Shorter Contributions to Paleontology and Stratigraphy

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CHAPTER A

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

U.S. GEOLOGICAL SURVEY BULLETIN 1664

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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 mathewi 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
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 megafossil 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 Epitoniwm (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 oreogonus cancellus was collected. We profited from discussions regarding this study with John A. Barron, Louie Marincovich, Jr., Kristin A. McDougal, 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.

Figure 1. Location of type areas of molluscan stages and geographic names referred to in text.
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 *Vertiguncus* (Dall), *Mytilus* n. sp. aff. *M. tichanm·itchi* Makiyama of Allison and Addicott (1976), and *Macoma optiva* (Yokoyama), and the gastropods *Priscofusus* aff. *P. geniculatis* (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)* gettysburghensis (Reagan) and *Anomalocardia carmanahensis* (Clark) and the gastropod, *Epitoniium (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 (Plicamytillus) 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”...

<table>
<thead>
<tr>
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<td>Delmontian</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Late Oligocene</td>
<td></td>
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</table>

Figure 2. Chronostratigraphic position and correlation of the Miocene Pillarian and Newportian (molluscan) Stages. Vertical dashes indicate possible extensions of stages.
arnoldi (Anderson), Nutella aff. N. lima Gmelin of Moore (1963), Opalia williamsoni (Anderson and Martin), Priscoceras medialis (Conrad), Spirotrypsis washingtonensis Etherington, and Trophon kernensis Anderson. Other mollusks now known to be restricted to the Newportian are the pelecypods Macoma flagleri Etherington, Spisula (Macromeris) selbyensis Packard, and Yoldia carnerosensis Clark and the gastropods Cancellaria ocyana Addicott, Molopophorus anglicanus (Anderson), Molopophorus matthewi 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 Juaanian 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 (Picatomytilus 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]

<table>
<thead>
<tr>
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<th>Lower Miocene</th>
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<tr>
<td></td>
<td>Juanian</td>
<td>Pillarian</td>
<td>Newportian</td>
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<tr>
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<td>Liracassis apta</td>
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<td>Molluscan zone</td>
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<td></td>
<td></td>
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</table>

Pelecypods:

* Acharax dalli (Clark) ................................................. - - x x
* Acharax ventricosa (Conrad) ............................................ - - - x
* Acila (Acila) gettysburgensis (Reagan) .......................... x - - x
* Acila (Truncacila) conradi (Dall) ................................. x - - x
* Acila (Truncacila) muta (Clark) ..................................... x - - x
* Acila (Truncacila) packardi (Clark) .............................. x - - x
* Aequipecten andersoni clemonensis (Etherington) ............. - - - x
* Anadara (Anadara) devincta (Conrad) ............................. - - - 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 x
* Dosinia (Dosinia) whitenyi (Gabb) ................................. x x x x
* Katherinella (Katherinella) angustifrons (Conrad) .......... - - - x
* Litorhada astoriana (Henderson) ................................. x x x x
* Lucinoma acutilineata (Conrad) .................................... ? x x x
* Lucinoma hannibali (Clark) ........................................ x - - -
* Macoma albaria (Conrad) .......................................... - - x x
* Macoma arctata (Conrad) ........................................... x x x x
* Macoma astori (Dall) .............................................. - - x ?
* Macoma flagleri Etherington ....................................... - - - -
* Macoma optiva Yokoyama ............................................ - - x -
* Macoma secta (Conrad) .............................................. - - - x
* Macoma sookensis (Clark and Arnold) ......................... x x - -
* Macoma tuvinensis Clark ........................................... x x - -
* Mytilus (Plicamontylus) middendorffi Grewingk .............. - - - - x
* Mytilus n. sp. aff. M. tichanoichi Makiyama of Allison and Addicott (1976) - - x - -
* Panopea abrupta (Conrad) .......................................... x x x x
* Panopea ramonensis (Clark) ....................................... x x - -
* Patinopecten oregonensis cancellous Moore ................... - - x x
* Patinopecten propatulus (Conrad) ................................ - - - - x
* Saccella amelga Moore ............................................. - - - x
* Saccella calcinsi Moore ........................................... - - x x
* Securella ensifera (Dall) ........................................... - - x x
* Solaen snavelyi Addicott ........................................... - - x -
* Spisula (Hemimactra) hannibali Clark .......................... x x - -
* Spisula (Mactromeris) albaria (Conrad) ......................... x x x x
* Spisula (Mactromeris) selbyensis Packard ..................... - - - - x
* Spisula (Mactromeris) sookensis Clark and Arnold ........ x x - -
* Tellina emacerata Conrad ......................................... x x x x
* Vertipecten fucus (Dall) ........................................... - - x -
* Yoldia carnerosenensis Clark ...................................... - - x x
* Yoldia callamensis Reagan ......................................... - - x x
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Pelecypods—Continued

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Gastropods:

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</tr>
<tr>
<td>Turritella (Idaella) oregonensis (Conrad)</td>
<td>Lower and middle Miocene</td>
</tr>
<tr>
<td>Turritella (Idaella) yaquinana Addicott</td>
<td>Lower and middle Miocene</td>
</tr>
<tr>
<td>Xenoturris antiselli (Anderson and Martin)</td>
<td>Lower and middle Miocene</td>
</tr>
</tbody>
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Cephalopod:

<table>
<thead>
<tr>
<th>Species</th>
<th>Subseries</th>
</tr>
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<tbody>
<tr>
<td>Aturia angustata (Conrad)</td>
<td>Lower and middle Miocene</td>
</tr>
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</table>
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) middenorffii* 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 occurrence of *Lituyapecten*, 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, *Vertepecten 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 *Vertepecten 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

*Vertepecten 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 cancellatus* 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 *Vertepecten fucanus* or *Patinopecten propatulus*. *Dosinia (Dosinia) whitneyi* (Gabb) also occurs in the unnamed sediment at the Coos Bay channel and has been found in southwestern 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) middendorfii*, 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 cancelllosus* 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.) middendorfii*.

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 *Vertepecten fucanus* in the Nye Mudstone south of Newport and on associated mollusks and benthic foraminifers. The occurrence of *Patinopecten oregonensis cancelllosus* in the uppermost Nye northeast of Newport may indicate that the uppermost part of the Nye is early Newportian. On the basis of *Vertepecten 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.) middendorfii* Grewingk and *Patinopecten propatulus* (Conrad) and the gastropods "Nassarius" *arnoldi* (Anderson), *Crepidula rostralis* (Conrad), *Antilophophos 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), *Dectepecten 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 (Barr 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 Verticpecten fucanus (Dall) identifies the Pillarian. Verticpecten 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 Miocene.

Patinopecten oregonensis cancellatus 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 southwestern Oregon. Its peak occurrence is in the late early Miocene part of the Pillarian. Patinopecten oregonensis cancellatus may have been confused in the past with \( P. \) propatulus and \( V. \) fucanus. The right valve of \( P. \) oregonensis cancellatus (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 cancellatus differs from \( P. \) propatulus by having a heavier shell and by both valves having fewer ribs that are higher and more undercuts 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 Wishkahán 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, \( A. \) 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 Olce 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 Salts 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 Salts 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 Javanian to the Pillarian Stages. It occurs in the upper part of the Poo 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 opitva 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 Poo 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 (Hove, 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, keel-like 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.
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 N1/2S1/2 sec. 9, T. 9 N., R. 9 W., Knappton 7.5-minute quadrangle. From landslide block in upper part of the Lincoln Creek Formation.

USGS 6613. South bank of Kern River, Barker’s Ranch, Kern County, Calif. Temblor 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.

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 NW1/4 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 M4690. Seaciff 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. NE1/4 NE1/4SW1/4 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. Nye Mudstone.
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
8. Locality USGS M4132. USNM 245710.
PATINOPECTEN, MOLOPOPHORUS, AND VERTIPECTEN
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. *Brucarkia 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. *Brucarkia 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.
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 (Cirrostrema) clallamensis* Durham
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   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 proptalus* (Conrad)
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7. *Macoma albaria* (Conrad)
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8. *Lucinoma acutilineata* (Conrad)
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9. *Securella ensifera* (Dall)
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12. *Musashia (Nipponomelon) shikami* Moore
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U.S. GEOLOGICAL SURVEY

BULLETIN 1664-A PLATE 4

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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
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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 lenses 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-

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posed 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 lophophyllioid 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 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 Tuasia, robust spiriferid brachiopods, Isoogramma 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 Thalassia-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 lophophyllioid 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 Isoogramma by its costate or plicated anterior margins. All other features are similar to Iso­gramma. The common features of the Isogrammidae and Eichwaldiidae are shell punctuation 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 punctuation 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 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.

SYNAPTIC 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, trough-like 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 anteriorly medianly, 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.

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**REFERENCES CITED**


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.

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8. Interior view of brachial valve USNM 399545.


11–12. Ventral and dorsal view of holotype USNM 305974.

13. Interior view of brachial valve USNM 399548.


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ISOGRAMMA
CHAPTER C

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

By I. G. Sohn
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FIGURE
1. Map of northern Alaska showing location of reference section of Shublik Formation C2

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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.


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 Thipsuracea?, Gen. indet. Beirichicopina?, Gen. indet. Cytheracea, and Gen. indet. Healdiidæ.
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.

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**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 Sweeney, 1982, pl. 111) and a central and southern portion composed of accretory terranes that are part of the active convergent Pacific microplates (Jones, Silberling, and Hillhouse, 1978, p. 71-74; Pfläger 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 Primoryé 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, makes 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 *Daoella 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 *Daoella 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 spiraliferid brachiopods; these indicate a Ladinian age for this interval. Only three ostracode taxa, *Covraycthyere gryci* n. sp., *O. sp. aff. O. owthopensis* (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, Carnian megafossils in the limestone member: *Halobia cf. H. zitteli* Lindstrom, *Leptochnondria nationalis* Smith, *Gryphea* sp., *Lima* sp., arcetid ammonites, rhynochellid 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. ornatisima*, 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. Silberling (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 scuitformis pinensis* Westermann, *M. cf. M. scuitformis* Westermann, *M. cf. M. obtusiscottata*, *Gryphea* sp. and rhynochellid brachiopods. Of the eight ostracode taxa recovered from the Norian, *Ogmoconcha marquardi* n. sp., *O. alaskaense* n. sp., *Hiatoberdia*? sp. ex gr. *H. arcuata* Kristan-Tollmann, 1970, *Triassocypris*? sp., and *Gen. 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

Middle And Upper Triassic Marine Ostracoda, Northeastern Alaska  C3
Primor'ye Province from the Pacific Ocean Zoogeographical Region (Burj 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), reflecting the presence of the various islands and shoals, the 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.

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

### Table 1. Stratigraphic occurrences of taxa in Alaska

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Ages</th>
<th>Ladinian</th>
<th>Carnian</th>
<th>Norian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covracythere binoda n. sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recytella sp. 1</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recytella sp. 2</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dettermania truncata n. sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Healdia” sp. 1</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Healdia” sp. 2</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhombocythere? sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogmocooncha? sp. aff. Hungarella limbata (Reuss, 1868)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavussurella? sp. 1</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavussurella? sp. 2</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogmocooncha unicerata n. sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogmocooncha taileului n. sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covracythere gryci n. sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogmocooncha sp. aff. O. owthropensis (Anderson, 1964)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>“Healdia” sp. 3</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cavussurella grammi n. sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudobythocypris? sp.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogmocooncha marquardii n. sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogmocooncha alaskaense n. sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ogmocooncha alaskaense n. sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triassocypris? sp.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gen. and sp. indet.</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Paleozoogeographical provinces and ages of related taxa**

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Age</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavussurella grammi n. sp.</td>
<td>*Upper Anisian</td>
<td>Do.</td>
</tr>
<tr>
<td>Covracythere binoda n. sp.</td>
<td>*Upper Anisian</td>
<td>Do.</td>
</tr>
<tr>
<td>“Healdia” sp. 1</td>
<td>*Upper Anisian</td>
<td>Do.</td>
</tr>
<tr>
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<td>*Upper Anisian</td>
<td>Do.</td>
</tr>
<tr>
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<td>*Upper Anisian</td>
<td>Do.</td>
</tr>
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<td>Do.</td>
<td></td>
</tr>
<tr>
<td>Covracythere gryci n. sp.</td>
<td>Do.</td>
<td></td>
</tr>
<tr>
<td>Cavussurella? sp. 1</td>
<td>Do.</td>
<td></td>
</tr>
<tr>
<td>Cavussurella? sp. 2</td>
<td>Do.</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
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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, Permain through Rhaetian; Leviella Sohn, 1968, Anisian through Rhaetian; Lobobairdia Kollmann, 1963, Norian through Rhaetian; Polycopsis Müller, 1894, Scythian through Holocene; Psychobairdia Kollmann, 1960, Norian through Rhaetian; Vavilovella Kozur, 1973, Norian; and additional, as yet unidentified, taxa.

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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 toptype 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, Felsors. 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

Middle And Upper Triassic Marine Ostracoda, Northeastern Alaska C5
Institute, Budapest, on August 10, 1976. All the specimens were on one large, plastic, multicellular 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 acauleata* 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 specimens 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 may represent different specimen than the one illustrated by similar material attached at the corner with tiny screws. The cover was inscribed with a grid covering each cavity identified as *Healdia* (Hungarella) *reniformis*. Kozur (1970a, p. 22, pl. 4, figs. 15–17) described and illustrated *Healdia* (Hungarella) *reniformis* (Méhes, 1911), from the Anisian and Ladinian of Hungary, including one from the Carnian marl that is equivalent to locality no. 5 of *Bairdia* (Hungarella) *reniformis*. Lord (1972, pl. 1, figs. 6–8; pis. 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) SW 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 65.5 m (210–215 ft). Field no. 3–28.

33130. 65.5 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 (275–285 ft). Field no. 5–9.

33134. 83.8 to 85.3 m (275–280 ft). Field no. 5–10. No ostracodes recovered.

C6 Shorter Contributions to Paleontology and Stratigraphy
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 BAIRDIAEAE Sars, 1888
Family BAIRDIAEAE Sars, 1888
Subfamily BAIRDINAE Sars, 1923

Genus HIATOBAIRDIA Kristan-Tollmann, 1970


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 Hiato Bairdia: H. subsymmetrica based on seven specimens and H. labrifer and H. arcuata based on a single specimen each. I doubt whether the three species are congeneric. Because I have only three small steinkems, I do not have sufficient information to establish a new generic category; consequently, I am referring them to Hiato Bairdia? sp. ex gr. H. arcuata.

Geologic range.—Upper Triassic.

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

Hiato Bairdia? sp. ex gr. H. arcuata

Kristan-Tollmann, 1970

Plate 2, figures 18, 19

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


not Hiato Bairdia aff. H. arcuata Bolz, 1971b, pl. 1, fig. 6.

Discussion.—The three small steinkems 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


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 genus). In addition, the complete carapace is covered by a net-forming pitted sculpture. The hinge is a simple, smooth bairdidi 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 a. sp. from the Rhaetian Zlambachmergeln at Kraitartenalm, Austria. Kristan-Tollmann (1971b, pl. 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) published 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. schulzi 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 hinge line and a second, smaller node located slightly higher than the subcentral node about equidistant from the hinge line and dorsoposterior margin. The dorso-posterior margin is obtuse, with about 130° angle from the posterior end of the hinge line, 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 dorso-anterior is straighter than the dorsoposterior. A rounded rim borders...
from the Territory, than two nodes occur in a straight line.

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.—

<table>
<thead>
<tr>
<th></th>
<th>Greatest length</th>
<th>Greatest height</th>
<th>Greatest width</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC 80063, larger R. V.</td>
<td>1.10</td>
<td>0.65</td>
<td>0.52</td>
</tr>
<tr>
<td>GSC 80064, smaller R. V.</td>
<td>1.05</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>GSC 80065, larger L. V.</td>
<td>1.04</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>GSC 80066, larger L. V.</td>
<td>0.96</td>
<td>0.50</td>
<td>0.45+</td>
</tr>
<tr>
<td>Paratype, USNM 389830, larger L. V.</td>
<td>1.00</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>Paratypes, USNM 389831, larger L. V.</td>
<td>1.0-1.20</td>
<td>0.53-0.64</td>
<td></td>
</tr>
<tr>
<td>Paratype, USNM 389833, larger L. V.</td>
<td>1.05</td>
<td>0.61</td>
<td></td>
</tr>
</tbody>
</table>

**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. 2, 3, 6). 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.
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 Edithinae Knüpf er, 1967, in the Bythocytheridae Sars, 1926. Although the nominate genus, Editia germanica Knüpf er, 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 Jones and Kirkby, 1886, in lacking a marginal frill as shown by Sohn (1984b, p. 21, fig. 111). 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 (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, Prim’or’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).

<table>
<thead>
<tr>
<th>Measurements (in mm)</th>
<th>Greatest length</th>
<th>Greatest height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paratype, USNM 389827, unfigd.</td>
<td>0.55</td>
<td>0.30</td>
</tr>
<tr>
<td>Paratype, USNM 389826, unfigd.</td>
<td>0.61</td>
<td>0.27</td>
</tr>
<tr>
<td>USNM 389822</td>
<td>0.61</td>
<td>0.32</td>
</tr>
<tr>
<td>USNM 389817</td>
<td>0.64</td>
<td>0.32</td>
</tr>
<tr>
<td>Paratype, USNM 389825, unfigd.</td>
<td>0.65</td>
<td>0.32</td>
</tr>
<tr>
<td>USNM 389823</td>
<td>0.72</td>
<td>0.32</td>
</tr>
<tr>
<td>USNM 389824</td>
<td>0.80</td>
<td>0.32</td>
</tr>
</tbody>
</table>

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 desig-
nated 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 Anisan in the Soviet Far East and present also in Alaska, in lateral outline and in having a subcentral node in front of the sulcus.

*Sapce 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 only 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 toward 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

Notocythere Will, 1969, p. 60.

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


The following Upper Triassic taxa have been described in, or referred to, Rhombocythere:
Notocythere elegans Will, 1969, p. 73, pl. 3, figs. 1, 2. Lower 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.


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. Lower 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.

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 \textit{Rhomboctythe} 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 \textit{Notocythere} (= \textit{Rhomboctythe}). 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 \textit{Rhomboctythe} 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.

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

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

\textbf{Suborder METACOPINA Sylvester-Bradley, in Moore, 1961}

\textbf{Superfamily HEALDIACEA Harlton, 1933}

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

\textbf{Family HEALDIIDAE Harlton, 1933}


\textbf{Genus HEALDIA Roundy, 1926}

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

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


Because Gramm (1969a, p. 457, figs. 1, 2; 1970, p. 45, figs. 1, 2) illustrated the adductor muscle-attachment scars of \textit{Healdia zharnikovae} with a few scars, similar to those illustrated herein, I am referring the specimens from Alaska to “\textit{Healdia}.” The Triassic species lack the dorsoposterior flattening originally described in \textit{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 coln. 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 Pennsylvaniaian *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 0.700, greatest height 0.350, greatest width 0.260.

**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


**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 (Verschmeltungszone) 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*:


*Ogmoconcha* sp. aff. *O. owtropensis* (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.


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. owtthropensis 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. owtthropensis 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).—

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**Geologic range.**—Ladinian through Norian, from 33.5 to 45.4 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.

**Ogmoconcha unicerata Sohn, n. sp.**

Plate 5, figures 1–10

*Ogmoconcha* n. sp. Sohn, 1984b, fig. 1A–D.

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

**Holotype.**—USMN 389855.
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. Urliics, 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.


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).—

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Middle And Upper Triassic Marine Ostracoda, Northeastern Alaska C17
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 punctuation. 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 of 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**.—Diffs 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 hinge line 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 hinge line 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/1 0.739; USNM 389889, greatest length 0.43, greatest height 0.30, h/1 0.750; USNM 389905, greatest length 0.45, greatest height 0.35, h/1 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 the specimen is unknown, this species is referred to *Ogmoconcha* because of the external morphology.

The Lower Pliensbachian (Jurassic) *O. eoctrocontula* 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/1 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). Carnian, Italy.
Hungarella limbata (Reuss, 1868) Urlich’s, 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 Urlich’s (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 hinge ment 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 Urlich’s measurements of an ontogenetic series.

Urlich’s (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. 1, fig. 2) has a minute posterovential 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/1 0.750. Specimens from Italy. USNM 147198, greatest length 0.62, greatest height 0.55, h/1 0.887; USNM 147199, greatest length 0.65, greatest height 0.52, h/1 0.800; USNM 147200, greatest length 0.65, greatest height 0.56, h/1 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.
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 grammii n. sp. are illustrated in informal nomenclature as Cavussurella? spp.

Geologic age.—Middle and Upper Triassic.


Cavussurella grammii 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.—Diffs 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 tecomorphs (males and juveniles) are widest behind midlength (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).—

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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 grammii 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. grammii 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. grammii (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; unfigd. steinkern USNM 389850, greatest length 0.7+, greatest height 0.40.

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

Subfamily RECYTELLINAE Gramm, 1970
See discussion under the Ussuricaviniae.

Genus RECYTELLA Gramm, 1970

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 Ussuricaviniae, Kozur (1972b) considered Cavussurella and Recytella to be junior synonyms of Reubenella. He stated (1972b, p. 19) that Ussuricavina Gramm, 1969b, and the Ussuricaviniae 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).

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.

REFERENCES
Burij, I. V., and Zharnikova, N. K., 1977, Paleobiogeograficheskoe raionirovanie bessina Tikhogo okeana v triassovoe vremya [Triassic biogeography of the Pacific Ocean basin], in Krassilov, V. A., ed., Evolyutsia organisich-
PLATES 1–11

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

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.
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.
"HEALDIA"
Figures 1–9. Recyrella 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. Recyrella 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.
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.
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.


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


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
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, approx. 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.
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.


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 characteristic of many of the smooth forms at this locality, shown best on figs. 25, 28. Paratype, USNM 389859. Norian, USGS colln. 33158.
OGMOCONCHA

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 another 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. Dettermannia 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 left), dorsal (anterior to right), and right views of carapace, approx.
X60. Paratype, USNM 389821. Same colln. as above.

16–25. Covracythere gryci n. sp.
16–20. Dorsal (anterior to left), left, posterior, right, and ventral (anterior to right) views of tech-
nomorph, 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 hetero-
COVRACYTHERE AND DETTERMANIA
PLATE 8

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


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. 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.


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


9–12. 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.

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.


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.


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.
OGMOCONCHA, CAVUSSURELLA?, AND RHOMBOCYTHERE?
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.


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.


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.


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.


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.


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.
TRIASSOCYPRIS?, OGMOCONCHA, CAVUSSURELLA?, AND RHOMBOCYTHERE?