcosipho*) and *Neptunea* (*Neptunea*). Generally speaking, these genera now distribute in temperate to cold waters, and none of these genera are reported from shallow water in tropical or subtropical regions.

Asian species among the Yakataga fauna are represented by *Miyagipecten* sp., *Delectopecten peckhami*, *Calyptogena chitanii*, *Mya cuneiformis*, *Periploma besshoense*, and *Turritella* (*Neohaustator*) *hamiltonensis* [=*T.* (*N.*) *chikubetsuensis*]. Teese species are muddy bottom dwellers in deep waters and sandy bottom dwellers in shallow water. *Miyagipecten*, *Mya cuneiformis*, *Turritella* " *chikubetsuensis* " are restricted to northern Japan where they are associated with shallow water dwellers. However, *Delectopecten peckhami*, *Calyptogena chitanii*, and *Periploma besshoense* are, in contrast, widely distributed in muddy deposits where they are associated with deep water dwellers.

Oregon and Washington species in the Yakataga fauna such as *Macoma arctata*, is few in number. This species is distributed in Oregon and Washington, as well as California in the strata of " lower " to middle Miocene age.

The above discussion was essentially based on the biogeographical and bathymetrical distribution. The next problem is the range of each species in the present area. Of course, the writer's collections are not sufficient to cover the whole area. On the basis of the data available to him, however, the following interpretation may be made.

The deep water, muddy bottom dwellers are distributed in the western part of the area on Kayak and Wingham Islands, where *Calyptogena chitanii* and *Delectopecten peckhami* occur abundantly. *Calyptogena* is a gregarious mollusk that tends to form large colonies. Some living species of this genus are usually collected from muddy bottoms about 700 to 1000 meters in depth of central Japan as well as off Oregon and Washington (oral information from Prof. M. KEEN, 1969). Both the living and fossil species occur in densely crowded clusters. The living species of *Delectopecten* is usually restricted to depths greater than 20 meters and are more common in depths greater than 200 meters. Accordingly, the *Calyptogena chitanii-Delectopecton peckhami* fauna may represent muddy bottom conditions in deep and cold waters less than hundreds of meters in depth in the Gulf of Alaska area (lat. 60°N).

In the eastern part of the mapped area, the Yakataga formation is well exposed in the Karr Hills, Chaix Hills, and Samovar Hills, where *Mytilus* sp.,* *Pododesmus* (*Monia*) *macroschisma*, *Mya cuneiformis*, and *Neptunea* cf. *N. tabulata* occur with *Conchocele disjuncta*. Except for the last one, all these species or genera are usually typical shallow and cold water dwellers as discussed in the systematic description. It is noteworthy that *Conchocele disjuncta* is associated with such shallow forms. This is one of the clear indication that the shallow water temperature was fairly cool and comparable to the present littoral zone of the Gulf of Alaska (KANNO, 1971).

As previously described, the molluscan faunal sequence at the Yakataga Reef is subdivided into the following three parts. The lowest part is represented by *Panomya arctica*, *Turritella hamiltonensis*, and *Neptunea* sp.. It is succeded by the fauna with *Nuculana* and *Acila* (*Truncacila*) in dark-gray or black mudstone. The upper part is characterized by *Patinopecten* (*Lituyapecten*), *Panomya*, *Mya truncata*, *Clinocardium*, and *Turritella hamiltonensis* which are associated with *Macoma arctata* and *Siliqua* sp.. Judging from the sequence of molluscan fauna at Yakataga Reef, the water temperature seems to be as cool as the present waters of that area throughout the time of Yakataga Reef section, but the bathymetric conditions of the

* All represented by fragmental specimens.

three faunas seem to be somewhat different. Thus, the basal part of the Yakataga fauna at the reef may represent water 60 to 100 meters in depth, but the overlying *Nuculana* and *Acila* (*Truncacila*) fauna seems to represent deeper water conditions. According to SCHENCK (1936, p. 33), most living species of *Acila* live in water having a temperature between 4.4° to 21°C, and *Truncacilla* prefers a cool temperature habitat, although it is not restricted to such conditions. Moreover, this subgenus is found in the neritic or bathyal, though it has not been collected in water deeper than about 1600 meters or in the intertidal zone (SCHENCK, 1936).

In contrast, the upper part of the Yakataga in the reef area is characterized by rather shallow water conditions as indicated by large number of *Mya truncata* which is restricted to the littoral zone in the circumpolar region north of Pugest Sound and north of Hokkaido in Japan.

In summary, the bathymetric conditions of the Yakataga fauna in the reef section seems to change from neritic (60 to 100 meters) at the base, through the lower nertic or bathyal in the middle part, to littoral at the top.

It is noteworthy that the bathymetric environments of the basal part of the Yakataga are very different from west to east. Thus, the fauna in the western part at Kayak and Wingham Islands is represented by cold and deep water dwellers, whereas it is represented by neritic dwellers at Yakataga Reef and a shallow and littoral fauna in the eastern part of the area on the Samovar Hills.

The ecological differences inferred from the respective faunal elements seem to be supported by lithologic and stratigraphic data. The Yakataga formation at Kayak and Wingham Islands consists mainly of thick, dark-gray mudstone underlain by the Poul Creek formation with conformity (PLAFKER, 1971). However, the Yakataga consists chiefly of granule-bearing conglomeratic sandstone in the Samovar Hills where the Yakataga is underlain by the Kulthieth with angular unconformity.

The available data suggest that the Yakataga formation may conformably overlie the Poul Creek in the Yakataga Reef area as well as in the area west of the Reef, whereas it is deposited unconformably on the underlying strata in the eastern part of the area, though there is no available evidence to show the change from south to north.

In addition to the above-mentioned data, attention should be directed to the existence of "conglomeratic sandy mudstone" in the Yakataga formation (MILLER, 1953, 1957; PLAFKER and MILLER, 1957). As pointed out by MILLER and PLAFKER, the conglomeratic sandy mudstone originated as ice-transported debris. The thick conglomeratic sandy mudstone appears about 190 meters above the base of the Yakataga at Yakataga Reef, although tillite-like thin beds occur immediately above the massive sandstone (no. 13 in Text-fig. 2) and between that sandstone and the thick conglomeratic sandy mudstone. Moreover, the cold water fauna appears at the base of the Yakataga formation. This may indicates the time necessary for development of tidal glaciers during a rapid climatic cooling between Poul Creek and Yakataga time. Glaciers may have developed on the mountains during the deposition of the basal part of the Yakataga after which ice-transported debris began to reach the sea.

SUMMARY: From the above discussion the paleoecologic conditions of the Tertiary faunas in the Yakataga District and adjacent areas may be summarized in Table 3.

Table 3. Paleoecologic conditions of the respective fauna.

Faunas \ Based on	Molluscan fauna	Foraminiferal fauna	Glauconite	Flora	Estimated shallow water marine climate[1]
Yakataga	W ⟵ ⟶ E 0–10 m 0–20 m more than 200 m 100–200 50–60				Cold[2] (Arctic)
Poul Creek	20–60 m 100–200 m	60–270 m 7.2°–12.8°C	50–250 m less than 15°C		Warm temperate, no month cooler than 10°C[3]
Kulthieth	Fresh water or marine (less than 20 m)			15°–25°C	Outer to inner tropical[4]

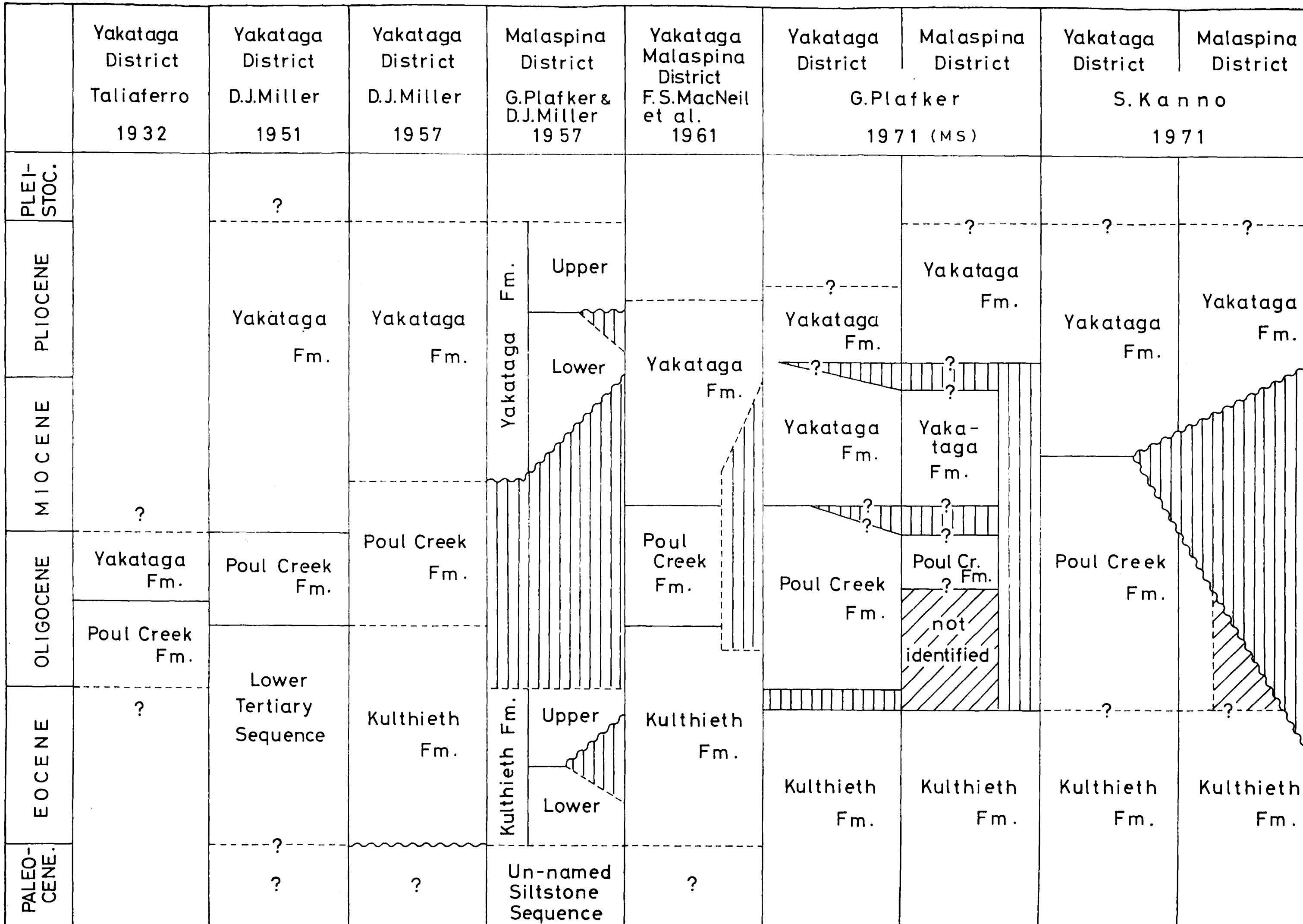
1) Marine climates defined by the duration of critical or near critical temperatures which apparently limit the northern range of shallow water marine mollusks in the northern Pacific along the west coast of North America (HALL, 1964).
2) Southern boundary is near the southern limit of winter ice.
3) Northern range lat. 34°N. No months cooler than 10°C, 4 months at 18°C.
4) Northern range of the outer tropical is lat. 28°N, approximate 4 months 20°C and no months cooler than 10°C. Northern range of inner tropical is lat. 24°N, and no months cooler than 18°C and 8 months 20°C.

V. GEOLOGICAL AGES

The geological ages of the Tertiary formations of the Yakataga and Malaspina Districts has been considered as Oligocene or Eocene to Pliocene by most previous workers. However, as indicated in Text-fig. 6, they have been assigned in somewhat different ways by various workers.

KULTHIETH FORMATION

The Kulthieth yields a few marine mollusks from the Malaspina District as *Ostrea* sp. and *Cristispira pugetensis*. According to ALLISON (1956) and ADDICOTT and PLAFKER (1971), *C. pugetensis* suggests that the Kulthieth is in part of middle Eocene age. Moreover, ADDICOTT and PLAFKER (1971) pointed out that the Kulthieth also contains marine invertebrate assemblages of undoubted late Paleocene to late Eocene ages suggested by the occurrence of turritellid mollusks resembling *Turritella buwaldana crooki* MERRIAM and TURNER. Although the fauna at hand is too small to discuss the geological age, it may be said that the available data indicate that the Kulthieth formation ranges in age from late Paleocene to late Eocene.



Text-fig. 6. Geological ages of the Tertiary formations in the Yakataga District and adjacent area.

POUL CREEK FORMATION

As already stated in the preceding chapter, the Poul Creek fauna includes about 36 percent of Washington and Oregon species and 26 percent of Asian Tertiary species.

Table 4 shows the species found in the Tertiary formations of Washington and Oregon.

Table 4. Poul Creek mollusks found in the Tertiary formations of Washington and Oregon.

Species	Eoc.-Olig.	Low. Mioc. Blakeley & Twin River	Mid. Mioc. Astoria & Clallam	Up. Mioc. or younger formations
Acila (*Acila*) *gettysburgensis*		+	+	
Crenella porterensis		+		
Vertipecten sp.			+	
Crassatella cf. *C. washingtoniana*	+			
Crassatina carmanahensis		+		
Tellina cf. *T. cowlitzensis arnoldi*	+			
Pitar (*Katherinella*) *arnoldi*		+		
P. (*K.*) *arnoldi etheringtoni*			+	
Macrocallista weaveri	+	?		
Panope snohomishensis	+			
Thracia schencki		+		
T. cf. *T. condoni*	+			
Epitonium (*Cirsotrema*) *clallamense*			+	
Turritella aff. *T. diversilineata blakeleyensis*		+		
Crepidula cf. *C. praerupta*			+	+
Liracassis apta	+	+		
Colus aff. *C. jordani*				+
Turricula cf. *T. washingtoniana*	+			

The Washington and Oregon species in the Poul Creek fauna are mostly similar to those of the Blakeley, and Twin River formations, and these mollusks are characteristically warm water inhabitants. Moreover, *Liracassis apta* was designated as a marker of the "*Echinophoria apta* zone" by DURHAM (1944). This zone represents the upper part of the Twin River formation. The Twin River formation is herein accepted as the equivalent to the upper part of the Blakeley formation, which is considered to be of early Miocene age (ADDICOTT, 1967).

The Poul Creek fauna also includes *Liracassis durhami* KANNO, n. sp., which is characterized by having the ancestral form of *L. petrosa* (CONRAD). *L. petrosa* is one of the characteristic species of the Astoria fauna which is accepted as the typical middle Miocene one along the west coast of North America.

Table 5 shows a list of the Poul Creek molluscan species found also in the Tertiary formations of Asian districts.

Table 5. Poul Creek mollusks found in the Asian Tertiary system.

Species	Eoc.-Olig.	Earl. Mioc.	Mid. Mio.	Lat. Mioc. or younger
Acila (Acila) submirabilis		+	+	
Acila (Truncacila) cf. *A. (T.) kamtschatica*				+
Yoldia (Yoldia) takaradaiensis	+			
Y. (Y.) biremis		+	+	
Solemya (Acharax) dalli		+	+	
Acesta cf. *A. yagenensis*		+	+	
Lucinoma cf. *L. tomitensis*		+		
Nemocardium aff. *yokoyamai*		+	+	
Spisula equilateralis		+	+	
Mya (Mya) salmonensis		+		
Panomya elongata	+	+		
Periploma besshoense	+	+	+	
Dentalium cf. *D. nunomae*	+		+	
Aturia alaskensis [=*A. minoensis*]		+	+	

Although *Acila (Truncacila) kamtschatica* occurs in the Pliocene Etron formation (upper part of the Kabran group, west Kamchatka), most of the species are reported from the early to middle Miocene age of the Horomui and the Takinoue formation or its equivalent in Hokkaido (KANNO et al., 1960, 1964, 1968). *Aturia alaskensis* [=*A. minoensis* KOBAYASHI, 1954] had been reported from several localities in Japan, where it is associated with distinctly subtropical mollusks. The type locality of "*Aturia minoensis* KOBAYASHI" seems to be in the *Globorotalia fohsi barisanensis* zone (lower part of the Burdigalian) (SAITO, 1963).

As already discussed in the preceding chapters, the Poul Creek fauna is characterized by warm water dwellers. Paleoclimatological studies by previous workers such as DURHAM (1950, 1960) and ADDICOTT (1969, 1970), indicate that the marine temperature of the west coast of North America reached the warmest during middle Miocene time in the mid-Tertiary. Judging from the above discussion, the upper part of the Poul Creek fauna may range in age from early to middle Miocene. However, the geologic age of the lowest part of the Poul Creek is not clear because of the molluscan fauna from the lowest part of the Poul Creek is inaccessible in the area studied by the writer.

YAKATAGA FORMATION

The Yakataga fauna includes about 39 percent of the Alaskan proper species and 32 percent of species now living in the northern Pacific region. Thus, about 70 percent of the fauna is boreal or cold water dwellers.

The species listed in Table 6 are also found in the Tertiary formations of the Asian districts.

Although *Delectopecten peckhami* ranges from Oligocene to Pliocene, it shows a somewhat wide variation in size with geologic age. UTASHIRO (1954) pointed out that *D. peckhami* becomes large during Miocene to Pliocene times. The Yakataga specimens are of UTASHIRO's Miocene type. *Calyptogena chitanii* from middle Miocene

Table 6. Yakataga mollsks found in the Asian Tertiary system.

Species	Eoc.-Olig.	Miocene			Pliocene or younger
		Early	Mid.	Late	
Nuculana alferovi sakhalinensis				+	
Miyagipecten sp.			+		
Delectopecten peckhami	+	+	+	+	+
Calyptogena chitanii			+		
Macoma cf. *M. incongrua*			+	+	+
Mya cuneiformis			+	+	
Periploma besshoense	+	+	+	+	
Turritella (*Neohaustator*) *hamiltonensis* [=*T. chikubetsuensis*]			+		

mudstones in Japan shows such a rapid increase in shell size and so remarkable changes in shell shape with time that it is one of the very useful Miocene molluscan horizon markers (KANNO et al., 1967). The specimens from the Yakataga at Kayak Island are very large and are strongly arcuate in form. Judging from their size and shape, the Kayak specimens may be of upper middle or late Miocene age (Text-fig. 12).

Mya cuneiformis ranges from the middle Miocene to early Pliocene, although it is most common in the middle to late Miocene in Japan. *Periploma besshoense* is reported from the late Oligocene to late Miocene in Japan and Sakhalin. *Turritella hamiltonensis* [=*T. chikubetsuensis*] is also reported from middle to late middle Miocene in Hokkaido.

Although the above listed species are chiefly restricted to the lower part of the Yakataga formation, they are known to range from middle to late Miocene in Japan.

Macoma arctata is reported from the Tertiary formations of Washington and Oregon. *M. arctata* seems to be restricted to the Astoria formation on the west coast of North America. *Macoma lorenzoensis arnoldi* and *Cryptonatica clausa* are reported from Oligocene to Pliocene in Washington and Oregon, though the Yakataga specimens are not well identified.

It is noteworthy that the Yakataga includes a large number of living cold water dwellers in contrast with the warm inhabitants of the Poul Creek fauna. ADDICOTT (1969, 1970) pointed out that the marine water temperature was rapidly decreasing in post middle Miocene time along the west coast of North America. Such a distinct faunal change in the mid-Tertiary was also pointed out by MATSUNO and the writer (KANNO and MATSUNO, 1960) in western Hokkaido, where the Sankebetsu formation which is characterized by a warm water fauna is unconformably overlain by the Chikubetsu formation which contains a distinct cold water fauna. The Sankebetsu and the Chikubetsu are almost equivalent to the Takinoue formation in central Hokkaido (Text-fig. 7).

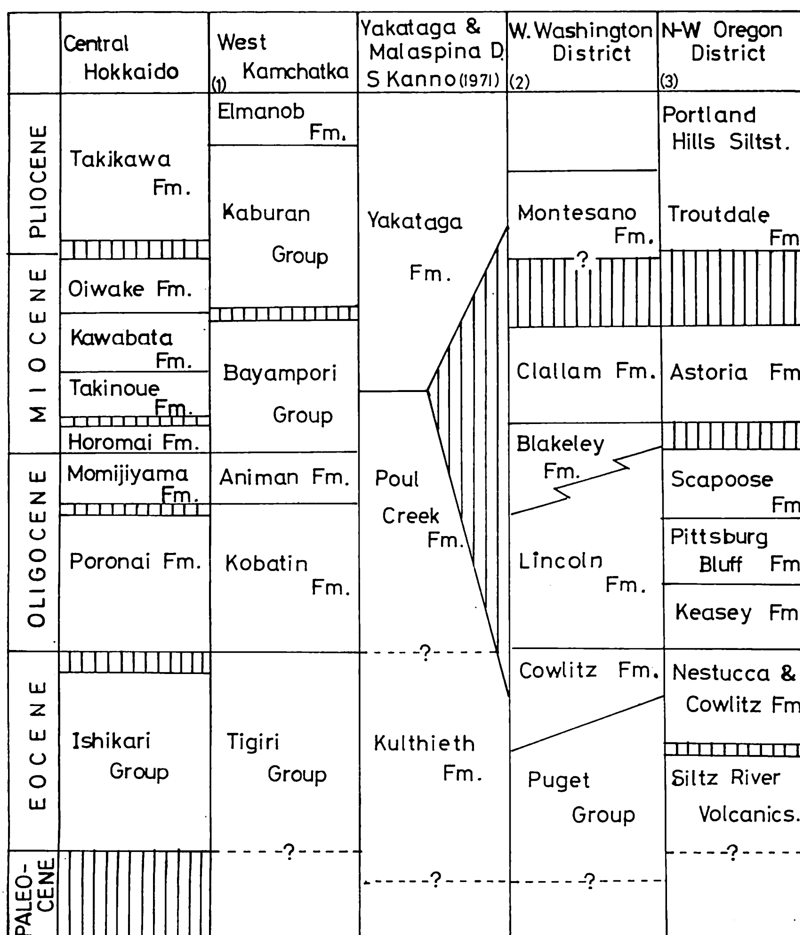
Judging from the above discussion, it seems probable that the lower part of the Yakataga formation is of late middle Miocene age, although the upper part of the Yakataga may range up into the Pliocene.

VI. Correlation

The opinions of the various workers on the correlation of Tertiary formations developed around the northern Pacific regions as well as the geological ages of the respective formations differ. This difference is apparently due to various factors such as lack of detailed paleontological work, direct comparison of specimens, misconception in interpretation of the stratigraphic sequence of the established units, and to the lack of data concerning the exact stratigraphic positions of the fossils in the geological column.

The writer's suggested correlation of Tertiary stratigraphic units in Hokkaido, west Kamchatka, Washington, Oregon, and the Yakataga District is shown in Text-fig. 7.

WASHINGTON AND OREGON: The Kulthieth formation may be correlated



Text-fig. 7. Correlation chart of the Tertiary formations in the northern circum-Pacific regions.

(1) L. B. Krishtofovich, 1960; (2) and (3) Weaver et al., 1944; Durham, 1944; Brown, Snavely, and Grower, 1956; Youngquist, 1961; Addicott, 1967.

Table 7. Geographic distribution of the Tertiary mollusks in the Yakataga District and adjacent areas, Alaska

Formations	YAKATAGA FORMATION																																								POUL CREEK FORMATION																						KULTHIETH FORMATION		
Species / Locality numbers	20459*	M1767*	80404	80405	80406	80408	80409	80502	80503	80505	80506	80904	81306	81305	81304	80605	80606	80703	80604 (80903)	80603	80901	7011	20484	20489	20494	81104	81105*	81106	81402	81403	80801	80802	20521	20526	20529	20540	20551	20523	20525	20541	80702	80902	80602b	80602a	80601	20505	20508-2	81203	80905	80906	20511	81001	81002	81003*	81004	81102*	81201	81202	81401	20493	81404	20503	81501	81502*	81503 (20537)
Bivalves																																																																	
Acila (Acila) gettysburgensis (Reagan)																																																									×				×				
A. (A.) cf. *submirabilis* Makiyama																																																										×			×				
A. (A.) sp.																																																	×												×				
A. (Truncacila) taliaferroi Clark																			×																																														
A. (T.) cf. *kamtschatica* Ilyina																																							×																										
Nuculana (Borissia) alferovi sakhalinensis Krishtofovich															×			×	×													×																																	
Yoldia (Yoldia) takaradaiensis Krishtofovich																																										×										×					×		×						
Y. (Y.) biremis Uozumi																																																				×					×		×						
Y. (Cnesterium) ensifera Dall																			×													×						×																											
Y. (C.) yakatagensis Kanno, n. sp.																																×																																	
Y. sp.																																																								×									
Solemya (Acharax) dalli Clark																																																×		×															
Anadara (Anadara) sp.																																																														×			
Modiolus sp.																																																		×											×				
Crenella porterensis Weaver																																																	×								×								
Swiftopecten donmilleri (MacNeil)																											×			×																																			
Vertipecten sp.																																																											×						
Patinopecten (Lituyapecten) lituyaensis MacNeil			×	×	×					×	×																																																						
P. (L.) yakatagensis (Clark)			×						×													×		×																												×													
P. (L.) poulcreekensis MacNeil																						×																																											
P. jonesi Kanno, n. sp.																													×																																				
Miyagipecten sp.												×																																																					
Delectopecten peckhami (Gabb)	×																																																																
Pododesmus (Monia) macroschisma (Deshayes)																																	×			×			×	×																									
Ostrea sp.																																																																×	
Acesta cf. *A. yagenensis* (Otuka)																																																					×									×			
Lucinoma cf. *L. tomitensis* Kanno																																																				×													
Conchocele disjuncta Gabb																	×																				×											×																	
Cyclocardia yakatagensis (Clark)																																																	×				×				×		×			×			
C. hamiltonensis (Clark)																																																					×						×						
C. sp.																																																											×						
Crassatella cf. *washingtoniana* (Weaver)																																																	×																
Crassatina carmanahensis (Clark)																																																	×																
Clinocardium yakatagense Clark																						×	×						×				×	×				×																											
C. brooksi (Clark)											×		×																	×																																			
C. hopkinsi Kanno, n. sp.																																																											×						
Papyridea hamiltonensis (Clark)																																																						×			×		×			×			
Nemocardium alaskense (Clark)																																																		×			×						×						
N. aff. *N. yokoyamai* Takeda																																																											×						
Spisula equilateralis (Clark)																																																									×		×			×			
S. addicotti Kanno, n. sp.																																																									×		×		×				
Siliqua sp.																×																																																	
Tellina cf. *T. cowlitzensis* Weaver																																																								×			×			×			
T. (Oudardia) sp.																																																											×						
Macoma incongrua v. Martens																																																									×		×						
M. cf. *M. incongrua* v. Martens																																×																																	
M. arctata (Conrad)																×																																																	
M. aff. *M. lorenzoensis arnoldi* Tegland											×																																																						
M. sp.																					×							×																																					
Calyptogena chitanii (Kanehara)		×																																																															
Corbicula (Corbicula) sp.																																																															×		
Pitar (Katherinella) arnoldi (Weaver)																																											×	×					×							×	×								
P. (K.) arnoldi etheringtoni (Tegland)																																														×				×				×		×			×			×			
P. (K.) sp.																																																				×													
Securella alaskensis (Clark)																													×		×																																		
Macrocallista weaveri Clark																																																									×								
Mya (Mya) salmonensis Clark																																																		×															
M. (M.) truncata Linné			×	×	×																								×		×																																		
M. (M.) cuneiformis (Böhm)																																×							×																										
Hiatella arctica (Linné)																																×																																	
Panope snohomishensis Clark																																																									×		×						
P. n. sp. ?																																																											×						
Panomya arctica (Lamarck)			×	×	×				×											×							×					×																																	
P. elongata Kanno																																																											×						
Periploma (Aelga) besshoense (Yokoyama)			×																							×																							×																
Thracia schencki Clark																																										×		×					×		×						×		×		×				
T. cf. *T. condoni* Conrad																																																									×		×						
Scaphopod																																																																	
Dentalium (Coccodentalium) cf. *D. (C.) nunomae* Takeda																																																	×				×						×		×				
Gastropods																																																																	
Bathybembix turbonata (Clark)																																																					×	×											
B. jonesi Kanno, n. sp.																																															×																		
Epitonium (Cirsotrema) clallamense Durham																																																	×				×												
E. (Gyroscala) sp.																																																	×																
E. sp.																																																											×						
Turritella (Neohaustator) hamiltonensis Clark			×	×	×		×	×	×			×														×				×																																			
T. aff. *T. diversilineata blakeleyensis* Weaver																																															×			×											×				
T. sp.																																																									×		×						
Cristispira pugetensis Allison																																																																	×
Calyptraea sp.																																											×											×											
Crepidula cf. *C. praerupta* Conrad																																																						×	×										
Euspira ramonensis (Clark)																																																	×								×		×		×	×			
Cryptonatica aff. *C. clausa* (Broderip & Sowerby)			×		×																										×																					×													
Liracassis apta (Tegland)																																															×	×	×	×		×		×			×		×			×			
L. durhami Kanno, n. sp.																																																	×	×		×					×								
Pteropurpura n. sp.																																																×																	
Eosiphonalia sp.																																																					×												
Neptunea (Neptunea) sp.											×																																																						
N. (N.) plafkeri Kanno, n. sp.																										×																																							
N. (Sulcosipho) cf. *N. (S.) tabulata* (Baird)			×			×							×					×		×					×							×								×																									
Beringius cf. *B. crebricostatus* (Dall)			×																																																														
Ancistrolepis rearensis (Clark)																																													×			×	×						×										
A. macneili Kanno, n. sp.																																																		×															
A. sp.																																																	×										×						
Colus aff. *C. jordani* Dall																																																	×									×							
Priscofusus clarki Kanno, n. sp.																																										×							×				×				×		×		×				
P. sp.																																																	×																
Musashia (Neopsephaea) corrugata (Clark)																																													×				×		×								×	×	×	×			
M. (N.) sp.																																									×																								
"Fulgoraria" sp.																																																									×								
Cancellaria (Crawfordina) alaskensis Clark																																																									×		×			×			
Antiplanes (Antiplanes) sp.																			×																																														
Turricula cf. *T. washingtoniana* (Weaver)																																																													×				
T. sp.																																																	×																
Scaphander alaskensis Clark																																																									×		×						
Cephalopod																																																																	
Aturia alaskensis Schenck																																																	×	×									×		×				

* The fossil locality is not plotted on the geologic map.

with Eocene strata developed around Puget Sound in Washington based on the occurrence of *Cristispira pugetensis*. The upper part of the Poul Creek formation is also correlated with the lower part of the Astoria and Clallam formations, but it may be correlated with Twin River formation and also the Blakeley formation, as stated in preceding chapters.

As already discussed the geologic age of the Yakataga formation, the lowest part of the Yakataga includes the characteristic late middle or late Miocene species. Moreover, the Yakataga is underlain conformably by the Poul Creek in the Yakataga area. Thus, the lowest part of Yakataga seems to be correlated with the upper most part of Astoria and Clallam formations. However, the Yakataga may include younger Pliocene strata. The geologic age of the upper part of the Yakataga requires further work.

KAMCHATKA: The Tertiary system of Kamchatka has recently studied by L. V. KRISHTOFOVICH (1960, 1963), L. V. KRISHTOFOVICH and A. P. ILYINA (1962), and U. V. GRADENKOV (1966, 1969).

The Tigiri group, the lowest Tertiary system of western Kamchatka, consists mainly of non-marine coal-bearing deposits that are locally intercalated with marine strata. This group seems to correlate stratigraphically with the Kulthieth formation in the Gulf of Alaska.

The Kobatin and Animan formations consist mainly of muddy strata containing *Yoldia olympiana*, *Modiolus restrationensis*, *Lima twinnensis*, and *Aforia clallamensis* (KRISHTOFOVICH, 1960). This fauna seems to correlate with that of the Poul Creek, Twin River, and Blakeley formations in the west coast of North America.

The Bayampoli group also consists of muddy rocks or siliceous strata and contains rather deep water dwellers such as *Delectopecten*, *Nuculana*, and *Yoldia*. This fauna is roughly comparable to the lower part of the Yakataga formation at Kayak Island, but precise comparison between them is difficult owing to the inadequate data on the molluscan fauna. The Kaburan group and Elmanob formation may corrrelate stratigraphically with the upper part of the Yakataga formation.

HOKKAIDO: The Ishikari group is definitely correlated with the Kulthieth formation based on the lithological and paleontological evidence. Like the Kulthieth formation, the Ishikari is underlain by the upper Cretaceous system with unconformity, and consists mainly of terrestrial or non-marine deposits intercalated with coal measures and also a few marine beds. Moreover, it yields plant fossils including such as the Eocene species of *Sabalites*, some marine mollusks, and a large number of fresh-water mollusks.

It is difficult to correlate directly between the Poronai and Poul Creek formations owing to the limited collections available to the writer from the lower part of the Poul Creek. However, the lower part of the Yakataga contains the same species as the Takinoue which overlies the Poronai and the Momijiyama with unconformity. Namely, the occurrence of *Calyptogena chitanii* and *Turritella* (*Neohaustator*) *hamiltonensis* [=*T. chikubetsuensis*] from the lower Yakataga may support correlation of the Yakataga and the upper part of Takinoue in Hokkaido. Moreover, the writer collected *Liracassis petrosa* from the strata equivalent to the Takinoue in southern Hokkaido. This evidence may be sufficient to permit correlation of the Takinoue with the lower part of the Astoria formation, though it is not equivalent to the entire Astoria formation.

The Kawabata formation overlies the Takinoue with conformity and consists chiefly of conglomerate and thick alternation of sandstone and mudstone. This sedimentary facies closely resembles some parts of the Yakataga formation.

The Takikawa formation is one of the typical Pliocene units in Hokkaido in which *Fortipecten takahashii* occurs. The "*Fortipecten takahashii*" fauna is characterized by cold water dwellers in northern Japan, Sakhalin, and Kamchatka, although it has not been reported from the Gulf of Alaska. However, two species of *Fortipecten* were reported from the Alaskan Peninsula (MACNEIL, 1968, and MACNEIL, et al., 1943).

VII. Systematic Descriptions

Class Bivalvia

Subclass Palaeotaxodonta

Order Nuculoida

Superfamily Nuculacea

Family Nuculidae

Genus *Acila* H. and A. ADAMS, 1858

Acila H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 545, 1858; *Acila* H. and A. ADAMS. STOLICZKA, Mem. Geol. Surv. India, Paleont. Indica, vol. 3, p. 325, 1871; *Acila* H. and A. ADAMS. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 112-113, 1931; *Acila* H. and A. ADAMS. SCHENCK, Geol. Soc. Am., Spec. Pap., no. 4, p. 22-23, 1936; *Acila* H. and A. ADAMS. KANNO, Tert. Sys. Chichibu Basin, p. 189, 1960; *Acila* H. and A. ADAMS. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 54, 1968; *Acila* H. and A. ADAMS. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 231, 1969.

Type-species (by subsequent designation, STOLICZKA, 1871):—*Nucula divaricata* HINDS, Recent, China Sea.

Remarks:—This genus is characterized by the diverицated radial ribs and marginal crenulations in the young stage. All known species of the genus are marine in habitat and chiefly live in fine-grained sediments.

Geographic distribution:—Temperate Indo-Pacific waters, rare in tropical and boreal Pacific.

Geologic range:—Cretaceous to Recent.

Subgenus *Acila* s. s. H. and A. ADAMS, 1858

Acila s. s. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 545, 1858; *Acila* s. s. H. and A. ADAMS. SCHENCK, Geol. Soc. Am., Spec. Pap., no. 4, p. 23, 1936; *Acila* s. s. H. and A. ADAMS. KANNO, Tert. Syst. Chichibu Basin, p. 190, 1960; *Acila* s. s. H. and A. ADAMS. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 231; 1969.

Type-species (by subsequent designation, STOLICZKA, 1871):—*Nucula divaricata* HINDS, Recent, China Sea.

Remarks:—This subgenus can be distinguished from the other subgenera of the genus by having a posterior rostrum. It has rather restricted distribution, i. e., the representatives of this subgenus range from off Hokkaido to the Bay of Bengal and the Arabian Sea (SCHENCK, 1936).

Geologic range:—Upper Oligocene to Recent.

Acila (*Acila*) *gettysburgensis* (REAGAN), 1909

Plate 1, figs. 4, 7

1909. *Nucula (Acila) gettysburgensis* REAGAN, Trans. Kans. Acad. Sci., vol. 22, p. 171, 175. 177, pl. 1, fig. 3.
1912. *Nucula gettysburgensis* REAGAN. WEAVER, Wash. Geol. Surv., Bull. no. 15, p. 18.
1916. *Acila gettysburgensis* (REAGAN). WEAVER, Univ. Wash. Publ. Geol., vol. 1, no. 1, p. 28, 35.
1922. *Nucula (Acila) gettysburgensis* (REAGAN). DALL, Am. Jour. Ser. 5, vol. 4, no. 22, p. 306.
1927. *Acila gettysburgensis* (REAGAN). SCHENCK, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 16, p. 458-459.
1932. *Nucula (Acila) gettysburgensis* REAGAN, Bull. Geol. Soc. Am., vol. 43, p. 804, pl. 14, fig. 12.
1932. *Nucula (Acila) gettysburgensis* var. *alaskensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 804-805, pl. 14, fig. 5.
1933. *Nucula (Acila) gettysburgensis* (REAGAN). TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, p. 105.
1934. *Acila (Acila) gettysburgensis* (REAGAN). SCHENCK, Bull. Mus. Roy. Hist. Belg., vol. 10, no. 20, p. 42.
1936. *Acila (Acila) gettysburgensis* (REAGAN). SCHENCK, Geol. Soc. Am., Spec. Pap., no. 4, p. 78-81, pl. 12, figs. 1-15; pl. 13. figs. 4, 7, 9, text-fig. 81.
1942. *Acila (Acila) gettysburgensis* (REAGAN). WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 32-34, pl. 7, figs. 1-4; pl. 8, fig. 1.
1963. *Acila (Acila) gettysburgensis* (REAGAN). MOORE, Geol. Surv. Prof. Pap., 419, p. 54, pl. 12, figs. 5, 10, 12, 13.
1964. *Acila (Acila) gettysburgensis* (REAGAN). L. V. KRISHTOFOVICH, BNIGRI., no. 232, p. 30, pl. 1, figs. 20, 20a, 20b.
1971. *Acila (Acila) gettysburgensis* (REAGAN). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, fig. 3, g, k, m.

Remarks:—This species is common in the faunas of the Twin River formation (type locality) as well as the Blakeley formation on Bainbridge Island, Washington, and the Nye shale at Newport, Oregon. This species is more or less similar to *Acila (A.) submirabilis* MAKIYAMA (1926, p. 151-152, pl. 2, fig. 9) from North Korea, which is also rather widely distributed in lower to middle Miocene strata in Japan. However, the latter is more finely sculptured and has a shorter posterior side than the former. *Acila (Acila) gettysburgensis* var. *alaskensis* (CLARK, 1932) is a varietal form of the present species. Some specimens from the type locality of CLARK's variety collected by the writer have the same characters as CLARK's type-specimen, but the others show just same as REAGAN's and SCHENCK's descriptions. Accordingly, the writer concludes that CLARK's taxon is a varietal form of the present species.

This species occurs in the Twin River formation (type locality) as well as lower Miocene in Washington and Oregon. Moreover, it ranges upward into the Astoria and "Monterey Miocene", but is unknown from older strata such as the Lincoln and Scappoose formations, nor known to occur in the *Acila shumardi* zone. Accordingly, this species ranges from the late Oligocene to middle Miocene.

This species has not been reported from Japan, however, the allied species, *A. (Acila) submirabilis* MAKIYAMA, and *A. (A.) iwadonozawensis* KANNO are known from the Tertiary system of the Chichibu Basin, central Japan (KANNO, 1960), and the Ashiya group in Kyushu (HATAI and NISIYAMA, 1952). These strata may represent some part of the "Aquitanian" age in Japan.

Localities:—81201, olive-green, fine-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green, silty sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 8341.

Acila (*Acila*) cf. *A.* (*A.*) *submirabilis* MAKIYAMA. 1926

Plate 1, fig. 2

1926. *Acila submirabilis* MAKIYAMA, Kyoto Imp. Univ. Mem. Coll. Sci., ser. B, no. 3, p. 151–153, pl. 12, fig. 9.
1928. *Nucula* (*Acila*) *mirabilis* var. *ashiyaensis* NAGAO, Tohoku Imp. Univ. Sci. Rep. ser. 2, vol. 12, no. 1, p. 21–22, pl. 7, figs. 6–10.
1931. ?*Nucula mirabilis* ADAMS et REEVE. KOMENKO, Geol. Proc. Ser. USSR, Tr., Fasc. 79, p. 65–66, pl. 10, fig. 3.
1934. *Acila* (*Acila*) *submirabilis* MAKIYAMA. SCHENCK, Mus. Roy. Hist. Nat. Belg., Bull., vol. 10, no. 20, p. 42.
1936. *Acila* (*Acila*) *divaricata* (HINDS) var. *submirabilis* MAKIYAMA. SCHENCK, Geol. Soc. Am., Spec. Pap., no. 4, p. 88–90, pl. 11, figs. 9–11; pl. 14, figs. 1, 5, 8–11; pl. 18, figs. 8, 9, 13–15; text-fig. 8.
1960. *Acila* (*Acila*) *submirabilis* MAKIYAMA. KANNO, Tert. Sys. Chichibu Basin, p. 190–192, pl. 31. figs. 3–7.

Remarks:—*A.* (*A.*) *divaricata* is characterized by the ribless escutcheonal area, whereas on *A.* (*A.*) *submirabilis* the escutcheon is sculptured by radial ribs.

The living species ranges from the southern part of central Japan to Celebes Island. The specimens are usually collected from 95–160 meters, where bottom temperature ranges from 12.5°–23.8°C (SCHENCK, 1936). The fossil species is reported from northern Korea (type locality), Japan, and the Gulf of Alaska. This species ranges from the upper Oligocene to Recent.

Locality:—81202, dark-gray mudstone, upper part of the Poul Creek formation.

Reg. No. TUE 8342.

Acila (*Acila*) sp.

Plate 1, fig. 3

Remarks:—Several specimens at hand are characterized by a rather low shell, and narrow apical angle, but most of the specimens are represented by internal moulds or are poorly preserved. Specific identification, therefore, is difficult.

Localities:—80905, olive-green, fine-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green silty sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 8343.

Subgenus *Truncacila* GRANT and GALE, 1931

Truncacila GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 115, 1931; *Truncacila* GRANT and GALE. SCHENCK, Geol. Soc. Am., Spec. Pap., no. 4, p. 23–24, 1936; *Truncacila* GRANT and GALE. MOORE, U.S. Geol. Surv. Prof. Pap. 419, p. 54, 1963; *Truncacila* GRANT and GALE. HICKMAN, Mus. Nat. Hist., Univ. Oregon. Bull., no. 16, p. 24; 1969; *Truncacila* GRANT and GALE. MOORE et al., Treat. Invert. Paleont., pt. N, p. 231, 1969.

Type-species (by original designation):—*Nucula castrensis* HINDS, Recent, Sitka, Alaska.

Remarks:—This subgenus is characterized by divaricating radial sculpture, but it lacks the rostrum on the posterior part of the ventral margin.

Geologic range:—Lower Cretaceous to Recent.

Acila (*Truncacila*) cf. *A.* (*T.*) *kamtschatica* ILYINA, 1964

Plate 1, fig. 8

1964. *Acila* (*Truncacila*) *kamtschatica* ILYINA, Moll. Neog. Kamchatka, p. 91, pl. 34, figs. 1-2.

Remarks:—This species was originally reported by ILYINA (1964, op. cit.) from the Etron formation (middle Pliocene) of Kamchatka, associated with *Swiftopecten swiftii* var. *etchegoini* (ANDERSON). This species is characterized by rather small shell for the genus, more or less roundly ovate in outline, a narrow apical angle, double divaricating radial ribs on the central part of disk, and rather distinct concentric growth lines which are densely crowded on the ventral margin.

This species seems to range from the Miocene to the Pliocene.

Locality:—20525-1, dark-gray, siltstone, lower part of the Yakataga formation.

Reg. No. TUE 8344.

Acila (*Truncacila*) *taliaferroi* SCHENCK, 1936

Plate 1, figs. 5, 6

1932. *Nucula* (*Acila*) *hamiltonensis* CLARK, Bull. Geol. Sci. Am., vol. 43, p. 806, pl. 14, figs. 11, 14.
1936. *Acila* (*Truncacila*) *taliaferroi* SCHENCK, Geol. Soc. Am., Spec. Pap., no. 4, p. 81.
1971. *Acila* (*Truncacila*) *taliaferroi* SCHENCK. ADDICOTT et al., U. S. Geol. Surv., Prof. Pap., 750-C, fig. 3, h, j.

Remarks:—This species was originally described by B. L. CLARK (1932), from the Yakataga District. Subsequently, the new name *A.* (*T.*) *taliaferroi* was introduced by SCHENCK (1936), because CLARK's name was preocupied by d'ORBIGNY's *Nucula hamiltonensis*, 1849. The present species is characterized by a shell which is small for the genus, secondary bifurcation which starts two-thirds of the distance from the beak and which is closely situated to the primary bifurcation, and having almost no radials on the gerontic stage where very fine concentric growth lines are developed.

The present species is more or less similar to *A.* (*T.*) *shumardi* (DALL) from Oligocene formations of California, Oregon and Washington, but the former differs from the latter by rather rough radial ornamentation and no radial ribs near the ventral margin in the gerontic stage. *A.* (*T.*) *empirensis* HOWE from the upper Miocene and Pliocene formations of Washington and Oregon (SCHENCK, 1936, p. 85-86, pl. 9, figs. 3, 4, 6-10, 12) is also similar to this species, but is distinguished by its larger size (about twice as large) and higher shell.

Locality:—80604, dark-gray or black mudstone, lower part of the Yakataga formation.

Reg. No. TUE 8345.

Superfamily Nuculanacea

Family Nuculanidae

Genus *Nuculana* LINK, 1807

Nuculana LINK, Beshr. Natur. Samml. Univ. Rost., Abth. 3, p. 155, 1807; *Nuculana* LINK. STOLICZKA, Mem. Geol. Surv. India, Paleont. 1871; *Nuculana* LINK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 118, 1931; *Nuculana* LINK. KEEN, Sea Shells Trop. West Am., p. 17, 1958; *Nuculana* LINK. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 27, 1969; *Nuculana* LINK. MOORE et al., Treat. Invert. Paleont., pt. N, no. 1, p. 235, 1969.

Type-species (by original designation):—*Arca rostrata* CHEMNITZ, [=*Arca pernula* MÜLLER, 1771], Recent, northern coast of Europe.

Remarks:—The characteristic features of the genus are the pointed posterior end, curved posterior dorsal margin, and the small and rounded pallial sinus. Most species of the genus are deeper water forms, and are characteristic of the cold northern waters.

Geographic distribution:—World-wide, abundant in cold seas.

Geologic range:—Triassic to Recent.

Subgenus *Borissia* SLODKEVICH, 1938

Borissia SLODKEVICH, Tertiary pelecypods, Far East, p. 79, 1938; *Borissia* SLODKEWITSCH. KRISCHTOFOVICH, Moll. Tert. Sakhalin. p. 69–70, 1964; *Borissia* SLODKEVICH. MOORE et al., Treat. Inver. Paleont., pt. N, vol. 1, p. 285, 1969.

Type-species:—*Nuculana alferovi* SLODKEVICH, Miocene of Sakhalin and Kamchatka.

Remarks:—This subgenus is characterized by the less rostrate shell with low, broad concentric ribs covering the median portion of valve.

Nuculana (*Borissia*) *alferovi sakhalinensis* KRISHTOFOVICH, 1964

Plate 1, figs. 19–22

1932. *Leda fossa* BAIRD. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 806, pl. 14, fig. 3.
1964. *Nuculana* (*Borissia*) *alferovi sakhalinensis* KRISHTOFOVICH, Tert. Moll. Sakhalin, p. 70, pl. 5, fig. 14.
1971. *Nuculana* (*Borissia*) *alferovi sakhalinensis* KRISHTOFOVICH. ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, fig. 3, i.

Description:—Shell small, elongate, convex beaks situated anteriorly, orthogyrous; postero-dorsal margin rather concave, and longer than the antero-dorsal one which is steeply down to the anterior border; posterior end narrow and truncated; anterior end short and evenly rounded; surface sculptured with distinct regular concentric growth lines which are more clear on the umbonal area and becoming obsolete toward the ventral margin; escutcheon long, smooth, and separated from the disk by a blunt ridge; a blunt ridge running from beak to postero-ventral corner making a small narrow area; an elongate process distinct on the middle of interior of posterior end; hinge with a small interior cartilage-pit, and numerous teeth on each side.

Measurements (in mm):—

Specimens	Length	Height	Thickness	H/L×100
No. 1	10.0	6.0	4.3	60.0
„ 2	9.9	6.2	4.2	62.6
„ 3	9.4	6.5	4.3	69.1
„ 4	9.0	6.3	4.6	70.0
„ 5	8.2	5.0	3.8	60.9
„ 6	7.3	5.0	3.0	68.4

Remarks:—This species is characterized by small and inflated valves which have distinct concentric sculpture. This species may be same as the CLARK's specimens identified as "*Leda fossa* BAIRD" (CLARK, 1932). However, *Nuculana fossa* (a Recent species living from Alaska to Puget Sound) is ornamented with only a few discernible concentric lines. Although eroded specimens of the present species do not clearly show such a concentric sculpture, it is very distinct on well-preserved specimens. Moreover, the present species differs from *N. fossa* by having small and inflated shell. The present species is also somewhat similar to *N.* (*N.*) *tatarica* KOGAN, 1936 (KRISHTOFOVICH, 1964, p. 56, pl. 4, figs. 14, 16, 18–20) from the upper Miocene Sertonai formation of Sakhalin, but it is distinguished by its smaller shell, more rostrated posterior margin and higher shell.

This species is characteristic in the black shale of the lower part of Yakataga formation and makes a horizon marker.

Localities:—80604, 80703, 80802, 81304, 20424-20, 20503-5, Sc-6*, Sc-8*, all consisted of black shale, lower part of the Yakataga formation.

Reg. No. TUE 8346.

Genus *Yoldia* MÖLLER, 1842

Yoldia MÖLLER, Index Molluscorum groenlandiae, p. 18, 1842; *Yoldia* MÖLLER. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 548, 1858; *Yoldia* MÖLLER. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 1, no. 1, p. 27, 1924; *Yoldia* MÖLLER. STEWART, Acad. Nat. Sci. Phila., Spec. Publ., no. 3, p. 59, 1930; *Yoldia* MÖLLER. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 126, 1931; *Yoldia* MÖLLER. HIRAYAMA, Sci. Rep. Tokyo Univ. Educat., sec. C, vol. 4, no. 29, p. 78, 1955; *Yoldia* MÖLLER. KANNO, Tert. Sys. Chichibu Basin, p. 198, 1960; *Yoldia* MÖLLER. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 58, 1963; *Yoldia* MÖLLER. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 31, 1969; *Yoldia* MÖLLER. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 239, 1969.

Type-species (by subsequent designation, ICZN, 1966):—*Nucula arctica* MÖLLER and GRAY, Recent, circumboreal region.

* Upper reaches of the Shokum Creek.

Remarks:—The present genus is closely related to the genus *Nuculana* LINK, 1807, but it can generally be distingished therefrom by the strong keel on the posterior dorsal margin, and by its gape at both ends.

Geographic distribution:—World-wide, especially, arctic and boreal regions.

Geologic range:—Cretaceous to Recent.

Subgenus *Yoldia* s. s.

Remarks:—This subgenus is characterized by an almost smooth surface excepting for the weakly developed concentric growth lines.

Yoldia (*Yoldia*) *takaradaiensis* KRISHTOFOVICH, 1954

Plate 1, figs. 13–15

1954. *Yoldia takaradaiensis* KRISHTOFOVICH, Tert. Moll. Fauna, South Sakhalin, p. 65, pl. 2, figs. 10–11.
1957. *Yoldia* (*Yoldia*) *akanensis* UOZUMI, Jour. Fac. Sci., Hokkaido Univ., ser. 4, vol. 9, no. 4, p. 550–551, pl. 4, figs. 1–3, 10.
1964. *Yoldia* (*Yoldia*) *takaradaiensis* KRISHTOFOVICH, BNIGRI, no. 232, p. 78–79, pl. 6, figs. 1–9.

Remarks:—This species was originally described by KRISHTOFOVICH (1954) from the Takaradi formation (Oligocene) of southern Sakhalin. According to his report, he recognized two forms, i. e., *Y.* (*Y.*) *takaradaiensis* forma *bruta* and *Y.* (*Y.*) *t.* forma *acuta*. The former one has a rather blunt posterior end, and the latter has a rather acute and rostrate posterior end. However, these two forms seem to intergrade and the present writer prefers to consider them as one species. UOZUMI (1957) reported *Y.* (*Y.*) *akanensis* from the Onbetsu formation of eastern Hokkaido. His specimens also show variation in outline of shell similar to the Takaradai specimens. *Y.* (*Y.*) *akanensis* may be represented by some varietal from of *Y.* (*Y.*) *takaradaiensis*.

Yakataga specimens at hand also show a rather broad range of variation, i. e., one is a rather low shell with a rostrate posterior end, but the other one has a distinctly higher shell with a blunt posterior end. However, there are many intermediate forms between these two extremes.

Localities:—80902, 81001, 81201, 81401, all fine-grained, olive-green sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8347.

Yoldia (*Yoldia*) *biremis* UOZUMI, 1957

Plate 1, figs. 16–17

1957. *Yoldia* (*Yoldia*) *biremis* UOZUMI, Jour. Fac. Sci., Hokkaido Univ., ser. 4, vol. 9, no. 4, p. 552–553, pl. 4, figs. 4–6, 12.
1968. *Yoldia* (*Yoldia*) *biremis* UOZUMI, KANNO, OHARA, and KAITEYA, Sci. Rep. Tokyo Univ. Education. sec. C, vol. 10, no. 94, pl. 1, fig. 1 (no description).

Remarks:—This species was originally reported from the Chikubetsu formation (middle Miocene) of Hokkaido, Japan (UOZUMI, 1957). It is characterized by an elongate shell and posteriorly situated, rather inconspicuous beaks. The present species ranges from the lower to middle Miocene in Hokkaido.

Localities:—81001, 81201, all olive-green, medium- to fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8348.

Subgenus *Cnesterium* DALL, 1898

Cnesterium DALL, Trans. Wagner Free Inst. Sci., Philad., pt. 4, p. 595, 1898; *Cnesterium* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 130, 1931; *Cnesterium* DALL. MOORE et al., Treat. Invert. Paleont., vol. 1, pt. N, p. 240, 1969.

Type-species (by original designation):—*Yoldia scissurata* DALL, 1898 [= *Y. ensifera* DALL, 1897], Recent, Arctic Ocean to Puget Sound, Washington.

Remarks:—The subgenus is characterized by surface ornamentation of obliquely incised and not inharmony with the growth lines. GRANT and GALE (1931, p. 130) believed that this character could not be relied upon as of systematic importance. However, the present writer inclines to believe that the oblique sculpture is a valid as subgeneric character.

This subgenus is widely distributed in temperate to cold waters. Subgenus *Cnesterium* ranges from the upper Miocene to Recent along the west coast of North America, but from the lower Miocene to Recent in Japan. It is also rather common in Sakhalin and Kamchatka, where it probably ranges from the upper Miocene to Recent, i. e., upper Miocene Sertonai and Okobikai formations (Sakhalin) and upper part of the Pachatinsk formation of the eastern Kamchatka, Pliocene Nutobo formation of Sakhalin and Etoron formation of Kamchatka yield some species of *Cnesterium*.

Yoldia (*Cnesteium*) *ensifera* DALL, 1897

Plate 1, figs. 10, 11

1897. *Yoldia ensifera* DALL, Nat. Hist. Soc. Brit. Col., Bull. no. 2, Art. 1, p. 9, pl. 2, fig. 4.
1898. *Yoldia scissurata* DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 595.
1924. *Yoldia ensifera* DALL. OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sc., vol. 1, no. 1, p. 32, pl. 5, fig. 3; pl. 37, fig. 6.
1924. *Yoldia scissurata* DALL. OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sci., vol. 1, no. 1, p. 31, pl. 5, fig. 2.
1931. *Yoldia scissurata* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 131, pl. 1, fig. 1.
1965. *Yoldia* (*Cnesterium*) *ensifera* DALL. HABE and ITO, Shells on the World (in clor), vol. 1, p. 106, pl. 34, fig. 22.

Remarks:—This species is characterized by having a rostrated posterior end and rather conspicuous beaks. *Y.* (*C.*) *strigata* DALL (1909, p. 104, pl. 14, figs. 9, 9a) is somewhat similar to the present species, but differs from the present one by having the truncated posterior end and higher shells.

Measurements (in mm.) :—

Specimens	Length	Height	Anterior portion	H/L×100	A/L×100
No. 1	13.4	6.5	6.4	46.4	47.7
" 2	22.5	10.5	11.5	46.6	51.1
" 3	18.7	9.0	9.0	48.1	48.1
" 4	30.6	14.3	13.7	46.7	44.7
" 5	35.8	19.0	20.8	53.0	58.0
" 6	37.3	18.5	21.5	49.5	57.6

A ··· Length measured from the beak to the anterior end of shell. Nos. 5–6 ··· *Y.* (*C.*) *strigata* DALL figured by WEAVER (1942, pl. 9, figs. 15, 20); No. 4 ··· *Y.* (*C.*) *scissurata* DALL figured by OLDROYD (1924, pl. 5, fig. 2).

This species has been reported from the Empire and Montesano formation (latest Miocene to Pliocene) and the living species distributes in the inner neritic north of California as well as Alaska.

Localities:—80802, 20503-5, 20523-3, black shale of the lower part of the Yakataga formation.

Reg. No. TUE 8349.

Yoldia (*Cnesterium*) *yakatagensis* KANNO, n. sp.

Plate 1, figs. 12, 18

Description:—Shell thin, rounded-ovate in outline, inequilateral, equivalve; beaks situated in almost central part of the shell; antero-dorsal margin gently arcuate and merging into the anterior border with a broad angle; postero-dorsal margin slightly concave, with a narrow, elongate and lanceolate escutcheon; lunule hardly developed; posterior end somewhat rostrate, almost pointed; posterior basal margin evenly arcuate merging into the broadly rounded basal one; surface ornamented with obscure incremental lines of growth and numerous sharp, slightly elevated, oblique ridges; these ridges run obliquely from the antero-dorsal part to the posterior-ventral border, and somewhat crowded at the umbonal area, but showing rather wider interspaces in the adult stage; oblique ridges somewhat flexous in the antero-ventral area.

Measurements (in mm) :—

Specimens	Length	Height	Thickness	H/L×100
Holotype	15.4	9.4	—	61.0
Paratype	18.1	11.4	—	62.9

Remarks:—This species is characterized by a rounded-ovate form. It is very similar to *Y.* (*C.*) *strigata* DALL (1909). However, the two taxa are easily distinguishable by their shell outline. The development of the oblique surface ornamentation may be slightly varying on each specimen, but it almost covers the disk except for the antero-dorsal part and on the rostrum.

Locality:—80802, rather massive black shale, lower part of the Yakataga formation.

Reg. No. TUE 8350 (holotype); TUE 8407 (paratype).

Yoldia sp.

Plate 1, fig. 9

Remarks:—An internal mould at hand is characterized by the transversely elongated lanceolate form, and an inconspicuous beak situated close to the central part of shell. This specimen is more or less similar to *Y. limatula* SAY (OLDROYD, 1924, p. 31, pl. 19, figs. 1, 1a–b), a living species ranging from the Arctic to San Diego, California, and into the Atlantic, but this specimen differs from the living one by a somewhat higher shell, and a more broadly rounded anterior margin. Moreover, according to GRANT and GALE (1931, p. 131), *Y.* (*Y.*) *limatula* may be one of the varietal forms of *Y.* (*Y.*) *scissurata* DALL, 1898 [=*Y. ensifera* DALL, 1897]. The present specimen is also somewhat similar to *Y.* (*Y.*) *biremis* UOZUMI, 1957, but it may be distinguished by the more posterior position of its beak.

This specimen may perhaps represent a new species, but a new name can not proposed until more well-preserved specimens are collected.

Locality:—81102, a float specimen, possibly from the upper part of the Poul Creek formation.

Reg. No. TUE 8408.

Subclass Cryptodonta

Order Solemyoida

Superfamily Solemyacea

Family Solemyidae

Genus *Solemya* LAMARCK, 1818

Solemya LAMARCK. Hist. Nat. Anim. Sans. Vert., vol. 5, p. 488, 1818; *Solemya* LAMARCK. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 482, 1858; *Solemya* LAMARCK. OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sci., vol. 1, no. 1, p. 9, 1924; *Solemya* LAMARCK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 109, 1931; *Solemya* LAMARCK. TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, no. 3, p. 100–102, 1933; *Solemya* LAMARCK. VOKES, Jour. Paleont., vol. 29, no. 3, p. 534–538, 1955; *Solemya* LAMARCK. KANNO, Tert. Sys. Chichibu Basin, p. 184, 1960; *Solemya* LAMARCK. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 51, 1963; *Solemya* LAMARCK. MOORE et al., Treat. Invert. Paleont., pt. N, p. 242, 1969.

Type-species (by subsequent designation, CHILDREN, 1823):—*Solemya mediterranea* LAMARCK, 1818, Recent, Adriatic and Mediterranean Seas, Atlantic Ocean of Spain, Madera, west Africa, and North Pacific Ocean.

Remarks:—This genus is characterized by an elongated solenshaped shell, a radially grooved surface sculpture, an epidermis which is extending beyond the ventral margin of the valve, and an edentulous hinge.

Species of this genus range from very small to large in size. It is noteworthy that large-sized species range from shallow water in boreal regions to deep water in tropical regions (DALL, 1908; KANNO, 1960).

Geographic distribution:—World-wide.

Geologic range:—Lower Paleozoic to Recent.

Subgenus *Acharax* DALL, 1908

Acharax DALL, Nautilus. vol. 1, no. 1, p. 1-2, 1908; *Acharax* DALL. TEGLAND, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 23, no. 3, p. 102, 1933; *Acharax* DALL. HABE, Gen. Jap. Shells, p. 17, 1951; *Acharax* DALL. KANNO, Tert. Sys. Chichibu Basin. p. 185, 1960; *Acharax* DALL. MOORE et al., Invert. Paleont., pt. N, p. 243, 1965.

Type-species (by original designation):—*Solemya johnsoni* DALL, Recent, deep water off Oregon to Panama.

Remarks:—The characteristic features of this subgenus are generally large-sized shell with an external and opisthodetic ligament.

Geographic distribution:—Pacific Ocean.

Geologic range:—Possibly lower Paleozoic to Recent.

Solemya (*Acharax*) *dalli* CLARK, 1925

Plate 1, fig. 1

1909. *Solemya ventricosa* CONRAD, REAGAN, Trans. Kans. Acad. Sci., vol. 22, p. 174, pl. 1, fig. 1.
1925. *Solemya dalli* CLARK, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 15, no. 4, p. 73. pl. 22, fig. 3.
1925. *Solemya tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 5, p. 31, pl. 6, figs. 1-3.
1933. *Solemya* (*Acharax*) *dalli* CLARK. TEGLAND, Univ. Calif. Pul., Bull. Dept. Geol. Sci., vol. 23, p. 103-104, pl. 4, figs. 1-10.
1942. *Solemya* (*Acharax*) *dalli* CLARK. WEAVER, Univ. Wash. Publ., vol. 5, pt. 1, p. 20-21, pl. 4, figs. 6-8; pl. 5, figs. 4-8.
1955. *Solemya dalli* CLARK. VOKES, Jour. Paleont., vol. 29, no. 13, p. 540.
1960. *Solemya* (*Acharax*) *dalli* CLARK. KANNO, Tert. Sys. Chichibu Basin, p. 186-187, pl. 31, fig. 1.

Remarks:—According to TEGLAND (1933, p. 103-104), topotypes of *S. dalli* show the following characters: "ligament external, parivincular, and opisthodetic. characteristics of the subgenus". However, VOKES (1955, p. 540) commented upon interior characters of specimens from the Keasey formation as follows; "there was also a considerable amount of the ligament that was internal and amphidetic in position, indicating its reference to *Solemya* (*Solemya*) of DALL's classification". Moreover, he noted that "there is also an internal rib supporting the condrophore and bounding the posterior adductor".

The present writer observed topotypes of *S. dalli*, but was unable to find any specimens with an amphiditic ligament and internal radial rib. Therefore the writer considers that *S. dalli* belongs to subgenus *Acharax* DALL, 1908. "*S. dalli*" described by VOKES (1955, p. 540) from the Keasey formation probably is a different species.

The present writer collected some specimens of *Solemya* from the type Keasey formation, but, unfortunately, was unable to find any one corresponded to specimens described by VOKES (1955, p. 540).

The present species seems to be restricted to the lower part of the Poul Creek formation of the Yakataga District from the dark-gray silty mudstone characterized by abundant calcareous concretions.

This species is very similar to *S.* (*A.*) *tokunagai* YOKOYAMA, 1925, from the Japanese Miocene (YOKOYAMA, 1925, p. 31, pl. 6, figs. 1-3). According to WEAVER (1942, p. 20), *S.* (*A.*) *dalli* has the length of the anterior dorsal margin averages about 75 percent of that of the shell, and the height of the shell is 35 percent of the length. The writer (1960, p. 186-187) discussed the distinction of *S.* (*A.*) *tokunagai* and *S.* (*A.*) *dalli* according to the results of WEAVER's measurements. However, the writer's measurement on topotypes of *S.* (*A.*) *dalli* from the Twin River formation, Restoration Point (type area of the Blakeley formation), and the Lincoln formation, show the following values;

Localities	Length	Height	Length of antero-dorsal border	H/L × 100	Ad/L × 100
Twin River	49.4	16.2	34.2	32.7	69.4
Restration Point	62.5	17.2	45.0	27.5	72.0
Lincoln formation	46.8	17.0	35.4	36.4	75.6
Poul Creek formation	64.0	19.0	45.7	28.1	71.4

Ad … The length of antero-dorsal border.

According to these data, although based on very few specimens, it seems clear that these ratios are considerably variable. In addition such inclination is very distinct on individual of *S.* (*A.*) *tokunagai* as already reported (KANNO, 1960). Namely, the ratios of height to length and the anterior portion to length of *S.* (*A.*) *tokunagai* range from 24.2 or 33.5 and from 74.7 to 77.3. These ratios are almost the same as those for *S.* (*A.*) *dalli*. So far as the form ratio is concerned, *S.* (*A.*) *tokunagai* can not be distinguished from *S.* (*A.*) *dalli*. The present writer feels that these species can not be distinguished and he is inclined to consider them conspecific.

This species distributes in Puget Sound Basin, and north slope of the Olympic Peninsula, Washington, and the Gulf of Alaska area in the west coast of N-America, and ranges from upper Oligocene to Miocene.

Localities:—80906, 81203 black mudstone, lower part of the Poul Creek formation.

Reg. No. TUE 8409.

Subclass Pteriomorphia

Order Arcoida

Superfamily Arcacea

Family Arcidae

Genus *Anadara* GRAY, 1847

Anadara GRAY, Proc. Zool. Soc. London, vol. 15, p. 198, 1847; *Anomalocardia* (KLEIN) H. and A. ADAMS, Gen. Rec. Moll., vol. 3, p. 535–536 (type species not designated. *Arca antiquata* LINNÉ cited as an example), 1858; *Arca* s.s. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 137, 1931; *Anadara* GRAY. REINHART, Mus. roy. d'Hist. nat., Belg., Bull., T. 11, no. 13, p. 39, 1935; *Anadara* GRAY. SCHENCK and REINHART, ditto, Mem. 2nd ser., fasc. 14, p. 10, 1938; *Anadara* GRAY. HABE, Gen. Jap. Shells, p. 36, 1951; *Anadara* GRAY. KANNO, Tert. Sys. Chichibu Basin, p. 203, 1960; *Anadara* GRAY. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 59, 1963; *Anadara* GRAY. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 33, 1969; *Anadara* GRAY. MOORE et al., Treat. Invert. Paleont., pt. N, p. 254, 1969.

Type-species (by original designation):—*Arca antiquata* LINNÉ, Recent, eastern America, probably West Indies.

Remarks:—The genus is characterized by a rotund and moderately heavy shell ornamented with strong costae which correspond to crenulations on the internal shell margin, and narrow cardinal area with an almost straight series of taxodont teeth.

Geographic distribution:—World-wide, generally in warm waters.

Geologic range:—Upper Cretaceous to Recent.

Subgenus *Anadara* s. s.

1969. *Anadara* (*Anadara*) GRAY. MOORE et al., Treat. Invert. Paleont., pt. N, p. 254.

Remarks:—This subgenus is characterized by a thick, equivalved shell, a more or less produced posterior margin, and radial ribs which are almost flat and sometimes bear shallow grooves.

Anadara (*Anadara*) sp.

Plate 1, figs. 23, 24

Remarks:—There are many poorly preserved specimens of *Anadara* in the collection. The specimens figured in this report definitely belong to the genus *Anadara* GRAY, 1847, but most are strongly deformed making it difficult to determine the natural form. However, the present specimens are clearly equivalved and inequilateral, and they have about twenty-four radial ribs which are almost as wide as their interspaces. The radial ribs are slightly grooved, rather squarish in cross section, and more or less granular near the ventral margin where they are sculptured with fine concentric growth lines.

The specimens are similar to *Anadara osmonti* (DALL), (REINHART, 1943, p. 50–53, pl. 4, figs. 9, 11–17; pl. 6, fig. 4; pl. 10, figs. 12, 15), but differ from the latter by having fewer radial ribs. Moreover, the present specimens have a lower shell than *A. osmonti* (DALL). *A. mediaimpressa mediaimpressa* (CLARK) (REINHART, 1943, p. 39, pl. 4, figs. 1, 5, 6) is more or less related to the present specimens, but differs in having a larger number of radials and a higher shell. Present specimens are more closely related to *A. mediaimpressa submontereyana* (CLARK), (REINHART, 1943, p. 40, pl. 4, fig. 7). Typical form of the latter has twenty-four radial ribs, but it seems to be more higher shell than the present one.

The specimens figured in this report may be apparently represent a new species, but the state of preservation does not permit to establish a new species until better preserved materials are collected.

It is noteworthy that the Recent species of genus *Anadara* range no farther north than the Gulf of California, Mexico. Moreover, the Tertiary species of genus *Anadara* occurred from the west coast of North America are also restricted south of Oregon from where *Anadara*? sp. c was reported by SCHENCK and REINHART (1938, p. 40) and REINHART (1943, p. 83, pl. 4, fig. 10) from the Eugene formation (Oligocene). The present locality represents, therefore, the northernmost limit of distribution in the Tertiary formations along the west coast of North America.

EAMES (1967, p. 303) pointed out that *A.* (*Scapharca*) appeared prior to *Anadara* (*Anadara*) and he rejects all claims that *Anadara* (*Anadara*) occurs in the Oligocene.

In the western Pacific, Recent species of *Anadara* (*A.*) occurs no farther north than lat. 31°N (south of Tanegashima Island, Japan), but *Anadara* (*Scapharca*) is restricted to south of lat. 41°N. Fossil species of *Anadara* (*A.*) may be represented in the early Neogene (or Aquitanian age) of Japan where *A.* (*A.*) *chichibuensis* KANNO occurs associated with subtropical gastropods such as *Conus* sp. In middle Miocene *A.* (*A.*) increases both in the number of species and individuals, and they range as far north as the northern part of Hokkaido. It occurs in southern Sakhalin in the upper Miocene and reached Kamchatka in the Pliocene (ILYINA, 1963).

Locality:—20503-19, olive-green, medium-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 8410.

Order Mytiloida

Superfamily Mytilacea

Family Mytilidae

Genus *Modiolus* LAMARCK, 1799

Modiolus LAMARCK, Mém. Soc. Hist. Nat. Paris, vol. 1, p. 87, 1799; *Modiolus* LAMARCK. DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 790-791, 1898; *Volsella* SCOPOLI. STEWART, Acad. Nat. Sc., Phila., no. 3, p. 98-99, 1930; *Volsella* SCOPOLI. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 248, 1931; *Volsella* SCOPOLI. ABBOTT, American Seashells, p. 351, 1954; *Modiolus* LAMARCK. PALMER, Geol. Soc. Amer., Mem., 79, p. 73, 1958; *Modiolus* LAMARCK. KANNO, Tert. Sys. Chichibu Basin, p. 209, 1960; *Modiolus* LAMARCK. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 63, 1963; *Modiolus* LAMARCK. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull., no. 16, p. 34, 1969; *Modiolus* LAMARCK. MOORE et al., Treat. Invert. Paleont., pt. N, p. 278, 1969.

Type-species (by subsequent designation, GRAY, 1847):—*Mytilus modiolus* LINNÉ, Recent in northern seas.

Generic diagnosis:—Shell small to large, obliquely oblong, thin, expanded posteriorly and inflated along an oblique medial line from the umbonal end to the posterior ventral margin; anterior end of the shell extends in front of the beak; hinge edentulous in adult (KANNO, 1960).

Geographic distribution:—World-wide.
Geologic range:—Possibly lower Paleozoic to Recent.

Modiolus sp.

Plate 17, figs. 3, 4

Description:—Shell very thin, rather small, somewhat elongate, interior surface nacreous; hinge line nearly straight and about two-thirds the length of shell; postero-dorsal margin broadly arcuate merging gradually into a rather narrowly rounded posterior border; ventral margin almost straight or very slightly convex making a narrowly rounded small circle with the posterior margin; anterior margin is slightly extending from the beak; beak low, pointed anteriorly, situated very near the anterior end; a blunt umbonal ridge runs from the beak to the posterior-ventral margin, becoming less conspicuous at the posterior end; surface ornamented with weakly developed concentric lines of growth.

Measurement (in mm):—

Specimens	Maximum length*	Width**	Thickness	Valve
No. 1	27.7	4.8	4.7	Left
„ 2	ca.45.0	22.4	ca.7.0	„
„ 3	ca.44.0	ca.22.0	ca.7.0	„

* Measured from beak to the postero-ventral margin.
** Measured at the posterior angulation.

Remarks:—The present specimens are somewhat similar to *M. porterensis* CLARK (1925, p. 85, pl. 9, fig. 11) from the Oligocene Lincoln formation of Chehalis River Valley, Washington, which differs by having a more strongly arcuate anterior ventral margin. *M. restorationensis* VAN WINKLE (WEAVER, 1942, p. 109, pl. 24, figs. 10-11) is also more or less similar to *Modiolus* sp., but differs by the broader posterior part measured at the posterior angulation, more narrowly rounded posterior dorsal-ventral corner, and slightly arcuate ventral margin.

Localities:—80906, 81404, lower part of the Poul Creek formation.

Reg. No. TUE 8411.

Genus *Crenella* BROWN, 1827

Crenella BROWN, Illus. Conchol. Great Britain. vol. 1, p. 31, fig. 12-14, 1827; *Crenella* BROWN. DALL, Trans. Wagner Free Inst. Sci,, vol. 3, p. 801-802, 1897; *Crenella* BROWN. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 254, 1931; *Crenella* BROWN. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 63, 1963; *Crenella* BROWN. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 33, 1969; *Crenella* BROWN. MOORE et al., Treat. Paleont., pt. N, vol. 1, p. 275, 1969.

Type-species (by monotypy):—*Mytilus decussatus* MONTAGU, 1808, Recent, Scottish coast.

Remarks:—This genus is characterized by a small- to medium-sized shell with prothogyrous or orthogyrous beaks, surface sculpture of radial ribs which are sometimes cancellated by concentric striae, denticulate cardinal border, and crenulated inner ventral margin.

This genus distributes widely from boreal to tropical seas mainly off-shore ranging from 4 to 500 meters in depth.

Geographic distribution:—World-wide.

Geologic range:—?Cretaceous to Recent.

Crenella porterensis WEAVER, 1912

Plate 1, fig. 27

1912. *Crenella porterensis* WEAVER, Wash. Geol. Surv., Bull., vol. 15, p. 18, pl. 14, fig. 116.
1916. *Crenella porterensis* WEAVER, Univ. Wash. Publ. Geol., vol. 1, p. 36–37, pl. 3, figs. 41–42.
1933. *Crenella porterensis* WEAVER. TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, p. 112, pl. 4, fig. 2.
1942. *Crenella porterensis* WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 115–116, pl. 25, figs. 3, 14.

Remarks:—Only two specimens are at hand. The present species was originally reported by WEAVER (1912) from the Lincoln formation (middle Oligocene) in Washington. Subsequently, TEGLAND (1933) reported it from the type Blakeley formation (late Oligocene to early Miocene) in Washington. This species is characterized by a subrectangular-ovate outline and fine, well developed dichotomous radial ribs.

Though the present genus ranges from tropical to boreal waters in the Pacific and the Atlantic Oceans, these species are rather common in temperate to cold waters.

Localities:—81201, 80905, olive-green, medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8412.

Order Pterioida

Superfamily Pectinacea

Family Pectinidae

Genus *Delectopecten* STEWART, 1930

Delectopecten STEWART, Acad. Nat. Sci. Phila., Spec. Publ. no. 3, p. 118–119, 1930; *Delectopecten* STEWART. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 354, 1969.

Type-species (by original designation):—*Pecten* (*Pseudamusium*) *vancouverensis* WHITEAVES, 1893, Recent, Vancouver Island, Canada.

Remarks:—This genus is characterized by a thin and delicate shell which has radial or reticulate surface ornamentation, and on which the posterior ear is not differentiated.

This genus is somewhat similar to *Hyalopecten* VERRILL, 1897, which differs in having more distinct undulations and in almost lacking the reticulate surface ornamentation.

The living species of this genus seem to be muddy bottom dwellers usually restricted to depths greater than 20 meters and are more common in depths greater than 200 meters.

Geographic distribution:—Northern Pacific region, northern Europe, and Australia.

Geologic range:—Upper Eocene to Recent.

Delectopecten peckhami (GABB), 1869

Plate 17, fig. 5

1869. *Pecten peckhami* GABB, Pal. Calif. vol. 2, p. 59, pl. 16, figs. 19, 19a.
1906. *Pecten* (*Pseudamusium*) *peckhami* GABB. ARNOLD, U. S. Geol. Surv. Prof. Pap., 47, p. 56, pl. 3, figs. 6–8.
1930. *Palliolum* (*Delectopecten*) *peckhami* (GABB). STEWART, Acad. Nat. Sci. Phila., Spec. Pap., no. 3, p. 119–120, pl. 13, fig. 4.
1938. *Hyalopecten* (*Delectopecten*) *peckhami* (GABB). WOODRING, U. S. Geol. Surv. Prof. Pap., 190, p. 35–40.
1954. *Palliolum* (*Delectopecten*) *peckhami* (GABB). OMORI and UTASHIRO, Shinseidai-no-kenkyu (The Study of Cenozoic), no. 19, p. 1–10, pl. 1, figs. 1–3, 10–12; pl. 2, figs. 1–7; pl. 3, fig. 1.
1957. *Palliolum peckhami* (GABB). UTASHIRO, Bull. Faculty of Educat., Niigata Univ., Takada, no. 1, p. 161–174, pl. 1–4.
1958. *Palliolum peckhami* (GABB). UTASHIRO, Jub. Publ. Commemorat. Prof. H. FUJIMOTO Sixtieth Birthday, p. 320–326, pl. 12–14.
1964. *Delectopecten peckhami* (GABB) of ARNOLD. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 67–68, pl. 18, figs. 2, 3; pl. 20, figs. 1, 3–5; pl. 21, fig. 2.

Remarks:—Many specimens from the calcareous concretions in the Yakataga formation are at hand, but they are so crowded that it is rather difficult to find the complete specimens. This species is characterized by small and thin shell with fairly weak concentric undulations. Most of the right valves in the collections have almost smooth shells excepting for concentric undulations. The surface ornamentation of left valve is inaccessible. The largest specimen at hand is 16.0 mm in length, 16.2 mm in height, and 6.4 mm along the hinge line.

The present species is widely distributed in Japan, Sakhalin, and Kamchatka ranging in age from Oligocene to Pliocene. UTASHIRO (1957, 1958) and OMORI and UTASHIRO (1954) studied the Japanese *Delectopecten peckhami* from the evolutionary standpoint of view. According to their results, the size of present species seems to have increased from the Miocene to the Pliocene; the present specimens are similar to their middle Miocene type*.

Locality:—20459-24, calcareous concretion in dark-gray mudstone, the Yakataga formation of southern point of Wingham Island.

Reg. No. TUE 8413.

Genus *Swiftopecten* HERTLEIN, 1936

* Utashiro (1958) calculated the value of (Length × Height/2). According to his results, the middle Miocene form shows values of about 120, as almost the same as the present one's 128.

Swiftopecten HERTLEIN, California Acad. Sci. Proc., 4th ser., vol. 21, no. 25, p. 319, 1936; *Swiftopecten* HERTLEIN. MACNEIL, U. S. Geol. Surv., Prof. Pap., 553, p. 11, 1967; *Swiftopecten* HERTLEIN. MOORE et al., Treat. Invert. Paleont., pt. N, p. 363, 1969.

Type-species (by original designation):—*Pecten swiftii* BERNARDI, 1858, Recent, Japan.

Remarks:—This subgenus is characterized by being inequivalved, and having strong, more or less prominently folded radial ribs; four in the right valve and five in the left valve.

Geographic distribution:—Northern Pacific region.

Geologic range:—Miocene to Recent in Japan; upper Miocene to middle Pliocene in California.

Swiftopecten donmilleri (MACNEIL), 1967

Plate 1, figs. 25, 26

1967. *Chlamys* (*Swiftopecten*) *donmilleri* MACNEIL, U. S. Geol. Surv. Prof. Pap., 553, p. 12, figs. 1, 4, 6.

Remarks:—This species was originally described by MACNEIL (1967) from the Yakataga formation of southeastern Alaska. The present specimens were collected from the dark-gray to rather black, sandy siltstone containing scattered granule- or pebble-sized pebbles near the base of the Yakataga formation near the type locality. The present specimens are represented by an incomplete right valve and other valves from which the umbonal part is missing. They are characterized by strongly plicated sculpture. This species is closely related to *S. swiftii* (BERNARDI, 1858), an extant species in the northern Pacific regions, but its strongly plicated and nodulose radial ribs serve to distinguish it from the living species. However, *S. swiftii* is rather variable in outline and radial ribbing, then it would be desirable to study specific variation within their species.

Localities:—81105, 81403, dark-gray, sandy siltstone, lower part of the Yakataga formation.

Reg. No. TUE 8414.

Genus *Miyagipecten* MASUDA, 1952

Miyagipecten MASUDA, Trans. Proc. Paleont. Soc. Japan, N. S., no. 8, p. 251, 1952; *Miyagipecten* MASUDA, Sci. Rep. Tohoku Univ., 2nd ser., vol. 33, no. 2, p. 226, 1962; *Miyagipecten* MASUDA. MACNEIL, U. S. Geol. Prof. Pap., 553, p. 44, 1967; *Miyagipecten* MASUDA. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 360, 1969.

Type-species (by original designation): *Miyagipecten matsumoriensis* MASUDA, 1952, Miocene Nanakita formation of Miyagi Prefecture, northern Honshu (main island of Japan).

Remarks:—This genus has no radial ribs and concentric sculpture on the right valve and radial ribs in the younger stage of the left which tend to become obsolete in the adult stage. Moreover, this genus has prominent auricular crurae and lacks internal ribs.

Geographic distribution:—Northern Honshu, Hokkaido, Alaska Peninsula, and the Yakataga District.

Geologic range:—Middle Miocene in Japan, and Miocene to lower Pliocene in Alaska.

Miyagipecten sp.

Plate 5, figs. 2, 3

Remarks:—Several specimens have been examined, but most are too poorly preserved to determine specifically. However, the right valve has no sculptures excepting fine concentric growth lines, and has auricles which show a rather distinct gape anteriorly. The left valve is sculptured with fine radial ribs in the juvenile stage, but they tend to become obsolete in the adult. The interior surfaces of both valves are almost smooth with no visible radial ribs or threads. These characters may be sufficient to assign the present specimens to *Miyagipecten* MASUDA 1952, although the present specimens are too poorly preserved to allow specific determination.

The present specimens occur in pebble-sized conglomerate (about 30–70 cm in thickness) which interbedded in alternating sandstone and black shale (Text-fig. 8).

Locality:—80904, pebble-sized conglomerate, lower part of the Yakataga formation.

Reg. No. TUE 8415.

Genus *Vertipecten* GRANT and GALE, 1931

Vertipecten GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 188, 1931; *Vertipecten* GRANT and GALE. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 66, 1963; *Vertipecten* GRANT and GALE. MACNEIL, Prof. Pap., 553, p. 38. 1967. *Vertipecten* GRANT and GALE. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 364, 1969.

Type-species (by original designation):—*Pecten nevadanus* CONRAD. Early and middle Miocene of California.

Remarks:—This genus is characterized by much greater inflation of the left valve over its right valve. Primitive species of the genus have weakly inflated left valves and fine ribs, but the more advanced species of the genus have strongly inflated left valves and very coarse ribs similar to *Patinopecten*. The more finely ribbed primitive species are similar to *Chlamys*, which usually has finely reticulate or metal lath-like microsculpture.

The genus *Vertipecten* is peculiar to western North America. As already pointed out by MACNEIL (1967), it is noteworthy from the standpoint of zoogeography that this genus has not been reported from the Asiatic side of the Pacific, though it was widespread and flourished during the Miocene in the west coast of North America.

Geographic distribution:—West coast of North America.

Geologic range:—Lower Miocene in California.

Vertipecten sp.

Plate 2, fig. 4

Description:—Shell of medium size and moderately inflated; left anterior ear rather long and very borad, sinus weak on the anterior margin; left posterior ear short, steeply sloping at its margin; anterior dorsal margin somewhat longer than the postero-dorsal one; hinge line straight, as long as about three-fifths of the length of shell; surface covered with reticulate microsculpture and with about seventeen radial ribs, of which four radials are distinctly stronger than the others; these four strong radials are round-topped, and intercalated with two rather weak radials which are almost roof-shaped in section; all of the interspaces are wider than the width of radial ribs.

Remarks:—A single external mould of a left valve and its rubber cast are at hand. The present specimen is similar to *Vertipecten* n. sp.? (MACNEIL, 1967, p. 40, pl. 2, fig. 2) from middle Oligocene strata of Chichagof Bay, Alaska Peninsula, but it differs by having a narrower apical angle and four distinct strong radial ribs in the left valve.

Locality:—81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8416.

Genus *Patinopecten* DALL, 1898

Patinopecten DALL, Trans. Wagner Free Inst. Sci., Phila., vol. 3, p. 695, 1898; *Patinopecten* DALL. ARNOLD, U.S. Geol. Surv., Prof. Pap., 47, p. 48–49, 1906; *Patinopecten* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 192, 1931; *Patinopecten* DALL. KANNO, Tert. Sys. Chichibu Basin, p. 220, 1960; *Patinopecten* DALL. MACNEIL, U.S. Geol. Surv. Prof. Pap., 354–J, p. 225–227, 1961; *Patinopecten* DALL. MASUDA, Sci. Rep. Tohoku Univ., Ser. 2, vol. 33, no. 2, p. 203, 1962; *Patinopecten* DALL. MOORE, U.S. Geol. Surv., Prof. Pap., 419, p. 63–64, 1963; *Patinopecten* DALL. MACNEIL, U.S. Geol. Surv., Prof. Pap., 553, p. 40, 1967; *Patinopecten* DALL. MOORE et al., Treat. Invert. Paleont., pt. N, p. 370, 1969.

Type-species (by original designation):—*Pecten caurinus* GOULD, Recent, Wrangell, Alaska, to Humboldt Bay, California.

Remarks:—This genus is characterized by its large, circular outline, and almost equivalve, low convex shells which have radial sculpture consisting of distinct ribs without minor striation, though sometimes with microscopic cross-hatching. Moreover, ribs of the right valve are comparatively broad and squarish whereas those of the left valve are narrow and roof-shaped in cross section.

This genus is distinguished from *Mizuhopecten* MASUDA, 1963, (MASUDA, 1963, p. 151) by having auricular crurae, narrow and rather squarish radial ribs in cross section, rather small auricles and a narrow and deep byssal notch.

This genus is particularly characteristic of the Pacific coast fauna from the Miocene to the present day.

Geographic distribution:—Northern Pacific region.

Geologic range:—Miocene to Recent.

Subgenus *Lituyapecten* MACNEIL, 1961

Lituyapecten MACNEIL, U. S. Geol. Surv. Prof. Pap., 354-J, p. 227, 1961; *Lituyapecten* MACNEIL, U. S. Geol. Surv. Prof. Pap., 553. p. 41, 1967; *Lituyapecten* MACNEIL. MOORE et al., Treat. Invert. Paleont., pt. N, p. 371, 1969.

Type-species (by original designation):— *Patinopecten* (*Lituyapecten*) *lituyaensis* MACNEIL, late Miocene (?), Lituya Bay, Alaska.

Remarks:—The present subgenus is characterized by medium to large shells with an elongated anterior ear on the right valve, and rather strong radial ribs which tend to be undercut on the sides, flat to rounded or irregular on top, and are sculptured with thin concentric raised lines (in juveniles) and scales on the left valve of adults.

This subgenus is a typical pectinid of the west coast of North America, but it has never been found on the Asian side. It ranges from middle to late Miocene, and possibly early Pliocene in Alaska, and from the middle Miocene to the Pliocene in California.

Patinopecten (*Lituyapecten*) *lituyaensis* MACNEIL, 1961

Plate 2, fig. 1; Plate 3, fig. 3; Plate 5, fig. 1

1961. *Patinopecten* (*Lituyapecten*) *lituyaensis* MACNEIL, U. S. Geol. Surv. Prof. Pap., 354, p. 231-233, pl. 29, figs. 1, 3; pl. 40, figs. 1-5; pl. 41, fig. 1; pl. 42, figs. 1, 2, 4; pl. 43, figs. 1-4.

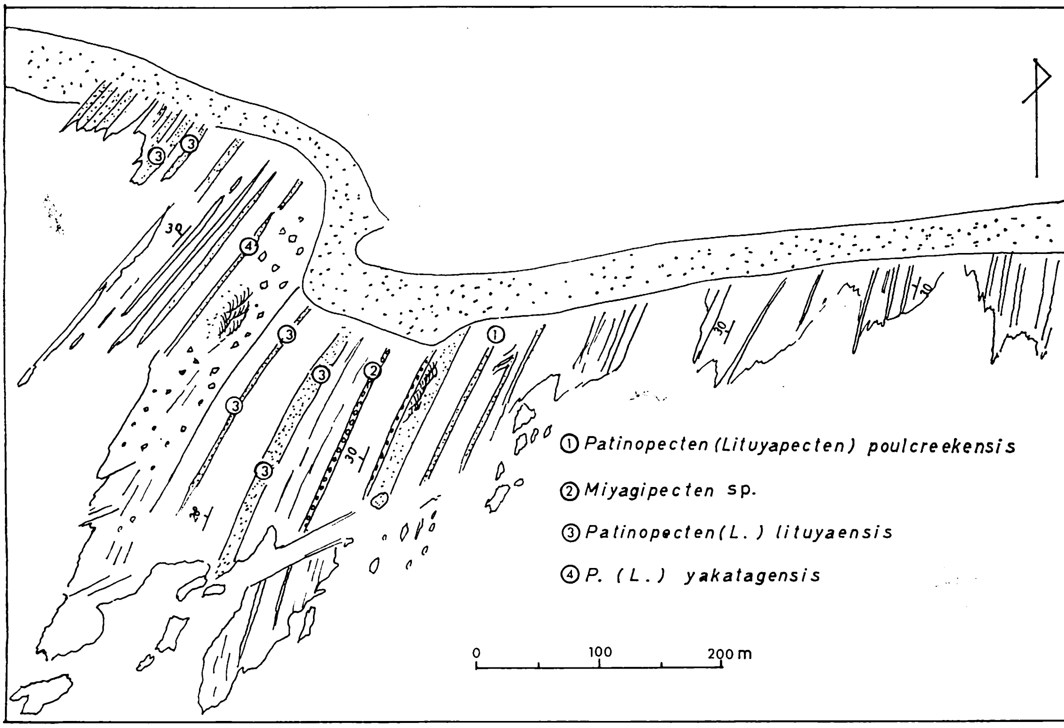
Remarks:—The present species is characterized by large, prosocline shells with 23 or 24 broad radial ribs which have frills on the both sides of ribs of the left valve. According to MACNEIL's original description, the present species is prosocline in form, but the holotype of this species (MACNEIL, 1961, pl. 39, fig. 1) is opisthocline. However, on specimens collected by the writer from Yakataga Reef the inclination of the median lines is variable, e. g., some specimens are strongly opisthocline (Pl. 2, fig. 1), but others are almost acline or prosocline. Therefore, it is not certain, whether the opisthocline shell of the holotype (MACNEIL, 1961) is an extreme variant or whether its shape is due to deformation after the deposition.

The present species occurs in both the lower sandstone-siltstone unit and the upper mudstone unit of late Miocene(?) and (or) early Pliocene of the Lituya Bay district, Alaska. However, it occurs abundantly in medium-grained sandstones (1-10 meters in thickness, loc. 80506) with dark-gray or black shale of the Yakataga formation (about 114 meters above the base of the Yakataga formation, Text-fig. 8). The phylogeny and the geologic range of the present species will be descussed under remarks on *P.* (*L.*) *poulcreekensis* (MACNEIL).

This species seems to be restricted to the Yakataga formation of the Yakataga and Lituya Bay districts.

Localities:—80404, 80405, 80406, 80505, 80506, all from medium-grained sandstone interbedded with dark-gray or black shale in the lower part of the Yakataga formation.

Reg. No. TUE 8417.



Text-fig. 8. Pectinid fossil localities in the Yakataga Reef.

Patinopecten (*Lituyapecten*) *yakatagensis* (CLARK), 1932

Plate 3, figs. 1, 2; Plate 6, fig. 3

1932. *Pecten* (*Patinopecten*) *yakatagensis* CLARK, Geol. Soc. Am. Bull. vol. 43, no. 3, p. 807, pl. 15, fig. 8; pl. 16, fig. 1.
1961. *Patinopecten* (*Lituyapecten*) *yakatagensis* (CLARK). MACNEIL, U. S. Geol. Surv. Prof. Pap., 354. p. 229-231, pl. 37, figs. 1-7; pl. 38, figs. 4, 6; pl. 39, fig. 2; pl· 41, figs. 2(?), 3; pl. 42, fig. 3.
1971. *Patinopecten* (*Lituyapecten*) *yakatagensis* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, fig. 3, p, q.

Remarks:—This species was originally described by CLARK (1932) from the Tertiary of the Yakataga District. Subsequently, MACNEIL (1961) re-examined this species and gave a detailed description of it. The characteristic features of the present species are its medium-sized, suborbicular shell sculptured with 26 to 31 radial ribs which are subrounded in juveniles but become flattened or bear a median groove in adults, and the well-defined denticles on both sides of left valve. Moreover, the present species is characterized by having two rows of frills or flanges on the radial ribs of the central parts of the left valve, but the both ribs of the anterior and posterior margins have only a single frill. The interspaces have rarely a scale-like interstitial riblet.

This species is rather similar to *Patinopecten* (*L.*) *lituyaensis* MACNEIL, 1961, but differs by having a large number of radial ribs. In addition, the radial ribs on the left valve of the latter sometimes have or bear a strong third beaded riblet on some of the middle ribs.

Localities:—7011-68, medium-grained sandstone, about 420 meters above the base of the Yakataga formation in the Duktoth Mountains, the lower part of the Yakataga formation; 81001, float specimens in the upper reaches of Poul Creek; 80503, fine-grained sandstone, Yakataga formation.

Reg. No. TUE 8418.

Patinopecten (*Lituyapecten*) *poulcreekensis* MACNEIL, 1961

Plate 2, figs. 2, 3

1961. *Patinopecten* (*Lituyapecten*) *poulcreekensis* MACNEIL, U. S. Geol. Surv. Prof. Pap., 354, p. 228-229, pl. 35, figs. 1-6; pl. 36, figs. 1, 2 (?), 3, 4, 6, 7; pl. 38, fig. 2.

Remarks:—This species was originally described by MACNEIL (1961) from the uppermost part of the Poul Creek formation* at Yakataga Reef.

This species is characterized by having about 23 strong radial ribs and frilled interstitial ribs. It is rather similar to *P.* (*L.*) *yakatagensis* (CLARK) (1932) from the same district, but the number of radial ribs and development of interstitial ribs serve to distinguish it from the latter. *P.* (*L.*) *lituyaensis* is an allied species, but it differs from the present one by having no interstitial ribs on the right valve, or rarely, very weakly developed ones. Moreover, the terminal ribs at both ends of the right valve of the *P.* (*L.*) *poulcreekensis* may have weak frills along one side or a single frill extending entirely across them.

The type locality of this species is USGS locality M271 on Yakataga Reef, along the strike of a bed that intersects the shoreline at a point "700 feet N. 30°E of the highest rock on the reef" (MACNEIL, 1961, p. 246). (Text-fig. 8).

The holotype of the present species is from the light brown, medium-grained sandstone (about 3 meters in thickness) which crops out about 40 meters east of a thick sandstone. *P.* (*L.*) *poulcreekensis* has never been collected from below this sandstone, indicatingly that this sandstone is the lowest limit of occurrence of this species as well as other large pectinids in this area.

The present species was also collected by KENNETH CIRIACKS and ALAN ORMISTON of Pan American Oil Co., from the eastern slope of the Ductoth Mountain where rather light brown, medium-grained sandstone occurs about 460 meters above the base of the Yakataga formation. This specimen, though it represented by a fragment of right valve, has the characteristic features of *P.* (*L.*) *poulcreekensis* (pl. 2, fig. 2); namely, the frilled main radials and distinct interstitial ribs are clear. Moreover, it is noteworthy that the present specimen occurs from about 38 meters higher stratigraphic occurrence of *P.* (*L.*) *yakatagensis* in the Ductoth Mountain.

The relationship between *P.* (*L.*) *poulcreekensis*, *P.* (*L.*) *yakatagensis*, and *P.* (*L.*) *lituyaensis* had been pointed out by MACNEIL (1961, p. 232-233). According to his opinion, *yakatagensis* was probably the direct ancestor of *lituyaensis*, and the latter

* This is the type locality (USGS loc. M271) of this species, but the locality is included in the lower part of the Yakataga formation by the writer (fig. 2, 8).

species occurs in beds believed to be equivalent to the upper part of the Yakataga formation, but so far no representatives of *Lituyapecten* are known from the highest part of the Yakataga formation (MACNEIL, 1961, p. 230–231). He also pointed out that *P.* (*L.*) *poulcreekensis* occurred abundantly only in the uppermost part of the Poul Creek formation at Yakataga Reef, and that it ranges into beds equivalent to the lowest part of the Yakataga formation, and was presumably coexisted with the earlist specimens of *P.* (*L.*) *yakatagensis*.

The present writer examined in detail the occurrence of *Patinopecten* (*Lituyapecten*) along the shoreline at Yakataga Reef, where the Poul Creek and the Yakataga are continuously well exposed. *P.* (*L.*) *poulcreekensis* seems to be restricted to sandstone in the lowest part of the Yakataga including USGS locality M271 and 17733. However, *P.* (*L.*) *yakatagensis* and *P.* (*L.*) *lituyaensis* have not yet been recorded from this horizon, but they have been collected from higher horizons (Text-fig. 8), where *P.* (*L.*) *lituyaensis* occurs abundantly whereas *P.* (*L.*) *yakatagensis* is very rare. According to MACNEIL (1961, p. 231), this species occurs at two localities along the shoreline of Yakataga Reef (UC loc. 3859, the type locality, and CAS loc. 29257). The present writer made detailed collections from this area, but unfortunately, found only a few fragments of *P.* (*L.*) *yakatagensis* along with a large number of *P.* (*L.*) *lituyaensis*. Although *P.* (*L.*) *yakatagensis* occurs in this horizon, it seems to be very rare.

The range of *P.* (*L.*) *poulcreekensis*, as already described, is from the lowest part of the Yakataga formation to about 460 meters above the base of formation, and *P.* (*L.*) *yakatagensis* occurs about 40 meters stratigraphically below the highest stratigraphic occurrence of *P.* (*L.*) *poulcreekensis*. Stratigraphically speaking, *P.* (*L.*) *poulcreekensis* seems to have appeared prior to the other two species, and *P.* (*L.*) *lituyaensis* possibly evolved from that species and is occasionally associated with *P.* (*L.*) *yakatagensis* which seems to be more abundant in the upper horizon, although a few *P.* (*L.*) *poulcreekensis* also survived.

Morphologically speaking, *P.* (*L.*) *poulcreekensis* is more similar to *P.* (*L.*) *lituyaensis* than to *P.* (*L.*) *yakataensis*. Namely, the former two have almost the same number of radial ribs which are undercut and squarish on the right valve. One of the distinct difference between two species is development of interstitial ribs, i. e., *P.* (*L.*) *poulcreekensis* has a distinct interstitial rib whereas one or more interstitials appear only in the terminal interspaces of *P.* (*L.*) *lituyaensis*. However, the development of interstitial radials on *P.* (*L.*) *poulcreekensis* seems to be very variable, i. e., as described by MACNEIL (1961, p. 230), some specimens have weakly flanged interstitial ribs in some of the interspaces but most of the interspaces are without them. He considered the latter specimen tentatively to be of subspecific rank.

P. (*L.*) *yakatagensis* differs strongly from *P.* (*L.*) *poulcreekensis* and *P.* (*L.*) *lituyaensis* by having a larger number of radial ribs.

From the above discussion the writer concludes that the phylogenetic relations between these three species are as follows; *P.* (*L.*) *poulcreekensis* appeared prior to the other species in the lower part of the Yakataga formation, and is of rather variable form; this species may be the stock of the subgenus *Lituyapecten* MACNEIL. *P.* (*L.*) *lituyaensis* branched from this stock and is characterized by a decreasing number of interstitial ribs. This seems to be a reversal of evolutional trends in this group. Another descendant of this stock may be *P.* (*L.*) *yakatagensis* which is characterized by extremely well-developed interstitial ribs and it has a large number of radial ribs. The stratigraphic occurrence and phylogenetic features show that *P.* (*L.*) *lituyaensis* is descendant of *P.* (*L.*) *poulcreekensis*, and *P.* (*L.*) *yakatagensis* may also be a descendant that appeared later than the *P.* (*L.*) *lituyaensis*. The writer is now estimating the geologic age of the *Lituyapecten* may be ranging from middle(?) to late Miocene in Alaska and also to Pliocene in California.

Localities:—USGS M271 (type locality), 7011-68, all medium-grained, light brown sandstone, lower part of the Yakataga formation.

Reg. No. TUE 8419.

Patinopecten jonesi KANNO, n. sp.

Plate 4, figs. 1-4; Plate 6, figs. 1, 2

Description:—Shell large, thick, suborbicular; strongly inequivalved, almost equilateral; dorsal margin weakly concave; no visible ctenolium along margin of byssal notch; both valves with about 25 strong radial ribs. Right valve distinctly convex with strong rather square, undercut radial ribs sculptured with very fine, raised concentric lines which continue across the interspaces; interspaces are round-bottomed and narrower than the width of radial ribs and have no interstitials; anterior ear somewhat produced providing a rather deep byssal gape, and sculptured with distinct growth lines; posterior ear rather small, terminal margin concave. Left valve almost flat, but undulating near the ventral margin; surface lacking microscopic sculpture; radial ribs are rather flat-topped, separated by more gently rounded interspaces than that of the right valve.

Length, 147 mm; height, more than 130 mm; length of hinge line, more than 78 mm on the holotype.

Remarks:—This species has not been found outside of the Lare Glacier area in the upper reaches of Little River, where the Yakataga formation is underlain unconformably by the Poul Creek formation. The present species occurs in the lowest part of the Yakataga formation which consists of pebble-bearing gray, medium-grained sandstone. The present new species occurs rather abundantly with valves oriented with the convex-side upward. Associated molluscs include *Clinocardium yakatagensis* (CLARK) and *Crepidula* sp.

This new species has the characteristic features of the genus *Patinopecten* DALL (1898). It is inequivalved and has a strongly inflated right valve and an almost flat left one, and distinct radial ribs. However, the right valve is sculptured with microscopic fine, silky concentric threads. This sculpture is rather similar to that of the juvenile left valve of *P.* (*L.*) *yakatagensis* (MACMEIL, 1961, pl. 37, figs. 3, 5). However, the left valve of the present species has almost no sculptures other than radial ribs whereas the subgenus *Lituyapecten* is characterized by raised, fine concentric growth lines in juvenile specimens and frill-like flanges on the radial ribs. Accordingly, the present new species can not be included in the subgenus *Lituyapecten* MACNEIL, 1961, or *Patinopecten* (*Patinopecten*) DALL, 1898. However, the general features show that it belongs to the genus *Patinopecten* DALL. The present new species may represent a new subgenus of *Patinopecten*, although the existing specimens are not sufficient to justify the proposal of a new subgenus at this time.

The new specific name is dedicated to Mr. RICHARD, L. JONES, a geologist of the Standard Oil Co., who co-operated in the field and assissted the present writer in collecting the present specimens.

Locality:—81402, gray pebble-bearing, medium-grained sandstone, lowest part of the Yakataga formation.

Reg. No. TUE 8420 (holotype); TUE 8421 (paratype).

Superfamily Anomiacea

Family Anomiidae

Genus *Pododesmus* PHILLIPPI, 1837

Pododesmus PHILIPPI. WIEGMANN's Arch. f. Naturg., p. 385, 1837; *Pododesmus* PHILIPPI. OLDROYD, Stanf. Univ. Publ., Geol. Sci., vol. 1, no. 1, p. 65, 1924; *Pododesmus* PHILIPPI. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 241, 1931; *Pododesmus* PHILIPPI. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 385, 1969.

Type-species (by monotype):—*Pododesmus decipiens* PHILIPPI, Recent, Cuba.

Remarks:—This genus is characterized by irregularly corrugated radial sculpture, and the shell attached by the right valve, which has a byssal foramen. There is a large byssal retractor scar on the left valve. *Anomia* LINNÉ is distinguished from the *Pododesmus* in having thin shell and two byssal scars.

Geographic distribution:—North America, South America, Europe, Australia, and Japan.

Geologic range:—?Oligocene, Miocene to Recent.

Subgenus *Monia* GRAY, 1850

Monia GRAY, Proc. Zool. Soc. London, p. 121, 1850; *Monia* GRAY. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 241, 1931; *Monia* GRAY. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 385, 1969.

Type-species (by subsequent designation, KOBELT, 1881):—*Anomia zealandica* GRAY, 1843, Recent, New Zealand.

Remarks:—The large byssal retractor scar and moderate to large-sized foramen serve to distinguish *Monia* from the allied subgenera.

Pododesmus (*Monia*) *macroschisma* (DESHAYES), 1839

Plate 17, fig. 1

1839. *Anomia macroschisma* DESHAYES, Rev. Zool. Soc. Cuvierienne, p. 359.
1924. *Pododesmus macroschisma* DESHAYES. OLDROYD, Stanf. Univ. Publ. Univ. Ser., Geol. Sci., vol. 1, no. 1, p. 65, pl. 26, figs. 1a–b.
1926. *Placunanomia macroschisma* DESHAYES. YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 1, pt. 8, p. 301, pl. 25, figs. 7–8.

1931. *Pododesmus macroschisma* (DESHAYES). GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 241, pl. 12, figs. 3, 4.
1937. *Pododesmus (Monia) macroschisma* (DESHAYES). NOMURA and HATAI, Saito Ho-on Kai Research Bull., no. 13, p. 131, pl. 19, figs. 7-8.
1943. *Pododesmus (Monia) macroschisma* (DESHAYES). MACNEIL, MERTIE, and PILSBRY, Jour. Paleont., vol. 17, no. 1, p. 87, pl. 13, figs. 6, 7.
1960. *Monia macroschima* (DESHAYES). KANNO, Sci. Rep. Tokyo Univ. Education. sec. C, vol. 8, no. 73, pl. 5, fig. 1 (no description).

Remarks:—A single right valve is at hand. The rounded shell outline, rather solid shell, rudely plicated radial ribs, and large perforation are the characteristics of the present species. This is a very common species in the northern Pacific region where it is found attached to stones and wharf piling from low-tide mark to about 70 meters in depth.

The living species ranges from north of lat. 39°N on the Japanese coast, and also ranges from Alaska to Lower California on the west coast of North America. The geologic range is from upper Miocene to Recent.

Localities:—20541-1, 20540, 20525, 20521, dark-gray, granule pebble-bearing conglomeratic sandstone, lower part of Yakataga formation.

Reg. No. TUE 8422.

Superfamily Limacea

Family Limidae

Genus *Acesta* H. and A. ADAMS, 1858

Acesta H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 558, 1858; *Acesta* H. and A. ADAMS. OYAMA, Conch. Asiatica, vol. 1, p. 37, 1943; *Acesta* H. and A. ADAMS. KANNO, Tert. Sys. Chichibu Basin, p. 228, 1960; *Acesta* H. and A. ADAMS. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 1, p. 386, 1969.

Type-species (by monotype):—*Ostrea excavata* FABRICIUS, 1779.

Remarks:—This genus is characterized by a large, thin, ovate shell with an indistinct anterior ear whereas the posterior one is distinct, although the boundary between the ear and disc is indistinct. The resilifer pit is situated posteriorly from the beak. This genus occurs or lives in cold waters or at great depths (about 100 to 1000 meters in the Pacific and the Atlantic Oceans).

Geographic distribution:—World-wide.

Geologic range:—Upper Jurassic to Recent.

Acesta cf. *A. yagenensis* (OTUKA), 1939

Plate 7, figs. 1-2

1925. *Lima goliath* YOKOYAMA (non SOWERBY), Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 5, p. 25, pl. 3, figs. 1, 4.
1925. *Lima goliath* YOKOYAMA (non SOWERBY), Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 1, pt. 3, p. 123, pl. 14, fig. 11.
1939. *Lima (Acesta) goliath yagenensis* OTUKA, Jour. Geol. Soc. Japan, vol. 46, no. 544, p. 27.
1943. *Lima (Acesta) yagenensis* OTUKA. OYAMA, Conch. Asiatica, vol. 1, p. 43, pl. 4, fig. 2;

pl. 5, fig. 4.
1960. *Lima (Acesta) yagenensis* OTUKA. KANNO, Tert. Sys. Chichibu Basin. p. 228-229, pl. 37, figs. 1-4; pl. 38, fig. 1.

Remarks:—Several specimens have been examined, but most are rather poorly preserved for specific determination. However, the large and thin shell, almost smooth surface ornamentation excepting for the gently undulating concentric ridges, the indistinct anterior ear and strongly anteriorly situated beaks serve to distinguish it from the allied species. The present specimens have very fine radial striations on the posterior ear. According to the original description by OTUKA (1939), this species has almost no radial ribs. Then the present specimens may represent a varietal form. These specimens are very similar to *Lima (Acesta) yagenensis* OTUKA from the Chichibu Basin (lower Miocene, KANNO, 1960), central Japan, but they differ somewhat from the Chichibu specimens by the fine radial striations on the surface of the posterior ear. Only the fine striations, it permit to be distinguished from *L. yagenensis* Otuka.

Localities:—81002, rather dark-gray silty sandstone, upper part of the Poul Creek formation; USGS loc. 1833 (western part of the Dahlgram Ridge), Poul Creek formation.

Reg. No. TUE 8423.

Superfamily Ostreacea

Family Ostreidae

Genus *Ostrea* LINNÉ, 1758

Ostrea LINNÉ, Syst. Nat., Ed. 10, p. 696, 1758; *Ostrea* LINNÉ. OLDROYD, Stanf. Univ. Publ., Geol. Sci., vol. 1, p. 50, 1924; *Ostrea* LINNÉ. WOODRING, Carnegie Inst. Wash. Publ., no. 366, p. 59, 1925; *Ostrea* LINNÉ. STEWART, Acad. Nat. Sci., Phila., Spec. Pap., no. 3, p. 126, 1930; *Ostrea* LINNÉ. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 149, 1931; *Ostrea* LINNÉ. KANNO, Tert. Sys. Chichibu Basin. p. 231-232, 1960.

Type-species (by subsequent designation, GRAY, 1847):—*Ostrea edulis* LINNÉ, Recent, European seas.

Remarks:—This genus is characterized by an inequilateral shell, a strongly convex left valve, an almost flat right valve, and crenulations near the hinge-line. This genus is a typical shallow dweller of tropical to temperate waters.

Geographic distribution:—Cosmopolitan, tropical to temperate waters.

Geologic range:—Triassic to Recent.

Ostrea sp.

Plate 18, figs. 1, 2

Remarks:—Several specimens were examined, but most are incomplete. The present specimens have rather small and thin shells for the genus, the right valve is almost flat and subovate in outline and the left valve is strongly convex. The hinge and hinge line are inaccessible.

These specimens resemble somewhat *Ostrea lurida* CARPENTER, 1864, a Recent species from the west coast of North America in general shape, but are difficult to compare exactly with the latter owing to their poor preservation.

Locality:—81502, medium-grained, arkosic sandstone, Kulthieth formation.

Reg. No. TUE 8424.

Subclass Heterodonta

Order Veneroida

Superfamily Lucinacea

Family Lucinidae

Genus *Lucinoma* DALL, 1901

Lucinoma DALL, U.S. Nat. Mus., vol. 23, p. 806, 1901; *Lucinoma* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 286, 1931; *Lucinoma* DALL. HABE, Gen. Jap. Shells, p. 129, 1941; *Lucinoma* DALL. HIRAYAMA, Jap. Jour. Geol. Geogr., vol. 25, nos. 1-2, p. 103, 1954; *Lucinoma* DALL. OLSSON, Moll. Trop. East. Pacif., p. 208, 1961; *Lucinoma* DALL. MOORE, U.S. Geol. Surv, Prof. Pap., 419, p. 70, 1963; *Lucinoma* DALL. MOORE et al., Treat. Invert. Paleont., pt. N, p. 500, 1969.

Type-species (by original designation):—*Lucina filosa* STIMPSON, Recent, Newfoundland to North Florida and Gulf Strait.

Remarks:—The present genus differs from *Lucina* LAMARCK, 1799, by the character of hinge teeth, i.e., *Lucinoma* has two cardinals while on *Lucina* they are lacking or are weakly developed. *Phacoides* BLAINVILLE, 1824, is said to be a vernacular name, but OLSSON (1961, p. 208) used it as a subgeneric name under the present genus.

Geographic destribution:—West coast of North America, Japan, Australia, Red Sea, and Europe.

Geologic range:—Oligocene to Recent.

Lucinoma cf. *L. tomitensis* KANNO, 1960

Plate 4, fig. 8

1958. *Lucinoma tomitensis* KANNO, Sci. Rep. Tokyo Univ. Educat., Sec. C, vol. 6, no. 55, p. 174, pl. 2, figs. 1-2.

1960. *Lucinoma tomitensis* KANNO, Tert. Sys. Chichibu Basin, p. 253, pl. 39, figs. 1-2.

Remarks:—One specimen is at hand. It is characterized by a high shell, whereas the usual form of the genus is almost orbicular. Though most of the surface ornamentation could not be observed because the specimen is an internal mould, it does show feebly developed rhythmic concentric growth lines and an elongated anterior muscle scar. These characters are strongly similar to *L. tomitensis* KANNO (1960, p. 253, pl. 39, figs. 1-2) from the Tertiary system of the Chichibu Basin, central Japan.

Locality:—81001, gray, fine-grained silty sandstone, upper-most of the Poul Creek formation.

Reg. No. TUE 8425.

Family Thyasiridae

Genus *Conchocele* GABB, 1866

Conchocele GABB, Geol. Surv. Calif., Paleont., vol. 2, p. 27, 1866; *Conchocele* GABB. STEWART, Acad. Nat. Sci., Phila. Spec. Publ., no. 3, p. 194, 1930; *Conchocele* GABB. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 281, 1931; *Conchocele* GABB. OMORI, Sci. Rep. Tokyo Univ. Education, sec. C, vol. 3, no. 20, p. 65, 1954; *Conchocele* GABB. KANNO, Tert. Sys. Chichibu Basin, p. 242, 1960; *Conchocele* GABB. MOORE et al., Treat. Invert. Paleont., pt. N, p. 508, 1969.

Type-species (by original designation):—*Conchocele disjuncta* GABB, 1866, Pliocene Deadman's Island, San Pedro, California.

Remarks:—The present genus is characterized by its large size, radial striations on the inner surface, a posterior furrow, and edenturous hinge structure.

The living species of this genus are reported from 6 to 2200 meters (KEEN, 1963), but geographically speaking, they live in the deep sea bottom in warm waters and in shallow sea bottom of cold waters. According to PARKER (1963, p. 159), the present genus occurs in depths of 57 to 320 meters in the Gulf of California where the water temperature is 12° to 19°C, and the sediments consist of mud, silty sand and sand. Specimens preserved at the California Academy of Sciences in San Francisco were collected from Puget Sound and the north side of Vancouver Island where the average temperature is about 10°C. Most of specimens collected from the Vancouver Island were from shallow water. Moreover, according to oral information from D. G. HANNA*, he collected many Recent specimens from the shoreline of Montague Island, Alaska, just after the 1964' Earthquake. These specimens clearly lived in very shallow waters before uplift by that big earthquake, because most of the specimens collected by HANNA are represented by articulated valves. NAKAJIMA (1958) reported living species dredged from the southern Japan Sea at a depth of 230 meters.

From the above discussion, this genus (or at least, species) seems to be restricted to cool water environments occurring in deeper water in low latitudes and rather shallow water in high latitudes. These ecological problems were discussed by KANNO (1971).

Geographic distribution:—Pacific Ocean.

Geologic range:—Oligocene to Recent.

Conchocele disjuncta GABB, 1869

Plate 7, fig. 3

1869. *Conchocele disjuncta* GABB, Geol. Surv. Calif. Paleont., vol. 2, p. 28, 99, pl. 7, figs. 48a, 48b.
1924. *Thyasira bisecta* (CONRAD). YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 8, p. 18, pl. 3, fig. 2.
1924. *Thyasira bisecta* (CONRAD). OLDROYD, Stanf. Univ. Publ., sci., vol. 1, no. 1, p. 120.
1925. *Thyasira bisecta* (CONRAD). YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45,

* Academy of Sciences, San Francisco.

art. 5, pl. 24, pl. 6, fig. 5.
1925. *Thyasira bisecta* (CONRAD). YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 1, pt. 3, p. 122, pl. 15, figs. 1-2.
1925. *Thyasira bisecta* (CONRAD). YABE and NOMURA, Sci. Rep. Tohoku Imp. Univ., ser. 2, vol. 7, no. 4, p. 84, pl. 23, figs. 2, 7-10.
1925. *Thyasira bisecta* var. *nipponica* YABE and NOMURA, ditto, p. 84, pl. 23, fig. 3; pl. 24, figs. 2-4.
1926. *Thyasira bisecta* (CONRAD). YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, vol. 1, pt. 8, p. 294, pl. 35, figs. 1-3.
1926. *Thyasira bisecta* var. *nipponica* YABE and NOMURA. YOKOYAMA, ditto, vol. 2, pt. 7, p. 243, pl. 31, fig. 12.
1930. *Thyasira disjuncta* (GABB). STEWART, Acad. Nat. Sci. Phila., Spec. Publ., no. 3, p. 194.
1931. *Thyasira (Conchocele) bisectoides* KURODA in HONMA's Geol. Central Shinano, p. 50, pl. 12, figs. 95-96.
1931. *Thyasira (Conchocele) bisecta nipponica* YABE and NOMURA. ditto, pl. 15, fig. 28.
1931. *Thyasira bisecta* (CONRAD). GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 281, pl. 13, fig. 15.
1932. *Thyasira bisecta* CONRAD. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 810, pl. 14, fig. 2.
1933. *Thyasira disjuncta* (GABB). TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, no. 3, p. 114.
1943. *Thyasira bisecta* (CONRAD). MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., ser. b, vol. 10, no. 2, art. 6, p. 147-151.
1942. *Thyasira bisecta* (CONRAD). WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 142, pl. 34, figs. 5-6.
1960. *Conchocele disjuncta* GABB. KANNO, Tert. Sys. Chichibu Basin, p. 242-245, pl. 38, figs. 9-13.
1971. *Conchocele disjuncta* GABB. ADDICOTT et al., U.S. Geol. Surv. Prof. Pap., 750-C, Fig. 3, a, b.

Remarks:—Several specimens have been examined. However, most of the specimens are from a huge erratic boulder containing a large number of individuals of the present species. This boulder seems to be a concretion consisting of calcareous mudstone, but it is not certain where it was derived from because this boulder is situated along the shoreline near thick sandstone at Yakataga Reef (no. 12 in Text-fig. 8), and this point is also close to the boundary between the Poul Creek and the Yakataga formations. The specimens collected from this locality are represented by rather variable forms, e.g., some have a rather broad apical angle similar to "*C. nipponica* (YABE and NOMURA)" but others have rather narrow ones as in the typical "*C. disjuncta* GABB". Judging from the variable form, the writer considers that the specimens might be from the Poul Creek formation (KANNO, 1960, p. 244).

Localities:—20551, dark-gray mudstone, Yakataga formation; 80606, a huge erratic boulder of calcareous mudstone, questionably from Poul Creek formation; 81203, calcareous concretion, lower part of the Poul Creek formation.

Reg. No. TUE 8426.

Superfamily Carditacea

Family Carditidae

Genus *Cyclocardia* CONRAD, 1867

Cyclocardia CONRAD, Amer. Jour. Conch., vol. 3, p. 191, 1867; *Cyclocardia* CONRAD. STE-

WART, Acad. Nat. Sci., Phila., Spec. Publ., no. 3, p. 150, 1930; *Cyclocardia* CONRAD. HABE, Gen. Jap. Shells, p. 108, 1951; *Cyclocardia* CONRAD. HIRAYAMA, Sci. Rep. Tokyo Univ. Education, sec. C, vol. 4, no. 29, p. 86, 1955; *Cyclocardia* CONRAD. KANNO, Tert. Sys. Chichibu Basin, p. 236, 1960; *Cyclocardia* CONRAD. MOORE et al., Treat. Invert. pt. N, p. 551, 1969.

Type-species (by subsequent designation, STOLICZKA, 1871):—*Cardita borealis* CONRAD, 1832, Recent, Labrador to Cape Hatteras, Eastern United States.

Remarks:—This genus is characterized by an orbicular, more or less inflated shell sculptured with strong radial ribs and covered with velvety epidermis. There is no right anterior cardinal.

Geographic distribution:—World-wide.

Geologic range:—Upper Cretaceous to Recent.

Cyclocardia yakatagensis (CLARK), 1932

Plate 3, figs. 7a-b; Plate 4, figs. 9a-b

1932. *Venericardia yakatagensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 809, pl. 14, figs. 6, 7.
1971. *Cyclocardia yakatagensis* (CLARK). ADDICOTT et al., U.S. Geol. Surv. Prof. Pap., 750-C, Fig. 3, d, n. o.

Remarks:—This specimen is characterized by fairly heavy, equilateral shell sculptured with 23 to 25 broadly rounded radial ribs with shallow interspaces which are somewhat narrower than the width of the rib. CLARK (1932) did not describe the hinge of this species, but the present specimens show that the right valve has a strong posterior cardinal tooth with a shallow groove on top and a faint posterior lateral one. The left cardinal teeth consist of an anterior one which is short and rather stout and a posterior one which is thin and elongate.

This species is closely related to *Venericardia tokunagai* YOKOYAMA, 1924 from the Asagai formation (Oligocene) of the Joban coal-field, Japan.

This species is one of the characteristic species of the upper part of the Poul Creek formation in which it occurs abundantly.

Localities:—80905, 81002, 81201, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8427.

Cyclocardia hamiltonensis (CLARK), 1932

Plate 3, fig. 6; Plate 4, figs. 10, 11

1932. *Venericardia hamiltonensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 810, pl. 14, figs. 9-10.
1971. *Cyclocardia hamiltonensis* (CLARK). ADDICOTT et al., U.S. Geol. Surv. Prof. Pap., 750-C, Fig. 3, e, f.

Remarks:—This species was originally reported by CLARK, 1932, from the upper reaches of Hamilton Creek about 6.5 kilometers east of Yakataga Reef, Alaska.

It is somewhat similar to *C. yakatagensis* (CLARK), but the smaller number of radial ribs (about 15 to 19), and higher shell serve to distinguish it from the allied species.

Localities:—81002, 81401, 81104 (float), olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8428.

Cyclocardia sp.

Plate 3, figs. 8, 9

Remarks:—Two right and left valves are at hand, of which the right one is mostly decorticated. The specimens are characterized by a shell which is extremely high for the genus, a small number of radial ribs (about 19), and a rather small shell. These characteristics serve to distinguish it from the associated *C. yakatagensis* and *C. hamiltonensis.*

Locality:—81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8429.

Superfamily Crassatellacea

Family Crassatellidae

Genus *Crassatella* LAMARCK, 1799

Crassatella LAMARCK, Mem. Soc. Historie Nat. Paris, vol. 1, p. 85, 1799; *Crassatella* LAMARCK. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 458, 1857; *Crassatellites* KRÜGER. DALL, Trans. Wagner Free Inst. Sci., vol. 3, p. 1468, 1903; "*Crassatellites*" STEWART, Acad. Nat. Sci. Phila., Spec. Publ., no. 3, p. 136, 1930; *Crassatellites* KRÜGER. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 270, 1931; *Crassatella* LAMARCK. KEEN, Sea Shells Trop. Am., p. 82, 1958; *Crassatellites* KRÜGER. KANNO, Tert. Sys. Chichibu Basin, p. 233, 1960; *Crassatella* LAMARCK. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 573, 1969.

Type-species (by subsequent designation, SCHMIDT, 1818):—*Mactra cygnaea* LAMARCK, 1799.

Remarks:—Some authors have KRÜGER's *Crassatellites* instead of *Crasstella.* The validity of KRÜGER's generic name has been discussed by several previous workers (STEWART, 1930; KANNO, 1960; KEEN 1958). According to KEEN (1958, p. 82), *Crassatellites* is invalid because KRÜGER, 1823, did not propose a type or give any description. Therefore, it seems best to retain the name *Crassatella* provisionally.

This genus is characterized by triangular, rather compressed shells which are more or less rostrated posteriorly. The species of this genus are restricted to south of Point Conception, California, in the eastern Pacific, and they are also restricted to waters south of lat. 35°N on the Pacific coast of Japan. They are shallow (0–80 meters in depth), sandy to fine-grained silty bottom dwellers.

Geographic distribution:—Europe, North America, and the west Pacific region.

Geological range:—Middle Cretaceous to Miocene. The fossil species of the genus extensively distributes in the northern hemisphere, where it is abundant in virtually all Eocene, Oligocene, and Miocene faunas. However, it is note-worthy the present genus seems to be restricted to middle Eocene to upper Oligocene formations in Washington and Oregon districts but ranges into the lower to middle Miocene in Alaska.

Crassatella cf. *C. washingtoniana* (WEAVER), 1912

Plate 4, figs, 5, 7

1912. *Crassatellites washingtoniana* WEAVER, Wash. Geol. Surv., Bull., no. 15, p. 32, pl. 4, fig. 42; pl. 5, fig. 51.
1925. *Crassatellites washingtoniana* WEAVER. CLARK, Univ. Calif. Publ., Bull. Geol. Sci., vol. 15, p. 87, pl. 12, figs. 1-5.
1942. *Crassatellites washingtoniana* WEAVER, Univ. Wash. Publ. Geol., vol. 5, pl. 126, pl. 30, figs. 1, 2, 4-8.

Remarks:—Two specimens are at hand. This species was originally reported by WEAVER (1912) from the Cowlitz formation (upper Eocene) in Washington. This species is characterized by an elongate, sub-trigonal, thick, equivalved shell with anteriorly situated beaks which are about one-fourth of the length of the shell from the anterior end. In addition the present species has the strong and nearly equally developed muscle scars, and fine crenulations on the interior ventral margin. Moreover, the type of species is sculptured by distinct concentric lines. Although the present specimens are strongly similar to *C. washingtoniana* in shape, the surface sculpture is unknown owing to poor preservation. Precise identification wait until well preserved specimens are collected.

Locality:—80905, olive-green, medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8430.

Genus *Crassatina* KOBELT, 1881

Crassatina KOBELT. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 754, 1969.

Type-species (by original designation):—*Crassatella triquetra* "SOWERBY" REEVE, 1842.

Remarks:—The genus is somewhat similar to the aforementioned *Crassatella* LAMARCK, but differs by having small lateral teeth on the posterior side of resilifer pit.

Geographic distribution:—Europe, Africa, Japan, and the Gulf of Alaska.

Geologic range: Paleocene to Recent.

Crassatina carmanahensis (CLARK), 1925

Plate 4, figs. 6a-b

1925. *Crassatellites carmanahensis* CLARK, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 15, p. 88, pl. 12, fig. 6.
1942. *Crassatellites carmanahensis* CLARK. WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 128–129, pl. 29, fig. 14.

Remarks:—This species is distinguished from allied species by having nearly equal, steeply sloping anterior- and posterior-dorsal borders, a relatively small umbonal angle, and a greater height of the shell compared with the length.

Three specimens are at hand which show the following characters; the surface of leached specimen is sculptured with numerous fine radial striations; the ligament is completely internal; the anterior cardinal of the left valve is rather heavy and short, the posterior cardinal is thin and elongate and unconnected dorsally; the posterior lateral tooth of the right valve is rather distinct and occurs just behind the resilifer pit.

These specimens are somewhat similar to some species of *Astarte* in outline but the internal ligament and lack of a nymph on the hinge line serve to distinguish it from *Astarte*.

The present species has been previously reported only from south of Vancouver Island. The occurrence of this species may be very significant for the interpretation of paleoclimatic conditions in the Gulf of Alaska area during deposition of the Poul Creek formation.

Locality:—80905, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8431.

Superfamily Cardiacea

Family Cardiidae

Genus *Clinocardium* KEEN, 1936

Clinocardium KEEN, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 17, p. 119–120, 1936; *Clinocardium* KEEN. HABE, Gen. Jap. Shells, p. 150, 1951; *Clinocardium* KEEN, Bull. Am. Paleont., vol. 35, no. 153, p. 14–21, 1954; *Clinocardium* KEEN. HIRAYAMA, Sci. Rep. Tokyo Univ. Educat., sec. C, vol. 4, no. 29, p. 92, 1955; *Clinocardium* KEEN. KANNO, Tert. Sys. Chichibu Basin, p. 255, 1960; *Clinocardium* KEEN. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 72, 1963; *Clinocardium* KEEN. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 590, 1969.

Type-species (by original designation):—*Cardium nuttallii* CONRAD, 1837, Recent, Bering Sea to San Diego, California.

Remarks:—The present genus is characterized by the markedly forward-pointing beaks, long, narrow, low ligament, arched hinge-line, and a large number of radial ribs. Recent species of this genus occur in temperate to cold waters, ranging from the intertidal zone to 130 meters (KEEN, 1963) on sandy bottoms.

Geographic distribution:—Recent species occurs north of lat. 34°N in Japan, and north of lat. 33°N in the eastern Pacific.

Geologic range:—Oligocene to Recent in Japan, upper Miocene to Recent in west coast of North America.

Clinocardium yakatagense (CLARK), 1932

Plate 8, figs. 1–3

1932. *Cardium* (*Cerastoderma*) *yakatagensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 813, pl.

18, fig. 8.
1971. *Clinocardium yakatagensis* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 4, a.

Description:—Shell rather large for the genus, subtrigonal, ventricose, thick; umbo prominent, situated anteriorly, prosogyrous; surface ornamented with about twenty-four radial ribs which are regular, rather low, noded by incremental ridges on their surface, and separated by wider interspaces; radial ribs almost obsolete anteriorly and posteriorly; ventral side of surface distinctly ornamented with rugose concentric lines, which become less prominent near the anterior and posterior margins; ventral margin roughly crenulated; ligament external; each valve with two cardinal teeth, of which the posterior of the right and the anterior of the left are prominent; anterior laterals short, heavy, and strong, but the posterior one rather small and weak compared with the anterior one; muscle scars prominent.

Measurements (in mm.):—

Specimens	Length	Height	Obliquity*	Thickness	Valve
No. 1	ca.62. 0	60. 0	72. 0	—	Left
„ 2	55. 0	50. 0	64. 4	20. 0	Right
„ 3	58. 0	51. 0	62. 0	—	Right

* Length measured from the beak to the maximum length to the ventral margin.

Remarks:—More than ten specimens are at hand, but most are incomplete. According to CLARK's (1932) description, there are about thirty radial ribs on this species, but the specimens at hand have about twenty-four, however the anterior and posterior ribs are almost obsolete. The present species is similar to *Clinocardium sookense* (CLARK and ARNOLD), 1923, from the Sooke formation (upper Oligocene) of Vancouver Island, but differs by having more conspicuous umbo, a prosogyrous beak, fewer radial ribs which are lower and finer than those of *C. sookense*. Moreover, the present species is characterized by the distinct rugose surface on adult shells, and more heavy and stout anterior lateral teeth. *Cerastoderma scapoosense* (CLARK), (CLARK, 1925, p. 91, pl. 22, fig. 5), from the Scappoose formation (upper Oligocene) of Oregon, is easily distinguished from *C. yakatagense* by having less prominent and almost orthogyrous beaks, and a smaller number of radial ribs.

Localities:—7011, 20484, 81402, 20521, 20526, 20523, conglomeratic sandstone, or dark-gray sandy siltstone, lowest part of the Yakataga formation.

Reg. No. TUE 8432.

Clinocardium brooksi (CLARK), 1932

Plate 5, fig. 9; Plate 6, fig. 4; Plate 7, figs. 7a-b

1932. *Cardium (Papyridea) brooksi* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 812, pl. 18. fig. 5.
1971. *Clinocardium brooksi* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 4, f.

Remarks:—The type specimen was collected from the upper reaches of Hamilton Creek, east of Yakataga Reef, where the upper part of the Poul Creek and the lowest part of the Yakataga are exposed. According to the original description, the type specimens shows following characters; "shell semiquadrate; beaks well anterior to the median line; apical angle about 113 degrees; surface with the line of greatest convexity extending from the beaks to the lower part of the rounded posterior end; sculptured by about 32 prominent radial ribs with interspaces averaging about equal to the width of the ribs. This ribbing is somewhat finer near the posterior end and becomes obsolete on the posterior dorsal margin; the ribs appear to have been originally V-shaped, becoming to a sharp edge, and probably were somewhat spinose. Incremental lines very fine."

Some specimens of the writer's show the same characters as the original description, but the others are somewhat different from CLARK's description, i. e., there are about 43 radial ribs which are separated by narrower interspaces than the width of radial ribs. In addition, there are many intermediate forms between the CLARK's type specimens and the specimen sculptured with many radial ribs. The present species seems to have a wide range of variation.

Localities:—80506, 81306, 81403, gray or dark-gray, granule conglomeratic sandstone, lower to lowest part of the Yakataga formation.

Reg. No. TUE 8433.

Clinocardium hopkinsi KANNO, n. sp.

Plate 5, figs. 6, 7

Description:—Shell rather thin, ovate-trigonal, equivalve, inequilateral, higher than long or obliquely elongated shell; beaks situated anteriorly, prosogyrous; surface sculptured with about 40 radial ribs which are separated by narrow interspaces, and with cross-threads which tend to crowd toward the ventral margin; hinge with two cardinals, of which the right posterior and the left anterior one are stout; lateral tooth distinct, well separated from the cardinals; inner ventral margin crenulated corresponding to the surface sculpture.

Measurements (in mm):—

Specimens	Length	Height	Thickness	Oliquity*	Valve
Holotype	50. 0	42. 0	ca.13. 0	50. 5	Left
Paratype	43. 0	44. 0	ca.14. 0	ca.48. 0	Right

* Length measured from the beak to the maximum length to the ventral margin.

Remarks:—Several specimens are at hand, but most are somewhat deformed. Although some deformed specimens are more or less similar to *Clinocardium yakatagense*, they differ distinctly by their inequilateral and higher shells.

This name is dedicated to Dr. DAVID M. HOPKINS, U.S. Geological Survey, who gave valuable suggestions and encouragement to the writer during the present work.

Locality:—81401 (type locality), olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. Nos. TUE 8434 (holotype); TUE 8435 (paratype).

Genus *Papyridea* SWAINSON, 1840

Papyridea SWAINSON, Treat. Malac., p. 374, 1840; *Papyridea* SWAINSON. STOLICZKA, Mem. Geol. Surv. India, vol. 3, p. 208, 1874; *Papyridea* SWAINSON. DALL, Trans. Wagner Free Inst. Sci., vol. 3, p. 1075, 1900; *Papyridea* SWAINSON. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 311, 1931; *Papyridea* SWAINSON. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 588, 1969.

Type-species (by subsequent designation, GRAY, 1847):—*Cardium soleniforme* BRUGUIÉRE, 1789, Recent, west Indies.

Remarks:—The elongate and equilateral shell, spinose radial ribs, and with gaping at both ends serve to distinguish it from the other genera of Cardiidae.

Geographic distribution:—Subtropical to tropical regions in the Pacific Ocean.

Geologic range:—Oligocene to Recent in Japan, and Miocene to Recent on the west coast of North America.

Papyridea hamiltonensis (CLARK), 1932

Plate 3, fig. 4; Plate 5, figs. 4, 5, 8

1932. *Cardium (Serripes?) hamiltonensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 813-814, pl. 18, figs. 6, 7, 10.

1971. *Papyridea? hamiltonensis* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 4, b, g, k.

Description:—Shell rather thin, equivalve, almost subequilateral, longer than high, without appreciable posterior gape; beaks slightly prosogyrate; surface sculptured with about 45 radial ribs; ribs with cross-threads but no spines, separated by narrow and shallow, round-bottomed interspaces; complete hinge armature consisting of an anterior and posterior lateral tooth in both valves; anterior lateral tooth situated apart from the beak, but the posterior ones elongate and thin rising from the umbonal cavity; margin crenulate corresponding to the surface ornamentation.

Measurements (in mm):—

Specimens	Length	Height	Thickness	Valve
No. 1	48.8	39.7	ca.11.0	Right
„ 2	55.0	45.8	ca.12.0	„
„ 3	29.5	22.8	11.5	Both valves

Remarks:—The present species was reported originally by CLARK (1932) from the Yakataga District (perhaps from type locality at Bear Glacier, and Hamilton Creek, near the Yakataga Reef). It is characterized by the large number of flat-topped radial ribs with narrow interspaces which are crossed by several distinct rough concentric ridges or constrictions. However, it is difficult to determine details of surface ornamentation owing to poor preservation. According to CLARK's original description, there are about 62 radial ribs but specimens collected from near the type locality have only 45 radial ribs. As CLARK pointed out, the outline of the shell is variable, e. g., some specimens have a rather equilateral shell, but others are rather inequilateral. These variations may depend on in part deformations after burial, but it may be due to original variation of the shell, because the original shell outlines almost all of the associated pelecypods are hardly deformed.

The present species was placed provisionally in *Serripes* by CLARK, but the surface ornamentation and shape serve to distinguish it from genus *Serripes* GOULD, 1941.

Localities:—81003, 81201, 81401, 20503, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green, silty sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 8436.

Genus *Nemocardium* MEEK, 1876

Nemocardium MEEK, Rept. U.S. Geol. Surv. Territories, vol. 9, p. 167, 1876; *Nemocardium* MEEK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 310, 1931; *Nemocardium* MEEK. MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., ser. B, vol. 10, no. 2, art. 6, p. 142–143, 1934; *Nemocardium* MEEK. HABE, Gen. Jap. Shells, p. 151–152, 1952; *Nemocardium* MEEK. TAKEDA, Studies Coal Geol., no. 3, p. 82, 1953; *Nemocardium* MEEK. KEEN, Bull. Am. Paleont., vol. 35, no. 153, p. 10, 1954; *Nemocardium* MEEK. KANNO, Tert. Sys. Chichibu Basin, p. 262, 1960; *Nemocardium* MEEK. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 72, 1963.

Type-species (by subsequent designation, SACCO, 1899):—*Cardium semiasperum* DESHAYES, 1858, Eocene of the Paris Basin.

Remarks:—The characteristic features of this genus are the medium- or small-sized shell with distinct but fine radial ribs on the surface and the change in ribbing on the posterior part of the shell where the ribs become spinose, tuberculate or cancellate instead of simple.

Geographic distribution:—The Recent species of the genus occur south of lat. 36°N along the Pacific coast of Japan, but south of Puget Sound, lat. 48°N on the eastern side of the Pacific Ocean.

Geologic range:—Lower Cretaceous to Recent.

Nemocardium alaskense (CLARK), 1932

Plate 17, fig. 2

1932. *Cardium (Laevicardium) alaskensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 814, pl. 18, fig. 4.
1971. *Nemocardium alaskensis* (CLARK). ADDICOTT et al., U.S. Geol. Surv. Prof. Pap., 750-C, Fig. 4, c.

Remarks:—The present species is characterized by a rather small (about 10 to 15 mm in height), almost equilateral shell, and finely sculptured surface ornamentation of about 70 radial ribs. Though a large number of specimens have been examined, most of the specimen are deformed and have leached shell surfaces. Accordingly, the detailed characters of this species are difficult to observe. The specimens at hand are rather small, inflated shells with fine silky radial ribs. The shape of shells and surface ornamentation seem to be sufficient to determine the generic characters.

Localities:—80906, 81002, dark gray, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 8437.

Nemocardium aff. *N. yokoyamai* TAKEDA, 1953

Plate 4, figs. 12a-b

1960. *Nemocardium yokoyamai* TAKEDA. KANNO and MATSUNO, Jour. Geol. Soc. Japan, vol. 66, no. 772, pl. 4, fig. 9 (no description).

Description:—Shell of medium size for the genus, suborbicular, swollen, subequilateral; beaks slightly prosogyrous, umbo prominent; postero-dorsal margin more convex than the antero-dorsal one which slopes abruptly downward; postero-ventral margin more or less angulated; surface ornamented with about 80 radial ribs separated by narrow interspaces, of which the posterior radials number about 20 and are somewhat coarser than the main radials.

Remarks:—One well preserved specimen is at hand. It is closely related to *Nemocarium yokoyamai* from the Poronai formation (Oligocene) of Hokkaido, Japan, which differs somewhat by having a more rounded shell. The present specimen seems to be conspecific with "*N. yokoyamai* TAKEDA" (KANNO and MATSUNO, 1960) from the Chikubetsu formation (middle Miocene) of Hokkaido.

Locality:—81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8438.

Superfamily Mactracea

Family Mactridae

Genus *Spisula* GRAY, 1837

Spisula GRAY, LOUDON's Mag. Nat. Hist., New Series, vol. 1, p. 372, 1837; *Spisula* GRAY. PACKARD, Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, no. 16, p. 283, 1916; *Spisula* GRAY. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 1, no. 1, p. 192, 1924; *Spisula* GRAY. STEWART, Acad. Nat. Sci. Phila., Spec. Publ., no. 3, p. 266, 1930; *Spisula* GRAY. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 393, 1931; *Spisula* GRAY. HABE, Gen. Jap. Shells, p. 194, 1952; *Spisula* GRAY. KANNO, Tert. Sys. Chichibu Basin, p. 290, 1960; *Spisula* GRAY. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 82, 1963; *Spisula* GRAY. KANNO and OGAWA, Sci. Rep. Tokyo Univ. Ed., vol. 8, no. 81, p. 286, 1964; *Spisula* GRAY. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 601, 1969.

Type-species (by subsequent designation, GRAY, 1847):—*Cardium solidum* LINNÉ, Recent, seas of Europe.

Remarks:—The present genus is closely similar to *Mactra* LINNÉ, 1717, which differs from the present one by having a shelly ridge between the chondrophore and the ligamental cavity. *Mulinia* GRAY, 1837, is somewhat similar to the present one, but differs by having an internal ligament, rather strong and stout teeth, and a small and short pallial sinus. *Pseudocardium* GABB, 1866, is also rather similar to the present one, but as discussed by KANNO and OGAWA (1964, p. 81), it may be better to treat it as a subgenus of *Spisula*.

Geographic distribution:—World-wide, especially, within the tropics.

Geologic range:—Eocene to Recent.

Spisula equilateralis (CLARK), 1932

Plate 6, fig. 7; Plate 8, fig. 9; Plate 9, figs. 1, 4, 5, 7-8

1932. *Mactra* (*Mactrotoma*) *californica equilateralis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 819-820, pl. 14, fig. 8.
1937. *Mactra* (*Mactrotoma*) *californica onnechiuria* OTUKA, Jap. Jour. Geol. Geogr., vol. 14, nos. 3-4, p. 168, pl. 16, fig. 2.
1940. *Mactra* (*Spisula*) *onnechiuria* OTUKA, ditto, vol. 17, nos. 1-2, p. 94, pl. 11, fig. 2.
1960. *Spisula onnechiuria* (OTUKA). KANNO and MATSUNO, Jour. Geol. Soc. Japan, vol. 66, no. 722, pl. 4, fig. 7.
1966. *Spisula onnechiuria* (OTUKA). UOZUMI, Jour. Fac. Sci., Hokkaido, Univ., ser. 4, vol. 13, no. 2, p. 130-131, pl. 10, figs. 1, 6.
1968. *Spisula onnechiuria* (OTUKA). KANNO et al., Sci. Rep. Tokyo Univ. Educat., sec. C, vol. 10, no. 94, p. 11, pl. 2, figs. 1-2.
1971. *Spisula californica equilateralis* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 4, 1.

Remarks:—The original description by CLARK was based on a specimen from Oil Creek, east of Yakataga Reef, presumably from the upper part of the Poul Creek formation. This species is characterized by having an almost equilateral, elongate, and low shell.

The specimens at hand are more or less variable in form. Some of them have higher shells than the type specimen, but most are equilateral. The typical form of this species is very similar to *Spisula onnechiuria* (OTUKA), 1937, from early to middle Miocene strata exposed in the northern part of Hokkaido, Japan. "*S. onnechiuria*" is also rather variable in shell outline (KANNO et al., 1967). However, the equilateral and low shell strongly suggests that these species might be conspecific, or at least, have a close relationship to each other. The migrational and dispersal trend of these mollusks are very interesting problems.

Localities:—81201, 81401, 20503, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8439.

Spisula addicotti KANNO, n. sp.

Plate 8, fig. 10; Plate 9, figs. 2-3, 6

1932. *Spisula ramonensis* PACKARD. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 820, pl. 14, fig. 5 (non figs. 1, 4).
1971. *Spisula* aff. *S. ramonensis* PACKARD. ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 4, j, m.

Description:—Shell medium-sized, equivalve, longer than high, strongly inequilateral, somewhat compressed; umbones prominent, sharply pointed, prosogyrous, situated posteriorly; antero-dorsal margin short, gently curving, and makes a rather acute angle with ventral margin; postero-dorsal border long, slightly concave and merges into the posterior end with narrowly rounded angle; posterior end somewhat produced; ventral margin broadly rounded; surface almost smooth excepting fine concentric growth lines; an indistinct low ridge running from umbo to the postero-ventral corner; hinge plate wide, chondrophore deep; left cardinal prominent, the posterior one bearing an indistinct lamella; lateral teeth long, the anterior one arising from the ventral edge of the plate; the hinge of the right valve as well as the pallial sinus inaccessible.

Measurements (in mm):—

Specimens	Length	Height	Thickness	H/L×100	Valve
No. 1 Holotype	57.7	48.4	ca. 9.0	83.6	Right
„ 2 Paratype	47.0	39.0	ca. 7.0	83.0	„
„ 3 „	49.0	41.3	ca. 8.0	84.0	Left
„ 4 „	59.5	42.8	ca.10.5	72.0	„
„ 5 „	28.7	22.3	—	78.0	„

Remarks:—This species was initially identified by CLARK as *Spisula ramonensis* PACKARD (CLARK, 1932). However, it is strongly inequilateral, and has a produced posterior end, whereas the *S. ramonensis* (PACKARD, 1916, p. 291, pl. 23, fig. 5; pl. 25, figs. 1-2) is characterized by a roundly trigonal form. The new species is also somewhat similar to *S. merriami longifrons* TURNER, (TURNER, 1938, Geol. Soc. Am., Spec. Pap., no. 10, p. 65, figs. 10-11), from the lower Umpqua formation (middle Eocene) of southwestern Oregon, but the Eocene species differs by having a more convex antero-dorsal margin, a more concave postero-dorsal border, and a rather smooth surface.

The new species is somewhat variable in form, some specimens have a rather low shell compared to the type, but these lower shells seem to be deformed.

The present specific name is dedicated to Dr. WARREN O. ADDICOTT, U.S. Geological Survey, who gave invaluable suggestions to the writer during the present work.

Localities:—81201, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green silty sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 8440 (holotype); TUE 8441 (paratype).

Superfamily Solenacea

Family Solenidae

Genus *Siliqua* MEGERLE von MÜHLFELD, 1811

Siliqua MEGERLE von MÜHLFELD, Gesells. Naturf. Freu. Mag., p. 44, 1811; *Siliqua* MÜHLFELD. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 345, 1856; *Siliqua* MEGERLE von MÜHLFELD. DALL, Proc. U.S. Nat. Mus., vol. 22, p. 108, 1899; *Siliqua* MEGERLE. OLDROYD, Stanf. Univ. Publ. Ser., Geol. Sci., vol. 1, no. 1, p. 189, 1924; *Siliqua* MEGERLE von MÜHLFELD.

GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 386–387, 1931; *Siliqua* MEGERLE von MÜHLFELD. HABE, Gen. Jap. Shells, p. 230, 1952; *Siliqua* MEGERLE von MÜHLFELD. KANNO, Tert. Sys. Chichibu Basin, p. 309–310, 1960; *Siliqua* MEGERLE von MÜHLFELD. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 612–613, 1969.

Type-species (by monotypy):—*Solen radiata* LINNÉ, 1758, Recent, East Indies.

Remarks:—This genus is somewhat similar to other genera in Solenidae, but it can be distinguished from them by the presence of an internal rib or ridge running vertically or obliquely from the beak to the ventral margin.

Geographic distribution:—World-wide occurring along the shore of Sitka, Ochotsk, Bering Strait, and Newfoundland as well as on the tropical shores of India and China Seas, and also around Japan. The Recent species of the genus range from the intertidal zone to 60 meters in sandy to silty bottoms.

Geologic range:—Eocene to Recent.

Siliqua sp.

Plate 17, fig. 6

Remarks:—Two specimens were collected from the basal part of thick sandstone which forms the highest rock on the Yakataga Reef. They are represented by internal moulds of the right and left valves. Although detailed observation is impossible owing to their poor preservation, the unique form indicated by the remaining part seems to be sufficient to distinguish it from the known species, i.e., both the dorsal and ventral margins are almost parallel, and the ventral margin is not broadly arcuate but is nearly straight. The internal radial ridge is almost perpendicular to the dorsal and ventral margins. Estimated length, ca. 80 mm; height, 33 mm; length from beak to anterior end, 28 mm.

This specimens differ from *S. patula* DIXON var. *oregonia* DALL from the Miocene Astoria formation of southwestern Oregon (WEAVER, 1942, p. 230, pl. 54, fig. 1) by the different ratio (length measured from the beak to the anterior end/height$\times$100) of length to height, i.e., *S. patula* var. *oregonia* shows about 37 percent whereas 84 percent of *Siliqua* sp. *S. patula* DIXON, a Recent species ranging from Alaska to Monterey, California, is distinguished from the present one by the higher shell, broadly arcuated ventral margin, and more slanting internal radial ridge (or rib). *S. alta* (BRODERIP and SOWERBY), a Recent species ranging from northern Japan to Sakhalin, Kamchatka, and Alaska, is rather similar to the present specimens in having a perpendicular interior ridal rib, but differs by the lower ratio of length measured from beak to anterior end to height, namely, on *S. alta* the ratio is about 62 percent whereas it is 84 percent on *Siliqua* sp.

The living species of *Siliqua* are of world-wide distribution and are especially abundant in temperate to cold waters. However, fossil species of the genus are rather rare in Tertiary deposits of the northwest coast of North America.

Locality:—80605, rather greenish brown, medium-grained sandstone, Yakataga formation.

Reg. No. TUE 8442.

Superfamily Tellinacea

Family Tellinidae

Genus *Tellina* LINNÉ, 1758

Tellina LINNÉ, Syst. Nat., Ed. 10, p. 674, 1758; *Tellina* LINNÉ. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 394, 1856; *Tellina* LINNÉ. OLDROYD, Stanf. Univ. Publ. Univ. Ser., Geol. Sci., vol. 1, no. 1, p. 163-164, 1924; *Tellina* LINNÉ. WOODRING, Carnegie Inst. Wash., Publ., no. 336, p. 166, 1925; *Tellina* LINNÉ. STEWART, Acad. Nat. Sci. Phila., Spec. Publ., no. 34, p. 199, 1930; *Tellina* LINNÉ. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 357, 1931; *Tellina* LINNÉ. KANNO, Tert. Sys. Chichibu Basin, p. 305, 1960; *Tellina* LINNÉ. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 78, 1963; *Tellina* LITNÉ. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 54, 1969; *Tellina* LINNÉ. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 613, 1969.

Type-species (by subsequent designation, CHILDREN, 1823):—*Tellina radiata* LINNÉ, Recent, West Indies.

Remarks:—The present genus is characterized by a very wide and deep pallial sinus which is the same shape in the both valves.

Geographic distribution:—World-wide.

Geologic range:—?Cretaceous, Tertiary to Recent.

Subgenus *Oudardia* MONTEROSATO, 1884

Oudardia MONTEROSATO, Nomencl. Gen. Spec. Conch. Medit., p. 22, 1884; *Oudardia* MONTEROSATO. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 361, 1931; *Oudardia* MONTEROSATO. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 619, 1969.

Type-species (by original designation):—*Tellina oudardii* PAYRAUDEAU.

Remarks:—This genus is characterized by a thick internal rib, radiating from beak to ventral margin in front of mid-line.

Geographic distribution:—Europe and west coast of North America, but this seem to be no record on the living species from the Japanese coast of the Pacific. However, fossil species are recorded from both sides of the Pacific.

Geologic range:—?Eocene, Oligocene to Recent.

Tellina (*Oudardia*) sp.

Plate 10, figs. 4, 5

Remarks:—Two specimens are at hand. These are characterized by an equilateral, slightly opisthogyrous shell that is elongate-ovate in outline, and a depressed and beveled area along the posterior dorsal margin which is set off by a ridge extending from the umbo to the posterior end. Moreover, there is a blunt internal ridge running from the beak to the anterior-ventral margin, although it tapers toward the antero-ventral margin.

Tellina (*Oudardia*) *t-matumotoi* OTUKA (1940, p. 96) from the middle Miocene strata of northern Hokkaido is more or less similar to the present specimens, but it differs by having an inequilateral shell.

Locality:—81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8443.

Tellina cf. *T. cowlitzensis* WEAVER, 1916

Plate 6, fig. 5

1916. *Tellina cowlitzensis* WEAVER, Univ. Wash. Publ. Geol., vol. 1, p. 42, pl. 2, fig. 14.
1938. *Tellina* cf. *cowlitzensis* WEAVER. TURNER, Geol. Soc. Am., Spec. Pap., no. 10, p. 61, pl. 7, fig. 7.
1942. *Tellina cowlitzensis* WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 198, pl. 51, fig. 13; pl. 57, fig. 12.

Remarks:—Three specimens have been examined. One is represented by a well preserved right valve, the others are articulated but are imcomplete and crushed. This species is characterized by an anteriorly situated beak, a convex antero-dorsal margin, and an attenuated posterior end. The present specimens are very similar to, but smaller than WEAVER's (1916) type species from the Cowlitz formation (upper Eocene).

Localities:—81102, 81401, 20503, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8444.

Genus *Macoma* LEACH, 1819

Macoma LEACH, in John Ross, A voyage of discovery for the propose of exploring Buffins Bay and inquiring into the probability of a northwest passage, appendix, 11, p. 62, 1819; *Macoma* LEACH. DALL, Proc. Univ. Stat. Mus., vol. 23, p. 292, 1900; *Macoma* LEACH. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 1, no. 1, p. 179, 1924; *Macoma* LEACH. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 365, 1931; *Macoma* LEACH. HABE, Gen. Jap. Shells, p. 219, 1952; *Macoma* LEACH. ABBOTT, American Seashells, p. 430, 1954; *Macoma* LEACH. KANNO, Tert. Sys. Chichibu Basin, p. 298, 1960; *Macoma* LEACH. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 80, 1963; *Macoma* LEACH. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 58, 1969; *Macoma* LEACH. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 623, 1969.

Type-species (by monotypy):—*Macoma tenera* LEACH [=*Macoma calcarea* GMELIN], Recent, North American and boreal seas to Japan in the Pacific, and Long Island Sound in the Atlantic.

Remarks:—This genus is distinguished from *Tellina* LINNÉ by 1) lacking lateral teeth; 2) there is usually a strong posterior twist; 3) the pallial sinus is larger in one valve than the other.

Geographic distribution:—World-wide, generally in temperate to cold waters.

Geologic range:—Eocene to Recent.

Macoma aff. *M. lorenzoensis arnoldi* TEGLAND, 1933

Plate 10, figs. 1, 2

Remarks:—Two articulated specimens are at hand, one of which is represented by an internal mould. The present species is moderately compressed, roundly trigonal in shape, and has a slightly twisted posterior end. Moreover, the pallial sinus has a unique form, i. e., in the left valve it runs anteriorly from the posterior muscle scar toward the anterior one, but it does not meet the latter, and then descend posteriorly in a rounded circle to meet the pallial line almost in the central part of the lower margin of the shell (Text-fig. 9). The present specimens are close to

Text-fig. 9. Pallial sinus of *Macoma* aff. *M. lorenzoensis arnoldi* TEGLAND.

TEGLAND's subspecies *M. lorenzoensis arnoldi* in general shape, but precise comparison is difficult because the pallial sinus of TEGLAND's type is inaccessible. *Macoma brota lipara* DALL, living from south of Bering Strait to the Puget Sound, is more or less similar to the present specimen in general outline, but differs by having a smaller and narrower pallial sinus.

Locality:—80506, dark gray or black mudstone, lower part of the Yakataga formation.

Reg. No. TUE 8445.

Macoma incongrua (v. MARTENS), 1865

Plate 6, fig. 6; Plate 9, figs. 9, 10, 12

1865. *Tellina incongrua* v. MARTENS. Ann. Mag. Nat. Hist., Ser. 3, vol. 16, p. 430–431.
1924. *Macoma incongrua* v. MARTENS. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 1, p. 170, pl. 42, fig. 10.
1931. *Macoma incongrua* v. MARTENS. GRANT and GALE, San Diego Soc. Nat. Hist., vol. 1, p. 373.
1932. *Macoma* cf. *M. middendorfii* DALL. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 816, pl. 16, fig. 4.
1965. *Macoma incongrua* v. MARTENS. HABE and ITO, Shells of the World (in color), vol. 1, p. 145, pl. 50, figs. 9–10.
1971. *Macoma* cf. *M. incongrua* (v. MARTENS). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750–C, Fig. 5, d, h, n, o.

Remarks:—Three specimens are at hand. This species is characterized by a small shell which is trigonal in shape, convex, and has concentrically and irregularly striated surface ornamentation. Moreover, this species has a more or less twisted posterior margin which is shorter than the anterior one. The pallial sinus of the present specimens is not accessible.

This species ranges from the Arctic Ocean to Washington in the eastern Pacific and north of Kyushu (lat. 31°N) in the western Pacific, where it lives in muddy bottoms ranging from the intertidal zone to about 10 meters in depth.

According to HABE and ITO (1965, p. 145), the American specimen described by ABBOTT (1954, p. 431, fig. 88b) differs from the type of Japanese species in the shape of pallial sinus, e. g., the pallial sinus of the left valve of American specimen does'nt reach to the anterior adductor muscle scar, while that of the Japanese type species does reach the anterior muscle scar. Thus the so-called *Macoma incongrua* MARTENS living along the east coast of North America should be re-examined taxonomically.

This species ranges from the upper Oligocene(?), and Miocene to Recent.

Localities:—81201, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 8446.

Macoma cf. *M. incongrua* (v. MARTENS), 1865

Plate 9, fig. 11

1932. *Heterodonax*? sp. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 819, pl. 15, figs. 6, 7.

Remarks:—Clark reported *Heterodonax*? sp. from the upper part of the Hamilton Creek. The writer also collected a specimen, presumably from the same locality as CLARK's collection. This specimen is somewhat deformed, accordingly its original shape is unknown.

Locality:—80802, black mudstone, Yakataga formation.

Reg. No. TUE 8447.

Macoma arctata (CONRAD), 1849

Plate 2, figs. 5, 6

1849. *Tellina arctata* CONRAD, U. S. Explor. Exped. Geol., p. 725, figs. 3, 3a.
1909. *Tellina arctata* CONRAD. REAGAN, Trans. Kansas Acad. Sci., vol. 22, p. 184, pl. 2, figs. 16a, 16b.
1932. *Macoma arctata* (CONRAD). LOEL and COREY, Calif. Univ.. Publ., Bull. Dept. Geol. Sci.. vol. 22, no. 3, p. 227, pl. 43, figs. 1-2.
1932. *Tellina* sp. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 818, pl. 15, fig. 10.
1942. *Macoma arctata* (CONRAD). WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 208-209, pl. 49, figs. 3, 5, 12; pl. 59, fig. 15.
1960. *Macoma arctata* (CONRAD). KANNO, Tert. Sys. Chichibu Basin, p. 301, pl. 44, figs. 3-4.
1963. *Macoma arctata* (CONRAD). ILYINA, BNIGRI., no. 202, p. 81, pl. 27, fig. 3.
1963. *Macoma arctata* (CONRAD). MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 81, pl. 28, figs. 6, 7, 10, 11, 13; pl. 29, fig. 8.
1971. *Macoma*? cf. *M. arctata* (CONRAD). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 5, f.

Remarks:—Eight specimens are at hand, all of which are represented by internal moulds. Although most of the specimens are poorly preserved, the slightly concave, sloping anterior margin, obliquely truncated anterior end, and straight, rather long posterior margin serve to distinguish these specimens from the known species of *Macoma*. The pallial sinus of *M. arctata* has not been previously described. The pallial sinus of a topotype collected from the Astoria formation of Oregon by the writer is very deep reaching seven-tenths of the length from the posterior end of the shell. However, the present specimens at hand are too poorly preserved to show the precise shape of the pallial line.

This species ranges from the lower Miocene (Vaqueros formation in California) to the upper Miocene (Ilinsk formation in Kamchatka), and is distributed from the north of west coast of California to southeastern Alaska, and central Japan.

Locality:—80605, brownish-gray in weathered and bluish green in fresh, medium-grained sandstone, lower part of the Yakataga formation.

Reg. No. TUE 8448.

Macoma sp.

Plate 10, fig. 3; Plate 11, fig. 1

1932. *Macoma* cf. *secta* CONRAD. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 818, pl. 16, figs. 3, 3a.

Remarks:—CLARK (1932) described this species from UC loc. 3854 (the right side of Big River) and loc. 3861 (not plotted on CLARK's map). The writer also collected a specimen, presumably same as CLARK's, from float in the middle reaches of Poul Creek. Although this specimens is represented by articulated valves, each valve is so strongly deformed that its natural shape is unknown.

Localities:—80901 (float), 81106 (float), olive-green, medium-grained sandstone, presumably Poul Creek formation.

Reg. No. TUE 8449.

Superfamily Glossacea

Family Vesicomyidae

Genus *Calyptogena* DALL, 1891

Calyptogena DALL, Proc. U. S. Nat. Mus., vol. 14, p. 189, 1891; *Calyptogena* DALL, Trans. Wagner Free Inst. Sci., vol. 3, p. 1410, 1435, 1903; *Calyptogena* DALL. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 1, p. 116, 1924; *Calyptogena* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 278, 1931; *Calyptogena* DALL. HABE, Gen. Jap. Shells, p. 109, 1953; *Calyptogena* DALL. OKUTANI, Jap. Jour. Malacol., vol. 24, no. 4, p. 297-301, 1966; *Calyptogena* DALL. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 664, 1969.

Type-species (by monotypy):—*Calyptogena pacifica* DALL, Recent, Pacific coast of North America.

Remarks:—This genus is characterized by an ovate or elongate-ovate shell without a lunule but with a long excavated escutcheon, a strong deep-seated, external ligament, and a hinge with a large, triangular posterior cardinal and a weak anterior one in the right valve, and a triangular anterior cardinal and a weak posterior one as well as anterior lateral tooth in the left valve. According to DALL (1903), "the teeth become more or less obsolete in the adult, and in the young specimens retain the link between laterals and cardinals, which in most bivalves is lost at a very early age".

This genus is closely related to *Akebiconcha* KURODA and *Hubertschenckia* TAKEDA. These relations may be discussed in another paper in near future.

Geographic distribution:—Living species of the genus range from Clarence Strait, Alaska, to Santa Barbara Channel, California, on the Pacific coast of North America, and Sagami Bay in the central Japan. Fossil species distributes from Japan to Alaska, Washington, and California.

Geologic range:—Oligocene to Recent.

Calyptogena chitanii (KANEHARA), 1937

Plate 7, figs. 5, 6a-b; Plate 17, fig. 12

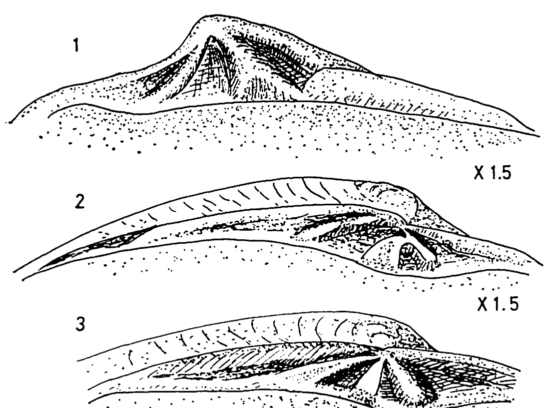
1937. *Adulomya chitanii* KANEHARA, Bull. Imp. Geol. Surv. Japan, vol. 27, no. 1, p. 19-20, pl. 5, figs. 1, 6-9.
1954. "*Adulomya*" *chitanii* KANEHARA. AOKI, Sci. Rep. Tokyo Univ. Education, sec. C, vol. 3, no. 17, p. 31, pl. 1, figs. 9-11.
1962. *Adulomya chitanii* KANEHARA. KAMADA, Paleont. Soc. Jap., Spec. Pap., no. 8, p. 39, pl. 1, figs. 4-7.
1964. *Akebiconcha chitanii* (KANEHARA). KANNO and OGAWA, Sci. Rep. Tokyo Univ. Educat., sec. C, vol. 8, no. 81, p. 285, pl. 1, figs. 17-18.
1967. *Akebiconcha chitanii* (KANEHARA). KANNO, Prof. H. SHIBATA Mem. vol., p. 401-402, pl. 1, figs. 9-11, 15.

Description:—Shell elongate-ovate or elongate, rounded at both ends, ventral margin slightly convex or broadly rounded in young and straight to broadly concave in adult; antero-dorsal slope short, sloping abruptly and merging into the anterior border; postero-dorsal margin long and gently sloping toward posterior border; beaks low, small, pointed, situated about one-fourth or one-fifth of shell length from the anterior end; surface sculptured with fine incremental growth lines; ligament external, deeply seated on a nymph, about one-fourth or one-third of the shell length; hinge with a large triangular posterior cardinal and a weak thin anterior one in the right valve, and a large triangular anterior cardinal and a thin elongated posterior one and an anterior lateral one in the left valve; inner side of the ventral margin smooth; pallial line entire; anterior muscle scar extremely distinct.

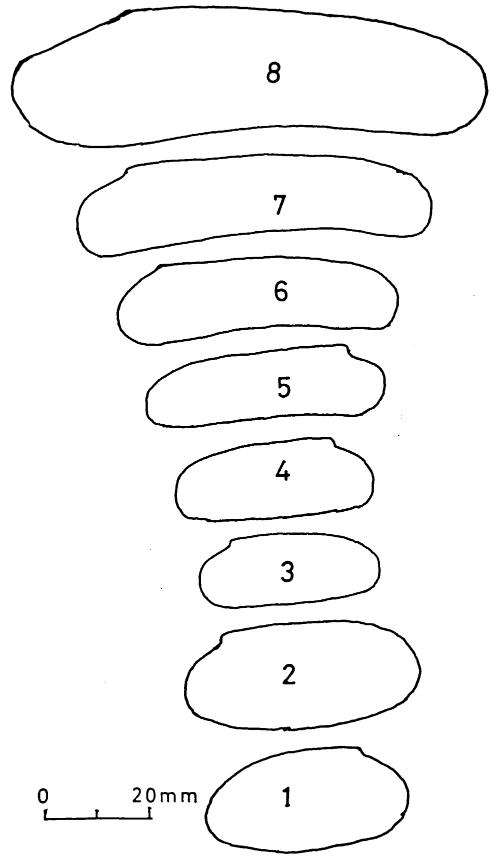
Measurement (in mm):—

Specimens	Length	Height	H/L×100	Valve
No. 1	39.5	16.0	41.0	Left
" 2	44.5	18.2	41.0	Right
" 3	ca.92.0	ca.26.0	28.3	Left

Remarks:—This species is characterized by an extremely elongate and somewhat arcuate form in adult shells, and a broad range of variation in shape and hinge apparatus according to its growth stage, e. g., the anterior cardinal tooth and the anterior lateral one of the left valve link together and show $\wedge$-shaped in young stages, but they are separated in the adult stage (Text-fig. 10). The younger specimens are more rounded ovate than adult ones, which are of an elongate and somewhat arcuate form as shown in Text-fig. 11. It is noteworthy that the size of the present species becomes to large with geologic age and approaches the elongate and arcuate form. Namely, the present species is extremely variable in shell form both in the phylogenetic and ontogenetic stages. KAMADA (1962) had been described the present species under genus *Adulomya* from the Kamenoo and Honya formations* of the Yunagaya group (Miocene) in the Joban coal-field, Japan. According to his report, the ratio of height to length of this species is 31.1 percent in 12 specimens from the Honya and 38.9 percent in 6 specimens from the Kamenoo formation. The variation



Text-fig. 10. Cardinal teeth of *Calyptogena chitanii* (KANEHARA) from the Kayak Island. 1–2. Young specimens; 3. Adult specimen.

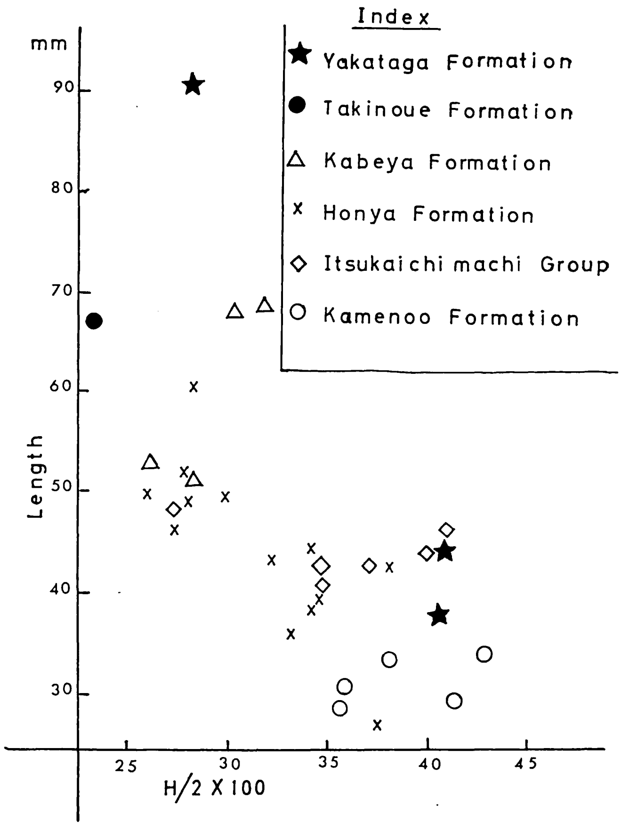


Text-fig. 11. Variation of *Calyptogena chitanii* (KANEHARA).
1–2. Tateya mudstone, middle Miocen, Itsukaichi-machi, Tokyo. 3–6. Honya formation, middle Miocene, Joban coal-field, Fukushima Prefecture, Japan (after KAMADA, (1962). 7. Takinoue formation, middle Miocene, Hokkaido, Japan. 8. Yakataga formation, Kayak Island, Alaska.

of the present species from various formations has been discussed by the writer (KANNO, 1967). So far as my knowledge is concerned, the Alaskan specimens are the largest fossil specimens known from the northern Pacific region. This fact seems to be suggesting the geologic age of the Yakataga formation, i. e., the Yakataga specimens seem to represent upper middle Miocene or upper Miocene. (Text-fig. 11, 12).

This species is somewhat similar to *C. elongata* DALL (OLDROYD, 1924, p. 116, pl. 22, fig. 6) from California, but the larger, more elongate and arcuate form serve to distinguish it from the Californian species. *C. pacifica* DALL (OKUTANI, 1966, pl. 27, figs. 1, 3) from the Clarence Strait, Alaska, is also similar to *C. chitanii*, but it dif-

* The Kamenoo shale is overlain conformably by the Honya shale.



Text-fig. 12. Variation of form ratio of *Calyptogena chitanii* (KANEHARA).

fers by having a more rounded-ovate shell outline.

This seems to be the first report of this species from the west coast of North America, but it is rather abundant in Japan where it is restricted to the middle Miocene.

Locality:—M 1769 (USGS locality number, Kayak Island), black shale, Yakataga formation.

Reg. No. TUE 8450.

Superfamily Corbiculacea

Family Corbiculidae

Genus *Corbicula* MEGERLE von MÜHLFELD, 1811

Corbicula MEGERLE von MÜHLFELD, Gesels. Naturf. Freu. Berlin, Magaz. Jahrg. 5, pt. 1, p. 56, 1811; *Corbicula* MÜHLFELD. WOODWARD, Man. Moll., p. 462, 1910; *Corbicula* MEGERLE. HABE, Gen. Jap. Shells, p. 112, 1952; *Corbicula* MEGERLE von MÜHLFELD. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 666, 1969.

Type-species (designated by ICZN, 1955):—*Tellina fluminalis* MÜLLER, 1774, Recent, Asia Minor.

Remarks:—This genus is characterized by a rounded-trigonal shell outline, concentric surface sculpture, and usually serrate lateral teeth. The species of the genus inhabit brackish or fresh waters.

Geographic distribution:—Cosmopolitan.

Geologic range:—Lower Cretaceous to Recent.

Subgenus *Corbicula* s. s.

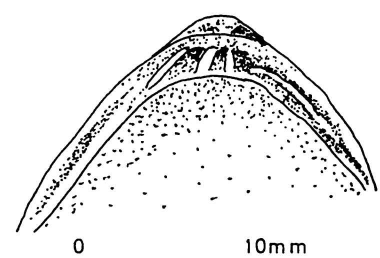
Corbicula s. s., MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 666, 1969.

Remarks:—The long lateral teeth, and entire pallial line serve to distinguish this from the other subgenera. This subgenus ranges from the upper Cretaceous to Recent.

Corbicula (*Corbicula*) sp.

Plate 17, figs. 13–15

Description:—Shell rather small for the genus, thick, rounded subtrigonal in outline, somewhat longer than high, more or less inequilateral, slighly short and rounded in anteriorly, subtruncated and obliquely produced posteriorly; beaks rather small and low; surface ornamented with the irregular concentric lines of growth; a blunt ridge runs from the beak to postero-ventral corner; hinge teeth of the left valve well developed, typical of the genus; anterior and middle cardinal teeth of almost equal shape and strength, the posterior one very narrow, and longer than the other cardinals, both anterior and posterior laterals fairly long but weak (Text-fig. 13); hinge of the right valve inaccessible; pallial line entire; length, 23.5 mm; height, 19.0 mm; thickness, about 7.0 mm (in a right valve).



Text-fig. 13. Cardinal teeth of *Corbicula* (*Corbicula*) sp.

Remarks:—The present specimens are from near the Oily Lake in the Samovar Hills, where the present specimens make several beds of 20 to 30 centimeters in thickness. However, they are so crowded that it is difficult to collect a well preserved specimens.

The present specimens are close to *Corbicula* (*Corbicula*) *atrata tokudai* (YOKOYAMA), (1932, p. 240, pl. 2, figs. 3, 4), from the Eocene Ishikari and Uryu group of Hokkaido, but the Hokkaido species differs slightly in having a more rounded outline. However, the writer supposes that this difference may fall within the variation range of individual. Accordingly, even if the specimens from the Kulthieth and Ishikari are not conspecific, they are quite closely related.

Locality:—81501, gray, fine- to medium-grained arkosic sandstone, upper part of the Kulthieth formation.

Reg. No. TUE 10007.

Superfamily Veneracea

Family Veneridae

Genus *Pitar* RÖMER, 1857

Pitar RÖMER, Krit. Untersuch. Art. Mollsk. geschi. Venus, p. 15, 1857; *Pitar* RÖMER. WOODRING, Carnegie Inst. Publ., no. 366, p. 152, 1925; *Pitar* RÖMER. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 344, 1931; *Pitar* RÖMER. HABE, Gen. Jap. Shells, p. 161, 1951; *Pitar* RÖMER. ABBOTT, Amer. Seashells, p. 414, 1954; *Pitar* RÖMER. KANNO, Tert. Sys. Chichibu Basin, p. 263, 1960; *Pitar* RÖMER. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 675, 1969; *Pitar* RÖMER. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull., no. 16, p. 46, 1969.

Type-species (by monotypy):—*Venus tumens* GMELIN, 1791, Recent, west coast of Africa.

Remarks:—This genus is characterized by its hinge apparatus, namely, the hinge of the right valve consists of two distinct anterior lateral lamellae flanking a deep socket, and three cardinals, of which the anterior and the middle ones are almost perpendicular to the hinge margin, and the posterior one is bifid. The hinge of left valve consists of a heavy anterior lateral and three cardinals, of which the anterior one resembles the right anterior cardinal, the middle one is very heavy and obscurely bifid, and the posterior one is slender and partly joined to the nymph.

Geographic distribution:—World-wide in warm water.

Geologic range:—Eocene to Recent.

Subgenus *Katherinella* TEGLAND, 1929

Katherinella TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 28, p. 276, 280, 1929; *Katherinella* TEGLAND. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 76–77, 1963; *Katherinella* TEGLAND. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 675, 1969.

Type-species (by original designation):—*Callocallista arnoldi* WEAVER, 1916, Blakeley formation (upper Oligocene, Washington). According to TEGLAND (1929, p. 280), *C. arnoldi* was not collected from the type locality of the Lincoln formation in Washington, but it came from the Blakeley formation, from either Restration Point, Bainbridge Island, or Alki Point, Seattle, Washington.

Remarks:—The present subspecies is characterized by having an anterior lateral teeth in the left hinge plate parallel to the anterior cardinal tooth and situated midway between the middle cardinal tooth and the anterior margin of the shell (pl. 8, fig. 7). This anterior lateral tooth is not parallel to the hinge plate and can not be considered as a true lateral. In addition, this subgenus has a thin shell and an elongate-ovate outline. These characteristics seem to be sufficient for the distinguishment from allied subgenera.

According to TEGLAND's study, there is no direct relationship between *P.* (*K.*) *arnoldi*, type of the subgenus, and other earlier species inhabiting the Tertiary embayments of America. She suspected that it might have migrated from northern or western waters, or probably originated from the Japanese fauna. This consideration is noteworthy for the development of the Alaskan molluscan fauna.

Geographic distribution:—West coast of North America.

Geologic range:—Oligocene to Recent.

Pitar (*Katherinella*) *arnoldi* (WEAVER), 1916

Plate 8, figs. 6, 7

1916. *Callocallista arnoldi* WEAVER, Univ. Wash. Publ. Geol., vol. 1, p. 40, 41, pl. 2, fig. 13.
1929. *Pitaria* (*Katherinella*) *arnoldi* (WEAVER). TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 18, no. 10, p. 280–282, pl. 23, figs. 1–11.
1932. *Pitaria* (*Katherinella*) *arnoldi* (WEAVER). CLARK, Bull. Geol. Soc. Am., vol. 43, p. 817.
1933. *Pitaria* (*Katherinella*) *arnoldi* (WEAVER). TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, p. 118.
1942. *Pitar* (*Katherinella*) *arnoldi* (WEAVER). WEAVER, Univ. Wash. Publ., Geol., vol. 5, pt. 1, p. 185–186, pl. 44, figs. 1–8, 12; pl. 104, fig. 10.

Remarks:—The present species is characterized by having a thin shell which is subquadrate to ovate in outline, and ornamentation of evenly developed concentric lines of growth. As pointed out by TEGLAND (1929), the left anterior lateral tooth is very characteristic of this species, namely, it is parallel to the anterior cardinal tooth and situated midway between the middle cardinal tooth and the anterior margin of the shell whereas the other subgenera of the genus provide the left anterior lateral tooth almost parallel to the shell margin or hinge plate. Moreover, the pallial sinus of this species is rather narrowly pointed and reaches the center of the shell.

This species occurs in the Puget Sound Basin and southwestern Washington as well as in the Gulf of Alaska.

Localities:—80602, 80905, 81102, 81201, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10008.

Pitar (*Katherinella*) *arnoldi etheringtoni* (TEGLAND), 1929

Plate 8, figs. 4, 5

1929. *Pitaria* (*Katherinella*) *arnoldi* (WEAVER) subsp. *etheringtoni* TEGLAND, Univ. Calif. Publ., Bull., Dept. Geol. Sci., vol. 18, p. 213, pl. 23, figs. 12–14.
1942. *Pitar* (*Katherinella*) *arnoldi* (WEAVER) subsp. *etheringtoni* TEGLAND. WEAVER, Univ. Wash. Publ. Geol., vol. 15, pt. 1, p. 186, pl. 44, figs. 9, 10, 13.

Remarks:—This subspecies is distinguished from *Pitar arnoldi* (s. s.) by a slight dorsal flattening of the valves, a low ridge extending from the umbo to the postero-ventral margin, and somewhat rounder outline. This subspecies was originally reported by TEGLAND (1929) from the middle Miocene of Clallam Bay, Washington.

Localities:—81003, 81102, 81401, 20503, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10009.

Pitar (*Katherinella*) sp.

Plate 7, figs. 4a–b

Remarks:—A right valve is at hand. This specimen shows a unique form and is more or less produced anteriorly. The hinge has a rather stout and heavy posterior cardinal tooth which is more or less grooved on top, the middle and anterior ones are thin and rather small. The anterior and posterior cardinals are connected under the beak and make an arch, but the middle cardinal is close to the anterior one and is separated from that arch. There is a socket corresponding to the anterior lateral tooth on the left valve.

Judging from the hinge apparatus, the present specimen may surely be assigned to *Pitar* RÖMER, 1857, and to the subgenus *Katherinella* TEGLAND, 1929, but no species with such a particular shell outline is known. This form, of course, may be the result of deformation in some degree after burial, but the writer believed that this specimen has not been deformed so hard because associated molluscs from the same locality are mostly undeformed.

Locality:—81001, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10010.

Genus *Securella* PARKER, 1949

Securella PARKER, Jour. Paleont., vol. 23, no. 6, p. 587, 1949; *Securella* PARKER. KANNO, Tert. Sys. Chichibu Basin, p. 277, 1960; *Securella* PARKER. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 74, 1963; *Securella* PARKER. MOORE et al., Treat. Invert. Paleont., pt. N. vol. 2, p. 686, 1969.

Type-species (by original designation):—*Venus securis* SHUMARD, 1858, Coast Range of California, Oregon and Washington.

Remarks:—This genus is characterized by a deeply sunken ligament wedging out between hinge plate, and a short, pointed pallial sinus. This genus is closely similar to *Chione* MEGERLE von MÜHLFELD, 1811, which differs from *Securella* because the ligament barely penetrates the valve to meet the nymph plate and the pallial sinus is shallow with a rounded apex or is sometimes lacking.

Geographic distribution:—Securella is recorded from as far south as the Transverse Range in southern California (lat. 34°30′N), northward to the Gulf of Alaska (lat. 60°N). This genus may have been a boreal type, while *Chione* is a warm water dweller. Fossil species of the genus are also recorded from Japan.

Geologic range:—Oligocene to Pliocene (MOORE et al., 1969).

Securella alaskensis (CLARK), 1932

Plate 8, figs. 8a–c

1932. *Chione securis alaskensis* CLARK, Geol. Soc. Am. Bull., vol. 43, p. 815, pl. 18, figs. 2, 3.
1944. *Chione* sp. DURHAM, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 27, p. 146.
1949. *Securella alaskensis* (CLARK). PARKER, Jour. Paleont., vol. 23, no. 6, p. 587–588, pl. 95, fig. 1.
1971. *Securella alaskensis* (CLARK). ADDICOTT et al., U.S. Geol. Surv. Prof. Pap., 750-C, Fig. 5, r, s.

Remarks:—This species was originally described by CLARK (1932) as a subspecies of *C. securis*, but the hinge structure was not described. The writer examined several specimens. A right valve shows the following hinge characters (pl. 8, fig. 8b): Ligament rather long, deeply sunken, right posterior cardinal grooved, and anterior cardinal rather small and thin and situated close to the middle cardinal.

This species occurs in the basal part of the Yakataga formation. Although the type locality is not plotted on CLARK's map, no securellid mollusks have been collected from the Poul Creek formation, but it occurs rather abundantly in the lowermost part of the Yakataga. Judging from the writer's observation, the type specimen might have been collected from the lowermost part of the Yakataga.

Localities:—80801 (float), 81402, gray, conglomeratic sandstone, lowest part of the Yakataga formation.

Reg. No. TUE 10011.

Genus *Macrocallista* MEEK, 1876

Macrocallista MEEK, Rept. U. S. Geol. Surv. Terretories. vol. 9, p. 179, 1876; *Macrocallista* MEEK. DALL, Trans. Wagner Free Inst. Sci., Phila., vol. 3, pt. 4, p. 1251-1252, 1903; *Macrocallista* MEEK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 343, 1931; *Macrocallista* MEEK. THIELE, Handb. Syst. Weicht., Band 2, p. 886, 1935; *Macrocallista* MEEK. MOORE et al., Treat. Invert. Paleont. pt. N, vol. 2, p. 677, 1969.

Type-species (by monotypy):—*Venus gigantea* GMELIN, 1791 [=*Venus nimbosa* LIGHTFOOT, 1786], Recent, Cape Hatteras south to Cuba and the Gulf coast of the United States.

Remarks:—This genus is sometimes confused with *Callista* POLI, 1791 (type species: *Venus chione* LINNÉ, by MEEK, 1876). However, according to THIELE (1931), *Callista* is a synonym of *Paradione* DALL, 1909, a section of subgenus *Macrocallista* MEEK. DALL (1903) also poined out that "the name *Macrocallista* of MEEK was intended to designate the *Venus gigantea* of GMELIN [=*nimbosa* SOLANDER], but this is only sectionally distinct from the forms which have been called *Dione* and *Callista*, and MEEK's name will therefore have to be taken as covering them both".

The present genus is characterized by three cardinals of which the right posterior one is slightly grooved or bified on top, an anterior lateral in the left valve and a corresponding socket in the right valve, and a moderately deep pallial sinus.

Geologic range:—Eocene to Recent, but apparently ranging from in Eocene to lower Miocene on the west coast of North America.

Geographic distribution:—East and west coast of North America and East Indies.

Macrocallista weaveri CLARK, 1918

Plate 17, figs. 7-11

1918. *Macrocallista weaveri* CLARK, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 11, p. 146, pl. 12, figs. 4, 7.
1925. *Macrocallista weaveri* CLARK, ditto, vol. 15, p. 92, pl. 18, figs. 10-12.
1932. *Macrocallista? rearensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 816-817, pl. 18, fig. 1.
1932. *Macrocallista pittsburgensis* DALL. CLARK, ditto, p. 816, pl. 19, figs. 1-2.
1942. *Macrocallista weaveri* CLARK. WEAVER, Univ. Washing. Publ., Geol., vol. 5, p. 176-177,

pl. 41, figs. 1–3.
1971. *Macrocallista pittsburgensis* (DALL). ADDICOTT et al., U.S. Geol. Prof. Pap., 750–C, Fig. 5, e, j, k.

Remarks:—Many rather well preserved specimens are at hand. Some of these show extreme variation in general outline. The writer believes that this extreme variation may be due to deformation of the specimens after burial. Actually, well preserved specimens which hardly show any variation occur at some localities, but at other localities the specimens are strongly variable.

The present specimens are characterized by a rather small, thick, inflated shell, strongly incurved beaks, and an ample and deep pallial sinus which is narrowly rounded anteriorly. The general features and teeth of the present specimens agree well with DALL's diagnosis of *Macrocallista*, excepting the shape of pallial sinus which is rounded anteriorly rather than pointed. However, the writer tentatively assigns the specimens to *Macrocallista*.

CLARK (1932) reported *Macrocallista*? *rearensis* CLARK from the Reare Glacier. He also described *M. pittsuburgensis* DALL from the same locality as *M.*? *rearensis*, but *M. pittsburgensis* differs from the present specimens by having a large, thin shell which is elongated posteriorly and lower than the present one. Moreover, the pallial sinus of the *M. pittsburgensis* is deeper and more pointed than the Poul Creek specimens. CLARK's specimens (1932, p. 816, pl. 19, figs. 1–2) seem to represent a deformed specimens of *M. weaveri*.

Localities:—9002–3 and 9002–5 (about 3.5 km east of loc. 81203, left side of the Yakataga Glacier), 81201, gray, fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10012.

Order Myoida

Suborder Myina

Superfamily Myacea

Family Myidae

Genus *Mya* LINNÉ, 1758

Mya LINNÉ, Sys. Nat. 10th Ed., p. 670, 1758; *Mya* LINNÉ. WOODWARD, Man. Moll., p. 489, 1910; *Mya* (LINNÉ) LAMARCK. OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sci., vol. 1, no. 1, p. 197, 1924; *Mya* LINNÉ. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 410, 1931; *Mya* LINNÉ. HABE, Gen. Jap. Shells, p. 237, 1952; *Mya* LINNÉ. ABBOTT, American Seashells, p. 454, 1954; *Mya* LINNÉ. MACNEIL, U.S. Geol. Surv. Prof. Pap., 483, p. 25, 1965; *Mya* LINNÉ. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 64, 1969; *Mya* LINNÉ. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 691, 1969.

Type-species (by subsequent designation, CHILDREN, 1822):—*Mya truncata* LINNÉ, Recent, north Atlantic, north Pacific, and Arctic Ocean.

Remarks:—The characteristic features of this genus are the oblong, inequivalved shell gaping posteriorly, and left valve with a large flattened projecting spoon-like chondrophore, and large pallial sinus.

The species of the genus are rather frequent in soft bottoms, especially in sandy and silty muds of river mouths or bays. They range from low water to 40 meters.

Geographic distribution:—Temperate and cold waters of Europe, North America and Japan.

Geologic range:—Eocene to Recent in Japan, and Oligocene to Recent in the west coast of North America.

Subgenus *Mya* s. s.

Remarks:—This subgenus is characterized by the truncated posterior end, and chondrophore with triangular anterior portion in front of anterior ridge.

Mya (Mya) truncata LINNÉ, 1758

Plate 10, figs. 6, 7; Plate 11, figs. 4a-b

1924. *Mya truncata* LINNÉ. OLDROYD, Stanf. Univ. Publ. Geol. Sci., vol. 1, no. 1, p. 197, pl. 10, fig. 4.
1931. *Mya truncata* LINNÉ. GRANT and GALE, San Diego Soc. Nat. Hist., Mem. vol. 1, p. 414.
1932. *Mya truncata* LINNÉ, n. subsp.? CLARK, Geol. Soc. Am., Bull., no. 43, p. 822, pl. 17, fig. 5.
1941. *Mya truncata* LINNÉ. NAGAO and INOUE, Hokkaido Imp. Univ. Fac. Sci. Jour., vol. 6, no. 273, p. 155, pl. 33, figs. 5, 9, 10.
1957. *Mya truncata* LINNÉ. FUJIE, ditto, vol. 4, no. 4, p. 399, pl. 3, figs. 1-4.
1965. *Mya (Mya) truncata* LINNÉ. MACNEIL, U. S. Geol. Surv., Prof. Pap., no. 483-G, p. 38-40, pl. 8, figs. 1-12; pl. 9, figs. 1-3, 5-20.
1965. *Mya truncata* LINNÉ. ADDICOTT, U. S. Geol. Surv. Prof. Pap., 525-C, pl. 3, fig. 6.
1971. *Mya (Mya) truncata* LINNÉ. ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 5, i, p, q, t, w.

Remarks:—This species has rugose shell and has several varietal forms, apparently caused by contact with objects in the substratum. However, *Mya (M.) truncata* has a short, truncated shell, and the shortest pallial sinus of any *Mya*, e. g., the pallial line extends from the posterior muscle scar to that of the ventral margin, and the point of maximum depth of pallial sinus is the juncture at the ventral margin. The spoon of the left valve is rather symmetrical and the dorsal part of the anterior ridge is broad and there is a narrow posterior furrow.

This species is very abundant in the middle and upper part of the Yakataga formation of this area where the dark-gray siltstone or black shale is the dominant lithology. The specimens from these rocks are all of small size whereas associated mollusks such as *Neptunea* are of normal size. However, specimens from the lowest part of the Yakataga where it consists of pebble-bearing sandstone are represented by full grown specimens (Plate 11, figs. 4a-b).

This species lives in the boreal regions such as the northern Pacific, northern Atlantic, and Arctic Ocean, and ranges southward to southern Hokkaido and Puget Sound.

The fossil specimens are recorded since the middle Miocene in the Pacific region and are also known from northern Europe throughout the Pleistocene time.

Localities:—80404, 80405, 80406, dark-gray or black shale, Yakataga formation;

80801, black mudstone, lower part of the Yakataga formation; 81402, brownish-gray, pebble-bearing sandstone, lowest part of the Yakataga formation.

Reg. No. TUE 10013.

Mya (*Mya*) *salmonensis* CLARK, 1932

Plate 11, fig. 5

1932. *Mya salmonensis* CLARK, Geol. Soc. Am., Bull., vol. 43, p. 822, pl. 17, figs. 3, 4, 8.
1941. *Mya grewingki* var. *elongata* NAGAO and INOUE, Jour. Fac. Sci., Imp. Univ. Hokkaido, Ser. 4, vol. 6, no. 2, p. 150, pl. 33, figs. 1–4.
1941. *Mya grewingki* var. *kusiroensis* NAGAO and INOUE, ditto, p. 150, pl. 32, figs. 2–6.
1958. *Mya grewingki nagaoi* OYAMA and MIZUNO, Bull. Jap. Geol. Surv., vol. 9, no. 9, p. 603 (no figure).
1965. *Mya* (*Mya*) *salmonensis* CLARK. MACNEIL, U.S. Geol. Surv., Prof. Pap., 483-G, p. 35, pl. 7, figs. 1–4.

Remarks:—This species was originally described by CLARK (1932) from the Yakataga District (the exact locality was not designated on his map and the type specimens were collected as float). However, according to MACNEIL's (1965) report, this species might be from the Poul Creek formation. The writer examined three specimens collected from float believed to have been derived from the upper part of the Poul Creek formation.

According to MACNEIL (1965), some specimens from the Oligocene and the lowest part of the Miocene in Japan are synonym of *M.* (*M.*) *salmonensis*.

Locality:—80906 (float), olive-green, medium-grained sandstone, presumably Poul Creek formation.

Reg. No. TUE 10014.

Mya (*Mya*) *cuneiformis* (BÖHM), 1915

1915. *Pleuromya cuneiformis* BÖHM, Jahrb. d. königl. Preussisch. Geol. Landesanst., vol. 26, p. 577, pl. 29, figs. 1a–c.
1925. *Mya arenaria* LINNÉ var. *japonica* JAY. YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 5, p. 16, pl. 16, fig. 4.
1926. *Mya arenaria* LINNÉ. YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 1, pt. 7, p. 241, pl. 30, fig. 1.
1927. *Mya arenaria* LINNÉ. YOKOYAMA, ditto, vol. 2, pt. 4, p. 198, pl. 51, fig. 2.
1929. *Mya arenaria* LINNÉ. YOKOYAMA, ditto, vol. 2, pt. 9, p. 385, pl. 74, fig. 3.
1931. *Mya donaciformis* KURODA. HOMMA's Geol. Central Shinano, pt. 4, p. 63, text-fig. 7.
1941. *Mya cuneiformis* (BÖHM). NAGAO and INOUE, Jour. Fac. Sci., Hokkaido Imp. Univ. Ser. 4, vol. 6, no. 2, p. 151–155, pl. 34, figs. 1–6.
1962. *Mya cuneiformis* (BÖHM). KAMADA, Paleont. Soc. Japan, Spec. Pap., no. 8, p. 141, pl. 16, figs. 14–16.
1965. *Mya* (*Mya*) *cuneiformis* (BÖHM). MACNEIL, U.S. Geol. Surv., Prof. Pap., 483-G, p. 35, pl. 7, figs. 2, 3, 5–8, 12, 15.

Remarks:—This species is characterized by the wedge-shaped shell outline. It occurs in northern Honshu (main island of Japan), Hokkaido, Sakhalin (type locality), and the Gulf of Alaska. This species ranges from the middle Miocene to lower Pliocene, although it flourished in the middle Miocene in Japan.

This species seems to be restricted to the lower part of the Yakataga formation.

Localities:—80802, 20525-1, dark-gray mudstone, lower part of the Yakataga formation.

Reg. No. TUE 10015.

Superfamily Hiatellacea

Family Hiatellidae

Genus *Hiatella* BOSC, 1801

Hiatella BOSC, Hist. Nat. Buffon, Coquilles, vol. 3, p. 120, 1801; *Saxicava* FLEURIAU. OLDROYD, Stanf. Univ. Publ. Geol. Sci., vol. 1, no. 1, p. 208, 1924; *Saxicava* FLEURIAU de BELLEVUE. GRANT and GALE, San Diego Soc. Nat. Hist., vol. 1, p. 427, 1931; *Hiatella* DAUDIN. HABE, Gen. Jap. Shells, p. 232, 1953; *Hiatella* BOSC. KEEN, Marine Moll. Gen. West. North Am., p. 92, 1963; *Hiatella* BOSC. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 700, 1969.

Type-species (by subsequent designation, WINCKWORTH, 1932):—*Hiatella monoperta* DAUDIN.

Remarks:—The present genus is characterized by a small, elongate-quadrate shell, anteriorly situated beaks, a distinct ridge running from the beak to the postero-ventral margin, and a discontinuous pallial line.

Geographic distribution:—Most species of the genus occur in boreal waters, but some species live in more southern areas such as Kyushu and Shikoku (about lat. 33°N) in the Pacific coast of Japan. This genus also distributes in Europe and North America.

Geologic range:—Upper Jurassic to Recent.

Hiatella arctica (LINNÉ), 1767

Plate 10, figs. 11a–b

1767. *Saxicava arctica* LINNÉ, Syst. Nat. Ed. 12, p. 113.
1924. *Saxicava arctica* LINNÉ. OLDROYD, Stanf. Univ. Publ., Geol. Sci., vol. 1, no. 1, p. 208, pl. 9, fig. 6; pl. 51, fig. 4.
1931. *Saxicava arctica* LINNÉ. GRANT and GALE, San Diego Soc. Nat. Hist., vol. 1, p. 427.
1943. *Saxicava arctica* LINNÉ. MACNEIL, MERTIE and PILSBRY, Jour. Paleont., vol. 17, no. 1, p. 93, pl. 15, fig. 6.
1965. *Hiatella arctica* (LINNÉ). HABE and ITO, Shells of the World (in color), vol. 1, p. 155, pl. 54, figs. 3–4.

Description:—Shell rather small, oblong, subquadrate, more or less thick for its size; ligament external, opisthodetic; equivalve, strongly inequilateral; beaks inconspicuous, situated one-fifth of the length from the anterior end; antero-dorsal border short, steeply sloping and merging into a narrowly rounded antero-ventral corner; postero-dorsal border long, almost parallel to the ventral margin; posterior end bluntly truncated, somewhat gaping; surface ornamented with concentric, irregular, rather weak undulations; a distinct but blunt ridge runs from umbo to postero-ventral margin; hinge and inner surface inaccessible. Length, 24.5 mm;

height, 12.5 mm; thickness, ca. 10.0 mm (articulated valves).

Remarks:—A single specimen is at hand. This species is living in the Arctic Ocean along the west coast of North America (north of California) in the eastern Pacific and to northern Honshu (north of lat. 37°N) in the western Pacific, and also occurs in the Atlantic Ocean.

The Recent species ranges from the intertidal to 130 meters, and is found in rock crevices and among the roots of seaweed. Accordingly the shape of shell is rather variable owing to its habitats.

According to F. STRAUCH (1968), shell size of Recent population of this species has been directly compared with temperature, and the results have been quantitively applied to fossil specimen. Although a single specimen is at hand, it is measured as 24 mm in length and about 9.5 mm in thickness (articulated valve). Granting that the present specimen represents an adult specimen, this value seems to represent the marine temperature of about 12°-13°C in August and about 0°C in February (F. STRAUCH, 1968, p. 220, fig. 2; p. 225, fig. 4). However, the Poul Creek specimen is extremely large size compared with the specimens occurred from other localities of the same geologic age (F. STRAUCH, 1968, p. 224, fig. 3; p. 225, fig. 4).

Locality:—80802, dark-gray siltstone, Yakataga formation.

Reg. No. TUE 10016.

Genus *Panope* MENARD, 1807

Panopea MENARD, Ann. Mus. Nat. Hist. Paris, vol. 9, p. 135, 1807; *Panopea* MENARD. STOLICZKA, Paleont. Indica, ser. 4, vol. 3, p. 85, 1871; *Panope* MENARD. DALL, Proc. Malac. Soc., vol. 10, pt. 1, p. 34-35, 1912; *Panopaea* MENARD. OLDROYD, Stanf. Univ. Publ. Univ. Ser. Geol. Sci., vol. 1, no. 1, p. 205, 1924; *Panopea* MENARD. STEWART, Acad. Nat. Sci. Phila., Sepec. Publ., no. 3, p. 294, 1930; *Panope* MENARD. GRANT and GALE, Mem. San Diego Nat. Hist., vol. 1, p. 423, 1931; *Panope* MENARD. HABE, Gen. Jap. Shells, p. 233, 1952; *Panope* MENARD. KANNO, Tert. Sys. Chichibu Basin, p. 311-312, 1960; *Panope* MENARD. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 83, 1963; *Panope* MENARD. MOORE et al., Treat. Invert. Paleont. N, vol. 2, p. 700, 1969.

Type-species (by monotypy):—*Panope aldrovandi* MENARD [=*Panopea glycimeris* Born], Recent, Mediterranean Sea.

Remarks:—This genus is characterized by having an equivalve, thick, oblong shell with gaping at both end, a subcentral beak, a rudely concentric undulated surface, a deep pallial sinus, and a hinge with one small cardinal tooth in each valve.

The generic name of this genus is rather controversial. Many authors (STOLICZKA, 1871; STEWART, 1930; KANNO, 1957, etc.) have discussed the spelling of the generic name. However, this problem may be still pending in the International Committee of Zoological Nomenclature. Therefore, the writer is following his previous work (KANNO, 1957).

Geographic distribution:—North Sea, Mediterranean, Australia, New Zealand, Patagonia, northwest coast of North America, and Japan.

Geologic range:—Lower Cretaceous to Recent.

Panope snohomishensis CLARK, 1925

Plate 11, figs. 2a-b

1925. *Panope snohomishensis* CLARK, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 15, p. 105, pl. 10, fig. 1; pl. 11, fig. 2.
1942. *Panope snohomishensis* CLARK. WEAVER, Univ. Wash. Publ. Geol., vol. 5, pt. 1, p. 261-262, pl. 59, figs. 3, 19.

Remarks:—This species was originally described by CLARK (1925) from the middle Oligocene of Snohomish County, Puget Basin, Washington. This species is rather common in the Poul Creek formation and several specimens were collected from the upper part of that formation.

This species is more or less similar to the Japanese species *P. japonica* (A. ADAMS) and the American species *P. generosa* GOULD, but its more slender posterior portion may serve to distinguish it from these two species.

Localities:—81201, 81401, olive-green, fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10017.

Panope n. sp.?

Plate 11, figs. 3a-b

Description:—Shell subquadrate, ventral and dorsal margins approximately parallel; beaks prominent, slightly prosogyrous, strongly inturned, situated a little in front of median line; antero-dorsal margin steeply sloping and making a rather narrowly rounded anterior margin with the postero-ventral one; postero-dorsal border almost straight but slightly concave in its posterior portion; posterior end broadly truncated and widely gaping; surface ornamented with irregularly rounded undulattions on and between which are fine incremental lines; concentric undulations on umbones and for considerable distance below fairly regular; below this they become irregular and on the marginal part of gerontic specimen becomes almost obsolete; a fairly broad, shallow depression runs from the umbo to the posterior ventral margin, where the depression becomes shallow, wide, and almost obsolete; connecting this depression a blunt ridge runs from umbo to the truncated posterior end; nymph plate rather short, and small. Length, 64.1 mm; height, 42.0 mm; thickness of articulated valves, 25.2 mm (more or less compressed specimen).

Remarks:—A well preserved specimen is at hand. It is characterized by a high shell, steeply sloping antero-dorsal margin, and a shallow depression on disc and a blunt ridge running from umbo to postero-ventral margin. These characteristics are somewhat similar to *P. abrupta* (CONRAD), (HICKMAN, 1969, p. 65, pl. 8, fig. 15), from Oligocene and younger formations of west coast of North America, but it differs from the present one by the lower shell with more gently sloping antero-dorsal margin. This specimen may represent a new species, but a new name can not be proposed until more specimens are available.

Locality:—81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10018.

Genus *Panomya* GRAY, 1857

Panomya GRAY, Fig. Moll. Anim., vol. 5, p. 29, 1857; *Panomya* GRAY. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 351, 659, 1858; *Panopaea* MENARD. STOLICZKA, Paleont. Indica, ser. 4, vol. 3, p. 85, 1871; *Panomya* GRAY. DALL, Trans. Wagner Inst. Sci., Phila., vol. 3, pt. 4, p. 832, 1898; *Panomya* GRAY. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 425, 1931; *Panomya* GRAY. HABE, Gen. Jap. Shells, no. 3, p. 233, 1952; *Panomya* GRAY. KANNO, Trans. Proc. Paleont. Soc. Jap., no. 25, p. 12-13, 1957; *Panomya* GRAY. KANNO, Tert. Sys. Chichibu Basin, p. 313-314, 1960; *Panomya* GRAY. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 700, 1969.

Type-species (by monotypy):—*Mya norvegica* SPENGLAR, 1793, Recent, northern Atlantic Ocean.

Remarks:—This genus is distinguished from *Panope* MENARD, 1807, by having a medial depression, prominent radial folds, and disconnected oval pallial impressions. *Mya* LINNÉ, 1758, is also more or less similar to *Panomya*, but differs in lacking the radial ridges running from beak to antero-ventral margin, and in having an entire pallial line, and a chondrophore in the left valve.

Panomya seems to be a boreal genus and usually lives offshore buried in muddy bottoms in comparatively cold water.

Geographic distribution:—Europe, North America, northern Asia, and Arctic regions. North of Puget Sound and north of Hokkaido in the northern Pacific ranging from 60 to 110 meters in depth.

Geologic range:—Tertiary to Recent.

Panomya arctica (LAMARCK), 1818

Plate 10, figs. 8-10

1818. *Glycimeris arctica* LAMARCK, Hist. Anim. s. Vert., vol. 5, p. 458.
1916. *Panomya turgida* DALL, Bull. U. S. Nat. Mus., no. 112, pl. 2, fig. 1.
1924. *Panomya turgida* DALL. OLDROYD, Stanf. Univ. Publ., Geol. Sci., vol. 1, no. 1, p. 206.
1931. *Panope (Panomya) arctica* (LAMARCK). GRANT and GALE, San Diego Nat. Hist., vol. 1, p. 426.
1932. *Panomya (Arctica) turgida* DALL. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 823, pl. 17, figs. 6, 9.
1963. *Panomya arctica* (LAMARCK). HABE and ITO, Shells of the World, vol. 1, p. 153, pl. 53, figs. 4, 5.
1971. *Panomya arctica* (LAMARCK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 6, e, g, f, k.
1971. *Panomya* cf. *P. arctica* (LAMARCK). ADDICOTT et al., ditto, Fig. 6, a. b, d.

Remarks:—Many specimens are at hand. All are articulated and some were collected in a position perpendicular to the bedding plane. It seems clear that they were preserved almost in the living state. This species was previously reported by CLARK (1932) as *Panomya (Arctica) turgida* DALL, 1917, living in Aleutian Islands, but HABE and ITO (1963) referred it to *P. arctica* (LAMARCK), and they pointed out that *P. turgida* DALL, 1916, is a synonym of the *P. arctica* (LAMARCK), 1818.

This species is characterized by having a rather short, quadrate, and swollen shell, which has a broad gape at the truncated posterior end. Crushed specimens of this species are apt to be misidentified as species of *Panope*, but the hinge structure (pl. 10, fig. 9) and pallial line serve to distinguish it from similar genera.

This species lives in the northern Pacific from north of Hokkaido, Japan, in the western Pacific, and north of Puget Sound, Washington, in the eastern Pacific.

Localities:—80404, 80405, 80406, 80503, 80603, 80802, 81105, dark-gray siltstone or black shale, Yakataga formation; 80801, fossil float, possibly derived from the Yakataga formation.

Reg. No. TUE 10019.

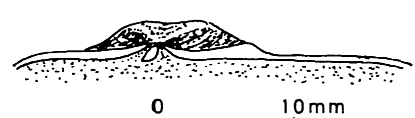
Panomya elongata KANNO, 1958

Plate 11, figs. 6, 7

1932. *Saxicava pholadis* LINNÉ. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 824, pl. 18, fig. 9.
1958. *Panomya elongata* KANNO, Sci. Rep. Tokyo Univ. Education, sec. C, vol. 6, no. 55, p. 195–196, pl. 4, fig. 19.
1960. *Panomya elongata* KANNO, Tert. Sys. Chichibu Basin, p. 314, pl. 46, fig. 3.
1963. *Saxicava* cf. *pholadis* LINNÉ. ILYINA, Moll. Neog. Kamchatka, BNIGRI., no. 202, p. 85, pl. 18, fig. 6.

Remarks:—Four specimens are at hand. This species was originally reported by the writer from the Chichibu Basin, central Japan. Subsequently, ILYINA (1963) reported it from the Kurben formation (possibly middle Miocene) in Kamchatka.

This species is characterized by a rather small shell for the genus. It is elongate-subquadrate in outline, moderately inflated, and has gaping posterior end. Moreover, the surface is ornamented with irregular concentric undulations, and the depressed medial portion is bounded by two radial folds which run from the beak to the antero- and postero-ventral margins.



Text-fig. 14. Hinge structure of *Panomya elongata* KANNO.

The present specimens are more or less similar to some species of *Panope* MENARD, 1807, or *Hiatella* BOSC, 1801, but the surface sculpture and hinge structure (Text-fig. 14) serve to distinguish it from the other genera.

Locality:—81041, fine- to medium-girained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10020.

Subclass Anomalodesmata

Order Pholadomyoida

Superfamily Pandoracea

Family Periplomatidae

Genus *Periploma* SCHUMACHER, 1817

Periploma SCHUMACHER, Ess. Nouv. Syst. Habit. Vers. Test., p. 115–116, 1817; *Periploma* SCHUMACHER. OLDROYD, Stanf. Univ. Publ. Geol. Sci., vol. 1, no. 1, p. 81, 1924; *Periploma*

SCHUMACHER. GRANT and GALE, San Diego Soc. Nat. Hist. Mem., vol. 1, p. 255, 1931; *Periploma* SCHUMACHER. HABE. Gen. Jap. Shells, p. 264, 1953; *Periploma* SCHUMACHER. ABBOTT, American Seashells, p. 472, 1954; *Periploma* SCHUMACHER. KEEN, Sea Shells Trop. West. Am., p. 228, 1958; *Periploma* SCHUMACHER. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 849, 1969.

Type-species (by monotypy):—*Periploma inaequivalvis* SCHUMACHER.

Remarks:—The present genus is characterized by an inequilateral, and nacreous shell with fissured beaks and with an oblique, spoon-shaped process in each valve, and an internal rib (lithodesma) extending from under the hinge to the posterior margin. Moreover, the anterior muscle scar is long and narrow, whereas the posterior one is small and semi-lunar.

This genus is very similar to *Cochlodesma* COUTHOUY, 1839, in general shape, but it differs by having a distinct lithodesma, whereas *Cochlodesma* either lacks it, or if present, it is only slightly developed. *Laternula* RÖDING, 1798, is also very similar to the *Periploma* but the elongate and swollen shell, and rostrated and truncated posterior margin which has a disinct gape, serve to distinguish it from allied genera.

Geographic distribution:—Cosmopolitan. Living species are collected along the seacoast of Japan from the intertidal zone to 200 meters. They seem to be fond of muddy or silty bottom.

Geologic range:—Upper Cretaceous to Recent.

Subgenus *Aelga* SLODKEWITSCH, 1934

Aelga SLODKEWITSCH, Ann. Soc. Paleont. USSR., no. 10, p. 55, 1934; *Aelga* SLODKEWITSCH. Paleont. USSR., vol. 10, pt. 3, Fasc. 18, p. 260, 1938; *Aelga* SLODKEWITSCH. HABE, Gen. Jap. Shells, p. 265, 1953; *Aelga* SLODKEWITSCH. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 849, 1969.

Type-species (by original designation):—*Tellina besshoensis* YOKOYAMA, 1924, Oligocene, Japan.

Remarks:—This subgenus is characterized by having rather large-sized shell for the genus. The shell is compressed and is somewhat twisted in the posterior portion. This subgenus seems to be restricted in Oligocene to Miocene age in the northern Pacific region.

Periploma (*Aelga*) *besshoense* (YOKOYAMA), 1924

Plate 3, fig. 5; Plate 11, fig. 10

1924. *Tellina besshoensis* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, vol. 45, art. 3, p. 14, pl. 2, figs. 1-5.
1934. *Periploma besshoensis* (YOKOYAMA). MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ. ser. B, vol. 10, no. 2, (art. 6), p. 153.
1938. *Periploma besshoensis* (YOKOYAMA). SLODKEWITSCH, Paleont. USSR., vol. 10, pt. 3, Fasc. 19, pp. 260-264, pl. 55, figs. 1-3.
1953. *Periploma besshoensis* (YOKOYAMA). TAKEDA, Studies on Coal Geol., no. 3, pl. 3, fig. 6, (no description).
1955. *Periploma besshoensis* (YOKOYAMA). HIRAYAMA, Sci. Rep. Tokyo Univ. Education, Ser. C, vol. 4, no. 29, p. 107, pl. 4, fig. 31.
1962. *Periploma* (*Aelga*) *besshoense* (YOKOYAMA). KAMADA, Paleont. Soc. Japan, Spec. Pap., no. 8, p. 75-77, pl. 6, figs. 1-4.

Remarks:—This species was described by YOKOYAMA (1924) from the Oligocene of Jo-ban coal-field in Japan. It has rather variable outline as pointed out by KAMADA (1962, p. 76), e. g., although the typical form has a rather equilateral and broadly rounded posterior margin as shown in YOKOYAMA's figures 4 and 5, the other individuals are somewhat rostrate posteriorly and have a depressed posterior area as indicated by YOKOYAMA's figures 1-3. The specimens at hand are also variable in outline (Pl. 3, fig. 5; Pl. 11, fig. 10). As far as the present specimens are concerned, YOKOYAMA's typical form seems to be restricted to the upper part of the Poul Creek formation, but the elongate and rather rostrate form seems to occur in the muddy facies of the lower part of the Yakataga formation. However, this conclusion must remain tentative until a larger number of specimens from each unit level is studied.

Localities:—80404, 81104, black shale, Yakataga formation; 80905, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10022.

Family Thraciidae

Genus *Thracia* SOWERBY, 1823

Thracia LEACH. H. and A. ADAMS, Gen. Rec. Moll., vol. 2, p. 364, 1856; *Thracia* BLAINVILLE. DALL, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1522, 1903; *Thracia* (LEACH) BLAINVILLE. WOODWARD, Man. Moll., p. 495, 1910; *Thracia* (LEACH) BLAINVILLE. OLDROYD, Stanf. Univ. Publ. Geol. Sci., vol. 1, no. 1, p. 83, 1924; *Thracia* BLAINVILLE. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 256, 1931; *Thracia* BLAINVILLE. HABE, Gen. Jap. Shells, p. 262, 1952; *Thracia* BLAINVILLE. KANNO, Tert. Sys. Chichibu Basin, p. 319, 1960; *Thracia* BLAINVILLE. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 84, 1963; *Thracia* SOWERBY. KEEN, Marine Moll. Gen. West. N. Am., p. 93, 1963; *Thracia* SOWERBY. MOORE et al., Treat. Invert. Paleont., pt. N, vol. 2, p. 850, 1969.

Type-species (by subsequent designation, ANTON, 1839):—"*Thracia pubescens* LAMARCK", Recent, England.

Remarks:—This genus is characterized by a rather thin shell with a bluntly rostrated posterior margin, a blunt ridge running from beak to postero-ventral margin and separating the main disk from the elongate-trigonal posterior depressed area, and perforated beaks (one or both valves, usually the right one).

Living species are reported from the intertidal zone to 200 meters in silty sand or muddy bottoms.

Geographic distribution:—Cosmopolitan.

Geologic range:—Jurassic to Recent.

Thracia schencki CLARK, 1932

Plate 11, figs. 8, 9

1932. *Thracia schencki* TEGLAND (MS). CLARK, Bull. Geol. Soc. Am., vol. 43, p. 808, pl. 15, figs. 2, 3, 5.

1933. *Thracia schencki* TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, p. 112-113,

pl. 6, figs. 6–11.
1942. *Thracia schencki* TEGLAND. WEAVER, Univ. Wash. Publ. Geol. vol. 5, p. 118, pl. 25, figs. 5, 22.
1971. *Thracia schencki* CLARK. ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750–C, Fig. 6, h–j, l, n.

Remarks:—More than ten specimens are at hand. These specimens are rather variable in outline owing in part to preservation and possibly also to individual variation.

This species is rather similar to *T. trapezoides* CONRAD, 1849, from the Astoria formation (middle Miocene) of Oregon, and to *T. condoni* DALL, 1909, from the Eugene formation (upper Oligocene) in Oregon. As pointed out by previous workers (CLARK, 1932; TEGLAND, 1933; WEAVER, 1942; MOORE, 1963), this species can be distinguished from allied species by the absence of the second flexure on the anterior third of the shell surface (from *T. trapezoides*), and by having smaller and relatively shorter shell (from *T. condoni*).

This species was first introduced by CLARK (1932) as a manuscript name of TEGLAND. However, he described the repository of the type specimens and comparison between the allied species together with figured specimens. A detail description was given by TEGLAND (1933).

Localities:—80602, 80902, medium-grained calcareous sandstone in the alternating sequence of sandstone and siltstone in the upper part of the Poul Creek formation; 20511, 80905, 81201, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10024.

Thracia cf. *T. condoni* CONRAD, 1909

Plate 17, figs. 16, 17

1909. *Thracia condoni* DALL, U. S. Geol. Surv., Prof. Pap., no. 59, p. 135–136, pl. 9, fig. 5.
1933. *Thracia condoni* DALL, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 23, no. 3, pl. 6, fig. 5.
1938. *Thracia condoni* DALL. SLODKEWITSCH, Paleont. USSR., vol. 10, pt. 3, Fasc. 18, p. 267–269, pl. 58, figs. 1–3.
1942. *Thracia condoni* DALL. WEAVER, Univ. Wash. Publ. Geol., vol. 5, pt. 1, p. 119, pl. 25, fig. 10; pl. 29, fig. 15.

Remarks:—Several specimens are at hand. Most are well preserved, but there are some variation in shape, e. g., although this species is characterized by having a lower shell than *T. trapezoides* and *T. schencki*, the ratio of length to height ranges from 64.2 to 72.3 whereas it is 74.1 in the holotype.

Localities:—81201, 81401, olive-green, fine- to medium-grained sandstone, middle to upper part of the Poul Creek formation.

Reg. No. TUE 10020.

Class Scaphopoda

Family Dentaliidae

Genus *Dentalium* LINNÉ, 1758

Dentalium LINNÉ, Syst. Nat., Ed. 10, p. 785, 1758; *Dentalium* LINNÉ. H. and A. ADAMS, Gen. Rec. Moll., vol., p. 456, 1854; *Dentalium* LINNÉ. WOODRING, Carnegie Inst. Wash. Publ., no. 366, p. 197, 1925; *Dentalium* LINNÉ. OLDROYD, Stanf. Univ. Publ., Geol. Sci., vol. 2, pt. 1, p. 99, 1927; *Dentalium* LINNÉ. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 436, 1931; *Dentalium* LINNÉ. HABE, Gen. Jap. Shells, p. 292, 1953; *Dentalium* LINNÉ. MOORE et al., Treat. Invert. Paleont., pt. I, Moll. I, p. 37, 1960; *Dentalium* LINNÉ. EMERSON, Jour. Paleont., vol. 36, no. 3, p. 467-471, 1962; *Dentalium* LINNÉ. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 50, 1963.

Type-species (by subsequent designation, MONTFORT, 1810):—*Dentalium elephantium* LINNÉ, 1758. Recent, Amboynaland and Philippine Islands.

Remarks:—The genus is characterized by longitudinal ribs, riblets, or striae, at least on the posterior portion of tube in juvenile stage. These riblets are straight, then often increase anteriorly by intercalation.

Most living species inhabit shallow water.

Geographic distribution:—Cosmopolitan.

Geologic range:—Middle Triassic to Recent.

Subgenus *Coccodentalium* SACCO, 1896

Coccodentalium SACCO. MOORE et al., Treat. Invert. Paleont., pt. I, Moll. I, p. 38, 1960; *Coccodentalium* SACCO. EMERSON, Jour. Paleont., vol. 36, no. 3, p. 468-469, 1962.

Type-species (by original designation):—*Dentalium radula* (SCHRÖTER), 1784, Miocene, Piemonte Basin, Italy.

Remarks:—This subgenus is distinguished by the surface ornamentation of many, almost equal longitudinal ribs crossed by circular riblets forming granules at the intersections to give a rasp-like appearance. Species of this subgenus occur as fossils in the East Indies, Europe, and Japan and Alaska, but living species are known from the East Indies.

Dentalium (*Coccodentalium*) cf. *D.* (*C.*) *nunomae* TAKEDA, 1953

Plate 12, figs. 1, 2

1953. *Dentalium nunomae* TAKEDA, Studies of Coal Geol., no. 3, p. 62, pl. 4, fig. 8; pl. 5, fig. 12.

Description:—Shell rather large for the genus, cylindrical, curved and tapering posteriorly; surface sculptured with dense, distinct annulated incremental lines and longitudinal ribs; annulated lines are very dense but are of variable strength; longitudinal ribs broad and flat-topped, about 30 ribs occur on the central part of shell; ribs separated by narrower interspaces; annulated incremental lines spaced closer than logitudinal ribs making a microscopic cancellate sculpture on the posterior two-thirds of the shell, anterior part sculptured only with indistinct annulated lines; figured specimen (Pl. 12, fig. 2) measures; 57.0 mm in length (incomplete, posterior part missing); maximum diameter, 10.2 mm; minimum diameter, 7.0 mm.

Remarks:—The type species was described by H. TAKEDA (1953) from the Poronai formation (Oligocene) in Hokkaido. This species is characterized by the cancellate surface sculpture, i. e., the specific name "nunome" means cancellate sculpture of the surface of cloth in Japanese.

The present specimens are closely similar to the type species, but the number of radial ribs are somewhat less than on the type, i. e., there are about 40 radial ribs on the type but about 30 on the present specimens. However, the writer suspects that these differences are due to individual variation or possibly due to the stage of growth. However, this problem must remains unsolved until more complete specimens are examined, because both the type and the Alaskan specimens are represented by incomplete specimens.

This species ranges from the Oligocene Poronai formation to the middle Miocene Takinoue formation in Hokkaido, Japan.

Localities:—80905, 81002, 81401, 81404, olive-green, fine-grained sandstone, lower and upper parts of the Poul Creek formation.

Reg. No. TUE 10025.

Class Gastropoda

Order Diotocardia

Suborder Rhipidoglossa

Family Trochidae

Genus *Bathybembix* CROSSE, 1893

Bembix WATSON. TRYON, Man. Conchol., vol. 11, p. 162–163, 1879; *Bathybembix* CROSSE. REHDER, Proc. Malacol. Soc. London, vol. 31, p. 5–6, 1955; *Bathybembix* CROSSE. MOORE et al., Treat. Invert. Paleont., pt. I, Moll. I, p. 253, 1960; *Bathybembix* CROSSE. KEEN, Mar. Moll. Gen. West. North Am., p. 21, 1963.

Type-species:—*Bembix aeola* WATSON, 1879, Recent, Pacific coast of Japan (north of lat. 36°N, ranging from 60 to 100 meters).

Remarks:—This genus is characterized by a thin and somewhat inflated shell with spirally nodose to smooth sculpture, an apressed to channeled suture, a smooth columella, and a pearly or nacreous interior surface.

Most species of this genus live in rather deep waters (50 to 100 meters).

Turcicula DALL, 1881, is closely related to *Bathybembix*, but differs by having a reflexed outer lip and vermiculate radial sculpture. *Bembix* WATSON, 1879, is preoccupied by *Bembix* FABRICIUS, 1775, a generic name of an insect.

Geographic distribution:—Japan, Bering Sea, and west coast of North America.

Geologic range:—Oligocene to Recent.

Bathybembix turbonata (CLARK), 1932

Plate 12, figs. 4a–b

1932. *Turcicula turbonata* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 826–827, pl. 20, fig. 11.
1971. *Bathybembix turbonata* (CLARK). ADDICOTT et al., U. S. Geol. Surv., Prof. Pap., 750-C, Fig. 1, l, o.

Remarks:—This species was described by CLARK (1932) as *Turcicula turbonata* from the Yakataga District. The writer also collected the specimens from the same area, some of which are well preserved. As pointed out by TEGLAND (1933, p. 141), these trochiids show a fairly wide variation in outline as well as ornamentation. Some specimens at hand reached more than 70 mm. in maximum diameter, but their heights are very variable. However, this species is characterized by the flat-sided, cone-like shell with an almost obsolete spiral ribs situated a little below the middle of the penultimate and body whorl, and several heavy spiral ribs on the base.

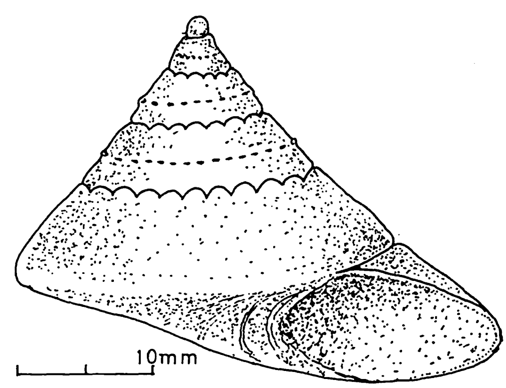
Localities:—81002, 81003, olive-green, fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No: TUE 10026.

Bathybembix jonesi KANNO, n. sp.

Plate 12, figs. 3a–c

Description:—Shell rather small, high-conic, with about six whorls; nucleus defective; more or less nodose spiral ridge situated a little below the middle of each whorl on the adapical three or four whorls; the spiral ridge tapers on the penultimate whorl where the surface becomes smooth excepting for microscopic fine incremental lines of growth; periphery of adapical four whorls denticulate or spinose (Text-fig. 15), but that of body whorl smooth and bluntly rounded; base with about four equally spaced, weak and low spirals; umbilicus imperforate, surrounded by fine closely spaced spirals; altitude of shell, 29.0 mm; maximum diameter, 36.0 mm; minimum diameter, 30.0 mm.



Text-fig. 15. Surface ornamentation of *Bathybembix jonesi* KANNO, n. sp.

Remarks:—Several specimens are at hand, although most are incomplete. These specimens were collected from calcareous concretions and have well preserved shell material. This species is characterized by its highly conical form, a nodulose spiral ridge on the adapical three or four whorls and an almost smooth body whorl, and denticulate or spinose periphery on the adapical three or four whorls.

This new species is somewhat similar to *B. turbonata* (CLARK), 1932, but a spiral nodulose ridge, small-sized shell, and denticulate or spinose periphery of the adapical three or four whorls serve to distinguish it from *B. turbonata*.

This new specific name is dedicated to Mr. R. L. JONES, Standard Oil Company of California, who supported the writer's field work in Alaska.

Locality:—20508-2, calcareous concretion in dark-gray, massive mudstone, lower part of the Poul Creek formation.

Reg. Nos. TUE 10027 (holotype); TUE 10028 (paratype).

Order Monotocardia

Suborder Ptenoglossa

Family Epitoniidae

Genus *Epitonium* RÖDING, 1798

Epitonium BOLTEN. DALL, U. S. Geol. Surv., Prof. Pap., 59, p. 52, 1909; *Epitonium* BOLTEN. OLDROYD, Stanf. Univ. Publ. Univ. Ser., Geol. Sci., vol. 2, pt. 2, p. 50–51, 1927; *Epitonium* BOLTEN. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 852, 1931; *Epitonium* BOLTEN. DURHAM, Jour. Paleont., vol. 11, no. 6, p. 485, 1937; *Epitonium* RÖDING. KEEN, Sea Shells Trop. West Am., p. 270, 1963.

Type-species (by subsequent designation, SUTER, 1913):—*Turbo scalaria* LINNÉ [=*Scalaria pretiosa* LAMARCK=*Epitonium pretiosum* (LAMARCK)], Recent, China Sea.

Remarks:—This genus is characterized by having a turreted and porcellaneous shell with axial varices or lamellae. It is found from low tide to 400 meters in depth but most species live in depths of less than 200 meters, usually on sandy bottoms, although some subgenera live at greater depths in tropical waters.

Geographic distribution:—Cosmopolitan.

Geologic range:—Paleocene to Recent (DURHAM, 1937).

Subgenus *Cirsotrema* MÖRCH, 1852

Cirsotrema MÖRCH, Cat. Conch. Yoldi, p. 49, 1852; *Cirsotrema* MÖRCH. DURHAM, Jour. Paleont., vol. 11, no. 6, p. 491, 1937; *Cirsotrema* MÖRCH. KEEN, Sea Shells Trop. West Am., p. 270, 1963.

Type-species (by monotypy):—*Scalaria varicosa* LAMARCK, Recent, Philippines and Oceanica.

Remarks:—The present subgenus is characterized by the thickened varices and spiral ribs, and well marked basal disk.

Epitonium (Cirsotrema) clallamense DURHAM, 1937

Plate 12, figs. 17, 18

1937. *Epitonium (Cirsotrema) clallamense* DURHAM, Jour. Paleont., vol. 11, no. 1, p. 491, pl. 56, figs. 27, 28.
1965. *Epitonium (Cirsotrema) clallamense* DURHAM. ADDICOTT, U. S. Geol. Surv. Prof. Pap., 525-C, Fig. 3, j.
1970. *Epitonium (Cirsotrema) clallamense* DURHAM. ADDICOTT, ditto, Prof. Pap., 642, p. 54, pl. 3, figs. 15, 16, 34–37.

Remarks:—This species was originally described from Oligocene strata of the east end of Clallam Bay, Washington (DURHAM, 1937). It is characterized by seven or eight broad axial ribs, slightly developed spiral striations, and very weak radial threads on the varices. The specimen figured in Plate 12, fig. 18 identified to this species, however, it has a larger number of varices, e. g., eleven varices on the body whorl instead of seven or eight on the type species. It is uncertain that the difference in the number of varices is genetic or is due to individual variation. This problem can not be solved until more specimens are examined.

According to the recent study by ADDICOTT (1970), the geologic age of the type locality of this species is probably early Miocene rather than middle Oligocene in terms of the Pacific coast invertebrate chronology (WEAVER and others, 1944). And he also pointed out that the type locality of the species is in the upper part of the Twin River formation or the Clallam formation. The former is referred to the *Echinophoria apta* zone of the Blakeley Stage by DURHAM (1944). This species occurs in the San Joaquin Valley, California, and the type locality in Washington besides the Yakataga area.

Localities:—80905, 81002, greenish gray, medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10029.

Subgenus *Gyroscala* de BOURY, 1887

Gyroscala de BOURY, Etude sous genres Scalidae, p. 15, 1887; *Gyroscala* de BOURY. COSSMANN, Essais Paleoconch. comp., vol. 9, p. 46, 1912; *Gyroscala* de BOURY. DURHAM, Jour. Paleont., vol. 11, no. 6, p. 485, 1937.

Type-species (by original designation):—*Scalaria ommutata* MONTEROSATO, Recent, tropical western Atlantic Ocean.

Remarks:—The subgenus is distinguished from other subgenera by lacking spiral surface ornamentation, and by having a distinct basal disk.

Geographic distribution:—Caribbean and Oceanica.

Geologic range:—Eocene to Recent.

Epitonium (*Gyroscala*) sp.

Plate 12, fig. 19

Description:—Shell medium in size, with more than four convex whorls (incomplete shell), of which the greatest diameter in near the middle of whorl; suture appressed; surface ornamented by 18 continuous, distinct, hardly reflexed varices; each whorl has a heavy varix; no spiral sculpture is observed; basal part of body whorl almost rounded, excepting weakly developed basal keel; aperture ovate; outer lip decidedly reflexed; inner lip with distinct callus which over-laps the anterior end of varix; umbilicus lacking; maximum diameter, 11.0 mm; height, 27.0 mm (of four whorls); aperture, 9.0×6.5 mm; apical angle, 22°.

Remarks:—One incomplete specimen has been examined. It is characterized by the large number of varices, slightly developed basal keel, and no spiral sculpture. The present specimen is somewhat similar to *E.* (*G.*) *effingeri* DURHAM, (1937, p. 485, pl. 56, fig. 25) from the lower middle Oligocene of Lower Cowlitz Valley, Washington, but it differs from the present one in having a smaller number of radial ribs (about 10 instead of 18).

Locality:—80905, greenish gray, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10030.

Epitonium sp.

Plate 12, fig. 16

Description:—Shell of moderate size, fairly heavy, having about seven or eight whorls (incomplete); whorls strongly inflated in the central part making a blunt angulation; sutures deep; surface ornamented with ten prominent varices on the body whorl, and weakly developed spiral striations; varices strongly reflexed posteriorly, bending slightly backward as they leave the suture; interspaces nearly twice as wide as base of varices; basal keel feebly developed; aperture ovate, oriented oblique to the axial line of shell; outer lip thick and reflexed, inner lip narrowly callous; height, 24.0 mm (about 6 whorls); maximum diameter, 14.0 mm; aperture, 9.0×6.0 mm; apical angle 33°.

Remarks:—A single specimen has been examined, but it is characterized by extremely inflated whorls forming a blunt medial angulation and obliquely oriented aperture. This specimen seems to represent a new species, but more specimens are needed to establish a new name.

Locality:—81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10031.

Suborder Taenioglossa

Family Turritellidae

Genus *Turritella* LAMARCK, 1799

Turritella LAMARCK, Mém. Soc. Hist. Nat. Paris, ser. 1, vol. 1, p. 74, 1799; *Turritella* LAMARCK. H. and A. ADAMS, Gen. Rec. Moll., vol. 1, p. 351, 1854; *Turritella* LAMARCK. WOODRING, Carnegie Inst. Wash., Publ., no. 385, p. 347–349, 1928; *Turritella* LAMARCK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 769, 1931; *Turritella* LAMARCK. OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sci., vol. 2, pt. 3, p. 54, 1937; *Turritella* LAMARCK. MERRIAM, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 26, no. 1, p. 26–29, 1941; *Turritella* LAMARCK. KOTAKA, Short. Pap., Inst. Geol. Paleont., Tohoku Univ., no. 1, p. 34, 1950; *Turritella* LAMARCK. IDA, Rep. Geol. Surv. Japan, no. 150, p. 39–40, 1952; *Turritella* LAMARCK. KOTAKA, Sci. Rep. Tohoku Univ. Ser. 2, vol. 31, no. 2, p. 63, 1959; *Turritella* LAMARCK. KANNO, Tertiary Sys. Chichibu Basin, pt. 2, p. 345–346, 1960; *Turritella* LAMARCK. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 25, 1963; *Turritella* LAMARCK. ADDICOTT, U. S. Geol. Surv. Prof. Pap., 642, p. 46, 1970.

Type-species (by monotypy):—*Turbo terebra* LINNÉ, Recent, tropical western Pacific.

Remarks:—This genus is characterized by having turriculate shell which has a rounded, entire aperture with a sinus on the outer lip. Species of this genus are classified chiefly upon surface ornamentation, outline of shell, growth line, shape of aperture, and size of the shell. Taxonimic problems were treated by several previous workers (MERRIAM, 1941; IDA, 1952; MARWICK, 1957; KOTAKA, 1959).

Geographic distribution:—World-wide in rather warm waters.

Geologic range:—Cretaceous to Recent.

Subgenus *Neohaustator* IDA, 1952

Neohaustator IDA, Rep. Geol. Surv. Japan, no. 150, p. 47, 1952; *Neohaustator* IDA. KOTAKA, Sci. Rep. Tohoku Univ. Ser. 2, vol. 31, no. 2, p. 66, 1959.

Type-species (by original designation):—*Turritella nipponica* YOKOYAMA, 1920, Pliocene Koshiba formation of the Miura Peninsula, Kanagawa Prefecture, Japan.

Remarks:—The characteristics of this subgenus are the double-arched and moderately positive inclination of the growth line, the comparatively broad and moderately deep sinus, and the first slender rib which appears on the third volutions somewhat proximal to middle part of the whorl.

Neoahustator differs from *Haustator* MONTFORT, 1810, in the features of the nuclear or juvenile whorls, although the charcter of the growth line is similar to both subgenera. The whorl profile of *T. imbricataria* LAMARCH, type of *Haustator* MONDFORT, is flat in the young stage, and is ornamented by spiral ribs.

Geographic distribution:—Living species occur in Japan Sea, and along the Pacific coast of northern Japan.

Geologic range:—Miocene to Recent.

Turritella (*Neohaustator*) *hamiltonensis* CLARK, 1932

Plate 12, figs. 9–12

1932. *Turritella hamiltonensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 827, pl. 21, figs. 13, 14.
1942. *Turritella hamiltonensis* CLARK. MERRIAM, Univ. Calif. Publ. Sci. vol. 27, no. 1, p. 101, pl. 40, figs. 7–9.
1971. *Turritella hamiltonensis* CLARK. ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750–C, Fig. 1, i, j, m.

Remarks:—This species was described by CLARK (1932) from the upper reaches of Hamilton Creek. It is characterized by having a rounded whorl profile and a rather large-sized shell which is ornamented by two broad, flat-topped spiral ribs on the abapical part of whorl and two slender spiral ribs on adapical half of the whorl. Generally speaking, the notation of spiral sculpture (MARWICK, 1957) of this species is (C B A r), but some adult specimens have the following notation, (u C t B s A r).

Judging from the development of spiral ribs, this species seems to be conspicific with, or at lest, to have been developed from the same stock as *T.* (*N.*) *chikubetsuensis* KOTAKA (1959) from the Takinoue formation (middle Miocene of central Hokkaido), which has the following spiral ribs (C B A r). *T.* (*N.*) *fortilirata* SOWERBY, living in northern Japan also resembles this species, but it differs by having round-topped spiral ribs and lacking intercalary spirals in adult specimens.

Localities:—80404, 80405, 80406, 80409, 80502, 80503, 80904, 81104, 81403, black shale, lower to middle part of the Yakataga formation.

Reg. No. TUE 10032.

Turritella aff. *T. diversilineata blakeleyensis* WEAVER, 1912

Plate 12, figs. 13, 14

1932. *Turritella* cf. *porterensis* WEAVER. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 828, pl. 21, figs. 10, 15.
1971. *Turritella* aff. *T. diversilineata blakeleyensis* WEAVER. ADDICOTT et al., U.S. Geol. Souv., Prof. Pap., 750-C, Fig. 1, c, k.

Remarks:—This specimens are closely related to *T. diversilineata blakeleyensis* WEAVER (1941) in general features, but the more convex whorl profile, less prominent lowest spiral rib, and lack of a small revolving rib and shallow groove just above the suture serve to distinguish them from WEAVER's subspecies. *T. porterensis* WEAVER (MERRIAM, 1941, p. 102, pl. 20, figs. 10–16) is also somewhat similar to the present specimens, but it differs by having a smaller number of revolving threads, i.e., *T. porterensis* has ordinary five ribs rather than seven in the present specimens. The present specimens seem to represent a new species, but the state of preservation and small number of specimens do not permit establishment of a new name.

Localities:—80906, 81404, gray, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10033.

Turritella sp.

Plate 18, figs. 3–5

Description:—Shell large for the genus, with about 18 whorls, which have a rather convex profile; suture impressed; the lower portion of the surface of each whorl is decorated but has seven revolving ribs which are separated by narrower interspaces; growth line with more or less shallow lateral sinus, its peak falls adapical to the middle part of the body whorl; aperture rounded; estimated length, about 130 mm; maximum diameter, 26 mm; apical angle, 15°.

Remarks:—Several specimens are at hand, but most are incomplete and somewhat leached. They are characterized by the large-sized shell, with seven spiral ribs which are separated by narrower interspaces, and a rather shallow lateral sinus of the growth line. *T.* aff. *T. diversilineata blakeleyensis* is somewhat similar to the younger specimens of *Turritella* sp., but it is uncertain whether these two are conspecific. This problem will remain unresolved until well-preserved specimens are available.

Localities:—81201, 81401, fine- to medium-grained, gray sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10034.

Genus *Cristispira* ALLISON, 1965

Cristispira ALLISON, Paleont., vol. 8, pt. 4, p. 676, 1965.

Type-species (by original designation):—*Cristispira pugetensis* ALLISON, Ranging River formation (middle Eocene), northwestern Washington.

Remarks:—This genus is characterized by the primary spirals of $a_3\ B_1\ C_2$ d, the growth-line of adult with double sinus, and the deepest part of antispiral sinus situated above whorl midline.

Geographic distribution:—The middle Eocene of Washington and Gulf of Alaska.

Geologic range:—Middle Eocene.

Cristispira pugetensis ALLISON, 1965

Plate 12, fig. 15

1965. *Cristispira pugetensis* ALLISON, Paleont., vol. 8, pt. 4, p. 676–679.
1971. *Cristispira pugetensis* ALLISON. ADDICOTT and PLAFKER, U. S. Geol. Surv. Prof. Pap., 750–B, p. 50, Figs. 3B–3D.

Remarks:—A single poorly preserved specimen was collected by R. L. JONES, Standard Oil Co. of California, who offered it to the writer for identification. Although it is incomplete, the whorl profile and the development of spiral ribs serve to distinguish it from similar species.

This species was originally described by ALLISON (1965) from the Ranging River formation (middle Eocene) of Puget Sound Basin, Washington. Subsequently, ADDICOTT and PLAFKER (1971) reported it from almost the same locality as the present in the Gulf of Alaska. It is noteworthy that this marine Eocene mollusk extended northward from Washington during the Kulthieth age.

Locality:—20537-6, (Standard Oil Co. locality), brownish-gray, medium-grained sandstone, Kulthieth formation.

Reg. No. USGS, Menlo Park.

Family Calyptraeidae

Genus *Calyptraea* LAMARCK, 1799

Calyptraea LAMARCK, Mém. Soc. Hist. Nat. Paris, vol. 1, p. 78, 1799; *Calyptraea* LAMARCK. DALL, U.S. Geol. Surv. Prof. Pap., no. 59, p. 81, 1909; *Calyptraea* LAMARCK. WOODWARD, Man. Moll., p. 276, 1910; *Calyptraea* LAMARCK. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 2, pt. 3, p. 114, 1927; *Calyptraea* LAMARCK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 794, 1931; *Calyptraea* LAMARCK. KANNO, Tert. Sys. Chichibu Basin, p. 352, 1960; *Calyptraea* LAMARCK. KEEN, Sea Shells Trop. West Am., p. 311, 1963; *Calyptraea* LAMARCK. HICKMAN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 79, 1969; *Calyptraea* LAMARCK. ADDICOTT, U.S. Geol. Surv. Prof. Pap., 642, p. 60, 1970.

Type-species (by monotypy):—*Patella chinensis* LINNÉ, Recent, western Europe.

Remarks:—This genus is characterized by a conical, limpet-shaped shell with a central or subcentral apex, and aperture with an internal spiral diaphragm. Living species of the genus occur in warm to temperate waters. Two living species are reported from Japan south of lat. 35°N in sandy bottom from 20 to 100 meters in depth. Two species are also reported from the west coast of North America, one from Alaska to southern California, and the other from south of Monterey to the Gulf of California.

Geographic distribution:—Warm to temperate waters of the world.

Geologic range:—?Cretaceous to Recent. Seven fossil species of the genus are reported from Oligocene and younger formations in Japan, but it appears in the Eocene of the west coast of North America.

Calyptraea sp.

Plate 12, figs. 5a-b, 6a-b

Description:—Shell medium in size; apical angle somewhat variable; apex rather blunt, central or nearly so; whorls about three with flat to slightly convex sides; suture indistinct; surface covered with obscure, coarse, radiating ribs which are separated by interspace of about equal width; septum well developed.

Remarks: Several specimens are at hand, but most are incomplete. These specimens are somewhat similar to *C. sookensis* CLARK and ARNOLD, 1923, from the Sooke formation of Vancouver Island, Canada, but they differ by having a rounded shape, and hardly developed radial ribs on the surface. This specimens are also more or less similar to some species of subgenus *Trochita*, but differ by lacking distinct radial sculpture.

Localities:—80602, 81003, calcareous concretions in greenish gray silty sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10037.

Genus *Crepidula* LAMARCK, 1799

Crepidula LAMARCK, Mém. Soc. Hist. Nat. Paris, Ser. 1, vol. 1, p. 78, 1799; *Crypta* HUMPHREY. H. and A. ADAMS, Gen. Rec. Shells, vol. 1, p. 268, 1854; *Crepidula* LAMARCK. DALL, U. S. Geol. Surv. Prof. Pap., 59, p. 82, 1909; *Crepidula* LAMARCK. WOODWARD, Man. Moll., p. 277, 1910; *Crepidula* LAMARCK. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 2, pt. 3, p. 116, 1927; *Crepidula* LAMARCK. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 789, 1931; *Crepidula* LAMARCK. KANNO, Tert. Syst. Chichibu Basin, p. 354, 1960; *Crepidula* LAMARCK. KEEN, Sea Shells Trop. West Am., p. 312, 1963; *Crepidula* LAMARCK. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 26, 1963; *Crepidula* LAMARCK. MORRIS, Field Guide Shells, p. 75, 1966; *Crepidula* LAMARCK. ADDICOTT, U. S. Geol. Surv. Prof. Pap., 642, p. 62, 1970.

Type-species (by monotypy):—*Patella fornicata* LINNÉ, Recent, Atlantic and Gulf coasts of North America.

Remarks:—The present genus is characterized by the oval limpet-like shell, large body whorl and aperture, and small closely appressed spire.

Three species have been recorded from the Pacific coast of Japan, all of which live south of lat. 47°N, but more than ten species have been reported from the west coast of North America ranging from south of Alaska to tropical regions. Most of species of the genus inhabit shallow water.

Geographic distribution:—World-wide.

Geologic range:—Cretaceous to Recent.

Crepidula cf. *C. praerupta* CONRAD, 1849

Plate 12, figs. 7, 8

1849. *Crepidula praerupta* CONRAD, U. S. Explor. Exped. Geol., p. 727, pl. 19, figs. 9, 9a, 10a, 10b.
1909. *Crepidula praerupta* CONRAD. DALL, U. S. Geol. Surv., Prof. Pap. 59, p. 83, pl. 7, fig. 8.
1942. *Crepidula praerupta* CONRAD. WEAVER, Univ. Wash. Publ. Geol.. vol. 5, p. 359, pl. 73, figs. 12, 13.

Description:—Shell of moderate size, rather solid, ovate, ventricose; surface smooth except for simple lines of growth; apex curved sharply in the extreme point of the shell and elevated above the plane of the aperture; margin simple, interior obstructed by matrix.

Measurements (in mm):—

Specimens	Longitude	Maximum width	Altitude
No. 1	34.0	19.0	18.0
„ 2	18.0	16.0	12.5
„ 3	18.0	14.0	11.5

Remarks:—The present specimens are closely similar to *C. praerupta* CONRAD reported from the Astoria formation (WEAVER, 1942, p. 359, pl. 73, figs. 1-3). The figured specimen (Pl. 12, fig. 7) is closely akin to CONRAD's holotype, but the other specimens represented by fig. 8 of the same plate are rather distinct from the type; the apex of these specimens is rather blunt, it is elevated above the plane of aperture, and the extreme point of the shell is not curved laterally. The variable shape of these shells may be due to individual variation or to deformation in some degree after burial.

Localities:—81003, 81004, greenish gray, fine- to medium-grained sandstone, and calcareous concretions in fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10037.

Family Naticidae

Genus *Euspira* AGASSIZ in SOWERBY, 1838

Euspira AGASSIZ in SOWERBY, Min. Conch. Gt. Brit., German Ed., p. 14, 320, 1838; *Euspira* AGASSIZ in SOWERBY. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 803, 1931.

Type-species (by subsequent designation, DALL, 1908, 1909):—*Natica glaucinoides* SOWERBY, Eocene of England.

Remarks:—This genus is distinguished from the allied genera by the globose shell, light callus coalescing with less developed funicle, and aperture inclined about 30° from vertical.

Geographic distribution:—World-wide.

Geologic range:—Possibly Eocene to Recent.

Euspira ramonensis (CLARK), 1918

Plate 13, figs. 1a–b

1918. *Natica* (*Euspira*) *ramonensis* CLARK, Univ. Calif. Publ. Bull. Dept. Geol., vol. 11, no. 2, p. 166, pl. 19, fig. 16.
1932. *Polinices* (*Euspira*) *ramonensis* (CLARK), Bull. Geol. Soc. Am., vol. 43, p. 826, pl. 20, figs. 4, 5, 8, 9.
1971. *Euspira ramonensis* (CLARK). ADDICOTT et al., U.S. Geol. Surv. Prof. Pap. 755–C, Fig. 1, i, j, n, o, t.

Description:—Shell somewhat large for the genus, subglobose, spire moderately high; whorls four or five; aperture wide, semi-lunar, acute posteriorly, broadly rounded anteriorly; outer lip boradly rounded, inner lip nearly straight, with light callus, a portion of which coalesces with a weakly developed funicle which fills part of the umbilicus; umbilicus open; surface marked by lines of growth; height, 45.0 mm; maximum diameter 43.0 mm; aperture, 36.0×18.0 mm.

Remarks:—Many specimens are at hand, but most are deformed and abraded. One well preverved specimen was collected from a calcareous concretion (loc. 81404).

Although the shape of shell is almost the same as the type species, the development of the callus and funicle is somewhat different in certain individuals, e.g., some have a rather developed funicle which fills part of the umbilicus and well marked transverse groove extending across the funicle like that of *Euspira* (Pl. 13, fig. 1b). However, other specimens have light callus, coalescing with less well developed funicle which hardly fills the umbilicus. Those are similar to specimens figured by CLARK (1932, pl. 20, figs. 4, 8).

Localities:—80905, 81201, 81401, 20503, greenish gray, fine-grained sandstone, upper part of the Poul Creek formation; 81404, calcareous concretion in fine-grained sandstone, the lower part of the Poul Creek formation.

Reg. No. TUE 10038.

Genus *Cryptonatica* DALL, 1892

Cryptonatica DALL, Trans. Wagner Free Inst. Sci., vol. 13, p. 362, 1892; *Cryptonatica* DALL, U.S. Geol. Surv. Prof. Pap., 59, p. 85, 1909; ?*Tectonatica* SACCO. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 797, 1931; *Cryptonatica* DALL. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 27, 1963.

Type-species (by subsequent designation, DALL, 1909):—*Natica clausa* BRODERIP, Recent, Arctic Ocean to Queen Charlotte Island, British Columbia.

Remarks:—This genus is characterized by its closed umbilicus and smooth operculum. It is characteristic of temperate or boreal waters.

Geographic distribution:—Arctic Ocean, northern Pacific and northern Atlantic regions.

Geologic range:—Possibly Miocene to Recent.

Cryptonatica aff. *C. clausa* (BRODERIP and SOWERBY), 1829

Plate 13, figs. 2a–b

1932. *Natica* (*Cryptonatica*) n. sp., CLARK, Bull. Geol. Soc. Am., vol. 43, p. 825, pl. 20, figs. 6, 7.
1971. *Cryptonatica* aff. *C. clausa* (BRODERIP and SOWERBY), ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 2, k, p.

Description:—Shell medium in size, globose in shape; suture abutting; spire slightly elevated; whorls about four, slightly shouldered; aperture semilunar, outer lip broadly rounded, inner lip slightly convex; umbilicus entirely closed by small, flat callus; height about 28.5 mm; maximum width, 28.0 mm; aperture, 25.5×14.0 mm.

Remarks:—Many specimens are at hand, but most are deformed. They are somewhat similar to the *Cryptonatica clausa*, but have a thicker and larger funicle and a more gently abutting suture. However, the state of preservation does not permit naming a new species.

Localities:—80404, 80406, 80801, 81001, dark-gray or black mudstone, Yakataga formation.

Reg. No. TUE 10039.

Suborder Stenoglossa

Family Cassididae

Genus *Liracassis* MOORE, 1963

Liracassis MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 30–31, 1963.

Type-species (by original designation):—*Dolium petrosum* CONRAD, Astoria formation (middle Miocene), Oregon and Washington.

Remarks:—This genus is closely similar to other cassidids, but the combination of the heavy strap-like spirals and of the wide, deep groove bordering the notched siphonal canal serve to distinguish it from other cassidid genera. This genus has a short, sharply recurved notched canal similar to *Echinophoria* SACCO, 1890, but it differs by having a wide and deep groove bordering the canal and strap-like spiral ribs.

Geographic distribution:—Oregon and Washington, northwest coast of North America, and Hokkaido and northern Honshu, Japan.

Geologic range:—Oligocene to middle Miocene.

Liracassis apta (TEGLAND), 1931

Plate 13, figs. 11–13

1931. *Galeodea apta* TEGLAND, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 19, no. 18, p. 415–417, pl. 63, figs. 1–10; pl. 64, figs. 1–2.
1932. *Gelodea apta* TEGLAND. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 828–829, pl. 21, figs. 1–3.
1942. *Galeodea apta* TEGLAND. WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 408, pl. 79, figs. 12–13; pl. 80, figs. 1, 3, 5.
1944. *Echinophoria apta* (TEGLAND). DURHAM, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 27, no. 5, p. 166, pl. 18, figs. 13, 15.
1942. *Echinophoria apta* (TEGLAND). DURHAM, Jour. Paleont., vol. 16, no. 2, p. 186, pl. 30, figs. 7–8.
1963. *Liracassis apta* (TEGLAND). MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 31, pl. 4, figs. 7, 10.
1971. *Liracassis apta* (TEGLAND). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap. 750–C, Fig. 1, g, h.

Remarks:—This species is characterized by having narrow and numerous spiral ribs (about 15 beneath the shoulder on the body whorl) which are separated by somewhat wider interspaces in which one or two fine spiral threads are weakly developed. Moreover, the nodes on shoulder of smaller size and are more numerous than on allied species. Some of the Alaskan specimens have about 15 nodes on the shoulder, but others have no nodes and a rounded shoulder. This species seems to be restricted to the "*Echinophoria apta* zone" of DURHAM (upper part of the Blakeley formation, lower Miocene) in northwestern Washington district.

Localities:—80905, 81001, 81003, 81201, 81203, 81401, 20503, 20508, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10040.

Liracassis durhami KANNO, n. sp.

Plate 13, figs. 14a–b

1932. *Galeodea apta* TEGLAND. CLARK, Geol. Soc. Am. Bull., vol. 43, p. 828–829, pl. 21, figs. 9, 15 (not figs. 1, 3).
1971. *Liracassis* aff. *L. petrosa* (CONRAD). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750–C, Fig. 1, a, b, e, f; Fig. 2, w, x.

Description:—Shell medium to large, globose, thin, with about five rounded whorls exclusive of the nucleus; earlier two whorls smooth excepting for several weak nodes, third whorl with three or four rather weak spirals, of which one has several rather distinct nodes; fourth whorl with five, somewhat nodulose spiral ribs separated by wider channeled interspaces; body whorl with about 16 spiral cords, of which 10 occur below the shoulder and the rest on the shoulder; spiral cords on the shoulder have about 12 nodes which continue as oblique ridges to the suture; spiral cords below the shoulder of the body whorl are subrounded, strap-like, and separated by interspaces which are smooth and are somewhat wider than the width of spiral cords; body whorl terminates in a slightly reflected and thickened outer lip in the adult; canal short, deeply excavated, twisted and more or less plicate, with a deep sulcus behind it.

Measurements (in mm):—

Specimens	Altitude of		Diameter of		Number* of	
	shell	body whorl	maximum	minimum	spiral ribs	nodes
Holotype**	ca.65.0	ca.50.0	51.0	25.0	10	12
Paratype**	59.0	45.0	41.0	26.0	10	11
" **	ca.40.0	25.0	33.0	30.0	9	9

* Number counted on the body whorl. ** Somewhat deformed specimens.

Remarks:—This species is closely related to *L. petrosa* (CONRAD), (MOORE, 1963, p. 31, pl. 2, figs. 7, 10–14; pl. 4, figs. 2, 4, 6; pl. 10, figs. 7, 17) from the Astoria Miocene of Oregon and Washington, but the smaller number of nodes on the body whorl and the lack of fine spiral threads in the interspaces serve to distinguish it from the *L. petrosa*.

It is noteworthy that the middle Miocene species *L. petrosa*, although it closely relates to the present new species, has a larger number of nodes on the body whorl than the present new species and a fine spiral thread in the interspace between the spiral cords. Judging from these characteristics, *L. durhami* may be an ancestral form of *L. petrosa* (CONRAD). *L. apta* (TEGLAND) from the Twin River formation of Washington is also somewhat similar to *L. durhami* but it differs by having a larger number of spiral threads and nodes on the body whorl.

This specific name is dedicated to Prof. J. WYATT DURHAM who gave a valuable suggestions to the writer on the classification of fossil cassidids from the northwest coast of North America.

Localities:—80906 (type), calcareous concretion in the fine-grained sandstone, lower part of the Poul Creek formation; 80905, 81001, 81201, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10041 (holotype); TUE 10042 (paratype).

Family Muricidae

Genus *Pteropurpura* JOUSSEAUME, 1880

Pteropurpura JOUSSEAUME. DALL, Trans. Wagner Free Inst., vol. 3, p. 242–243, 1892.

Type-species (by subsequent designation, DALL, 1892):—*Murex macropterus* DESHAYES, Recent, East coast of North America.

Remarks:—This genus is characterized by three thin varices which are broad and frill-like.

Geographic distribution:—This genus seems to be restricted to warm subtropical to tropical regions. Most species of this genus occur south of Monterey Bay, California, on the west coast of North America and south of lat. 35°N in Japan. They are found from 20 to 100 meters in depth.

Geologic range:—Possibly Oligocene to Recent.

Pteropurpura n. sp.

Plate 13, figs. 6, 7

Description:—Shell rather large for the genus, with about six whorls; suture distinct, appressed; surface ornamented with spiral ribs which are separated by narrower interspaces; largest varix situated near the outer lip, and is sculptured with about 30 spiral ribs which become broader towards the outer margin; varices on the body whorl extend to the penultimate whorl (Pl. 13, fig. 6); intervarical surface with a single obscure radial rib; aperture inaccessible; anterior canal rather long, bent to the left in incomplete apertural view; apical angle about 38°.

Remark:—Two incomplete specimens are at hand. No previous occurrences of pteropurpurids with such large frill-like varices have been reported from the west coast of North America and other parts of the North Pacific either as fossil or living species. However, there is not enough well preserved material to warrant giving this form a new specific name.

Locality:—81203, calcareous concretions in the dark-gray, massive siltstone, lower part of the Poul Creek formation.

Reg. No. TUE 10043.

Family Buccinidae

Genus *Eosiphonalia* RUTH, 1942

Eosiphonalia RUTH, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 26, no. 3, p. 288, 1942.

Type-species (by original designation):—*Strepsidura washingtonensis* WEAVER, 1916, Lincoln formation (middle Oligocene), Washington.

Remarks:—This genus was originally proposed by RUTH (1942) as a subgenus of *Siphonalia* A. ADAMS. It is characterized by a low spire, a short and less reflected canal than *Siphonalia*, a biangulate and strongly nodose body whorl, and the lack of lirations on the inner side of the outer lip. Although the surface sculpture of some species of *Siphonalia* show an extremely broad range of variation, the lirations on the inner side of the outer lip is one of the most diagnostic characters of the genus. The smooth outer lip and extremely strong biangulated body whorl serve to distinguish *Eosiphonalia* from allied genera.

Geographic distribution:—California, Washington, Oregon, and the Gulf of Alaska.

Geologic range:—Oligocene to early Miocene.

Eosiphonalia sp.

Plate 15, figs. 6a–b

Remarks:—An incomplete specimen represented only by the body whorl is at hand. The surface sculpture on the body whorl, aperture, canal, and outer and inner lips are well preserved. The body whorl is sculptured with two well pronounced revolving ridges making two rows on the shoulder and the periphery, but there are no revolving ridges anterior to these two ridges. There are about fourteen revolving ribs on the body whorl. The surface between the two revolving ridges is slightly concave. The entire surface is covered with spiral threads, but number can not be determined. The aperture is elongate-ovate in outline, and becomes narrower anteriorly where it merges into a slightly reflected canal. A well defined fasciole is present. The inner surface of the outer lip is smooth.

The present specimen is closely similar to *E. washingtonensis* (WEAVER, 1916; 1942, p. 438, pl. 86, figs. 9–11, 13), from the Lincoln formation (Oligocene of Washington), but it seems to differ somewhat from *Eosiphonalia* sp. in having a third revolving ridge anterior to two primary ridges, and a smaller number of distinct nodes on the revolving ridges. However, these differences, may not be very significant, because living species of the allied genus *Siphonalia* exhibit a very broad range of variation in the development of nodes (MAKIYAMA, 1941). However, specific determination must await the collection of more complete specimens.

Locality:—81002, greenish-gray, fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10044.

Family Neptuneidae

Genus *Neptunea* RÖDING, 1798

Neptunea RÖDING in BOLTEN, Mus. Boltenianum, p. 115, 1798; *Neptunea* BOLTON. H. and A. ADAMS, Gen. Rec. Moll., vol. 1, p. 79, 1853; *Neptunea* BOLTEN. STRICZKA, Paleont. Indica, Ser. 4, vols. 1–4, p. 116, 1871; *Neptunea* "BOLTEN" RÖDING. STEWART, Acad. Nat. Soc. Phila., vol. 78, p. 393–394, 1926; *Chrysodomus* SWAINSON. OLDROYD, Stanf. Univ. Publ., Univ. Ser., vol. 2, pt. 1, p. 227, 1927; *Neptunea* BOLTEN. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 652, 1931; *Neptunea* (BOLTEN) RÖDING. THIELE, Handbuch der Sys. Weicht., p. 309, 1931; *Neptunea* RÖDING. ABBOTT, Am. Seashells, p. 229, 1954; *Neptunea* BOLTEN. KANNO, Tert. Sys. Chichibu Basin, p. 369, 1960.

Type-species (by subsequent designation, MONTEROSATO, 1872):—*Fusus antiquus* LINNÉ [=*Murex contrarius* LINNÉ], Recent, Europe.

Remarks:—This genus is characterized by moderately large, elongate-ovate to subfusiform, ventricose shell which is sculptured mostly spiral ribs and have usually simple outer lip, and slightly curved anterior canal of moderate length.

The Recent species of *Neptunea* are mostly living in rather cold waters.

Geographic distribution:—Cold and temperate waters.

Geologic range:—?Late Eocene to Recent.

Subgenus *Neptunea* s. s.

Neptunea s. s., TLIELE, Handb. Syst. Weicht., p. 309, 1931.

Remarks:—*Neptunea* s. s. is characterized by having the moderately high spire which is mostly smooth surface with no sulci or groove below suture. Subgenus *Sulcosipho* DALL, 1916, differs from this subgenus by having fairly slender shell with conspicuously widely sulcated or tabulate whorl below suture.

Neptunea (Neptunea) plafkeri KANNO, n. sp.

Plate 14, figs. 1, 2, 3

Description:—Shell slender with about six whorls; spire acute, nucleus inaccessible; whorls gently swollen, surface smooth besides the fine incremental lines of growth; body whorl ventricose, with several very weak radial ribs, of which one or two near the outer lip are rather distinct; suture distinct, very narrow and deep; aperture wide, elongate-ovate in outline, outer lip sharp, thin, smooth within; inner lip thin, with narrow callous deposit; canal rather narrow and moderately twisted to the left, no fasciole.

The holotype measures; height of shell, 96.0 mm; height of body whorl, 59.0 mm; maximum diameter, 49.0 mm; minimum diameter, 24.0 mm (holotype is represented by a more or less deformed specimen).

Remarks:—Several specimens are at hand, but most are deformed or incomplete. However, the high spire and acute apical angle, the almost smooth outer surface excepting for fine incremental lines of growth and a few radial ribs near the aperture, and the rather long anterior canal serve to distinguish it from known species.

The new specific name is dedicated to Mr. GEORGE PLAFKER, U. S. Geological Survey, who gave the writer valuable information on the stratigraphy of the Tertiary strata developed along the Gulf of Alaska.

Locality:—81104, dark-gray, massive mudstone, lower part of the Yakataga formation.

Reg. No. TUE 10045 (holotype); TUE 10046 (paratype).

Neptunea (*Neptunea*) sp.

Plate 18, figs. 10a–b

Description:—Shell thick, moderate in size with six or seven whorls; spire very low less than one-fourths of the height of shell (one or two teleoconchs are missing); body whorl and pinultimate one are extremely swollen compared with the whorls of spire; surface ornamented with spiral ribs which are alternating size, of which one situated beneath the suture is strongest among the other spirals and making a shoulder; suture distinct, rather deep; aperture large, elongate ovate in outline; outer lip thick, inner side of it smooth; inner lip with thin and narrow callous deposit; canal rather narrow and moderately long, fairly twisted to left, but no fasciole; height of shell, about 100 mm (protoconch and teleoconch missing), maximum diameter, 57 mm (more or less compressed after burial by rock pressure); height of aperture, 73 mm; width of aperture, 28 mm.

Remarks:—One specimen which is more or less deformed and incomplete one is at hand. The present specimen is characterized by the extremely low spire in the genus, the surface ornamentation of alternating spiral ribs of strong and weak, and fairly long and twisted anterior canal. *N. leffingwelli* (DALL), 1920, *N. pribiloffensis* DALL, 1919, *N. lyrata* (GMELIN), 1791, and *N. ventricosa* (GMELIN) are more or less similar to the present specimen. However, the present specimen differs from *N. leffingwelli* (DALL), (MACNEIL, 1957, p. 111, pl. 13, figs. 1–4, 9) by having low spire and narrow and more twisted anterior canal; from *N. pribiloffensis* DALL (OLDROYD, 1927, p. 231, pl. 21, fig. 4) by having low spire, more distinct alternation of strong and weak spiral ribs, and narrow and more twisted anterior canal; from *N. lyrata* (GMELIN) (MACNEIL, 1957, p. 113, pl. 17, fig. 11) by having low spire and many spiral ribs on shoulder of the body whorl; from *N. ventricosa* (GMELIN) (MACNEIL, 1957, p. 112, pl. 17, fig. 14) by having low spire and distinct alternation of strong and weak spiral ribs.

This specimen probably represents an ancestral form of those allied species, and seems to be a new species, but the few number of specimen and the state of preservation does not permit to establish a new specific name.

Locality:—80506, gray, fine-grained sandstone, Yakataga formation.

Reg. No. TUE 10047.

Subgenus *Sulcosipho* DALL, 1916

Sulcosipho DALL, Proc. Biol. Soc. Washington, vol. 29, p. 7, 1916; *Sulcosipho* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 658, 1931.

Type-species (by original designation):—*Chrysodomus tabulata* BAIRD, Recent, south of British Columbia to San Diego in 60 to 400 meters in depth.

Remarks:—The present subgenus is characterized by a slender and elongate shell with conspicuously widely sulcate or tabulate whorls below the suture.

Neptunea (Sulcosipho) cf. *N. (S.) tabulata* (BAIRD), 1863

Plate 13, fig. 10; Plate 15, figs. 1-2

1932. *Neptunea* aff. *N. tabulata* BAIRD. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 830-831, pl. 20, fig. 13.

1971. *Neptunea (Sulcosipho)* aff. *N. (S.) tabulata* (BAIRD). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 1, n. p.

Remarks:—Deformed and incomplete two specimens are at hand. These specimens are characterized by a wide, flat channel next to the suture which is bounded by a raised, scaly cord. Moreover, it is sharply angulated and keeled above, forming a rimmed spiral table. The surface is ornamented with about 5 or 6 revolving ridges of alternating size on the penultimate whorl. The canal and columella are inaccessible because the specimens are deformed. This specimens are closely similar to *N. (S.) tabulata* in general shape, but it is unable to compare completely the present specimens with *N. (S.) tabulata* owing to the poor preservation of the present specimens.

Localities:—80404, 80408, 80603, 80703, 80802, 81306, 20494, 20541-7, dark-gray or black mudstone, Yakataga formation.

Reg. No. TUE 10048.

Genus *Ancistrolepis* DALL, 1895

Ancistrolepis DALL, Proc. U. S. Nat. Mus., vol. 17, no. 1896, p. 709, 1895; *Ancistrolepis* DALL. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 2, pt. 1, p. 203, 1927; *Ancistrolepis* DALL. KURODA, The Venus (Jap. Jour. Malac.), vol. 2, no. 5, p. 288, 1931; *Ancistrolepis* DALL.

GRANT and GALE, Mem. San Diego Soc., Nat. Hist., vol. 1, p. 675, 1931; *Ancistrolepis* DALL. THIELE, Handb. System. Wiecht., p. 308, 1931; *Ancistrolepis* DALL. DURHAM, Univ. Calif. Publ. Geol., vol. 27, no. 5, p. 176, 1944; *Ancistrolepis* DALL. KANNO, Tert. Sys. Chichibu Basin, p. 367, 1960.

Type-species (by original designation):—*Chrysodomus eucosmius* DALL, Recent, Pacific coast. The type specimen was collected from the Bering Sea from the depth of 450 meters by the SS. Albatross.

Remarks:—This genus is characterized by a short, wide anterior canal which is almost obsolete but broadly open, and twisted to the left.

Living species of the genus seem to be restricted to the northern Pacific, i. e., four species are reported from the west coast of North America and nine species and three subspecies from Japan. Japanese species of *Ancistrolepis* are reported from north of off Shikoku (lat. 33°N to 51°N) in deep waters. Judging from the present habitat of this genus, it is a cold water form.

Geographic distribution:—Northern Pacific waters ranging from 70 to 2000 meters (KEEN, 1963, p. 99).

Geologic range:—Oligocene to Recent (in Japan).

Ancistrolepis rearensis (CLARK), 1932

Plate 13, figs. 5, 9; Plate 14, figs. 4–6

1932. *Colus rearensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 831.
1933. *Ancistrolepis clarki* var.?, TEGLAND, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 23, p. 132, pl. 12, figs. 15–17.
1944. *Ancistrolepis clarki teglandae* DURHAM, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 27, no. 5, p. 177, pl. 17, fig. 2.
1971. *Ancistrolepis rearensis* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 2, b, c, s.

Description:—Shell medium, robust, with six or seven rounded whorls; nuclear whorl inconspicuous, globose; first and second whorls almost smooth, rounded; third whorl with two weak spiral ribs; the fourth ornamented with two heavy, flat-topped revolving ribs, of which the upper one is carinate on the most expanded part of the whorl, and a faint spiral thread appears beneath the suture; the fifth has the same ornamentation as the fourth, although the spiral ribs are stronger than that of the fourth whorl; the body whorl has about eleven spiral ribs, of which three on the most expanded part of the whorl are somewhat stronger than the others and are separated by interspaces broader than the width of spiral ribs, whereas the spirals on the distal part are separated by interspaces narrower than the width of rib; the whole surface excepting the apical part is ornamented with closely set, faint, silky spiral striations and radial growth lines (Pl. 14, fig. 5), but the general appearance of shell is smooth to polished; aperture ovate, almost equal in height to the spire; outer lip rather thin, inner side almost smooth; inner lip with a thin callous deposit; canal short, narrow, and slightly recurved; altitude of shell, 48.0 mm; height of spire, 26.0 mm; maximum diameter, 28.0 mm.

Remarks:—This species was originally described by CLARK (1932) from the Yakataga District, although its exact locality was not plotted on his map. The place name "Rear" does not appear on the topographic map published by U. S. Geological Survey, it may refer to "Bear Glacier" or "Lare Glacier".

The present species is characterized by the deeply incised suture and more rounded whorl profile, prominent spiral ribs, and the presence of moderately well defined spiral rib in a short distance below the suture. However, the last character is somewhat variable as showing plate 13, fig. 9, which has very weak spiral thread beneath the suture.

Localities:—80601, 80905, 81004, 81203, greenish-gray or olive-green, fine- to medium-grained sandstone, the upper part of the Poul Creek formation; 81404, olive-green, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10050

Ancistrolepis macneili, KANNO, n. sp.

Plate 14, fig. 7

Description:—Shell large, robust, with seven rounded whorls which are somewhat sulcate below the suture; nuclear whorl inaccessible; first whorl smooth, rounded; second whorl swollen, almost smooth, excepting two very weak spiral threads; third whorl ornamented with three distinct spiral striations and a very weak spiral thread beneath the suture; fourth and fifth whorls have the same ornamentation as the third one, but the spiral ribs are stronger; spiral ribs on the penultimate whorl are almost of equal size, flat-topped, and are separated by interspaces wider than the spiral ribs; the body whorl has about eleven spiral ribs, of which five on the most expanded part of the whorl are stronger than the others and are separated by interspaces as broad as on the penultimate whorl; the other spiral ribs on the body whorl are separated by narrower interspace than the main spirals, and a fine spiral thread occurs in each interspace; aperture ovate in outline, shorter than the spire; outer lip rather thin, inner side almost smooth; inner lip with thin, somewhat broad callous deposit; canal short, narrow, and almost straight; altitude of shell, 79.0 mm; height of spire, 47.0 mm; maximum diameter, 45.0 mm; minimum diameter, about 40.0 mm; height of aperture, 39.0 mm; breadth of aperture, 20.0 mm; apical angle, 56°.

Remarks:—One well preserved specimen is at hand. This new species is closely related to the preceding one, but the large number of spiral ribs on each whorl, and the intercalary threads on the distal part of the body whorl serve to distinguish it from allied species.

This specific name is dedicated to Dr. F. STEARNS MACNEIL, formerly of the U. S. Geological Survey, and who gave valuable help to the writer.

Locality:—80906, calcareous concretion in greenish-gray, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10051 (holotype).

Ancistrolepis sp.

Plate 13, fig. 4

Description:—Shell small with six rather inflated whorls; suture depressed to slightly channeled; surface ornamented with flat-topped rather squarish spiral ribs; nuclear whorl globose; first whorl smooth and swollen; second whorl with a weakly developed spiral thread; the third with two disinct spiral threads of which the anterior one is flat-topped, and which are separated by an interspace nearly equal to the width of rib; fourth and fifth whorls with three spiral ribs, of which the anterior two are flat-topped, squarish, and stronger than the rest; body whorl with about six spiral ribs, of which the third one beneath the suture is strongest; distal part of body whorl almost smooth; canal rather short, twisted to the left; outer lip thin, inner lip callused; length of shell, 30.0 mm; height of aperture, 14.0 mm; maximum diameter, 10.5 mm; and minimum diameter, 10.0 mm (somewhat deformed specimen); apical angle about 37°.

Remarks:—Two specimens are at hand, one of which is more or less well preserved, although it is somewhat deformed, especially, the body whorl. It is difficult then to estimate the original shape of the aperture and canal. The specimens are tentatively included under *Ancistrolepis* DALL, based on general features.

Localities:—80905, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10052.

Genus *Beringius* DALL, 1887

Beringius DALL, Proc. U.S. Nat. Mus., vol. 9, no. 571, p. 304, 1887; *Beringius* DALL. OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sci., vol. 2, pt. 1, p. 192, 1927; *Beringius* DALL. THIELE, Handbuch der System. Weicht., p. 306, 1931.

Type of genus (original designation):—*Chrysodomus crebricostatus* DALL, Recent, Arctic to British Columbia.

Remarks:—This genus is somewhat similar to genus *Neptunea* BOLTEN, 1798, but the former differs from the latter by having wide, short, and hardly recurved canal, large cylindrical or bulbose nuclear whorl, and the spire which is usually longer than the aperture.

Geographic distribution:—Arctic to British Columbia, and Japan.

Geologic range:—Questionably Miocene to Recent.

Beringius cf. *B. crebricostatus* (DALL), 1879

Plate 15, fig. 3

1879. *Chrysodomus crebricostatus* DALL, Proc. Calif. Acad. Sci., vol. 7, p. 6, pl. 2, figs. 1a-c.
1927. *Beringius crebricostatus* (DALL). OLDROYD, Stanf. Univ. Publ., Univ. Ser., Geol. Sci., vol. 2, pt. 1, p. 193, pl. 23, fig. 1.
1954. *Jumala crebricostata* DALL. ABBOTT, Amer. Seashell, p. 227, fig. 51, b.

Remarks:—An incomplete, somewhat compressed specimen has been examined. It is represented by anterior three whorls, of which the body whorl is somewhat well preserved, although the anterior canal is missing. The pinultimate one is complete and the most posterior whorl lacks its posterior half.

This species is characterized by having a deep suture and a wide sulci beneath suture, and the strong, flat-topped, spiral cords separated by channeled interspaces. The pinultimate whorl has four spiral cords, of which three are distinctly strong and the rest situated just above the suture is weaker than the others. The body whorl of the present specimen is ornamented with more than eight spiral cords, of which three one beneath the suture are stronger than the other. These spiral cords are separated by rather wide interspaces which have no intercalary spiral threads.

This specimen is somewhat similar to *N.* (*S.*) *lyrata* of MACNEIL (1957, p. 113, pl. 17, fig. 11) from the moraine of Gyuot Glacier, Gulf of Alaska, Pleistocene or Recent, but the present specimen is distinguished from *N. lyrata* of MACNEIL by having more tabulate beneath suture, and a large number of spiral cords on the pinultimate and body whorls, i. e., the present specimen has four spiral cords on the pinultimate whorl, of which the most anterior one (just above the suture) is weaker than the other, whereas *N. lyrata* of MACNEIL has three spiral cords on the pinultimate whorl. Moreover, the spiral cords on the body whorl of MACNEIL's *N. lyrata* provides almost equal-sized spiral cords separated by the fairly wide interspaces which bear usually fine secondary spiral threads, whereas no intercalary spirals develop on the present specimen.

Locality:—80404, dark-gray siltstone, Yakataga formation.

Reg. No. 10049.

Genus *Colus* RÖDING, 1798

Colus RÖDING in BOLTON, Mus. Boltineanum, p. 117, 1798; *Colus* BOLTEN. OLDROYD, Stanf. Univ. Publ. Univ. Ser. Geol. Sci., vol. 2, pt. 1, p. 211, 1927; *Colus* BOLTEN. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 661, 1931.

Type-species (by subsequent designation, DALL, 1906):—*Murex islandicus* GMELIN, Recent, Iceland to Ireland.

Remarks:—This genus is characterized by the long-fusiform, slender shell, with numerous rounded whorls which are ornamented with spiral sculpture or are smooth. Moreover, the moderate size of the aperture, simple, not reflexed outer lip, smooth pillar, and somewhat tortuous canal serve to distinguish it from allied genera. This genus is closely related to *Neptunea* RÖDING, 1798, but *Colus* is usually smaller, more slender, with less inflated whorls and a shorter aperture than those of *Neptunea*.

Geographic distribution:—Circumboreal, Arctic Ocean to San Diego, California, and north of lat. 33°N in the western Pacific region.

Geologic range:—Possibly Oligocene to Recent.

Colus aff. *C. jordani* DALL, 1913

Plate 13, figs. 3a–b

Description:—Shell of moderate size with about six whorls; suture distinct, whorls moderately rounded; surface ornamented with fine, close-set incremental lines of growth, crossed by numerous fine spirals with very narrow interspaces; aperture elongate-ovate in outline, less than half the length of the shell; outer lip thin, simple, flexuous, gently inflated; canal short, rather narrow, more or less recurved; height of shell, 34.0 mm; height of aperture, 15 mm; maximum diameter, 15.5 mm; minimum diameter, 15.0 mm; apical angle, 41°.

Remarks:—Several specimens on which periostracum and the nuclear whorl are missing are at hand. They are closely similar to the specimen reported by GRANT and GALE (1939) from the upper Pliocene of Oregon, but which differs slightly by having a wide anterior canal and a more expanded outer lip on the anterior part of the aperture. Recent species are somewhat similar to the present one but they differ by having a more slender shell, a wider anterior canal, and a more expanded outer lip than the fossil species.

These specimens seem to represent a new species, but they are too poorly preserved to establish a new species.

Localities:—80905, 81202, olive-green, fine-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10053.

Family Fusinidae

Genus *Priscofusus* CONRAD, 1865

Priscofusus CONRAD, Am. Jour. Conchology, vol. 1, p. 150, 1865; *Priscofusus* CONRAD. GRANT and GALE, Mem. San Diego Nat. Hist., vol. 1, p. 490, 1931; *Priscofusus* CONRAD. MOORE, U.S. Geol. Surv. Prof. Pap., 419, p. 39, 1963; *Priscofusus* CONRAD. HICKMANN, Mus. Nat. Hist., Univ. Oregon, Bull. no. 16, p. 96, 1969.

Type-species (by subsequent designation, COSSMANN, 1901):—*Fusus geniculus* CONRAD, Astoria formation, Miocene, Oregon.

Remarks:—*Priscofusus* is characterized by a fusiform shell, moderately high spire, and a moderately short and strongly recurved canal. The spire is angulated, and has rounded or transversely elongated nodes, or an intermittent or constant swelling of one spiral cord. The body whorl is noded like the spire or may be smooth. The surface is sculptured by numerous strong spiral lines between which secondary spirals are sometimes intercalated, and growth lines bending backward below the suture in a broad, shallow, rounded embayment with its maximum depth close to the periphery. The suture is appressed and generally even and collared.

The present genus is closely similar to *Siphonalia* A. ADAMS, 1863, which differs by having a distinct posterior canal, large fasciole, and crenulations inside of the outer lip.

This genus seems to have flourished in the middle Miocene age on the west coast of North America.

Geographic distribution:—West coast of North America, south of Kodiak Island, Gulf of Alaska, to California.

Geologic range:—?Eocene, Oligocene to early Pliocene of the Pacific coast of North America.

Priscofusus clarki KANNO, n. sp.

Plate 13, fig. 8; Plate 14, figs. 8, 9, 15

1932. *Fusinus* cf. *F. hannibali* CLARK and ARNOLD. CLARK, Bull. Geol. Soc. Am., vol. 43, p. 833, pl. 20, figs. 1-3.
1971. *Priscofusus* aff. *P. hannibali* (CLARK and ARNOLD). ADDICOTT et al., U.S. Geol. Surv. Prof. Pap., 750-C, Fig. 2, a, d, e, f.

Description:—Shell medium for the genus, fusiform, with about six whorls; spire rather high, with a blunt apex; whorls of the spire obtusely angulated a little anterior to the middle, nearly flat above and slightly convex below; ornamentation consisting of fine spiral threads separated by wider interspaces carrying fine intercalary lines and thirteen to fifteen nodes which run obliquely from the shoulder to behind the suture; on the penultimate whorl with about thirteen major spiral threads; suture distinct; body whorl inflated, ornamented with a row of nodes in a little above the middle producing, a slight angular appearance, convex above and below; spiral sculpture similar to that of the whorls of the spire, excepting the rhythmic alternation with secondary spirals; aperture elongate-ovate in outline, with a broad and shallow posterior canal; anterior canal narrow and moderately long, and twisted to left.

Measurements (in mm):

Specimens	Altitude of		Maximum diameter	Apical angle
	shell	aperture		
Holotype	41.5	21.0	20.0	48°
Paratype*	28.0	15.0	14.0	50°

* Apex and anterior part of canal defective.

Remarks:—Many specimens are at hand, but most are represented by inner moulds or rubber casts made from external moulds. Although the specimens are incomplete, the rubber casts represent detailed sculpture. The surface sculpture of intercalary spiral threads seems to be variable; e.g., some specimens show rhythmic alternation of the main and secondary spiral threads, but on others this alternation is restricted to only a part of the surface of the whorl.

The new species was originally described by CLARK (1932) as *Fusinus* cf. *hannibali* CLARK and ARNOLD, based on incomplete specimens. The type species of *F. hannibali* is from the Sooke formation (Oligocene) of Vancouver Island, however, it differs by having a more slender spire, smaller number of longitudinal nodes (about nine to eleven), a distinct sutural collar, and coarse internal striations on the outer lip. *Priscofusus lincolnensis* (ANDERSON and MARTIN), (WEAVER, 1942, p. 487, pl. 93, figs. 8-9), is somewhat similar to this species but it can be distinguished by the large number of main spiral threads on the penultimate whorl (about twenty-four).

Localities:—80902, 80905, 81002, 81201, 81401, greenish gray, fine-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. Nos. TUE 10054 (holotype); TUE 10055 (paratype).

Priscofusus sp.

Plate 14, figs. 11, 12, 13

Remarks:—Several deformed and incomplete specimens are at hand. These specimens are closely akin to the preceding species, but the less number of radial nodes (about ten) and spiral threads (about nine to ten) on the penultimate whorl serve to distinguish it from the preceding species. However, it is difficult to decide that these differences may be due to individual variation rather than of specific rank. The present writer hesitates to give a conclusion because the specimens are incomplete and there are very few complete specimens of *P. clarki* at hand.

Localities:—80905, greenish gray, fine- to medium-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10056.

Family Volutidae

Genus *Musashia* HAYASHI, 1960

Musashia HAYASHI, Jap. Jour. Malac., vol. 21, no. 1, p. 2, 1960; *Musashia* HAYASHI. SHIKAMA, Sci. Rep. Yokohama Nat. Univ. sec. 2, no. 13, p. 32, 1967.

Type-species (by original designation):—*Voluta hirasei* SOWERBY, Recent, Suruga Bay to off Kochi, Shikoku, Japan.

Remarks:—This genus was originally described by HAYASHI (1960), as a subgeneric taxon, as follows; "protoconch similar to the group 'b' (*Psephaea*); shell without a colour pattern (except the weak spiral lines); ground colour of shell deep fleshy; columellar plaits generally 1 (sometimes with a weak additional one above". Subsequently, SHIKAMA (1967) raised it to generic rank, and gave this diagnosis: "no operculum; initial columella plaits 1-2 and last columellar plaits 1-4; the value of the y/x ratio* rather small, species with above 0.60 being less than 30 percent of the total; subsutural band almost present; shell often becomes very large".

Geographic distritution:—Northern Pacific, Japan and the west coast of North America.

Geologic range:—Possibly Oligocene to Recent.

Subgenus *Neopsephaea* TAKEDA, 1953

Neopsephaea TAKEDA, Stud. Coal Geol., no. 3, p. 59, 1953; *Neopsephaea* TAKEDA. SHIKAMA, Sci. Rep. Yokohama Nat. Univ., Sec. 2, no. 12, p. 33, 1967.

Type-species (by original designation):—*Psephaea antiquior* TAKEDA, Poronai formation (Oligocene), Hokkaido, Japan.

Remarks:—The original description of the subgenus *Neopsephaea* TAKEDA (1953) is as follows: "columella thick, with one oblique plait; *Aurinia* A. ADAMS and *Guivillea* WATOSON are distinguished from this subgenus by lacking the fold on pillar".

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* y ··· width of ultimate protoconch volution; x ··· width of the first teleoconch volution.

SHIKAMA (1967) gave this diagnosis: " initial and last columella plaits one; teleoconch with 4-5 volutions; suture not deep, without subsutural band; spire very low and slender, fusiform in general outline; small size ".

Musashia (Neopsephaea) corrugata (CLARK), 1932

Plate 15, figs. 5a-b; Plate 18, fig. 11

1932. *Psephaea corrugata* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 831-832, pl. 21, figs. 4, 5, 11.
1971. *Musashia (Miopleiona) corrugata* (CLARK). ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 751-C, Fig. 2, y, aa, bb.

Description:—Shell rather thin, slender, with five or six whorls; the height of aperture greater than that of the spire; surface sculptured by fine threads and longitudinal ribs which taper on the anterior part of the body whorl; longitudinal ribs, about 13 on penultimate whorl, slightly deflected near the sture; ribs prominent, heavy, rounded separated by interspaces slightly wider than the ribs, a few fine longitudinal threads cover the ribs; whole surface sculptured by fine, closely spaced subequal spiral threads, which are not swollen where they cross the ribs and do not produce denticles on the edge of the outer lip; suture appressed; subsutural band more or less distinct; number of volutions of protoconch about 2, ratio of the width of ultimate protoconch (y) and that of first teleoconch volution (x) is about 6.3; pillar straight, with one strong plait, which tapers toward the posterior whorl, and is hardly visible on the few whorls beneath the protoconch (Plate 18, fig. 11); outer lip arcuate, receding toward the suture, not denticulate; shell consists of three layers i. e., the fine spiral threads are distinct on the outer surface of fresh specimens, but many microscopic longitudinal striations appear when the outer surface is weathered; moreover, there is a different inner layer under the meso-layer; inner layer shows many microscopic transverse striations; length, 89.0 mm; maximum diameter, 27.5 mm (somewhat compressed specimen); length of spire above the aperture, 43.0 mm; height of aperture, 46.0 mm.

Remarks:—This species was originally described by CLARK (1932) from the upper reaches of Hamilton Creek. Its characteristics are the surface sculpture of about 13 to 15 radial ribs and fine spiral lines, and the single plait on the columella of the anterior whorls of mature specimens. Ontogenetically, the columella plait seems to be only in the later stages of growth. Judging from SHIKAMA's study (1967), this species seems to be suggestive of a rather primitive development of the plait, because the columella plait of this species hardly develops in the young stage. However, this species is tentatively assigned to *Musashia* HAYASHI, which has one columella plait on the initial volution, whereas there is hardly developed plait on the younger growth stage of the present species.

Psephaea (Miopleiona) indurata (CONRAD), (DALL, 1909, pl. 18, fig. 5; MOORE, 1963, p. 43, pl. 7, figs. 1-3, 6-9, 11; pl. 8, figs. 1-5), seems to be related to the present species but it differs from CONRAD's species in having fewer longitudinal ribs (about 13 to 14 instead of 18 to 21), and one distinct columellar plait instead of two. *Musashia (Neopsephaea) antiquior* (TAKEDA) from the Oligocene Poronai formation (TAKEDA, 1953, pl. 4, figs. 1-4; pl. 5, fig. 7) is closely related to this species in general shape, but detailed comparison of the two species is difficult because of the defective columellar fold on TAKEDA's specimen.

Localities:—80601, 80905, 81401, 20493, 20503, fine- to medium-grained sandstone, upper part of the Poul Creek formation; 81404, olive-green, fine-grained sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10057.

Musashia (*Neopsephaea*?) sp.

Plate 15, fig. 4

Description:—Shell rather thick for the genus, somewhat swollen, with six or seven whorls, although the present specimen is somewhat compressed and its apical part is missing; aperture much higher than the height of spire; surface sculptured by longitudinal ribs and barely visible fine spiral threads; longitudinal ribs seem to be slightly deflected near the suture, and separated by the interspaces as wide as or slightly narrower than the ribs, number of ribs indeterminate; surface of longitudinal ribs ornamented by a few fine radial threads; pillar straight, with two distinct, almost equal sized plaits; outer lip arcuate, receding toward the suture, not denticulate; shell consists of, at least, two layers viewed under the microscopic, i. e., an outer longitudinal layer and an inner transverse layer; length of shell (incomplete specimen), about 100.0 mm; height of aperture, 55.5 mm; height of spire above the aperture, 48.0 mm.

Remarks:—A rather compressed specimen and its external mould are at hand. Though it is represented by compressed specimen, this species is more or less similar to *M.* (*N.*) *corrugata* but the larger number of columella plaits and the lesser height of spire serve to distinguish it.

Locality:—80702, fine-grained silty sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10058.

"*Fulgoraria*" sp.

Plate 14, figs. 14a-b

Description:—Shell thin, rather small for the genus, slender, with more than five whorls (apical portion missing); surface sculptured by fine spiral threads and longitudinal ribs; fine spiral threads are well developed over the entire surface, i. e., about 20 main spiral threads occur on the penultimate whorl, and separated by wider interspaces where secondary fine spirals are intercalated between the main and intercalary spirals; longitudinal ribs are distinct on the teleoconch, but it tapers towards the body whorl where the longitudinal ribs become indistinct and are represented by a few irregular radial undulations; number of volutions of protoconch inaccessible; pillar somewhat curved to the left, although this form might be dure to deformation; columella plait barely visible; shell structure same as in *M.* (*N.*) *corrugata* (CLARK); apertue elongate ovate, higher than spire; length of shell (incomplete specimen), 59.0 mm; height of spire, 33.0 mm; maximum diameter about 18.0 mm.

Remarks:—The rather small incomplete specimen at hand is characterized by poorly developed longitudinal ribs which are distinct only beneath the suture, and well developed fine spiral threads. The general features of this species bears some reseblance to *Miopleona weaveri* TEGLAND, (WEAVER, 1942, p. 492, pl. 94, figs. 6, 10, 11), but it differs from the present species by its well developed longitudinal ribs which are distinct on the whole surface, and its large apical angle. Although the present specimen is somewhat similar to *Musashia*, the surface sculpture, obsolete columellar plait, and state of preservation make it difficult to determine its generic position.

Locality:—81201, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10059.

Suborder Toxoglossa

Family Cancellariidae

Genus *Cancellaria* LAMARCK, 1799

Cancellaria LAMARCK, Soc. Hist. Nat. Paris, Ser. 1, p. 71, 1799; *Merica* H. and A. ADAMS, Gen. Rec. Shells, vol. 1, p. 277, 1854; *Euclia* H. and A. ADAMS, ditto, p. 277, 1854; *Cancellaria* LAMARCK. OLDROYD, Stanf. Univ. Publ. Univ. Ser. Geol. Sci., vol. 2, pt. 1, p. 151, 1927; *Cancellaria* LAMARCK. GRANT and GALE, Mem. San Diego Nat. Hist., vol. 1, p. 612, 1931; *Cancellaria* LAMARCK. THIELE, Handb. Sys. Weicht., p. 352, 1931; *Cancellaria* LAMARCK. MOORE, U. S. Geol. Surv. Prof. Pap., 419, p. 44, 1963; *Cancellaria* LAMARCK. ADDICOTT, U. S. Geol. Surv. Prof. Pap., 642, p. 105-106, 1970.

Type-species (by monotypy):—*Voluta reticulata* LINNÉ, Recent, North Carolina to both sides of Florida, and the West Indies.

Remarks:—This genus is characterized by cancellate surface sculpture, a short anterior canal, and a columella with several strong oblique folds. *Cancellaria* occurs south of lat. 39°N to tropical regions in the western Pacific, but most species occur south of lat. 35°N. This genus is representative of warm water conditions.

Fossil species in Japan range from the Oligocene to the Pleistocene. According to ADDICOTT (1970, p. 105), genus reached to a sudden flood of species and many subgeneric units appeared in the middle Miocene, "Temblor stage" of the Pacific coast megafaunal chronology of WEAVER and others (1944).

Geographic distribution:—Florida, West Indies, Mediterranean, West Africa, India, China, Japan, West Coast of North America.

Geologic range:—Upper Cretaceous to Recent (WOODWARD, 1910).

Subgenus *Crawfordina* DALL, 1919

Crawfordina DALL, U. S. Nat. Mus., vol. 56, p. 306, 1919; *Crawfordina* DALL. GRANT and GALE, Mem. San. Diego Nat. Hist., vol. 1, p. 614, 1931; *Crawfordina* DALL. ADDICOTT, U. S. Geol. Surv. Prof. Pap., 642, p. 117, 1970.

Type-species (by monotypy):—*Cancellaria crawfordina* DALL, Pliocene to Recent, northeastern Pacific Ocean, from Alaska to San Diego, California.

Remarks:—*Crawfordina* is characterized by an elongate-ovate shell with axial and spiral sculpture, and a long columella with two oblique folds. The subgenus is distinguished from *Cancellaria* (*Cancellaria*) by its more elongate shape, smaller, more oblique plaits, and shorter columella.

Cancellaria (*Crawfordina*) *alaskensis* CLARK, 1932

Plate 14, figs. 17, 18; Plate 18, fig. 9

1932. *Cancellaria* (*Progabbi*) *alaskensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 832, pl. 20, figs. 10, 12, 16, 17.

1971. *Cancellaria* (*Crawfordina*) *alaskensis* CLARK. ADDICOTT et al., U. S. Geol. Surv. Prof. Pap., 750-C, Fig. 2, l, m, q, r.

Remarks:—This species was originally described by CLARK (1932) from U. C. locality 3864, which was not plotted on his locality map. However, according to the present study this species seems to be restricted to the upper part of the Poul Creek formation where it occurs abundantly.

This species is characterized by: 1) about five whorls with a rather strongly depressed suture; 2) 18 to 19 narrow, rounded, obliquely longitudinal ribs on the body whorl; 3) about seven major spiral ribs on the penultimate whorl and 17 to 18 spiral ribs on the body whorl; 4) a short, straight anterior canal; and 5) two distinct columellar folds. However, it is rather difficult to observe the columellar folds unless an axial section through the columella is made, because the most specimens are somewhat deformed and poorly preserved. This species is somewhat similar to *C. weaveri* ETHERINGTON, (WEAVER, 1942, p. 505, pl. 96, fig. 4), from the Astoria formation (Miocene), which has a larger number of longitudinal ribs (about 26 compared with 17-18 in the present species).

Localities:—81201, 81401, 20503, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10060.

Family Turridae

Genus *Antiplanes* DALL, 1902

Antiplanes DALL, Proc. U. S. Nat. Mus., vol. 24, p. 513, 1902; *Antiplanes* DALL. OLDROYD, Stanf. Univ. Publ. Univ. Ser., Geol. Sci., vol. 2, pt. 1, p. 81-82, 1927; *Antiplanes* DALL. THIELE, Handb. Syst. Weicht., p. 360, 1931; *Antiplanes* DALL. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 552-553, 1931; *Antiplanes* DALL. KEEN, Mar. Moll. Gen. West. North Am., p. 40-41, 1963.

Type-species (by original designation):—*Pleurotoma* (*Surcula*) *perversa* GABB, Pleistocene?, San Pedro, California; the species is living from Alaska to off the coast of Lower California, in muddy bottoms from 80 to 120 meters in depth.

Remarks:—According to DALL, this genus is characterized by having an almost smooth shell surface, a shallow and more or less rounded posterior sinus which usually is situated some distance from the suture, a rather wide and long canal which is often somewhat recurved, and is represented by both dextral and sinistral species. However, KEEN (1963) subdivided this genus into two subgenera, *Antiplanes* s. s. and *Rectiplanes* BARTSCH, of which the former is coiled sinistrally and the latter is characterized by dextral coiling.

Geographic distribution:—North Pacific, mostly in deep water.

Geologic range:—Eocene to Recent (GRANT and GALE, 1931).

Subgenus *Antiplanes* s. s.

Remarks:—This subgenus is characterized by elongate, and sinistral shell, with aperture about one-half the length of the spire.

The present subgenus is reported from the Pacific coast of Japan north of lat. 35°N at depths of 30 to 250 meters.

Antiplanes (*Antiplanes*) sp.

Plate 15, figs. 9a-b

Description:—Shell small, sinistral, with six or seven whorls (apical part missing); spire more or less high, nuclear whorls inaccessible; suture deep; body whorl large, ventricose, higher than the half of the length of the entire shell; surface smooth excepting for incremental lines of growth which bend backwards; aperture rounded-ovate, broadest in the middle, narrowing regularly anteriorly; inner lip moderately incrusted; outer lip simple; sinus rather broad, deep, rounded, and adjoining the suture; canal very short and rather borad; height of shell, (apical portion missing), 15.0 mm; height of aperture, 8.0 mm; maximum diameter (somewhat compressed specimen), ca. 9.0 mm; apical angle, about 40°.

Remarks:—A rather well preserved, but somewhat compressed specimen is at hand. It is characterized by an extremely short and small shell, compared to known species. The present specimen seems to represent a new species, but more specimens are needed to establish a new name.

Locality:—80604, dark-gray, massive siltstone, lower part of the Yakataga formation.

Reg. No. TUE 10061.

Genus *Turricula* SCHUMACHER, 1817

Turricula SCHUMACHER, Ess. d'um Nouv. Syst., p. 217, 1817; *Turricula* SCHUMACHER. THIELE, Handb. Syst. Weicht., p. 360, 1931; *Turricula* SCHUMACHER. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 486, 1931; *Turricula* SCHUMACHER. ADDICOTT, U.S. Geol. Surv. Prof. Pap., 642, p. 129, 1970.

Type-species (by monotypy):—*Turricula flammea* SCHUMACHER, Recent, East Indies.

Remarks:—This genus is characterized by having high spire, shouldered whorls with spiral sculptures, large aperture about half as long as the whole length, and long and narrow anterior canal curved backwards.

This genus is related to *Clavatula* LAMARCK, 1801, but *Turricula* differs by having longer and narrower anterior canal, more inconspicuous sutural band, and simpler surface sculpture than those of *Clavatula*.

Geographic distribution:—Warm waters of tropical to subtropical regions.

Geologic range:—Cretaceous to Recent.

Turricula cf. *T. washingtoniana* (WEAVER), 1912

Plate 14, figs. 10

1912. *Pleurotoma washingtoniana* WEAVER, Wash. Geol. Surv., Bull. no. 15, p. 78, pl. 3, fig. 31.
1916. *Turris washingtonianus* (WEAVER), WEAVER, Univ. Wash. Publ. Geol., vol. 1, pl. 4, fig. 45.
1942. *Turricula washingtonensis* (WEAVER), WEAVER, Univ. Wash. Publ. Geol., vol. 5, p. 533, pl. 98, figs. 16, 17, 22.

Remarks:—A single rather poorly preserved external mould and its rubber-cast are at hand. This species is characterized by a high fusiform spire with heavy, noded cord-like, spiral angles and a smooth concave surface above, and a spirally striated surface below. According to WEAVER (1942), the apical angle and strength of nodes of this species show a rather wide range of variation. The present specimen has a distinct, strong cord-like spiral angle, but heavy nodes are poorly developed on the cord. It seems to represent a varietal form.

Locality:—81404, olive-green, fine-grained sandstone, lower part of the Poul Creek formatton.

Reg. No. TUE 10062.

Turricula sp.

Plate 14, fig. 16

Remarks:—An external mould and its rubber cast are at hand. This specimen is similar to the preceding one, but its large apical angle and more acute keel-like cord are different from *Turricula* cf. *T. washingtonensis*. Both specimens have the same surface sculpture of fine, silk-like spiral threads beneath the spiral cord on the body whorl.

Locality:—80905, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10063.

Order Tectibranchiata

Family Scaphandridae

Genus *Scaphander* MONTFORT, 1810

Scaphander MONTFORT, Conch. Syst., vol. 2, p. 335, 1810; *Scaphander* MONTFORT. OLDROYD, Stanf. Univ. Publ., Univ. Ser. Geol. Sci., vol. 2, pt. 1, p. 35, 1927; *Scaphander* MONTFORT. GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 451, 1935; *Scaphander* MONTFORT. KEEN, Mar. Moll. Gen. West. North Am., p. 18, 1963; *Scaphander* MONTFORT. ADDICOTT, U.S. Geol. Surv. Prof. Pap. 642, p. 139, 1970;

Type-species (by original designation):—*Bulla lignaria* LINNÉ, Recent, eastern North Atlantic and Mediterranean Sea.

Remarks:—*Scaphander* is characterized by having a large elongate-ovate shell, an involute spire, a shallow apical perforation, a large and wide aperture broadly expanded anteriorly, and a surface sculptured by narrow spiral grooves.

Geographic distribution:—World-wide, on sandy bottom about 100 meters in depth.

Geologic range:—Eocene to Recent.

Scaphander alaskensis CLARK, 1932

Plate 15, figs. 7-8; Plate 18, figs. 6, 7

1932. *Scaphander alaskensis* CLARK, Bull. Geol. Soc. Am., vol. 43, p. 834, pl. 21, figs. 6, 7.
1932. *Haminoea* n. sp.? CLARK, Bull. Geol. Soc. Am., vol. 43, p. 834, pl. 21, fig. 12.
1971. *Scaphander alaskensis* CLARK. ADDICOTT et al., U. S. Geol. Surv. Prof. Paper 750-C, Fig. 1, g, h.
1971. *Haminoea* n. sp.? CLARK. ADDICOTT et al., U. S. Geol. Surv. Prof. Paper, 750-C, Fig. 2, u, v.

Remarks:—Several specimens are at hand. This species was originally described by CLARK (1932) from the Poul Creek formation (U.C. loc. 3854) exposed on the right side of Beare Glacier. Although the writer was unable to collect it from the type locality, several specimens were collected from the Poul Creek formation at Lear Glacier and Johnstone Creek, about 8 kilometers and 12.5 kilometers respectively west of the type locality.

The present species is characterized by a large shell, numerous fine spiral grooves which alternate in strength. It is noteworthy that the shape of the present shell is extremely variable, i. e., some specimens are rather elongate form (Plate 15, figures 8a-b), but others are more globose (Plate 15, figures 7a-b). Specimens figured in Plate 18, figures 6, 7 are the most globose, but their general features are the same as the preceding ones.

Localities:—81201, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation.

Reg. No. TUE 10064.

CEPHALOPODA

Subclass Nautiloidea

Order Nautilida

Family Aturiidae

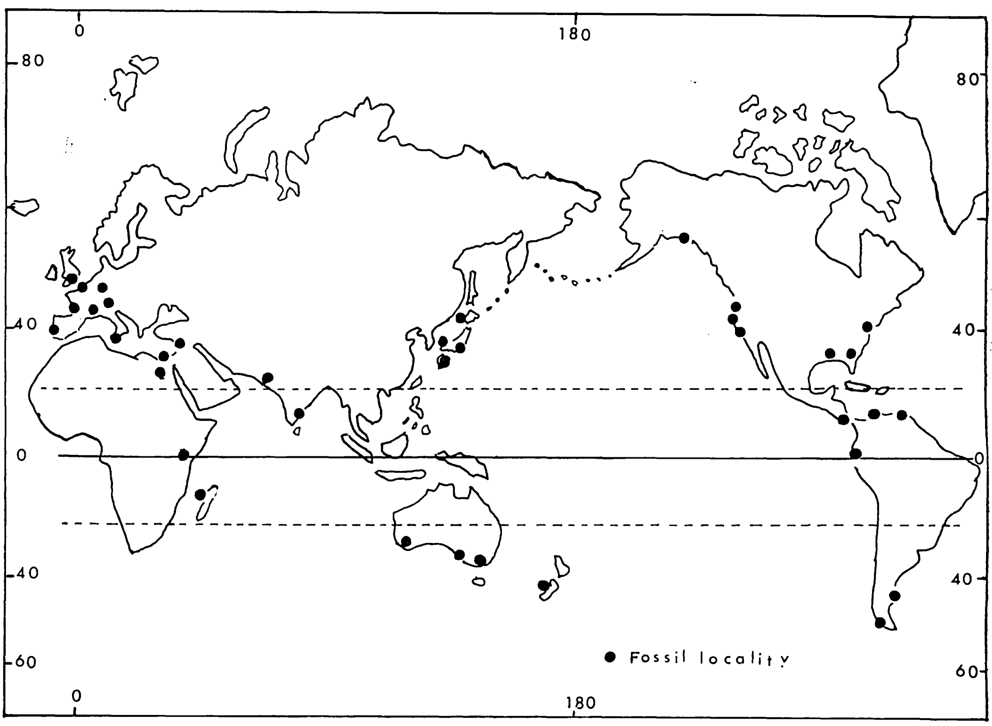
Genus *Aturia* BRONN, 1838

Aturia BRONN, Lethaea geognostica, vol. 2, p. 1122-1123, pl. 42, figs. 17a-c, 1838; *Aturia* BRONN. SCHENCK, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 19, no. 19, p. 448-450, 1931; *Aturia* BRONN. MILLER. Geol. Soc. Am., Mem. 23, p. 78-81, 1948; *Aturia* BRONN. MOORE, U. S. Geol. Surv. Prof. Paper 419, p. 85, 1963; *Aturia* BRONN. MOORE et al., Treat. Invert. Paleont., pt. K, Moll. 3, p. 457, 1964.

Type-species (by tautonomy):—*Nautilus aturi* BASTEROT, lower Miocene (lower Burdigalian) in St. Poul de Dax (Landes), France.

Remarks:—The genus is characterized by having a quite narrow umbilicus, a rounded venter, a siphuncle situated very near the dorsum, almost tubular and pointed simple funnels similar to the siphuncle, and very simple sutures.

About 40 species are reported from the Tertiary strata throughout the world, and they are restricted in age from the Eocene to the Miocene, excepting one species from the Chico formation (upper Cretaceous) of the west coast of North America (SCHENCK, 1931) and one from the questionable Pliocene of Australia (SCHENCK, 1931) (Text-fig. 16). However, there are no reported occurrences of *Aturia* from upper



Text-fig. 16. Geographic distribution of *Aturia*.

Miocene or younger strata in the northern Pacific region both from the west coast of North America and the western Pacific. There are seven species from Eocene to middle Miocene strata of the west coast of North America and four species from Japan. These species are usually associated with rather warm water inhabitants. However, it is noteworthy that no species of *Aturia* have been reported from the Philippine and Taiwan.

Geographic distribution:—World-wide, essentially in the tropical to subtropical regions.

Geologic range:—Paleocene to Miocene (rarely in the upper Cretaceous and questionably in Pliocene).

Aturia alaskensis SCHENCK, 1931

Plate 16, figs. 1–4; Plate 18, fig. 8

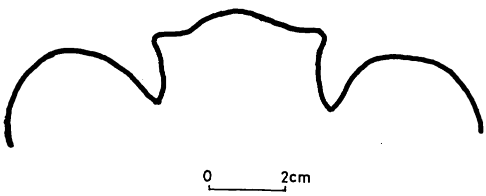
1931. *Aturia angustata* (CONRAD) *alaskensis* SCHENCK, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 19, no. 19, p. 463–464, pl. 71, fig. 2.
1932. *Aturia angustata* (CONRAD) *alaskensis* SCHENCK. CLARK, Bull. Geol. Sci. Am., vol. 43, p. 835, pl. 16, fig. 5, 6.
1954. *Aturia minoensis* KOBAYASHI, Jap. Jour. Geol. Geogr., vol. 25, nos. 1–2, p. 36–39, pl. 5, figs. a–d.
1955. *Aturia minoensis* KOBAYASHI. KOBAYASHI and MASATANI, Trans. Proc. Paleont. Soc. Japan, N.S., no. 17, p. 1–3, pl. 1, figs. a–d.
1956. *Aturia* cf. *A. minoensis* KOBAYASHI. KOBAYASHI and HORIKOSHI, Jap. Jour. Geol. Geogr., vol. 29, nos. 1–3, p. 52–53, pl. 5, figs. 1, 2.
1957. *Aturia minoensis* KOBAYASHI var., KOBAYASHI, Proc. Paleont. Soc. Japan, N.S., no. 28, p. 111–114, pl. 19, figs. 1–3.
1971. *Aturia alaskensis* SCHENCK. ADDICOTT et al., U.S. Geol. Surv. Prof. Paper 750–C, Fig. m, o.

Remarks:—The present species was originally described by H. G. SCHENCK based on a specimen collected from the Poul Creek formation exposed along Johnson Creek, near Yakataga Reef. According to his discription, the present species is characterized by having narrow and pointed lateral lobes which seem to be telscoped into the preceding one. Subsequently, CLARK (1932) described *A. angustata* (CONRAD) *alaskensis* based on the holotype of this species, and stated that "when more and better materal representing these two subspecies is found they will prove to be sufficiently different from the typical species *angustata* to be described as distinct species".

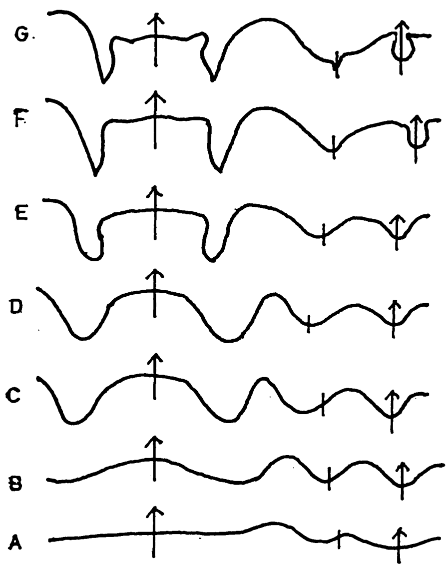
The single specimen upon which this species was described is somewhat deformed. Fortunately, the writer collected more than ten specimens from the type area, of which a few specimens are rather well preserved. The supplemental description based on these specimens is as follows:

Shell fairly large, thin more or less compressed; most expanded at about one-third or half of its height; ventral side regularly rounded but lateral sides are slightly convex; umbilicus closed; siphuncle in the ultimate whorl located at about one-third the distance from the venter of the penultimate whorl to that of the ultimate one; septa closely set; ventral saddle subquadrate and almost same as or somewhat narrower than the lateral saddle; suture nearly transversal on the ventral side except a pair of a small shoulders which protrude antero-laterally and are slightly sinuated backward before their protrusion; lateral saddle large, very high and more convex on the inner side than on the outer side of the whorl; following the lateral saddle umbilical seam distinct (Text-figs. 17, 18).

The ratio (Text-fig. 19) of the height of ventral saddle (x), lateral saddle (z), and the diameter of lateral saddle (y) seems to be variable in various stages of growth in each species, but there are some distinctions between different species. The writer believes that the ratio of the height of the ventral and lateral saddles in correlation with the breadth of lateral saddle has specific significance. Text-fig. 20 is based upon species from the Pacific coast of America and Japan. It is clear that

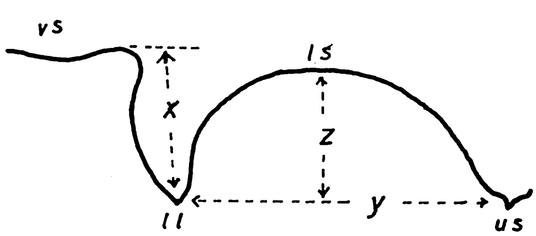


Text-fig. 17. Suture of *Aturia alaskensis* SCHENCK.



Text-fig. 18. Developmental series nautiloid sutures (after MILLER and FURNISH, 1938).

A. *Cimomia* (Paleocene). B. *Hercoglossa* (Lower Eocene), primitive from. C. *Hercoglossa* (Lower Eocene), advanced form. D. *Aturia* (Lower Eocene). F. *Aturia* (Upper Eocene), typical form. G. *Aturia* (Miocene), advanced form.



Text-fig. 19. Ratio* between height of ventral and lateral saddles in suture of *Aturia*.

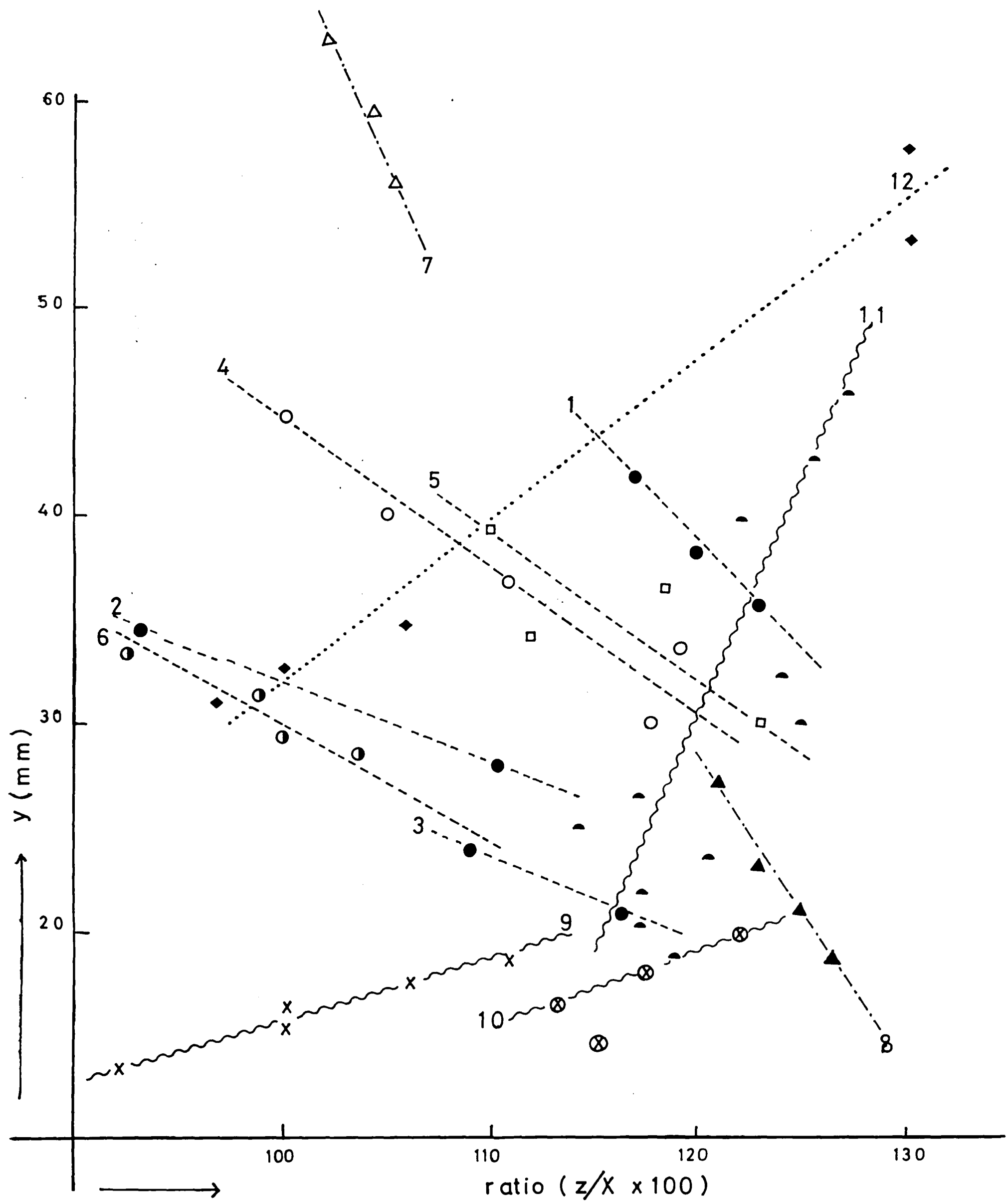
*…Z/X×100, vs…ventral saddle; ls…lateral saddle; ll…lateral lobe; us…umbilical seam.

with the exception of the Alaskan species, the American species are inclined to the right side whereas Japanese ones are inclined to the left side (Text-fig. 20).

The inclination of *A. alaskensis* is almost the same as that of the Japanese species *A. minoensis* KOBAYASHI which has been reported from several lower to middle Miocene localities in Japan. According to the original description (KOBAYASHI, 1954, p. 36–39), *A. minoensis* KOBAYASHI is characterized by having narrow, pointed lateral lobe which form an angle of about 30–35 degrees and which are in contact with the shoulder of the preceding ventral saddle. Moreover, he stated "lateral saddle large, occupying three-fourths of the radius of the whorl, very high and more convex on the inner side than on the outer where it becomes nearly straight or even a little concave near the ventro-lateral lobe". The writer measured the relative growth ratio of *A. minoensis* and other known species of Japan, and these results are shown in Text-fig. 20.

It seems clear that *A. alaskensis* SCHENCK differs from *A. angustata* (CONRAD) which was originally described from the Miocene of Astoria, Oregon. Moreover, the present species is conspecific with *A. minoensis* KOBAYASHI, 1954. Accordingly, KOBAYASHI's *minoensis* is preoccupied by SCHENCK's *alaskensis*.

The present species occurs abundantly in the Yakataga area and is represented by individuals of every growth stage. It is noteworthy that the Asian species of *A. alaskensis* flourished on the Pacific coast of Alaska during deposition of the Poul Creek formation.



Text-fig. 20. Relative dimensions in the sutures of Pacific coast species of *Aturia*. 1-3. Poul Creek specimens; 4-6. "*A. minoensis* KOBAYASHI, 1954" (Miocene species in Japan); 4. Tsukiyoshi specimen; 5. Kurosedani specimen; 6. Oita specimen; 7-8. *A. yokoyamai* NAGAO (Oligocene species in Japan); 7. Ashiya specimen; 8. Poronai specimen; 9-11. *A. angustata* (CONRAD); 9. Washington specimen (Miocene); 10. Licoln Oligocene specimen; 11. Temblor Miocene specimen; 12. *A. myrlae* M. A. HANNA, middle Eocene of Calif.

This species occurs from lower to middle Miocene strata in Japan.

Localities:—80905, 81401, olive-green, fine- to medium-grained sandstone, upper part of the Poul Creek formation; 80906, 81404, dark-gray, calcareous concretions, in dark-gray silty sandstone, lower part of the Poul Creek formation.

Reg. No. TUE 10065.

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Explanation of Plate 1

(All figures are in natural size unless otherwise stated.)

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* Tp....Poul Creek formation.
** Ty....Yakataga formation.

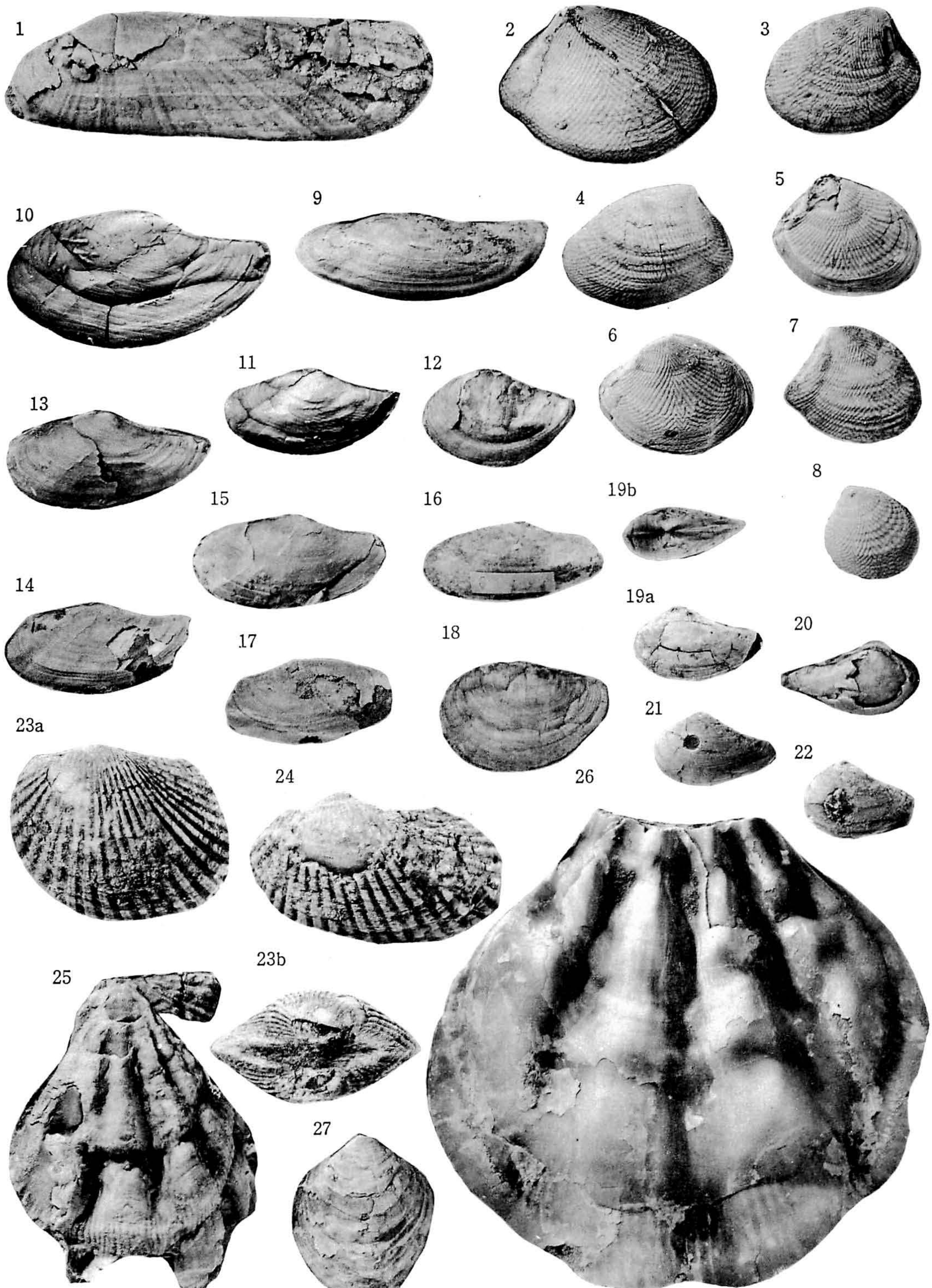
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Plate 2

Explanation of Plate 2

(All figures are in natural size unless otherwise stated.)

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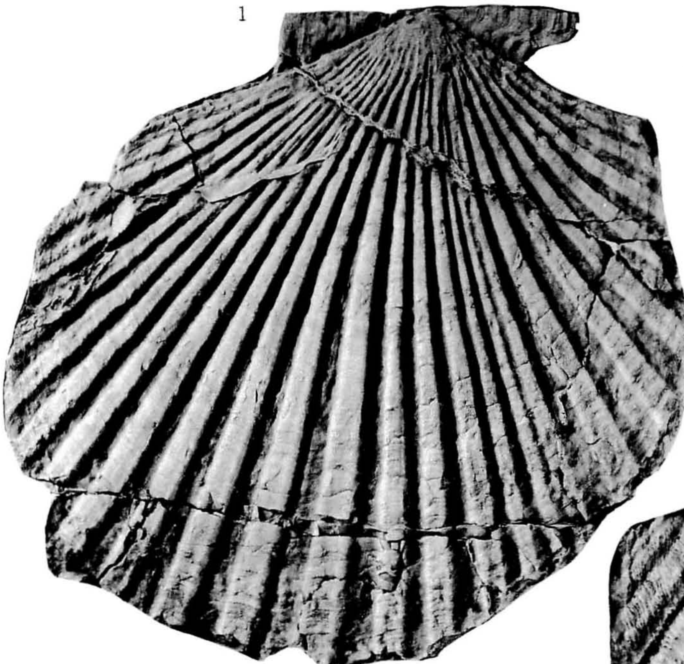

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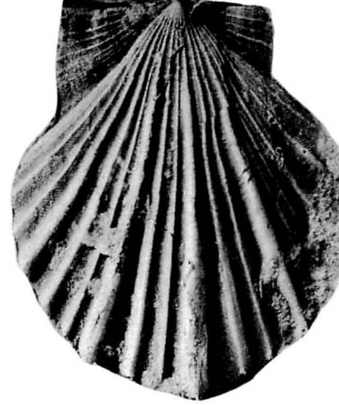

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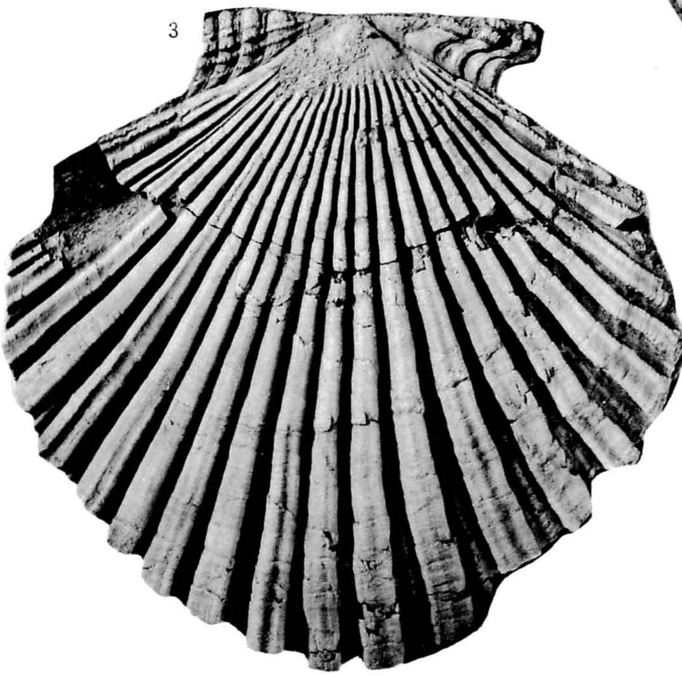

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Plate 3

Explanation of Plate 3

(All figures are in natural size unless otherwise stated.)

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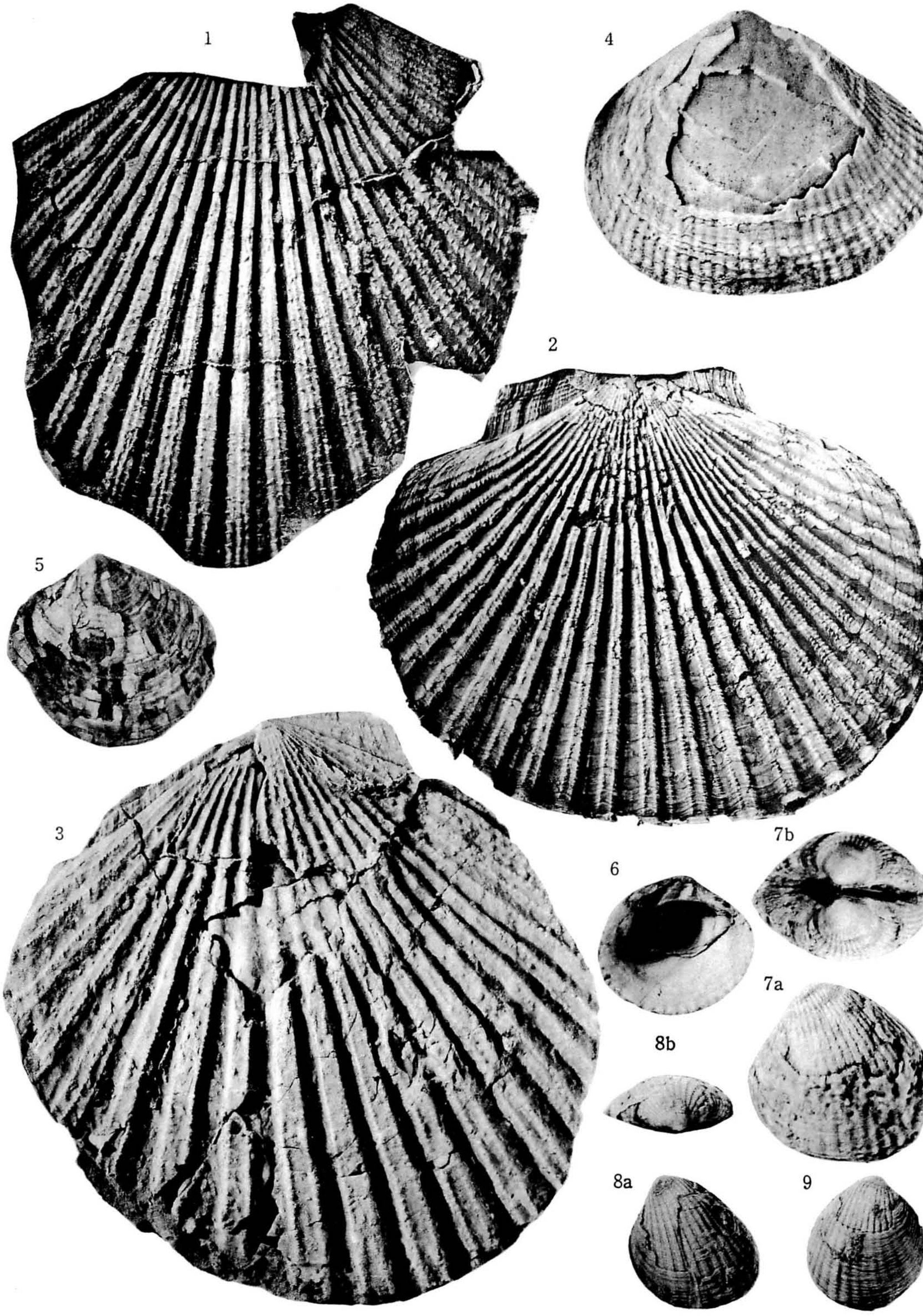
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Plate 4

Explanation of Plate 4

(All figures are in natural size unless otherwise stated.)

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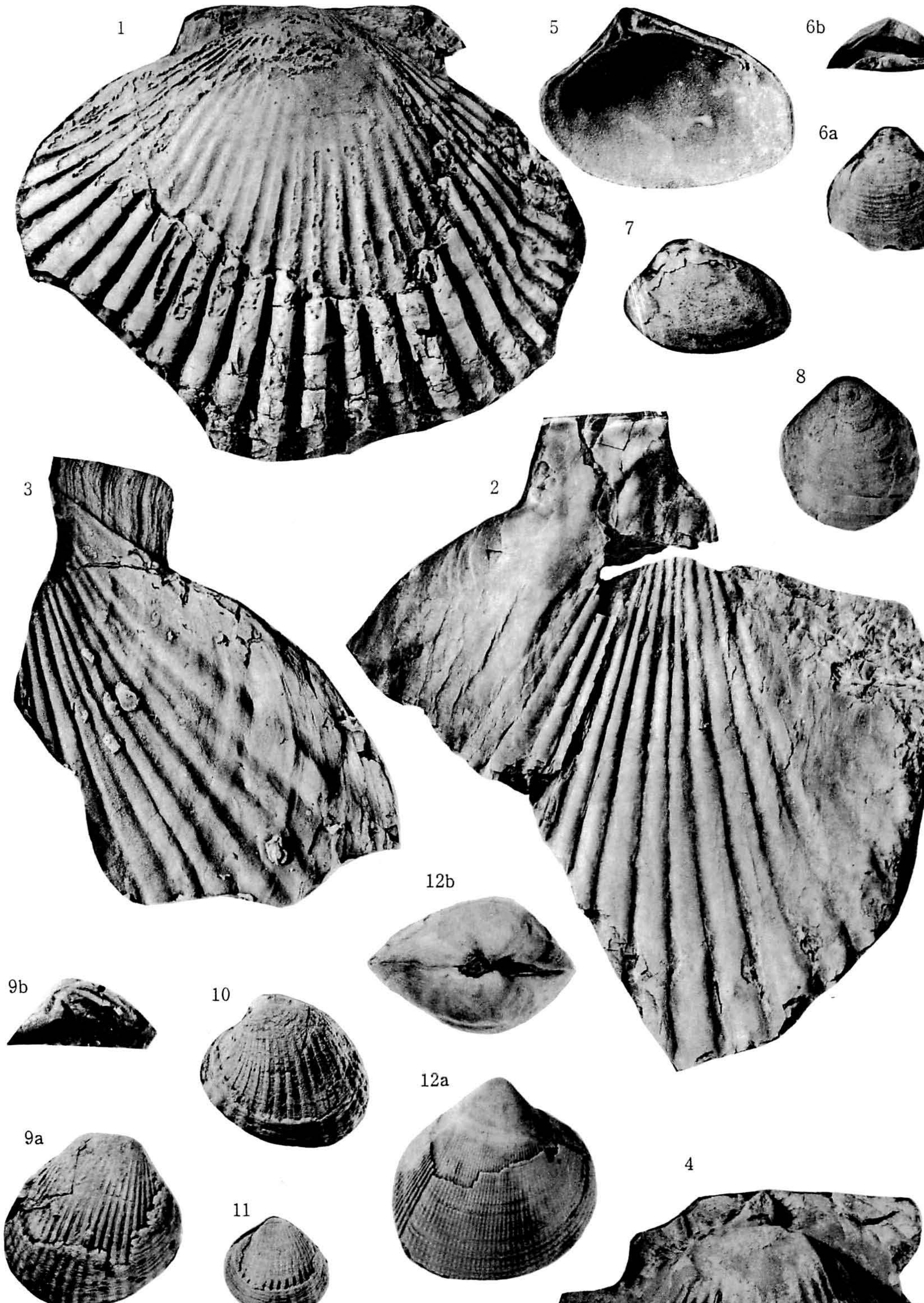
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Plate 5

Explanation of Plate 5

(All figures are in natural size unless otherwise stated.)

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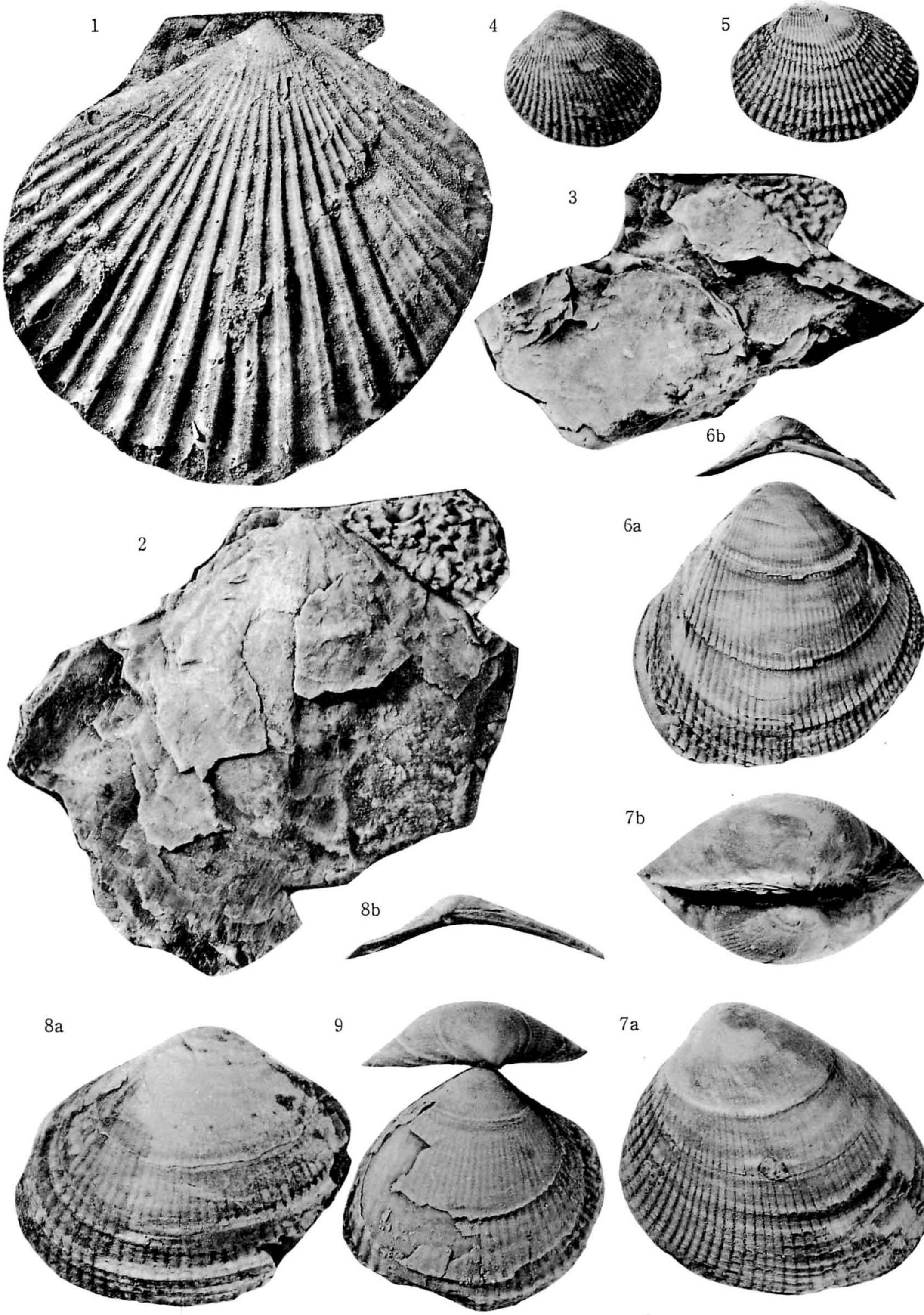
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Plate 6

Explanation of Plate 6

(All figures are in natural size unless otherwise stated.)

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1. Paratype, incomplete right valve about ×0.6, rubber cast, height 142 mm (incomplete). Loc. 81402(Ty) Reg. No. TUE 8421.
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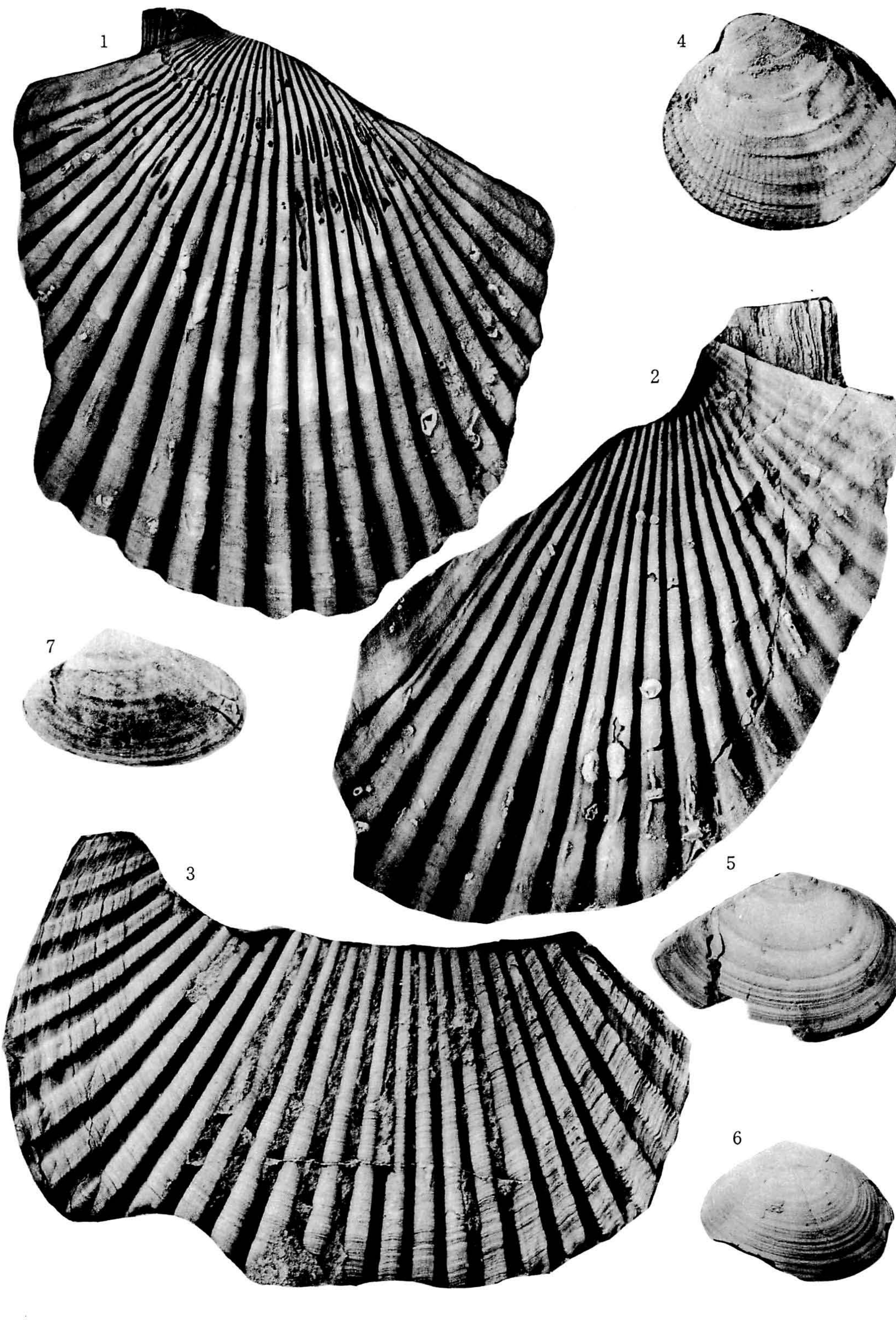
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Plate 7

Explanation of Plate 7

(All figures are in natural size unless otherwise stated.)

Figs. 1, 2. *Acesta* cf. *A. yagenensis* (OTUKA) .... page 58
1. Incomple right valve, about $\times 0.8$, apical part missing, obliquity (longest length measured from beak to ventral margin) ca. 127 mm, width 95 mm. Loc. 81002(Tp) Reg. No. TUE 8423.
2. Anterior ear, rubber cast. Loc. 81002(Tp) Reg. No. TUE 8423.

Fig. 3. *Conchocele disjuncta* GABB.. page 61
Decorticated left valve. Float, Loc. 80606(?Tp) Reg. No. TUE 8426.

Figs. 4a–b. *Pitar* (*Katherinella*) sp. .... page 85
4b. Hinge teeth of fig. 4a. Loc. 81001(Tp) Reg. No. TUE 10010.

Figs. 5, 6a–b. *Calyptogena chitanii* (KANEHARA) .... page 80
Loc. M 1769 (locality number of USGS, Menlo Park)(Ty)
5. Inner mould of immature specimen of right valve.
6a. Rubber cast of fig. 6b, showing the hinge teeth. Reg. No. TUE 8450.

Figs. 7a–b. *Clinocardium brooksi* (CLARK) .... page 67
7a. A left valve, showing the surface sculpture;
7b. Lateral view of the same specimen of fig. 7a. Loc. 81403 Reg. No. TUE 8433.

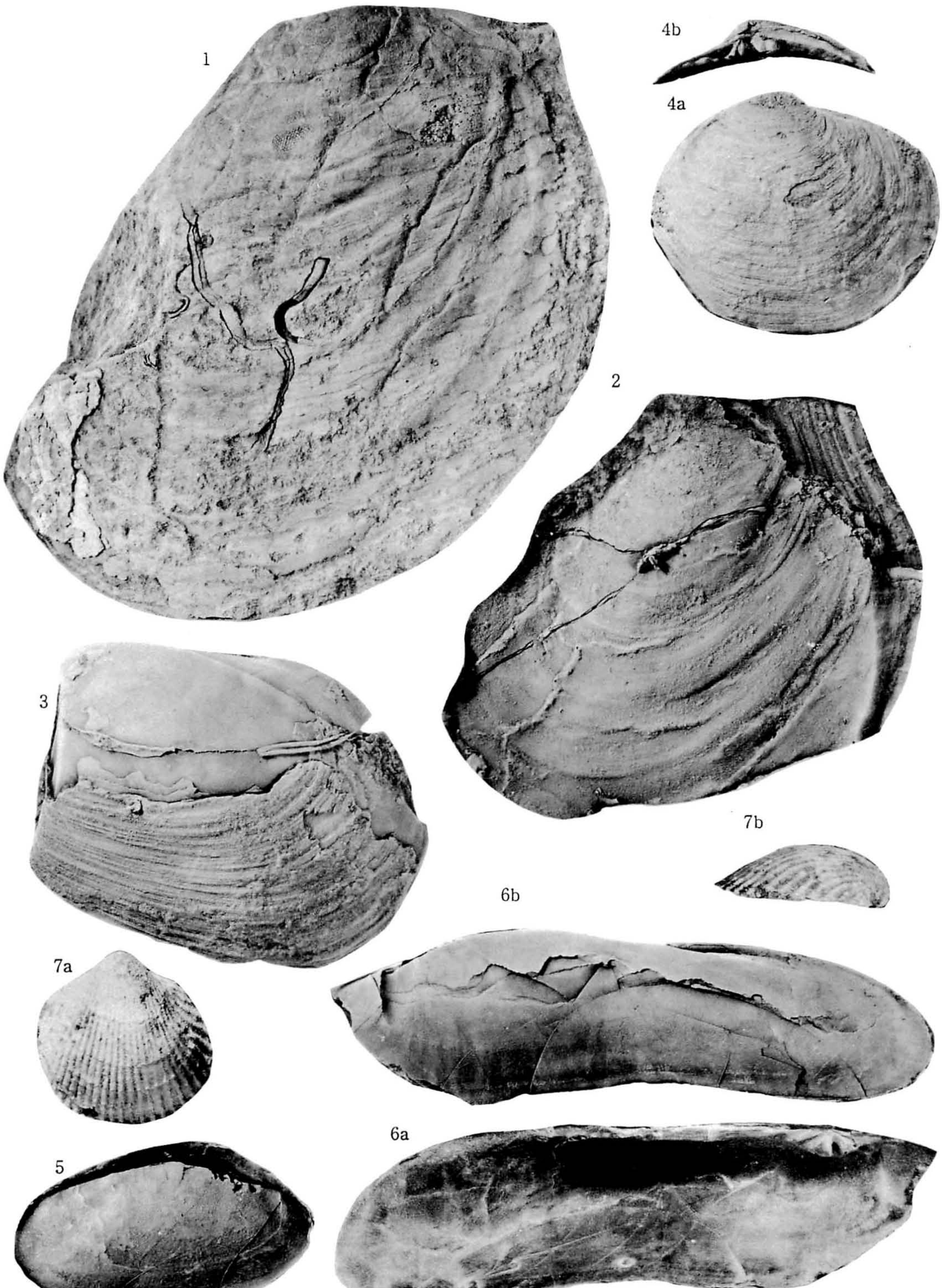
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Plate 8

Explanation of Plate 8

(All figures are in natural size unless otherwise stated.)

Figs. 1–3. *Clinocardium yakatagense* (CLARK) .... page 66
1a. Decorticated left valve.
1b. Apical view of fig. 1a.
2, 3. Incomplete right valves. 2b. Cardinal teeth of fig. 2a.
Loc. 81402(Ty) Reg. No. TUE 8432.

Figs. 4, 5. *Pitar (Katherinella) arnoldi etheringtoni* (TEGLAND)...................... page 85
4b. Apical view of fig. 4a. Loc. 81401(Tp).
5. Deformed left valve. Loc. 81401(Tp) Reg. No. TUE 10009.

Figs. 6, 7. *Pitar (Katherinella) arnoldi* (WEAVER) .... page 85
6b. Apical view of fig. 6a. Loc. 80602(Tp).
7. Cardinal teeth and inner surface of left valve. Loc. 81102(Tp)
Reg. No. TUE 10008.

Figs. 8a–c. *Securella alaskensis* (CLARK) .... page 86
8b. Cardinal teeth of fig. 8a.
8c. Apical view of fig. 8a.
Loc. 81402(Ty) Reg. No. TUE 10011.

Fig. 9. *Spisula equilateralis* (CLARK) .... page 72
Incomplete specimen of right valve. Loc. 81401(Tp) Reg. No. TUE 8439.

Fig. 10. *Spisula addicotti* KANNO, n. sp. .... page 72
Paratype, immature left valve. Loc. 81401(Tp) Reg. No. TUE 8441.

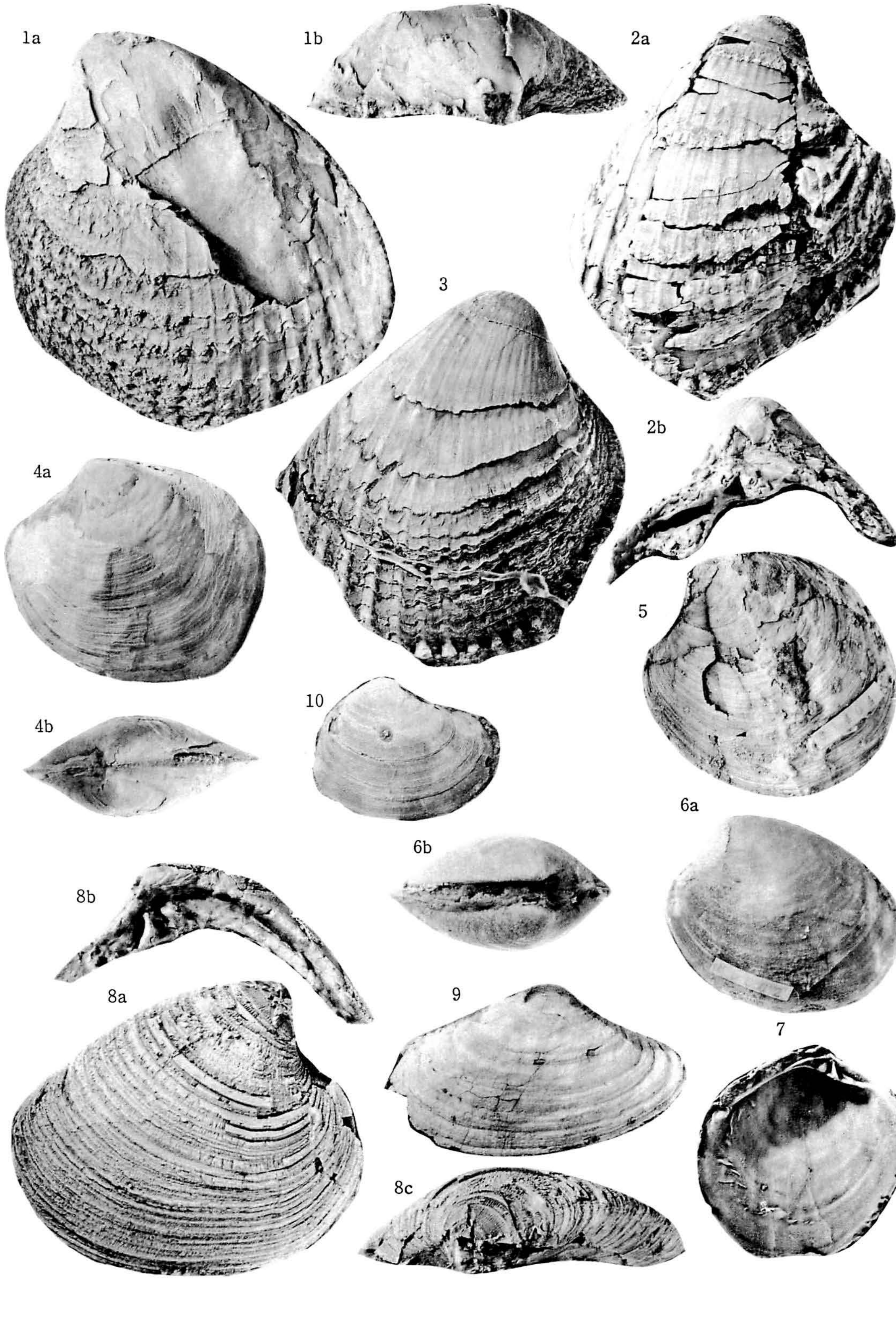
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Plate 9

Explanation of Plate 9

(All figures are in natural size unless otherwise stated.)

Figs. 1, 4, 5, 7, 8. *Spisula equilateralis* (CLARK) .... page 72

1b. Apical view of fig. 1a.

4. Dorsal view of right valve.

Loc. 81401(Tp) Reg. No. TUE 8439.

5, 8. More or less deformed right valves.

8b. Apical view of fig. 8a. Loc. 81201(Tp)

7. Somewhat deformed right valve. 7b. Cardinal teeth of fig. 7a.

Loc. 81401(Tp) Reg. No. TUE 8439.

Figs. 2, 3, 6. *Spisula addicotti* KANNO, n. sp. .... page 72

2a. Holotype, right valve. 2b. Apical view of fig. 2a.

Loc. 81401(Tp) Reg. No. TUE 8440.

3a. Paratype, left valve. 3b. Cardinal teeth of fig. 3a.

6. Paratype, somewhat deformed specimen.

Loc. 81401(Tp) Reg. No. TUE 8439.

Figs. 9, 10, 12. *Macoma incongrua* v. MARTENS...................................... page 77

All specimens are intact valves.

9, 12. Loc. 81401(Tp) Reg. No. TUE 8446.

10. Loc. 81201(Tp) Reg. No. TUE 8446.

Fig. 11. *Macoma* cf. *M. incongrua* v. MARTENS...................................... page 78

Deformed specimen of right valve (intact valves). Loc. 80802(Tp)

Reg. No. TUE 8447.

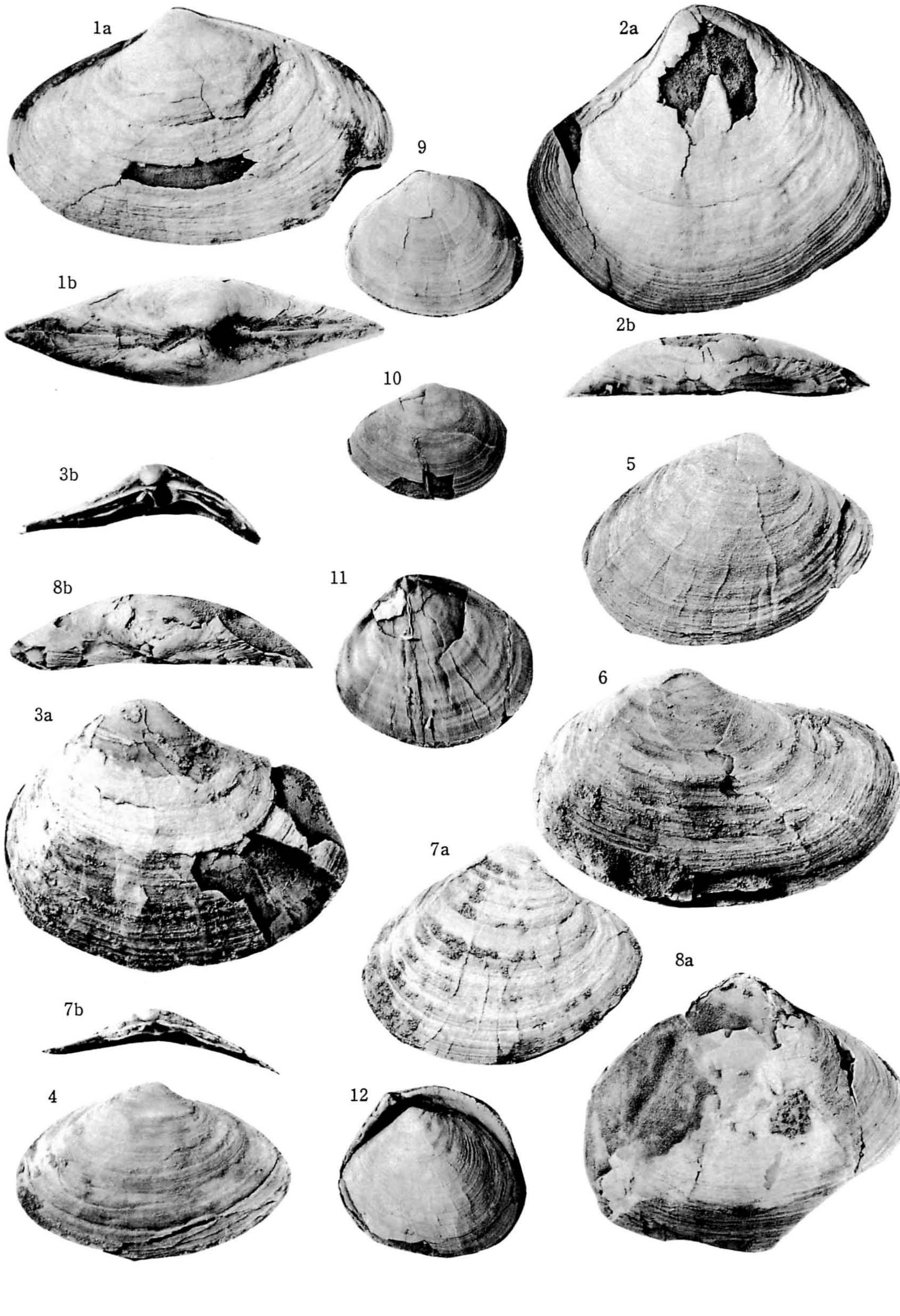
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Plate 10

Explanation of Plate 10

(All figures are in natural size unless otherwise stated.)

Figs. 1, 2. *Macoma* aff. *M. lorenzoensis arnoldi* TEGLAND............................ page 76
1. Right valve. 2. Incomplete inner mould of intact valve, showing the pallial sinus. Loc. 80506(Ty) Reg. No. TUE 8445.

Fig. 3. *Macoma* sp. .... page 79
Strongly deformed specimens, each valve of right and left shows different shape by the difference of deformation. Float, Loc. 81106(?Tp) Reg. No. TUE 8449.

Figs. 4, 5. *Tellina (Oudardia)* sp. .... page 75
4. Decorticated right valve.
5. Decorticated left valve, showing the thick internal rib radiating from beak to antero-ventral corner. Loc. 81401(Tp) Reg. No. TUE 8443.

Figs. 6, 7. *Mya (Mya) truncata* LINNÉ .... page 89
6a. Decorticated left valve. 6b. Apical view of fig. 6a. Loc. 80406(Ty) Reg. No. TUE 10013.
7. Showing the surface sculpture of left valve. Loc. 80404(Ty) Reg. No. TUE 10013.

Figs. 8–10. *Panomya arctica* (LAMARCK) .... page 94
8b. Apical view of fig. 8a. Loc. 80406(Ty) Reg. No. TUE 10019.
10. Somewhat decorticated left valve. Loc. 80406(Ty) Reg. No. TUE 10019.
9. Rubber cast, showing the cardinal teeth and inner surface of right valve. Loc. 81105(Ty) Reg. No. TUE 10019.

Figs. 11a–b. *Hiatella arctica* (LINNÉ) .... page 91
11a. Somewhat decorticated intact valve.
11b. Rubber cast of fig. 11a. Loc. 80802(Ty) Reg. No. TUE 10016.

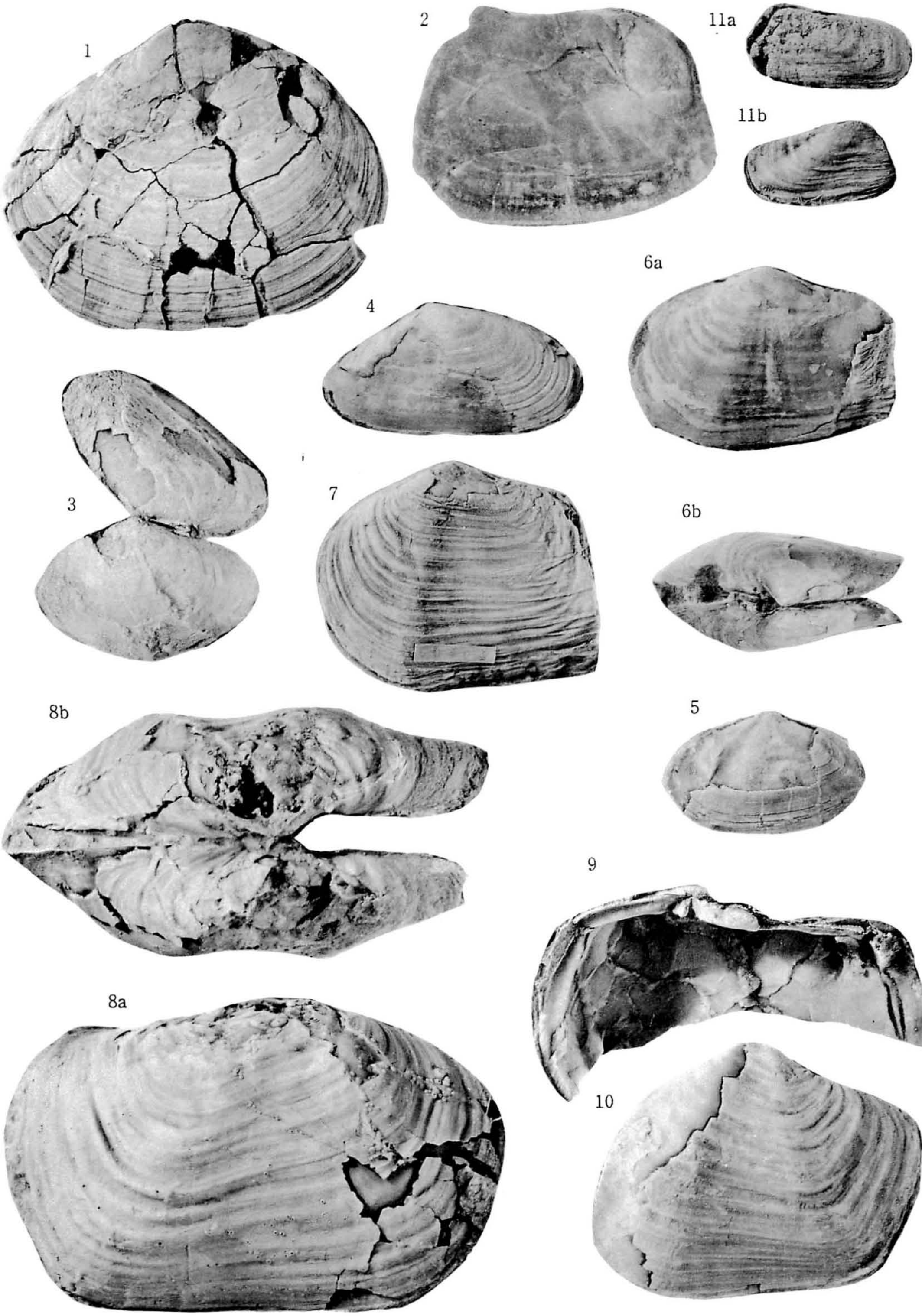
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Plate 11

Explanation of Plate 11

(All figures are in natural size unless otherwise stated.)

Fig. 1. *Macoma* sp. ×2 .... page 79
Rubber cast, showing the hinge structure. Float, Loc. 81106(?Tp) Reg. No. TUE 8449.

Figs. 2a–b. *Panope snohomishensis* CLARK .... page 93
2b. Apical view of fig. 2a. Loc. 81401(Tp) Reg. No. TUE 10017.

Figs. 3a–b. *Panope* n. sp.?.. page 93
3b. Apical view of fig. 3a. Loc. 81401(Tp) Reg. No. TUE 10018.

Figs. 4a–b. *Mya* (*Mya*) *truncata* LINNÉ .... page 89
4a. Decorticated left valve, showing the large pallial sinus.
4b. Apical view of fig. 4a, showing the condrophore. Loc. 81402(Ty) Reg. No. TUE 10013.

Fig. 5. *Mya* (*Mya*) *salmonensis* CLARK .... page 90
Decorticated intact spacimen. Flart, Loc. 80906(Tp) Reg. No. TUE 10014.

Figs. 6, 7. *Panomya elongata* KANNO .... page 95
6. Somewhat deformed right valve. Loc. 81401(Tp) Reg. No. TUE 10020.

Figs. 8, 9. *Thracia schencki* CLARK .... page 97
8. Decorticated and incomplete right valve.
9. Decorticated left valve.
Loc. 81401(Tp) Reg. No. TUE 10023.

Fig. 10. *Periploma* (*Aelga*) *besshoense* (YOKOYAMA) .... page 96
More or less deformed specimen. Loc. 80404(Ty) Reg. No. TUE 10022.

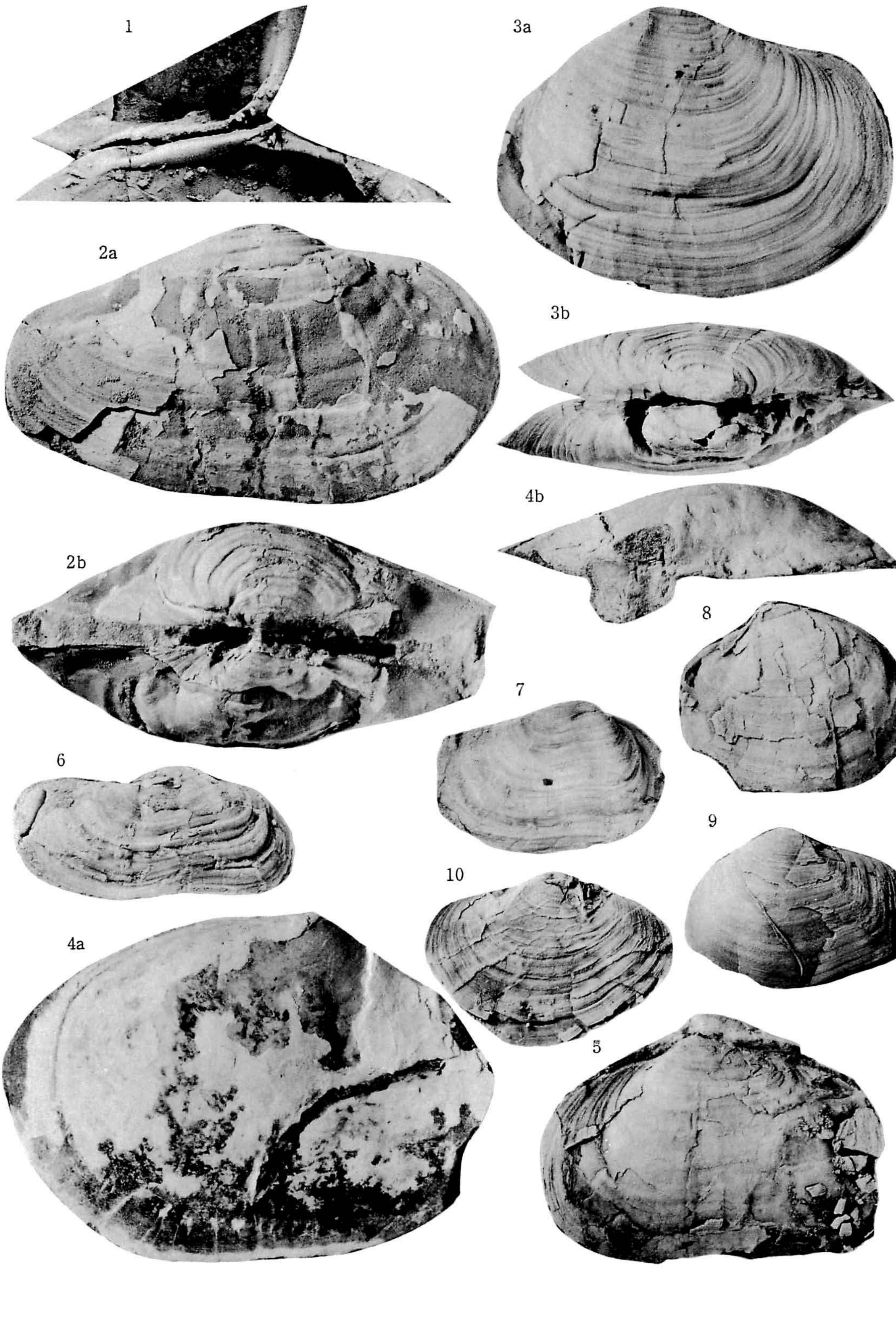
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Plate 12

Explanation of Plate 12

(All figures are in natural size unless otherwise stated.)

Figs. 1, 2. *Dentalium* (*Coccodentalium*) cf. *D.* (*C.*) *nunomae* TAKEDA .... page 99

1. Deformed specimen, showing the microscopic cancellate surface sculpture, ×2. Loc. 80905(Tp) Reg. No. TUE 10025.
2. Decorticated specimen. Loc. 81401(Tp) Reg. No. TUE 10025.

Figs. 3a–c. *Bathybembix jonesi* KANNO, n. sp. .... page 101

3a–b. Side view of holotype. 3c. Basal view of the same. Loc. 20508–2 Reg. No. TUE 10027.

Figs. 4a–b. *Bathybembix turbonata* (CLARK) .... page 100

4a. Apertural view. 4b. Side view of fig. 4a, showing a spiral cord on the body whorl. Loc. 81103(Tp) Reg. No. TUE 10026.

Figs. 5, 6. *Calyptraea* sp. .... page 108

5. Loc. 80602(Tp) Reg. No. TUE 10036.
6. Loc. 81003(Tp) Reg. No. TUE 10036.

Figs. 7, 8. *Crepidula* cf. *praerupta* CONRAD .... page 109

Loc. 81004(Tp) Reg. No. TUE 10037.

Figs. 9–12. *Turritella* (*Neohaustator*) *hamiltonensis* CLARK .... page 105

9, 10. Loc. 81104(Ty) Reg. No. TUE 10032.

11, 12. Loc. 81403(Ty) Reg. No. TUE 10032.

Figs. 13, 14. *Turritella* aff. *T. diversilineata blakeleyensis* WEAVER .... page 106

13. Loc. 81404(Tp) Reg. No. TUE 10033.
14. Loc. 80906(Tp) Reg. No. TUE 10033.

Fig. 15. *Cristispira pugetensis* ALLISON ×2 .... page 107

Loc. 20537–6(Tk*)

Fig. 16. *Epitonium* sp. .... page 104

Loc. 81401(Tp) Reg. No. TUE 10031.

Figs. 17, 18. *Epitonium* (*Cirsotrema*) *clallamense* DURHAM .... page 102

17. Outer lip brocken. Loc. 81002(Tp) Reg. No. TUE 10029.
18. Varietal form, providing rather large number of axial varices. Loc. 80905(Tp) Reg. No. TUE 10029.

Fig. 19. *Epitonium* (*Grysoscala*) sp. .... page 103

Loc. 80905(Tp) Reg. No. TUE 10030.

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* Tk....Kultieth formation.

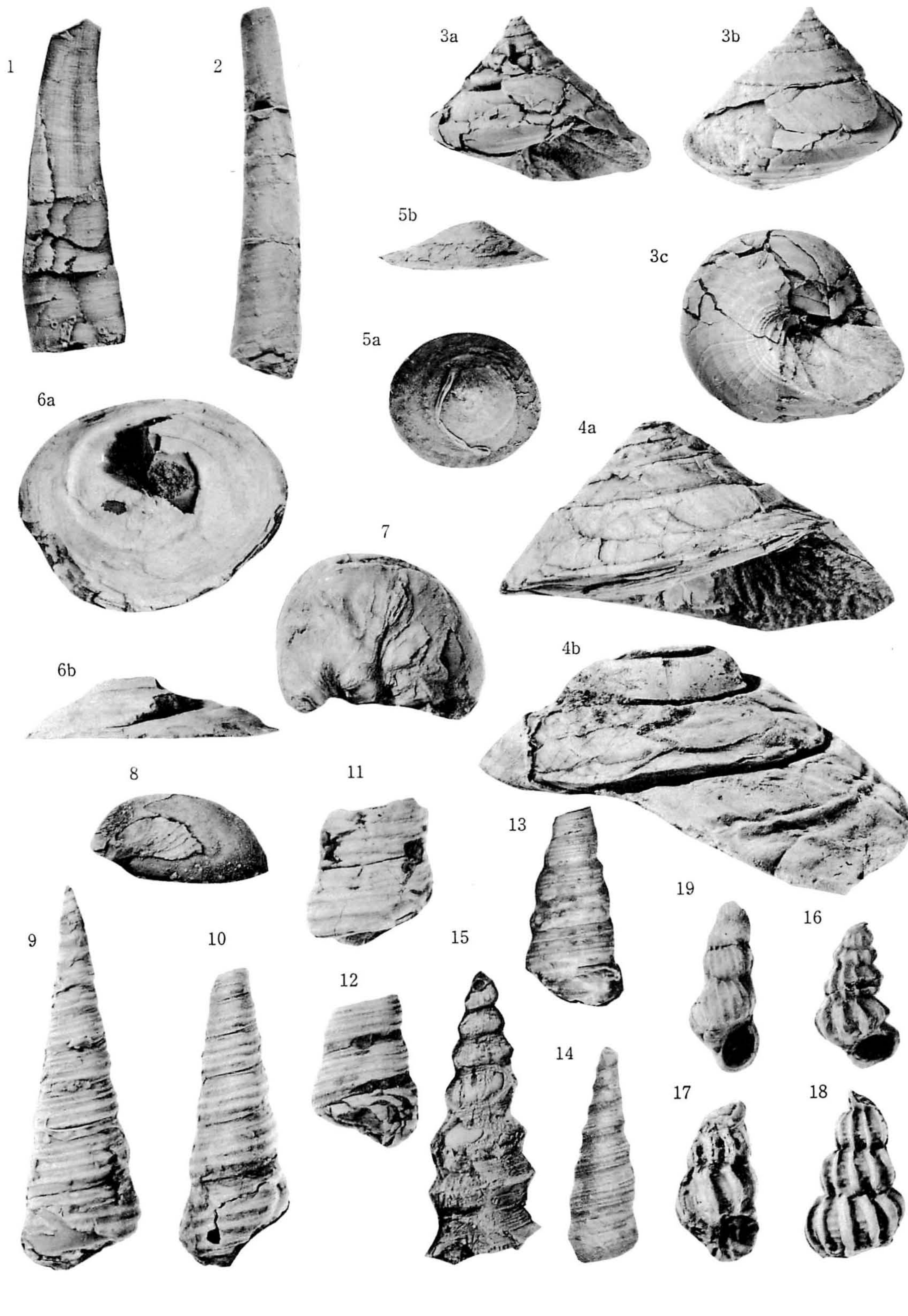
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Plate 13

Explanation of Plate 13

(All figures are in natural size unless otherwise stated.)

Figs. 1a–b. *Euspira ramonensis* (CLARK) .... page 110
1b. Apertural view of fig. 1a, showing the well developed funicle. Loc. 81404(Tp) Reg. No. TUE 10038.

Figs. 2a–b. *Cryptonatica* aff. *C. clausa* (BRODERIP and STEWART) .... page 111
2b. Apertural view of fig. 2a, showing the umbilicus which entirely closed by small and flat callus. Loc. 80406(Ty) Reg. No. TUE 10039.

Figs. 3a–b. *Colus* aff. *C. jordani* DALL .... page 121
3a. Apertural view of fig. 3b. Loc. 81202(Tp) Reg. No. TUE 10053.

Fig. 4. *Ancistrolepis* sp. .... page 119
Loc. 81401(Tp) Reg. No. TUE 10052.

Figs. 5, 9. *Ancistrolepis rearensis* (CLARK) .... page 118
5a. Apertural view of fig. 5b. Loc. 80905(Tp)
9. Incomplete specimen. Loc. 81203(Tp) Reg. No. TUE 10050.

Figs. 6, 7. *Pteropurpura* n. sp. .... page 113
6. Rubber cast, body whorl missing. Loc. D161, USGS Menlo Park.
7. Rubber cast, showing the large frill on the body whorl. Loc. 81203(Tp) Reg. No. TUE 10043.

Fig. 8. *Priscofusus clarki* KANNO, n. sp. .... page 122
Apertural view, rubber cast based on the holotype. Loc. 81002(Tp) Reg. No. TUE 10054.

Fig. 10. *Neptunea* (*Sulcosipho*) cf. *N.* (*S.*) *tabulata* (BAIRD) .... page 117
Immature specimen. Float, Loc. 80802(Ty) Reg. No. TUE 10048.

Figs. 11, 12, 13. *Liracassis apta* (TEGLAND) .... page 111
11. Back view, showing two distinct nodulose rows and more faint nodulose rows beneath the distinct one. Loc. 81404(Tp) Reg. No. TUE 10040.
12b. Apical view of fig. 12a, showing no node on the shoulder. Loc. 81401(Tp) Reg. No. TUE 10040.
13. Apertural view, showing slightly developed nodes on the shoulder. Loc. 81401(Tp) Reg. No. TUE 10040.

Figs. 14a–b. *Liracassis durhami* KANNO, n. sp. .... page 112
14a. Holotype, showing the back view and surface ornamentation.
14b. Apical view of fig. 14a. Loc. 80906(Tp) Reg. No. TUE 10041.

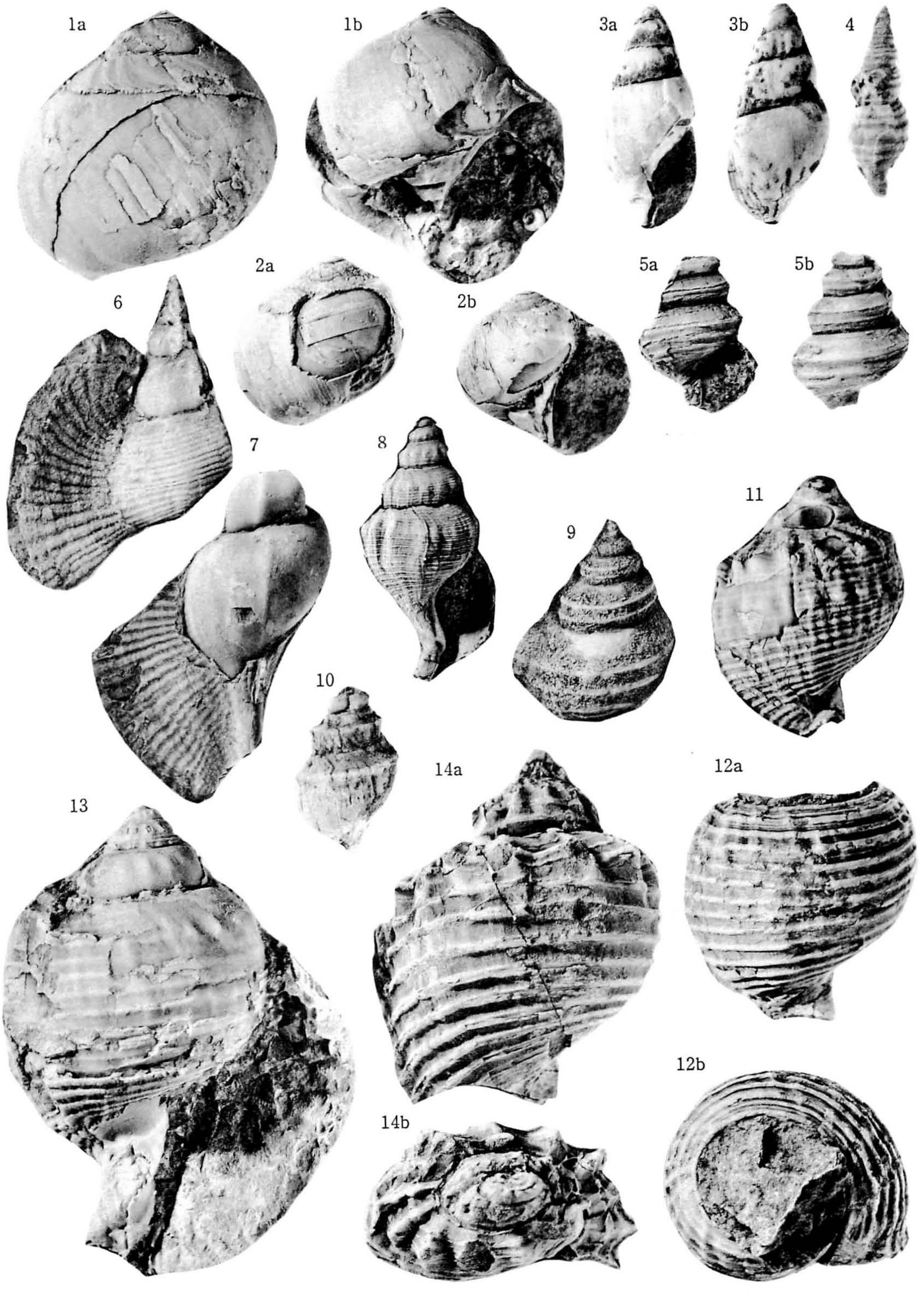
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Plate 14

Explanation of Plate 14

(All figures are in natural size unless otherwise stated.)

Figs. 1–3. *Neptunea (Neptunea) plafkeri* KANNO, n. sp. .... page 115
All specimens are somewhat deformed or crashed.
1. Holotype. Loc. 81104(Ty) Reg. No. TUE 10045.
2, 3. Paratype (incomplete). Loc. 81104(Ty) Reg. No. TUE 10046.

Figs. 4–6. *Ancistrolepis rearensis* (CLARK) .... page 118
4. Apertural view.
5. Incomplete specimen, showing the surface sculpture, ×2.
6. Incomplete specimen, showing the spire.
Loc. 81404(Tp) Reg. No. TUE 10050.

Fig. 7. *Ancistrolepis macneili* KANNO, n. sp. .... page 119
Holotype, Loc. 80906(Tp) Reg. No. TUE 10051.

Figs. 8, 9, 15. *Priscofusus clarki* KANNO, n. sp. .... page 122
Paratype, all incomplete specimens. Loc. 80905(Tp) Reg. No. TUE 10055.

Fig. 10. *Turricula* cf. *T. washingtoniana* (WEAVER) .... page 130
Incomplete specimen, missing its spire and aperture. Loc. 81404(Tp) Reg. No. TUE 10062.

Figs. 11–13. *Priscofusus* sp. .... page 124
11, 12. Incomplete specimens. Loc. 81404(Tp) Reg. No. TUE 10056.
13. Rubber cast. Loc. 80905(Tp) Reg. No. TUE 10056.

Figs. 14a–b. "*Fulgoraria*" sp. .... page 126
14a. Apertural view of fig. 14b. Loc. 81201(Tp) Reg. No. TUE 10059.

Fig. 16. *Turricula* sp. .... page 130
Loc. 80905(Tp) Reg. No. TUE 10063.

Figs. 17, 18. *Cancellaria (Crawfordina) alaskensis* CLARK .... page 128
17. Apertural view. Loc. 81201(Tp) Reg. No. TUE 10060.
18. Back view, rubber cast. Loc. 81401(Tp) Reg. No. TUE 10060.

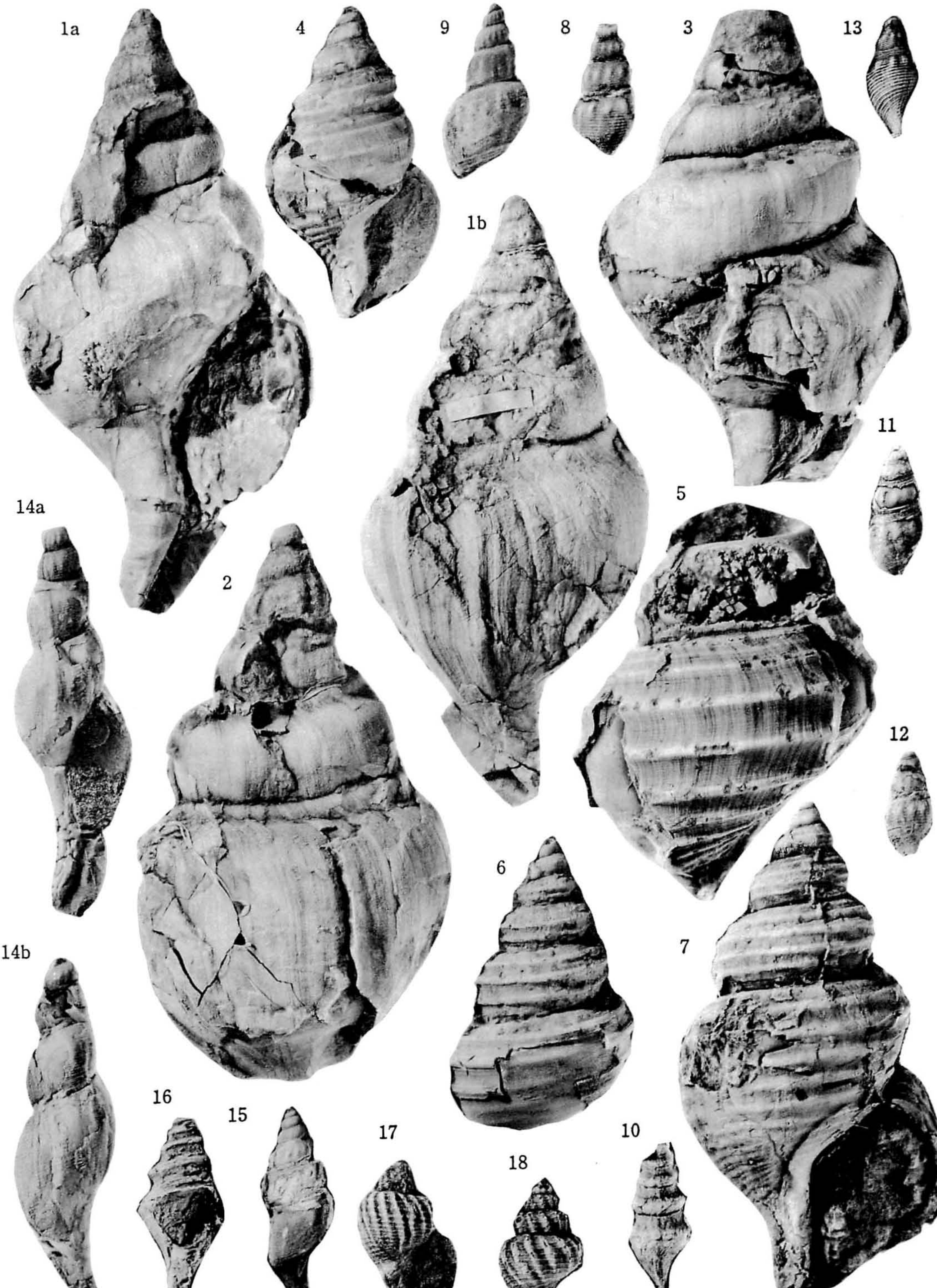
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Plate 15

Explanation of Plate 15

(All figures are in natural size unless otherwise stated.)

Figs. 1, 2. *Neptunea (Sulcosipho)* cf. *N. (S.) tabulata* (BAIRD) .... page 117
1. Apertural view, somewhat deformed specimen. Loc. 20541-7(Ty) Reg. No. TUE 10048.
2. Decorticated and incomplete specimen. Loc. 81306(Ty) Reg. No. TUE 10048.

Fig. 3. *Beringius* cf. *B. crebricostatus* (DALL) .... page 120
Incomplete specimen. Loc. 80404(Ty) Reg. No. TUE 10049.

Fig. 4. *Musashia (Neopsephaea?)* sp. .... page 126
Rubber cast, showing two columella folds and surface ornamentation. Loc. 80702(Tp) Reg. No. TUE 10058.

Figs. 5a-b. *Musashia (Neopsephaea) corrugata* (CLARK) .... page 125
5a. Apertural view of fig. 5b. Loc. 81401(Tp) Reg. No. TUE 10057.

Figs. 6a-b. *Eosiphonaria* sp. .... page 114
Incomplete specimen, showing some part of body whorl. Loc. 81002(Tp) Reg. No. TUE 10044.

Figs. 7, 8. *Scaphander alaskensis* CLARK .... page 131
7. Showing somewhat lower shell than fig. 8. Loc. 81401(Tp) Reg. No. TUE 10064.

Figs. 9a-b. *Antiplanes (Antiplanes)* sp. .... page 129
9a. Apertural view of fig. 9b. Loc. 80604(Ty) Reg. No. TUE 10061.

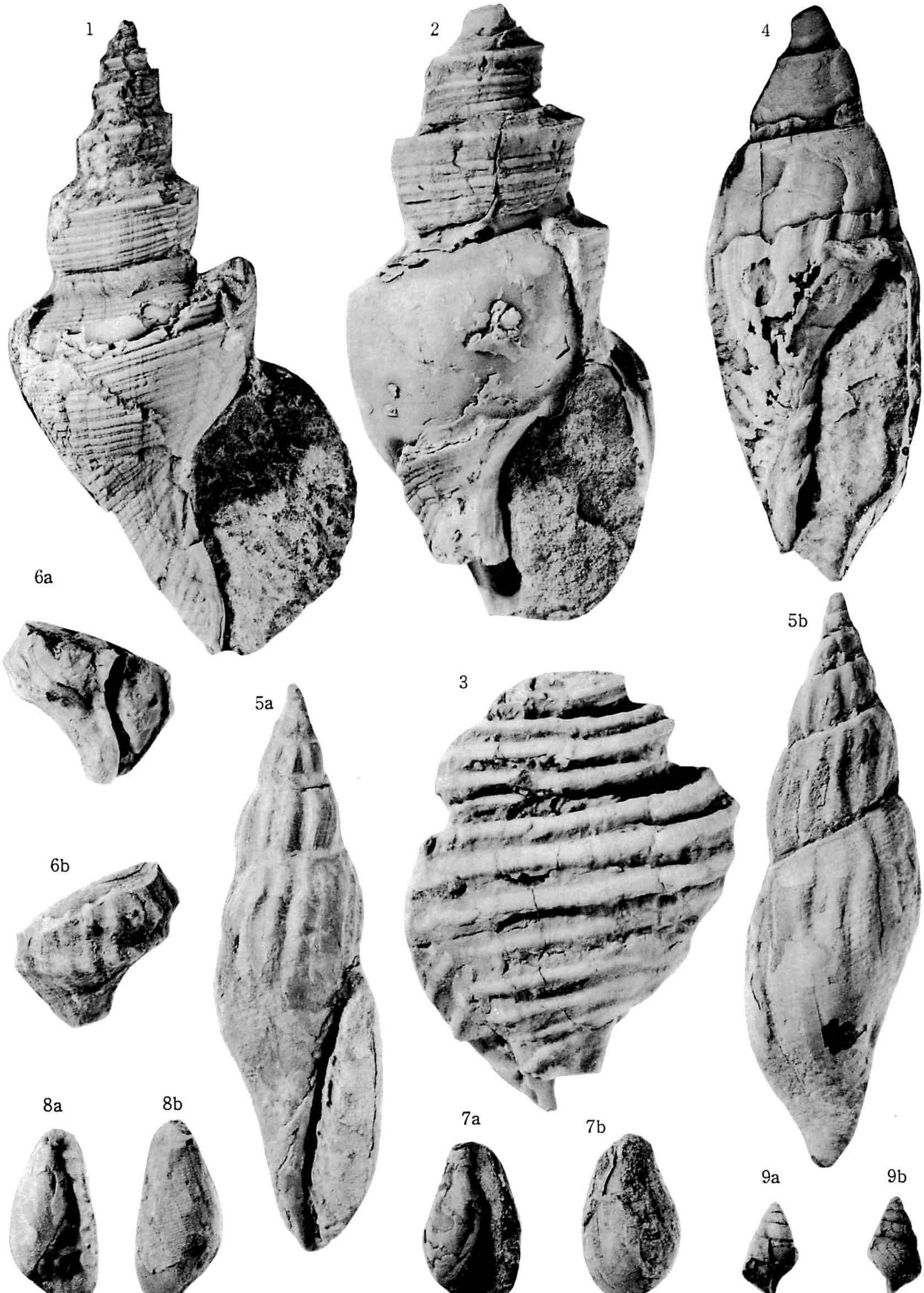
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Plate 16

Explanation of Plate 16

(All figures are in natural size unless otherwise stated.)

Figs. 1–4. *Aturia alaskensis* SCHENCK .... page 133

1. Deformed specimen, showing almost complete aperture. Loc. 81401 Reg. No. TUE 10065.

2. Almost complete immature specimen. Loc. 81401 Reg. No. TUE 10065.

3a. Incomplete specimen. Loc. 81401 Reg. No. TUE 10065.

3b. Showing the surture of fig. 3a.

4. *Aturia "minoensis* KOBAYASHI, 1954", refigured from the KOBAYASHI's original paper for comparison.

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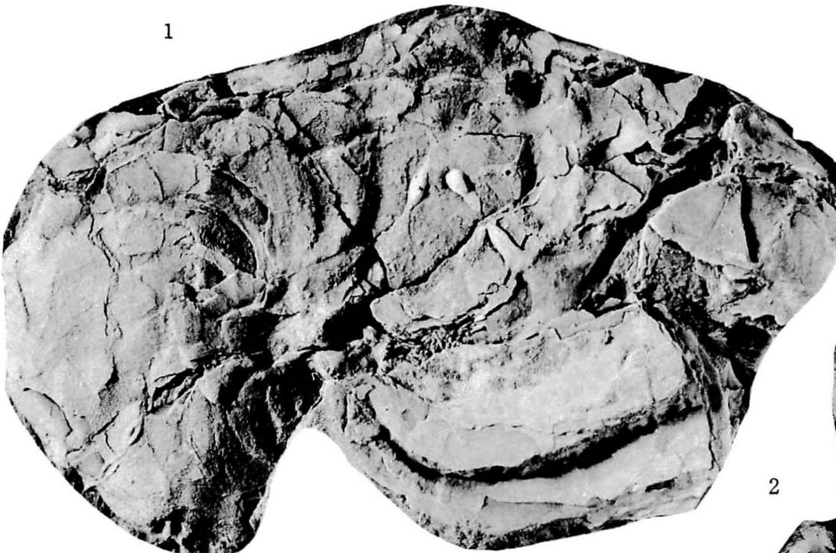

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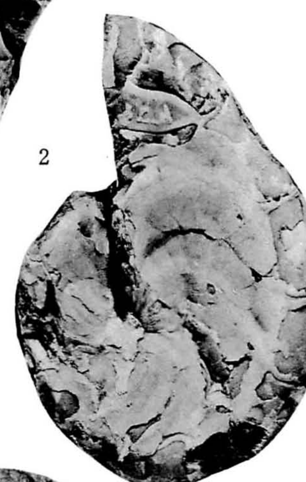

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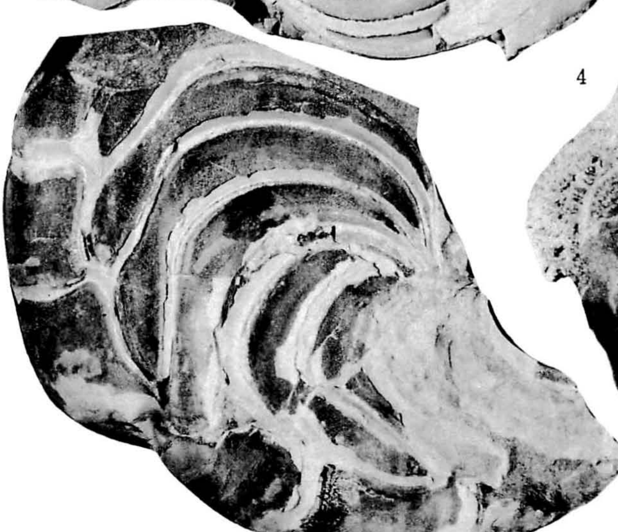

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Plate 17

Explanation of Plate 17

(All figures are in natural size unless otherwise stated.)

Fig. 1. *Pododesmus* (*Monia*) *macroschisma* (DESHAYES) .... page 57
Incomplete right valve, showing large byssal foramen. Loc. 20541-1(Ty)
Reg. No. TUE 8422.

Fig. 2. *Nemocardium alaskense* (CLARK) ×2 .... page 70
Showing the silk-like fine radial threads. Loc. 80906(Tp) Reg. No. TUE 8437.

Figs. 3, 4. *Modiolus* sp. .... page 46
Decorticated left valves. Loc. 80906(Tp) Reg. No. TUE 8411.

Fig. 5. *Delectopecten peckhami* (GABB) ×2 .... page 48
Loc. 20495-24(Ty) Reg. No. TUE 8413.

Fig. 6. *Siliqua* sp. .... page 74
Incomplete specimen, showing the internal rib running vertically from beak to the ventral margin. Loc. 80605(Ty) Reg. No. TUE 8442.

Figs. 7–11. *Macrocallista weaveri* CLARK .... page 87
Showing the varietal forms; 7, 8. Rather higher form, but fig. 11 shows rather lower form.
9. Rubber cast, showing cardinal teeth, ×2.
11. Internal mould, showing the pallial sinus. Loc. 9002-2(Tp) Reg. No. TUE 10012.

Fig. 12. *Calyptogena chitanii* (KANEHARA) .... page 80
Rubber cast, showing cardinal teeth. USGS, Menlo Park, Loc. M 1767. Reg. No. TUE 8450.

Figs. 13–15. *Corbicula* (*Corbicula*) sp. .... page 83
13. Right valve, missing its beak.
14. Mode of occurrence of *Corbicula* (*C.*) sp. in Kultieth formation.
15a. Rubber cast of fig. 15b, showing cardinal teeth. ×2.
Loc. 81501(Tk) Reg. No. TUE 10007.

Figs. 16, 17. *Thracia* cf. *T. condoni* CONRAD .... page 98
16. Slightly decorticated left valve. Loc. 81401(Tp) Reg. No. TUE 10024.
17. Decorticated right valve. Loc. 81201(Tp) Reg. No. TUE 10024.


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Plate 18

Explanation of Plate 18

(All figures are in natural size unless otherwise stated.)

Figs. 1–2. *Ostrea* sp. .... page 59
  1. Decorticated right valve.
  2. Inner surface of left valve (almost flat). Loc. 81502(Tk) Reg. No. TUE 8424.

Figs. 3–5. *Turritella* sp. .... page 106
  3, 4. Somewhat decorticated specimens.
  5. Showing the growth line. TUE loc. 81401(Tp) Reg. No. 10034.

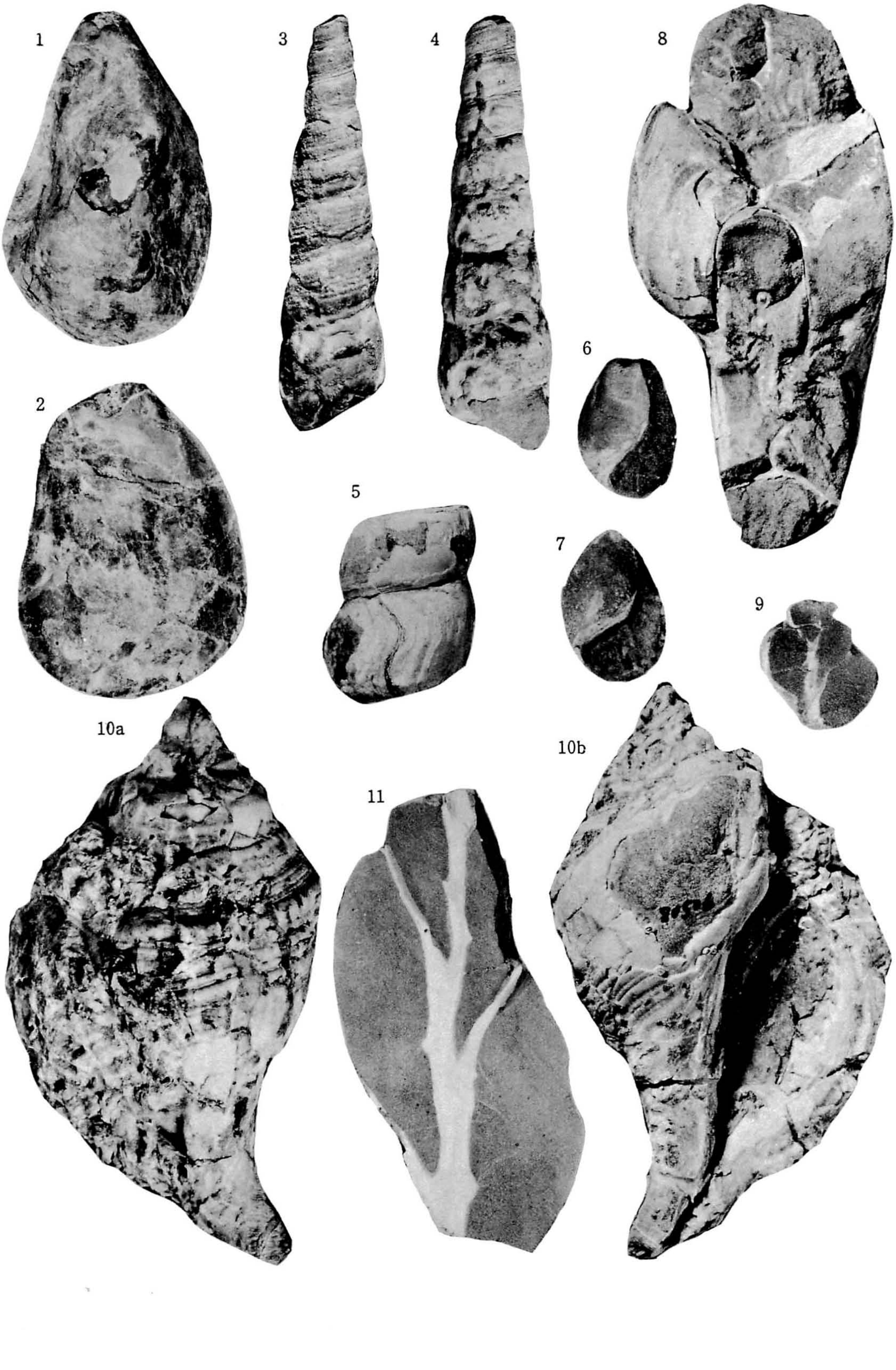
Figs. 6, 7. *Scaphander alaskensis* CLARK .... page 131
  Showing lower form of the present species. Loc. 81201(Tp)
  Reg. No. TUE 10064.

Fig. 8. *Aturia alaskensis* SCHENCK .... page 133
  Showing apertural view of plate 16, fig. 3. Loc. 81401(Tp) Reg. No. TUE 10065.

Fig. 9. *Cancellaria (Crawfordina) alaskensis* CLARK .... page 128
  Axial section, showing the columella folding. Loc. 81201(Tp)
  Reg. No. TUE 10060.

Figs. 10a–b. *Neptunea (Neptunea)* sp. .... page 116
  10a. Surface mostly covered by barnacle.
  10b. Showing the aperture. Loc. 80506(Ty) Reg. No. TUE 10047.

Fig. 11. *Musashia (Neopsephaea) corrugata* (CLARK) .... page 125
  Axial section, showing the columella folding. Loc. 80905(Tp)
  Reg. No. TUE 10057.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