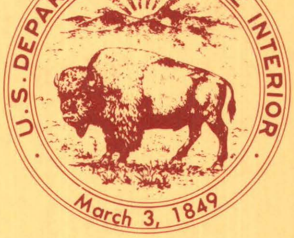
Shorter Contributions to Paleontology and Stratigraphy

U.S. GEOLOGICAL SURVEY BULLETIN 1664



Shorter Contributions to Paleontology and Stratigraphy

Edited by Ellis L. Yochelson

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The Miocene Pillarian and Newportian (Molluscan) Stages of Washington and Oregon and Their Usefulness in Correlations From Alaska to California

By ELLEN J. MOORE and WARREN O. ADDICOTT

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The Miocene Pillarian and Newportian (Molluscan) Stages of Washington and Oregon and Their Usefulness in Correlations From Alaska to California

By Ellen J. Moore and Warren O. Addicott

Abstract

Mollusks are common to abundant in shallow-water facies, which predominate in many geographically isolated Tertiary basins, and are reliable for correlation. The global cooling that began during middle Miocene (Newportian Stage, in part) and increased in intensity across the middle to late Miocene boundary (Newportian, in part, to Wishkahan Stage) strongly affected the usefulness of mollusks for correlating these stages from California to Alaska. The warming trend that peaked during the late early and early middle Miocene, however, allows good correlations between the "Temblor" Stage of California and the middle part of the Newportian Stage of the Pacific Northwest. Mollusks restricted to either the Pillarian or Newportian and those with first or last occurrences in either stage have helped to identify the two stages and to differentiate between them. Additional collecting and appraisal of faunas show that these molluscan stages can be further refined and divided on the basis of peak occurrences of molluscan species that are related, in part, to global changes in climate.

Unnamed Miocene sediments at Coos Bay, Ore., are Newportian in age but probably somewhat older than the Astoria Formation in the Newport embayment, Oregon. The lower part of a section of unnamed Miocene sediments in northern California is Newportian in age, based on the occurrence of *Molopophorus matthewi* Etherington, and the upper part of the section is no younger than Newportian.

INTRODUCTION

The initial chronostratigraphic framework for the marine Cenozoic of the Western United States was proposed by Arnold (1906) for California. He used names of formations in the sense that we use our present stages and defined the biostratigraphic units mostly by distinctive invertebrate assemblages, principally pectinids. These units were refined and modified on the basis of mollusks by subsequent workers (Smith, 1912; Clark, 1921, 1929; Loel and Corey, 1932) who variously termed them "faunas," "formations," or "horizons." Kleinpell (1938) proposed Miocene benthic foraminiferal stages for California and reviewed the relations of the molluscan sequence to his stages.

In contrast to California, Neogene strata are distributed less widely in Oregon, Washington, British Columbia, and Alaska, where marine basins, most extensive during the early and middle Miocene, consisted of isolated coastal embayments from southern Oregon to the Queen Charlotte Islands and the Gulf of Alaska (fig. 1). Weaver (1916a) proposed faunal zones for western Washington on the basis of molluscan faunas and key species and later correlated the Tertiary sequence of the Pacific Northwest with the California formations by using the existing formational names as stages (Weaver, 1942).

In 1944, a basic framework for all Pacific Coast Cenozoic molluscan correlation was prepared under Weaver's chairmanship (Weaver and others, 1944). In that correlation scheme, Neogene stages were first used, and zonal index fossils were cited. These stages, however, were based primarily on type sections in California and were difficult to use in correlating within and beyond the Pacific Northwest. Previously, Schenck (1936) had proposed three biozones for Oregon and Washington on the basis of species of the bivalve *Acila*, and Durham (1944) proposed seven megafossil zones for northwestern Washington. These zones proved so useful for provincial correlation that they still are used today.

For the Pacific Northwest, Addicott (1976b) proposed a series of six Neogene molluscan stages that have type sections in Washington and Oregon and correlated them with California benthic foraminiferal stages; later, he somewhat modified the ages of the molluscan stages (Addicott, 1981, 1983). Armentrout (1975) proposed the late Eocene and early Oligocene Galvinian and Oligocene Matlockian (molluscan) Stages; to avoid conflict with the late Oligocene part of the Juanian (molluscan) Stage of Addicott (1976b), he (1977, 1981) subsequently revised the Matlockian to include only the early Oligocene. Using Durham's (1944) megafossil zones for the Oligocene, Addicott (1976b) also

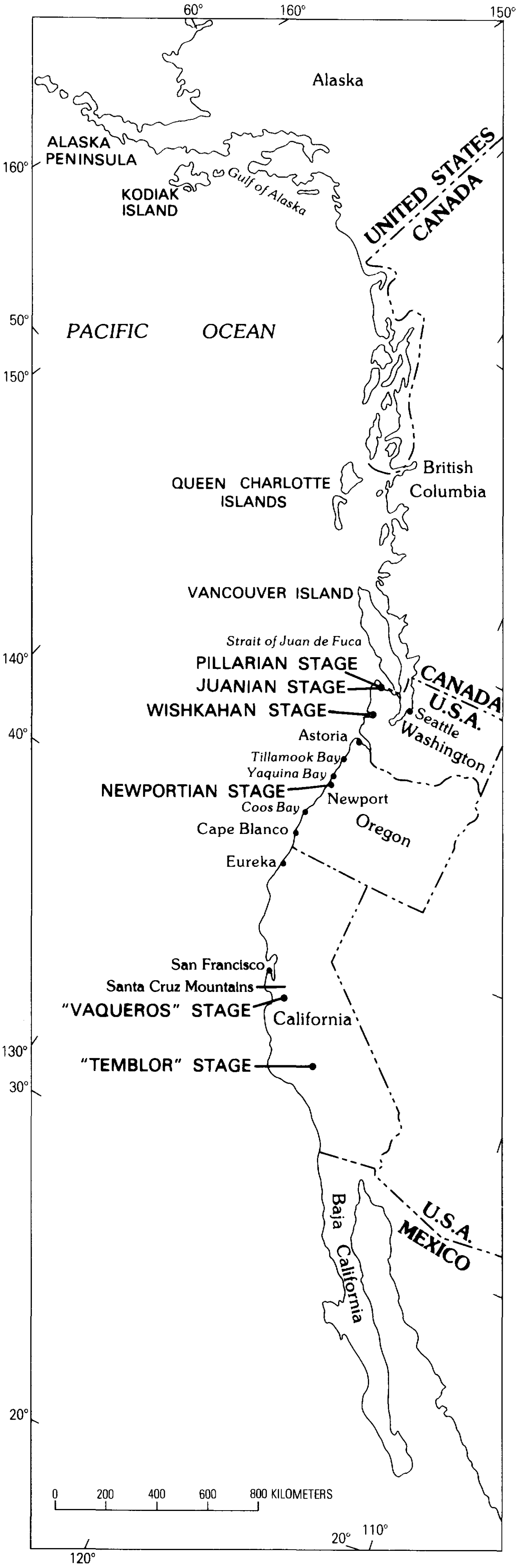

Figure 1. Location of type areas of molluscan stages and geographic names referred to in text.

proposed new molluscan zones for his Miocene molluscan stages. These stages and zones, intended originally for provincial correlation, have been used to correlate these units with Tertiary units north to Alaska (Allison, 1978; Marincovich, 1983; Allison and Marincovich, 1981) and south to middle California (Moore, 1984).

Armentrout and others (1984) have summarized the correlation of Cenozoic molluscan stages of Oregon and Washington with microfossil datum planes and with megafloral and mammalian stages and radiometric dates. Poore and others (1981) have presented a biochronology standard for the Miocene of the Eastern Pacific by correlating planktic foraminifer, coccolith, and diatom zones with California molluscan stages.

This paper focuses on the early Miocene Pillarian and the early and middle Miocene Newportian (molluscan) Stages proposed by Addicott (1976b) that have type sections in Washington and Oregon, respectively. These stages primarily are based on range zones of taxa, mostly endemic species. Some difficulty may be encountered, however, in distinguishing the Pillarian and Newportian Stages when the key zonal species *Vertipecten fucanus* (Dall) and *Patinopecten propatulus* (Conrad) are not present. Additional collecting and appraisal of faunas has led to the recognition of more molluscan species that serve to distinguish the Pillarian and Newportian Stages and also has led to distinguishing times of peak abundance for some species that permit subdivisions within a stage.

ACKNOWLEDGMENTS

We thank Gail H. Goedert for donating a specimen of *Epitonium (Cirsotrema) clallamensis* that she collected from the Nye Mudstone, James L. Goedert for collecting and donating specimens of *Vertipecten fucanus* from the Nye, and Parke D. Snavely, Jr., for calling attention to a locality in the Nye Mudstone northeast of Newport from which *Patinopecten oregonensis cancellosus* was collected. We profited from discussions regarding this study with John A. Barron, Louie Marincovich, Jr., Kristin A. McDougall, and Parke D. Snavely, Jr., U. S. Geological Survey; Richard C. Allison, University of Alaska; and Weldon W. Rau, Washington Division of Mines and Geology.

PILLARIAN AND NEWPORTIAN STAGES

The Pillarian Stage (Addicott, 1976b) is defined in rocks which contain an inner sublittoral molluscan fauna and is of early Miocene age. The Clallam Formation, designated as the type section of the Pillarian, directly overlies the type section of the Juanian of late Oligocene and early Miocene age, and the lower boundary of the Pillarian is placed at the contact between the Twin River Formation and the overlying Clallam Formation. The Clallam Formation is not overlain by younger strata at its type section along the Strait of Juan de Fuca, Wash., so the top of the Pillarian Stage could not be defined in that area. Therefore, the upper boundary stratotype was defined as the contact between the Nye Mudstone and the overlying Astoria Formation exposed south of Yaquina Bay, Ore. (fig. 1). The Pillarian originally was dated as late early Miocene but subsequently has been revised to include the early early Miocene (Allison, 1977, 1978; Addicott, 1983), and this usage is here accepted.

Mollusks recognized by Addicott (1976b) as restricted to the Pillarian Stage in the Eastern Pacific include the pelecypods *Vertipecten fucanus* (Dall), *Mytilus* n. sp. aff. *M. tichanovitchi* Makiyama of Allison and Addicott (1976), and *Macoma optiva* (Yokoyama), and the gastropods *Priscofusus* aff. *P. geniculus* (Conrad) of Moore (1963) and *Aforia tricarinata* Addicott. Additional mollusks now known to be restricted to, or with their last occurrence in, the Pillarian are the pelecypods *Acila (Acila) gettysburgensis* (Reagan) and *Anomalocardia carmanahensis* (Clark) and the gastropod, *Epitonium (Cirsotrema) clallamensis* Durham.

The Newportian Stage (fig. 1) is based on the molluscan fauna in the Astoria Formation in the Newport embayment on the coast of northwestern Oregon. Originally dated as middle Miocene, it subsequently has been revised (Addicott, 1977) to include the late early Miocene (fig. 2). The lower boundary is placed at the base of the Astoria Formation, best exposed in sea cliffs between Yaquina Head and Newport, Ore. The top of the Newportian is best defined in the Astoria Formation in southwestern Washington (Addicott, 1976b), where the upper part is conformably overlain by the Montesano Formation of Fowler (1965) that contains shallow-water molluscan assemblages referable to the late middle Miocene Wishkahan Stage (fig. 2). Allison (1977, 1978) revised the Wishkahan to include the late middle Miocene as well as the late Miocene, and this usage is here accepted.

Mollusks recognized by Addicott (1976b) as restricted in stratigraphic occurrence to the Newportian Stage include the pelecypods *Aequipecten andersoni clemonensis* (Etherington), *Mytilus (Plicatomytilus) middendorffi* Grewingk, *Patinopecten propatulus* (Conrad), and *Saccella amelga* Moore and the gastropods *Acteon boulderanus* Etherington, *Antillophos posunculensis* (Anderson and Martin), *Chlorostoma pacificum* (Anderson and Martin), *"Nassarius"*

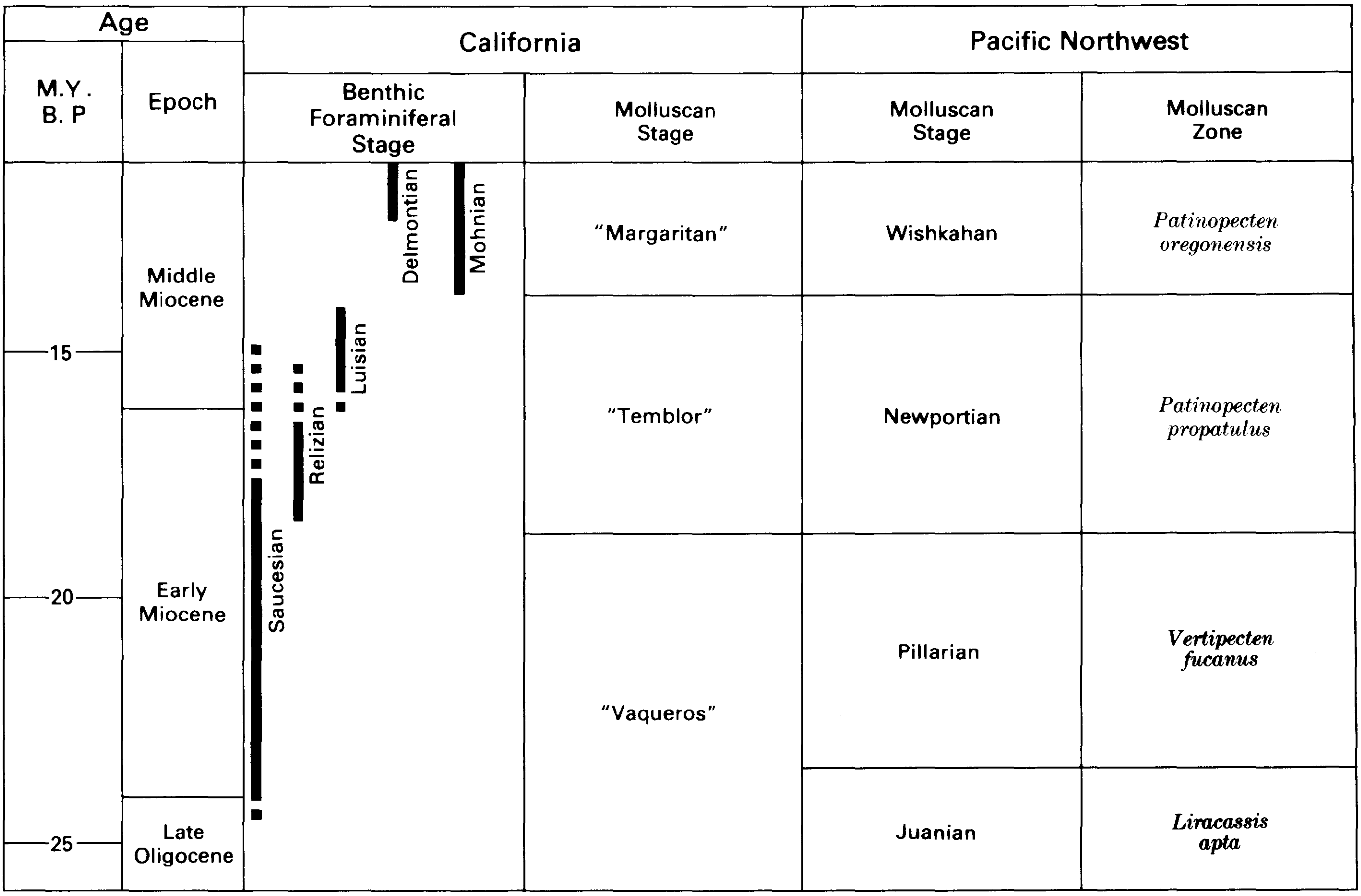

Figure 2. Chronostratigraphic position and correlation of the Miocene Pillarian and Newportian (molluscan) Stages. Vertical dashes indicate possible extensions of stages.

arnoldi (Anderson), *Nucella* aff. *N. lima* Gmelin of Moore (1963), *Opalia williamsoni* (Anderson and Martin), *Priscofusus medialis* (Conrad), *Spirotropis washingtonensis* Etherington, and *Trophon kernensis* Anderson. Other mollusks now known to be restricted to the Newportian are the pelecypods *Macoma flagleri* Etherington, *Spisula (Mactromeris) selbyensis* Packard, and *Yoldia carnerosensis* Clark and the gastropods *Cancellaria ocoyana* Addicott, *Molopophorus anglonanus* (Anderson), *Molopophorus mattewi* Etherington, *Nucella packi* (Clark), and *Olivella ischnon* Keen.

In addition to the mollusks known to be restricted to either the Pillarian or the Newportian Stages, the combination of first and last occurrences of species further identifies the two stages, and some of these ranges are shown graphically in table 1. The Newportian Stage can be correlated with the "Temblor" Stage of California (Weaver and others, 1944) on the basis of the cooccurrence of molluscan species. Correlation of the Pillarian Stage with the "Vaqueros" Stage of California (Weaver and others, 1944) has not been feasible using mollusks. The predominately tropical and subtropical molluscan fauna of the "Vaqueros," from the northward-transported west side of the San Andreas fault, has not been recognized in Washington or Oregon.

RATIONALE OF MOLLUSCAN DISTRIBUTION AND CORRELATION

Past discussions of climate, as interpreted by molluscan distribution and by most other biologic groups, were premised on two assumptions: temperature tolerances of species remained the same through time and the continents were fixed. Tectonic reconstructions have shown that fragments of the Pacific coastal areas of North America have been transported long distances along strike-slip faults and that terranes from distant areas to the south and east have been accreted to the coast of North America at various times. In addition, the cooccurrence of both subtropical and cold-water molluscan genera within the same stratigraphic interval, especially in Alaska, indicates that some parameters of past molluscan distributions do not match those of today; for example, in the Narrow Cape Formation of Newportian age on Kodiak Island, the warm-water genera *Dosinia* s. s., *Securella*, and *Anadara* s. s. are found with genera of cool-water aspect, such as *Neptunea* and *Mya*. Nevertheless, some patterns of distribution that are related to climatic events seem evident.

Post-Eocene steepening of latitudinal climatic gradients and the accompanying development of restricted molluscan faunal provinces isolated the faunas of the Pacific Northwest from California for prolonged periods of time. Warming events interrupted this pattern, most noticeably in the late early and early middle Miocene, when the warm temperate and subtropical to tropical molluscan faunas of California reached as far north as the western part of the Gulf of Alaska. This Miocene warming and its wide dispersal of species allows both tentative and definite assignment of formations to the Newportian Stage from Alaska south to California ("Temblor" Stage). The occurrence in the Newportian of genera such as the pelecypods *Dosinia* s. s. and *Securella* and the gastropod *Ficus*, genera now living in subtropical to tropical regions, indicates that, during the early middle Miocene, the ocean as far north as the Alaska Peninsula may have been much warmer than it is today. Warming was not sufficient during the older Pillarian Stage, however, to make definite ties between the Pacific northwest and California, although the cephalopod *Aturia* flourished during the late Juanian and early Pillarian.

The global warming trend across the early and middle Miocene boundary (Woodruff and others, 1981) allowed the dispersal of subtropical to tropical molluscan genera as far north as the western part of the Gulf of Alaska (Addicott, 1969). As stated above, warm-water genera are found in the Narrow Cape Formation of Newportian age on Kodiak Island (Allison, 1978). However, in the northeastern Gulf of Alaska, the middle Miocene faunas in the lower part of the Yakataga Formation (Addicott, 1969) and in the Topsy Formation (Marincovich, 1979) include no warm-water genera. Thus, the Topsy and Yakataga faunas presumably coincide with or postdate the major cooling event.

The distribution in Oregon of the warm-water genus *Dosinia* s. s. is particularly interesting. It is extremely common in the dredgings of unnamed Miocene sediment in the Coos Bay channel, where more than 200 specimens were collected in a short period of time (Moore, 1963). Yet *Dosinia* s. s. has not been collected from the Astoria Formation in the Newport area, about 140 kilometers north of Coos Bay, despite its record from the Gulf of Alaska in the Newportian. We believe, therefore, that the maximum warming trend occurred in the early Newportian and that the unnamed Miocene sediment at the Coos Bay channel is older than the Astoria Formation at Newport, although still assigned to the Newportian on the basis of *Mytilus (Plicatomytilus) middendorfi* Grewingk. The upper part of the Astoria Formation in southwestern Washington is the youngest unit assigned to the Newportian.

ALASKA

Formations Assigned to the Pillarian Stage

The uppermost part of the Poul Creek Formation, in the northeastern Gulf of Alaska, was assigned to the Pillarian (Addicott, 1977) on the basis of the occurrence of the zonal fossil *Vertipecten fucanus* and associated mollusks such as *Acila (Acila) gettysburgensis*, which are not known to occur in younger strata (Allison, 1978). The lower part of the Yakataga Formation on Kayak Island, also in the northeastern Gulf of Alaska, was assigned to the Pillarian on the basis of the cooccurrence of the pelecypod *A. (A.) gettysburgensis*

Table 1. Distribution of selected mollusks from the upper Oligocene to the middle Miocene

[x, present; ?, possibly present]

Subseries	Upper Oligocene and lower Miocene	Lower Miocene	Lower and middle Miocene
Molluscan stage	Juanian	Pillarian	Newportian
Molluscan zone	*Liracassis apta*	*Vertipecten fucanus*	*Patinopecten propatulus*
Pelecypods:			
Acharax dalli (Clark)	--	x	x
Acharax ventricosa (Conrad)	--	--	x
Acila (*Acila*) *gettysburgensis* (Reagan)	x	x	--
Acila (*Truncacila*) *conradi* (Dall)	--	--	x
Acila (*Truncacila*) *muta* (Clark)	x	x	--
Acila (*Truncacila*) *packardi* (Clark)	--	x	--
Aequipecten andersoni clemonensis (Etherington)	--	--	x
Anadara (*Anadara*) *devincta* (Conrad)	--	x	x
Anomalocardia carmanahensis (Clark)	x	x	--
Clinocardium n. sp. aff. *C. nuttalli* (Conrad) of Moore (1963)	--	--	x
Conchocele bisecta (Conrad)	--	?	x
Cyclocardia castor (Dall)	x	--	--
Cyclocardia subtenta (Conrad)	x	x	x
Dosinia (*Dosinia*) *whitneyi* (Gabb)	x	x	x
Katherinella (*Katherinella*) *angustifrons* (Conrad)	x	x	x
Litorhadia astoriana (Henderson)	x	x	x
Lucinoma acutilineata (Conrad)	?	x	x
Lucinoma hannibali (Clark)	x	--	--
Macoma albaria (Conrad)	--	x	x
Macoma arctata (Conrad)	x	x	x
Macoma astori (Dall)	--	x	?
Macoma flagleri Etherington	--	x	--
Macoma optiva Yokoyama	--	x	--
Macoma secta (Conrad)	--	--	x
Macoma sookensis (Clark and Arnold)	x	x	--
Macoma twinensis Clark	x	x	--
Mytilus (*Plicatomytilus*) *middendorffi* Grewingk	--	--	x
Mytilus n. sp. aff. *M. tichanovitchi* Makiyama of Allison and Addicott (1976)	--	x	--
Panopea abrupta (Conrad)	x	x	x
Panopea ramonensis (Clark)	x	x	--
Patinopecten oregonensis cancellosus Moore	--	x	x
Patinopecten propatulus (Conrad)	--	--	x
Saccella amelga Moore	--	--	x
Saccella calkinsi Moore	--	x	x
Securella ensifera (Dall)	--	x	x
Solamen snavelyi Addicott	--	x	--
Spisula (*Hemimactra*) *hannibali* Clark	x	x	--
Spisula (*Mactromeris*) *albaria* (Conrad)	x	x	x
Spisula (*Mactromeris*) *selbyensis* Packard	--	--	x
Spisula (*Mactromeris*) *sookensis* Clark and Arnold	x	x	--
Tellina emacerata Conrad	x	x	x
Vertipecten fucanus (Dall)	--	x	--
Yoldia carnerosensis Clark	--	--	x
Yoldia clallamensis Reagan	x	x	--

Table 1. Distribution of selected mollusks from the upper Oligocene to the middle Miocene—Continued

Subseries	Upper Oligocene and lower Miocene	Lower Miocene	Lower and middle Miocene
Molluscan stage	Juanian	Pillarian	Newportian
Molluscan zone	*Liracassis apta*	*Vertipecten fucanus*	*Patinopecten propatulus*
Pelecypods—Continued			
Yoldia supramontereyensis Arnold	--	x	--
Yoldia tenuissima Clark	x	--	--
Gastropods:			
Acteon boulderanus Etherington	--	--	x
Aforia tricarinata Addicott	--	x	--
Ancistrolepis jimgoederti Moore	--	x	--
Ancistrolepsis rearensis (Clark)	x	x	--
Antillophos posunculensis (Anderson and Martin)	--	--	x
Bruclarkia oregonensis (Conrad)	--	x	x
Bruclarkia yaquinana (Anderson and Martin)	--	x	x
Cancellaria ocoyana Addicott	--	x	--
Cancellaria oregonensis Conrad	--	--	x
Cancellaria weaveri Etherington	x	x	--
Cancellaria wynoochensis Weaver	--	--	x
Chlorostoma pacificum (Anderson and Martin)	--	--	x
Crepidula rostralis (Conrad)	--	--	x
Epitonium (*Cirsotrema*) *clallamensis* Durham	x	x	--
Ficus modesta (Conrad)	--	x	x
Liracassis apta (Tegland)	x	--	--
Liracassis petrosa (Conrad)	--	--	x
Megasurcula wynoocheensis (Weaver)	--	?	x
Molopophorus anglonanus (Anderson)	--	--	x
Molopophorus matthewi Etherington	--	--	x
Molopophorus newcombei (Merriam)	--	x	--
Musashia (*Miopleiona*) *indurata* (Conrad)	--	x	x
Musashia (*Nipponomelon*) *shikami* Moore	x	--	--
"Nassarius" arnoldi (Anderson)	--	--	x
"Nassarius" lincolnensis (Anderson and Martin)	--	--	x
Neverita jamesae Moore	x	x	x
Nucella aff. *N. lima* Gmelin of Moore (1963)	--	--	x
Nucella packi (Clark)	--	--	x
Olivella ischnon Keen	--	--	x
Opalia williamsoni (Anderson and Martin)	--	--	x
Priscofusus aff. *P. geniculus* (Conrad) of Moore (1963)	--	x	--
Priscofusus medialis (Conrad)	--	--	x
Priscofusus slipensis Addicott	--	x	x
Semicassis pyshtensis Addicott	--	x	--
Spirotropis washingtonensis Etherington	--	--	x
Trophon kernensis Anderson	--	--	x
Trophosycon clallamensis (Weaver)	--	x	?
Turritella (*Idaella*?) *oregonensis* (Conrad)	--	x	x
Turritella (*Idaella*) *yaquinana* Addicott	x	x	--
Xenoturris antiselli (Anderson and Martin)	--	x	x
Cephalopod:			
Aturia angustata (Conrad)	x	x	--

with foraminifers of Saucesian or Relizian age (Allison, 1978).

Formations Assigned to the Newportian Stage

The type Narrow Cape Formation on Kodiak Island was assigned to the Newportian on the basis of the occurrence throughout the section (Allison, 1978) of *Mytilus (Plicatomytilus) middendorffi* Grewingk, a mytilid that occurs in the Newportian as far south as central California. The Unga Conglomerate Member of the Bear Lake Formation on the Alaska Peninsula is believed to be late Newportian in age on the basis of the combined ranges of a few molluscan taxa (Allison, 1978). Strata near the base of the Yakataga Formation at Yakataga Reef, Alaska, were assigned to the Newportian on the basis of the presence of *Macoma arctata* (Conrad), not known to occur in strata younger than Newportian, and the genus *Lituyapecten*, not known to occur in strata older than Newportian (Addicott, 1974). On the basis of overlapping ranges of Pillarian and Newportian mollusks, the Topsy Formation in the Lituya district was inferred to be of Newportian age (Marincovich, 1979).

BRITISH COLUMBIA

Strata that can be assigned to either the Pillarian or Newportian Stages have not been found in British Columbia. Division D of Jeletzky (1954, 1973) and the type Sooke Formation are assigned to the late Oligocene and the earliest Miocene Juanian Stage.

WASHINGTON

Formations Assigned to the Pillarian Stage

The Clallam Formation, exposed in northernmost Washington along the Strait of Juan de Fuca, was designated the type section for the Pillarian Stage (Addicott, 1976b). The zonal fossil, *Vertipecten fucanus*, is the most characteristic mollusk in faunal assemblages from the Clallam. The Hoh Formation of Weaver (1915), just to the south on the western side of the Olympic Mountains, also was assigned to the Pillarian on the basis of the occurrence of *Vertipecten fucanus*. Strata assigned to the Astoria Formation in Wahkiakum and Pacific Counties, Wash. (Wolfe and McKee, 1972) include faunas characteristic of the Pillarian and the Newportian Stages. On the basis of the occurrence of pectinid zonal fossils and on first and last occurrences of associated mollusks, unit I (Wolfe and McKee, 1972) in the lower part of the Astoria Formation in southwestern Washington was assigned to the Pillarian (Addicott, 1976b).

Formations Assigned to the Newportian Stage

The Astoria Formation in the southern part of the Montesano quadrangle east of Grays Harbor and units II and III in the Astoria Formation in the Grays River quadrangle, Wahkiakum County (Wolfe and McKee, 1972), were assigned to the Newportian on the basis of the zonal fossil *Patinopecten propatulus* and associated mollusks and benthic foraminifers (Addicott, 1976b).

OREGON

Formations Assigned to the Pillarian Stage

Vertipecten fucanus and *Patinopecten propatulus*, zonal fossils from the Pillarian and Newportian Stages, respectively, are present in the Dana collection from the type area of the Astoria Formation in Astoria, Ore. (Conrad, 1849). The original exposures of the Astoria Formation are now covered by the city of Astoria, thereby prohibiting verification of the occurrence. Other mollusks from the type Astoria Formation that have their last occurrence in the Pillarian (Addicott, 1976c) are *Acila (Acila) gettysburgensis* (Reagan) and *Aturia angustata* (Conrad) (Addicott, 1976b; 1976c). On the basis of the available data, the lower part of the type Astoria Formation is assumed to be Pillarian in age.

In the Astoria Formation in northwestern Oregon, some exposures contain meager and poorly preserved molluscan faunas that seem to be late Pillarian or early Newportian in age, but no definite assignment can be made. Specimens believed to represent *Patinopecten oregonesis cancellosus* Moore have been found in some of these collections. This species originally was described from the unnamed sediment at the Coos Bay channel, but it has since been found in the uppermost part of the Nye Mudstone at the northeast side of the Newport embayment. Future study likely will show that this pectinid is restricted to the late Pillarian and early Newportian. It is not known to cooccur with *Vertipecten fucanus* or *Patinopecten propatulus*. *Dosinia (Dosinia) whitneyi* (Gabb) also occurs in the unnamed sediment at the Coos Bay channel and has been found in southern California in the Wygal Sandstone Member of the Temblor Formation [previously known as the Phacoides Sand Member of Stinemeyer and others (1959)] (Addicott, 1973), the San Ramon Sandstone (Clark, 1918), and the "Sobrante Sandstone" (Lutz, 1951). All but possibly the "Sobrante Sandstone" are pre-Newportian in age. Loel and Corey (1932) have called attention to the abundance of the pelecypod *Dosinia* s. s. in the ''Vaqueros'' Stage, which is represented by a subtropical to tropical fauna. Today, *Dosinia* s.s. lives no farther north than Baja California. The post-Oligocene warming trend reached a peak probably in the late early and early middle Miocene. This was followed during the middle Miocene by global cooling that intensified across the middle and late Miocene boundary (Barron, 1985). In northwestern Oregon, *Dosinia* s. s. *whitneyi* has been found in the Astoria Formation of Newportian age and in the unnamed Miocene sediment at Coos Bay channel, where it is exceptionally abundant and occurs with *Mytilus (Plicatomytilus) middendorfi*, which is considered to be restricted to the Newportian Stage (Moore, 1963). It has not been found in the Newportian part of the Astoria Formation in the Newport area, however, and may have become extinct in Washington, Oregon, and Alaska at the end of the early Newportian. *Dosinia (D.) whitneyi* also is found associated with *Patinopecten oregonensis cancellosus* rather than with *Patinopecten propatulus*. Thus, the unnamed Miocene sediments at Coos Bay may represent the earliest part of the Newportian Stage, a time when Newportian mollusks were first evolving. In northwestern Oregon, *Dosinia (D.) whitneyi* is found in the Angora Peak Member of the Astoria Formation of Niem (1975) associated with *Mytilus (P.) middenforffi*.

All but the lowermost part of the Nye Mudstone in the Newport embayment was assigned to the Pillarian (Addicott, 1976b). This assignment is based on the occurrence of *Vertipecten fucanus* in the Nye Mudstone south of Newport and on associated mollusks and benthic foraminifers. The occurrence of *Patinopecten oregonensis cancellosus* in the uppermost Nye northeast of Newport may indicate that the uppermost part of the Nye is early Newportian. On the basis of *Vertipecten fucanus* and associated mollusks, the upper part of the Yaquina Formation south of Newport is assigned to the Pillarian.

Formations Assigned to the Newportian Stage

The upper part of the type Astoria Formation at Astoria is assigned to the Newportian on the basis of *Patinopecten propatulus* and associated mollusks (Conrad, 1848, 1849; Moore, 1963). Exposures of the Astoria Formation on Big Creek east of Astoria and near Cannon Beach to the south also are assigned to the Newportian (Addicott, 1976b), as is the Astoria Formation in the Cathlamet, Saddle Mountain, Cape Foulweather, and Yaquina quadrangles in northwestern Oregon (Moore, 1963). The sandstone of Floras Lake at Cape Blanco is assigned to the Newportian (Addicott, 1983) on the basis of the gastropods *Molopophorus matthewi* Etherington and *"Nassarius" arnoldi* (Anderson) and the pelecypods *Mytilus (P.) middendorffi* Grewingk and *Macoma flagleri*, all restricted to the Newportian, and on the cooccurrence of other species with longer ranges.

CALIFORNIA

The Pillarian Stage is coeval with the upper part of the "Vaqueros" Stage, and the Newportian Stage is coeval with the "Temblor" Stage, both of California.

Formations Assigned to the Pillarian Stage

Vertipecten fucanus occurs in the Jewett Sand and in the upper part of the Olcese Formation in southern California, which can be correlated with the Pillarian. The Juanian and Pillarian gastropod *Epitonium (Cirsostrema) clallamensis* Durham also is found in the Jewett Sand. As stated above, the tropical and subtropical fauna of the "Vaqueros" Stage did not reach as far north as Oregon, and correlations between Oregon and California are difficult.

Formations Assigned to the Newportian Stage

The "Temblor" Stage of California is characterized by the restricted stratigraphic occurrence of molluscan species that also are restricted to the Newportian Stage. Species common to the two stages and restricted to them include the pelecypods *Mytilus (Plicatomytilus) middendorffi* Grewingk and *Patinopecten propatulus* (Conrad) and the gastropods *"Nassarius" arnoldi* (Anderson), *Crepidula rostralis* (Conrad), *Antillophos posunculensis* (Anderson and Martin), *Opalia williamsoni* (Anderson and Martin), and *Olivella ischnon* Keen (Addicott, 1972). Thus, the Buttonbed Sand Member of the Temblor Formation of Stinemeyer and others (1959) as well as the Round Mountain Silt in southern California can be correlated with the Newportian (Addicott, 1970).

The pelecypods *Acila (Truncacila) conradi* (Dall), *Delectopecten peckhami* (Gabb), *Katherinella (Katherinella) angustifrons* (Conrad), *Securella ensifera* (Dall), *Tellina emacerata* Conrad, and *Thracia trapezoides* (Conrad) and the gastropods *Ficus modesta* Conrad, *Megasurcula wynoocheensis* (Weaver), and *Molopophorus matthewi* Etherington were discovered recently in unnamed Miocene sediments in northern California on the south flank of the Coast Range in the Garberville area southeast of Eureka (Barry Roth, oral commun., 1984). All of these mollusks except *Acila (T.) conradi* and *Molopophorus matthewi* are found in both the Pillarian and the Newportian. One locality that is near the base of the section (Julie Menack, oral commun., 1984) yielded the gastropod *Molopophorus matthewi*, restricted to the Newportian, and these unnamed sediments are assigned here to the Newportian.

BAJA CALIFORNIA

Miocene molluscan faunas in Baja California have been poorly known until recent years (Minch and others, 1970; Smith, 1984), and precise age determinations based on faunal analyses and potassium-argon dating are much less precise than those in California. Currently, the Rosarito Beach Formation is assigned to the middle Miocene (Minch and others, 1970), the Isidro Formation to the earliest Miocene to early middle Miocene, the Tortugas Formation to the early middle Miocene, and the San Ignacio Formation to the late middle Miocene (Smith, 1984).

PEAK OCCURRENCES OF KEY SPECIES

Patinopecten propatulus (Conrad) is the zonal fossil of the Newportian Stage, whereas *Vertipecten fucanus* (Dall) identifies the Pillarian. *Vertipecten* is differentiated easily from species of *Patinopecten* when the left valve is preserved (pl. 1, fig. 5; pl. 4, figs. 9, 11) but not as easily distinguished when only the right valve is preserved (pl. 1, fig. 1; pl. 2, fig. 9; pl. 4, fig. 1). The left valve of *V. fucanus* has three ribs raised above the others: the middle rib and the third rib on either side of the middle. The left valve *of P. propatulus* has evenly spaced, low, rounded ribs (pl. 1, fig. 4). The right-valve auricles of *V. fucanus* (pl. 1, fig. 9) are relatively much larger than those of *P. propatulus* (pl. 1, fig. 1; pl. 3, fig. 6); on *V. fucanus*, the length of the auricles is more than half the width of the valves, whereas on *P. propatulus* the auricles are less than half the width of the valves. The ribbing on right valves of *V. fucanus* is much more irregular than that on *P. propatulus*; many specimens have one or more irregular ribs in the middle part of the disk (pl. 1, fig. 10), and most specimens have a widening and deepening of the medial interspace that corresponds to the strongly raised opposing rib on the left valve.

Patinopecten propatulus is abundant in units II and III in the Astoria Formation of southwestern Washington (Wolfe and McKee, 1972) and in the Astoria Formation in the Newport embayment, and its peak occurrence is in the early middle Miocene.

Patinopecten oregonensis cancellosus Moore, originally described from the unnamed Miocene sediment of the Coos Bay channel, Oregon (Moore, 1963), has been found in abundance in the upper part of the Nye Mudstone in the Newport embayment northeast of Newport, Ore., and it has been recognized in a few collections of Newportian age from northwestern Oregon. Its peak occurrence is in the late early Miocene part of the Pillarian. *Patinopecten oregonensis cancellosus* may have been confused in the past with *P. propatulus* and *V. fucanus*. The right valve of *P. oregonensis cancellosus* (pl. 2, figs. 1, 4) has regularly spaced, strongly undercut ribs that look like railroad ties in cross section (pl. 4, fig. 5) and no strongly raised ribs on the left valve (pl. 2, fig. 5; pl. 3, fig. 1). These characters differentiate it from *V. fucanus*. *Patinopecten oregonensis cancellosus* differs from *P. propatulus* by having a heavier shell and by both valves having fewer ribs that are higher and more undercut than those on *P. propatulus*, which has a low rib profile (pl. 1, fig. 7).

Anadara (Anadara) devincta (Conrad) ranges from the late Pillarian to the Wishkahan Stages. The occurrence in the Pillarian is based on the rare occurrence of this species in the Nye Mudstone. It is not found in other stratigraphic units assigned to the Pillarian. Abundant in the Astoria Formation in the Newport embayment, this species was not found in the unnamed Miocene sediment dredged from Coos Bay channel. We believe that this indicates that the Astoria Formation at Newport is younger than the unnamed sediment at Coos Bay channel and further suggests that the peak abundance of *A. (A.) devincta* was in the middle Newportian. In California, *A. (A.) devincta* has been collected in the Sobrante and Briones Sandstones and in the Temblor Formation.

Dosinia (D.) whitneyi (Gabb), when found in abundance, probably indicates an early Newportian age. This species occurs in Alaska in the type Narrow Cape Formation (Louie Marincovich, Jr., written commun., 1978), in Oregon, rarely in the Angora Peak Member of the Astoria Formation of Niem (1975), and abundantly in the unnamed Miocene sediment dredged from Coos Bay channel (pl. 3, fig. 13) and in California in the San Ramon Formation (Gabb, 1866; Stewart, 1930), the Wygal Sandstone Member of the Temblor Formation (Addicott, 1973), and in the "Sobrante Sandstone" of Lutz (1951). *Dosinia (D.) whitneyi* has not been found in the Newportian Astoria Formation in the Newport area.

Securella ensifera (Dall) ranges from the Pillarian Stage through the Newportian. Although the species is present in the Newportian and common in the unnamed Miocene sediment of Coos Bay, Ore., its peak abundance is in the Pillarian; for example, it is one of the most abundant bivalves in the Clallam Formation in Washington (Addicott, 1976a) and is common in the Nye Mudstone south of Newport, Ore. (pl. 3, fig. 9).

Anomalocardia carmanahensis (Clark) ranges from the Juanian Stage through the Pillarian and is not found in the Newportian. It is distinct and easily differentiated from the more common Pillarian and Newportian chionid *Securella ensifera* (pl. 3, fig. 9). *Anomalocardia carmanahensis* is differentiated on the basis of its very thick and rounded concentric ridges (pl. 3, figs. 4, 5) that disappear near the anterior margin. Originally described from the Sooke Formation of British Columbia, this species has been collected from strata of Pillarian age in northwestern Oregon.

Bruclarkia yaquinana (Anderson and Martin) and *Bruclarkia oregonensis* (Conrad) sometimes cooccur in the Pillarian Clallam Formation, but typical *B. yaquinana* is the most common. Typical *B. oregonensis* occurs almost exclusively at the top of the Clallam, and *B. yaquinana* occurs at or near the base (Addicott, 1976a). In the Kern River area of California, *B. yaquinana* is restricted in occurrence to the basal early Miocene part of the Jewett Sand. *Bruclarkia yaquinana* occurs in Washington in the Clallam Formation, in Oregon in the Astoria Formation and in the Nye Mudstone, and in California in the Jewett Sand and Painted Rock Sandstone Member of the Vaqueros Formation, both of early Miocene age, and in the basal part of the Saltos Shale Member of the Monterey Shale of Hill and others (1958), also of early Miocene age. The peak occurrence of *B. yaquinana* is in the middle early Miocene. *Bruclarkia oregonensis* occurs in Washington in the Clallam Formation and the Hoh Formation of Weaver (1915), in Oregon in the

Scappoose and Astoria Formations and in the sandstone of Flores Lake (Addicott, 1983), and in California in the Sobrante(?) Sandstone, the Oursan Sandstone, lower and upper parts of the Olcese Sand, the Buttonbed Sandstone Member of the Temblor Formation, the Twisselmann Sandstone Member of the Monterey Formation of Heikkila and MacLeod (1951), unnamed Miocene sediment in the Santa Cruz Mountains, and the Saltos Shale Member of the Monterey Shale of Hill and others (1958). These two species occur together in the Clallam Formation of Washington and the Astoria Formation of Oregon and possibly in the Saltos Shale Member of the Monterey Shale, California, of Hill and others (1958), although *B. yaquinana* is restricted to the basal part. Transitional specimens (pl. 2, fig. 3) that link the two species have been found in the Astoria Formation in Oregon (Moore, 1963) and in the Clallam Formation in Washington (Addicott, 1976a). Typical *B. oregonensis* (pl. 2, figs. 2, 8) differs from typical *B. yaquinana* (pl. 2, figs. 6, 7) by having uniformly fine sculpture through all stages of growth, whereas *B. yaquinana* has four or five coarsely noded spiral cords on the body whorl. The peak abundance of *B. yaquinana* seems to be in the Pillarian, possibly continuing into the early Newportian, and the peak abundance of *B. oregonensis* is in the middle Newportian.

Epitonium (Cirsotrema) clallamensis Durham ranges from the Juanian to the Pillarian Stages. It occurs in the upper part of the Poul Creek Formation of the Gulf of Alaska (Kanno, 1971), in the Sooke Formation in British Columbia (Durham, 1937), in the Clallam Formation in Washington, in the Nye Mudstone south of Newport, Ore. (pl. 3, fig. 3), and in the Jewett Sand (pl. 3, fig. 11; pl. 4, figs. 7, 10) in central California (Addicott, 1970). It also has been found in the Miocene *Macoma optiva* molluscan zone in the Tochilinski sequence of western Kamchatka (Gladenkov and Sinelnikova, 1984). The species is distinguished by the heavy bladelike to blocky costae and by the three to nine low, broad spiral ribs that cross the costae and form nodes on the central part of the whorl.

Musashia (Nipponomelon) shikami Moore (pl. 3, fig. 12; pl. 4, fig. 3) first appeared in the early Miocene within the upper part of the Juanian Stage (Moore, 1984). This species has a wide distribution: in Alaska in the upper part of the Poul Creek Formation; in Washington in the Clallam Formation, the upper part of the Pysht Formation of the Twin River Group, and the upper part of the Lincoln Creek Formation; in Oregon in the Nye Mudstone (Howe, 1922; Moore, 1984); and in California in the Freeman-Jewett silt of Matthews (1955) and the Vaqueros Formation. *Musashia (N.) shikami* lacks the deeply impressed, channeled suture and strongly twisted, keellike ribs of *Musashia (Miopleiona) indurata* (Conrad), the Newportian volutid (pl. 3, fig. 15).

Priscofusus aff. *P. geniculus* (Conrad) of Moore (1963) has been found in the lower part of the Clallam Formation in Washington and in the Nye Mudstone south of Newport, Ore. (pl. 4, fig. 8). It occurs in strata of presumed Pillarian age in northwestern Oregon and is assumed to be restricted to the Pillarian Stage.

Molopophorus matthewi Etherington and *Molopophorus anglonanus* (Anderson) are restricted to the Newportian. *Molopophorus matthewi* (pl. 1, figs. 6, 8) has a smooth, rounded body whorl, whereas *M. anglonanus* (pl. 1, figs. 2, 3) has a sharply angulated and noded body whorl profile.

The cephalopod *Aturia angustata* (Conrad) is thought to have become extinct at the end of the early Miocene (late Pillarian). This extinction may be related to the global cooling that began in the middle Miocene. The species is doubtfully identified from the Clallam Formation of Washington (Addicott, 1976a) and is positively identified from the Pysht Member of the Twin River Group. It is extremely abundant in the southwesternmost Washington (Moore, 1984) at the top of the Lincoln Creek Formation of late Juanian (earliest Miocene) age and has been found in Oregon in the Newport embayment in the Nye Mudstone of Pillarian age.

Aturia angustata is very rare in the California Miocene with only two specimens reported from the upper part of the "Vaqueros" Stage of Addicott (1972). The scarcity of *Aturia* in California in the early Miocene cannot be explained by cooling because the "Vaqueros" molluscan fauna is subtropical to tropical. *Nautilus*, the only living relative of *Aturia*, lives today in the South Pacific, mostly near islands with shallow water near shore and nearby steep continental shelves where depths drop off rapidly to 600 meters or more. *Aturia* probably lived in similar geographic areas in the early Miocene, and its scarcity in California may be related to the absence of habitats with shallow water close to deep water. In addition, other "Vaqueros" faunas generally represent shallower water than the common depth for *Aturia* of 100-350 meters (Moore, 1984). Nevertheless, the worldwide extinction of *Aturia* probably is related to the middle Miocene global cooling event.

Some of the mollusks common to the Pillarian and Newportian Stages, and about equally abundant in both, are *Ficus modesta* (Conrad) (pl. 4, fig. 2), *Cyclocardia subtenta* (Conrad) (pl. 3, fig. 16), *Lucinoma acutilineata* (Conrad) (pl. 3, fig. 8), *Katherinella (Katherinella) angustifrons* (Conrad) (pl. 3, figs. 2, 10, 14), *Macoma albaria* (Conrad) (pl. 3, fig. 7), and *Saccella amelga* Moore (pl. 4, figs. 4, 6).

On the basis of peak occurrences of key species, we believe that the unnamed Miocene sediments at Coos Bay, Ore., and the type section of the Narrow Cape Formation, on Kodiak Island, Alaska, represent the late early Miocene part of the Newportian and that units II and III of the Astoria Formation in southwestern Washington (Wolfe and McKee, 1972) and the Astoria Formation in the Newport embayment, Oregon, represent the early middle Miocene part of the Newportian.

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ABBREVIATIONS

CAS	California Academy of Sciences, San Francisco, Calif.
LACMP	Natural History Museum of Los Angeles County, Invertebrate Paleontology Section, Calif.
LAM	Natural History Museum of Los Angeles County, Calif.
USGS	United States Geological Survey, Washington, D.C., Cenozoic Locality Register.
USGS M	United States Geological Survey, Menlo Park, Calif., Cenozoic Locality Register.
USNM	National Museum of Natural History, Washington, D.C.

FOSSIL LOCALITIES

California Academy of Sciences, San Francisco, Calif.

CAS 12115.	Tillamook Bay, Ore. Astoria Formation.
CAS 12129.	3.2 m south of Yaquina Bay, Ore. Nye Mudstone.
CAS 12132.	3 km north of Yaquina Head, Ore. Astoria Formation.

Natural History Museum of Los Angeles County, Calif.

LAM 5842.	On the Columbia River, Wash., between Knappton and Grays Point, in the center of the N$^1/_2$N$^1/_2$ sec. 9, T. 9 N., R. 9 W., Knappton 7.5-minute quadrangle. From landslide block in upper part of the Lincoln Creek Formation.

U.S. Geological Survey, Washington, D.C.

USGS 2464.	Clallam Bay, Wash. Clallam Formation.
USGS 6613.	South bank of Kern River, Barker's Ranch, Kern County, Calif. Temblor Formation.
USGS 15328.	On north side of Yaquina River, southwest of Toledo, Ore., 455 m north and 30 m east of southwest corner sec. 26, T. 11 S., R. 11 W., Toledo 15-minute quadrangle, Ore. Yaquina Formation.
USGS 16047.	South tip of rock point at junction of ocean beach and north shore of Yaquina Bay, Ore., 365 m west and 60 m south of intersection of Yaquina Bay Bridge and north shore of the bay, Oregon. Astoria Formation.
USGS 18284.	Dredgings in unnamed Miocene sediments at Coos Bay, Oreg.
USGS 18860.	Road cut on U.S. Highway 101, east side of highway, about 305 m south of Spencer Creek, Ore. Astoria Formation.
USGS 18884.	From 8-ft massive siltstone, about 10 m above base of exposed section in beach cliffs forming first headland south of fill at Spencer Creek, Ore. Astoria Formation.
USGS 18890.	Road cut on U.S. Highway 101, immediately north of Spencer Creek Bridge. From fault block and landslide in unknown stratigraphic horizon.
USGS 18907.	From shale and siltstone exposed in beach at low tide, just south of Yaquina Head, Ore. Astoria Formation.
USGS 18939.	Slump south of Wade Creek, Ore. Astoria Formation.
USGS 18942a.	Float south of Moore Creek, Ore. Astoria Formation.

U.S. Geological Survey, Menlo Park, Calif.

USGS M1591.	On the southwest flank of Pyramid Hill, Kern County, Calif., on north side of westerly-trending gully, 655 m north, 150 m east from SW cor. in NW$^1/_4$ sec. 14, T. 28 S., R. 29 E., Rio Bravo Ranch 7.5-minute quadrangle. Marine conglomeratic sandstone in the basal part of the Jewett Sand.
USGS M4132.	North bank of small draw in SE$^1/_4$NE$^1/_4$ sec. 18, T. 31 S., R. 15 W. Curry County, Ore. Concretions in massive sandstone, Empire Formation.
USGS M4690.	Seacliff exposure about 825 m south, 290 m west of NE cor., sec. 2, T. 32 S., R. 16 W., Curry County, Ore.
USGS M6385.	Cut on east side of road spur #85. NE$^1/_4$ NE$^1/_4$SW$^1/_4$ sec. 23, T. 6 N., R. 9 W., Cannon Beach 15-minute quadrangle, Clatsop County, Ore. Massive, finely laminated sandstone of the Angora Peak Member of the Astoria Formation.
USGS M8195.	Sea cliff just south of Moore Creek, south of Newport, Yaquina 15-minute quadrangle, lat 44°34′00″ N., long 124°04′30″ W., Ore. Nye Mudstone.
USGS M8203.	Lat 44°34.4′N., long 124°4.2′W., Yaquina 15-minute quadrangle, Oregon. Nye Mudstone.
USGS M8205.	Lat 44°34.6′N., long 124°04.1′W., Yaquina 15-minute quadrangle, Lincoln County, Ore. Nye Mudstone.
USGS M8210.	Lat 44°48.7′N., long 124°01.2′W., Yaquina 15-minute quadrangle, Lincoln County, Ore. Astoria Formation.
USGS M8213.	Lat 44°33.5′N., long 124°04.4′W., Yaquina 15-minute quadrangle, Lincoln County, Ore. Nye Mudstone.
USGS M8220.	Lat 44°37.4′N., long 124°03.7′W., Yaquina 15-minute quadrangle, Lincoln County, Ore. Nye Mudstone.

PLATES 1–4

Contact photographs of the plates in this report are available at cost from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225

PLATE 1

[All specimens are natural size except as noted.]

FIGURES 1, 4, 7. *Patinopecten propatulus* (Conrad)

- 1. Right valve showing low flat ribs and auricles. Locality USGS 18884. USNM 563236 (x2).
- 4. Left valve showing evenly spaced rounded ribs. Locality USGS 18884. USNM 563238.
- 7. View of anterior side showing low-rib profile. Same specimen as illustrated in fig. 4.

2, 3. *Molopophorus anglonanus* (Anderson)

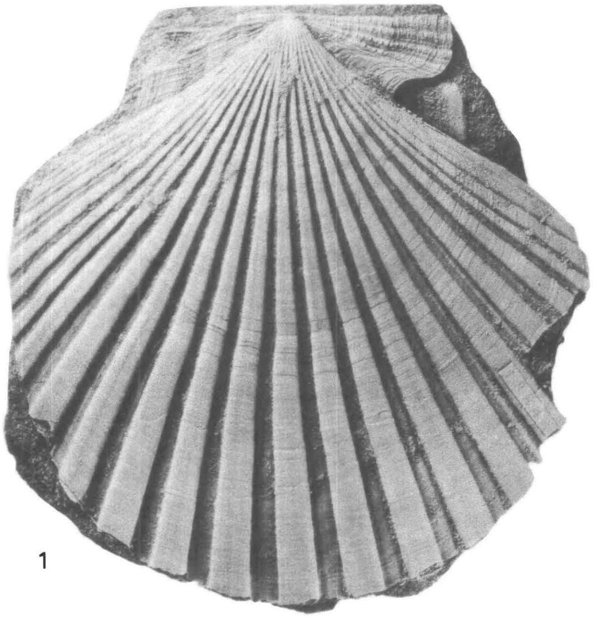
Specimen showing noded overlapping sutural color and body whorl spire outline. Locality USGS 6613. USNM 563136.

5, 9, 10. *Vertipecten fucanus* (Dall)

- 5. Latex impression of left valve holotype showing raised median rib. Locality, Astoria, Ore. USNM 107790.
- 9. Incomplete specimen showing right valve auricles. Locality USGS M8195. USNM 388232.
- 10. Right valve showing irregularly spaced flat ribs and anterior auricle. Locality CAS 12132.

6, 8. *Molopophorus matthewi* Etherington

- 6. Latex cast. Locality USGS M4690. USNM 245711.
- 8. Locality USGS M4132. USNM 245710.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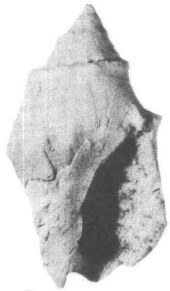
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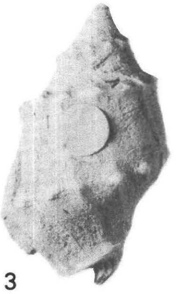
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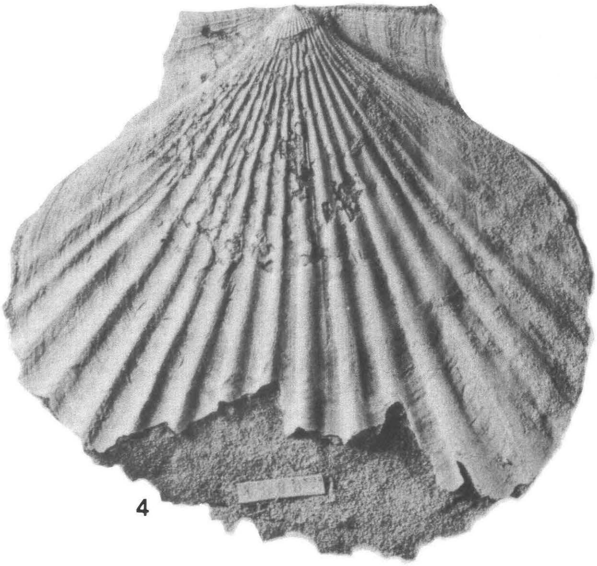
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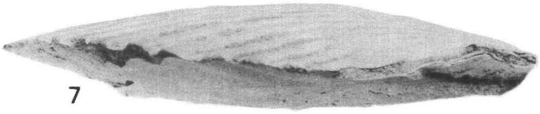
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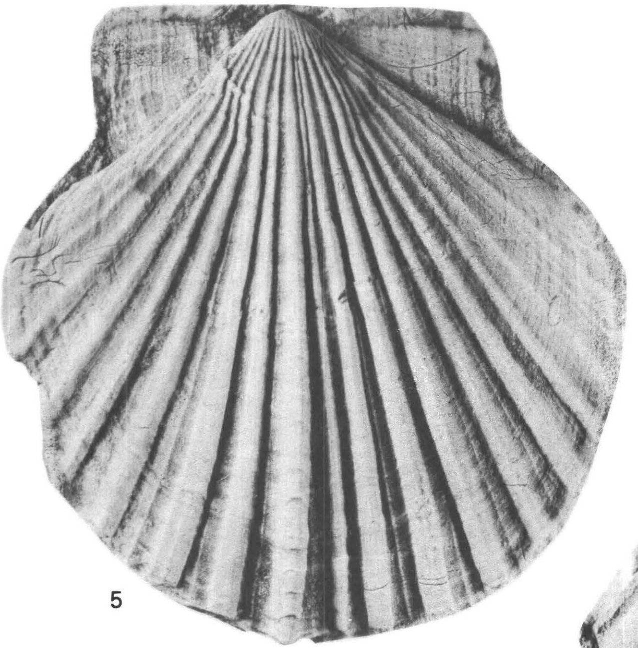
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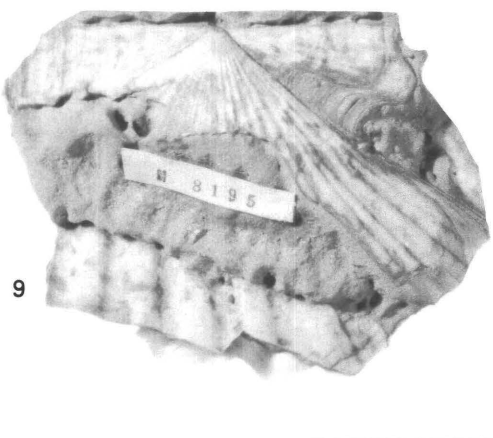

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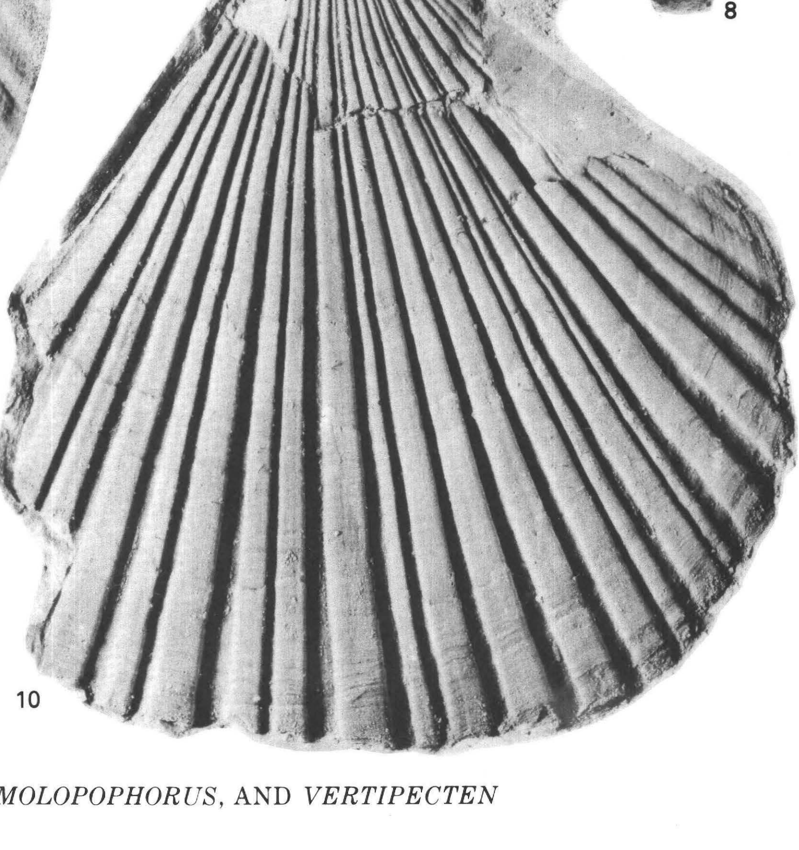
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PATINOPECTEN, *MOLOPOPHORUS*, AND *VERTIPECTEN*

PLATE 2

[All specimens are natural size.]

FIGURES 1, 4, 5. *Patinopecten oregonensis cancellosus* Moore.

1. Right valve of holotype showing high, regularly spaced ribs. Locality USGS 18284. USNM 563242.
4. Latex impression of right valve showing ribs and auricles. Locality USGS M6385. USNM 328233.
5. Left valve showing high rounded ribs. Locality USGS 18284. USNM 563239.

2, 3, 8. *Bruclarkia oregonensis* (Conrad). Locality USGS 18284.

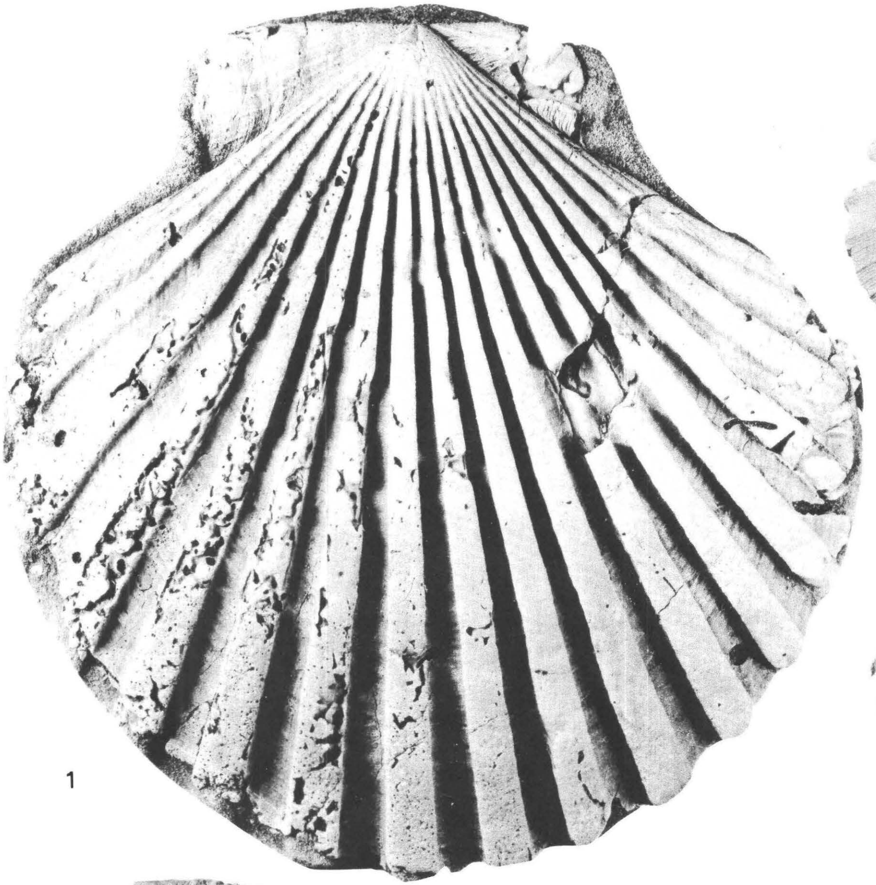
2. Specimen showing body-whorl spirals with a few small nodes. USNM 563138.
3. Specimen showing body-whorl spirals with some large nodes. USNM 563139.
8. Specimen showing body-whorl spirals without nodes. USNM 563141.

6, 7. *Bruclarkia yaquinana* (Anderson and Martin)

Specimen showing body whorl with small spines. Locality USGS 18284. USNM 563140.

9. *Vertipecten fucanus* (Dall)

Right valve showing irregular spacing of ribs and riblets in interspaces. Locality, Tillamook Bay, Ore., Astoria Formation. CAS 12115.



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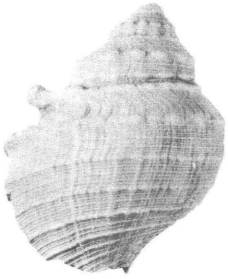

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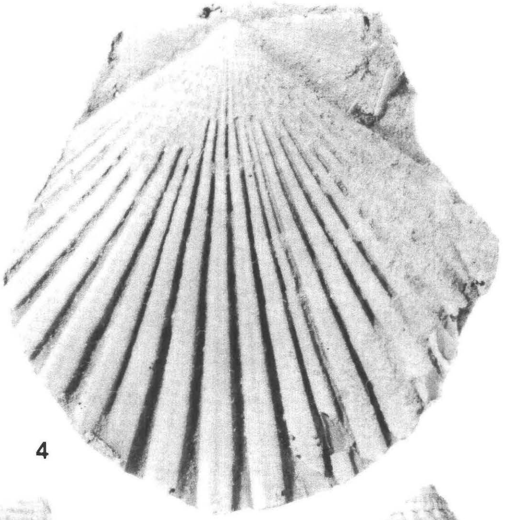

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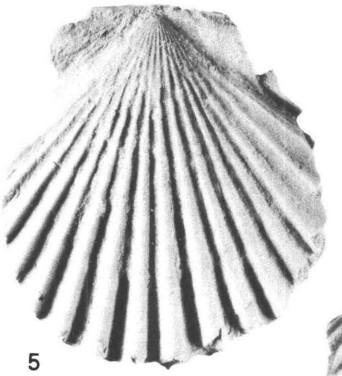

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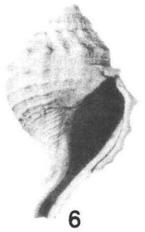

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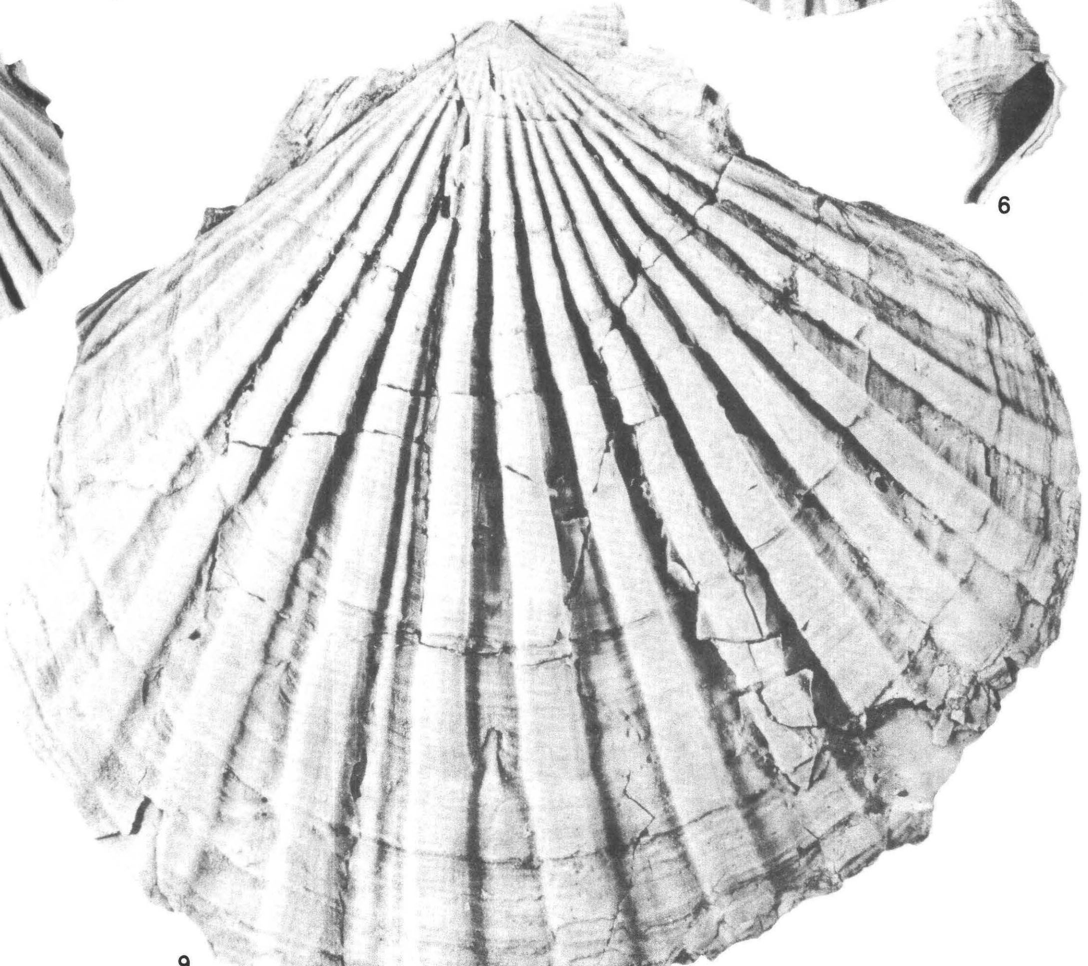

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PATINOPECTEN, *BRUCLARKIA*, AND *VERTIPECTEN*

PLATE 3

[All specimens are natural size except as noted.]

FIGURE 1. *Patinopecten oregonensis cancellosus* Moore
Latex impression of left valve showing large auricles and smooth rounded ribs. Locality USGS M8210. USNM 388234.

2, 10, 14. *Katherinella (Katherinella) angustifrons* (Conrad)
2. Right valve showing shell outline and drill hole. Locality USGS M8205. USNM 388235.
10. Left valve showing shell outline. Locality USGS 18890. USNM 563270.
14. Dorsal view of double-valved specimen shown in fig. 10.

3, 11. *Epitonium (Cirsostrema) clallamensis* Durham
3. Specimen showing thick axial ribs crossed by spiral sculpture. Locality USGS M18942a. USNM 388236.
11. Specimen showing axial ribs and spiral sculpture. Locality USGS M1591. USNM 388237.

4, 5. *Anomalocardia carmanahensis* (Clark)
4. Latex impression of right valve showing thick radial sculpture with fine radial sculpture where eroded. Locality USGS 15328. USNM 388238.
5. Left valve with thick concentric sculpture. Locality USGS 2464. USNM 388239.

6. *Patinopecten propatulus* (Conrad)
Incomplete right valve showing auricles. Locality USGS 18860. USNM 63237.

7. *Macoma albaria* (Conrad)
Right valve showing outline. Locality USGS 18284. USNM 563297 (X2).

8. *Lucinoma acutilineata* (Conrad)
Lectotype showing outline and concentric sculpture. Locality Astoria, Ore. USNM 3519.

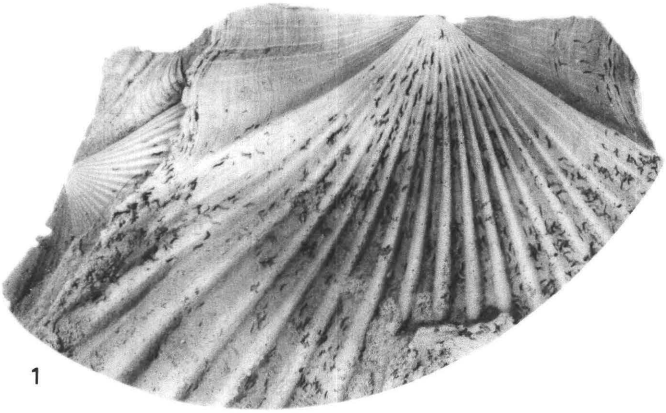
9. *Securella ensifera* (Dall)
Left valve showing fine concentric sculpture. Locality USGS M8220. USNM 388240.

12. *Musashia (Nipponomelon) shikami* Moore
Specimen showing narrow axial ribs and shallow suture. Locality LAM 5842. LACMP 6648.13.

13. *Dosinia (Dosinia) whitneyi* (Gabb)
Outline of right valve. Locality USGS 18284. USNM 563261.

15. *Musashia (Miopleiona) indurata* (Conrad)
Specimen showing thick axial ribs deflected by deeply impressed suture. Locality USGS 18284. USNM 563174.

16. *Cyclocardia subtenta* (Conrad)
Outline of left valve. Locality USGS 16047. USNM 563260.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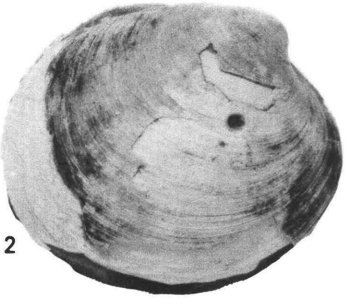
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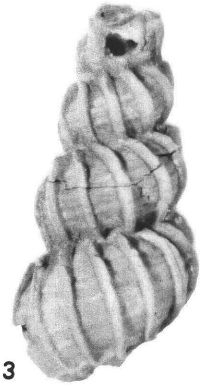
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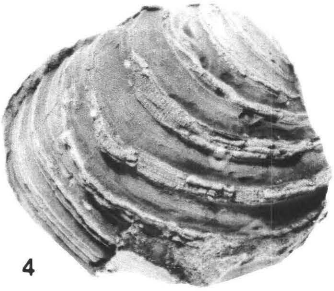
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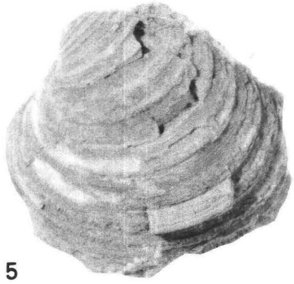
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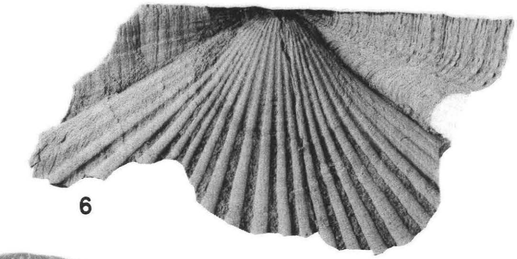
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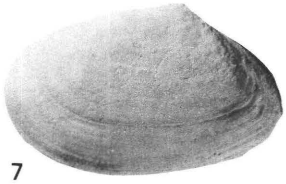
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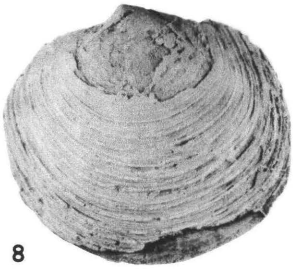
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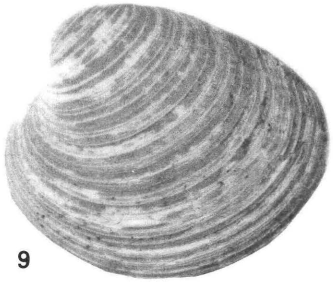
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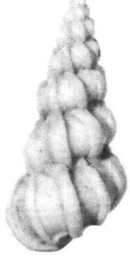
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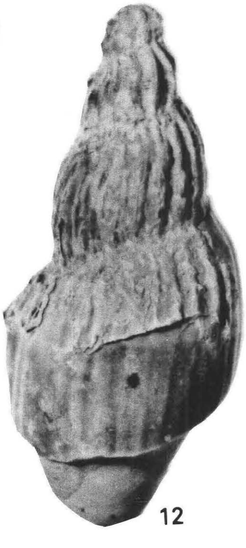
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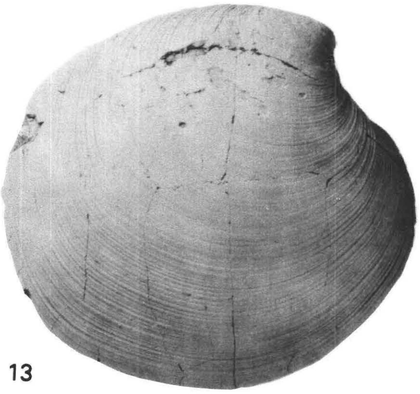
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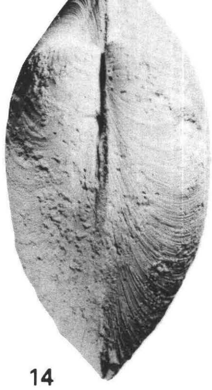
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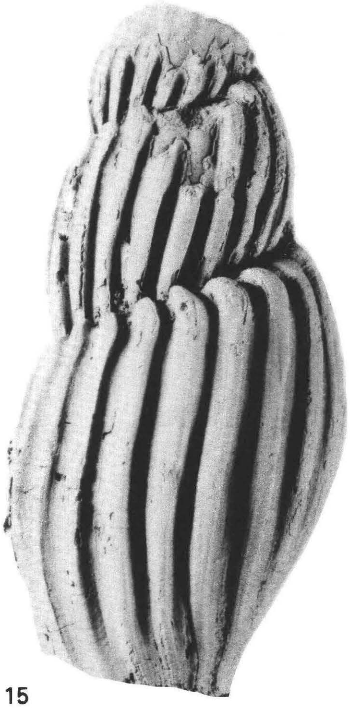
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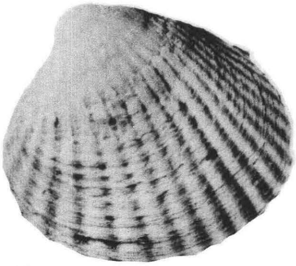
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PATINOPECTEN, KATHERINELLA, EPITONIUM, ANOMALOCARDIA, MACOMA, LUCINOMA, SECURELLA, MUSASHIA, DOSINIA, AND *CYCLOCARDIA*

PLATE 4

[All specimens are natural size except as noted.]

FIGURES 1, 9, 11. *Vertipecten fucanus* (Dall)

1. Right valve showing irregularly spaced ribs. Locality USGS M8203. USNM 391847.
9. Left-valve fragment showing raised median rib. Locality USGS M8213. USNM 391848.
11. Left valve showing raised median rib and irregular ribbing. Locality USGS 18831. USNM 563250.

2. *Ficus modesta* (Conrad)

Outline of specimen. Locality USGS 18939. USNM 563212.

3. *Musashia (Nipponomelon) shikami* Moore

Specimen showing thin axial ribs. Locality LAM 5842. LACMP 6650.

4, 6. *Saccella amelga* Moore

4. Right valve showing outline and concentric sculpture. Locality USGS 18907. USNM 563214 (X3).
6. Dorsal view. Same specimen illustrated in figure 4.

5. *Patinopecten oregonensis cancellosus* Moore

Ventral view. Locality USGS 18284. USNM 563239.

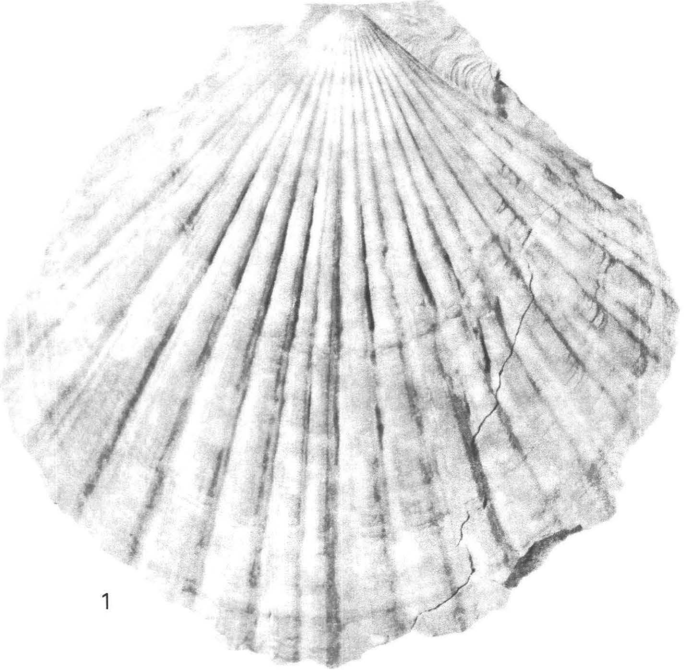
7, 10. *Epitonium (Cirsostrema) clallamensis* Durham

Locality USGS 1591. USNM 388237. Same specimen as pl. 3, fig. 11.

7. Basal disk of specimen.
10. Specimen showing thick axial costae.

8. *Priscofusus* aff. *P. geniculus* (Conrad) of Moore, 1963

Specimen showing sculpture. Locality 3.2 km south of Yaquina Bay, Ore. CAS 12129.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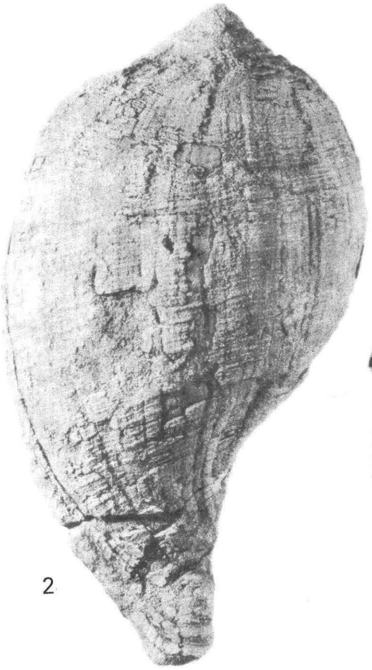
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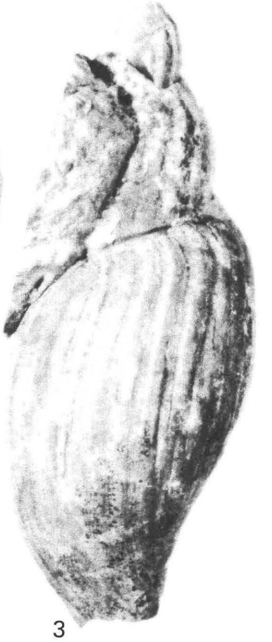
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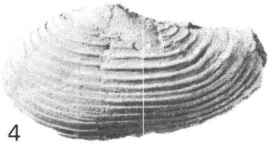
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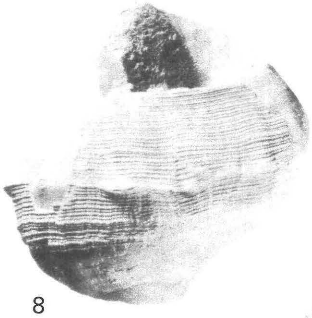
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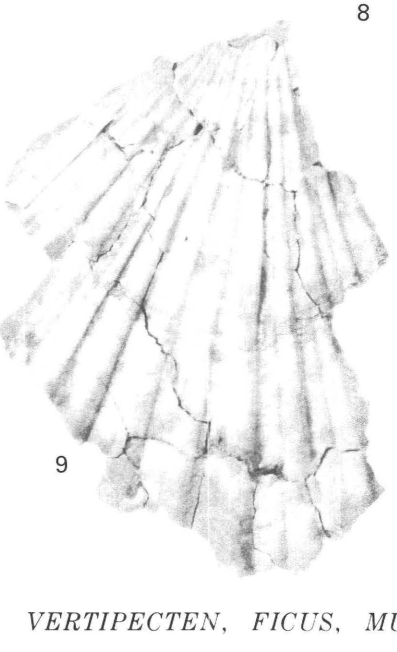
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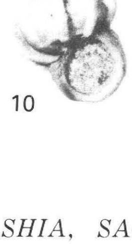
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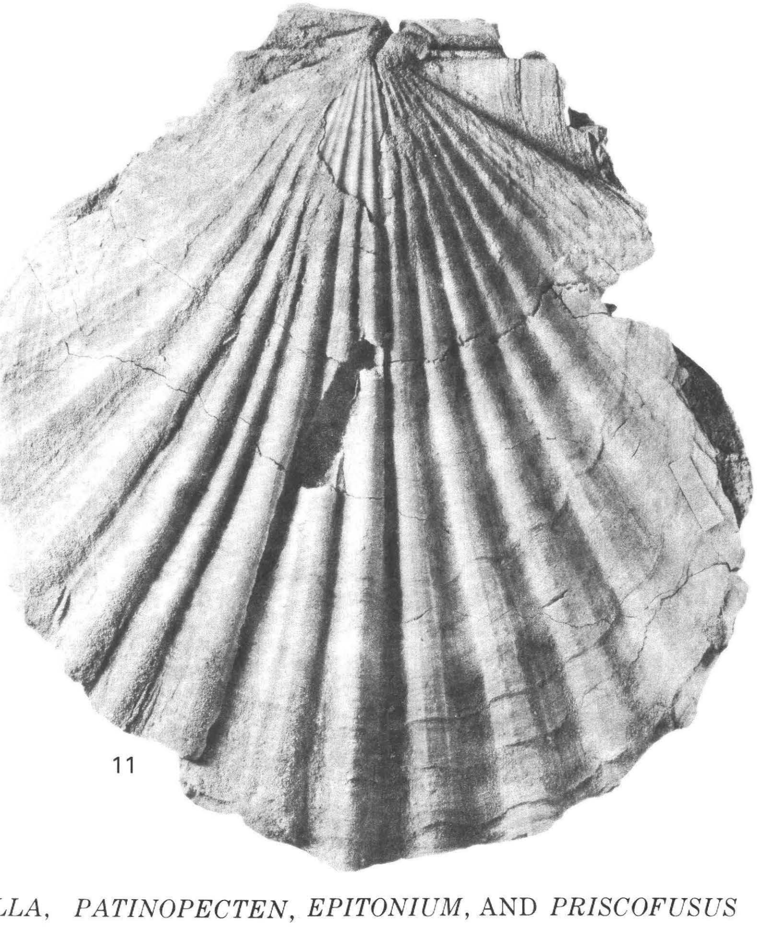
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VERTIPECTEN, FICUS, MUSASHIA, SACCELLA, PATINOPECTEN, EPITONIUM, AND *PRISCOFUSUS*

CHAPTER B

A New Species of *Isogramma* (Brachiopoda) From the Pennsylvanian of North-Central Texas

By BRUCE R. WARDLAW, DAVID E. SCHINDEL, and
ELLIS L. YOCHELSON

U.S. GEOLOGICAL SURVEY BULLETIN 1664

Shorter Contributions to Paleontology and Stratigraphy

CONTENTS

PLATE

[Plate follows References Cited]

FIGURES

A New Species of *Isogramma* (Brachiopoda) From the Pennsylvanian of North-Central Texas

By Bruce R. Wardlaw, David E. Schindel[1], and Ellis L. Yochelson

Abstract

Isogramma coopi, new species, is described from the Gonzales Limestone Member of the Graham Formation (Pennsylvanian) of north-central Texas. It is interpreted as having lived in a coralgal patch attached to corals and other hard substrate with its anterior commissure vertical. The Isogrammidae are transferred to the order Strophomenida.

INTRODUCTION

Isogramma has long been known from its distinctive shell fragments and has been reported from several localities and stratigraphic levels in the Pennsylvanian of north-central Texas. Several new, whole specimens of *Isogramma coopi* n. sp. were collected in apparent life position by the authors during summer 1976 and 1977 from the Gonzales Limestone Member of the Graham Formation, Cisco Group (Upper Pennsylvanian, Virgillian). These collections represent the only ones with abundant, whole, articulated specimens. None has been reported or illustrated. The collections provide an opportunity to reassess the genus *Isogramma* and its taxonomic position.

I. coopi is found in the Gonzales Limestone Member exposed in the bluffs and gullies approximately 200 meters east-northeast of the Mt. Zion Cemetery on the La Casa quadrangle, Stephens County, Tex. (fig. 1). This limestone caps an 8.5-m bluff of richly fossiliferous, medium-light-gray marine mudstone in the Finis Shale Member of the Graham Formation. Additional exposures occur in gullies approximately 150 m east of the cemetery, roughly 8 m stratigraphically below the sandstone on which the cemetery is built.

OCCURRENCE AND DEPOSITIONAL SETTING OF *ISOGRAMMA COOPI*

The Gonzales Limestone Member is laterally persistent for less than 20 kilometers in central Stephens County. It continues along strike virtually unchanged in composition or thickness for 11 km to the north-northeast and for 8 km to the south of the Mt. Zion Cemetery before pinching out. Beyond this limited lateral extent, the underlying Finis Shale Member and the overlying Gonzales Shale Member, both of Sellards, Adkins, and Plummer (1933), form an undivided shale sequence. The Gonzales Limestone is identified and mapped in other areas of north-central Texas primarily on the basis of its relative position in the stratigraphic sequence. The composition and thickness of limestone are markedly different in those other areas. Thus, the correlation between the several limestone bodies called Gonzales is not precise; these lentils may or may not be time equivalents. No evidence from field observations indicates that the Gonzales Limestone Member was at one time laterally persistent throughout north-central Texas and was subsequently limited in extent by erosion. It is more easily demonstrated that conditions under which this unit was de-

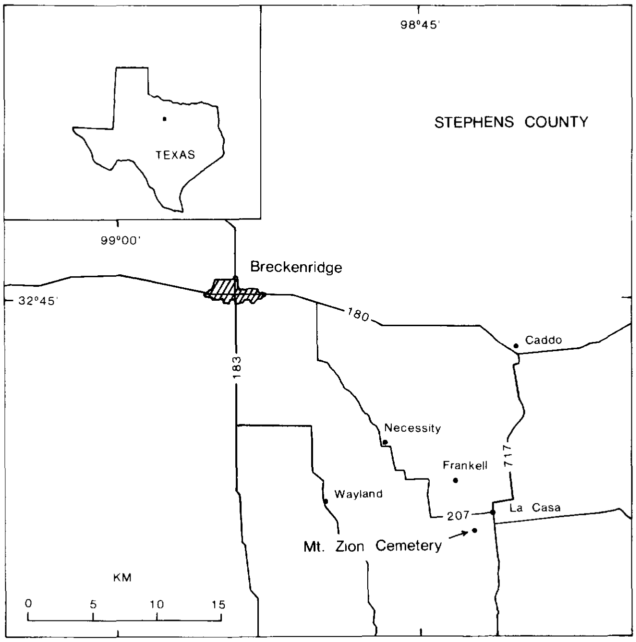

Figure 1. Location of Mt. Zion Cemetery in Stephens County, Texas.

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posited differed among areas that were separated by regions of clastic deposition in which limestone was prevented from forming.

The fauna of the Gonzales Limestone Member of central Stephens County is dominated by abundant solitary rugose corals. These lophophyllidioid corals are laterally compressed, and some reach lengths exceeding 6 centimeters. They shed conspicuously as yellow-tan debris onto the slopes of the Finis Shale Member below. Individual corals are found in situ, generally with apex lowermost, in positions ranging from upright to recumbent. Most specimens grow with straight axes, or with only slight curvature, suggesting that excavation and toppling of individuals by excessive water movement was not common. Algae and ectoprocts occurring as epibionts on the outer surfaces of the corals indicate shallow, gently agitated, normal marine conditions. Occurrence of a range of coral growth stages in life position strongly suggests lack of faunal mixing or winnowing, although the presence of clay in the Gonzales Limestone indicates sufficient current action for the influx of very fine clastic particles. These clay-sized particles probably settled quickly to the bottom as a result of the wave-damping effect on the coral cover.

Other constituents of the fauna in the Gonzales Limestone Member at the Mt. Zion Cemetery include colonial *Syringopora* corals, crinoid stems, the high-spired gastropod *Taosia*, robust spiriferoid brachiopods, *Isogramma coopi*, rare specimens of *Enteletes*, and infaunal pelecypods belonging to the genera *Astartella*, *Schizodus*, and *Allorisma*. All bivalved taxa are represented by at least a few articulated, unabraded specimens. Crinoid columnals remain articulated in lengths up to 10 cm; many of these stems are encrusted and bleached lengthwise along one side, indicating an interval of post-mortem, preburial response on the bottom. These observations support the suggestion that this 20-km-long lentil of the Gonzales Limestone Member was deposited in a shallow, gently agitated, normal marine setting. This local limestone probably represents the growth of a meadowlike patch, densely carpeted by a coral-dominated assemblage, analogous to modern *Thallassia*-dominated subtidal meadows of the Caribbean.

Transition from the preexisting mud-bottom condition of Finis Shale Member deposition to the shelly-bottom condition under which the overlying Gonzales Limestone Member accumulated seems geologically rapid; the diverse mollusk-dominated fauna of the Finis Shale Member is replaced vertically by the coral-dominated assemblage within a few centimeters of strata. Rugose corals were not found in the underlying Finis, although extensive collecting from the weathered slopes of this unit has yielded a few lophophyllidioid corals, all of which are laterally crushed and stained yellow tan. We believe that these individuals originated in the Gonzales, as no rugosans have been found in situ below this unit. A vertical sequence of bulk sediment samples taken through the entire Finis Shale at the Mt. Zion Cemetery was disaggregated and wet-sieved for fossils above the 200 mesh fraction (0.074 millimeter and larger). These 24 samples represented more than 60 kilograms of sediment and produced thousands of specimens greater than 1.0 mm; however, not a single coral adult, protocorallium, or fragment was among them (Schindel, 1979).

The presence of clay in the Gonzales Limestone Member shows that influx of terrigenous clastics did not cease before the growth of the coral thicket, though turbidity may have decreased to a level tolerable to the corals. Although we cannot demonstrate that environmental conditions changed at or near the level of faunal replacement, it is apparent that rugose corals were not present in the area before Gonzales deposition. We suggest that the initial arrival of coral colonists was the first step in the change from a quiet-water, mud-bottom environment, dominated by low-level deposit- and suspension-feeding mollusks, to a very quiet-water, wave-damped shelly bottom environment, dominated by epifaunal grazers and by filter-feeders, including *I. coopi*.

ISOGRAMMIDAE

Currently (Rowell, 1965, p. 359), the Isogrammidae are associated with the Eichwaldiidae in the superfamily Eichwaldiacea. *Megapleuronia* Cooper (1952) and its junior synonym, *Schizopleuronia* Liao (1983), are the only other genera included in the Isogrammidae. *Megapleuronia* is differentiated from *Isogramma* by its costate or plicated anterior margins. All other features are similar to *Isogramma*. The common features of the Isogrammidae and Eichwaldiidae are shell punctation and a pedicle plate (umbonal plate of Rowell, 1965). The Eichwaldiidae have an opening at the anterior end of the pedicle place communicating to the outside of the valve. This also results in an interior raised posterior plate in the pedicle valve anterior to the opening to the pedicle plate. This opening to the pedicle plate has been postulated for the Isogrammidae (Dittmar, 1872; Schmidt, 1931), but we find no evidence for it in our specimens or in those illustrated by Cooper (1952) or Cooper and Grant (1974).

The Isogrammidae differ from the Eichwaldiidae in having no teeth, a lophophore platform, and articulation achieved by a prominent trilobate cardinal process extending posterior to the hingeline as in the Productidina. *Isogramma* has a lophophore platform (brachial ridges? of Cooper and Grant, 1974) that is diagnostic of Strophomenida. The valve shape and fit of the Isogrammidae are like that of the Strophomenida, whereas the Eichwaldiidae valve shape and fit are more like the Rhynchonellida. The Isogrammidae occur in Carboniferous and Permian rocks, and the Eichwaldiidae are found in Ordovician and Silurian rocks, a significant hiatus between occurrences.

The punctation and shell structure found in the Isogrammidae differ from that of most brachiopods. The punctae are large and occupy as much space as the intervening shell.

The ridges of shell coalesce to form the exterior ornamentation of concentric ridges; these ridges can cover the entire valve, as reported by Cooper and Grant (1974) or can leave interridge areas exposing punctae to the exterior (fig. 2; Schmidt, 1931). Interior impunctate shell material forms the cardinal process, shaft, and long median septum. Similar impunctate shell is deposited to form the pedicle plate, with no punctate layer deposited over it. The pedicle plate narrows and ends at or near the posterior end of the beak and does not have an anterior opening to communicate with the exterior. The delthyrium of the pedicle valve is filled with the cardinal process of the brachial valve. It is hard to imagine how any pedicle could have been extended from this shell. The pedicle plate is not covered by the external shell layers of the punctate shell and concentric ridges but appears internal to these layers. Because the pedicle plate is composed of impunctate shell material like some internal features that were covered by living mantle tissue and because it is internal to the normal punctate shell forming the exterior, perhaps it, too, was covered by living tissue. The pedicle plate, therefore, was probably not a "pedicle track" but may have been a specialized attachment surface. Communication to the interior may be maintained through the bordering punctae along the margin of the pedicle plate. These punctae appear to be the only "openings" available to the pedicle plate. Nevertheless, *Isogramma* has a different

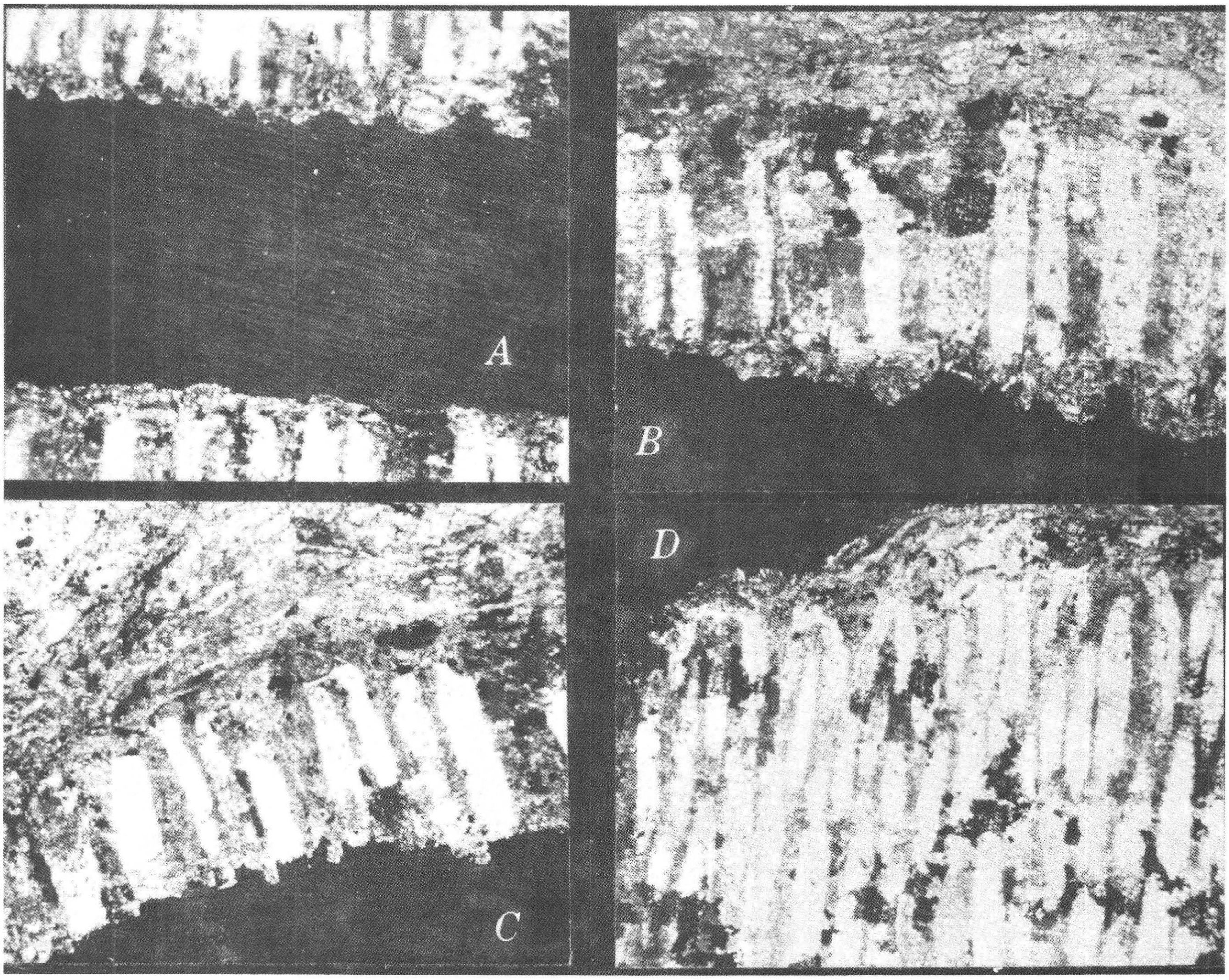

Figure 2. Shell structure of *Isogramma coopi,* all views X100. *A,* View of median cross section showing interior and interior valve surfaces of an articulated specimen; white represents the calcite skeleton, and clay with some silt fill open punctae and, in part, line some of the interior, but clay is post-mortem and depositional in occurrence; generally the punctae open to the interior. *B,* View of median cross section showing both exterior and interior surfaces of a brachial valve, only about one-half the punctae are covered by ridge-forming exterior ornament, the other one-half are open to the exterior. *C,* View of median cross section showing exterior and interior surfaces of a brachial valve with poorly developed ridges. *D,* View of oblique median cross section showing exterior surface of pedicle valve with poorly developed ridges, slightly more than one-half the punctae are covered.

attachment than members of the Eichwaldiidae which do have an obvious "pedicle track" and an obvious pedicle opening to the exterior at the anterior of the "track" and probably had a pedicle.

The Isogrammidae developed during the explosive radiation of the Strophomenida; they are articulated like the Productidina of the Strophomenida. Though the shell structure is aberrant for a member of the Strophomenida, the Strophomenida being pseudopunctate, or rarely impunctate, all other features support a relationship with that order. This argument is not new; Schmidt (1931) also discussed this possible affinity. Modification of hollow taleolae, as in the Chonetidina, could lead to the shells of the Isogrammidae. The Stropheminida include the Oldhaminidina and many strange Productidina. In our view, the Isogrammidae can fit comfortably in the order without unduly extending its limits.

SYTEMATIC PALEONTOLOGY

Genus *Isogramma* Schuchert, 1929

Isogramma coopi Wardlaw, Schindel, and Yochelson, new species

Plate 1, figures 1–17

The specific name is in honor of "Coop," G. Arthur Cooper, emeritus curator, Department of Paleobiology, Smithsonian Institution.

Holotype.—USNM 305974, pl. 1, figs. 11-12.

Diagnosis.—This species is recognized by the folding of the valves and its oval shape.

Description.—Medium to large brachiopod, with a roughly oval shape, widest just anterior to hinge, valves concavoconvex. Pedicle valve flatly convex with broad median fold and shallow lateral sulci anteriorly; interarea short but wide, tapering laterally, with smaller triangular interarea short but wide, tapering laterally, with small triangular delthyrium, beak slightly recurved over interarea. Brachial valve shallowly concave with median sulcus and lateral folds anteriorly; no interarea.

Shell composed of two layers: a highly punctate, honeycombed layer making up most of the valve and an impunctate layer restricted to the center part of each valve. The punctae are round, as large as the intervening shell material. External ornament of concentric ridges produced by intervening shell coalescing, sealing some punctae from exterior. Interior of brachial valve with cardinal process, shaft, and median septum all composed of impunctate inner shell; exterior covered by punctate shell; pedicle valve interior with pedicle plate made up of impunctate "inner shell," exteriorly not covered.

Shell ornamented by folds and elevated concentric ridges; one broad median fold with low lateral sulci on pedicle valve and complementary median sulcus with two lateral folds on brachial valve; concentric ridges randomly ending, beginning, and bifurcating, locally some crosscutting, but giving the overall impression of concentric ornament; ridges start at and perpendicular to hinge, ridges forming wavy ornamentation at various points on valve; punctae exposed in interridge areas, interridge areas approximately one-half the width of ridges; concentric ornament interrupted by narrow triangular pedicle plate, starting near posterior of beak and extending anteriorly for a variable distance commonly about one-third to one-half the length of valve; pedicle plate is notched in middle.

Pedicle valve interior rarely observed, with deep, troughlike posterior depression in middle of valve made up of impunctate shell representing interior of the pedicle plate, remainder of valve with radially arranged small ridges and depressions, anteriomedianly, representing muscle attachment or pallial marks. Brachial valve interior with thick, short, trilobate cardinal process supported by a thick shaft becoming a high median septum extending anteriorly nearly entire length of valve, all composed of impunctate shell; articulation accomplished by inner "socket" ridge that forms shallow groove to hinge, groove receives thickened margin of pedicle valve interarea; cardinal process completely fills delthyrium; muscle scars consisting of radially arranged ridges and depressions forming large triangular areas anteriormedianly, posterior one-third of muscle scars depressed, anteriorly muscle scars elevated; lophophore platform simple, outlined by low "socket" ridge posteriorly and low ridge laterally and anteriorly, forming symmetric wings, narrowing medianly about the posterior shaft and median septum (fig. 3). Brachial valve interior surface marked by numerous pits (punctae).

Discussion.—The pedicle plate has no direct connection to the interior of the brachiopod and, thus, probably does not represent a "pedicle track" (Cooper and Grant, 1974). It is composed of impunctate shell material, which in the brachial valve, represents inner shell. This implies that impunctate shell is secreted by mantle inside the mantle-shell margin where normal (punctate) shell deposition takes place. Because, in *Isogramma*, the impunctate shell appears to represent "inner" shell material that was probably secreted by covering mantle tissue, the inner shell exposed in the pedicle plate may have been covered by mantle. The pedicle plate seems to have been involved in attachment, and commonly corals are cemented to it. This cementation appears postdepositional, but the proximity of the fossils seems original. No evidence exists that *Isogramma* could cement itself to a substrate. However, the proximity of possible attachment objects implies attachment, and this may have been accomplished by a living attachment surface of exposed mantle. The occurrence of *I. coopi* in upright life position within a coral thicket also suggests some attachment. Communication to the interior for the live exposed mantle is difficult to demonstrate, but access could be through the open punctae bordering the pedicle plate. Mantle tissue probably existed in all the punctae, at least sometime during the brachiopod's life. The mantle in the punctae bordering the pedicle plate was probably specialized and extended to cover the plate, which prevented outer shell development and made an attachment surface during life.

Isogramma coopi differs from *I. renfrarum* Cooper (1952), which occurs in the Finis Shale Member in north-central Texas, in its smaller size, oval shape, and folding on brachial valve. This difference may be due to different living environments—*I. renfrarum* occurred on marine mudflats, and *I. coopi*, in a coralgal thicket. The folding in *I. coopi* may have been a response for sharper separation of incoming and outgoing currents in a crowded environment.

In its anterior folding, *Isogramma coopi* most closely resembles *I. lobatum* Cooper and Grant from the Leonardian (late Early Permian) of west Texas, though the folding is less pronounced in *I. coopi*. *I. coopi* differs internally in having a different-shaped lophophore platform and in having radial ornament confined to the muscle scars. *I. lobatum* is based on only two brachial valves, so further comparison is precluded.

Occurrence.—Gonzales Limestone Member of the Graham Formation (Upper Pennsylvania, Virgilian), Mt. Zion Cemetery, Stephens County, Texas.

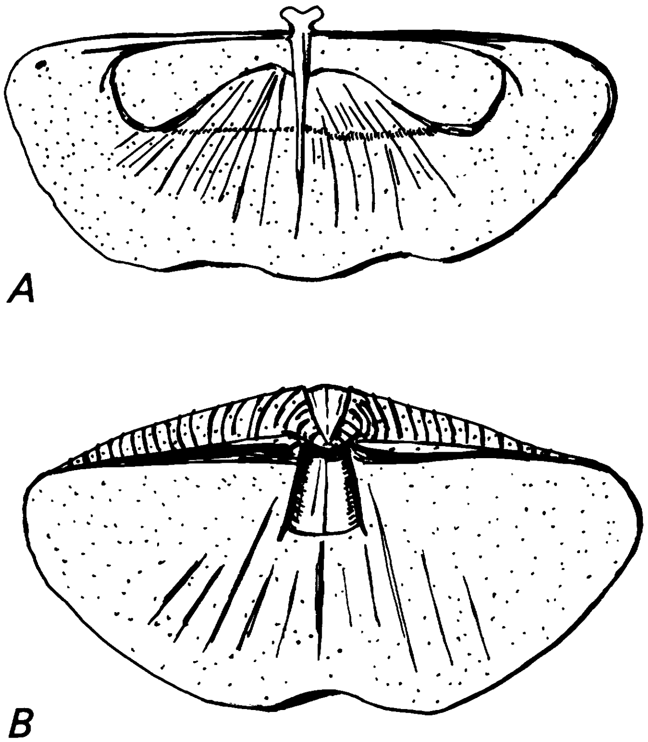

Figure 3. Diagrammatic interpretation of the interior of *Isogramma coopi*. *A*, Brachial valve showing cardinal process and median septum, lophophore platform, and muscle scars; impunctate shell makes up only the cardinal process and septum. *B*, Pedicle valve showing interior surface of pedicle plate of impunctate shell and muscle scars; the interior of the pedicle plate forms a trough.

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PLATE 1

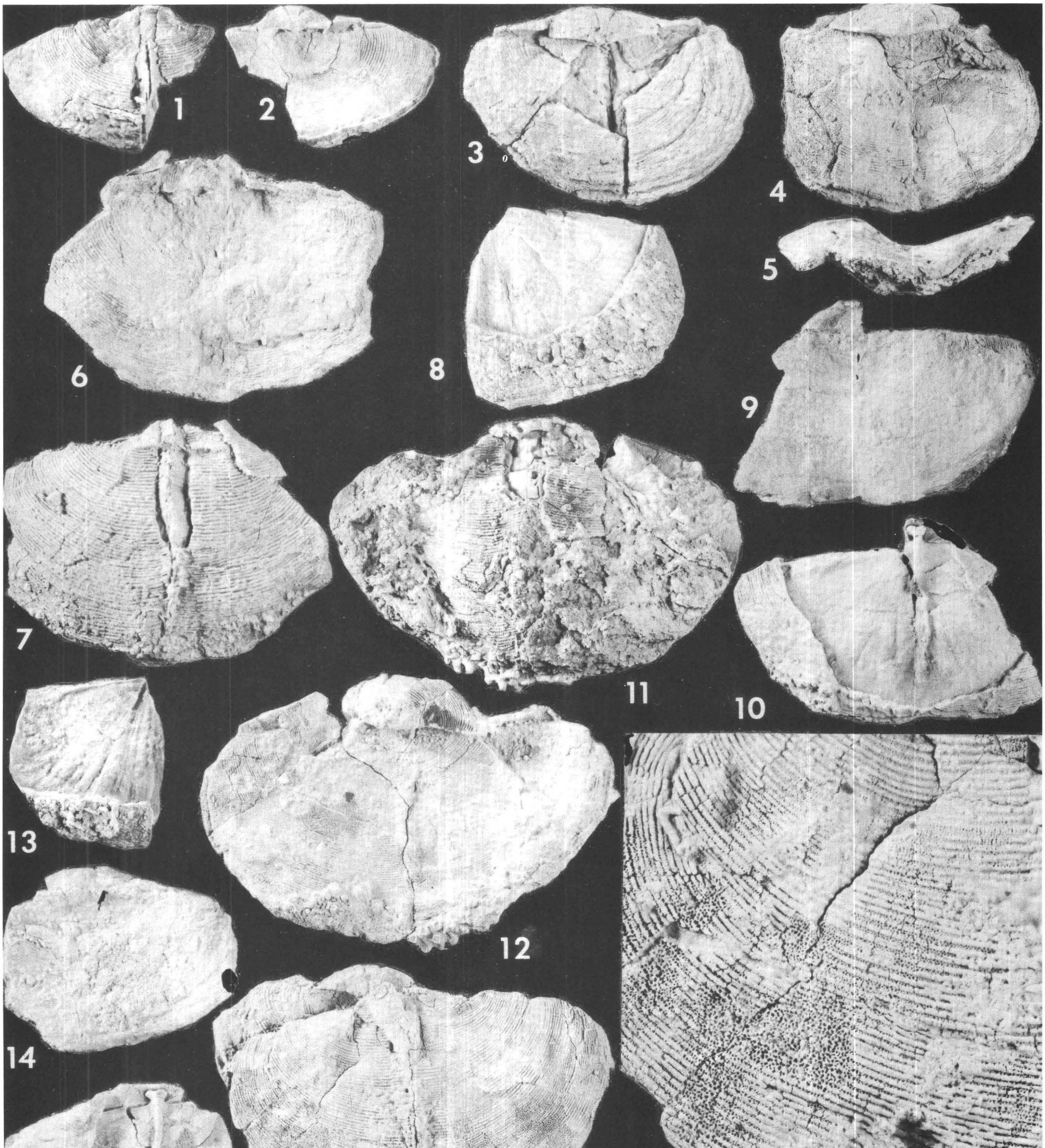
Contact photograph of the plate in this report is available at cost from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225

PLATE 1

Isogramma coopi

[All figures of holotypes and paratypes, xl, unless stated otherwise.
Specimens articulated, and partially covered by caliche and clay.]

FIGURES 1–2. Ventral and dorsal views USNM 305972.
3. Dorsal view, showing part of pedicle interior USNM 399544.
4–5. Dorsal and anterior views, showing folding USNM 305971.
6–7. Dorsal and ventral views, showing long pedicle plate USNM 305970.
8. Interior view of brachial valve USNM 399545.
9–10. Dorsal and interior view of brachial valve USNM 399546.
11–12. Ventral and dorsal view of holotype USNM 305974.
13. Interior view of brachial valve USNM 399548.
14–15. Dorsal and ventral interior of brachial valve views USNM 305969.
16–17. Ventral view of specimen with coral attached to pedicle plate with dorsal view of another attached specimen; X3 enlargement to show surface ornament and punctae of lower left side of same specimen USNM 305973.



ISOGRAMMA

CHAPTER C

Middle and Upper Triassic Marine Ostracoda From the Shublik Formation, Northeastern Alaska

By I. G. SOHN

U.S. GEOLOGICAL SURVEY BULLETIN 1664

Shorter Contributions to Paleontology and Stratigraphy

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PLATES

[Plates follow References]

FIGURE

TABLES

Middle and Upper Triassic Marine Ostracoda From the Shublik Formation, Northeastern Alaska

By I. G. Sohn

Abstract

Twenty-two taxa from beds dated by megafossils as Ladinian through Norian are described and illustrated in 7 new species, 13 in open nomenclature, and 1 as Gen. and sp. indet. The *Hungarella–Ogmoconcha* problem is discussed, and specimens of *Ogmoconcha* from the Carnian of Hungary are illustrated as evidence that the genus was present during the Triassic. Twelve of the taxa are restricted to the Ladinian part of the Shublik Formation of the reference section, one taxon is restricted to the Carnian, and six taxa are restricted to the Norian. Related genera have been recorded from the Middle Triassic of the Primor'ye Zoogeographical Province of the Pacific Realm and from the Middle and Upper Triassic in the Tethyan Zoogeographical Province of Eurasia.

The following taxa are included: *Cavussurella grammi* n. sp., C.? sp. 1, C.? sp. 2, Covracytheridae n. fam., *Covracythere binoda* n. sp., *C. gryci* n. sp., *Dettermania truncata* n. gen., n. sp., *Ogmoconcha tailleuri* n. sp., *O. unicerata* n. sp., *O. alaskaense*. n. sp., *O. marquardti* n. sp., *O*.? sp. aff. *Hungarella limbata* (Reuss, 1868), *O*. aff. *O. owthropensis* (Anderson, 1964), *Cavussurella*? sp. 1, *C*?. sp. 2, "*Healdia*" sp. 1, "*H*" sp. 2, "*H*" sp. 3, *Hyatobairdia*? ex gr. *H. arcuata* Kristan-Tollman, 1970, *Recytella* sp. 1, *R*. sp. 2, *Triassocypris*? sp., *Pseudobythocypris*? sp. *Rhombocythere*? sp., and Gen. and sp. indet.

In addition, *Cornutobairdia reidae* n. sp. from the Lewes River Formation (Norian), Yukon Territory, Canada, is described. This species is representative of an abundant and varied silicified ostracode assemblage that differs on the generic level from those in northern Alaska. This assemblage is similar to ostracodes from Nevada and to taxa described from the Carnian and Rhaetian of the Tethyan Zoogeographical Region. During the Middle Triassic (Anisian and Ladinian), the sea that became northern Alaska was located in the Primor'ye Zoogeographical Province not directly connected with the Tethyan Zoogeographical Region. During the Late Triassic (Norian and ?Rhaetian), that sea had connections with the Tethyan Zoogeographical Province of Eurasia. Northern Alaska is not one of the accretionary exotic terranes postulated for western North America and southern Alaska.

INTRODUCTION

Purpose and Scope

The discovery and production of oil in the North Slope of Alaska involved detailed geologic, stratigraphic, and paleontologic studies by the U.S. Geological Survey (USGS) and many private companies. This report deals with Middle and Late Triassic ostracodes from the reference section of the Shublik Formation, 10.4 kilometers N83°W of the confluence of Fire Creek and the Sadlerochit River (fig. 1) in the Mount Michelson quadrangle (Detterman and others, 1975, p. 14–16, fig. 6). Stage assignments for the units in this reference section are based on megafossils identified by N. J. Silberling (Detterman and others, 1975, p. 43). Because ostracodes also are present in boreholes in the North Slope (Sohn, 1984a, p. 334), description of the ostracodes from surface collections makes these microfossils available for surface and subsurface identification.

Previous Work

From 1857 through 1966, only 25 publications dealing with marine Triassic ostracodes were published (Sohn, 1968, p. 6, 64), and all were from Europe and Asia. During the past two decades, the number of publications on the Triassic ostracodes from Europe and Asia has increased dramatically. Sohn (1965) recorded *Hungarella*? spp., *Paracypris*? spp., *Darwinula*? sp., and unidentified steinkerns in 30 collections of very poorly preserved pyritized ostracodes from the Shublik Formation on Dodo Creek about 10 km east-northeast of the Fire Creek reference section. In the same publication, the following taxa were recorded for silicified ostracodes from the Grantsville Formation (Ladinian), Shoshone Mountains, Nye County, Nev. (USGS Mesozoic loc. M76): *Acratia*? sp., *Carinobairdia*? sp., *Cytherelloidea* n. sp. 1, *Cytherelloidea* n. sp. 2, new genus Thlipsuracea?, Gen. indet. Beyrichicopina?, Gen. indet. Cytheracea, and Gen. indet. Healdiidae.

Harlan Bergquist gave me 37 slides with ostracodes he found while studying the foraminifers from the Fire Creek reference section of the Shublik Formation for R. L. Detterman. In 1973, I reported that they contained *Hungarella* spp., *Bairdia* sp. (one carapace), and steinkerns of undetermined genera. As result of my report, Detterman sent me 88 samples from the reference section of the Shublik Formation that had been prepared by grinding for mineralogical studies. Sixty-one of these contained ostracodes. Both suites of samples from the reference section were documented by collection numbers and by distances measured in feet above the base of the Shublik Formation. These samples were small, ranging in dry weight from 22 to 104 grams; the ostracodes recovered, which varied from 1 to more than 30 specimens per sample, provided the ostracodes for this study.

Acknowledgments

I thank the following colleagues in the Geological Survey for specimens, information, and advice: Jean M. Berdan, R. L. Detterman, J. T. Dutro, Jr., George Gryc, N. J. Silberling, I. L. Tailleur, and the late Harlan Bergquist. Kathleen M. Flynn, October 1981 to May 1982, Jane A. Bubek, June 1982 to August 1982, and T. Chad Walter, October 1982 to April 1984, processed and picked the samples, and Marija Balanc assisted with translations from the Russian. Pamela Reid, University of Miami, Florida, supplied etched residue and limestone samples from the Lime Peak Formation (Norian), Yukon, Canada. Dr. M. N. Gramm, Vladivostok, U.S.S.R., compared scanning electron micrographs of two taxa with the types and duplicates of taxa he had described from the Primor'ye Territory, U.S.S.R. The National Petroleum Reserve in Alaska provided technical support during fiscal years 1982 and 1983 to process these samples, as well as portions of borehole cores that I selected in Menlo Park during January 26 and 27, 1982.

Preservation and Laboratory Techniques

All the samples were treated in Quaternary-O, sieved and picked using a binocular microscope. Selected specimens were prepared for scanning electron microscope (SEM) photomicrography. Both methods have been described by Sohn (1983, p. 10).

Because the samples had been crushed previously, most of the ostracodes are either steinkerns or broken or corroded carapaces and are small, from 0.4 to 0.8 millimeter in greatest length. Clean dissociated valves are rare. The outer surfaces of many of the carapaces, particularly those taxa with smooth surfaces, are rough because they are coated with an as yet undetermined mineral (pl. 6, figs. 15–18). Some have adhering mineral grains (pl. 6, figs. 6–9), and others are pitted and gouged (pl. 9, figs. 15, 18). On some of the steinkerns and broken carapaces, either the hinge structure or the adductor muscle-attachment scar is exposed

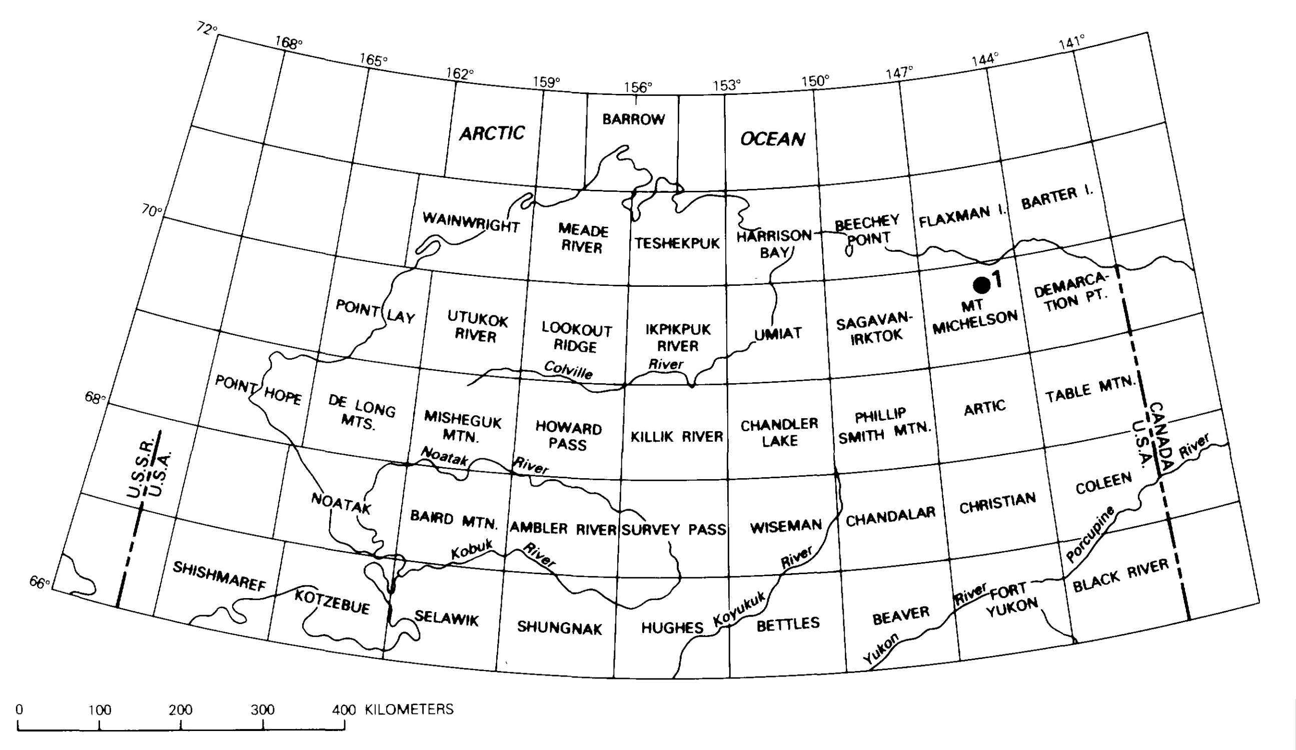

Figure 1. Map of northeastern Alaska showing location of Fire Creek reference section of Shublik Formation; 1 is the Fire Creek outcrop section.

(pl. 1, figs. 7, 8, 15, 16, 18, 20; pl. 5, figs. 14, 16; pl. 8, figs. 25, 26; pl. 9, figs. 11, 12, 22, 23; pl. 10, figs. 18, 19, 26; pl. 11, fig. 26). These two morphologic characters are particularly important in the generic and suprageneric classification of ostracodes.

GEOLOGIC SETTING

Current interpretations suggest that modern-day Alaska is composed of at least two unrelated blocks: A northern segment consisting of the North Slope and the Brooks Range that was once connected to the Canadian Arctic Islands (Grantz, Johnson, and Sweeny, 1982, pl. 111) and a central and southern portion composed of accretionary terranes that are part of the active convergent Pacific microplates (Jones, Silberling, and Hillhouse, 1978, p. 71–74; Plafker and Jones, 1982, p. 78, fig. 1). The Brooks Range and the Canada Basin may have formed simultaneously during the Late Jurassic or Early Cretaceous by the counterclockwise rotation of Arctic Alaska (Mull, 1984; Tozer 1982, p. 1085). Several studies, however, suggest no post-Triassic rotation (Churkin, 1972; Churkin and Trexler, 1981; Dutro, 1981). The affinities of the ostracodes, on the generic level, to those in the Primor'ye Territory support the latter view.

With one exception, *Cornutobairdia reidae* n. sp., from the Lewes River Formation (Norian), Yukon Territory, Canada, the ostracodes described herein are from the Shublik Formation in the northern segment of Alaska. The distinctive lithology, namely thin-bedded black phosphatic limestone and dolomite, shale and chert, and abundant fossils, make the Shublik Formation a readily recognized stratigraphic unit in northern Alaska. This formation represents a condensed sequence of rock of remarkably uniform thickness. Detterman and others (1975, p. 14–16) designated the Fire Creek outcrop section as the reference section of the Shublik Formation. They described the distribution of the formation and the stratigraphic relations, lithology, and age based on megafossils of the section. *C. reidae* is included to indicate that the accretionary terranes may contain entirely different Triassic ostracode assemblages.

Age of the Ostracodes

Silberling (Detterman and others, 1975, p. 15, fig. 6; p. 43) recorded *Daonella frami* Kittl and *Leiophyllites* sp. in the basal siltstone member of the Shublik Formation at the reference section. USGS colln. M6052, collected from 8.2 to 21.9 meters (27–72 feet) above the base of the Shublik Formation, indicates an Anisian or Ladinian age. Only a small carapace of *Ogmoconcha tailleuri* (USNM 389916) was recovered from the siltstone member of the Shublik Formation at 25.9 m (85 ft) above the base of the Shublik Formation (USGS colln. 33106).

The lower part of the overlying limestone and dolomite member of the Shublik Formation yielded most of the ostracodes. The majority occurred from approximately 30 to 70 m (100–235 ft) above the base of the formation. Based on the megafossils, this interval is Ladinian in age. USGS colln. M6054 from the limestone and dolomite member, 30.5 m (100 ft) above the base of the Shublik Formation, contains *Daonella frami* Kittl, and USGS colln. M6053 in the same member, 30.5 to 33.5 m (100–110 ft) above the base of the Shublik Formation, contains *D. frami*, *Lima* sp., *Camptonectes* sp., and spiriferoid brachiopods; these indicate a Ladinian age for this interval. Only three ostracode taxa, *Covracythere gryci* n. sp., *O.* sp. aff. *O. owthropensis* (Anderson, 1964), and *O. tailleuri* n. sp. extend above this interval into the Norian. The ostracodes from 30.5 to 70 m (100–230 ft) must be Ladinian because of the associated megafossils.

The middle part of the section, the limestone member of the Shublik Formation, from approximately 69 m (225 ft) to approximately 97 m (320 ft) above the base of the Shublik Formation is Carnian in age. Silberling (Detterman and others, 1975, p. 15, fig. 6, p. 43) recorded the following Carnian megafossils from USGS colln. M6056, from 68.6 to 71.6 m (225–235 ft) above the base of the Shublik Formation in the limestone member: *Halobia* cf. *H. zitteli* Lindstrom, *Leptochondria nationalis* Smith, *Gryphea* sp., *Lima* sp., arcetid ammonites, rhynchonellid brachiopods, and gastropods. In USGS colln. M6057, from about 74 to 97 m (245–320 ft) Silberling recorded the following Carnian megafossils: *Halobia* cf. *H. zitteli* Lindstrom, *H. ornatissima*, and *Sirenites* sp. Only *Pseudobythocypris*? sp. is restricted to this interval.

The overlying clay shale member of the Shublik Formation, from approximately 106 to 145.5 m (350–477 ft) above the base of the Shublik Formation is Norian in age based on the megafossils from the upper part of this member, from about 127 m (420 ft) above the base of the Shublik Formation. Siberling (Detterman and others, 1975, p. 16, 45) recorded the following megafossils in USGS collns. M6058, M6059, and M6067: *Halobia* cf. *H. fallax* Mojsisovics, *H.* cf. *H. lineata* Mojsisovics, *Monotis scutiformis pinensis* Westermann, *M.* cf. *M. scutiformis* Westermann, *M.* cf. *M. obtusicostata*, *Gryphea* sp. and rhynchonellid brachiopods. Of the eight ostracode taxa recovered from the Norian, *Ogmoconcha marquardti* n. sp., *O. alaskaense* n. sp., *Hiatobairdia*? sp. ex gr. *H. arcuata* Kristan-Tollmann, 1970, *Triassocypris*? sp., and Gen. and sp. indet. are confined to this unit; the other three taxa extend upward from the Ladinian.

The Triassic ostracodes described from northeastern Alaska are new species, taxa tentatively referred to related or known Triassic species, or undescribed species discussed and illustrated in open nomenclature. Except for *Dettermania* n. gen., *Ogmoconcha* Triebel, 1941 [originally described from the Liassic (Lower Jurassic)], and *Pseudobythocypris* Shaver, 1958 (previously known from the Paleozoic), all the taxa are related to genera known from the

Primor'ye Province from the Pacific Ocean Zoogeographical Region (Burij and Zharnikova, 1977, p. 90–92) or from the Tethyan Zoogeographical Region, as shown in table 1.

Paleogeographic Implications

The affinity of the ostracodes in northeastern Alaska with those in the Primor'ye Territory (table 2) poses a paleogeographical problem. Tozer (1982) based a model for the Triassic paleogeography on plate tectonics, paleomagnetics, and paleontology. The upper map of Tozer (1982, p. 1094–1095, fig. 2) represents the Triassic, and the lower map as well as a large scale map (Tozer, 1982, p. 1083, fig. 1) show the current world geography. The paleogeographic model shows the paleopacific (Panthalassa) to contain scattered shoals and islands. Plate-bound areas on Tozer's maps of the present are shown to include northeastern Alaska, where the ostracodes were collected. The Triassic model shows the Primor'ye Territory as part of a midpaleolatitude, about 40°N. of the Triassic equator (Tozer, 1982, p. 1086), volcanic terrane that later became part of Japan and part of Asia (Tozer, 1982, p. 1095, fig. 2, no. 18). Blome and Reed (oral commun., 1984) reported that some of the Triassic radiolarians in the Brooks Range, Alaska, are related on the generic level to those in Japan.

Table 1. Stratigraphic occurrences of taxa in Alaska

Taxa	Ages		
	Ladinian	Carnian	Norian
Covracythere binoda n. sp.	X		
Recytella sp. 1	X		
Recytella sp. 2	X		
Dettermania truncata n. sp.	X		
"*Healdia*" sp. 1	X		
"*Healdia*" sp. 2	X		
Rhombocythere? sp.	X		
Ogmoconcha? sp. aff. *Hungarella limbata* (Reuss, 1868)	X		
Cavussurella? sp. 1	X		
Cavussurella? sp. 2	X		
Ogmoconcha unicerata n. sp.	X		
Ogmoconcha tailleuri n. sp.	X		X
Covracythere gryci n. sp.	X		X
Ogmoconcha sp. aff. *O. owthropensis* (Anderson, 1964)	X	X	X
"*Healdia*" sp. 3	X	X	
Cavussurella grammi n. sp.	X	X	
Pseudobythocypris? sp.		X	
Ogmoconcha marquardti n. sp.			X
Ogmoconcha alaskaense n. sp.			X
Hiatobairdia? sp. ex gr. *H. arcuata* Kristan-Tollmann, 1970			X
Triassocypris? sp.			X
Gen. and sp. indet.			X

Table 2. Paleozoogeographical provinces and ages of related taxa

[Provinces: *=Primor'ye, **=Tethyan, ***=Britain and Germany]

Taxa	Age
Cavussurella grammi n. sp	*Upper Anisian
Covracythere binoda n. sp.	Do.
"*Healdia*" sp. 1	*Upper Anisian
"*Healdia*" sp. 2	Do.
"*Healdia*" sp. 3	Do.
Cavussurella grammi n. sp.	Do.
Covracythere gryci n. sp.	Do.
Cavussurella? sp. 1	Do.
Cavussurella? sp. 2	Do.
Recytella sp. 1	*Ladinian
Recytella sp. 2	Do.
Ogmoconcha? sp. aff. *Hungarella limbata* (Reuss, 1868)	**Lower Carnian
Ogmoconcha unicerata n. sp.	Do.
Rhombocythere sp.	**Norian-Rhaetian
Pseudobythocypris? sp.	Do.
Ogmoconcha tailleuri n. sp.	***Rhaetian
Ogmoconcha sp. aff. *O. owthropensis* (Anderson, 1964)	Do.
Hiatobairdia? sp. ex gr. *H. arcuata* Kristan-Tollmann, 1970	**Rhaetian
Ogmoconcha alaskaense n. sp.	Do.
Triassocypris? sp.	Do.
Ogmoconcha marquardti n. sp.	Do.

A different model for the Triassic faunal relation was proposed by Kristan-Tollmann and Tollmann (1981, fig. 1; 1983, fig. 9). They considered the Triassic Pacific Ocean as a gigantic ocean without any islands in which a major paleocurrent, the "Tethys current," transported the Triassic fauna from the west coast of North America to the Mediterranean (Tethyan) Zoogeographical Province.

Neither model explains the similarity on the generic level of the ostracodes in northern Alaska to those in the Primor'ye Territory. A combination of the above models may explain more closely the similarities. Although Tozer (1982) did not discuss paleocurrents, currents in the Triassic certainly influenced the distribution of marine organisms (Choi, 1984, p. 731). If the paleocurrent patterns proposed by Kristan-Tollman and Tollmann (1981) were modified, reflecting the presence of the various islands and shoals, the new model could explain the similarity on the generic level shown in table 2.

Burij and Zharnikova (1977) used the Jaccard coefficient in the analysis of Triassic ammonite genera to determine paleozoogeographic provinces. They distinguished two latitudinal zoogeographic provinces in the northern Pacific Basin: a northern, colder, Yakutian–Canadian (including northern Alaska) subregion in the Boreal Zone and a warmer Primor'ye–Californian subregion in the Equatorial Zone. During the early Middle Triassic (Anisian), the Yakutian province was connected closely with the Primor'ye province (Burij and Zharnikova, 1977, p. 102). During the Ladinian, the Yakutian and Canadian provinces (including northern Alaska) were interconnected (Burij and Zharnikova, 1977, p. 104). Paleocurrents during the Anisian could have distributed the Primor'ye taxa described by Gramm (1969a, b, 1970, 1975) into the Yakutian province, and, during the Ladinian, paleocurrents could have transported those taxa into the area of northeastern Alaska.

Environment of the Ostracodes

The genera to which the taxa in northeastern Alaska are assigned indicate a benthic life style, probably less than 200 m in depth. Dutro (1981, p. 25) proposed that the Shublik Formation was deposited in relatively deep water far from shore. He based his conclusions on the fact that the sediments consist of thin-bedded phosphatic limestone, shale, and chert. According to Dutro, the Shublik Formation represents a comparatively long period of time in which very little sediment was deposited.

Burij and Zharnikova (1977) considered Alaska to be located in a Boreal Paleozoogeographical Province. The presence in Alaska of taxa related on the generic level (table 2) to forms originally described from Britain and northern Germany that were connected to the Boreal Sea (Fisher, 1984) supports their interpretation.

The ostracode assemblage in northeastern Alaska differs markedly on the generic level from the ostracodes in the Lewes River Formation (Norian), Yukon Territory, Canada. This formation contains *Cornutobairdia reidae* n. sp., described herein, and undescribed taxa tentatively referred to the following genera: *Acratia* Delo, 1930, Paleozoic through Upper Triassic; *Alatobairdia* Kristan-Tollmann, 1971b, Rhaetian; *Bairdia* McCoy, 1844, smooth type, Paleozoic through Holocene; *Bairdiacypris* Bradfield, 1935, Paleozoic through Rhaetian; *Carinobairdia* Kollmann, 1963, Norian through Rhaetian; *Ceratobairdia* Sohn, 1954 sensu Kristan-Tollman, 1970, Permian through Rhaetian; *Leviella* Sohn, 1968, Anisian through Rhaetian; *Lobobairdia* Kollmann, 1963, Norian through Rhaetian; *Polycopsis* Müller, 1894, Scythian through Holocene; *Ptychobairdia* Kollmann, 1960, Norian through Rhaetian; *Vavilovella* Kozur, 1973, Norian; and additional, as yet unidentified, taxa.

THE *HUNGARELLA-OGMOCONCHA* PROBLEM

The *Hungarella–Ogmoconcha* problem was created when Méhes (1911, p. 21, pl. 2. figs. 14–18) described *Bairdia? problematica* and stated (p. 22) that if subsequent investigations determined that the species belonged to a new genus, that genus should be named in the literature as *Hungarella*. The original description of *Bairdia? problematica* (Méhes, 1911, p. 21, 22) stated that the valves were very well preserved and not thick, were completely glassy, and were transparent. The above description suggests a Holocene or Tertiary contamination, either in the field or in the laboratory, of some of the collections that Méhes studied.

Triebel (1941, p. 377) described and illustrated with excellent photographs the genus *Ogmoconcha* from the Liassic of Germany. Shaver (Moore, 1961, p. Q161), van Morkhoven (1963, p. 132), and Anderson (1964, p. 146) considered *Ogmoconcha* to be a junior subjective synonym of *Hungarella* because conditional names, such as *Hungarella*, were declared valid according to Article 17(8) in the second edition of the International Code of Zoological Nomenclature [Stoll and others, 1961, p. 17; article 51c (ii) of the third edition (International Commission on Zoological Nomenclature, 1985, p. 97)]. Sohn (1968, p. 28) discussed the differences between *Ogmoconcha* and *Hungarella* Méhes, 1911. Since that time, the *Hungarella–Ogmoconcha* problem has been discussed by Kozur (1970b, p. 20), Bolz (1971b, p. 156, 243), Malz (1971, p. 434), Lord (1972, p. 332; 1982, p. 262), Gerry and Kozur (1973, p. 67–69), Kristan-Tollmann (1977, p. 133, 142, 143), and Bate (1978, p. 186). Except for Lord (1972, p. 352), the above writers did not take into account the possibility that Méhes included younger contaminants in his faunule (Mandelstam, 1960, footnote p. 292; Sohn, 1968, p. 39; Tappan, 1951, p. 7; Vadasz, 1933, p. 173). Lord (1982, p. 262) considered the relationship of *Ogmoconcha* and *Hungarella* to be unresolved until topotype material of *Hungarella* would be restudied and reillustrated.

The basic problem involves the presence or absence of a calcified inner lamella (duplicature), a denticulate hinge, and an aggregate, so-called healdiid, adductor muscle scar in *Hungarella*. An aggregate adductor muscle scar has been described in *Ogmoconcha* and also in the original and subsequent descriptions of *Hungarella*. Gerry and Kozur (1973, p. 67–69) reported that they examined a "cell" containing type material of Méhes (1911) at the Hungarian Geological Institute and noted the following regarding *Hungarella* "*Bairdia*"? *problematica* Méhes, 1911: "Syntype T685 AFL Ladinian, Felsörs. Destroyed, some badly preserved fragments showing no calcified inner lamella. (Generotype of *Hungarella*!!)"

My experience with ostracode types (Zalanyi, 1959) at the Hungarian Geological Survey may provide a plausible explanation as to the condition of the types of *Hungarella*. I saw Zalányi's Aptian types at the Hungarian Geological

Institute, Budapest, on August 10, 1976. All the specimens were on one large, plastic, multicelled slide that was covered by similar material attached at the corners with tiny screws. The cover was inscribed with a grid covering each cavity so that the species in each cavity was identified by coordinates written in a notebook. I recognized in this multicelled slide that the specimen in the cavity identified as *Metacypris aculeata* Zalányi, 1959, was not that species, and I saw many specimens, some crushed, that had moved into neighboring cavities with time and handling since Boda (1964) published his catalogue of Hungarian fossils. It is possible that the fragments examined by Gerry and Kozur (1973. p. 67, 69) in the *Bairdia? problematica* cavity may have had a similar history and belong to a different species, or they may represent different specimen than the one illustrated by Lord (1972, pl. 1, figs. 1a, b) with the same catalog number. Lord (1972, p. 321) stated that his illustration was provided by the Hungarian Geological Institute.

Hungarella? pricei Sohn, 1968, from the Ladinian of Israel, and *Hungarella?* sp. Sohn, 1970, from the Early Triassic of the Salt Range, West Pakistan, have calcified inner lamellas and denticulate hingements (Sohn, 1968, p. 29, pl. 2, figs. 28, 29, text fig. 3; 1970, p. 204, pl. 1, figs. 41, 42). Méhes (1911, p. 21) did not record a denticulate hinge in the type species, *Bairdia? problematica*, nor in the second taxon, *B.? problematica* var. *reniformis*. He did mention that two specimens of the variety *reniformis* have a strong ventroposterior spine. Kozur (1970a, p. 22, pl. 4, figs. 15–17) described and illustrated *Healdia* (*Hungarella*) *reniformis* (Méhes, 1911), from the Anisian and Ladinian of Hungary, and stated that the hinge is not denticulate ("Schlosselemente glatt").

Dr. J. Fülöp, Director of the Hungarian Geological Survey, mailed me some washed samples from the Triassic of Hungary, including one from the Carnian marl that is equivalent to locality no. 5 of Méhes (USGS colln. 33172). He informed me (written commun., June 22, 1966) that it was (and still may be) impossible to collect at the localities studied by Méhes. Specimens with a posteroventral spine and a denticulated hinge are present in the collection, and one is illustrated herein as *Ogmoconcha* sp. (pl. 10, figs. 12, 13; Sohn, 1984b, fig. 11E–G). Other specimens in the collection have thick valves and are opaque, and the adductor muscle scar could not be discerned even after treatment with hydrofluoric acid (pl. 11, figs. 13–16, 20–23).

A "healdiid" adductor muscle scar combined with a denticulate hinge were illustrated by Gramm (1982, p. 198, text figs. 6–8; pls. 2–5) for the Lower Carboniferous genus *Healdianella* Posner, 1951. Anderson (1970, fig. 1) and Sohn (1977, fig. 1b; 1985, figs. 2.3, 2.7, 2.10, 2.14, 3.18) illustrated a similarly aggregate adductor muscle scar for the nonmarine genus *Carbonita* Strand, 1928, that does not have a denticulate hinge. The number of individual adductor muscle scars in the living *Darwinula stevensoni* (Brady and Robertson, 1870) is not related to growth stages and may vary in opposite valves of the same individual (Sohn, 1976, p. 305). The "healdiid" adductor muscle scar is clearly developed in several different groups of Ostracoda; consequently, the "healdiid" pattern should not be used as the sole criterion for generic determination. To validate *Hungarella* Méhes, 1911, a neotype should be selected from the Hungarian Triassic, and the genus should be redefined, because, based on the present information, the taxon should be considered a nomen dubium.

USGS MESOZOIC FOSSIL COLLECTION LOCALITIES

[All collections measured from base of Shublik Formation, conversion of feet to meters to the nearest 0.1 m. Measured reference section of the Shublik Formation (Detterman and others, 1975, p. 14, fig. 6), located 13.4 km (6.3 mi) 84°W. of the confluence of Fire Creek with the Sadlerochit River, Mount Michelson quadrangle, Alaska; lat. 69°31'45"N., long. 145°12'20"W. Collected by R. L. Detterman, field station 69 ADT 105]

Siltstone Member (Anisian and Ladinian)

33106. 25.9 to 27.4 m (85–90 ft). Field no. 3–3.

Limestone and Dolomite Member (Ladinian)

33107. 30.5 to 32.0 m (100–105 ft). Field no. 3–6.
33108. 32.0 to 33.5 m (105–110 ft). Field no. 3–7.
33109. 33.5 to 35.1 m (110–115 ft). Field no. 3–8.
33110. 35.1 to 36.6 m (115–120 ft). Field no. 3–9.
33111. 36.6 to 38.1 m (120–125 ft). Field no. 3–10.
33112. 38.1 to 39.6 m (125–130 ft). Field no. 3–11.
33113. 39.6 to 41.1 m (130–135 ft). Field no. 3–12.
33114. 41.1 to 42.7 m (135–140 ft). Field no. 3–13.
33115. 42.7 to 44.2 m (140–145 ft). Field no. 3–14.
33116. 44.2 to 45.7 m (145–150 ft). Field no. 3–15.
33117. 45.7 to 47.2 m (150–155 ft). Field no. 3–16.
33118. 47.2 to 48.8 m (155–160 ft). Field no. 3–17.
33119. 48.8 to 50.3 m (160–165 ft). Field no. 3–18.
33120. 50.3 to 51.8 m (165–170 ft). Field no. 3–19.
33121. 51.8 to 53.3 m (170–175 ft). Field no. 3–20.
33122. 53.3 to 54.8 m (175–180 ft). Field no. 3–21.
33123. 54.8 to 56.4 m (180–185 ft). Field no. 3–22.
33124. 56.4 to 57.9 m (185–190 ft). Field no. 3–23.
33125. 57.9 to 59.4 m (190–195 ft). Field no. 3–24.
33126. 59.4 to 61.0 m (195–200 ft). Field no. 3–25.
33127. 61.0 to 62.5 m (200–205 ft). Field no. 3–26.
33128. 62.5 to 64.0 m (205–210 ft). Field no. 3–27.
33129. 64.0 to 65.3 m (210–215 ft). Field no. 3–28.
33130. 65.3 to 67.1 m (215–220 ft). Field no. 4–1.
33131. 67.1 to 68.6 m (220–225 ft). Field no. 4–2.

Limestone Member (Carnian)

33132. 68.6 to 70.1 m (225–230 ft). Field no. 4–3.
33133. 82.2 to 83.8 m (27–275 ft). Field no. 5–9.
33134. 83.8 to 85.3 m (27–280 ft). Field no. 5–10. No ostracodes recovered.

33135. 85.3 to 86.9 m (280–285 ft). Field no. 5–11. No ostracodes recovered.

33136. 86.9 to 88.4 m (285–290 ft). Field no. 5–12.

33137. 88.4 to 89.9 m (290–295 ft). Field no. 5–13.

33138. 89.9 to 91.4 m (295–300 ft). Field no. 5–14. No ostracodes recovered.

33139. 91.4 to 93.0 m (300–305 ft). Field no. 5–15. No ostracodes recovered.

33140. 93.0 to 94.5 m (305–310 ft). Field no. 5–16.

33141. 94.5 to 96.0 m (310–315 ft). Field no. 5–17.

33142. 96.0 to 97.5 m (315–320 ft). Field no. 5–18.

33143. 97.5 to 99.1 m (320–325 ft). Field no. 5–19.

Clay Shale Member (Norian)

33144. 106.7 to 108.2 m (350–355 ft). Field no. 6–6.

33145. 108.2 to 109.7 m (360–365 ft). Field no. 6–7.

33146. 109.7 to 111.3 m (360–365 ft). Field no. 6–8.

33147. 111.3 to 112.8 m (365–370 ft). Field no. 6–9.

33148. 112.8 to 114.3 m (370–375 ft). Field no. 6–10.

33149. 114.3 to 115.8 m (375–380 ft). Field no. 6–11.

33150. 115.8 to 117.3 m (380–385 ft). Field no. 6–12.

33151. 117.3 to 118.9 m (385–390 ft). Field no. 6–13.

33152. 118.9 to 120.4 m (390–395 ft). Field no. 6–14.

33153. 120.4 to 121.9 m (395–405 ft). Field no. 6–15.

33154. 121.9 to 123.4 m (400–405 ft). Field no. 6–16.

33155. 123.4 to 125.0 m (405–410 ft). Field no. 6–17.

33156. 125.0 to 126.5 m (410–415 ft). Field no. 6–18.

33157. 126.5 to 128.0 m (415–420 ft). Field no. 6–19.

33158. 128.0 to 129.5 m (420–425 ft). Field no. 6–20.

33159. 129.5 to 131.1 m (425–430 ft). Field no. 6–21.

33160. 131.1 to 132.6 m (430–435 ft). Field no. 6–22.

33161. 132.6 to 134.1 m (435–440 ft). Field no. 6–23.

33162. 134.1 to 135.6 m (440–445 ft). Field no. 6–24.

33163. 135.6 to 137.2 m (445–450 ft). Field no. 6–25.

33164. 137.2 to 138.7 m (450–455 ft). Field no. 6–26.

33165. 138.7 to 140.2 m (455–460 ft). Field no. 6–27.

33166. 140.2 to 141.7 m (460–465 ft). Field no. 6–28.

33167. 141.7 to 143.3 m (465–470 ft). Field no. 6–29.

33168. 143.3 to 144.8 m (470–475 ft). Field no. 6–30.

33169. 144.8 to 145.4 m (475–477 ft). Field no. 6–31.

Other localities

33170. South side of Lime Peak, about 300 m above level of Lake Thomas, 60°04′24″N., 134°51′6″W., Whitehorse Trough, Yukon Territory, Canada. Interreef limestone beds in the Lewes River Formation, Norian. Collected by Pamela Reid, field no. R–80–b.

33171. North side of Lime Peak, about 450 m above Thomas Lake (on south side of peak), and 250 m above ponds in valley on north side, 61°04′02″N., 134°53′42″W. Collected by Pamela Reid, field no. R–39–8.

33172. Lower Carnian marl from Csopak, Neszteri Valley, Hungary, corresponds to that of locality no. 5 studied by Méhes (1911). Sent by Dr. J. Fülöp, Director, Hungarian Geological Survey, June 1966.

SYTEMATIC PALEONTOLOGY

Except those illustrated specimens deposited in the geological Survey of Canada, Ottawa (GSC), all specimens are deposited in the National Museum of Natural History, Washington, D.C. (USNM).

Order PODOCOPIDA Sars, 1866
Suborder BAIRDIOCOPINA Gründel, 1967
Superfamily BAIRDIACEA Sars, 1888
Family BAIRDIIDAE Sars, 1888
Subfamily BAIRDIINAE Sars, 1923
Genus HIATOBAIRDIA Kristan-Tollmann,1970

Hiatobairdia Kristan-Tollmann, 1970, p. 285. Rhatean, Austria.

Type species.—H. subsymmetrica Kristan-Tollmann, 1970, p. 286, pl. 35, figs. 1-3.

Discussion.—Kristan-Tollmann (1970, p. 286-289) described three species in *Hiatobairdia: H. subsymmetrica* based on seven specimens and *H. labrifera* and *H. arcuata* based on a single specimen each. I doubt whether the three species are congeneric. Because I have only three small steinkerns, I do not have sufficient information to establish a new generic category; consequently, I am referring them to *Hiatobairdia?* sp. ex gr. *H. arcuata.*

Geologic range.—Upper Triassic.

Geographic distribution.—Known from Europe, and ?northeastern Alaska.

Hiatobairdia? sp. ex gr. H. arcuata Kristan-Tollmann, 1970

Plate 2, figures 18, 19

Hiatobairdia arcuata Kristan-Tollmann, 1970, p. 288, pl. 35, fig. 5. Rhaetian, Austria.

Hyatobairdia sic. sp. ex gr. *H. arcuata* Kristan-Tollmann, 1970. Sohn 1984b, p. 21 figure 11H.

not *Bairdia arcuata* (Kristan-Tollmann, 1970). Bolz, 1971a, p. 170, pl. 6, figs. 65–67. Differs in lateral outline.

not *Hiatobairdia* aff. *H. arcuata* Bolz, 1971b, pl. 1, fig. 6.

Discussion.—The three small steinkerns resemble *H. arcuata* in lateral outline and in that both ends curve upwards; they differ in that the ventral margins are convex instead of straight, and the greatest width is above the midheight instead of below the midheight.

Measurements (in mm).—USNM 389814, greatest length, 0.50, greatest height 0.30; measured specimen, USNM 389815, greatest length 0.45, greatest height 0.30; measured specimen, USNM 389816, greatest height 0.42, greatest height 0.35.

Geologic range.—Norian, from 112.0 to 140.9 m (370–465 ft) above the base of the Shublik Formation.

Genus CORNUTOBAIRDIA Kristan-Tollmann, 1970

Cornutobairdia Kristan-Tollman, 1970, p. 303.

Triebelina (Triebelina) van den Bold, 1946, of Bolz, 1971a, p.183.

Type species.—C. reticulata Kristan-Tollmann, 1970, p. 305, pl. 37, figs. 4–6. Rhaetian, "Plackles," Austria.

Original diagnosis (translated).—"Carapace elongated, strongly to moderately sculptured with three more or less elongated elements of which the two outer may join into a ring. The sculpture of both valves is different, in that the dorsal area of the left valve differs from the right; the left has additional strong sculpture, that expands into knobs and spines particularly in the posterodorsal area (compare generotype). In addition, the complete carapace is covered by a netforming pitted sculpture. The hinge is a simple, smooth bairdiid hinge terminated by numerous toothlets."

Discussion. —Kristan-Tollmann illustrated the type species with drawings of two carapaces that are dimorphic in width of dorsal and ventral outlines (1970, pl. 37), figs. 4a–d, 5a–d) and the hingement of a right valve (1970, pl. 37, figs. 61, b). She referred to *C. reticulata* a specimen from the same locality, illustrated by Kollmann as *Triebelina* sp./498 with photographs of the inside and outside of a right valve (Kollmann, 1963, 1979, pl. 8, figs. 11, 13). Kristan-Tollmann (1970, p. 306) stated that the right valve illustrated in outside view by Kollmann (1963, p. 1979, pl. 8, fig. 12) as *Triebelina* sp. 158 represents an additional species in this genus and illustrated a juvenile left valve (Kristan-Tollmann, 1970, pl. 37, fig. 3a, b) as *Cornutobairdia* n. sp. from the Rhaetian Zlambachmergeln at Krautgartenalm, Austria. Kristan-Tollmann (1971b, p. 77, pl. 5, figs. 4, 5) referred the above specimen to *C. trinodosa* Kristan-Tollmann, 1971b. Bolz (1971a, p. 720) considered the above specimen as the A-3 stage of *Triebelina* sp./158 Kollmann, 1963, and illustrated a right valve of *C. reticulata* (Bolz, 1971b, p. 721, pl. 2, fig. 12). Bolz (1971a, p. 184, pl. 9, figs. 122–126, text fig. 24) considered *Cornutobairdia* a synonym of *Triebelina* and referred all the above taxa except *C. trinodosa* to *Triebelina (Triebelina) reticulata* (Kristan-Tollmann, 1970), republished his plate 2, figure 12 as plate 9, figure 124, and recorded the range of the species as Upper Norian-?Liassic. Kozur (1972a, p. 652, pl. 2, fig. 2) republished Bolz's (1971b) plate 9, figure 122, as *"Triebelina reticulata"* and included Bolz's photograph on a plate illustrating a shallow neritic Upper Norian ostracode assemblage.

Bolz (1971a, p. 176–183) reviewed the literature on *Triebelina* van den Bold, 1964, and constructed a table showing characters of species in that genus. All the species of Tertiary to present ages, except *Triebelina schulzi* Hartmann, 1964, are from 0.59 to 0.75 mm in greatest length. The living *T. schultzi* Hartmann, 1964, is recorded to be 1.04 mm in greatest length, and the species is smooth (Hartmann, 1964, p. 44, pl. 4, fig. 14) and has a denticulated hinge (Hartmann, 1964, p. 45, pl. 4, figs. 20, 21); consequently, *T. schulzi* should not be classified with either *Triebelina* or *Cornutobairdia.* Van Morkhoven (1963, p. 35) recorded the length of species in *Triebelina* to be from 0.6 to 0.9 mm. Specimens of *Cornutobairdia* are larger than 1.0 mm (Bolz, 1971b, text figs. 23, 24), and all the species described in the genus have a dorsoposterior horn on the larger valve or on both valves, a feature not recorded in *Triebelina. Cornutobairdia,* although related to *Triebelina,* is considered a valid genus for the above reasons. Combining the two taxa masks the stratigraphic utility of both genera. The following species are known:

Cornutobairdia bicornuta Kristan-Tollmann, 1979, p. 153, pl. 7, fig. 4; pl. 8, fig. 4, Rhaetian, Persia.

C. reidae n. sp., Norian, Canada.

C. reticulata Kristal-Tollmann, 1970, p. 305, pl. 37, figs. 4–6, Upper Norian-?Liassic, Austria.

C. trinodosa Kristen-Tollmann, 1971b, p. 77, figs. 4, 5, Upper Norian-Austria.

Geologic range.—Upper Norian-?Liassic.

Geologic distribution.—Known from Europe and North America.

Cornutobairdia reidae Sohn, n. sp.

Plate 3, figures 1–6

Etymology of name.—In honor of Ms. Pamela Reid, University of Miami, who collected the samples that contain this species.

Holotype.—GSC 80063.

Paratypes.—GSC 80064-80066, USNM 389830–389834.

Type locality.—Southern slope of Lime Peak, Yukon Territory, Canada, USGS colln. 33170.

Other locality.—Northwest slope of Lime Peak, Yukon Territory, Canada, USGS colln. 33171.

Type level.—Lewes River Formation, Norian, USGS colln. 33170.

Diagnosis.—Cornutobairdia with two subcentral nodes, dorsal margin of the larger valve with upward-trending spine near anterior and dorsolateral trending spine near posterior, minute spinelets on anterior and ventroposterior margins. Reversal of overlap and hingement present, but mostly left valve larger.

Description.—The shells are heavily calcified, asymmetrical; larger valve overreaches the smaller along a straight dorsal hinge, overlaps slightly along the gently convex ventral margin. The surface of the larger valve bears a large node at or slightly below midheight in front of the greatest length of the hingeline and a second, smaller node located slightly higher than the subcentral node about equidistant from the hingeline and dorsoposterior margin. The dorsoposterior margin is obtuse, with about 130° angle from the posterior end of the hingeline, extends backward to about three-fourths of the height or below the posterior node, and then points to the rear to form a posterior spine; it then curves gently forward to meet the gently convex ventral margin. The anterior margin is subround, the dorsoanterior is straighter than the dorsoposterior. A rounded rim borders the ventral and anterior margins and continues above the dorsal margins as a spine (pl. 3, figs. 2, 3, 6). From this spine, a straight, narrower ridge extends backwards to the posterior corner where it forms a posterolateral-pointing sharp spine. Above the dorsal ridge, the dorsal margin forms a pleatlike ridge that bends inward to overreach the hingeline (pl. 3, figs. 2, 5).

The smaller valve has two nodes and a rounded rim along the ventral and anterior margins as well as along the posteroventral margin but lacks the dorsal spines and the pleatlike overreaching structure of the larger valve. The anterior and ventroposterior margins bear minute spinelets (pl. 3, figs. 4, 5). The duplicature is wide along the anterior margin, narrow or missing along the posterior margins on both valves.

Measurements (in mm).—Width measured on subcentral nodes. USNM 389831 contains seven specimens, USNM 389832 contains two specimens. R. V. = right valve, L. V. = left valve).—

	Greatest length	*Greatest height*	*Greatest width*
GSC 80063, larger R. V.	1.10	0.65	0.52
GSC 80064, smaller R. V.	1.05	.50	
GSC 80065, larger L. V.	1.04	.63	
GSC 80066, larger L. V.	.96	.50	.45+
Paratype, USNM 389830, larger L. V.	1.00	.50	.45
Paratypes, USNM 389831, larger L. V.	1.0–1.20	.53–.64	
Paratype, USNM 389833, larger L. V.	1.05	.61	

Discussion.—The ostracodes are silicified, many are poorly preserved, and the adductor muscle scar is not observed. The marginal spines can be seen on the single valve (pl. 3, figs. 4, 5). This species is associated with specimens on which the subcentral nodes coalesce to form a ridge (USNM 389835, 389836) similar to those illustrated by Bolz (1971b, pl. 9, figs. 122–126) as *Triebelina (Triebelina) reticulata* (Kristan-Tollmann, 1970) = *Cornutobairdia.* A few specimens have three distinct nodes in a straight line, with or without the posterior node extending into a lateral spine (USNM 389836). These variants are not yet available in sufficient numbers for a population study to determine whether they represent one or more species. They are, however, distinct from *C. reidae* because the posterior node in the new species is located higher on the lateral surface than the subcentral node, and, on the variants, more than two nodes occur in a straight line.

Geologic range.—Known only from the two collections from the Lewes River Formation (Norian) in the Yukon Territory, Canada. USGS collns. 33170, 33171.

Suborder unknown
Superfamily unknown
?Family PARACYPRIDIDAE Sars, 1923
Genus TRIASSOCYPRIS Kozur, 1970

Type species.—*Macrocypris? pusilla* Kozur, 1968b, p. 500, pl. 2, figs. 14, 20–27. Lower and Middle Triassic, Thuringia.

Diagnosis (translated).—"Carapace small, right valve larger than left; dorsal margin convex, not angled; posterior margin pointed; ventral margin almost straight. Shell surface smooth. Hinge adont. Calcified inner lamella and vestibule wide in front, otherwise narrow."

Kozur assigned to this genus the holotype *T. pusilla* (Kozur, 1968b) and *T. tenuis* (Kozur, 1968b), both originally described as *Macrocypris?*.

Discussion.—Kozur (1970b, p. 445) referred *Triassocypris* to the Paracyprididae. The Paracyprididae were defined in Moore (1961, p. Q245) as having a wide duplicature and large anterior and posterior vestibules. *Triassocypris* has a wide anterior and a narrow posterior vestibule and probably should not be classified in the Paracyprididae.

Geolgoic range.—Triassic.

Geographic distribution.—Known from Europe and, questionably, from northeastern Alaska.

Triassocypris? sp.
Plate 11, figures 1–4

Discussion.—The Upper Triassic specimen from Alaska is a poorly preserved carapace with most of the shell probably missing; consequently, the internal morphology of the valves is unknown. Because the specimen resembles *Triassocypris* in lateral outline, I am tentatively referring it to the genus.

Measurements (in mm).—Plate 11, figures 1–4, USNM 390005, greatest length 0.30, greatest height 0.15.

Geologic range.—Norian, from 111.3 to 112.8 m (365–370 ft) above the base of the Shublik Formation. USGS colln. 33147.

Gen. and sp. indet.
Plate 11, figures 5, 6

Discussion.—The illustrated specimen is a poorly preserved carapace from the same collection as *Triassocypris?* sp. It differs in having a less pointed posterior, and the left valve apparently overlaps the right.

Measurements (in mm).—Plate 11, figures 5, 6, USNM 390006, greatest length 0.27, greatest height 0.15.

Geologic range.—Norian, from 111.3 to 112.8 m (365–370 ft) above the base of the Shublik Formation. USGS colln. 33112.

Suborder CYTHEROCOPINA Gründel, 1967
Superfamily CYTHERACEA Baird

Discussion.—The adductor muscle-attachment scar illustrated on pl. 2, figs. 22–26, is typical for Cyntheracea.

Family COVRACYTHERIDAE n. fam.

Diagnosis.—Small, less than 1 mm in length, elongated, with straight dorsal and gently convex ventral margins, with sulcus in front of midlength, two or more horizontal ribs that may or may not join at end margins, surface finely punctate or smooth. Hingement unknown, hingeline obscured by dorsal rib; overlap slight, left over right. Dimorphic in width of posterior.

Discussion.—Gramm (1975) referred *Covracythere* and two additional Triassic genera to the subfamily Editinae Knüpfer, 1967, in the Bythocytheridae Sars, 1926. Although the nominate genus, *Editia germanica* Knüpfer, 1967, has a cytheracean adductor muscle-attachment scar, it has a well-developed eye tubercle that is not present in *Covracythere* nor the other genera referred herein to the new family. Except for the adductor muscle scar, the hingement and other internal morphology of *Covracythere* were unknown to Gramm (1975, p. 108) and are not known for the species in Alaska.

When originally examined, the specimen illustrated on plate 7, figures 16–20, was tentatively referred to the Paleozoic family Beyrichiopsidae Sohn (Moore, 1961) because of the horizontal ribs (Sohn, 1984b, p. 21, fig. 11I). SEM micrography, with the carapace tilted, disclosed the cast of the horizontal ribs on a specimen with a cytheracean adductor muscle scar (pl. 2, fig. 25), thus placing that specimen in the Cytheracea Baird, 1850. The specimens from the Triassic differ from *Beyrichiopsis* Jones and Kirkby, 1886, in lacking a marginal frill as shown by Sohn (Moore, 1961, p. Q183, fig. 6). The new family is established to include the nominate genus, *Racvetina* Gramm, 1975, *Acvocarina* Gramm, 1975, and, tentatively, *Dettermania* new genus because the aductor muscle scar of the new genus is unknown.

Geologic range.—Known only from the Middle and Upper Triassic.

Genus COVRACYTHERE Gramm, 1975

Type species.—*Covracythere kiparissovae* Gramm, 1975, p. 108, pl. 1, figs. 23–27, 33. Middle Triassic, Primor'ye Territory.

Original diagnosis (translated).—"Carapace small, nearly rectangular, with dorsal and ventral flattenings, and poorly defined transverse depression. Extremities rounded, the posterior narrower. Dorsal and ventral margins straight and parallel. Surface faintly pitted; a thin looplike ridge stretches along the anterior and ventral margins and the middle of the surface (parallel to dorsal margin). Adductor muscle scar comprises five elongate, obliquely directed spots juxtaposed in a vertical row.

"Assigned species: Only the type species."

Discussion.—Gramm's illustration of the adductor muscle-attachment scar (1975, pl. 1, fig. 33) is identical to those illustrated on the species from Alaska (pl. 2, figs. 20–26).

Geologic range.—Upper Anisian to Norian.

Geographic distribution.—Primor'ye Territory, U.S.S.R., and northeastern Alaska.

Covracythere gryci n. sp.

Plate 2, figures 20–26; plate 7, figures 16–25

New genus, n. sp. Sohn, 1984b, p. 21. fig. 11I.

Etymology of name.—In honor of George Gryc, Chief, National Petroleum Reserve in Alaska.

Holotype.—Pl. 7, figs. 23-25, USNM 389824.

Paratypes.—USNM 389817, 389822, 389823, 389825–389828, ?389829, ?389940.

Type level.—Ladinian, from 36.4 to 37.9 m above base of Shublick, Formation.

Other levels.—Norian, from 143.9 to 144.5 m above base of Shublik Formation.

Diagnosis.—*Covracythere* with three horizontal ribs, lower two ribs joined to form elongated ellipse, middle rib unbroken across subcentral sulcus, surface finely pitted.

Description.—The carapace is elongated, the greatest length is above midheight, about twice the greatest height; the greatest width is in the posterior quarter of the greatest length. The ends are rounded, the posterior margin meets the convex ventral margin slightly higher than it does the anterior margin. The sulcus is deep, concave towards the anterior, located in the front part of the central one-third of the greatest length. The adductor muscle-attachment scar consists of a vertical row of five scars concave towards the anterior and is located on the anterior wall of the sulcus. The dorsoanterior part of the sulcus curves forward above the central horizontal rib to outline a low rounded node on the interior of the valve (pl. 2, figs. 21, 23–25; pl. 7, fig. 24). The lower two horizontal ribs are joined at the ends to form an ellipse, the lower rib is located just below the bottom of the sulcus, and the middle rib crosses the sulcus (pl. 7, figs. 17, 19).

Measurements (in mm) (unfigd. = unfigured specimen).—

	Greatest length	*Greatest height*
Paratype, USNM 389827, unfigd.	0.55	0.30
Paratype, USNM 389826, unfigd.	.61	.27
USNM 389822	.61	.32
USNM 389817	.64	.32
Paratype, USNM 389825, unfigd.	.65	.32
USNM 389823	.72	.32
USNM 389824	.80	.32

Discussion.—The diagnosis and description are based on seven poorly preserved specimens. Dimorphism appears to be reflected by the greater width near the posterior of the largest available specimen (pl. 7, figs. 23–25) presumed to be a female. Although a steinkern, this specimen is designated as the holotype. A poorly preserved steinkern (USNM 389940) also may belong to this species.

Geologic range.—Middle and Upper Triassic, Ladinian to Norian, from 36.4 to 144.5 m (120–447 ft) above the base of the Shublik Formation.

Covracythere binoda Sohn, n. sp.

Plate 7, figures 1–3

Etymology of name.—Two small nodes in front of sulcus on each side of the second rib.

Holotype.—Left valve, USNM 389818.

Type level.—Ladinian, from 36.4 to 37.9 m above the base of Shublik Formation.

Type locality.—Fire Creek section, Mount Michelson quadrangle, Alaska. USGS Mesozoic colln. 33111.

Diagnosis.—*Covracythere* with four horizontal ribs, elongated posterior-trending sulcus below first to above third rib, and two small nodes in front of sulcus on each side of second rib.

Description.—The valve is subquadrate, the dorsal and ventral margins are straight, the anterior margin is evenly rounded, the anterior is probably straight in the dorsal two-thirds and probably truncated towards the venter. The dorsal rib is connected to the second rib, subparallel and slightly removed from the anterior margin, the second rib is connected to the third rib near the posterior margin, and the fourth rib is convex ventrad and connected to the anterior of the third rib. A straight sulcus extends backward from below the first rib to above the third rib. Two small rounded nodes are located on each side of the third rib in front of the sulcus. The second rib is broken by the sulcus.

Discussion.—Although only a single left valve is available, it is formally described because it differs from the known taxa in the genus by having two nodes.

Measurements (in mm).—USNM 389818, greatest length 0.50, greatest height 0.30.

Geologic range.—Known only from the Ladinian part of the Shublik Formation, from 36.4 to 37.9 m (120–125 ft) above the base of the Shublik Formation.

Genus DETTERMANIA n. gen.

Type species.—*D. truncata* n. sp.

Etymology of name.—In honor of my colleague R. L. Detterman, U.S. Geological Survey, who collected the samples.

Diagnosis.—Small, greatest length less than 1 mm. Straightbacked; sulcate, with anterocentral node anterior to sulcus. Smooth or finely punctate; with two or more horizontal ribs; dorsum flat, dorsal margin straight, ventral margin convex, rounded anterior margin and pointed posterior margin. Left over right overlap slight, dimorphic in width of posterior. Hingement and adductor muscle scar unknown.

Discussion.—This genus differs from *Covracythere* Gramm, 1975, described from the Upper Anisian in the Soviet Far East and present also in Alaska, in lateral outline and in having a subcentral node in front of the sulcus.

Species assigned.—*D. truncata* n. sp. and *?Monoceratina subtriangulata* Huang and Gou, 1977 (Ye and others, 1977) from the Norian of Yunnan, The People's Republic of China (P.R.C.).

Geologic range.—Middle and Upper Triassic.

Geographic distribution.—Known from Yunnan, P.R.C., and northeastern Alaska.

Dettermania truncata Sohn, n. sp.

Plate 7, figures 4–15

New genus, n. sp. Sohn, 1984b, p. 21, fig. 11J.

Etymology of name.—Truncated posterior.

Holotype.—Heteromorph, USNM 389820.

Paratypes.—USNM 389819, 389821.

Type level.—Ladinian, from 37.9 to 39.4 m above base of Shublik Formation.

Type locality.—Fire Creek section, Mount Michelson quadrangle. USGS Mesozoic colln. 33112.

Diagnosis.—*Dettermania* with four ribs, second rib from top weakly developed; straight dorsal margin, convex ventral margin curving sharply backwards to form acute posterior margin, anterior margin evenly rounded. Sulcus wide, shallow, posterior to low rounded node extending from the third, strongest rib to level of weak second rib; fourth rib weaker than first. Dimorphic in width of posterior.

Description.—The shell is relatively thick as illustrated in plate 7, figure 4. The hinge margin is straight, the dorsum is flat, bounded by the straight dorsal rib. The ventral margin is convex, curves roundly into the anterior margin, and bends backward and upwards below the approximate posterior end of the third, strongest rib. A shallow, wide sulcus extends from below the dorsal rib to the third, best developed rib. This sulcus curves towards the anterior to delineate a subround node that extends upwards to the elevation of the very faint second rib (pl. 7, figs. 9–11).

Measurements (in mm).—USNM 389820, greatest length 0.43+, greatest height 0.5+; USNM 389819, greatest length 0.75+, greatest height 0.39+; USNM 389821, greatest length 0.98, greatest height 0.42.

Discussion.—This species is dimorphic in width of posterior. Plate 7, figure 9, illustrates the heteromorph which has a relatively wider posterior than the tecnomorph that is shown on plate 7, figure 14.

In lateral outline the species resembles *Monoceratina subtriangulata* Huang and Gou, 1977 (Ye and others, 1977, p. 282, pl. 1, fig. 21), from the Upper Triassic Shizhongshan Formation of Jinchuan, Yunnan, P.R.C. Although that species was described as having only one ventral rib, the original illustration shows also a dorsal rib and a deep subcentral sulcus; consequently, *M. subtriangulata* is questionably referred to *Dettermania.*

Geologic range.—Known only from the Ladinian, from 37.9 to 39.4 m (125–130 ft) above the base of the Shublik Formation.

Family unknown

Anderson (1964, p. 138) questionably classified the genus *Rhombocythere* in the Brachycytheridae Puri, 1954. Based on the species assigned to the genus, the genus probably does not belong in the Brachycytheridae.

Genus RHOMBOCYTHERE Anderson, 1964

Rhombocythere Anderson, 1964, p. 138.

Notocythere Will, 1969, p. 60.

Type species.—Rhombocythere wicheri Anderson, 1964, p. 138, pl. 9, figs. 1–8. Lower Rhaetian, borehole, Germany.

Original diagnosis.—"Medium sized oblong-ovate carapace, smooth or with close small circular puncta set in wide shallow depressions. Normal pore canals open into the punctae frequently in pairs. Anterior and posterior margins flanged. Dorsal and ventral margins carinate. Venter flattened. Hinge straight, long and sunk. Dentition of *Hemicythere* type. In the left valve a crenulate bar terminates anteriorly in a small undivided tooth in front in which is a deep socket. A similar socket occupies the postero-dorsal angle. In the right valve a shallow socketted groove is succeeded anteriorly and posteriorly by large anvil-shaped teeth. Lamella free and wide, radial pore canals straight and widely spaced. General shape like *Camptocythere*. Left valve larger."

Discussion.—In addition to the type species, Anderson (1964) described and illustrated *R. ruegeri* and *R. schotti*. He based the holotypes of the three species on specimens originally illustrated in open nomenclature by Wicher (1951) from Lower Rhaetian cores in boreholes, Germany. In addition, Anderson (1964) described and illustrated *R. penarthensis* from the Lower Rhaetian of South Wales.

The following Upper Triassic taxa have been described in, or referred to, *Rhombocythere:*

Notocythere elegans Will, 1969, p. 73, pl. 3, figs. 1, 2. Rhaetian.

Gemmanella (*Rhombocythere*) *gracilis* Kozur, 1968a, p. 851, pl. 2, figs. 1, 2, text figs. 2, 3 = *R. gracilis* (Kozur, 1968) fide Kozur, 1972a, p. 642. Lower Rhaetian.

Notocythere hechti brevis Will, 1969, p. 72, pl. 2, figs. 6a–d. Upper Norian.

N. hechti hechti Will, 1969, p. 68, pl. 2, figs. 3a, b, text figs. 25–28. Upper Norian.

N. hechti longa Will, 1969, p. 71, pl. 2, figs. 5a–d. Upper Norian.

N. hechti nodosa Will, 1969, p. 70, pl. 2, figs. 4a, b. Upper Norian = junior secondary homonym of *Rhombocythere nodosa* (Kozur, 1968a).

Notocythere magna intermedia Will, 1969, p. 79, pl. 3, figs. 4a, b. Rhaetian.

N. magna magna Will, 1969, p. 75, pl. 3, figs. 2a, b, text figs. 29–31 = *R. wicheri* Anderson, 1964. Rhaetian.

N. magna maritima Will, 1969, p. 77, pl. 3, figs. 3a–d. Rhaetian = *R. schotti* Anderson, 1964.

N. media excelsa Will, 1969, p. 66, pl. 2, figs. 2a, d. Rhaetian. Not conspecific with *Notocythere media excelsa* Will *in* Dadlez and Kopik, 1963, p. 139, pl. 1, fig. 10.

N. media media Will, 1969, p. 65, pl. 1, figs. 6a–d. Norian (type species of *Notocythere*).

N. media prima Will, 1969, p. 63, pl. 1, figs. 7a–d. Upper Norian.

Gemmanella (*Rhombocythere*) *nodosa* Kozur, 1968a, p. 852, pl. 1, figs. 14, 15 = *R. nodosa* Kozur, 1968, fide Styk, 1982, p. 21. Lower Rhaetian.

Notocythere obliqua Will, 1969, p. 79, pl. 1, figs. 5a, b. Rhaetian.

Rhombocythere penarthensis Anderson, 1964, p. 140, pl. 10, figs. 18–25. Rhaetian.

R. ruegeri Anderson, 1964, p. 139, pl. 9, figs. 9–12. Rhaetian.

R. schotti Anderson, 1964, p. 139, pl. 11, figs. 13–15. Rhaetian.

Gemmanella willi willi Dreyer, 1967, p. 506, pl. 7, figs. 1a–d = *R. penarthensis* Anderson, 1964. Rhaetian.

G. willi laevis Dreyer, 1965, p. 507, pl. 7, figs. 2, 3, 4a–d = *R. wicheri* Anderson, 1964. Rhaetian.

Rhombocythere wicheri Anderson, 1964, p. 138, pl. 9, figs. 1–8. Rhaetian.

The Lower Rhaetian species *Rhombocythere gorvoziensis* Styk, 1972 (p. 876, 884, pl. 3, figs. 6–8) does not belong in the genus. Styk (1982, p. 22, pl. 3, figs. 1, 2) placed her species in subjective synonymy with *Speluncella tenuistriata* Kozur, 1968a, in the new combination *R. tenuistriata* (Kozur, 1968a). Based on their lateral outlines and surface morphology, the two are not conspecific, and neither belongs in *Rhombocythere*.

The two inadequately preserved specimens from the Ladinian of Alaska are questionably referred to *Rhombocythere* solely on external morphology.

Geologic range.—Ladinian?, Norian, and Rhaetian.

Geographic distribution.—Known only from Europe, and ?northeastern Alaska.

Rhombocythere? sp.

Plate 10, figures 10, 11; plate 11, figures 28–31

Discussion.—A fragment of a left valve with the dorsal and end margins missing, and a poorly preserved steinkern of a right valve on matrix resemble *Rhombocythere*. Features in common with the genus are as follows: Straight-backed in lateral outline; carinate anterior and ventral margins (the posterior and dorsal margins are not preserved), anterior margin wider than posterior in lateral outline, in dorsal outline wider towards anterior; and puncta similar to *R. penarthensis* Anderson, 1964 (Anderson, 1964, pl. 10, figs. 18, 19; Bate, 1978, pl. 1, fig. 10) preserved near the posterior margin (pl. 11, fig. 30). Because the dorsal and end margins are missing and the adductor muscle-attachment scar is not preserved on the fragment, the internal morphology diagnostic of *Rhombocythere* is unknown for the specimens on hand.

The fragment of a left valve illustrated on plate 10, figure 11, was tilted in the SEM (to look for a possible adductor muscle-attachment scar) so that the dorsal edge was below the plane of the micrograph. The tilting resulted in the distortion of the ventral groove for reception of the smaller valve. Examination with reflected light at X160 shows the proximal boundary of the groove is at the edge of the valve surface as shown by arrows. I cannot interpret the thin ridge that is terminated by minute toothlets inside the groove. Anderson (1964, pl. 10, figs. 21–23) showed that the left valve overlaps the right along the free margins, and Will (1969, p. 69, text figs. 25, 26) illustrated widely spaced radial pore canals along the ventral margin of *Notocythere* (= *Rhombocythere*). The thin ridge inside the groove along the ventral margin shown on figure 11 may represent infilling of the vestibule. The minute toothlets on either side of the ridge could possibly represent bases of radial pore canals; however, the entire structure may be an artifact resulting from fossilization.

The specimens on hand differ from all the known species in *Rhombocythere* in having a shallow kidney-shaped trough on the central part of the lateral surface; a shallow indentation from above into the dorsal boundary of the trough (pl. 10, fig. 10; pl. 11, figs. 29, 30); and widest in front of midlength in dorsal outline.

Measurements (in mm).—USNM 389853, greatest length 0.50, greatest height 0.40; USNM 389912, greatest length 0.62, greatest height 0.33.

Geologic range.—Ladinian, from 65.3 to 67.1 m (215–220 ft) above the base of the Shublik Formation.

Suborder METACOPINA Sylvester-Bradley, *in* Moore, 1961

Superfamily HEALDIACEA Harlton, 1933

Sohn (1965) discussed this superfamily. The aggregate adductor muscle-attachment scar also is present in nonmarine podocopids of Mississippian age (Sohn, 1985). This similarity indicates homeomorphy rather than phylogeny in the evolution of the so-called healdiid adductor muscle scar.

Family HEALDIIDAE Harlton, 1933

Gramm (1982, p. 194–198) published the best and most recent discussion of the family and the genus *Healdia* with superb SEM micrographs of the adductor muscle-attachment scars of genera in the family.

Genus HEALDIA Roundy, 1926

Type species (original designation).—*H. simplex* Roundy, 1926, p. 8, pl. 1, fig. 11a–c. Graham Formation (Upper Pennsylvanian), Stephens County, Texas.

Discussion.—Shaver (Moore, 1961, p. Q361) recorded the stratigraphic range of *Healdia* to be Devonian to Permian, but Coryell (1963, p. 929) listed three Lower Jurassic species of *Healdia*. Sohn (1968, p. 52) recorded two taxa in the Triassic: *Healdia bella* Gerke, 1937, from the Lower Triassic of Siberia, as a nomen nudum, and Ostracode C Kristan-Tollmann, 1964, as *Healdia?* sp. However, Kristan-Tollmann (1971a, p.51) described the new genus *Torohealdia* and designated Ostracode C as the type species, *T. amphicrassa* n. gen. n. sp., from the Norian-Rhaetian of the Alpine Triassic.

The following species from the Triassic have been described in or referred to *Healdia*:

Will (1969, p. 52) described from the Rhaetian of northwestern Germany *Healdia? tenuivirgata* = *Ogmoconcha martini* (Anderson, 1964) fide Bate, 1978, p. 82. Gramm (1969a) illustrated the adductor muscle scars in open nomenclature of *Healdia* sp. 1, *H.* ? sp. 2, and *H*. sp. 3, and the carapaces of *H.* sp. 1 and *H.*? sp. 2 from the Upper Anisian of the Primor'ye Region, U.S.S.R. The next year, Gramm (1970) described the specimens and erected *Healdia unitumulata* and also *H. zharnikovae* to which he referred *H.* sp. 1 Gramm, 1969, and *H.* spp. 3 to 8 Gramm, 1969a. Kozur (1970a, p. 21–23) described from the Upper Anisian of Hungary *Healdia* (*Healdia*) *anisica, H.* (*H.*) *felsooerensis,* and *H.* (*Hungarella*) *reniformis* (Méhes, 1911) and stated that the three species have a nondenticulated hinge. Bolz (1971b, p. 742, 744, pls. 3, 4) illustrated *Healdia* spp. A to G from the Alpine Norian-Rhaetian. Kozur (1972a, table 1) listed from the Rhaetian of Germany *Healdia* (*Hungarella*) *aspinata* Drexler, 1958, originally described from the Lower Jurassic, *H.* (*Hungarella*) *caudata* Anderson, 1964, *H.* (*Hungarella*) *martini* Anderson, 1964, and *H.* (*Hungarella*) *owthropensis* Anderson, 1964. Urlichs 1972 (1973 fide Kristan-Tollmann and Hamedani, 1973, p. 210), p. 688, identified *Healdia martini* (Anderson, 1964) from the German Upper Norian-Rhaetian. Urlichs' illustrated specimens, however, do not have a posterolateral hump on the left valve; consequently, they are not conspecific with Anderson's species. Gheorgian (1976, p. 37) identified and illustrated *Healdia* (*Healdia*) *felsooerensis* Kozur, 1970, from the Ladinian of Rumania. The presence of two spines on each valve of the Rumanian specimen excludes that species from *Healdia* (*H.*) *felsooerensis.* Hou and Gou, 1977 (Ye and others, 1977, p. 301), described and illustrated *Healdia jingguensis* from the Carnian of Yunnan, P.R.C.

Because Gramm (1969a, p. 457, figs. 1, 2; 1970, p. 45, figs. 1, 2) illustrated the adductor muscle-attachment scars of *Healdia zharnikovae* with a few scars, similar to those illustrated herein, I am referring the specimens from Alaska to "*Healdia.*" The Triassic species lack the dorsoposterior flattening originally described in *Healdia*. The discovery of better preserved Triassic specimens may require the establishment of a new genus.

These specimens are not formally named because only one carapace with part of the right valve and the posterior dorsal portion of the left valve retained is available; the others are steinkerns. Plate 1, figures 1–4, are of a steinkern with the same lateral outline as the other illustrated specimens. Although the posterior lateral ridge is not preserved, this specimen is included because the denticulate hinge is partly preserved on the posterior and dorsal views (pl. 1, figs. 1, 3). Plate 1, figures 5–9, are of a smaller steinkern that has a well preserved adductor muscle scar as well as dorsal attachment muscle scars (pl. 1, figs. 6–8) and a faint indication of a denticulate hinge (pl. 1, fig. 5).

Plate 1, figures 10–14, are of the largest available steinkerns that show straight posterior lateral ridges instead of curved ridges as on the illustrated specimens that follow. Plate 1, figure 13, has a poorly preserved adductor muscle-attachment scar that is similar in number of individual spots (stigmata) to that illustrated on figures 7, 8, and 18. These scars resemble the pattern illustrated by Gramm (1969a, p. 457, fig. 1.1–1.5) for *Healdia* sp. 1 (= *H. zharnikovae* Gramm, 1970) from the upper Anisian, and the posterior ridge on *H.* sp. 3 Gramm [1969a, figs. 4g, d (4d, e in English translation)] resembles the specimen illustrated herein as figures 12 and 13.

Prof. M. N. Gramm kindly examined the illustrations and a preliminary version of this discussion. He stated (written commun., July 12, 1984) that the adductor muscle-attachment scar pattern on the specimens from Alaska are close to those he had illustrated on specimens from the Primor'ye Region. He added that he had seen denticulation along the hinge of the right valve of *Healdia* sp. 3 (Gramm, 1970, pl. 7, fig. 2). Plate 1, figures 15–21, show the adductor muscle-attachment scar pattern and denticulate hinge, but, because the posterior lateral ridges are curved on this specimen and appear to be straight on the steinkern illustrated on plate 1, figures 12 and 13, this specimen probably represents a different species. The specimens are illustrated herein as *"Healdia"* sp. 1, sp. 2, and sp. 3.

Geologic range.—Devonian-Triassic, ?Lower Jurassic.

Geographic distribution.—Cosmopolitan.

"Healdia" sp. 1

Plate 1, figures 1–9

Discussion.—Two steinkerns and one measured specimen (USNM 389808) on which the right valve is missing and the anterior part of the left valve is missing are illustrated herein. The cast of the right valve on this specimen has a well-preserved adductor muscle-attachment scar that is similar to those illustrated herein (pl. 1, figs. 7, 8, 10), and the posterior of the left valve does not have a posterolateral ridge nor is one preserved on the cast of the right valve.

Measurements (in mm).—USNM 389804, greatest length 0.48, greatest height 0.30; measured specimen USNM 389808, greatest length 0.50, greatest height 0.28; USNM 389803, greatest length 0.53, greatest height 0.30.

Geologic range.—Ladinian, limestone and dolomite member, from 36.6 to 66.5 m (120–215 ft) above the base of the Shublik Formation.

"Healdia" sp. 2

Plate 1, figures 10–14

Discussion.—One steinkern with straight posterolateral ridges that differ from the curved ridges of *"Healdia"* sp. 3 is illustrated. The adductor muscle-attachment scar is poorly preserved (fig. 13) but is within the limits of those illustrated herein for *"Healdia"*.

Measurements (in mm).—USNM 389805, greatest length 0.60, greatest height 0.40.

Geologic range.—Ladinian, limestone and dolomite member, from 65.5 to 70.1 m (215–220 ft) above the base of the Shublik Formation.

"Healdia" sp. 3

Plate 1, figures 15–21

Discussion.—In addition to the illustrated specimen, a steinkern (USNM 389807) from the Ladinian has an adductor muscle scar with four rows of stigmata arranged in a more circular outline than those illustrated. In addition, two specimens from the Carnian (USGS colln. 33143), one of which is a carapace and the other the posterior half of a carapace (USNM 389809), have curved posterolateral ridges. These specimens are probably conspecific with the one illustrated herein.

Measurements (in mm).—Unfigured specimen, USNM 389807, greatest length 0.42, greatest height, 0.28; USNM 809806, greatest length 0.53, greatest height 0.35; two unfigured specimens, USNM 389809, broken carapace greatest length 0.35, greatest height 0.31, carapace, greatest length 0.50, greatest height 0.32.

Geologic range.—Ladinian, limestone and dolomite member, from 35.1 to 36.6 m (115–120 ft) above the base of the Shublik Formation, and Carnian, Limestone Member, from 97.5 to 99.1 m (320–325 ft) above the base of the Shublik Formation.

Genus PSEUDOBYTHOCYPRIS Shaver, 1958

Type species.—Bythocypris pediformis Knight, 1928

Discussion.—Sohn (1983, p. 27) discussed this genus and recorded the geologic range of *Pseudobythocypris* to be Mississippian through Permian, but, based on this possible Triassic occurrence, the range is here questionably extended into the Upper Triassic (Carnian).

Psuedobythocypris? sp.

Plate 2, figures 14–17

Discussion.—The unique specimen is a thin-shelled, smooth carapace with a gently curved dorsal margin, a rounded anterior margin, and a truncated posterior margin.

The dorsal outline is elliptical, with gently curved sides and relatively blunt, equal ends. The greatest width is in front of the midlength. The carapace resembles the Pennsylvanian *Bythocypris pediformis* Knight, 1928, the type-species of *Pseudobythocypris*. Bolz (1971a, p. 235, pl. 8, figs. 120–121) illustrated from the Norian-Rhaetian, Norten Alps, the right views of one instar and one adult of *Bythocypris* sp. B that differ from the specimen on hand in being slightly higher and larger (length 0.80–0.91 mm, height 0.41–0.50 mm, and width 0.38–0.43 mm). Bate (1978, p. 180, pl. 1, fig. 4) illustrated the left view of a carapace of Lower Anisian age as *Bythocypris* sp. B Bolz, 1971. The specimen from Britian has the right valve larger than the left instead of the reverse as in both *Bythocypris* and *Pseudobythocypris* and should not be considered congeneric with the specimens discussed above. Because the adductor muscle-attachment scar of the carapace from Alaska is unknown, it is only tentatively referred to the Paleozoic genus.

Measurements (in mm).—USNM 389813, greatest length 0.70, greatest height 0.35, greatest width 0.26.

Geologic range. —Known only from the Carnian, limestone member, 94.5 to 96.0 m (310–315 ft) above the base of the Shublik Formation.

Genus OGMOCONCHA Triebel, 1941

Ogmoconcha Triebel, 1941, p. 377; Sohn, 1968, p. 29; Malz, 1971, p. 434; Lord, 1972, p. 332; 1982, p. 262; Kristan-Tollmann, 1977, p. 133, 142.

Hungarella Méhes, 1911 sensu Anderson, 1964.

Type species.—O. contractula Triebel, 1941, p. 377, pl. 14, figs. 156–160. Liassic, borehole, Germany.

Diagnosis (from Anderson, 1964, p. 146).—"A smooth genus in the Healdiidae with strong overlap of the left valve over right on all margins. Hinge margin of right valve with minute vertically oriented teeth which articulate with serial sockets in left valve. Adductor muscle-attachment scar aggregate."

Description.—According to Triebel (1941, p. 378), *Ogmoconcha* is small to medium sized, with thick, smooth shells. The carapace is elliptical to egg-shaped in lateral, dorsal, and end views. The left valve has a marginal groove for the reception of the right valve. Abundant minute, normal pore canals are simple; marginal pore canals are barely discernable, and a definite zone of concrescence (Verschmeltzungszone) is not discernible.

Discussion.—As indicated in the discussion of the *Hungarella-Ogmoconcha* problem, most of the Triassic species have been recorded as *Hungarella* Méhes, 1911. Lord (1972, p. 323) listed the Triassic species under *Hungarella* and the Liassic species under *Ogmoconcha*. Following is an objective list of Triassic species that have been described in, or transferred to, *Ogmoconcha:*

Torohealdia amphicrassa Kristan-Tollmann, 1971a, by Urlichs, 1972, p. 691. Upper Norian.

Hungarella bristolensis Anderson, 1964, by Bate, 1978, p. 182. Upper Rhaetian, Liassic.

H. caudata Anderson, 1964, by Bate, 1978, p. 182. Lower Rhaetian.

Ogmoconcha hagenowi Drexler, 1958, by Urlichs, 1972, p. 690. Upper Norian.

O.? limbata (Reuss, 1868) sensu Urlichs, 1971, herein. Ladinian.

Hungarella martini Anderson, 1964, by Bate, 1978, p. 182. Upper Rhaetian.

H. moorei (Jones, 1894) Anderson, 1964, by Bate, 1978, p. 182. Upper Rhaetian.

H. owthropensis Anderson, 1964, by Bate, 1978, p. 180. Lower Rhaetian.

Ogmoconcha sp. Urlichs, 1972, p. 693. Norian-Rhaetian.

Because several Triassic ostracodes in Alaska have an aggregate adductor muscle-attachment scar and some of these have denticulate hinges, the genus *Ogmoconcha* is confirmed in the Triassic. Many, but not all, of the Triassic species referred to *Hungarella* Méhes, 1911, that have a denticulate hinge probably belong in *Ogmoconcha.*

Key to the species of Ogmoconcha *in Alaska*

1. Posteroventral spine on right valve .... *unicerata*
1a. No posteroventral spine on right valve 2
2(1a). Height over length index less than 0.700 .... *tailleuri*
2a. Height over length index 0.700 or more 3
3(2a). Horizontal pleat below dorsal margin of left valve .... aff. *limbata*
3a. No horizontal pleat below dorsal margin of left valve 4
4(3a). Anterior margin of left valve higher than posterior .... *marquardti*
4a. Anterior margin of left valve not higher than posterior 5
5(4a). Posterior margin in dorsal outline obtuse .... aff. *owthropensis*
5a. Posterior margin in dorsal outline acute .... *alaskaense*

Geologic range.—Triassic-Jurassic.

Geographic distribution.—Europe, Asia, and northeastern Alaska.

Ogmoconcha sp. aff. O. owthropensis (Anderson, 1964)

Plate 5, figures 11–16; plate 6, figures 1–9; plate 8, figures 7–9, 20–27; plate 9, figures 9–16, 19–23.

Hungarella owthropensis Anderson, 1964, p. 147, pl. 14, figs. 96–101. Lower Rhaetian, Nottinghamshire, Great Britian.

Ogmoconcha owthropensis (Anderson, 1964) Bate, 1978, p. 180, pl. 1, figs. 11, 15. Same specimens as above.

Gen. and sp. indet. ex gr. *Ogmoconcha* Triebel, 1941. Sohn, 1984b, p. 21, fig. 11K.

Discussion.—The holotype, a carapace, was recorded by Anderson (1964, p. 147) to be 0.625 mm long and 0.450 mm high. The height over the length (h/l) index of the holotype equals 0.720. Specimens from Alaska range in length from 0.41 to 0.61 mm and in height from 0.29 to 0.43 mm, and their h/l ranges from 0.700 to 0.800. In addition to size and h/l index, these specimens have in common with *O. owthropensis* a relatively straight ventral contact, a relatively blunt posterior outline in dorsal view with evenly curved sides that taper more towards the anterior than towards the posterior, and a similar outline in end view. The hinge of a paratype of *O. owthropensis* is denticulated and tripartite with a narrow central portion and wider end portions (Anderson, 1964, pl. 14, fig. 101; Bate, 1978, pl. 1, fig. 15). The specimens in Alaska have poorly preserved denticulate hingements. The posterior two-thirds of the right valve of the carapace illustrated on plate 5, figures 11–16, is missing, thus exposing denticulations only along the center of the hinge, and the left valve illustrated on plate 9, figures 9–12, has a denticulated hinge that may not be tripartite. Twelve specimens from Ladinian to Norian collections in Alaska are illustrated to show that they can vary. Better preserved material may disclose that more than one species may be represented.

Measurements (in mm).—

	Greatest length	*Greatest height*	*Height/ length*
USNM 389860	0.41	0.29	0.707
USNM 389919	.41	.30	.732
USNM 389881	.41	.31	.756
USNM 389880	.44	.32	.727
USNM 389857	.45	.32	.711
USNM 389884	.50	.36	.720
USNM 389861	.50	.40	.800
USNM 389886	.50	.40	.800
USNM 389852	.51	.39	.765
USNM 389879	.52	.40	.769
USNM 389877	.56	.40	.714
USNM 389878	.61	.43	.705

Geologic range.—Ladinian through Norian, from 33.5 to 145.4 m (110–477 ft) above the base of the Shublik Formation.

Ogmoconcha alaskaense n. sp.

Plate 5, figures 23–28; plate 9, figures 17, 18, 24, 25; plate 11, figures 17–19

Gen. and sp. undet. ex gr. *Ogmoconcha* Triebel, 1941. Sohn, 1984b, p. 21, fig. 1F. Herein pl. 11, figs. 17–19.

Etymology of name.—Type locality in Alaska.

Holotype.—USNM 389887.

Paratypes.—USNM 389859, 389870, 389885, 389894, 389896, 389935, 389937, 389938, 389950, 389951.

Type locality.—Fire Creek reference section of Shublik Formation. USGS colln. 33149.

Type level.—Norian, clay shale member of Shublik Formation.

Diagnosis.—A species of *Ogmoconcha* with a height to length index of more than 0.700 and with an acute posterior outline in dorsal view.

Description.—The carapace is smooth, without any spines or pleats. In lateral outline, the dorsal margin is convex with the greatest height behind midlength, the ventral margin is straight, and the anterior margin is narrower than the posterior margin. The dorsal margin is elliptical, with the greatest width behind midlength, and the anterior end is slightly more acute than the posterior end. The hingement is denticulate.

Measurements (in mm) (figd. = figured specimen).—

	Greatest length	*Greatest height*	*Height/ length*
USNM 389870	0.40	0.30	0.750
USNM 389951	.40	.30	.750
USNM 389938	.41	.30	.732
USNM 389935	.42	.30	.714
USNM 389885, figd.	.42	.31	.738
USNM 389950	.42	.31	.738
USNM 389859, figd.	.43	.31	.721
USNM 389896, figd.	.46	.34	.739
USNM 389887, figd.	.51	.40	.784
USNM 389894	.55	.40	.727
USNM 389937	.55	.42	.763

Discussion.—Specimens with the height to length index of more than 0.700 differ from the specimens illustrated herein as *O.* sp. aff. *O. owthropensis* (Anderson, 1964) in that they have a more acute posterior in dorsal outline. These specimens are not considered to be sexual dimorphs of the above taxon because they range in length from 0.40 to 0.55 mm, thus representing two or more growth stages younger than *O.* sp. aff. *O. owthropensis* of which the largest specimen is 0.61 mm in length. The hingement of a juvenile is denticulate (pl. 5, figs. 25, 28), but the adductor muscle scar of the new species is unknown. The holotype (pl. 9, figs. 24, 25) lacks part of the posterior of the right valve, but the outline of the posterior end of the left valve in dorsal view is definitely acute.

Geologic range.—Norian, clay shale member, from 112.8 to 143.3 m (370–470 ft) above the base of the Shublik Formation.

Ogmoconcha unicerata Sohn, n. sp.

Plate 5, figures 1–10

Ogmoconcha n. sp. Sohn, 1984b, fig. 11A–D.

Etymology of name.—Posteroventral spine on right valve only.

Holotype.—USMN 389855.

Paratype.—USNM 389856.

Type level.—Ladinian. USGS colln. 33112.

Diagnosis.—*Ogmoconcha* with a posteroventral spine on the smaller right valve.

Description.—The carapace is small, less than 0.5 mm in greatest length, the valves are subovate, the ends are rounded, the dorsoanterior margin is more gently rounded than the dorsoposterior margin, and the overlap is even around all the margins. A stout spine, of which only the base is preserved on the specimens recovered, is located about equidistant from the ventral and posterior margins on the right valve. The greatest length is approximately at midheight, the greatest height is slightly behind midlength. The dorsal outline is subelliptical, the anterior end is narrower than the posterior end, and the greatest width is behind midlength.

Measurements (in mm).—USNM 389855, greatest length 0.42, greatest height 0.30, h/l 0.714; USNM 389856, greatest length 0.43, greatest height 0.29, h/l 0.674.

Discussion.—*Healdia (Hungarella) reniformis* (Méhes, 1911) of Kozur, 1970, as illustrated by Kozur (1970b, p. 22, pl. 4, figs. 15–17) from the Anisian and Ladinian near Felsoörs, Bakony, Hungary, also has a ventroposterior spine on the right valve. The specimens from Alaska differ from Hungarian specimens not only in a more elongate lateral outline and in lacking a ridge below the posterior half of the dorsal margin of the right valve (pl. 10, figs. 12, 13) but also in the fact that the hingement of the Hungarian specimens is smooth ("Schlosselemente glatt"), whereas the specimens from Alaska have a denticulated hinge as shown herein (pl. 5, figs. 1, 2). The largest specimen from Felsoörs recorded by Kozur (1970b) is 0.520 mm long. Méhes (1911, p. 22), however, recorded the length of his *Bairdia*(?) *problematica* var. *reniformis* as 0.71 mm. Specimens as long as 0.70 mm with a ventroposterior spine on the right valve and a denticulate hinge are present in the Lower Carnian marl from Csopak, Nesztery Valley, Hungary (Sohn, 1984b, figs. 11E–G; herein pl. 10, figs. 12–14). In addition, specimens in the same collection without a posteroventral spine on the right valve that have denticulate hinges (pl. 11, figs. 13–16, 20–24) are present in the Hungarian Triassic. Unfortunately, I have not been able to determine the adductor muscle scar in my specimens from Hungary, even after converting some specimens to fluorite.

Geologic range.—Ladinian, limestone and dolomite member, from 38.1 to 39.6 m (125–130 ft) above the base of the Shublik Formation.

Ogmoconcha tailleuri n. sp.

Plate 5, figures 17–22; plate 6, figures 10–18;
plate 8, figures 1–6, 10–19; plate 9, figures 1–4;
plate 10, figures 1–8, 15–22; plate 11, figures 7–12.
?*Ogmoconcha* sp. Urlichs, 1972, p. 693,
pl. 4, fig. 6. Norian, Austrian Alps.

Etymology of name.—In honor of my colleague I. L. Tailleur, U.S. Geological Survey.

Holotype.—USNM 389865.

Paratypes.—USNM 389858, 389862–389864, 389866–389869, 389875, 389876, 389883, 389888, 389899, 389901–389904, 389907, 389908, 389910, 389911, 389914–389917, 389926.

Type level.—Ladinian, limestone and dolomite member, from 48.8 to 50.3 m (160–165 ft) above the base of the Shublik Formation. USGS colln. 33119.

Other levels.—Anisian?, Ladinian through Norian, from 25.9 to 154.4 m (85–477 ft) above the base of the Shublik Formation.

Diagnosis.—Elongated; dorsal margin evenly convex, ventral margin gently convex; end margins rounded, posterior broader than anterior. Dorsal outline subelliptical, anterior narrower than posterior, lateral sides evenly convex, greatest width at or behind midlength, h/l index less than 0.700.

Description.—The holotype, a carapace with a fragment of the shell missing on the posterior of the left valve, has a relatively thick shell as shown on plate 8, figures 12 and 14. The dorsal margin of the larger valve does not overreach and overlap the smaller valve as much as the ventral margin does (pl. 8, figs. 1, 12). The greatest convexity of the anterior margin of the left valve is lower in relation to the height than that of the posterior margin (pl. 8, figs. 14, 18; pl. 9, fig. 2; pl. 10, figs. 3, 5). The denticulate hinge of the right valve is not as distinctly tripartite (pl. 5, figs. 20–22) as it is in *O. owthropensis* (Anderson, 1964) (Anderson, 1964, pl. 14, fig. 101; Bate, 1978, pl. 1, fig. 15), as well as in the Hungarian *O.* sp. illustrated herein (pl. 10, figs. 12, 13). Although the adductor muscle scar is poorly preserved (pl. 8, figs. 18, 19; pl. 10, fig. 5), the aggregate outline is typical of *Ogmoconcha*.

Measurements (in mm) (R. V. = right valve; B = steinkern).—

	Greatest length	*Greatest height*	*Height/ length*
USNM 389883	0.33	0.21	0.636
USNM 389888, R. V.	.42	.24	—
USNM 389911	.43	.25	.581
USNM 389866	.44	.30	.682
USNM 389901	.44	.30	.682
USNM 389858, R. V.	.44	.30	—
USNM 389903, R. V.	.45	.30	—
USNM 389910	.46	.27	.587
USNM 389876	.46	.31	.674
USNM 389899, B	.48	.27	.563
USNM 389862	.50	.30	.600
USNM 389875	.50	.32	.640
USNM 389864	.50	.33	.660
USNM 390004	.59	.30	.508
USNM 389865	.60	.40	.667
USNM 389863	.60	.40	.667

Discussion.—The carapace from the Austrian Alps that was illustrated by Urlichs (1972, pl. 4, fig. 6) resembles a paratype illustrated herein (pl. 8, figs. 15–19) in lateral outline and in apparent surface punctation. I attribute the relatively thin shell of the illustrated specimen to corrosion which removed part of the outside of the shell. Urlichs' specimen also represents a corroded carapace as indicated by the missing shell material along the dorsoanterior margin. The puncta that are present on the anterior half on my specimen and that are barely visible on the posterior half of Urlichs' illustration are interpreted to be cross sections of normal pores.

Geologic range.—Anisian?, Ladinian through Norian, from 25.9 to 145.4 m (85–477 ft) above the base of the Shublik Formation. The Anisian age is questioned because USGS colln. 33106, from which a carapace (USNM 389916) was recovered, is located below the Ladinian as determined by megafossils.

Ogmoconcha marquardti n. sp.

Plate 9, figures 5–8; plate 10, figures 23–32

Etymology of name.—In honor of Mr. J. F. Marquardt, Reference Librarian, Smithsonian Institution Libraries, whose expert and cooperative assistance for more than 25 years is greatly appreciated.

Holotype.—USNM 389905.

Paratype.—USNM 389882, 389889.

Type level.—Norian, clay shale member, from 128.0 to 129.5 m (420–425 ft) above the base of the Shublik Formation. USGS colln. 33158.

Other level.—The same member as above, from 121.9 to 123.4 m (400–405 ft) above the base of the Shublik Formation. USGS colln. 33154.

Diagnosis.-Differs from all other species of *Ogmoconcha* in subtriangular lateral outline, the anterior margin being much higher than the posterior margin.

Description.—The carapaces are small, less than 0.5 mm in greatest length. The hingeline is almost straight; it extends forward from the posterior margin to about two-thirds of the greatest length of the valves. The anterior margin is broadly rounded and is about twice the height of the posterior margin, and its greatest convexity is located below the hingeline at or lower than the junction of the posterior margin with the ventral margin. The ventral margin curves steeply backward and upward to meet the posterior margin. The left valve overlaps the right along the free margins and overreaches slightly along the hinge margin. The paratype (pl. 10, figs. 23–26) lacks a small part of the right valve at the dorsoposterior, where the denticulated hinge is exposed (pl. 10, figs. 23, 26).

Measurements (in mm).—USNM 389882, greatest length 0.23, greatest height 0.17, h/l 0.739; USNM 389889, greatest length 0.43, greatest height 0.30, h/l 0.750; USNM 389905, greatest length 0.45, greatest height 0.35, h/l 0.778.

Discussion.—Although only two carapaces and one steinkern of this species have been recovered, they differ in lateral outline from the described species in *Ogmoconcha*, thus warranting their description as a new species. Both carapaces have what appears to be a minute ventroposterior spine on the right valve (pl. 10, figs. 24, 28, 29). Because both carapaces are covered with adhering grains of an undetermined mineral, I did not use the presence of the spinelet(?) as an additional specific character. A minute steinkern (pl. 9, figs. 5–8) is referred to this species because of its lateral outline. Although the adductor muscle scar of specimens is unknown, this species is referred to *Ogmoconcha* because of the external morphology.

The Lower Pliensbachian (Jurassic) *O. eocontractula* Park, 1984, from Europe, has a triangular lateral outline, but that species (0.87–0.91 mm long) is much larger than *O. marquardti*, its ventral margin is not as truncated towards the posterior, and both valves have spinelets along the anterior margin—features that differentiate the two species. *Cytherella inaequata* Donze, 1966, as illustrated by Blaszyk and Gazdzicki (1982, p. 133, pl. 46, fig. 2) from the Hettangian (Late Jurassic) of Poland, differs from Donze's (1966) species in having a triangular lateral outline similar to the new species. This unnamed species is larger than *O. marquardti* (L = 0.76 mm), and it has an obtuse posterior in dorsal outline.

Geologic range.—Norian, clay shale member, from 119.3 to 129.5 m (365–425 ft) above the base of the Shublik Formation.

Ogmoconcha sp.

Plate 10, figures 12–14

Ogmoconcha n. sp. Sohn, 1984b, p. 21, fig. 11E–G, Carnian, Hungary.

Discussion.—See discussion under *O. unicerata* n. sp. Kozur's species, however, does not have a denticulated hinge and does not belong to *Ogmoconcha*. The Hungarian species is not formally named and described because study of Hungarian material is beyond the scope of this paper. The Upper Triassic (Carnian) taxon illustrated herein has a tripartite denticulate hinge, suggesting that *O. unicerata* from Alaska is not related on the generic level with the Anisian and Ladinian specimens illustrated by Kozur (1970a, p. 22, pl. 4, figs. 15–17) as *Ogmoconcha reniformis* (Méhes, 1911).

Measurements (in mm).—USNM 389999, greatest length 0.70, greatest height 0.50, h/l 0.714.

Geologic range.—Carnian (Upper Triassic), Hungary. USGS colln. 33172.

Ogmoconcha? sp. aff. Hungarella limbata (Reuss, 1868) sensu Urlichs, 1971

Plate 3, figure 7

Cytherella limbata Reuss, 1868, p. 108 (no illustration). Cassinian, Italy.

Hungarella limbata (Reuss, 1868) Urlichs, 1971, p. 707, pl. 1, figs. 3–14, text figs. 4–6. Cassinian, Italy (topotypes).

?Ogmoconcha sp. Sohn, 1968, p. 29, pl. 3, figs. 1–3, 8. Ladinian, Italy.

Discussion.—Because only one left valve on matrix from the Ladinian part of the Shublik Formation (63.6–65.2 m above the base) is available, the species is not named. The specimen is probably a left valve because of the well developed dorsal pleat and narrower ventral pleat or rim. This specimen differs from the left valves illustrated by Urlichs (1971, pl. 1, figs. 3, 5, text fig. 4) in lateral outline and size of dorsal pleat. Because the interior of the valve is obscured by rock, neither the hingement nor the adductor muscle scar can be determined; it is only questionably referred to *Ogmoconcha*. To orient the specimen for measurement, an attempt to smooth the rock below the valve resulted in breaking the anteroventral part of the shell. Approximate measurements are 0.8 mm long and 0.6 mm high.

Because Reuss (1868, p. 108) did not illustrate *Cytherella limbata*, that species was listed as "Gen. and sp. indet." (Sohn, 1968, p. 45), and the illustrated specimens were identified as *Ogmoconcha* sp. (Sohn, 1968, pl. 3, figs. 1–3, 8). Unfortunately, the valve illustrated on fig. 8 is lost; consequently, only the three remaining carapaces illustrated above could be measured to compare them with Urlichs' measurements of an ontogenetic series.

Urlichs (1971, p. 708) stated that his collections were from Reuss' type locality, and he identified and illustrated the species based on the original description. He described the right valve as having a small ventroposterior spine (1971, pl. 1, figs. 7, 8, 11) and a narrow frill along the anterior margin. The anterior marginal frill is not discernible on the three carapaces from Italy in the National Museum. The illustrated carapace (Sohn, 1968, pl. 3, fig. 2) has a minute posteroventral spine not seen on the published magnification of X30, but the other two carapaces do not have that spine preserved.

Only the specimens discussed above have pleats on the left valve; all the other species in *Ogmoconcha* have smooth left valves. Figure 7 was included on the plate that illustrates specimens of the Ussuricavininae Gramm, 1969, to suggest that these *Ogmoconcha* specimens are possible relatives of the Ussuricavininae, a subfamily that is poorly known.

Measurements (in mm).—Plate 3, figure 7, USNM 389837, greatest length 0.8, greatest height 0.6, h/l 0.750. Specimens from Italy, USNM 147198, greatest length 0.62, greatest height 0.55, h/l 0.887; USNM 147199, greatest length 0.65, greatest height 0.52, h/l 0.800; USNM 147200, greatest length 0.65, greatest height 0.56, h/l 0.862.

Geologic range.—Ladinian, limestone and dolomite member, from 63.6 to 65.2 m (210–215 ft) above the base of the Shublik Formation.

Order PLATYCOPIDA Sars, 1866
Suborder PLATYCOPINA Sars, 1866
Superfamily CAVELLINACEA Egorov, 1950
Family CAVELLINIDAE Egorov, 1950

Discussion.—Sohn (1968, p. 17) discussed the above classification.

Subfamily USSURICAVININAE Gramm, 1969

Discussion.—Gramm (1969b, p. 55) described this subfamily for the Triassic marine genera *Ussuricavina* Gramm, 1969, *Orlovicavina* Gramm, 1969, and *Cavussurella* Gramm, 1969. The following year, Gramm (1970, p. 100) established the subfamily Recytellinae in the family Cytherellidae Sars, 1866, for the Middle Triassic genera *Recytella* Gramm, 1970, and *Recytelloidea* Gramm, 1970. Kozur (1972b, p. 18) considered *Cavussurella* Gramm, 1969, and *Recytella* Gramm, 1970, to be synonyms of *Reubenella* Sohn, 1968; *Orlovicavina* Gramm, 1969, to be a synonym of *Issacharella* Sohn, 1968; and *Recytelloidea* Gramm, 1970 to be a synonym of *Leviella* Sohn, 1968—all in the family Cytherellidae Sars, 1866. Sohn (1968, p. 21) questionably referred *Leviella* to the Cytherellidae Sars, 1866, because the adductor muscle-attachment scar pattern of this genus was not known. Kristan-Tollmann (1973, p. 360, 363, 370) illustrated aggregate adductor muscle-attachment scars of several species of Triassic (Carnian) *Leviella* similar to those in the Cavellinacea as defined in Moore (1961, p. Q368) but not to those in the Cytherellacea as defined in Moore (1961, p. Q382).

The subfamily Recytellinae Gramm, 1970, was defined as having an external depression on the ventral portion of the brood pouch on each female valve (Gramm, 1970, p. 100), a feature absent in the Ussuricavininae. *Cavussurella* and *Recytella* are considered in this study to be valid genera.

Geologic range.—Middle and Upper Triassic.

Geographic distribution.—Primor'ye Territory, U.S.S.R., and northeastern Alaska.

Genus CAVUSSURELLA Gramm, 1969

Cavussurella Gramm, 1969b, p. 72.

Type species.—*C. kramtchanini* Gramm, 1969b, p. 72, pl. 5, figs. 5–15; pl. 6, fig. 8; pl. 8, figs. 1–24; text fig. 3.8. Upper Anisian, Primor'ye Region, U.S.S.R.

Original diagnosis (translated).—"Middle-sized Ussuricavininae, with variable oval outlines, elongated or shortened. Unequivalved. Surface pitted punctate. Adductor scar consists of three or four rows of spots; rows 1 and 2 prominent, posterior rows considerably reduced."

Discussion.—The holotype of *C. kramtchanini* Gramm (1969b, pl. 5, fig. 14) is a possible juvenile right valve 0.775 mm long and 0.520 mm high. A paratype, the carapace of a male (Gramm, 1969b, pl. 5, figs. 15a–d), 0.925 mm long, 0.575 mm high, and 0.350 mm wide was illustrated in right, left, dorsal, and ventral views. Both specimens have a weak subcentral pit and a marginal rim that is stronger along the convex dorsal and ventral margins similar to the specimens illustrated herein. Gramm did not illustrate or describe the dimorphism observed in the present specimens from Alaska.

Gramm did not describe the hingement of *Cavussurella*. A fragment of a valve that is herein provisionally assigned to *Cavussurella* in informal nomenclature as *Cavussurella*? sp. 1 (pl. 10, fig. 9; pl. 11, figs. 25, 26) has a well-developed ridge and groove along the hinge and a groove along the venter to receive the smaller valve similar to the ventral groove shown on plate 4, figure 16. Fragments and a steinkern of a valve (pl 10, fig. 9; pl. 11, figs. 25–27) that differ in lateral outline from *Cavussurella grammi* n. sp. are illustrated in informal nomenclature as *Cavussurella*? spp.

Geologic age.—Middle and Upper Triassic.

Geographic distribution.—Primor'ye Territory, U.S.S.R., and northeastern Alaska.

Cavussurella grammi Sohn, n. sp.

Plate 3, figures 8–21; plate 4, figures 1–21

Etymology of name.—In honor of Dr. M. N. Gramm, Vladivostok, U.S.S.R.

Holotype.—A damaged female carapace, USNM 389845.

Paratypes.—USNM 389838–389844, 389846–389849, 389854, 390039.

Type level.—Ladinian, limestone and dolomite member, from 48.8 to 50.3 m (160–165 ft) above the base of the Shublik Formation.

Diagnosis.—Differs from *Cavussurella kramtchanini* Gramm, 1969b, in that the posterior margin is more broadly rounded, dimorphic in width of posterior.

Description.—Although the specimens are poorly preserved, the following composite conception of the new species can be constructed. The valves are relatively thick (pl. 3, figs. 13, 14, 15–17, 18, 19; pl. 4, figs. 14, 18), subovate, almost elliptical. The dorsal and ventral margins are gently convex and are of approximately the same curvature and height. The right valve overlaps the left slightly along the ventral margin (pl. 3, figs. 16, 17; pl. 4, figs. 3, 12–14) and overreaches along the dorsal margin (pl. 4, figs. 5, 10); it is more convex along the dorsum than the smaller left valve (pl. 4, fig. 2). The right valve has a thicker marginal rim than the left valve (pl. 4, figs. 1, 3, 10–15), and the rim is more pronounced along the dorsum than along the ventral margin and is subdued along the end margins (pl. 3, figs. 14, 15; pl. 4, figs. 3, 4, 10, 14). The species is dimorphic in dorsal outline; the heteromorphs (females) are widest near the posterior (pl. 4, fig. 12), and the tecnomorphs (males and juveniles) are widest behind mid-length (pl. 3, figs. 15, 18; pl. 4, figs. 1, 3, 9). One juvenile (pl. 4, figs. 1–5) has a punctate surface, and it is assumed that the smooth specimens were also punctate. The adductor muscle scar is not preserved, except possibly on the steinkern of the left valve (pl. 3, fig. 20) where it is too poorly preserved to determine the individual rows of spots. Fragments and steinkerns from the same collection as the paratypes (USGS colln. 33132) are tentatively referred to this species (USNM 390039). Because the genus is based primarily on the adductor muscle scar of the type species, the illustrations and a preliminary draft of the description of this species were sent to Prof. M. N. Gramm who very kindly compared the illustrations with the holotype and paratypes of *C. kramtchanini*. He stated (written commun., July 12, 1984) that, in his opinion, the forms are congeneric.

Measurements (in mm) (unfigd. = unfigured specimen, L. V. = left valve).—

	Greatest length	*Greatest height*
USNM 389843	0.53	0.32
USNM 389839	.60	.36
USNM 389841	.60	.40
USNM 389844	.70	.40
USNM 389840	.70+	.50
USNM 38954	.75	.50
USNM 389842	.75+	.5+
USNM 389838	.8+	.4+
USNM 389845	.8+	.5+
USNM 390039, unfigd., L. V.	.80	.60

Geologic range.—Ladinian to Norian, from 36.6 to 145.4 m (120–477 ft) above the base of the Shublik Formation.

Cavussurella? spp.

Plate 10, figure 9; plate 11, figures 25–27

Discussion.—Fragments and steinkerns of specimens that cannot be assigned with certainty to *Cavussurella grammi* are provisionally assigned to the genus. A fragment of a left valve (pl. 10, fig. 9; pl. 11, figs. 25, 26) and a steinkern of a left valve (pl. 11, fig. 27) are illustrated.

The fragment (pl. 10, fig. 9; pl. 11, figs. 25, 26), illustrated as *Cavussurella* sp. 1, has a relatively thick shell similar to *C. grammi* shown on plate 3, figures 13–21, and plate 4, figures 10–21, and has a pleat below the dorsal margin similar to those on plate 3, figure 10, and plate 4, figure 11. The hinge consists of a groove (pl. 10, fig. 9; pl. 11, fig. 26) hitherto not known in *Cavussurella* because neither Gramm (1969b) nor I have been able to observe the hingement on specimens of this genus. The groove along the venter for the reception of the smaller valve resembles the groove exposed on broken carapaces of *C. grammi* (pl. 3, figs. 16, 17; pl. 4, figs. 14, 15, 18). Neither of the two spots seen on plate 11, figure 26, represents the adductor muscle scar when examined in the SEM at X500.

The steinkern of a left valve, illustrated herein as *Cavussurella*? sp. 2 (pl. 11, fig. 27), differs in lateral outline from

C. grammi, as does a second damaged steinkern (USNM 389850).

Measurements (in mm).—USNM 389851, greatest length 0.7+, greatest height 0.60; USNM 389003, greatest length 0.80, greatest height 0.50; unfig. steinkern USNM 389850, greatest length 0.7+, greatest height 0.40.

Geologic range.—Ladinian, limestone and dolomite member, from 45.7 to 64.0 m (155–215 ft) above the base of the Shublik Formation.

Subfamily RECYTELLINAE Gramm, 1970

See discussion under the Ussuricavininae.

Genus RECYTELLA Gramm, 1970

Type species.—*R. amnekhoroshevi* Gramm, 1970, p. 101. text fig. 1, pl. 4, figs. 1–9. Ladinian (AGI translation, p. 86), Primor'ye Territory, U.S.S.R.

Diagnosis.—"Cytherellid Recytellinae of average size. Inequivalvular. The adductor scar is of complex structure consisting of a double-row group and is in the stage of reduction of the supernumerary maculae."

Discussion.—As stated in the discussion of the subfamily Ussuricavininae, Kozur (1972b) considered *Cavussurella* and *Recytella* to be junior synonyms of *Reubenella*. He stated (1972b, p. 19) that *Ussuricavina* Gramm, 1969b, and the Ussuricavininae belong in the Cavellinidae and that the Recytellinae, including *Reubenella*, belong to the Cytherellidae. The females (heteromorphs) of *Reubenella* have a ventroposterior lobe on the outside of the valves (Sohn, 1968, pl. 1, figs. 40, 43–45) that are represented on the inside by distinct cavities (Sohn, 1968, pl. 4, fig. 12). These cavities are lobes on steinkerns as illustrated herein (pl. 2, figs. 1–13) and by Gramm (1969b, pl. 4, figs. 1a, b, 4a).

The adductor muscle-attachment scar of *Recytella* Gramm, 1970, consists of four rows of scars (Gramm, 1970, text fig. 1, pl. 4, figs. 4–9), including the supplementary maculae.

The adductor muscle scar of *Reubenella* Sohn, 1968, consists of more than four rows (Sohn, 1968, pl. 4, fig. 12). The adductor muscle scars illustrated herein (pl. 2, figs. 2, 3, 5) are similar in pattern to the adductor muscle-attachment scar illustrated by Gramm for *Recytella* and document the presence of *Recytella* in Alaska. Because of very poor preservation and inadequate material, the specimens from Alaska are placed in open nomenclature.

Geologic range.—Middle Triassic (Anisian-Ladinian).

Geographic distribution.—Primor'ye Territory, U.S.S.R., and northeastern Alaska.

Recytella sp. 1

Plate 2, figures 1–9

Discussion.—The adductor muscle scar illustrated on plate 2, figure 5, and the posterolateral bulge shown on figures 2, 4, 6, 8, 9 identify the two steinkerns as belonging in *Recytella*.

Measurements (in mm).—USNM 389810, greatest length 0.72+, greatest height 0.41+; USNM 389811, greatest length 0.7+, greatest height 0.4+.

Geologic range.—Ladinian, limestone and dolomite member, from 56.4 to 67.1 m (185–220 ft) above the base of the Shublik Formation.

Recytella sp. 2

Plate 2, figures 10–13

Discussion.—The illustrated specimen appears to have shell material retained on the right valve. The fact that this apparent shell material extends on the left over the area of the impression of the ventral contact on the steinkern (figs. 10, 11, 13) suggests that this is neither original nor replaced shell material. A steinkern of a left valve and the inside of a damaged left valve in USGS colln. 33132 (USNM 390010) probably belong to this taxon.

Measurements in (mm).—USNM 389812, greatest length 0.72, greatest height 0.5+; unfigd. spec. USNM 390010, greatest length 0.71, greatest height 0.44.

Geologic range.—Ladinian, limestone and dolomite member, from 67.1 to 68.6 m (220–225 ft) above the base of the Shublik Formation.

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PLATES 1–11

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PLATE 1

FIGURES 1–9. "*Healdia*" sp. 1

1–4. Posterior, right, dorsal (anterior to left), and ventral views of steinkern, approx. X120. Figured specimen, USNM 389803. Ladinian, USGS colln. 33123.

5–9. Dorsal (anterior to right), right, detail of adductor muscle-attachment scar of right valve, left, and detail adductor muscle scar of left valve of steinkern, approx. X80, details approx. X280. Note frontal and dorsal muscle-attachment scars in figs. 7, 8. Figured specimen, USNM 389804. Ladinian, USGS colln. 33111.

10–14. "*Healdia*" sp. 2. Dorsal (anterior to left), left, right, and ventral (anterior to right) views of steinkern, approx. X120. Figured specimen, USNM 389805. Ladinian, USGS colln. 33130.

15–21. "*Healdia*" sp. 3. Detail of denticulated hinge in area shown by arrow on fig. 16, approx. X267, dorsal (anterior to left), posterior, detail of adductor muscle scar of left valve, approx. X400, detail of denticulated hinge in area shown by arrow on fig. 21, approx. X600, and right views of steinkern with retained parts of shell, approx. X120. Figured specimen, USNM 389806. Ladinian, USGS colln. 33110.


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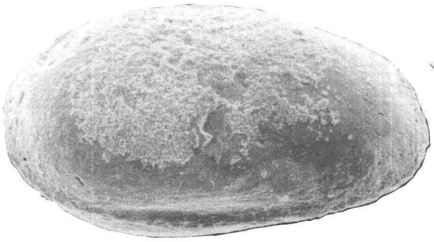
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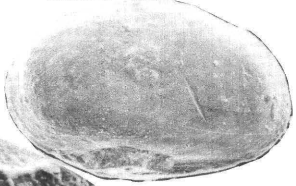
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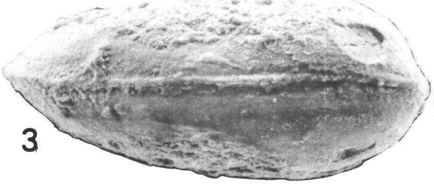
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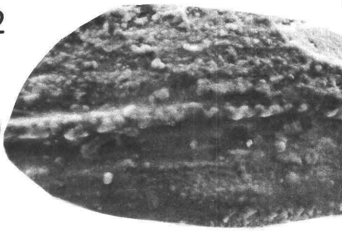
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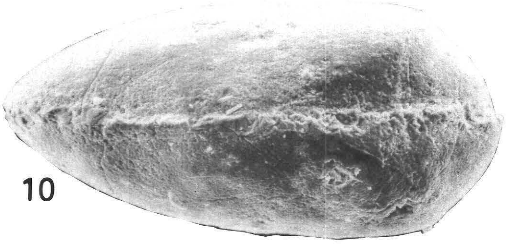
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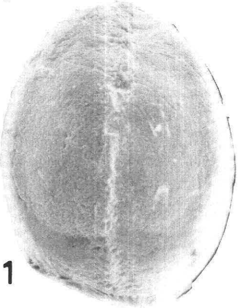
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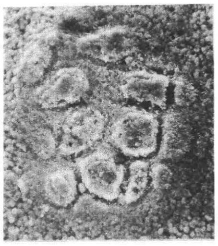
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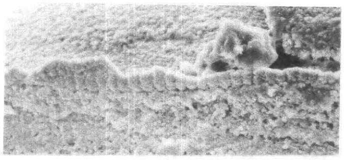
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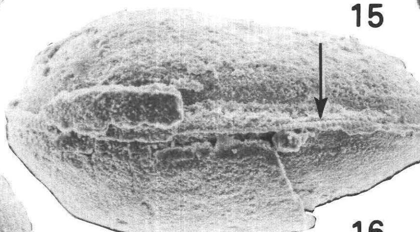
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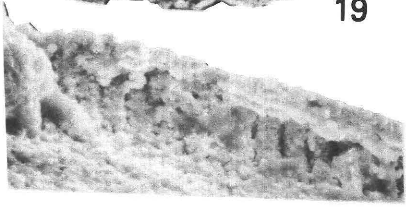
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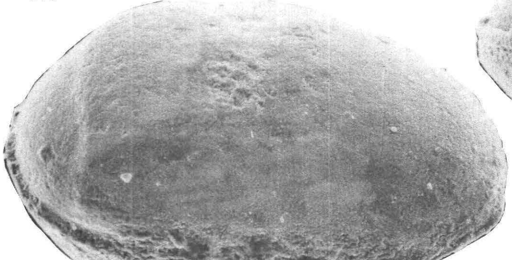
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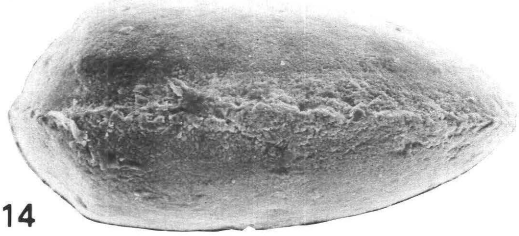
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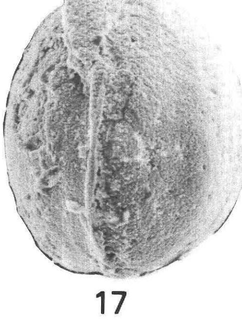
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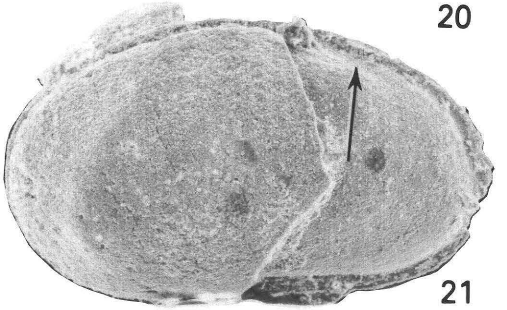
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"HEALDIA"

PLATE 2

FIGURES 1–9. *Recytella* sp. 1.

1–5. Dorsal (anterior to left), right, left, and ventral (anterior to right) views of broken steinkern, approx. X80, detail of left adductor muscle-attachment scar, approx. X400. Figured specimen, USNM 389810. Ladinian, USGS colln. 33124.

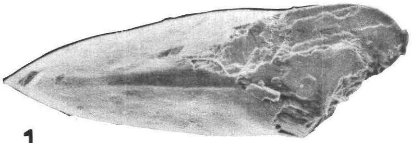
6–9. Dorsal (anterior to left), left, right, and ventral (anterior to right) views of steinkern, approx. X80. Figured specimen, USNM 389811. Ladinian, USGS colln. 33130.

10–13. *Recytella* sp. 2. Left, ventral (anterior to left), dorsal (anterior to right), and posterior views of carapace with poorly preserved right valve and missing left valve, approx. X80. Figured specimen, USNM 389812. Ladinian, USGS colln. 33131.

14–17. *Pseudobythocypris*? sp. Dorsal (anterior to right), right, left, and posterior views of carapace, approx. X60. The white spot and line near the ventroposterior of fig. 16 is an artifact due to adhering lint. Figured specimen, USNM 389813. Carnian, USGS colln. 33141.

18, 19. *Hiatobairdia*? sp. ex gr. *H. arcuata* Kristan-Tollman, 1970. Dorsal (anterior to left) and left, slightly tilted towards venter, views of abraded carapace, approx. X120. Figured specimen, USNM 389814. Norian, USGS colln. 33148.

20–26. *Covracythere gryci* n. sp. Posterior oblique, dorsal (anterior to right), detail of right adductor muscle-attachment scar, right, left, left tilted to show costae, and detail of left adductor muscle-attachment scar, approx. X100; details of adductor muscle-attachment scar approx. X400. Paratype, USNM 389817. Ladinian, USGS colln. 33129.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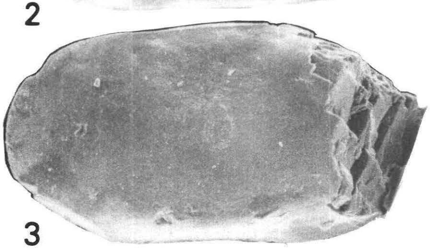
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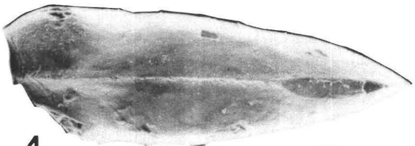
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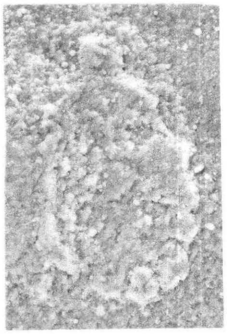
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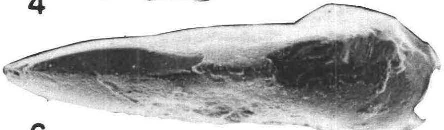
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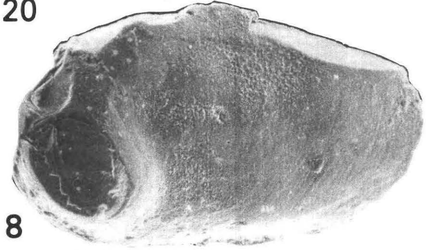
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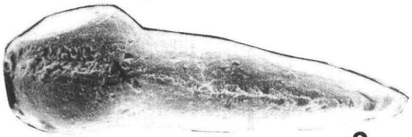
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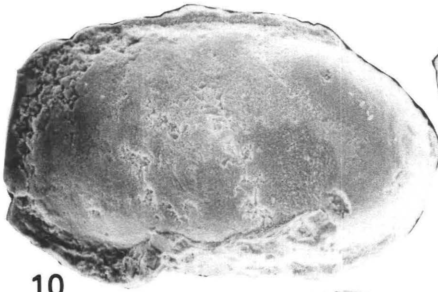
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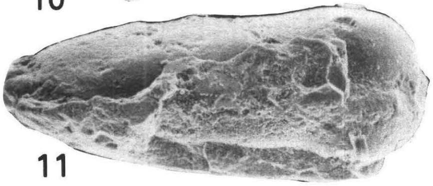
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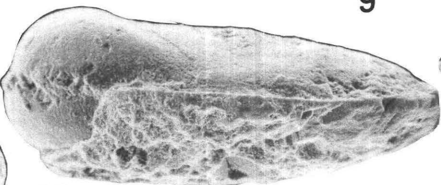
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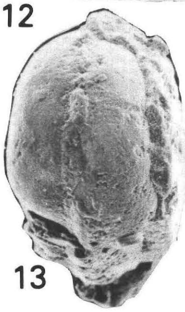
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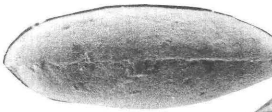
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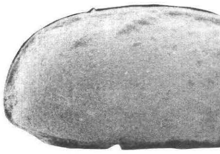
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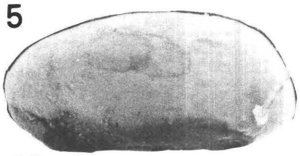
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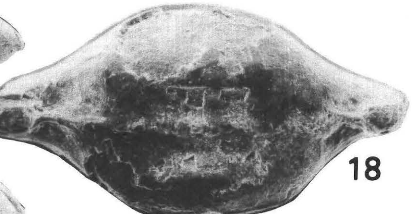
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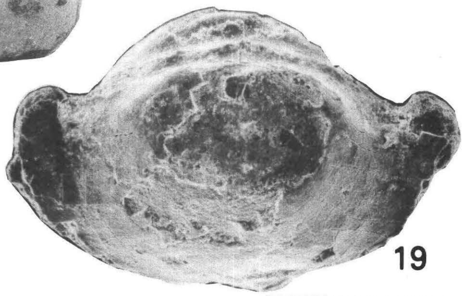
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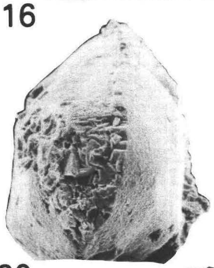
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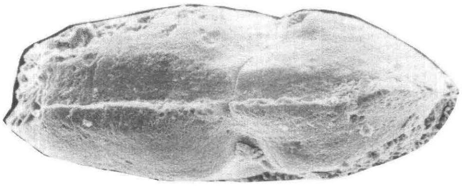
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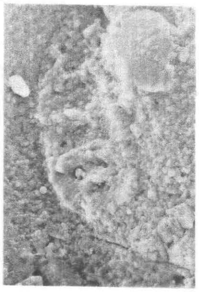
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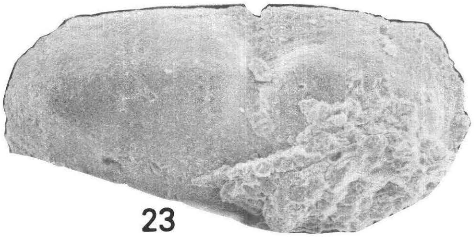
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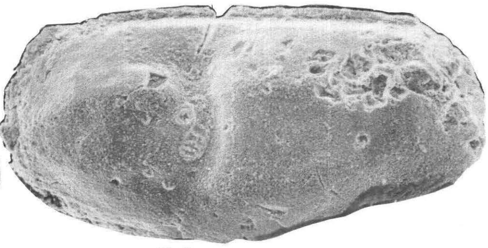
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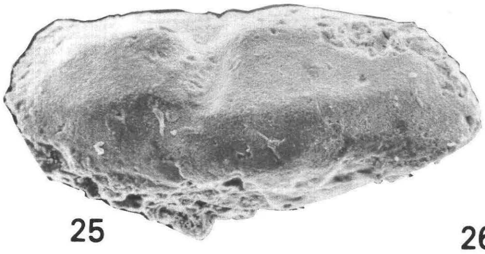
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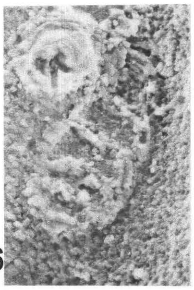
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RECYTELLA, *PSEUDOBYTHOCYPRIS?*, *HIATOBAIRDIA?*, AND *COVRACYTHERE*

PLATE 3

FIGURES 1–6. *Cornutobairdia reidae* Sohn, n. sp.

1–3. Dorsal (anterior to right), left, and right views of carapace, approx. X60. Holotype, CGS 80063. Norian, Lewes River Formation, Yukon Territory, USGS colln. 33170.

4. Inside view of right valve showing reversal of overlap and symmetry, approx. X60. Paratype, CGS 80064. Same colln. as above.

5. Inside view of left valve showing reversal of overlap and symmetry, approx. X60. Paratype, CGS 80065. Same colln. as above.

6. Left view of carapace with broken subcentral node, approx. X60. Paratype, CGS 80066. Same colln. as above.

7. *Ogmoconcha*? sp. aff. *H. limbata* (Reuss, 1868) *sensu* Urlichs, 1971. Outside view of left valve on matrix, approx. X60. Figured specimen, USNM 389837. Ladinian, USGS colln. 33129.

8–21. *Cavussurella grammi* Sohn, n. sp.

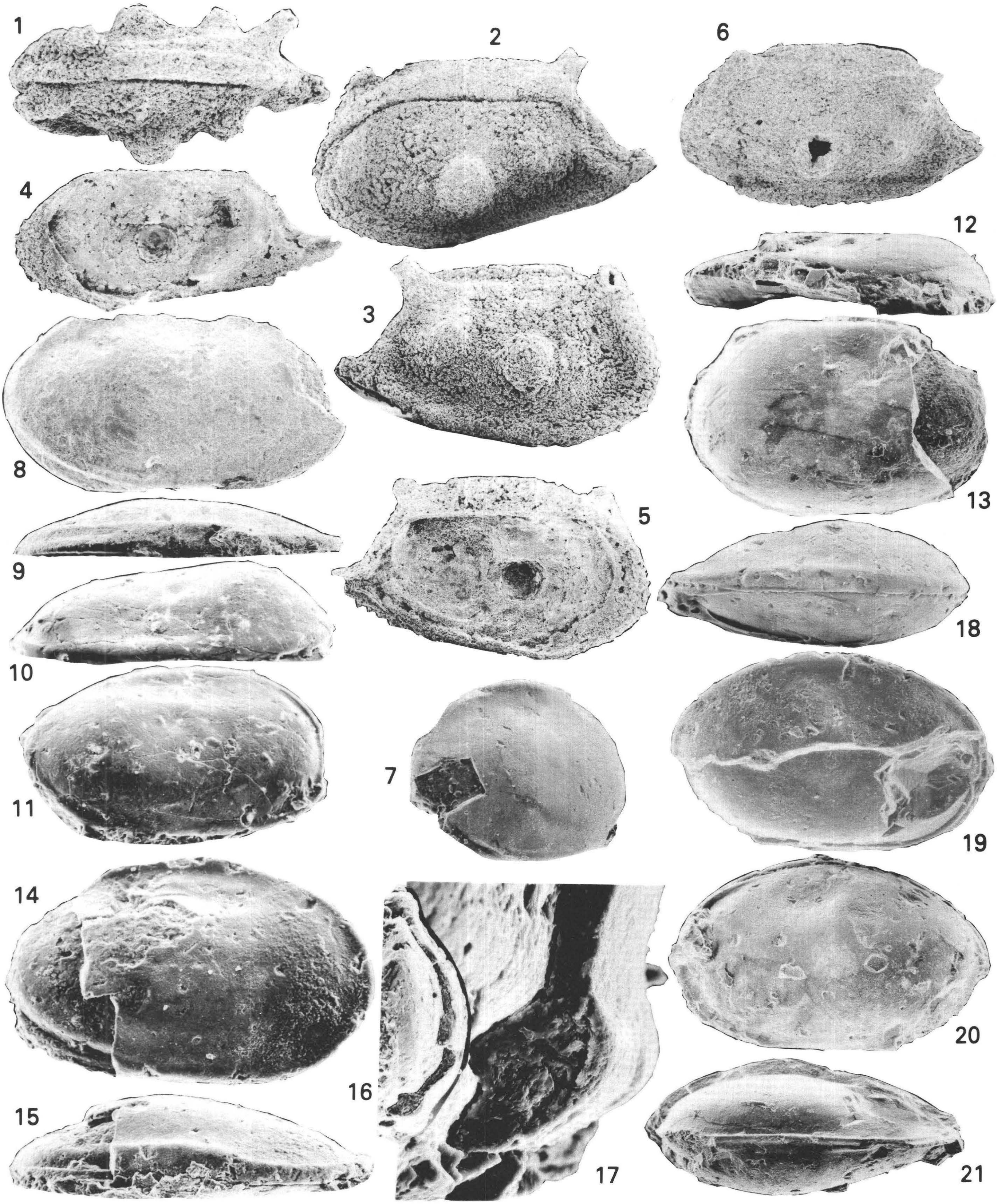
8, 9. Outside and ventral (anterior to right) views of right valve, male, approx. X80. Paratype, USNM 389838. Ladinian, USGS colln. 33124.

10, 11. Dorsal oblique (anterior to left) and outside views of right valve, approx. X100. Paratype, USNM 389839. Ladinian, USGS colln. 33132.

12, 13. Dorsal (anterior to left) and outside views of right valve, anterior part of shell missing, approx. X80. Paratype, USNM 389840. Ladinian, USGS colln. 33132.

14–17. Outside, ventral (anterior to right), posterior, and detail of ventroposterior showing overlap of right valve, young growth stage on matrix, posterior part of shell missing, approx. X120; fig. 17, approx. X600. Paratype, USNM 389841. Ladinian, USGS colln. 33121.

18–21. Dorsal (anterior to right), right, left, and ventral (anterior to left) views of steinkern with dorsal part of right valve retained, young growth stage, approx. X80. Note poorly preserved adductor muscle scar on fig. 20. Paratype, USNM 389842. Ladinian, USGS colln. 33132.



CORNUTOBAIRDIA, *OGMOCONCHA?*, AND *CAVUSSURELLA*

PLATE 4

FIGURES 1–21. *Cavussurella grammi* Sohn, n. sp.

1–5. Dorsal (anterior to right), left (slightly tilted), ventral (anterior to left), and posterior views of carapace with part of the ventroposterior missing, young growth stage, approx. X120. Paratype, USNM 389843. Ladinian, USGS colln. 33119.

6–9. Inside, posterior, outside, and ventral (anterior to right) views of right valve of larger growth stage, approx. X80. Paratype, USNM 389844. Same colln. as above.

10–15. Posterior, right, ventral (anterior to right), left, carapace of female, appox. X80; fig. 15, approx. X400. Holotype, USNM 389845. Same colln. as above.

16–21. Dorsal (anterior to right), right, anterior, left, ventral (anterior to left), and detail of shell (venter to left) at anteroventral of right valve of damaged carapace, approx. X80; fig. 21, approx. X400. Paratype, USNM 389854. Norian, USGS colln. 33169.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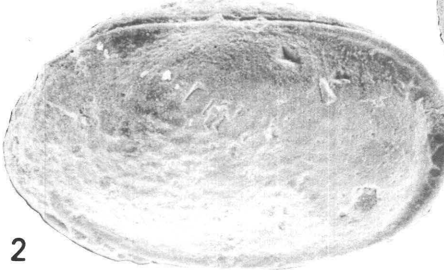
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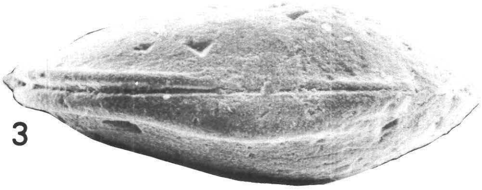
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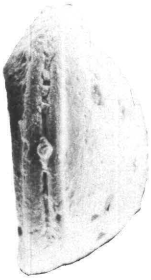
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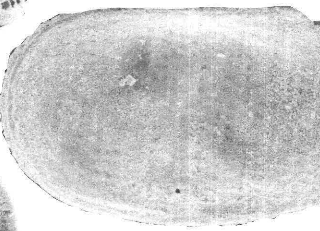
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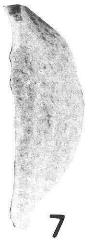
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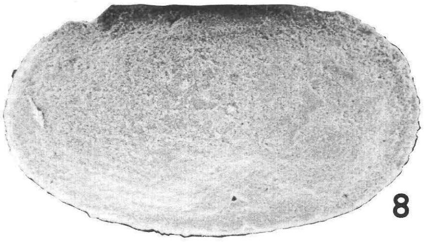
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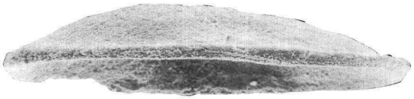
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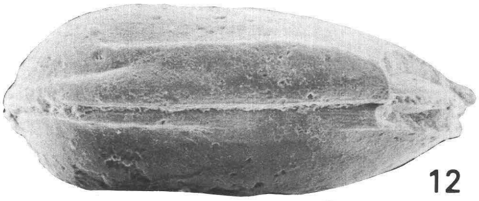
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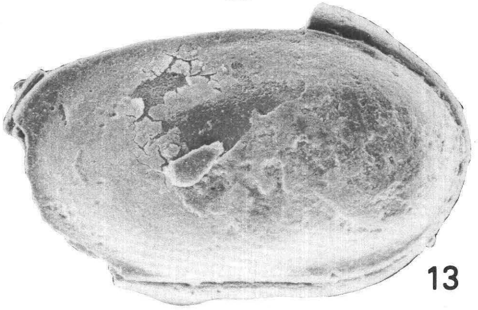
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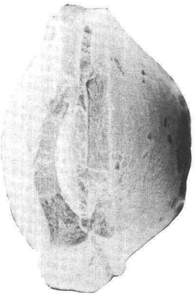
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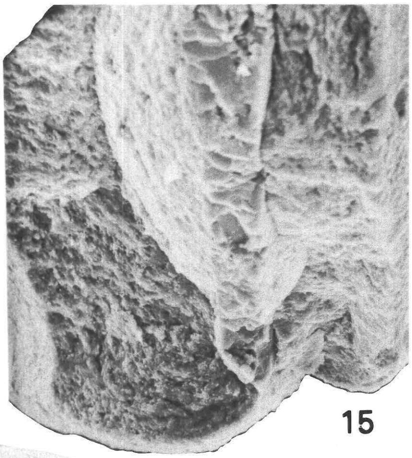
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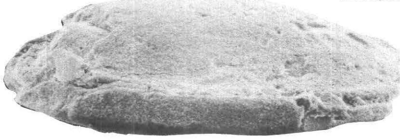
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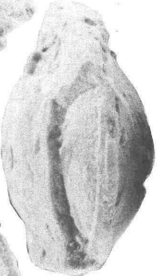
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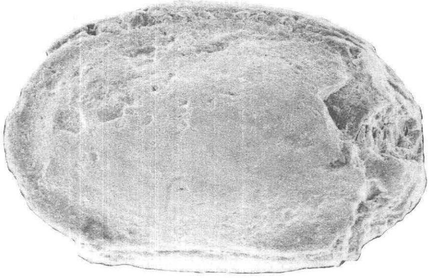
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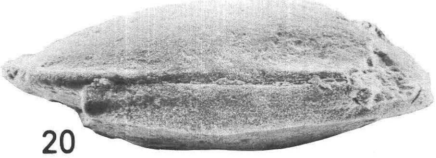
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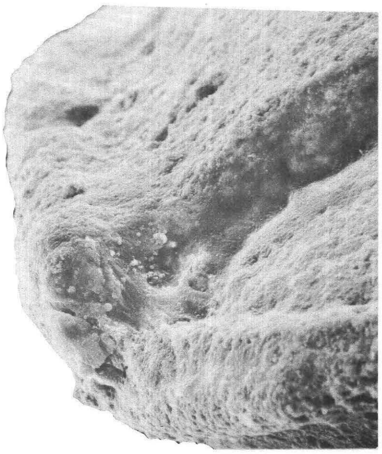
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CAVUSSURELLA

PLATE 5

FIGURES 1–10. *Ogmoconcha unicerata* Sohn, n. sp.

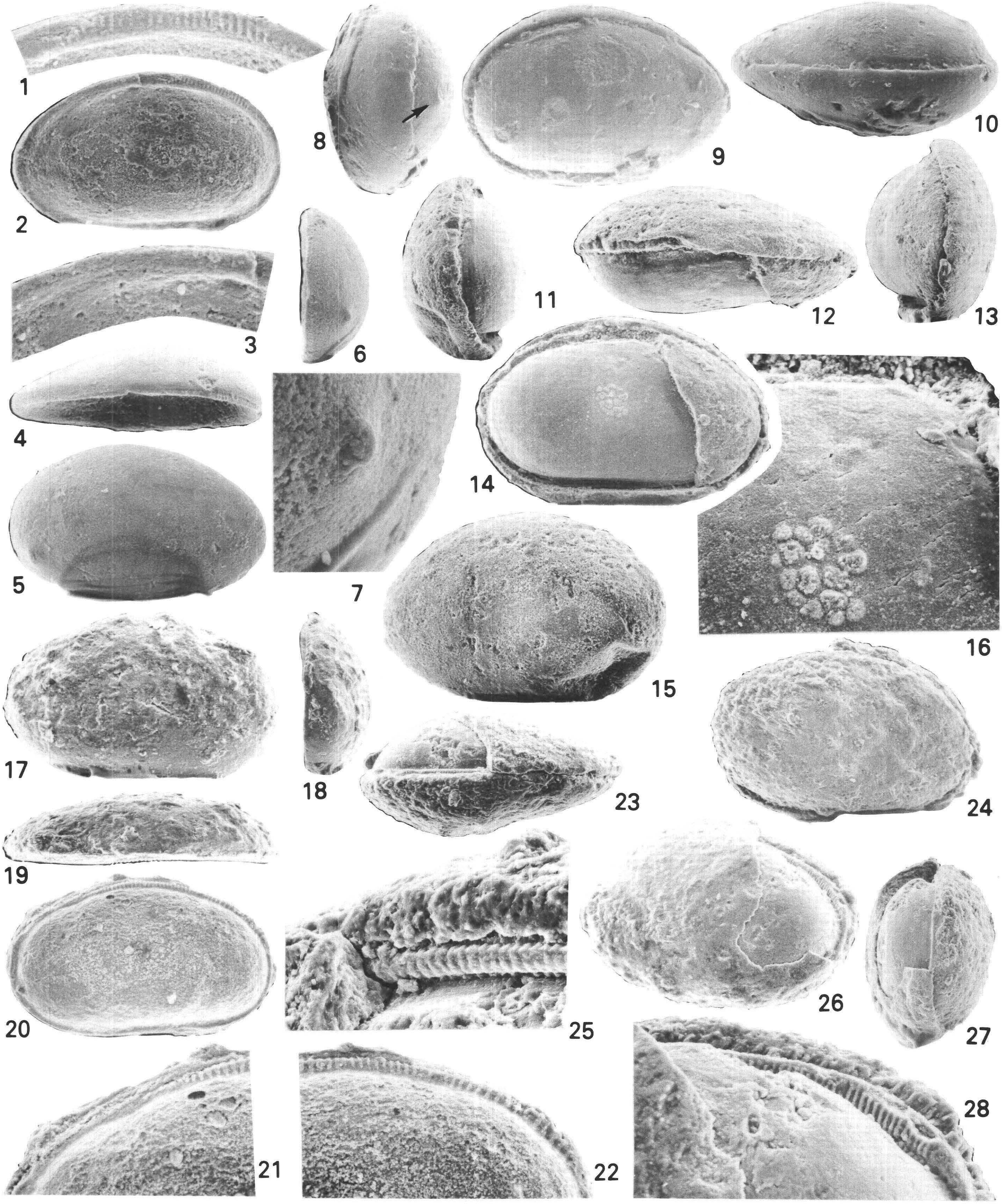
1–7. Detail of posterior part of hinge, approx. X275; dorsal (anterior to left), outside, and posterior views of right valve, approx. X120, and detail of posteroventral spine, approx. X533. Holotype, USNM 389855. Ladinian, USGS colln. 33112.

8–10. Posterior, right, and dorsal views of carapace, approx. X120. Arrow on fig. 8 shows posterodorsal spine. Paratype, USNM 389856. Ladinian, same colln. as above.

11–16. *Ogmoconcha* aff. sp. *O. owthropensis* (Anderson, 1964). Posterior, dorsal (anterior to left), anterior, right, and left views of carapace with posterior two-thirds of right valve missing to expose adductor muscle-attachment scar, approx. X120; detail adductor muscle-attachment scar, approx. X360. Figured specimen, USNM 389857. Ladinian, USGS colln. 33154.

17–22. *Ogmoconcha tailleuri* n. sp. Outside, posterior, dorsal (anterior to left), and inside views of right valve, approx. X120; details of anterior and posterior parts of hinge, approx. X240. Paratype, USNM 389858. Norian, USGS colln. 33155.

23–28. *Ogmoconcha alaskaense* n. sp. Dorsal (anterior to right), right, posterior oblique detail of exposed part of right hinge, left, posterior, and exposed right hinge of carapace with posterior part of left valve missing, approx. X120; fig. 25, approx. X500; fig. 28, approx. X340. Note rough outside surface of shell, presumed to be surface deposit chartacteristic of many of the smooth forms at this locality, shown best on figs. 25, 28. Paratype, USNM 389859. Norian, USGS colln. 33158.



OGMOCONCHA

PLATE 6

FIGURES 1–9. *Ogmoconcha* sp. aff. *O. owthropensis* (Anderson, 1964).

1–3. Dorsal (anterior to right), right, and ventral (anterior to right) views of carapace, approx. X120. Figured specimen, USNM 389852. Norian, USGS colln. 33156.

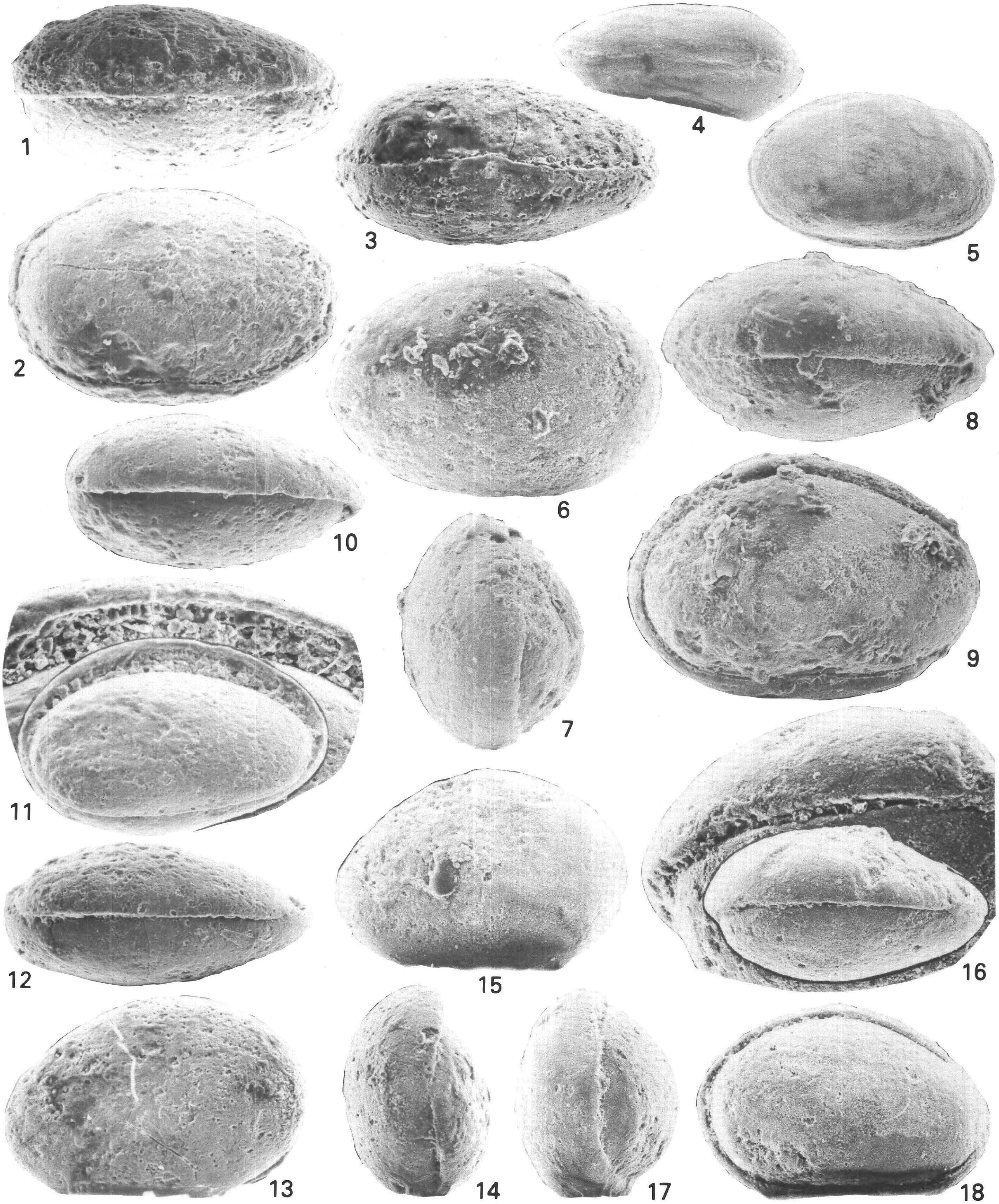
4, 5. Dorsal (anterior to left) and right views of steinkern of carapace with poorly preserved adductor muscle-attachment scar, approx. X120. Figured specimen, USNM 389860. Norian, USGS colln. 33159.

6–9. Left, posterior, dorsal (anterior to right), and right views of carapace, approx. X120. Figured specimen, USNM 389861. Norian, USGS colln. 33169.

10–18. *Ogmoconcha tailleuri* n. sp

10–14. Dorsal (anterior to right), right and detail of left hinge to show denticulation, ventral (anterior to right), left, and posterior views of a left valve with a right valve of an other individual inside, approx. X120; detail of hinge, approx. X240. Paratype, USNM 389862. Norian, USGS colln. 33156.

15–18. Left, dorsal (anterior to right) and detail of dorsal slightly tilted to show poorly preserved denticulated hinge, posterior, and right views of carapace, approx. X100; detail, approx. X200. Paratype, USNM 389863. Norian, USGS colln. 33165.



OGMOCONCHA

PLATE 7

FIGURES 1–3. *Covracythere binoda* Sohn, n. sp.

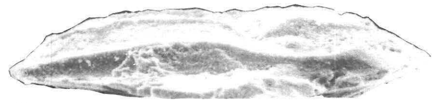
Dorsal (anterior to left), outside, and ventral (anterior to right) views of left valve, approx. X120. Holotype, USNM 389818. Ladinian, USGS colln. 33111.

4–15. *Dettermania truncata* Sohn, n. sp.

- 4–6. Dorsal (anterior to right), left, and ventral (anterior to left) views of steinkern with ventral two-thirds of left valve preserved to expose the thickness of the valve, approx. X60. Paratype, USNM 389819. Ladinian, USGS colln. 33112.
- 7–11. Ventral (anterior to left), anterior, dorsal (anterior to right), right, and left views of carapace with missing posterior, approx. X80. Holotype, USNM 389820. Same colln. as above.
- 12–15. Left, ventral (anterior to right), dorsal (anterior to left), and right views of carapace, approx. X60. Paratype, USNM 389821. Same colln. as above.

16–25. *Corvacythere gryci* n. sp.

- 16–20. Dorsal (anterior to left), left, posterior, right, and ventral (anterior to right) views of tecnomorph, carapace with only the innermost surface of the valves preserved, approx. X100. Paratype, USNM 389822. Norian, USGS colln. 33169.
- 21, 22. Left (ventral up) and ventral views of poorly preserved steinkern of heteromorph, approx. X80. Paratype USNM 389823. Ladinian, USGS colln. 33113.
- 23–25. Dorsal (anterior to right), left, and ventral (anterior to right) views of steinkern of heteromorph, approx. X53. Holotype, USNM 389824. Ladinian, USGS colln. 33111.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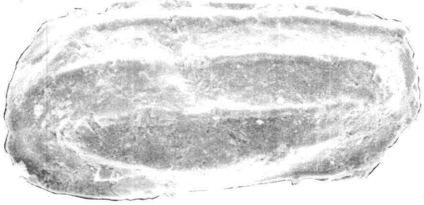
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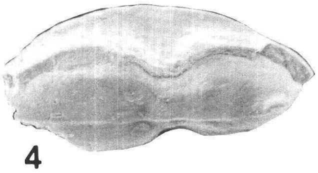
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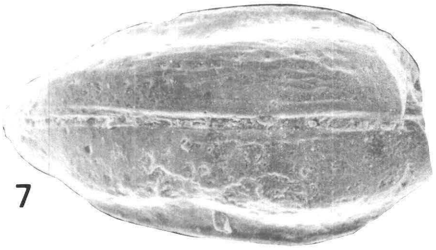
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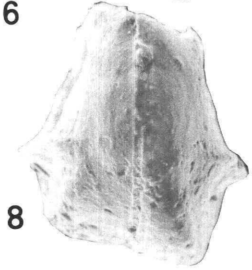
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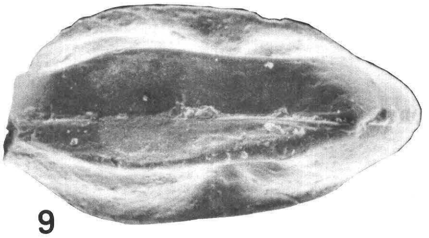
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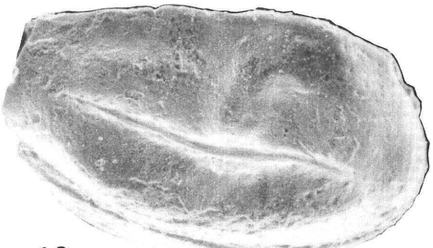
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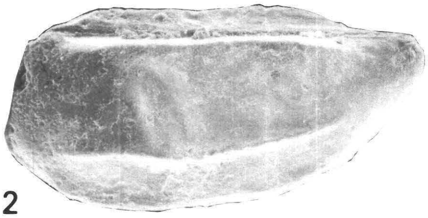
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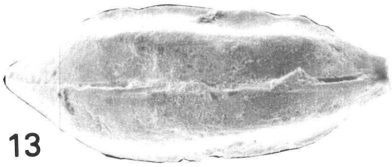
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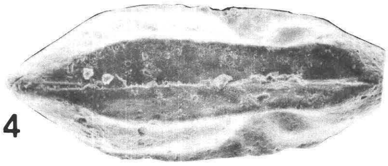
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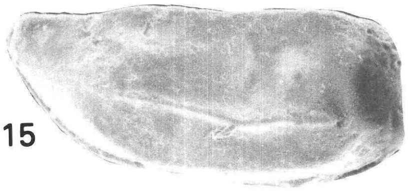
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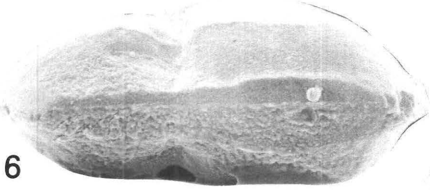
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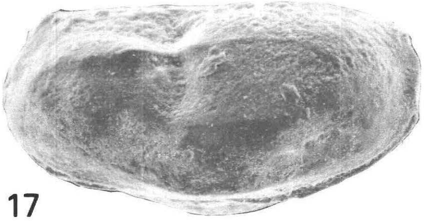
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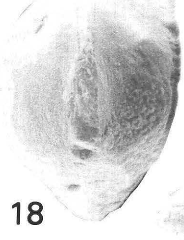
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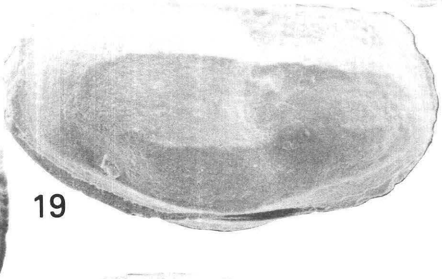
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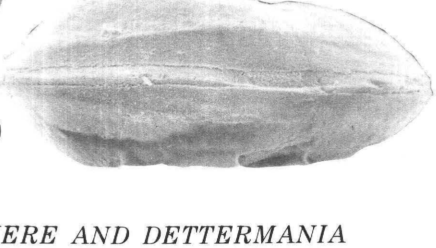
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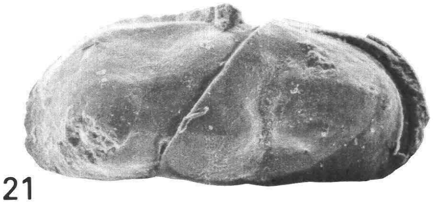
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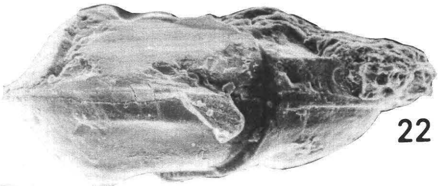
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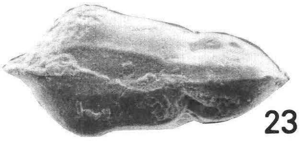
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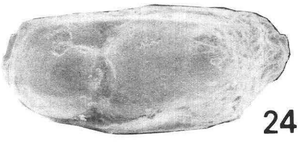
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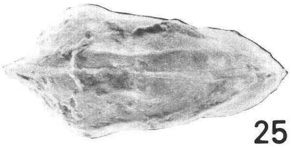
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COVRACYTHERE AND DETTERMANIA

PLATE 8

FIGURES 1–6, 10–19. *Ogmoconcha tailleuri* n. sp.

1–3. Posterior, right, and dorsal (anterior to left) views of carapace, approx. X80. Paratype, USNM 389875. Ladinian, USGS colln. 33119.

4–6. Posterior, right, and dorsal (anterior to right) views of carapace, approx. X100. Paratype, USNM 389876. Ladinian, USGS colln. 333124.

10, 11. Dorsal (anterior to left) and posterior views of carapace, approx. X120. Paratype, USNM 389864. Ladinian, USGS colln. 33117.

12–14. Posterior, dorsal (anterior to right), and left views of carapace with a fragment of posterior of left valve missing to expose thickness of shell, approx. X120. Holotype, USNM 389865. Ladinian, USGS colln. 33119.

15–19. Dorsal (anterior to left), posterior, right, and left views of carapace with part of the ventral valve missing, approx. X80; detail of adductor muscle scar, approx. X400. Paratype, USNM 389866. Same colln. as above.

7–9, 20–27. *Ogmoconcha* sp. aff. *O. owthropensis* (Anderson, 1964).

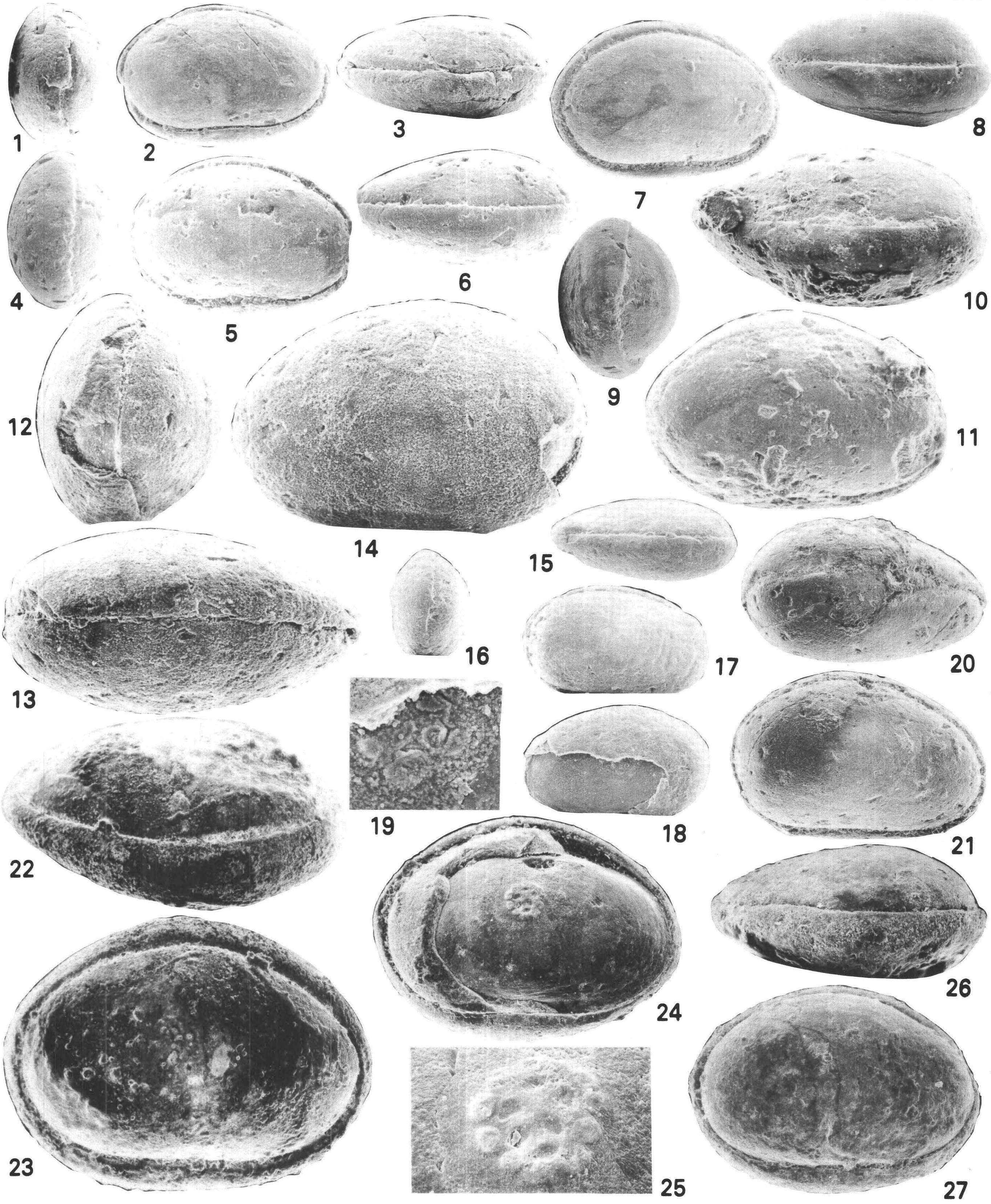
7–9. Right, dorsal (anterior to left), and posterior views of carapace, approx. X80. Figured specimen, USNM 389877. Ladinian, USGS colln. 33109.

20, 21. Dorsal oblique (anterior to right), and right views of carapace, approx. X80. Figured specimen, USNM 389878. Ladinian, USGS colln. 33130.

22, 23. Dorsal (anterior to left) and right views of carapace, approx. X120. Figured specimen, USNM 389879. Norian, USGS colln. 33148.

24, 25. Right view of carapace with most of the valve missing to expose the adductor muscle-attachment scar, approx. X127, and detail of adductor muscle-attachment scar, approx. X433. Figured specimen, USNM 389880. Norian, USGS colln. 33145.

26, 27. Dorsal (anterior to left) and right views of carapace, approx. X127. Figured specimen, USNM 389881. Norian, USGS colln. 33149.



OGMOCONCHA

PLATE 9

FIGURES 1–4. *Ogmoconcha tailleuri* n. sp. Ventral (anterior to left), left, posterior, and right views of corroded carapace, approx. X80. Paratype USNM 389883. Ladinian, USGS colln. 31127.

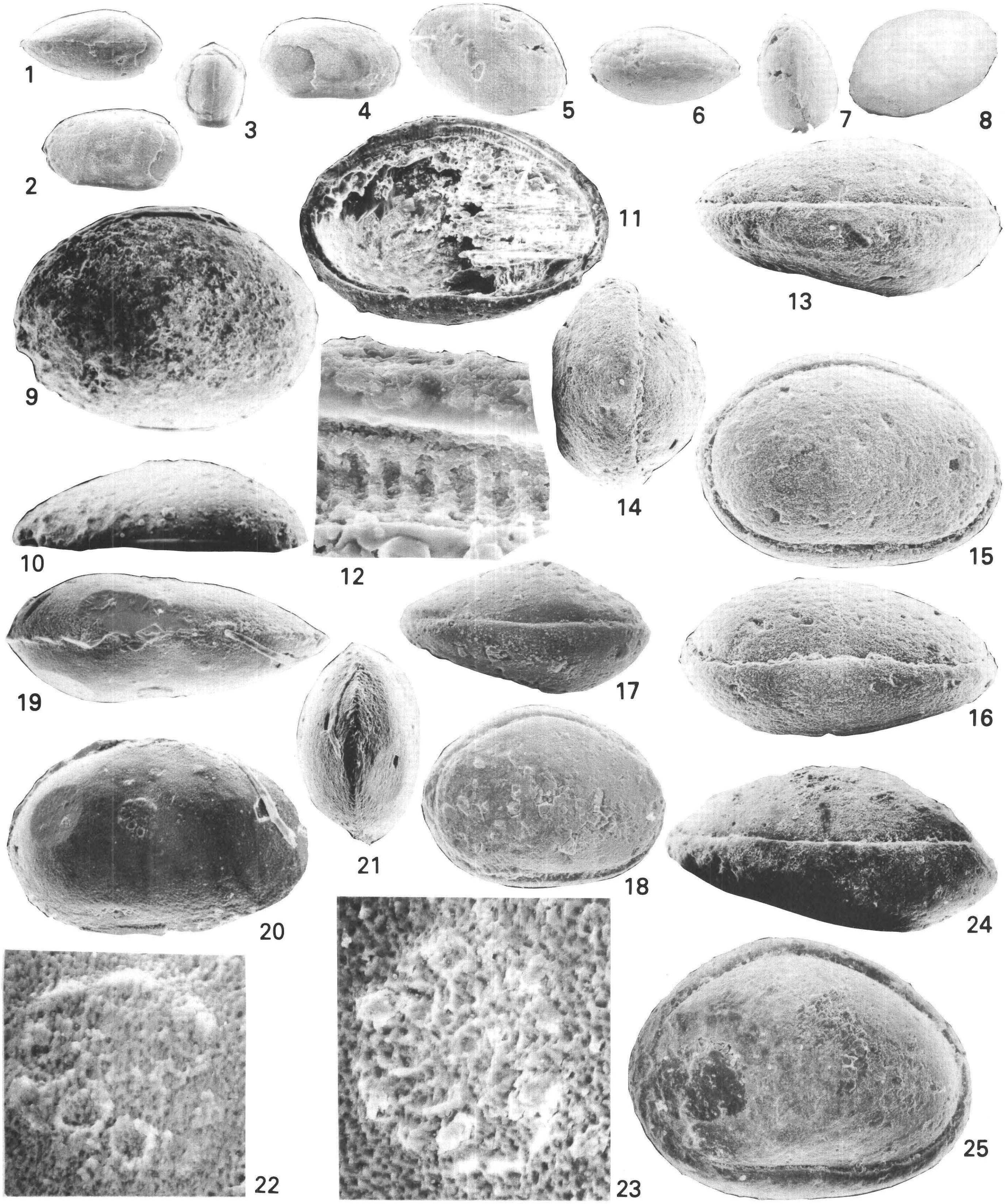
5–8. *Ogmoconcha marquardti* n. sp. Left, dorsal (anterior to left), posterior, and right views of steinkern, very young instar, approx. X120. Paratype, USNM 389882. Norian, USGS colln. 33147.

9–16, 19–23. *Ogmoconcha* sp. aff. *O. owthropensis* (Anderson, 1964).

- 9–12. Outside, ventral (anterior to left), and inside views of left valve, approx. X133; detail of anterior part of denticulated hinge, shown by arrow on fig. 11, approx. X820. Figured specimen, USNM 389919. Norian, USGS colln. 33156.
- 13–16. Dorsal (anterior to left), posterior, right, and ventral (anterior to right) views of carapace, approx. X120. Figured specimen, USNM 389884. Ladinian, USGS colln. 33119.
- 19–23. Dorsal (anterior to right), right, and anterior views of steinkern, approx. X120; details of right and left adductor muscle-attachment scar, approx. X600. Figured specimen, USNM 389886. Ladinian, USGS colln. 33130.

17, 18, 24, 25. *Ogmoconcha alaskaense* n. sp.

- 17, 18. Dorsal (anterior to left) and right views of carapace, posterodorsal part of right valve missing, approx. X120. Paratype, USNM 389885. Norian, USGS colln. 33148.
- 24, 25. Right view of carapace with most of the valve missing to expose the adductor muscle-attachment scar, approx. X127, and detail of adductor muscle-attachment scar, approx. X433. Holotype, USNM 389887. Norian, USGS colln. 33149.



OGMOCONCHA

PLATE 10

FIGURES 1–8, 15–22. *Ogmoconcha tailleuri* n. sp.

1–4. Dorsal (anterior to left), posterior, right, and ventral (anterior to right) views of carapace, approx. X80. Paratype, USNM 389901. Ladinian, USGS colln,. 33119.

5–7. Left showing poorly preserved adductor muscle scar, posterior, and dorsal (anterior to left) views of steinkern, approx. X80. Note poorly preserved denticulation on dorsoposterior of fig. 7. Paratype, USNM 389899. Ladinian, USGS colln. 33111.

8. Inside view of right valve showing denticulated hinge, approx. X120. Paratype USNM 389888. Norian, USGS colln. 33155.

15–19. Dorsal (anterior to right), posterior, right, left, and detail of adductor muscle scar exposed on left valve of carapace, approx. X120; detail, approx. X290. Paratype, USNM 389910. Ladinian, USGS colln. 33120.

20–22. Posterior, dorsal oblique tilted on right valve, and right views of carapace, approx. X120. Paratype, USNM 389911. Ladinian, USGS colln. 33129.

9. *Cavussurella?* sp. 1. Posterior oblique view of fragment of left valve showing hinge groove and groove along venter for reception of smaller valve, approx. X80. Left end of micrograph trimmed to fit plate, compare with pl. 4, figs. 15, 21. Figured specimen, USNM 389851. Ladinian, USGS colln. 33117.

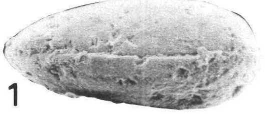
10, 11. *Rhombocythere?* sp. Outside and inside views of fragment of left valve showing groove along the venter, approx. X100. Apparent denticulations on both ends of ridge above groove are probably artifacts due to preservation. Figured specimen, USNM 389853. Ladinian, USGS colln. 33132.

12–14. *Ogmoconcha* sp. Dorsal (anterior to left), detail of dorsum to show denticulation, and right views of carapace with the right valve slightly rotated within the left to show denticulation hinge, approx. X80; detail, approx. X160. Figured specimen, USNM 389999. Lower Carnian, Hungary, USGS colln. 33172.

23–32. *Ogmoconcha marquardti* n. sp.

23–26. Dorsal (anterior to left), right, and ventral (anterior to right) views of carapace on which dorsoposterior edge of right valve is missing to expose denticulated hinge, approx. X120; detail of exposed denticulation, approx. X600. Paratype, USNM 389889. Norian, USGS colln. 33154.

27–32. Posterior, right tilted down to show dorsal overlap, right tilted up to show ventral overlap, dorsal (anterior to right), left, and ventral (anterior to left) views of carapace. Holotype, USNM 389905. Norian, USGS colln. 33158.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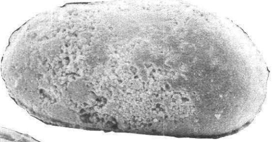
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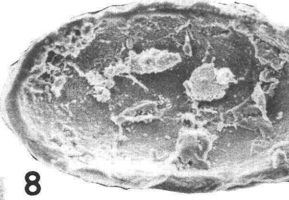
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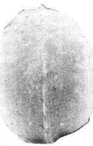
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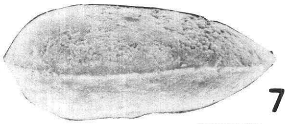
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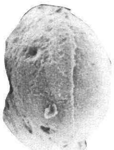
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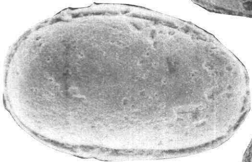
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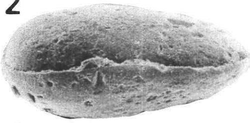
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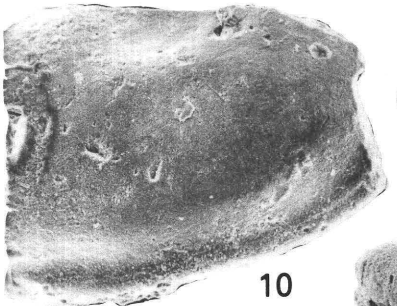
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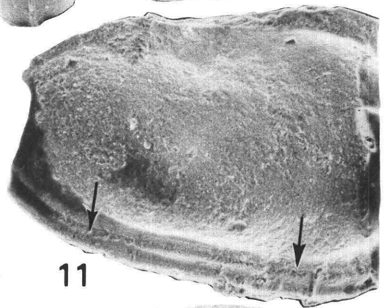
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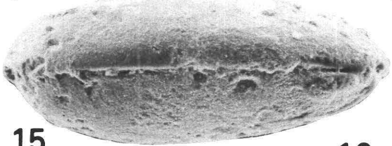
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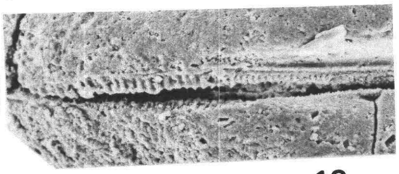
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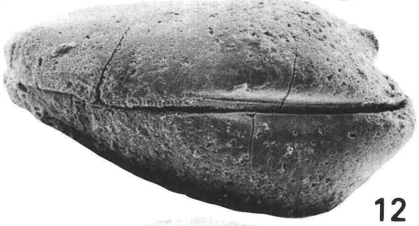
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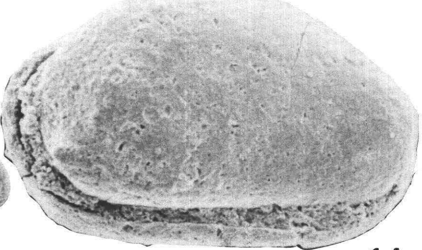
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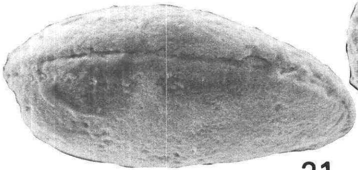
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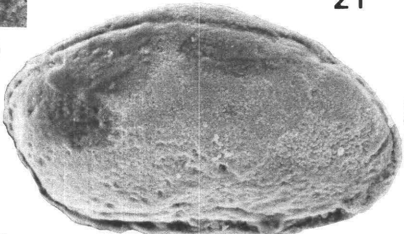
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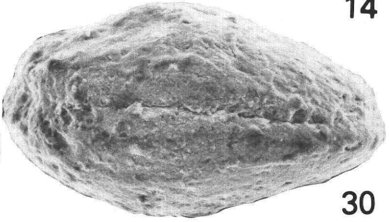
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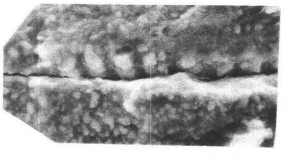
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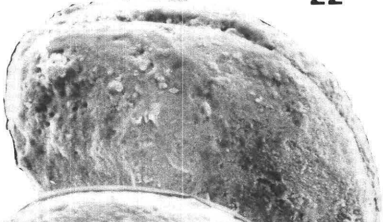
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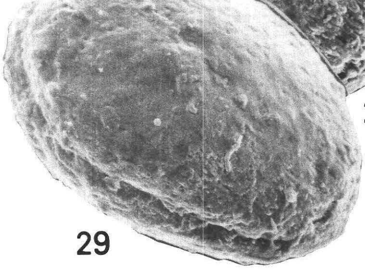
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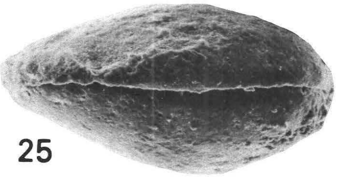
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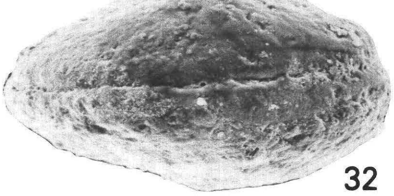
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OGMOCONCHA, *CAVUSSURELLA?*, AND *RHOMBOCYTHERE?*

PLATE 11

FIGURES

1–4. *Triassocypris?* sp. Dorsal (anterior to right), left, ventral (anterior to left), and posterior views of carapace, approx. X80. Figured specimen, USNM 390005. Norian, USGS colln. 33149.

5, 6. Gen. and sp. indet. Right and ventral views of carapace, approx. X125. Figured specimen, USNM 390006. Norian, same colln. as above.

7–12. *Ogmoconcha tailleuri* n. sp.

- 7–9. Posterior, right, and ventral (anterior to right) views of right valve, approx. X55. The particle in the posteroventral area is not a spine. Paratype, USNM 389903. Ladinian, USGS colln. 33112.
- 10. Right view of steinkern, approx. X120. Paratype, USNM 390004. Norian, USGS colln. 33152.
- 11. Right view of carapace, approx. X120. Holotype, USNM 389865, same specimen as pl. 8, figs. 12–14. Ladinian, USGS colln. 33119.
- 12. Ventral (anterior to right) view of carapace, approx. X80. Paratype, USNM 389875, same specimen as pl. 8, figs. 1–3. Ladinian, USGS colln. 33119.

13–16, 20–24. *Ogmoconcha* sp.

- 13–16. Outside, detail of denticulate hinge, detail of dorsal, and inside views of left valve, approx. X100; fig. 14, approx. X500; fig. 15, approx. X200. Figured specimen, USNM 390009. Carnian, Hungary, USGS colln. 33172.
- 20, 21. Inside view of right valve converted to fluorite, approx. X100; detail of posterior part of denticulate hinge, approx. X300. Compare with figs. 14, 15, 18, 19. Figured specimen, USNM 390007. Carnian, Hungary, USGS colln. 33172.
- 22–24. Inside view of right valve treated with hydrogen peroxide, converted to fluorite with hydrofluoric acid, and then treated with ultrasonic waves to clean and break the carapace. Fragment of left valve, approx. X80; right view of carapace before treatment, approx. X40. Figured specimen, USNM 390008. Carnian, Hungary, USGS colln. 33172.

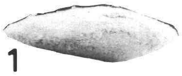
17–19. *Ogmoconcha alaskaense* n. sp. Dorsal (anterior to right), approx. X130; detail of denticulate hinge, approx. X250; inside of left valve, approx. X125. Paratype, USNM 389896. Norian, USGS colln. 33148.

25, 26. *Cavussurella?* sp. 1. Outside and inside views of fragment of left valve, approx. X80. Note dorsal pleat on fig. 25, and hinge and ventral grooves on fig. 26. Figured specimen, USNM 389851, same specimen as pl. 10, fig. 9. Ladinian, USGS colln. 33117.

27. *Cavussurella?* sp. 2. Outside view of steinkern of left valve on matrix, approx. X60. Figured specimen, USNM 39003. Ladinian, USGS colln. 33129.

28–31. *Rhombocythere?* sp.

- 28, 31. Dorsal and ventral views of fragment of left valve, approx. X100. Figured specimen, USNM 389853, same specimen as pl. 10, figs. 10, 11. Ladinian, USGS colln. 33132.
- 29, 30. Dorsal and outside views of right valve, possibly a steinkern, approx. X100. Figured specimen, USNM 389912. Ladinian, USGS colln. 33132.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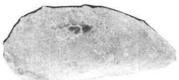
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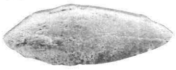
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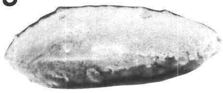
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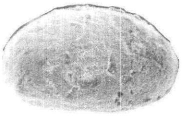
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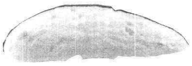
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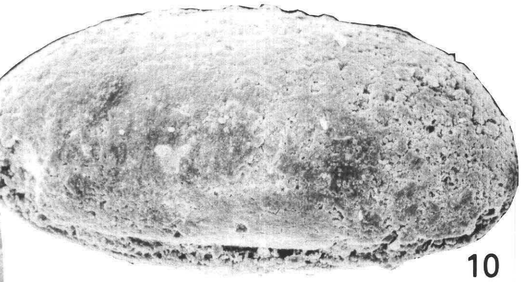
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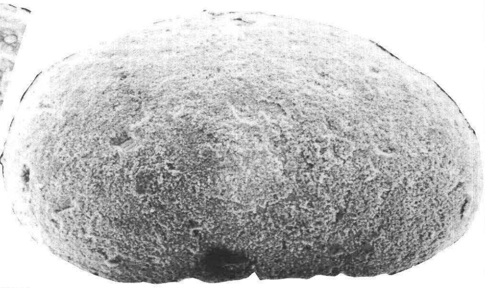
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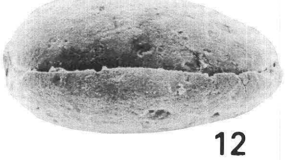
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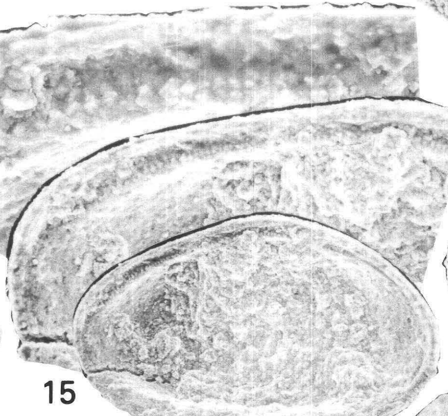
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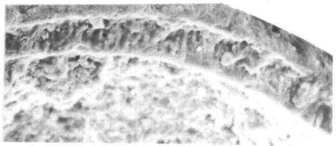
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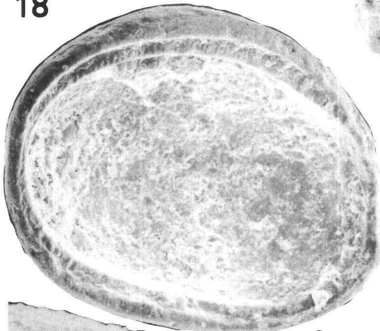
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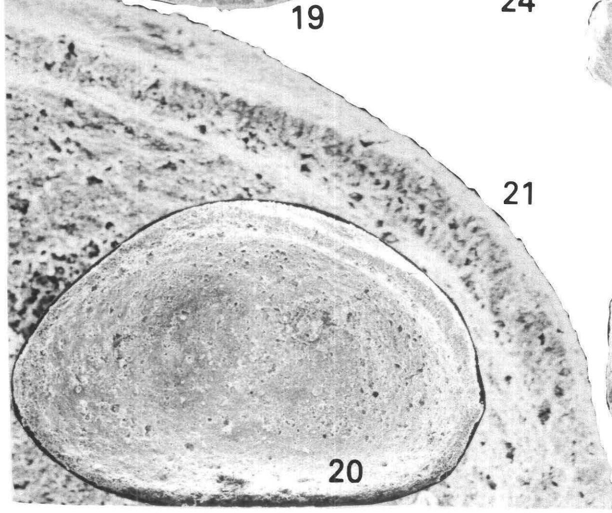
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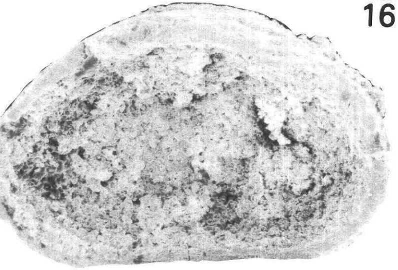
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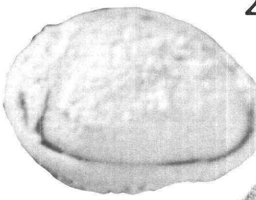
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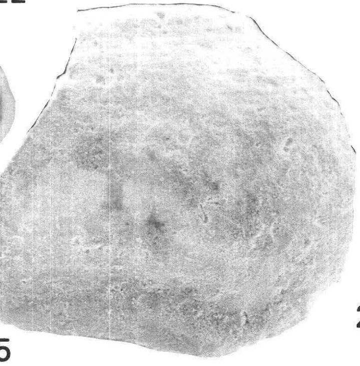
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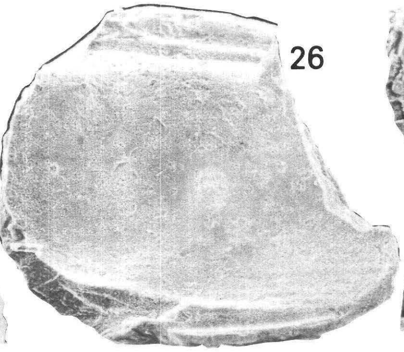
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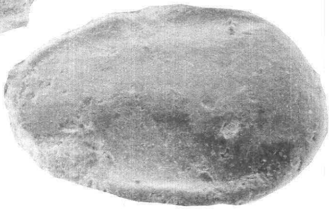
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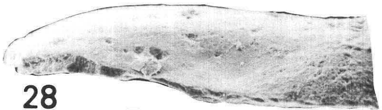
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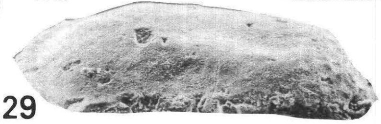
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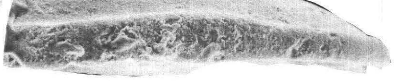
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TRIASSOCYPRIS?, *OGMOCONCHA*, *CAVUSSURELLA?*, AND *RHOMBOCYTHERE?*