THE OLIGOCENE MARINE MOLLUSCAN FAUNA OF THE EUGENE FORMATION IN OREGON

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CONTENTS

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ABSTRACT

Tuffaceous marine sandstone and siltstone of the Oligocene Eugene Formation occur in the southern portion of the Willamette Valley in Oregon from Cottage Grove northward along the margin of the Coburg Hills to Brownsville and Lebanon and into the Salem and Eola Hills west of Salem.

The faunal assemblages and associated rocks indicate that the Eugene Formation was deposited in shallow water, 0-40 fathoms. The fauna contains a mixture of subtropical and temperate forms which coexisted in what is interpreted as a gradually cooling environment. Relatively undisturbed assemblages of infaunal pelecypods and scaphopods are common along with concentrated layers of reworked infaunal assemblages containing a variety of epifaunal species.

The age of the fauna is believed to span portions of the lower and middle Oligocene. The fauna is partly intermediate between the faunas of the Keasey and Pittsburg Bluff Formations in northwestern Oregon and is considered the partial time equivalent of these formations and the missing interval between them.

The author collected several thousand fossil specimens from localities throughout the formation and incorporated them into the collections at the University of Oregon. In addition, previous collections housed at the University of California, California Academy of Sciences, Stanford University, and the U.S. Geological Survey at Menlo Park, California, were examined.

Sixty-seven species, representing 48 genera and 31 families, are discussed and figured; and their affinities and stratigraphic ranges are analyzed. Supplementary descriptions are given for previously described species. In addition, nine new taxa are proposed and described: *Nemocardium formosum, Tellina aduncanasa, Semele willamettensis, Martesia turnerae, Pandora laevis, Dentalium laneensis, Neverita thomsonae, Bruclarkia vokesi,* and *Acila nehalemensis* subsp. *minima.*

INTRODUCTION

Many of the marine Oligocene formations of Oregon contain molluscan faunas which although recognized for many years have never been systematically described. Isolated specimens have been described from all these formations and species lists have appeared, but comprehensive studies have yet to be published on the invertebrate faunas of the marine Oligocene of Oregon.

Present trends in paleontology away from the systematic description of faunas in the direction of paleoecological or interpretive studies are unfortunate in view of such large gaps in our basic knowledge of the fossil record. The following study of the Eugene molluscan fauna is an attempt to close one of these gaps. The purpose of this report is to describe and illustrate the mollusks of the Eugene Formation and to evaluate the affinities of the species and lineages present in the fauna. The stratigraphic implications of the fauna are considered with respect to the Oligocene faunas of California and Washington as well as the undescribed faunas of Oregon. Some effort has been made to discuss and figure comparative material from other Oligocene formations in Oregon, particularly from the undescribed faunas of the Keasey and Pittsburg Bluff Formations, since many species from these formations are also present in the Eugene fauna.

Although the Eugene fauna has never been treated systematically, interest in fossils from the Eugene area dates back to the middle of the 19th century. Various early exploring expeditions recorded the occurrence of marine invertebrate fossils, and several collections were sent to specialists in the east for identification. Since the Pacific Coast Tertiary was originally defined on a three-fold basis of Eocene, Miocene, and Pliocene, these fossils were assigned a Miocene age. In 1898 Dall suggested that Oligocene might be a valid term in West Coast stratigraphy, and a controversy soon arose between workers who chose to recognize the Oligocene and those who continued to accept a broad faunal definition of the Miocene. Since direct correlation of the so-called Oligocene of the Pacific Coast with the type Oligocene of Germany is impossible on a megafaunal basis, the whole Oligocene-Miocene controversy soon became circular in its reasoning. Much of this circularity enters into early arguments over the age of the Eugene Formation.

Dutton (1889) was the first of the early explorers to note the presence of fossils in the Eugene area, which he characterized as a Miocene basin (p. 190). Dall and Harris (1892) briefly described two fossiliferous exposures in this area and listed eight characteristic genera from the layers at Smith's quarry in Eugene. Dall and Harris also considered the fossils to be Miocene. A more complete report on the geology of northwestern Oregon was issued by Diller (1896) who did not specifically consider the beds at Eugene, but did suggest that the Willamette Valley contained beds of Oligocene age.

Dall (1909) did not discuss the Eugene Formation in his systematic consideration of the Miocene faunas of Astoria and Coos Bay, but he included descriptions of four new Miocene mollusks from the Eugene area: *Thracia condoni, Tellina eugenia, Epitonium condoni,* and *Epitonium condoni* var. *oregonense.*

During the summers of 1909 to 1913 Arnold and Hannibal made a number of collections in the marine Tertiary of Washington and Oregon. In 1913 they presented a discussion of the Oligocene problem and included the beds at Eugene in their "San Lorenzo Horizon of the Astoria Series" which they defined as middle Oligocene.

Washburne (1914) made the first extensive collections in the Eugene area and published a list of 27 species which were identified by Dall. Since Dall included the Eugene Formation in the Miocene it is not surprising that 18 of his broadly defined species are cited both from the beds at Eugene and from the Miocene of Coos Bay. Three years later Smith (1917) published a very different list of species based on identifications made by Bruce Clark. Clark, who became one of the foremost champions of the Oligocene on the Pacific Coast, described hundreds of species from the Tertiary of California, defined them as Oligocene, and subsequently (Clark, 1918; Clark and Arnold, 1918) argued for the existence of the Oligocene in Oregon on the basis of the presence of Oligocene species.

In a master's thesis at the University of Oregon, Schenck (1923) proposed the name "Eugene Formation" and listed 33 species which he identified primarily from the California literature and with the help of Clark. His thesis is primarily a review of the status of the marine Oligocene of the West Coast. Schenck maintained his interest in the Oligocene of Oregon, and although he never returned to a systematic account of the Eugene fauna, specimens from the Eugene Formation were studied in conjunction with his monographs of *Aturia* (1931) and *Acila* (1936).

Several isolated elements of the Eugene fauna received attention in the years following Schenck's 1923 list. Clark (1925) described and illustrated four pelecypods from the Eugene Formation: *Mulinia eugenensis, Solen eugenensis, Cardium eugenensis,* and *Modiolus eugenensis.* In 1926 Rathbun described 12 decapods which were sent to her from the Eugene area. Durham (1937) discussed and figured a number of specimens in the *Epitonium condoni* complex from the Eugene Formation in conjunction with a study of the West Coast Epitoniidae. Individual specimens from the Eugene Formation are mentioned but not figured in a number of other papers, such as Bentson's systematic study of the gastropod *Exilia* (1940, p. 218) and Reinhart's consideration of *Anadara* (1943, p. 83).

The most recent list of species from the Eugene Formation is based on collections made in the course of mapping the southern portion of the Willamette Valley (Vokes, Snavely, and Myers, 1951). Vokes' list is different from earlier lists, primarily because he recognized the similarities between the Eugene fauna and the Oligocene faunas of Washington. These similarities had not been appreciated at the time of Schenck's studies.

Many of the early collections from the Eugene Formation are still intact. During the course of this study, collections at the University of Oregon, University of California, California Academy of Sciences, and Stanford University were reexamined. The collections of Vokes, Snavley, and Myers (1951) at the U.S. Geological Survey at Menlo Park, California, were examined also, and extensive collections of new material were made by the writer. Since many localities in the Eugene Formation are temporary excavations and since fresh cuts are subject to rapid and deep weathering, the earlier collections have provided valuable information about localities which are no longer accessible.

ACKNOWLEDGMENTS

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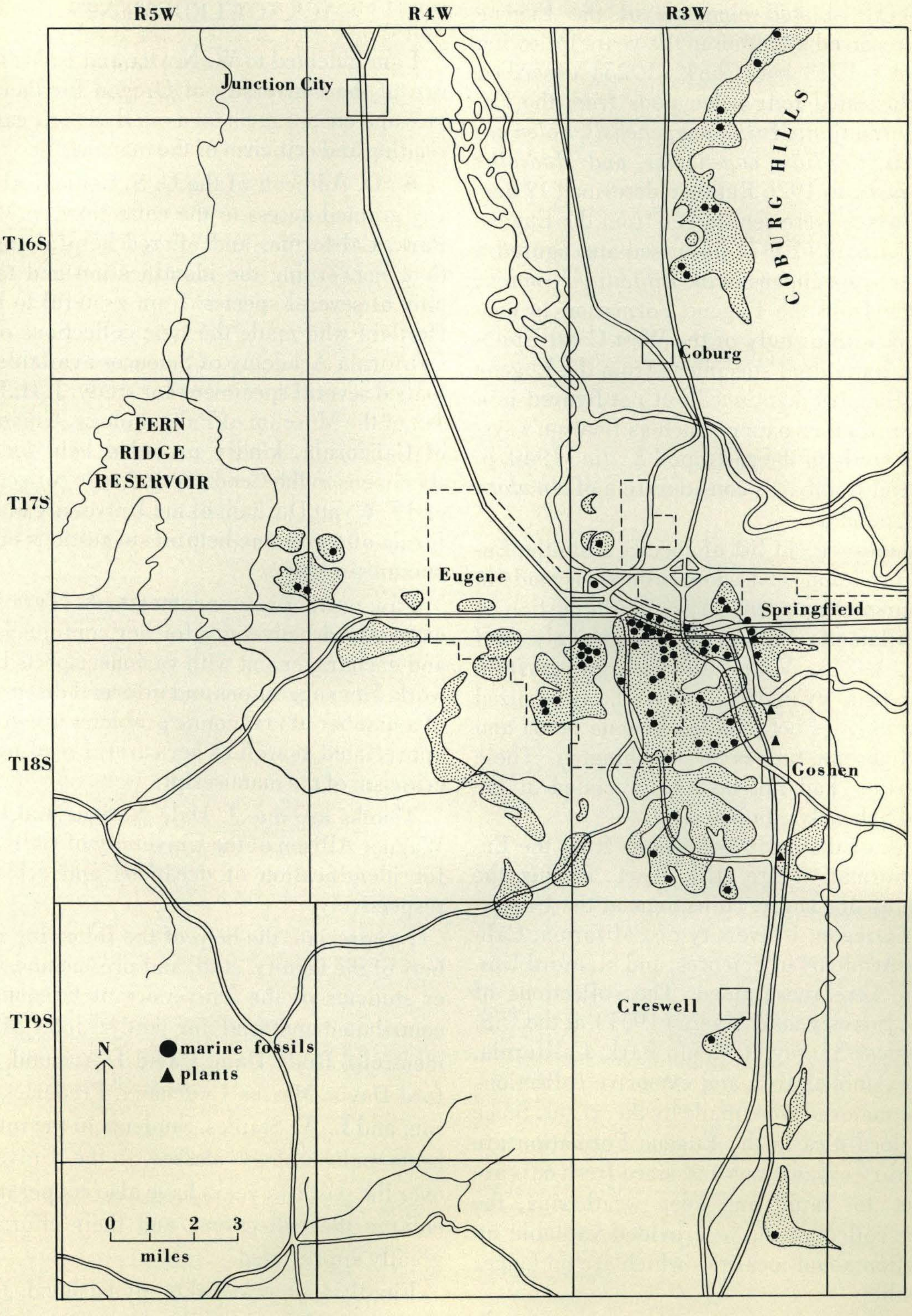
Finally I am grateful to my husband, James Hickman, who assisted in the collecting and photography of specimens, read and criticized the manuscript, listened patiently to com-



Textfigure 1. *Distribution of the Eugene Formation and marine fossil localities in the Eugene area, Oregon. After Vokes, Snavely, and Myers (1951).*

plaints, and provided an invaluable source of perspective on all aspects of the problem.

The cost of 12 thin sections from representative horizons of the Eugene Formation was met through funds made available by Humble Oil Company.

EUGENE FORMATION

Stratigraphy

The Eugene Formation was defined by Schenck, who first discussed the unit in an unpublished master's thesis (1923, p. 28). The naming of the formation, however, is generally attributed to Smith, who used the name in print a year later (1924, p. 462), although he did not define or describe the unit. A description was published three years later (Schenck, 1927, p. 453), and the type area was designated as roadcuts and quarries within the city limits of Eugene. Due to deep weathering and a paucity of outcrops, Schenck was unable to present a measured section or subdivide the formation. He characterized the formation as deposits of sandstone, sandy shale, conglomerate, and tuff cut by basaltic dikes and sills and with a prevailing dip of 10 degrees to the northeast.

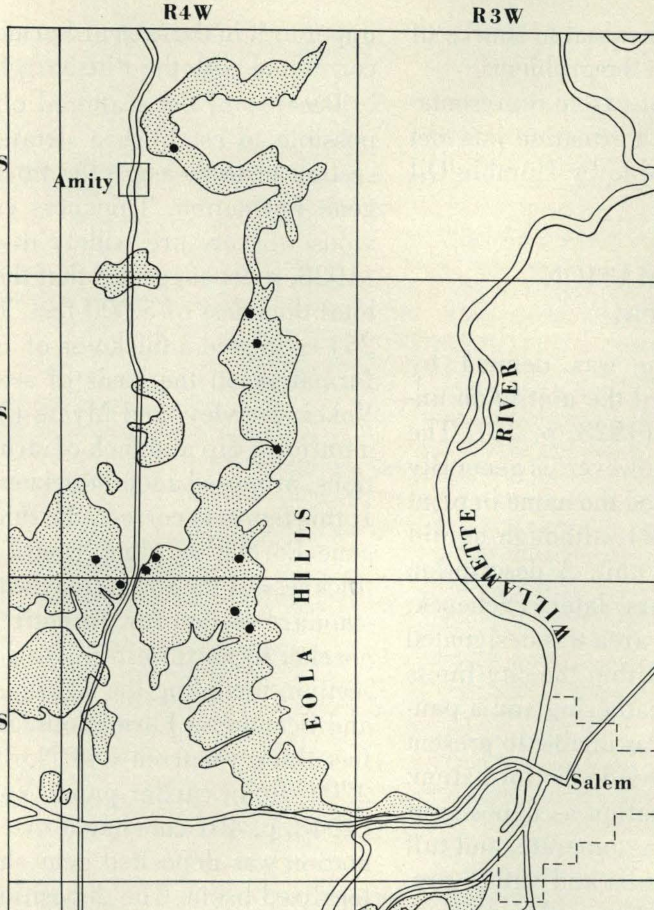
Schenck (1928, p. 10) and Vokes, Snavely, and Myers (1951) extended the definition to include all Oligocene marine sedimentary rocks exposed in the hills to the south and west of Eugene, exposures on the hills and flanks of intrusives which stand above the floor of the Willamette Valley, and the belt of exposures extending northward along the margin of the Coburg Hills. Textfigure 1 shows the distribution of the Eugene Formation in the vicinity of Eugene as mapped by Vokes, Snavely, and Myers (1951).

Vokes, Snavely, and Myers (1951) were unable to subdivide the Eugene Formation lithologically, but they did propose a faunal subdivision into three units: a lower unit exposed to the west of Eugene which they correlated with the Keasey Formation, a middle unit within the Eugene city limits which they correlated with the Gries Ranch Beds of Washington, and an upper unit in the area of Springfield which they correlated with the Pittsburg Bluff Formation.

Because of the scattered outcrops, it is not possible to establish a detailed stratigraphic section or to measure the thickness of the Eugene Formation. Thickness estimates of previous workers are widely divergent. Schenck (1928, p. 9) suggested that the beds attained a total thickness of 5,000 feet. Turner (1938, p. 25) estimated a thickness of 7,500 feet for the formation on the basis of scattered outcrops. Vokes, Snavley, and Myers (1951), assuming a uniform dip and lack of structural complications, proposed a total thickness of 15,000 feet. If this figure is correct, the thickness of the Eugene Formation alone would exceed the total thickness of the formations which comprise the standard section for the entire West Coast Oligocene. In northwestern Oregon the Oligocene section, including the Keasey, Pittsburg Bluff, and Scappoose Formations, is less than 5,000 feet thick (Warren and Norbisrath, 1946, p. 220). In an earlier paper Vokes and Snavely (1948, p. 40) concluded that the Eugene Formation was deposited near shore in a shallow localized basin. The deposition of 15,000 feet of sediment in such an environment would require almost 15,000 feet of downwarping to accommodate it. Thus it is tempting to speculate that there are undiscovered structural complications in the formation which have confused estimates of thickness.

The present study cannot offer any further direct evidence on the problem of thickness, but observations in the field suggest that the dip of the Eugene Formation is not constant throughout the type area and that the total thickness of the formation is probably closer to Schenck's original estimate of 5,000 feet. The dip increases gradually to the east where the beds finally disappear beneath the younger volcanic rocks of the Coburg Hills. Minor faults have been observed in the field, but there is no field evidence to support major duplications of the section through faulting.

Most of the roadcuts, quarries, and natural outcrops from which Schenck and other early



Textfigure 2. *Distribution of Oligocene beds and marine fossil localities in the Salem area, Oregon, compiled from Thayer (1939), Mundorff (1939), Brown (1951), and Baldwin, Brown, Gair, and Pease (1955).*

workers made their collections are no longer accessible, although the temporary cuts and excavations examined in the course of this study show that the formation has the same general character. The most common rock is a tuffaceous and highly feldspathic sandstone or siltstone which is bluish gray to olive when fresh and weathers to a buff or orange-brown color. These gray sandstone and siltstone beds range from several feet to 50 feet in thickness and are interbedded with minor amounts of sandy shale and clay shale, occasional beds of conglomerate, and thin lenses of gray or buff-colored volcanic ash.

Petrographic examination indicates that the arenaceous rocks consist predominantly of angular grains of plagioclase (primarily andesine) and lithic fragments enclosed in a dark, argillaceous and probably recrystallized groundmass in which abundant glass shards commonly exhibit axiolitic structures indicative of devitrification. These rocks are perhaps best classified as lithic graywacke. The most striking features of these rocks are: (1) scarcity of quartz; (2) high proportion of feldspar; (3) angular, unweathered condition of the feldspar; (4) high proportion of lithic fragments, predominantly glassy basalt and tuff with minor amounts of chert; (5) presence of minor amounts of fresh pyroxene, dark and light micas, and hornblende; and (6) high proportion of dark, agrillaceous, chloritic, and sometimes glassy matrix.

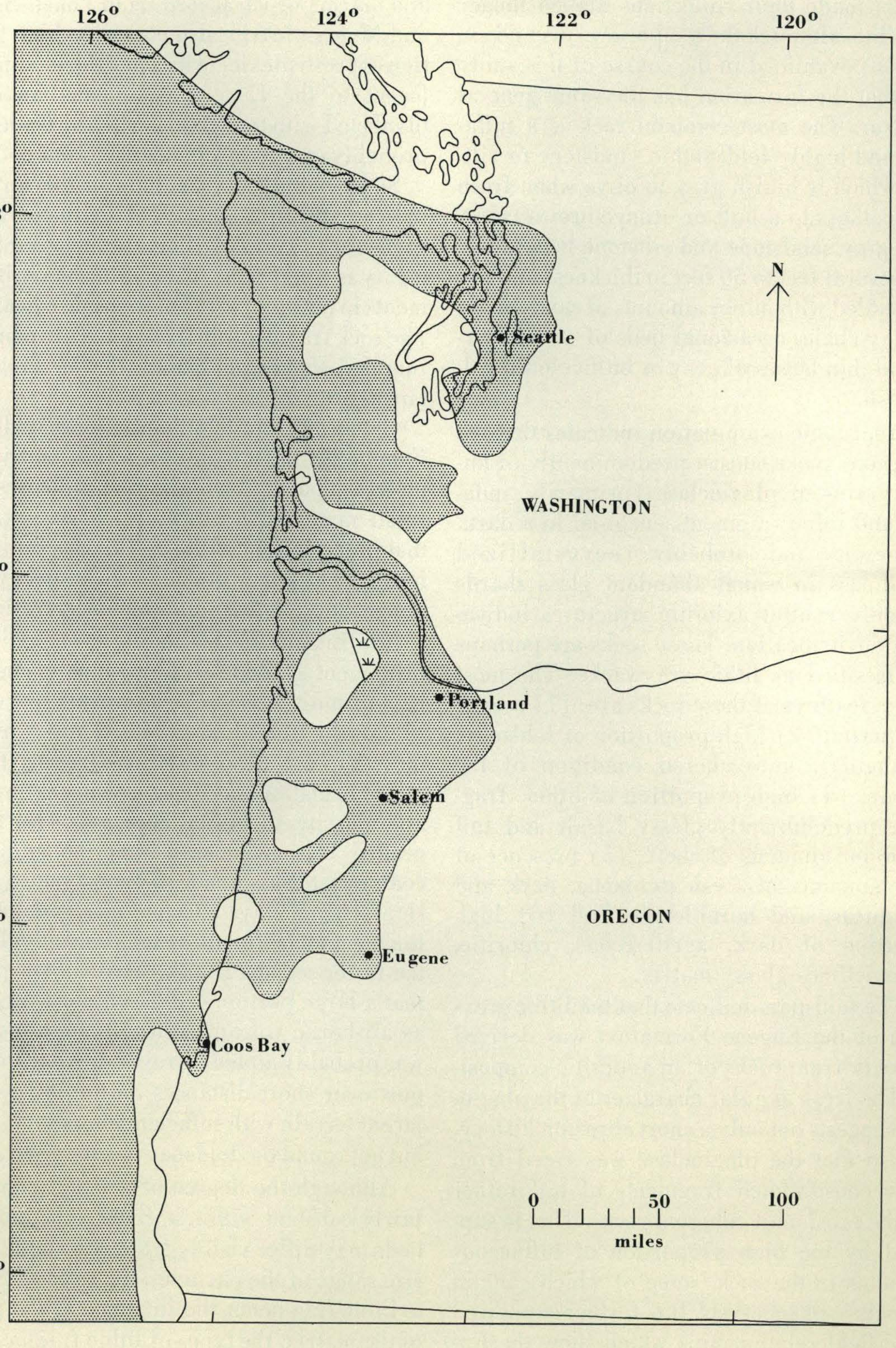
The feldspars indicate that the lithic graywacke of the Eugene Formation was derived primarily from rocks of an andesitic composition. The fresh angular character of the plagioclase suggests not only a short abrasion history, but also that the plagioclase was freed from poorly consolidated fragments of tuff rather than the erosion of coherent rocks. This is supported by the high proportion of tuffaceous fragments in the rock, some of which contain plagioclase phenocrysts. It is further supported by the field relationships which show the Eugene Formation interfingering to the south and east with continental deposits of andesitic tuff and breccia which according to Vokes, Snavely, and Myers (1951) also contain a high proportion of fresh plagioclase. Thus the landmass adjacent to the Eugene basin was apparently blanketed with terrigenous vitric tuff which was probably erupted from nearby vents.

Some of the coarser units in the formation indicate multiple sources of sediment. Several of the rocks examined contain such granitic elements as microcline, chert, and quartzite fragments in addition to the more basic constituents. The rock fragments in these units are commonly rounded suggesting transport over longer distances.

Calcite was precipitated locally within the Eugene basin to form a micritic matrix. This matrix is particularly common in lenses where fossil material is concentrated. It is possible that precipitation of the calcite was initiated by local pH changes created by the decay of organic matter at these sites of concentration.

The Eugene Formation does not exhibit the prominent graded bedding which is characteristic of most graywacke according to Pettijohn (1957, p. 312) and others. Unlike many of these typical deep water sediments, the Eugene Formation was deposited in shallow water and not by turbidity currents. The lack of graded beding suggests that the addition of coarse materials was fairly constant, so that the slow-settling clays and fine materials comprising the matrix are uniformly intermingled with the faster-settling coarse detritus. It is possible that a large portion of the sediment was added as air-borne volcanic tuff, although most of it was probably added by rapid erosion and transport over short distances on the low-lying adjacent terrain with sufficient abrasion to release but not round the feldspar phenocrysts.

Although the degree of sorting seems to be fairly constant within a given unit, individual beds may differ visibly from one another in the size range of the particles, the ratio of feldspar to lithic fragments, the amount and composition of the matrix, the types of lithic fragments, and the type and quantity of accessory minerals present.



Textfigure 3. *Distribution of Oligocene seas in Washington and Oregon. After Snavely and Wagner (1963).*

As mapping has progressed in the Willamette Valley numerous small outcrops of Oligocene strata have been located between Eugene and Salem and in the Salem area. These are discussed by Felts (1936), Thayer (1939), Mundorff (1939), Brown (1951), Allison (1953), and Baldwin, Brown, Gair, and Pease (1955), who have assigned the beds in the areas they mapped to several different formations and expressed various views regarding their correlation. In this report the beds in the Salem area are considered a northward extension of the Eugene Formation, following Baldwin (1964, p. 54). Textfigure 2 shows the distribution of Eugene and equivalent Oligocene beds in the Salem area.

In an unpublished master's thesis Felts (1936, p. 30) tentatively assigned small outcrops of marine siltstone, sandy shale, and pebble conglomerate in the Brownsville and Lebanon Quadrangles to the Eugene Formation. The largest outcrop in this area is on the west side of Peterson Butte, three miles southwest of the town of Lebanon, where the fauna contains a number of typical Eugene species. Felt's tentative correlation of these beds was based on similarities in the species lists from the Eugene and Lebanon areas published by Washburne (1914, p. 33-34), although Washburne (1914, p. 15) had identified both faunas as late Miocene.

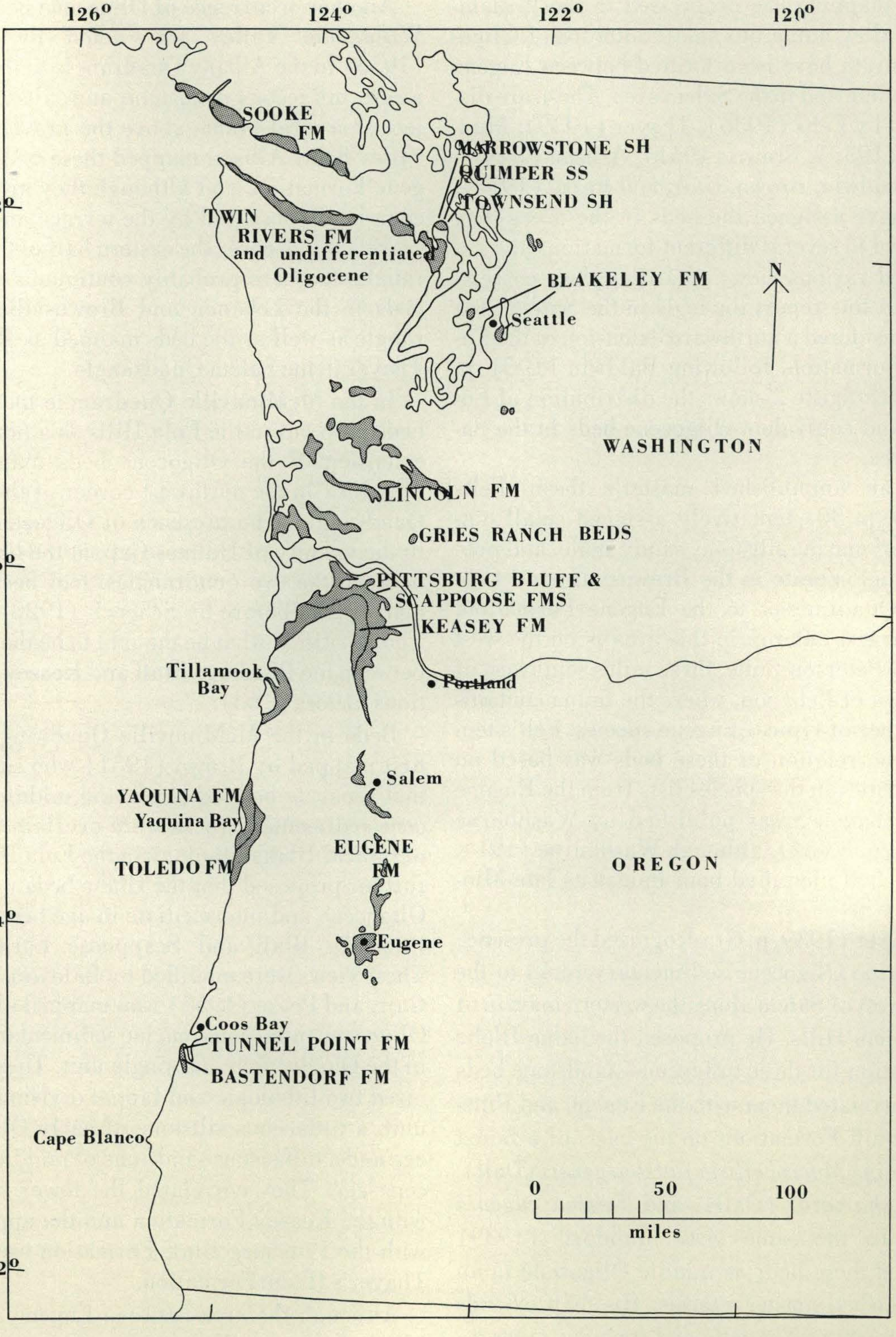
Thayer (1939, p. 6) recognized the presence of marine Oligocene sedimentary rocks to the southwest of Salem along the western margin of the Salem Hills. He proposed the name Illahe Formation for these tuffaceous standstone beds and correlated them with the Eugene and Pittsburg Bluff Formations on the basis of a fauna containing *Macrocallista pittsburgensis* (Dall), *Acila shumardi* (Dall), and *Tellina eugenia* Dall. In the same year Mundorff (1939) mapped these beds as middle Oligocene in an unpublished master's thesis. His map extends to the north of Thayer's and includes outcrops of the same beds to the west and northwest of Salem beneath Miocene basalt in the Eola Hills.

Another occurrence of Oligocene beds in the Willamette Valley was noted by Allison (1953) in the Albany Quadrangle to the south, where tuffaceous sandstone and siltstone project at several points above the gravels of the valley floor. Allison mapped these beds as Eugene Formation, and although they are almost completely obscured by the terrace and bench gravels which cover the eastern half of the quadrangle, they are probably continuous with the beds in the Lebanon and Brownsville Quadrangle as well as the beds mapped as Illahe by Thayer in the Salem Quadrangle.

In the McMinnville Quadrangle these same beds crop out in the Eola Hills as a northward extension of the Oligocene beds mapped by Mundorff in the northwest corner of the Salem Quadrangle. The presence of Oligocene rocks in the vicinity of Holmes Gap, at the boundary between the two quadrangles, had been noted many years before by Schenck (1928, 1936), who identified what he thought to be the contact between the Pittsburg Bluff and Keasey Formations (1936, p. 63).

Beds in the McMinnville Quadrangle were first mapped by Brown (1951) who suggested that separate beds of lower and middle Oligocene sedimentary rocks were overlain by beds of typical Illahe lithology in the Eola Hills. He further proposed that the Illahe beds were late Oligocene and intermediate in age between the Pittsburg Bluff and Scappoose Formations. These views were modified by Baldwin, Brown, Gair, and Pease (1955) who mapped all of the Oligocene tuffaceous marine sedimentary rocks in the Quadrangle as a single unit. They recognized two lithologic and faunal divisions in the unit, a tuffaceous siltstone of early Oligocene age and a tuffaceous sandstone of middle Oligocene age. They correlated the lower siltstone with the Keasey Formation and the upper unit with the Pittsburg Bluff Formation as well as Thayer's Illahe Formation.

Although the area between Eugene and Salem is still partially unmapped, the evidence from the foregoing reports coupled with the present author's faunal investigations, seems to



Textfigure 4. *Distribution of Oligocene formations in Washington and Oregon. Compiled from Wells and Peck (1961) and Huntting, Bennett, Livingston, and Moen (1961).*

justify extending the Eugene Formation northward from the type area into the Salem area as suggested by Baldwin (1964, p. 15) and others.

Age and Correlation

The Oligocene formations of the Pacific Coast were deposited in local basins or embayments with the result that Oligocene faunas have been difficult to correlate with one another and with the standard West Coast section. Formations are geographically disjunct, and it is often difficult to determine whether faunal dissimilarities from one area to another result from time disparities or from facies differences. Textfigure 3 shows the generalized distribution of Oligocene seas in Washington and Oregon, and Textfigure 4 illustrates the present distribution and physical disjunction of Oligocene formations in the same area.

Although a number of early workers considered the Eugene Formation to be Miocene, it has been interpreted for the past four decades as Oligocene on the basis of the molluscan fauna. It has been correlated with the Lincoln Formation in Washington and the Pittsburg Bluff and Tunnel Point Formations in Oregon.

Vokes, Snavely, and Myers (1951) suggested that the Eugene Formation spanned a greater segment of time than middle Oligocene and correlated it in part with the Keasey Formation of lower Oligocene age and in part with the Gries Ranch Beds and Pittsburg Bluff Formation of middle Oligocene age.

The present author cannot find evidence to support such precise correlation of the Eugene Formation, although there does seem to be a gradual transition from assemblages with Keasey affinities to assemblages more closely resembling those of the Pittsburg Bluff and equivalent formations. Many of the assemblages contain a mixture of Keasey and Pittsburg Bluff species. Table 1 shows the occurrence of Eugene Formation mollusks in related formations. Of the 67 species which occur in the Eugene, 9 also occur in the Keasey. The most striking Keasey-like elements in the fauna are *Acila nehalemensis* (G. D. Hanna) and *Acila nehalemensis minima* Hickman, n. subsp.; a new species of *Nemocardium* which closely resembles *N. weaveri* Anderson and Martin; and two distinctive gastropods, *Olequahia schencki* Durham and *Gemmula bentsonae* Durham.

Nineteen of the species in the Eugene fauna are also present in the Pittsburg Bluff Formation. Three of these, *Macrocallista pittsburgensis* (Dall), *Acila shumardi* (Dall), and *Bruclarkia columbianum* (Anderson and Martin), were collected only in the highest stratigraphic portions of the Eugene Formation. Other species such as *Tellina pittsburgensis* Clark, *Solena eugenensis* (Clark), *Thracia condoni* Dall, *Diplodonta parilis* (Conrad), *Nuculana washingtonensis* (Weaver), *Tellina aduncanasa* Hickman, n. sp.; *Polinices washingtonensis* (Weaver), and *Neverita thomsonae* Hickman, n. sp.; also occur lower in the Eugene Formation with the Keasey elements discussed above.

This same admixture of faunal elements is less prominent in the vicinity of Holmes Gap in the Salem Quadrangle. In a recent roadcut north of the railroad crossing the author collected two distinct faunas. The lower of the two occurs in a fine-grained siltstone and contains *Acila nehalemensis* (G. D. Hanna). The upper fauna occurs in a sandstone containing *Acila shumardi* (Dall) and *Macrocallista pittsburgensis (Dall)*. In this same area Schenck (1936, p. 63) located what he interpreted as a contact between the Keasey and Pittsburg Bluff Formations. However, the lower fauna also includes such typical Eugene species as *Parvicardium eugenense* (Clark) and the upper fauna such forms as *Solena eugenensis* (Clark) and *Macoma* aff. *M. inquinata* (Deshayes). The lower unit in particular appears to represent a transition between the shallow-water deposits of the Eugene Formation and the deep-water deposits of the Keasey Formation. The faunal assemblages from both units are included with the Eugene fauna in this report because of their similarity to assemblages in the type Eugene, although it should be noted that there is insuf-

TABLE 1. Geologic Distribution of the Eugene Formation Mollusks

	Eocene	Keasey Formation	Toledo Formation	Gries Ranch Beds	Lower Quimper Sandstone	Middle Quimper Sandstone	Upper Quimper Sandstone	Lincoln Formation	Pittsburg Bluff Formation	Tunnel Point Formation	Marrowstone Shale	Yaquina Formation	Blakeley Formation	Twin Rivers Formation	Sooke Formation	Oligocene of California	Miocene	Recent
PELECYPODS																		
Acila (Truncacila) nehalemensis (G. D. Hanna)		X																
Acila (Truncacila) nehalemensis minima Hickman, n. subsp.																		
Acila (Truncacila) shumardi (Dall)			X		X	X	X	X	X	X	X					X		
Nuculana washingtonenis (Weaver)			X		X	X		X	X	X	X		X					
Portlandia (Portlandella) chehalesensis (Arnold)		X	X					X			X		X					
Yoldia (Kalayoldia) oregona (Shumard)																		
Yoldia (Kalayoldia) tenuissima (Clark)									X							X	X	
Anadara (Anadara) n. sp. ?																		
Crenella ? sp.																		
Modiolus eugenensis Weaver																		
Mytilus snohomishensis Weaver								X					X	X	X			
Nemocardium (Nemocardium) formosum Hickman, n. sp.																		
Nemocardium (Keenaea) lorenzanum (Arnold)			X					X	X		X	X	X	X		X		
Parvicardium eugenense (Clark)																		
Lucinoma acutilineata (Conrad)			X				X	X				X		X		X		
Diplodonta parilis (Conrad)									X							X	X	X
Macrocallista pittsburgensis (Dall)			X					X	X	X	X					X		
Macrocallista n. sp.																		
Pitar (Pitar) dalli (Weaver)			X					X	X	X	X					X		
Pitar (Pitar) n. sp. ?																		
Pitar (Lamelliconcha) clarki (Dickerson)	X	X		X	X	X	X		X							X		
Spisula eugenensis (Clark)																		
Spisula pittsburgensis Clark			X			X			X	X			X					
Pseudocardium n. sp.																		
Tellina eugenia Dall																		
Tellina pittsburgensis Clark					X	X			X	X						X		
Tellina aduncanasa Hickman, n. sp.									X									
Tellina ? n. sp.																		
Tellina (Moerella) lincolnensis (Weaver)				X				X			X							
Macoma aff. *M. inquinata* (Deshayes)																		X
Macoma (Heteromacoma) vancouverensis (Clark and Arnold)			X									X		X	X			
Sanguinolaria townsendensis Clark					X	X		X										
Semele willamettensis Hickman, n. sp.																		
Solena (Eosolen) eugenensis (Clark)			X					X	X									
Solen sicarius Gould																	X	X
Mya (?Arenomya) kusiroensis (Nagao and Inoue)													X	X		X	X	X
Panopea (Panopea) abrupta (Conrad)									X							X		

TABLE 1. (CONTINUED) GEOLOGIC DISTRIBUTION OF THE EUGENE FORMATION MOLLUSKS

	Eocene	Keasey Formation	Toledo Formation	Gries Ranch Beds	Lower Quimper Sandstone	Middle Quimper Sandstone	Upper Quimper Sandstone	Lincoln Formation	Pittsburg Bluff Formation	Tunnel Point Formation	Marrowstone Shale	Yaquina Formation	Blakeley Formation	Twin Rivers Formation	Sooke Formation	Oligocene of California	Miocene	Recent
Panopea (Panopea) ramonensis Clark																		
Martesia turnerae Hickman, n. sp.																		
Martesia sp.																		
Pandora (Pandora) laevis Hickman, n. sp.																X		
Thracia condoni Dall			X			X			X			X						
SCAPHOPOD																		
Dentalium (?Fissidentalium) laneensis Hickman, n. sp.																		
GASTROPODS																		
Epitonium (Boreoscala) condoni (Dall)		X		X	X	X										X		
Epitonium (Boreoscala) condoni eugenense Durham																		
Epitonium (Boreoscala) condoni oregonense (Dall)				X	X													
Acrilla (Ferminoscala) becki Durham					X													
Acrilla (Ferminoscala) dickersoni Durham				X												X		
Calyptraea diegoana (Conrad)				X	X	X	X				X		X					
Calytraea sookensis Clark and Arnold															X			
Crepidula ungana Dall													X					
Natica (Natica) n. sp. ?												X						
Neverita thomsonae Hickman, n. sp.									X									
Polinices washingtonensis (Weaver)			X		X	X		X	X	X	X							
Sinum obliquum (Gabb)	X	X			X						X							
Ficus modesta (Conrad)													X				X	
Olequahia schencki Durham		X																
Molopophorus fishii (Gabb)												X			X	X		
Molopophorus dalli Anderson and Martin						X		X								X		
Bruclarkia vokesi Hickman, n. sp.																		
Bruclarkia columbianum (Anderson and Martin)			X				X	X	X	X	X					X		
Perse lincolnensis (Van Winkle)			X					X		X	X							
Exilia lincolnensis (Weaver)		X	X		X	X		X		X	X					X		
Priscofusus n. sp. ?																		
Conus ? sp.																		
Gemmula bentsonae Durham		X			X	X												
Aceton parvum Dickerson				X	X	X			X									
Cylichnina turneri Effinger				X	X													
Scaphander stewarti Durham		X			X	X	X		X									
CEPHALOPOD																		
Aturia augustata (Conrad)								X			X		X	X		X		
TOTALS:	2	9	15	8	16	15	6	17	19	10	14	6	10	6	4	19	6	4

TABLE 2

SUGGESTED CORRELATION OF THE EUGENE FORMATION WITH FORMATIONS AND DIVISIONS OF WEST COAST OLIGOCENE.

	Standard West Coast section Weaver et al 1944	Columbia County Warren and Norbisrath 1946	Central Oregon Coast Vokes et al 1949	Salem Area Baldwin et al 1955	Eugene Area Vokes et al 1951 & this report	Coos Bay Allen & Baldwin 1944	Durham 1944		Reed 1951 & Zimmerman 1944	BIOZONES Schenk 1936	MEGAFAUNAL ZONES Durham 1944	STAGES Kleinpell 1938
	OREGON						WASHINGTON		CALIF.			
OLIGOCENE	Blakeley	Scapoose Fm	Yaquina Fm				Twin Rivers Fm	Sooke Fm	Kirker San Ramon	Acila gettysburgensis	Echinoporia apta	Zemorrian
OLIGOCENE	Blakeley	Scapoose Fm	Yaquina Fm				Twin Rivers Fm	Blakeley Fm	San Lorenzo Pleito Fms	Acila gettysburgensis	Echinophoria rex	Zemorrian
OLIGOCENE	Lincoln		Toledo Fm				Type Lincoln --- ? ---	Marrow-stone Shale	Butano		Turritella porterensis	Refugian
OLIGOCENE	Lincoln		Toledo Fm					Quimper Sandstone	Butano		Turritella olympicensis	Refugian
OLIGOCENE	Lincoln	Pittsburg Bluff Fm	Toledo Fm	Eugene Fm	Eugene Fm	Tunnel Point Fm		Quimper Sandstone	Tumey Kreyen-hagen San Emigdo Fms	Acila shumardi	Molopophorus gabbi	Refugian
OLIGOCENE	Lincoln		Toledo Fm	Eugene Fm	Eugene Fm	Bastendorf Fm	Gries Ranch Beds	Quimper Sandstone	Tumey Kreyen-hagen San Emigdo Fms	Acila shumardi	Molopophorus stephensoni	Refugian
OLIGOCENE	Keasey	Keasey Fm	Toledo Fm	Eugene Fm	Eugene Fm --- ? --- Fisher Fm	Bastendorf Fm	Townsend Shale / Lyre Conglomerate		?	Acila nehalemensis	Turcicula columbiana	Refugian

ficient stratigraphic and lithologic evidence to assign a formation name to these beds.

Nineteen Eugene species have been reported from the Oligocene of California, although none of the California faunas has been examined in conjunction with this study. Schenck (1928, p. 15) correlated the Eugene Formation with the San Emigdio and Pleito Formations of Kern County, the San Juan Batista Formation of San Benito County, and the San Ramon Formation of the San Francisco Bay Region. The most closely related California fauna seems to occur in the Tumey Sandstone and Shale Members of the Kreyenhagen Formation in Fresno County. Zimmerman (1944, p. 963-964) lists faunas from these units containing *Acila shumardi* (Dall), *Pitar dalli* (Weaver), *Macrocallista pittsburgensis* (Dall), *Tellina pittsburgensis* Clark, *Nuculana* cf. *N. washingtonensis* (Weaver), *Taras parilis* (Conrad), and *Gemmula* n. sp. (= *Gemmula bentsonae* Durham). Zimmerman (1944, p. 970-971) correlates the Tumey with Durham's *Molopophorus stephensoni* Zone and with the Gries Ranch Beds of southwestern Washington as well as with portions of the *Turcicula columbiana* and *Molopophorus gabbi* Zones. He also correlates the Tumey with part of the San Emigdio Formation of Kern County, California.

The Eugene fauna shows a higher degree of similarity to the Oligocene faunas of Washington than to those of California. Of the 67 species which occur in the formation, Durham (1944, p. 117-119) has reported 16 from the lower portion of the Quimper Sandstone *(Molopophorus stephensoni* Zone) and 15 from the middle portion of the Quimper *(Molopophorus gabbi* Zone). It is important to note here that Durham's megafaunal zones for northwestern Washington cannot be related to the Oregon Oligocene except in a very broad sense. A number of Eugene species, such as *Acrilla becki* Durham , *Molopophorus dalli* Anderson and Martin, *Thracia condoni* Dall, *Tellina pittsburgensis* Clark, and *Epitonium condoni* Dall, are restricted to the *Molopophorus stephensoni* and *Molopophorus gabbi* Zones in Washington. Other Eugene species such as *Macrocallista pittsburgensis* (Dall), *Perse lincolnensis* (Van Winkle), and *Pitar dalli* (Weaver), are present only in the *Turritella porterensis* Zone in Washington. Durham (1944, p. 112) places the type Lincoln fauna and the *Turritella porterensis* Zone higher in the Oligocene, although it is questionable that the type Lincoln is significantly younger than the Pittsburg Bluff Formation.

Vokes, Snavely, and Myers (1951) correlate a portion of the Eugene Formation with the Gries Ranch Beds of southwestern Washington. The Gries Ranch fauna contains only eight of the species present in the Eugene, but the Gries Ranch fauna is admittedly unique, occurring in a conglomeratic facies which has been somewhat difficult to correlate.

In conclusion, faunal evidence indicates that the Eugene Formation spans portions of both the lower and middle Oligocene. In the Eugene area the beds contain a fauna of mixed Keasey and Pittsburg Bluff affinities. It is possible that this fauna represents in part a transitional phase which is absent in northwestern Oregon where there is an abrupt lithologic and faunal break separating the Keasey and Pittsburg Bluff Formations. This transitional fauna is not as well developed in the Salem area. The youngest portions of the Eugene Formation are correlated with the Pittsburg Bluff and Tunnel Point Formations in Oregon. The proposed correlation of the Eugene Formation with the Oligocene formations and divisions on the Pacific Coast is presented in Table 2.

Paleontology

The molluscan fauna of the Eugene Formation contains 67 species including 41 pelecypods, 24 gastropods, 1 scaphopod, and 1 cephalopod. Most of these species can be collected in the type area of the formation in and around the city of Eugene. Only six of the species are restricted to outcrops farther north in the vicinity of Salem.

Preservation is poor in the Eugene Formation. Specimens are most commonly preserved

TABLE 3. CHECKLIST OF EUGENE FORMATION PELECYPODS

Species	Type Area, Eugene, Oregon*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acila (Truncacila) nehalemensis (G. D. Hanna)															
Acila (Truncacila) nehalemensis minima Hickman, n. subsp.								X				X			X
Acila (Truncacila) shumardi (Dall)															
Nuculana washingtonensis (Weaver)							X	X				X			X
Portlandia (Portlandella) chehalisensis (Arnold)								X							
Yoldia (Kalayoldia) oregona (Shumard)			?		X										
Yoldia (Kalayoldia) tenuissima (Clark)															
Anadara (Anadara) n. sp. ?															
Crenella ? sp.															
Modiolus eugenensis Clark							X		X			X	X		X
Mytilus snohomishensis Weaver															
Nemocardium (Nemocardium) formosum Hickman, n. sp.															
Nemocardium (Keenaea) lorenzanum (Arnold)															
Parvicardium eugenense (Clark)		X			X		X	X				X			
Lucinoma acutilineata (Conrad)															
Diplodonta parilis (Conrad)			X				X				X	X	X		
Macrocallista pittsburgensis (Dall)												X			
Macrocallista n. sp.											X	X	X	X	X
Pitar (Pitar) dalli (Weaver)												X	X	X	X
Pitar (Pitar) n. sp. ?												X			
Pitar (Lamelliconcha) clarki (Dickerson)			X									X			
Spisula eugenensis (Clark)	X	X	X	X	X		X		X		X	X	X	X	X
Spisula pittsburgensis Clark															
Pseudocardium n. sp.		X													
Tellina eugenia Dall															
Tellina pittsburgensis Clark											X	X			
Tellina aduncanasa Hickman, n. sp.			X												
Tellina ? n. sp.												X	X	X	
Tellina (Moerella) lincolnensis (Weaver)			X								X	X	X		
Macoma aff. *M. inquinata* (Deshayes)											X	X	X		X
Macoma (Heteromacoma) vancouverensis (Clark and Arnold)		X										X	X	X	X
Sanguinolaria townsendensis Clark															
Semele willamettensis Hickman, n. sp.							X	X							X
Solena (Eosolen) eugenensis (Clark)						X					X	X		X	X
Solen sicarius Gould									X			X			
Mya (? Arenomya) kusiroensis (Nagao and Inoue)															
Panopea (Panopea) abrupta (Conrad)															
Panopea (Panopea) ramonensis Clark															
Martesia turnerae Hickman, n. sp.															
Martesia sp.															
Pandora (Pandora) laevis Hickman, n. sp.												X			
Thracia condoni Dall												X			X

* Locality descriptions are included in Appendix A.

TABLE 3. Checklist of Eugene Formation Pelecypods

																			Salem Area											
0	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
																										X				
X					X			X	X							X				X										
															X				X		X	X		X						
X					X	X	X	X	X	X						X						X		X	X			X	X	
																X												X		
			X	X				X		X											X	X							X	
				X																										
							X																							
							X																							
			X	X	X			X												X										
																						X								
																				X										
																														X
X					X	X	X	X	X	X		X	X	X	X	X	X		X	X		X				X				
							X														X									
			X	X	X	X		X		X					X		X				X	X				X	X		X	
														X	X							X				X				
X	X					X	X	X							X		X				X									
X	X		X	X		X	X	X			X		X	X	X		X		X			X	X			X				X
					X	X	X	X	X																					
X	X					X		X			X						X								X	X	X			
X	X	X	X	X	X	X	X	X			X	X	X	X	X		X	X		X									X	
																						X		X						
				X				X			X			X													X			
			X	X						X					X															
X					X	X	X	X	X							X								X		X				
					X	X	X	X														X		X						
X						X		X									X													
					X	X	X	X	X						X		X												X	
X	X					X		X								X	X									X				
X								X					X																	
				X																										
X	X							X																						
X	X	X		X	X	X	X	X	X					X	X		X					X		X	X	X	X	X	X	X
	X				X	X		X	X	X					X							X							X	
						X	X	X																						
				X																										
																						X		X				X		
								X																						
							X	X	X																					
X			X	X	X		X	X		X			X		X						X					X		X		

TABLE 4. CHECKLIST OF EUGENE FORMATION MOLLUSKS OTHER THAN PELECYPODS

SPECIES	TYPE AREA, EUGENE, OREGON*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SCAPHOPOD															
Dentalium (? Fissidentalium) laneensis Hickman, n. sp.				X					X			X		X	
GASTROPODS															
Epitonium (Boreoscala) condoni (Dall)												X			
Epitonium (Boreoscala) condoni eugenense Durham															
Epitonium (Boreoscala) condoni oregonense (Dall)															
Acrilla (Ferminoscala) becki Durham												?			
Acrilla (Ferminoscala) dickersoni Durham					X						X	X			
Calyptraea diegoana (Conrad)												X			X
Calyptraea sookensis Clark and Arnold															
Crepidula ungana Dall		X		X	X		X				X	X	X	X	X
Natica (Natica) n. sp. ?															
Neverita thomsonae Hickman, n. sp.			X	X	X						X	X	X	X	X
Polinices washingtonensis (Weaver)				X	X						X	X	X	X	X
Sinum obliquum (Gabb)								X				X			
Fiscus modesta (Conrad)				X	X							X	X		X
Olequahia schencki Durham		X													
Molopophorus fishii (Gabb)			X		X					X			X		
Molopophorus dalli Anderson and Martin		X													
Bruclarkia vokesi Hickman, n. sp.			X		X				X	X	X	X	X		X
Bruclarkia columbianum (Anderson and Martin)												X			
Perse lincolnensis (Van Winkle)															
Exilia lincolnensis (Weaver)												X			
Priscofusus n. sp. ?															
Conus ? sp.											X				
Gemmula bentsonae Durham											X	X	X	X	
Acteon parvum Dickerson												X			
Cylichnina turneri Effinger															
Scaphander stewarti Durham															
CEPHALOPOD															
Aturia angustata (Conrad)				X											

* Locality descriptions are included in Appendix A.

TABLE 4. CHECKLIST OF EUGENE FORMATION MOLLUSKS OTHER THAN PELECYPODS

																			Salem Area											
0	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
X	X				X	X	X	X	X	X		X					X								?					
						X	X	X		X	X			X	X		X													
								X					X	X	X															
													X		X		X													
		X					?	X	?																					
						X	X	X	X																		X			
X						X	X	X																						
																											X			
			X	X	X	X		X		X							X			X	X									
								X							X							X								
X	X	X	X	X	X	X	X	X								X				X		X				X	X			
X	X	X	X		X	X	X	X	X	X	X																			
	X				X		X	X	X	X																				
X								X																						
						X	X	X											X		X									
		X	X	X			X	X			X			X	X															
											X																X			
X	X	X	X	X	X	X	X	X	X	X				X	X		X	X	X	X										
								X																		X	X			
						X		X																						
							X	X																						
						X																								
					X		X	X	X											X										
			X		X				X	X																				
					X		X	X	X																					
					X			X	X						X				X			X								
							X																	X						

either as internal molds or as chalky decorticated specimens. The best preservation is often present in highly indurated layers where specimens are difficult to remove from the matrix. Even in fresh exposures of the formation the shell material is often loosely attached to the internal mold and exfoliates easily during preparation. The other major problem in preservation is the common distortion in certain species. The author's collections contain thousands of crushed and distorted internal molds and decorticated specimens which cannot be positively identified, and the faunal listing for the Eugene Formation will not be complete until well-preserved specimens of some of these distorted forms are found.

The composition of the fauna and its distribution within the Eugene Formation are summarized in Tables 3 and 4. Faunal composition varies from one locality to another as a function of environment, so that the fauna of the formation as a whole can be broken down into a number of types of aggregations ranging from highly reworked concentrations of shell material to apparently natural assemblages in which the fossils have been preserved in the living position.

In the layers of concentrated small shell material the typical assemblage includes large numbers of small taxodonts such as *Nuculana washingtonensis* (Weaver) and *Acila nehalemensis minima* Hickman, n. subsp.; small tellens such as *Tellina pittsburgensis* Clark; large numbers of naticoid gastropods; small, current-oriented scaphopods; and a variety of other small forms including *Parvicardium eugenense* (Dall), *Diplodonta parilis* (Conrad), *Gemmula bentsonae* Durham, *Acteon parvum* Dickerson, and *Cylichnina turneri* Effinger. Layers of larger shell material are common at many localities, particularly in the coarser units in the formation. These layers generally contain assemblages of *Pitar dalli* (Weaver), *Modiolus eugenensis* Clark, and *Bruclarkia vokesi* Hickman, n. sp.; large mactrids such as *Spisula eugenensis* (Clark) and *Pseudocardium* n. sp.; and large naticoid gastropods of the genus *Neverita*. Concentrations of *Crepidula ungana* Dall are common in numerous localities. A number of other species may be found in occasional local concentrations or pockets. Thin lenses of *Solena eugenensis* (Clark) in various stages of disarticulation were apparently preserved in small local depressions on the ocean floor. *Modiolus eugenensis* Clark is almost always found in concentrations of articulated specimens, and *Spisula eugenense* (Clark) and *Bruclarkia vokesi* Hickman, n. sp. also occur in local aggregations at some localities. In the finer-grained units many assemblages contain a preponderance of infaunal siphon-feeding pelecypods which are preserved in the living position along with other burrowing forms such as the nuculid taxodonts which gather food particles directly from the sediment.

Although most of the variation in faunal composition from one locality to another is related to variation in the environment, there is some stratigraphic restriction of species. For example, *Acila nehalemensis minima* Hickman, n. supsp., which is common throughout most of the formation, is replaced by *A. Shumardi* (Dall) in beds near the top of the formation. There are few such clear examples, however, and subdivision of the Eugene Formation into faunal zones is unwarrented.

Paleoecology

The subject of paleoecology is so broad and the approaches so varied that it would be presumptuous to imply that the following brief remarks constitute a paleoecological analysis of the Eugene Formation. Some suggestions are offered as to the temperature and depth of water, and these are in turn related to the climate of the Pacific Coast Oligocene as it is presently understood. Reconstruction of the sediment as a substrate introduces a consideration of the types of living communities that inhabited the Eugene seas and factors leading to the formation of several different types of fossil assemblages. These interpretations and deductions are based on a variety of qualitative observations of faunal composition and affinities, morphological adaptations, preservations and condition of the fossil material, the nature of the rocks, and the relationship of the fossils to the enclosing rocks.

Paleoecological analysis of Tertiary environmental parameters such as temperature and depth depends upon extensive use of the uniformitarian principle of analogy with modern situations. This dependence has led to the development of taxonomic paleoecology in which the requirements and limits of tolerance of living genera and species are used to reconstruct the ecology of fossil environments. Although it has become popular to collect and utilize the temperature records and depth ranges of living taxa, it should be pointed out that this kind of uniformitarianism can be misused when it is applied strictly because it assumes that genera and species have retained the same physiological requirements over long periods of geologic time.

This kind of uniformitarianism, with its inherent assumption of long-term genetic stability, seems particularly tenuous when applied to Oligocene and older faunas since the differentiation of mollusks into warm-water and cool-water forms and the establishment of faunal provinces did not begin until the close of the Eocene. The importance of the foregoing observations has been reinforced in the mind of the present author through discussions with several workers on the Pacific Coast who have expressed surprise at the "anomalous" co-occurrence of tropical and temperate genera in the Eugene fauna. If two genera which cannot coexist today are found side by side in the Oligocene, their co-occurrence does not necessarily represent an anomaly which must be explained in terms of outside contamination or the mixing of warm and cold currents. For this reason the following brief interpretation of the environment of the Eugene basin will remain somewhat general in nature.

The character of Oligocene marine climates and paleoecology has been discussed by Arnold (1909a), Dickerson (1917), Smith (1919), Clark (1921), Durham (1950), and others. The picture which has emerged shows the Oligocene as a time of transition from the universally distributed tropical and subtropical climates and faunas of the Paleocene and Eocene, with a preponderance of genera which are now extinct or confined to the tropics, to the establishment of the essentially modern climatic zones and provincial faunas of the Miocene, where large numbers of Recent species are characteristically present. The climatic and faunal transition resulted from the Oligocene depression in the polar region and the origin of the Arctic Ocean as a source of cold currents, forcing northern mollusks to adapt to colder environments or migrate to warmer water (Dickerson, 1916, p. 163). Shallow seas and embayments may have remained warmer relative to the cooling offshore currents of arctic origin giving rise to highly heterogeneous environments.

Although the early Oligocene is not well represented on the West Coast, faunas such as the Keasey indicate that the climate was still basically subtropical. The transition is most marked in the middle Oligocene faunas where a number of cold-water elements begin to appear. In addition, modern species of *Thracia, Macoma, Panopea, Lucinoma,* and others are found for the first time. The Oligocene is also a time of development and proliferation of several endemic Pacific Coast genera such as *Bruclarkia* and *Molopophorus* which flourished during this interval of instability and transition but disappeared shortly after the close of the epoch.

The fauna of the Eugene Formation definitely reflects the trends noted above. Three Recent species are present in the fauna: *Panopea abrupta* (Conrad) (= *P. generosa* of authors), *Diplodonta parilis* (Conrad) (= *D. sericata* of authors), and *Solen sicarius* Gould. Another common species in the formation is compared to the Recent *Macoma inquinata* (Deshayes). A number of genera which are presently best represented in cold or temperate waters are also present in the Eugene fauna. *Yoldia, Nuculana, Acila, Macoma* s. s., *Mya, Spisula, Panopea, Scaphander,* and large epitoniums of the subgenus *Boreoscala* are examples of such genera.

At the same time there are a large number of genera such as *Anadara, Sanguinolaria, Macrocallista, Pitar, Semele, Sinum, Ficus,* and *Gemmula* which are either restricted to or most abundantly represented in tropical waters at the present time. A few of these genera are represented by species such as *Pitar clarki* (Dickerson) which are survivors from the Eocene.

The co-occurrence of these so-called warm- and cold-water genera in the Eugene Formation would present an anomaly if taxonomic paleoecology were applied strictly. It seems much more reasonable to regard the fauna of the Eugene Formation as a complex intermingling of modified Eocene lines of adaptation and invading progenitors of the modern fauna in a cooling subtropical to warm temperate sea. By this time many of our Recent genera had become highly canalized in ther external morphology and basic mode of life, but physiologically these same genera were perhaps making profound adaptive responses to the climatic changes initiated in the Oligocene.

The complexity of this picture is compounded by the invasion of Asian genera and species during the Oligocene. The migrational history of the Oligocene fauna is virtually unexplored, although workers such as Smith (1904), Keen (1940), and MacNeil (1965, 1967) have recognized the importance of the Asian element in Western American faunas. There is little basis at present for discussing possible migrations into the Eugene basin, but the work of MacNeil (1965) suggests that the presence of *Mya* in the formation represents an invasion from Asia and that *Acila shumardi* (Dall) is a part of a long-ranging Asiatic stock which made a sudden but brief appearance on the east side of the Pacific.

Several lines of evidence suggest that most of the Eugene Formation was deposited in shallow water, at depths no greater than 30 fathoms. The coarse, tuffaceous, and arkosic character of many beds and the interfingering of the Eugene Formation with non-marine tuffaceous rocks to the east and south indicates the proximity of the Oligocene shoreline as well as the nearness of volcanic vents which produced intermittent periods of vigorous pyroclastic volcanism. Although mollusks are generally not good indicators of depth, genera such as *Panopea, Modiolus, Solen,* and *Spisula* are presently restricted to depths of less than 40 fathoms. The Foraminifera in the Eugene Formation further support the above observations. According to Orr (personal communication, 1967), "The preponderance of miliolids, arenaceous forms, and certain of the Nonionidae, notably species of *Elphidium,* indicate that the Eugene Formation was deposited in shallow water, where Formaminifera have been collected from the unit." Orr also believes that the high diversity of the benthonic fauna is an indication that the environment was not one of a bay or otherwise highly restricted environment. The absence of planktonic forms is typical of turbid, near-short environments.

The composition of fossil assemblages and the extent to which they represent living communities is one of the more fascinating aspects of paleoecology. A number of different kinds of assemblages are represented in the Eugene Formation, and these are briefly discussed and interpreted below.

The existence of relatively calm portions of the basin is indicated by the gray tuffaceous silts that formed a substrate which supported communities of burrowing organisms similar to many modern infaunal communities. Many of these organisms died in their burrows and are preserved in the positions customarily maintained through life. Thus forms such as *Solena* are preserved with the shell vertical to the bedding and the posterior or siphonal end up, while genera like *Tellina* are preserved horizontally with the right valve on the bottom and the siphonal ends of both valves deflected upward. The siphon feeders in these infaunal communities include representatives of such genera as *Parvicardium, Nemocardium, Macrocallista, Pitar, Spisula, Tellina, Macoma, Semele, Solena, Panopea, Pandora,* and *Thracia.* Non-siphon-feeding bivalves in these burrowing communities include such genera as

Nuculana, *Acila*, and *Diplodonta*. A rich and varied naticoid gastropod fauna is also characteristic of these beds, and signs of naticoid predation are evident on many of the bivalves. In these infaunal assemblages the pelecypods are articulated with the valves tightly closed indicating lack of transport after death. The wide range of sizes in the specimens precludes sorting, although no attempt has been made to assess the significance of the size range in terms of age distribution in the populations involved.

In the same units with these relatively undisturbed infaunal assemblages there are occasional thin layers of concentrated shell material which show definite signs of reworking and current sorting. The layers range from 1 to 10 cm in thickness and cannot be traced over great distances. The shells in these layers are small and include an admixture of infaunal and epifaunal species. The shells show little sign of wear or breakage, but many of the pelecypod valves are disarticulated, indicating some degree of transport. The scaphopods in these layers show parallel alignment by the current. There is also evidence that currents were intermittent and fluctuating in strength: the assemblages contain varying percentages of large shells mixed in with the smaller ones, and in some places there are higher proportions of broken and abraded shell debris mixed in.

Although undisturbed and reworked infaunal assemblages are common in the Eugene Formation, epifaunal communities are very poorly represented. This is perhaps partially explained by the fact that epifaunal communities in general are best developed near shore (Thorson, 1957, p. 461) where wave action and hard substrates are less conducive to preservation. The most abundantly represented epifaunal element in the Eugene Formation is the gastropod *Crepidula ungana* Dall. This species is common in many of the reworked assemblages and is occasionally the dominant element in thin layers of concentrated shell material. At locality 14, specimens were still cemented to one another, and the original colonial form was preserved, indicating lack of vigorous transport. Decapods, mussels, barnacles, and epifaunal gastropods are represented at many localities, but they always occur in heterogeneous or reworked assemblages so that it is difficult to reconstruct any of the epifaunal communities which inhabited the Eugene sea.

SYSTEMATIC PALEONTOLOGY

A brief explanation of the author's philosophy as a taxonomist will aid readers in evaluating some of the decisions which appear on the following pages.

Species are recognized primarily on the basis of major morphological discontinuities in the range of variation of large numbers of individuals. In keeping with the population concept of the species, the holotype cannot be regarded as typical of the species. In paleontology, holotypes are commonly chosen on the basis of exceptional preservation and do not necessarily fall in the middle of the range of variation of the population, but may represent an extreme. In descriptions of new species every effort has been made to define the range of variation with respect to the holotype and to select and illustrate paratypes which suggest the morphological boundaries of the taxon. Wherever possible an attempt has been made to redefine the range of variation in previously described species.

In several instances remarkable individual specimens are described or discussed because of a lack of additional material. The value of such descriptions will depend upon their subsequent use in a growing concept of the taxa involved.

Synonymies in this report are not exhaustive. Citations which are not accompanied by illustrations or descriptions and citations for which specimens are not readily accessible have been omitted in most cases.

MOLLUSKS

PELECYPODS

Superfamily NUCULACEA

Family Nuculidae

Genus *ACILA* H. and A. Adams, 1858

TYPE: By subsequent designation (Stoliczka, 1871), *Nucula divararicata* Hinds.

Subgenus *TRUNCACILA* Grant and Gale, 1931, *ex* Schenck MS

TYPE: By original designation, *Nucula castrensis* Hinds

Acila is a Pacific Coast genus which appears in the Cretaceous and becomes widespread and numerous during the Tertiary. Since species of the genus *Acila* have been used as zone fossils in the marine Oligocene of the Pacific Coast of North America, it is necessary to discuss the occurrences of this form in the Eugene Formation at some length.

The term "*Acila shumardi* Zone" appeared in the Oligocene literature for many years without rigorous definition before Schenck (1936, p. 41-44) provisionally established it as a biozone for beds deposited during the existence of the species. At the same time he proposed the *Acila nehalemensis* biozone for the beds limited by the upper and lower limits of the range of this lower Oligocene species from the Keasey Formation. Since this time all beds bearing *A. shumardi* have been correlated with the Pittsburg Bluff Formation and other formations of middle Oligocene age, and those beds bearing *A. nehalemensis* have been correlated with the Keasey.

The presence of *Acila* in the Eugene Formation has been noted in species lists for many years. The form has consistently been identified as *A. shumardi. A. shumardi* does occur occasionally in the upper portion of the Eugene, but virtually everyone has overlooked or misidentified the small unique *Acila* which occurs in large numbers and is recognized here as a subspecies of *A. nehalemensis*. More typical *A. nehalemensis* also occurs in beds recently exposed at Holmes Gap northwest of Salem in association with a Eugene rather than Keasey Fauna.

Acila (Truncacila) nehalemensis (G. D. Hanna)

Pl. 1, figs. 1, 2, 3

Nucula (Acila) cordata Dall, 1898, p. 573; Dall, 1900, p. 1196, pl. 40, fig. 4; Dall, 1909, p. 103.

Acila nehalemensis G. D. Hanna, 1924, p. 155.

Acila (Truncacila) nehalemensis (G. D. Hanna). Schenck, 1935, p. 43; Schenck, 1936, p. 57-63, pl. 5, figs. 1, 5, 6, 7, 8, 10, 11, 12, text fig. 7, 19 (Synonymy); Weaver, 1942, p. 24-25, pl. 6, fig. 9 (Synonymy).

DISCUSSION: *Acila nehalemensis* is a large, inflated, relatively ovate species with coarse radial ribbing, a marked tendency toward secondary bifurcation of radial ribs, and an area of partially-obscured radial ribbing along the ventral margin of the shell. Schenck (1936, p. 57-63) discusses this species in some detail and uses it as a basis for his lower Oligocene biozone.

Since rocks bearing *A. nehalemensis* have been considered Keasey or Keasey equivalents, and because the Eugene *Acila* has been consistently identified as *A. shumardi*, it seemed advisable to restudy these two taxa. Specimens were collected from a number of localities in the Pittsburg Bluff, Keasey, and Tunnel Point Formations as well as the Eugene Formation and the beds at Holmes Gap northwest of Salem, which Schenck assigned to the Keasey Formation.

In Schenck's key to the species of *Acila*, *A. nehalemensis* is differentiated from *A. shumardi* by the presence of an incipient rostral sinus. This feature does not appear on most specimens, however, and it may occur occasionally in *A. shumardi*. Schenck also weighted shell outline heavily as a distinguishing character at the species level. Populations of *A. shumardi* and *A. nehalemensis* may be distinguished on the basis of mean ratio of altitude to length, but there is a large area in which individuals from both populations overlap.

The only character in which no overlap was discerned was in the width of the radial ribs, a character also noted by Schenck. The actual distance measured was from the center of one interspace across the rib to the center of the next interspace at comparable points on the shell. This distance fell between 340 and 510 microns on all specimens collected from the Pittsburg Bluff and Tunnel Point Formations and between 560 and 680 microns on specimens from the Keasey and Eugene Formations as well as the beds at Holmes Gap. The greater frequency of secondary bifurcation in *A. nehalemensis* and the tendency for the growth lines to coalesce into ridges toward the ventral margin of the shell are also helpful in distinguishing this species.

Specimens from the Eugene area represent a new subspecies of *A. nehalemensis* and will be treated separately. The beds at Holmes Gap contain typical *A. nehalemensis*. These beds were assigned by Schenck (1936, p. 63) to the Keasey Formation; but the associated fauna at this locality includes *Parvicardium eugenense* (Clark), *Nuculana washingtonensis* (Weaver), *Pitar clarki* (Dickerson), *Polinices washingtonensis* (Weaver), and fragments of a large *Solena* resembling *S. eugenensis* (Clark). A suite of 42 specimens of *A. nehalemensis* was collected at this locality. There is no sign of an incipient rostral sinus on any of the specimens, and many have an outline which might be considered more typical of *A. shumardi*. However, the width of the radial ribs and the coarse texture of the ribbing, the numerous secondary bifurcations, and the coalescing of growth lines to obscure the radial ribbing along the ventral margin definitely place these forms with *A. nehalemensis*.

HYPOTYPES: UO 27166, 27167, 27168.

LOCALITY: 46.

Acila (Truncacila) nehalemensis
subsp. *minima* Hickman, n. subsp.
Pl. 1, figs. 4, 5

DESCRIPTION: Shell small; shape highly variable, ovate to quadrate in outline, moderately inflated; anterior dorsal margin long and broadly convex, posterior dorsal margin straight and posterior end abruptly truncated; beaks conspicuous and strongly opisthogyrate; lunule obscure; escutcheonal area broad, cordate, and flat, bordered by ridge along which radial ribs divaricate before crossing escutcheon; escutcheonal face slightly pouted along hingeline; radial ribbing coarse and prominent, interspaces slightly narrower than ribs; combined width of rib and interspace 560 microns on specimen 10.5 mm long; secondary bifurcation common along line of primary bifurcation and along ventral margin of shell; line of primary bifurcation may shift; growth lines fine and visible only with magnification, crowding together and coalescing at varied intervals to produce visible ridges; concentric ridges most numerous at ventral margin where they tend to obscure radial ribbing; dentition and shell interior not visible.

Acila nehalemensis minima differs from the typical species primarily in its small size. *A. nehalemensis* is a relatively large species attaining lengths up to 25 mm. The smallest specimen measured was 14 mm long. The average specimen of *A. nehalemensis minima* is only 7 mm long, and the largest specimen measured was 12.5 mm long. The Eugene populations do not represent sorted concentrations of juvenile individuals since specimens commonly occur articulated and in the same sediments with large specimens of other species. The specimens also exhibit characters that are present only in adult individuals of the typical species, such as divarication of the ribbing along the ventral margin and concentration of growth lines in this same area. These forms were perhaps growing at a very slow rate and attaining sexual maturity at a smaller size.

A. nehalemensis minima is an abundant species in the fine-grained, gray, tuffaceous siltstone units of the Eugene Formation. In addition to occurring in natural infaunal assemblages, individual valves and entire specimens are common in lenses of concentrated shell material. On the surface of one slab, approximately 20 x 30 cm, 59 specimens (including fragments) of *A. nehalemensis minima* were counted.

MATERIAL STUDIED: 38 specimens (not including specimens in matrix).

HOLOTYPE: UO 27169. PARATYPES: UO 27170, 27171, 27172, 27173, 27174, 27175, 27176.

LOCALITIES: 8, 12, 15, 18, 20, 25, 28, 29, 36, 40.

Acila (Truncacila) shumardi (Dall)
Pl. 1, figs. 6, 7, 10

Nucula decisa Conrad, Dall, 1898, p. 573; not *Nucula decisa* Conrad in Blake 1855, p. 322, pl. 3, fig. 19.

Nucula (Acila) decisa (Conrad). Dall, 1900, p. 1196, pl. 40, figs. 1, 3.

Nucula (Acila) shumardi Dall, 1909, p. 103; Clark, 1925, p. 75, pl. 8, fig. 11; Tegland, 1933, p. 107, pl. 5, fig. 10.

Nucula conradi Meek. Weaver, 1912, p. 19.

Acila conradi (Meek). Washburne, 1914, p. 33-35.

Acila shumardi (Dall). Clark, 1918, p. 85, 95, 121, pl. 13, figs. 7, 8, 17; Weaver, 1916, p. 62, pl. 13, fig. 43.

Acila (Truncacila) shumardi (Dall). Schenck, 1934, p. 43; Schenck, 1936, p. 64-67, pl. 4, figs. 5-9, pl. 6, figs. 1-11, text figs. 7, 18 (Synonymy); Weaver, 1942, p. 25; pl. 7, figs. 5-7, 11, pl. 8, figs. 2, 5 (Synonymy).

DISCUSSION: *Acila shumardi* is a large, inflated, quadrangular species with a characteristically straight truncated posterior margin. *A. shumardi* has been described in detail by Schenck (1936, p. 64-67), who used the range of the species as a basis for one of his Oligocene biozones.

The holotype of this species and the topotypes upon which Schenck based his supplementary description come from exposures of the Pittsburg Bluff Formation in Columbia County, Oregon. The first specimens collected from this locality were identified by Dall (1898, p. 573) as *Nucula decisa* Conrad. Since Conrad's species was poorly known and the type was lost, Dall later (1909, p. 103) introduced the name *Nucula (Acila) shumardi*. Specimens from the type locality are generally very well preserved, and a suite of 52 specimens collected in conjunction with the preparation of this report compare well with Schenck's topotype material.

There are several points in Schenck's description, however, which need clarification. Schenck cites *A. shumardi* as an example of a species in which secondary bifurcation of radial ribs rarely develops. Secondary bifurcations are not immediately evident due to the low relief and typically worn state of the radial ribbing, but they are present on many specimens. Double bifurcation along the line of primary bifurcation also occurs and is even evident on one of Schenck's topotypes (Stanford Univ. Pal. Type Coll. no. 529). Schenck also attaches importance to the fineness of the radial ribbing. It is true that the ribs and interspaces are relaitvely narrow in this species, but it is the low relief of the radial ribs rather than their width that gives the shell its characteristic appearance.

A. shumardi occurs only in the upper part of the Eugene Formation. It rarely occurs in the Eugene area, but is more common in the Salem area. One external mold from the Salem area has a length of 33 mm, the largest size yet recorded for the species.

A complete list of the occurrences of *A. shumardi* in the Pacific Coast Tertiary is given by Schenck (1936, p. 65-67).

MATERIAL STUDIED: 63 specimens.

HYPOTYPES: UO 27177, 27178, 27179.

LOCALITIES: 35, 39, 41, 42, 44, UO 2567.

Family Nuculanidae

Genus *NUCULANA* Link, 1807

TYPE: By monotypy, *Arca rostrata* Chemnitz (= *Mya pernula* Müller).

Nuculana is a primitive and conservative genus which has persisted since Early Paleozoic times without major innovation. There have been numerous attempts to subdivide this group of small, markedly-rostrate burrowing forms, but many species are difficult to fit into any of the existing classifications. The genus is most common in cold northern waters, and tropical members of the genus are usually found at great depths. In the West Coast Tertiary, *Nuculana* is found primarily in fine-grained sedimentary rocks.

Nuculana washingtonensis (Weaver)

Pl. 1, fig. 8, 11

Leda washingtonensis (Weaver, 1916, p. 34-35, pl. 3, figs. 25-26.

Leda lincolnensis Weaver, 1916, p. 35, pl. 3, figs. 23-24.

Leda washingtonensis Weaver n. subsp., Tegland, 1933, p. 108-109, pl. 5, fig. 19.

Nuculana washingtonensis (Weaver). Weaver, 1942, p. 38-39, pl. 8, figs. 18, 20, 26.

DISCUSSION: *Nuculana washingtonensis* is an elongate species terminating posteriorly in a sharply-pointed rostrum. The beaks are characteristically located two-fifths of the distance from the anterior end of the shell. The anterior dorsal margin is convex, and the anterior end is regularly curved. The ventral margin is long and broadly arcuate. On both valves a shallow sinus radiates from the beaks to the posterior ventral margin just below the end of the rostrum. This sinus varies in prominence. There is also some variation in shape, degree of inflation, and relative position of the umbos. One of the most constant features is the sculpture, which consists of closely-spaced, well-developed, flat-topped concentric ridges. The escutcheon is long and narrow and bordered by a slight ridge. Within the escutcheonal area the shell is produced at the dorsal margins. There is a slight posterior gape. The anterior hinge on a well-preserved Eugene specimen contains about 26 V-shaped teeth, and the posterior hinge contains 20. This compares closely with one of Weaver's syntypes which contains 26 and 21 respectively.

This species is abundant in the fine-grained units in the Eugene Formation, although it is seldom well preserved. It occurs in large numbers in lenses of concentrated shell material both as whole articulated specimens and as disarticulated valves. It also occurs commonly as articulated specimens in the fine-grained, gray, tuffaceous siltstone units. Specimens from Eugene beds in the Salem area attain greater average sizes than those in the Eugene area. It is

PLATE 1

Figure 1-3. *Acila (Truncacila) nehalemensis* (G. D. Hanna)

1. Length 20.5 mm, altitude (incomplete) 14 mm, convexity 10 mm. Loc. 47. UO 27166.

2. Length 19 mm, altitude 15 mm, convexity 11.5 mm. Loc. 47. UO 27167.

3. Length 14 mm, altitude 11.5 mm, convexity 8.5 mm. Keasey Formation. UO 27168.

Figure 4, 5. *Acila (Truncacila) nehalemensis minima* Hickman, n. subsp.

4. Holotype. Right valve, length 10.5 mm, altitude 8.5 mm, convexity 3 mm. Loc. 25. UO 27169.

5. Paratype. Left valve, length 8 mm, altitude 7 mm, convexity 2.5 mm. Loc. 25. UO 27170.

Figure 6. 7, 10. *Acila (Truncacila) shumardi* (Dall)

6. Length 18 mm, altitude 16 mm, convexity undetermined. Loc. 35. UO 27177.

7. Length 15 mm, altitude 11 mm, convexity 8 mm. Pittsburg Bluff Fm. UO 27178.

8. Length 14.5 mm, altitude 13mm, convexity 8 mm. Tunnel Point Fm. UO 27179.

Figure 8, 11. *Nuculana washingtonensis* (Weaver)

Length 16 mm, altitude 8 mm, convexity 3.5 mm, ratio of length to altitude 2.0. Loc. 12, UO 27180.

Figure 9, 12, 13. *Portlandia (Portlandella) chehalisensis* (Arnold) (p. 53)

9, 12. Length 23.5 mm, altitude 14 mm, convexity 11 mm. Keasey Fm. UO 27182.

13. Length 26 mm, altitude 16 mm. Loc. 37. UO 27181.

Figure 14, 15. *Yoldia (Kalayoldia) oregona* (Shumard)

14. Length (incomplete) 49 mm, altitude 24 mm. Loc 49. UO 27183.

15. Length 51 mm, altitude 26 mm, ratio of length to altitude 2.0. Loc. 42. UO 27184.

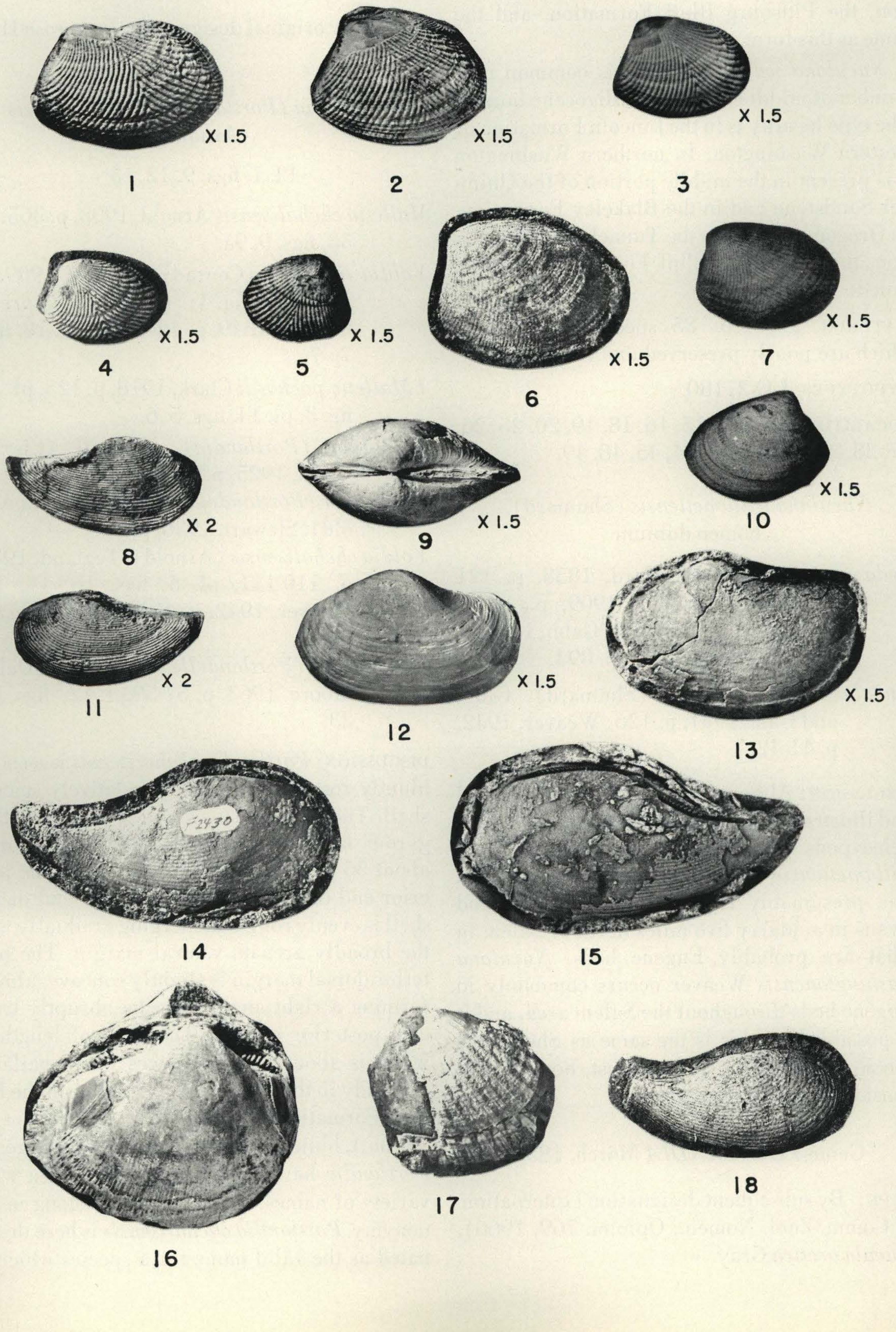
Figure 16, 17. *Anadara (Anadara)* n. sp.?

16. Length (incomplete 45 mm, altitude (incomplete) 33.5 mm, convexity 24 mm. UO 27187.

17. Loc. 27, UO 27188.

Figure 18. *Yoldia (Kalayoldia) tenuissima* (Clark)

Length 34 mm, altitude 16 mm. Loc. 24. UO 27185.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possible that the missing type of *Leda willam-*tion, the Pittsburg Bluff Formation, and the same as this form.

Nuculana washingtonensis is common in a number of middle and upper Oligocene faunas. The type locality is in the Lincoln Formation of western Washington. In northern Washington it is present in the middle portion of the Quimper Sandstone and in the Blakeley Formation. In Oregon it occurs in the Tunnel Point Formation, the Pittsburgh Bluff Formation, and the Toledo Formation.

MATERIAL STUDIED: 85 specimens, most of which are poorly preserved and incomplete.

HYPOTYPES UO 27180.

LOCALITIES: 7, 8, 12, 15, 16, 18, 19, 20, 25, 26, 27, 28, 29, 30, 36, 42, 44, 45, 48, 49.

Nuculana willamettensis (Shumard), nomen dubium

Leda willamettensis Shumard, 1858, p. 121 (Reprinted in Dall, 1909, p. 187); Dall, 1909, p. 104, 187; Gabb, 1869, p. 122; Trumbull, 1958, p. 894.

Nuculana willamettensis (Shumard). Grant and Gale, 1931, p. 126; Weaver, 1942, p. 41-42.

DISCUSSION: Although Trumbull (1958) found and illustrated a number of Shumard's Tertiary pelecypods from Oregon, the type of "*Leda willamettensis*" is still missing. The specimen was presumably collected by Shumard and Evans in a quarry five miles north of Salem in what are probably Eugene beds. *Nuculana washingtonensis* Weaver occurs commonly in Eugene beds throughout the Salem area, and it is possible that this is the same as Shumard's species. Shumard's species must, however, be considered a *nomen dubium.*

Genus *PORTLANDIA* Mörch, 1857

TYPE: By subsequent designation (International Comm. Zool. Nomen., Opinion 769, 1966), *Nucula arctica* Gray.

Subgenus *PORTLANDELLA* Stewart, 1930

TYPE: By original designation, *Leda rosa* Hanna.

Portlandia (Portlandella) chehalisensis (Arnold)

Pl. 1, figs. 9, 12, 13

Malletia chehalisensis Arnold, 1908, p. 365, pl. 33, figs. 9, 9a.

Yoldia impressa (Conrad). Reagan, 1909, p. 177, pl. 1, fig. 4; (not *Nucula impressa* Conrad, 1849, p. 726, atlas pl. 18, figs. 7a-7c.

? *Malletia packardi* Clark, 1918, p. 125, pl. 12, fig. 3, pl. 14, figs. 5, 6.

? *Yoldia (Portlandia) packardi* (Clark). Clark, 1925, p. 77, pl. 9, fig. 7.

Portlandia (Portlandella) chehalisensis (Arnold). Stewart, 1930, p. 62.

Yoldia chehalisensis (Arnold). Tegland, 1933, p. 110-111, pl. 5, figs. 16, 17, 18; Weaver, 1942, p. 45-46, pl. 8, figs. 35-38.

Portlandia (Portlandella) reagani (Dall). Moore, 1963, p. 57-58, pl. 12, figs. 22, 23.

DISCUSSION: *Portlandia chehalisensis* is a short, bluntly rostrate form with a relatively smooth shell. The inconspicuous and slightly opisthogyrous beaks are located slightly anterior—about 55 percent of the distance from the poserior end of the shell. The anterior end of the shell is evenly rounded, merging gradually with the broadly arcuate ventral margin. The posterior dorsal margin is slightly concave, almost forming a right angle with the abruptly truncate posterior margin. The ratio of length to width is about 1.7. No hinges were available for study in the material collected from the Eugene Formation.

Short, bluntly rostrate members of the genus *Portlandia* have been described under a wide variety of names, many of which belong in synonymy. *Portlandia chehalisensis* is here designated as the valid name for a species which is widely distributed in Oligocene and Miocene formations on the Pacific Coast. Specimens from lower and middle Oligocene formations have usually been classified under *P. chehalisensis,* forms from the upper Oligocene under *P. chehalisensis, P. packardi* (Clark), or *P. reagani* (Dall), and specimens from the Miocene under *P. reagani.* In the course of preparing this report, specimens were collected in the lower Oligocene Keasey Formation in Oregon (pl. 1, figs. 9, 12) which are indistinguishable from the populations in the Miocene Astoria Formation.

P. chehalisensis is not common throughout the Eugene Formation, but it may be abundant locally in fine-grained, buff-colored, highly tuffaceous siltstone units which crop out primarily in the upper portions of the formation. In the Salem area this species was collected at locality 48 in a fine-grained gray tuffaceous siltstone. Specimens are usually preserved as internal and external molds showing a range of sizes from 10 to 26 mm in length.

MATERIAL STUDIED: 18 specimens.

HYPOTYPES: UO 27181, 27182.

LOCALITIES: 8, 36, 48.

Genus *YOLDIA* Möller, 1842

TYPE: By subsequent designation (International Comm. Zool. Nomen., Opinion 769, 1966), *Yoldia hyperborea* Torell.

Yoldia is typically a northern, cold-water genus occurring in deep water off the coast in the southern part of its range. Most of the Recent species have thin delicate shells, which may explain why representatives of this genus are not more common in Tertiary rocks.

Subgenus *KALAYOLDIA* Grant and Gale, 1931

TYPE: By original designation, *Yoldia cooperi* Gabb.

Yoldia (Kalayoldia) oregona (Shumard)

Pl. 1, figs. 14, 15

Leda oregona Shumard, 1858, p. 121-122 (Reprinted in Dall, 1909, p. 187).

Yoldia (Cnesterium) oregona (Shumard). Dall, 1909, p. 105, 187, pl. 19, fig. 4.

Yoldia oregona (Shumard). Arnold and Hannibal, 1913, p. 576; Washburne, 1914, p. 25; Grant and Gale, 1931, p. 130.

Yoldia (Portlandia) oregona (Shumard). Weaver, 1942, p. 49, pl. 9, fig. 16, not pl. 9, fig. 8.

Yoldia (Kalayoldia) oregona (Shumard). Trumbull, 1958, p. 900, pl. 115, figs. 2, 3 (Synonymy); Moore, 1963, p. 58, pl. 12, fig. 20.

not *Yoldia (Cnesterium) oregona* (Shumard). Etherington, 1931, p. 67, pl. 1, fig. 8.

DISCUSSION: *Yoldia oregona* is a relatively large species characterized by a broadly rounded anterior end and a markedly recurved and attenuate posterior end. The beaks are located centrally or slightly posterior to the center of the shell, and the surface of the shell is covered with moderately-incised concentric lines which are closely spaced at first becoming more widely spaced near the ventral margin. The posterior dorsal margin is markedly concave, and the hingeline bears about 20 V-shaped teeth. The convex anterior hingeline bears about 25 V-shaped teeth. The ratio of length to altitude for the shell is 2.0.

Shumard did not figure the holotype of *Y. oregona,* and the type specimens were considered lost until Trumbull (1958, p. 900) discovered one of the paratypes at Washington University in St. Louis. For a complete discussion of the history of this species the reader is referred to her discussion. The name has been used by various authors over the past 60 years for various Oligocene and Miocene specimens, but the species is probably restricted to the Oligocene. It is common in the buff-colored tuffaceous siltstones of the upper portion of the Eugene Formation in the Salem area where it is one of the characteristic faunal elements. The beds at Finzer Station (locality 42) contain large numbers of *Y. oregona.* It is rare in the lower portions of the formation in the Eugene area, but several specimens are present in the collections.

Y. oregona is easily distinguished from other Tertiary nuculid taxodonts. Its closest relative is probably the Recent species *Y. cooperi* Gabb of the southern California coast. The beaks of *Y. cooperi* are much more posterior in their placement, and hence the rostrum is shorter. Consequently the anterior dorsal margin has a much more prominent convex curve. *Y. tenuissima* Clark has a rostrum intermediate in length between that of *Y. oregona* and *Y. cooperi*, although it is probably more closely related to *Y. cooperi*.

There is some confusion as to the number of anterior and posterior hinge teeth in *Y. oregona*. Dall (1909, p. 105) states that this species has 32 anterior and 17 posterior hinge teeth, while Trumbull (1958, p. 900) illustrates a specimen with 25 anterior and 20 posterior to the beaks. Specimens collected in the course of this study all correspond very closely with Trumbull's figures. Etherington (1931, p. 67) identified specimens from the Miocene Astoria Formation of Washington as *Y. oregona* on the basis of their agreement with the number of teeth reported by Dall, but the available evidence indicates that all such specimens should be assigned instead to *Y. tenuissima* Clark. There seems to be a direct correlation between the length of the margin and the number of hinge teeth such that in *Y. oregona* the numbers are more nearly equal on either side of the beaks than in species in which the lengths of the margins are more disproportionate.

MATERIAL STUDIED: 13 specimens.

HYPOTYPES: UO 27183, 27184.

LOCALITIES: 3?, 23, 24, 28, 30, 41, 42, 49.

Yoldia (Kalayoldia) tenuissima (Clark)

Pl. 1, fig. 18

Yoldia cooperi Gabb, 1865, p. 31, pl. 9, fig. 54; not *Y. cooperi* Gabb, 1865, p. 89.

Yoldia cooperi var. *tenuissima* Clark, 1918, p. 125, pl. 11, fig. 10, pl. 12, figs. 8, 14.

Yoldia tenuissima Clark, 1925, p. 78, pl. 8, figs. 5, 9; Grant and Gale, 1931, p. 129.

Yoldia (Portlandia) oregona (Shumard). Etherington, 1931, p. 67, pl. 1, fig. 8; Weaver, 1942, pl. 9, fig. 8, not pl. 9, fig. 16.

DISCUSSION: Two specimens of *Yoldia (Kalayoldia) tenuissima* were collected at Smith's quarry in Eugene. They are relatively large and agree very closely with the specimens described by Clark (1918, p. 125) from the San Ramon Formation of California.

Y. tenuissima was originally described as a variety of the Recent *Y. cooperi* Gabb, but Clark later decided (1925, p. 78, 79) on the basis of better material from the type locality, that it was a distinct species, characterized by more anterior placement of the beaks and greater number of hinge teeth along the relatively longer posterior dorsal margin of the shell. In *Y. cooperi* the beaks lie one-third of the distance from the posterior end of the shell. In *Y. oregona* (Shumard), on the other hand, the beaks are almost central in their placement, so that *Y. tennuissima* represents an intermediate form with respect to this character.

Specimens from the Pliocene and Pleistocene of California fall within the range of variation in the Recent *Y. cooperi* (Grant and Gale, 1931, p. 129). *Y. tenuissima* seems to occur in the Oligocene and Miocene of the Pacific Coast. In addition to its occurence in the San Ramon and Eugene Formations, it may be present in the Pittsburg Bluff Formation according to Warren, Norbisrath, and Grivetti (1945). It also occurs in the Astoria Formation in Washington where it was misidentified by Etherington(1931, p. 67) as *Yoldia oregona* (Shumard).

Y. supramontereyensis Arnold from the Miocene of Santa Cruz may also belong in this Oligo-Miocene complex since shell proportions and placement of the beaks are quite similar. Stewart (1930, p. 62-64) considered *Y. supramontereyensis* to be a subspecies of *Y. cooperi* and placed *Y. tenuissima* in synonymy with this form. Arnold's species is not well enough known, however, to justify the use of this name for the group.

MATERIAL STUDIED: 2 specimens.
HYPOTYPES: UO 27185, 27186.
LOCALITY: 24.

Superfamily ARCACEA

Family Arcidae

Genus *ANADARA* Gray, 1847

TYPE: By original desgination, *Arca antiquata* Linné.

Anadara is confined primarily to tropical and subtropical waters at the present time, and its presence in the Eugene Formation in association with typically temperate and cold-water genera could be interpreted as something of an anomaly. The genus *Anadara* did not become morphologically well defined, however, until the Miocene, and the geographic differentiation of mollusks into warm and cold-water genera as we know them today was incomplete enough in the Oligocene that it is not always desirable to apply uniformitarian principles at the generic level in Oligocene faunas.

Subgenus *ANADARA s. s.*

Anadara (Anadara) n. sp. ?

Pl. 1, figs. 16, 17

Anadara (?) sp. C Schenck and Reinhart, 1938, p. 40; Reinhart, 1943, p. 83, pl. 4, fig. 10.

DISCUSSION: There are two poorly-preserved specimens of *Anadara* in the collections: one from locality 27 and another that is labeled "Eugene Formation." One additional specimen, also from locality 27, resides in the Stanford University Paleontology Type Collection and was discussed by Schenck and Reinhart (1938, p. 40) and Reinhart (1943, p. 83) as *Andara* (?) sp. C. They state, "although this specimen is too poorly preserved to allow its unquestioned assignment to the Arcidae, it strongly resembles *Anadara* in general appearance."

The specimens figured in this report are definitely *Anadara* and apparently represent a new species, although the material is not sufficient to justify the proposal of a new name at this time. It is not possible to determine whether or not the valves overlapped along the margin but the thickness of the shell and the flattened biplicate ribs are typical of *Andara* s. s. rather than *Anadara (Scapharca)*. The teeth are arranged in a continuous series becoming larger and slanting inward at the ends.

Eames (1967, p. 303) feels that *Anadara (Scapharca)* occurred earlier than *Anadara* s.s. and rejects all claims that *Anadara* s.s. occurs in the Oligocene. He rejects some reported Oligocene occurrences by demonstrating taxonomically that the forms involved belong in *Scapharca* and dismisses the rest by questioning the stratigraphic data and refusing to accept the reported age as Oligocene. He further recommends that Schenck and Reinhart's report of *Anadara* ? from the Eugene Formation "be forgotten" because of the poor preservation of the specimen. Such forms of argument are unconvincing as well as detrimental to stratigraphic and paleontologic inquiry. The presence of *Anadara* in the Eugene Formation indicates that the early phylogenetic history of the genus is still open to question and that stratigraphic correlations based on assumptions that cannot tolerate the presence of *Anadara* s.s. in the Oligocene are questionable.

Superfamily MYTILACEA

Family Mytilidae

Genus *CRENELLA* Brown, 1827

TYPE: By monotypy ?, *Mytilus decussatus* Montagu.

Crenella ? sp.

DISCUSSION: A single specimen from locality 27 is too poorly preserved for positive generic identification, but the ovate shape and placement of the beaks suggest the genus *Crenella*. The shell material is gone except for a thin narcreous layer which is characteristic of the inner shell layers in this genus. There is no hint of the radial ornamentation which might help to confirm the identification. A number of other small distorted specimens in the collections have the same general outline, but their identity is even more questionable due to distortion and lack of shell material.

Genus *MODIOLUS* Lamarck, 1799

(*VOLSELLA* Scopoli, 1777)

Nomen conservandum, 1955, International Comm. Zool. Nomen.

TYPE: By tautonymy, *Mytilus modiolus* Linné.

Modiolus eugenensis Clark

Pl. 2, figs. 1, 2, 3, 4, 5

Modiolus eugenensis Clark, 1925, p. 86, pl. 9, fig. 4.

Volsella eugenensis (Clark). Weaver, 1942, p. 111, pl. 24, fig. 8.

DISCUSSION: *Modiolus eugenensis* is a large, elongate form ranging from 48 to 95 mm in length and from 23 to 39 mm in altitude. The rounded anterior end extends for a short distance in front of the small inconspicuous beaks. The hinge margin is longer than the posterior dorsal margin, and the two meet to form an angle of about 125°. The posterior ventral margin is straight to broadly convex, and the area of maximum convexity corresponds to the angulation in the posterior dorsal margin. The umbonal ridge, which distinguishes this genus from *Mytilus,* is prominent and convex, extending obliquely from the beaks to the rounded posterior end. The posterior dorsal and ventral slopes are slightly depressed on either side of the umbonal ridge. Surface sculpture is formed by threads radiating from the beak. These threads are prominent dorsal to and along the umbonal ridge and are only faintly developed ventrally. Generally only the pearly inner shell layers are preserved, but fragments of the outer layer indicate that the surface was a golden brown.

Clark's holotype (UC 30319) is a poorly-preserved broken specimen in matrix with smaller than average dimensions when compared with subsequent collections. Only a faint hint of ornamentation is preserved on the holotype.

M. eugenensis is a distinctive form, apparently endemic to the Eugene Formation within the Eugene area. It is closely related to *M. sookensis* (Clark and Arnold) from the upper Oligocene of Vancouver Island. *M. sookensis* may be distinguished by a less prominent umbonal ridge, lack of prominent radial ornamentation, and by the equal length of the posterior and dorsal slopes on either side of the angulation.

M. eugenensis occurs in local concentrations of tightly-closed, double-valved specimens in fine tuffaceous siltstones in the Eugene area. It also occurs as occasional single valves in layers of concentrated shell fragments.

MATERIAL STUDIED: 63 specimens.

HYPOTYPES: UO 27190, 27191, 27192, 27193.

LOCALITIES: 7, 9, 12, 13, 15, 16, 23, 24, 25, 28, 40.

Genus *MYTILUS* Linné, 1758

TYPE: By subsequent designation (Gray, 1847), *Mytilus edulis* Linné.

Mytilus snohomishensis Weaver

Pl. 2, fig. 6

Mytilus snohomishensis Weaver, 1912, p. 59, p. 13, fig. 110; Grant and Gale, 1931, p. 245; Weaver, 1942, p. 102-103, pl. 23, fig. 8, pl. 26, fig. 3.

Mytilus sammamishensis Weaver, 1912, p. 58, pl. 13, fig. 111; Weaver, p. 102, pl. 25, fig. 12, pl. 26, fig. 6.

DISCUSSION: Six specimens of *Mytilus snohomishensis* were collected at Finzer Station (locality 42) southwest of Salem, although none has been found in exposures within the Eugene area. This species is readily distinguished from *Modiolus eugenensis* by its small size and lack of umbonal ridge and radial sculpture.

Grant and Gale (1931, p. 245) suggest that *M. snohomishensis* represents the earliest occurrence of the well-known *M. edulis* on the Pacific Coast. *M. edulis* is typically a North Atlantic species, however, and the mytiliform shell is so variable within a given species that it is impossible to determine phylogenetic relationships on the basis of shell form alone. In fact, Soot-Ryen (1955) has demonstrated that the genus *Mytilus* is itself a form genus and that internal shell characters are the key to reconstructing patterns of differentiation within the Mytilidae. Although *M. snohomishensis* is a relatively distinctive species in the middle and upper Oligocene of Washintgon and Oregon, its affinities remain extremely uncertain.

M. snohomishensis has been reported from the middle Oligocene Lincoln Formation and the upper Oligocene Blakeley and Twin Rivers Formations.

HYPOTYPE: UO 27194.

Superfamily CARDIACEA

Family Cardiidae

Subfamily Protocardiinae

Genus *NEMOCARDIUM* Meek, 1876

TYPE: By subsequent designation (Sacco, 1899), *Cardium semiasperum* Deshayes.

Subgenus *NEMOCARDIUM s.s.*

Nemocardium (Nemocardium) formosum

Hickman, n. sp.

Pl. 2. figs. 11, 12

DESCRIPTION: Shell ovate to subquadrate, moderately inflated, posterior dorsal margin of shell only slightly convex, central and anterior margins broadly arcuate; 18 radial ribs on posterior slope, 55 to 56 radial ribs on central and anterior slopes; ribs on central and anterior slope broad and flat with shallowly-incised interspaces, ribs on posterior slope slightly coarser and with wider interspaces; line separating posterior slope from rest of shell meeting hingeline at an angle of 135°; hinge on right valve not exposed, anterior and posterior cardinals present in left valve, anterior cardinal strong, posterior cardinal weakly developed; interior of shell not exposed. Dimensions: Holotype (left valve), length 56 mm, altitude 51 mm, convexity 16 mm. Paratype (right valve) length 49 mm, altitude (incomplete) 42 mm, convexity 12 mm.

DISCUSSION: This *Nemocardium* is closely related to *N. weaveri* (Anderson and Martin) from the lower Oligocene Keasey Formation in Oregon. *N. weaveri* occurs in large numbers in the Keasey and is exceptionally well preserved. It is more inflated than the Eugene species. The line separating the posterior slope from the rest of the shell is more nearly vertical in *N. weaveri*, making an angle of 115° rather than 135° with the hingeline. Both species have 18 radial ribs on the posterior slope of the shell, but on the remainder of the shell *N. weaveri* has 60 or more ribs as opposed to 55 or 56 in *N. formosum*. In adult specimens of *N. weaveri* altitude is the greatest dimension while length is slightly greater than altitude in *N. formosum*. The anterior ventral margin of the shell in the Eugene species is more broadly rounded giving the shell an ovate rather than quadrate appearance. The dentition is also weaker in the Eugene species, and the posterior ribs are much weaker and less markedly different from the anterior ribs.

N. formosum also has characters in common with *N. (Arctopratulum) griphus* Keen from the Miocene Astoria Formation of Washington. Keen (1954, p. 11-14) cites ovate shape, weakness of ribs on the posterior slope, and relative weakness of the hinge teeth among the distinguishing characters of the subgenus *Arctopratulum*. Since *Arctopratulum* first appears in the upper Oligocene, it is not unreasonable to suggest that it arose as an offshoot of *Nemocardium* s. s. through a form similar to *N. formosum*. The number of ribs on the central and anterior slopes of the disc shows a reduction in number from 60 or more in *N. weaveri* to 55 or 56 in *N. formosum* to 52 in *A. griphus*, further supporting the hypothesis.

PLATE 2

Figure 1-5. *Modiolus eugenensis* Clark

1. Length 76 mm, altitude (at posterior angulation) 33 mm, convexity 21 mm. Loc. 28. UO 27191.

2. Length 73 mm, altitude 33 mm, convexity undetermined. Loc. 28. UO 27192.

3, 4, 5. Length 66 mm, altitude 29 mm, convexity 20 mm. Loc. 28. UO 27190.

Figure 6. *Mytilus snohomishensis* Weaver

Length 28 mm, altitude 15 mm. Loc. 42. UO 27194.

Figure 7. *Nemocardium (Keenaea) lorenzanum* (Arnold)

Length 20 mm, altitude 18 mm, convexity (left valve) 6 mm. Loc. 50. UO 27198.

Figure 8-10. *Parvicardium eugenense* (Clark)

8. Length 12 mm, altitude 13 mm. Loc. 19. UO 27199.

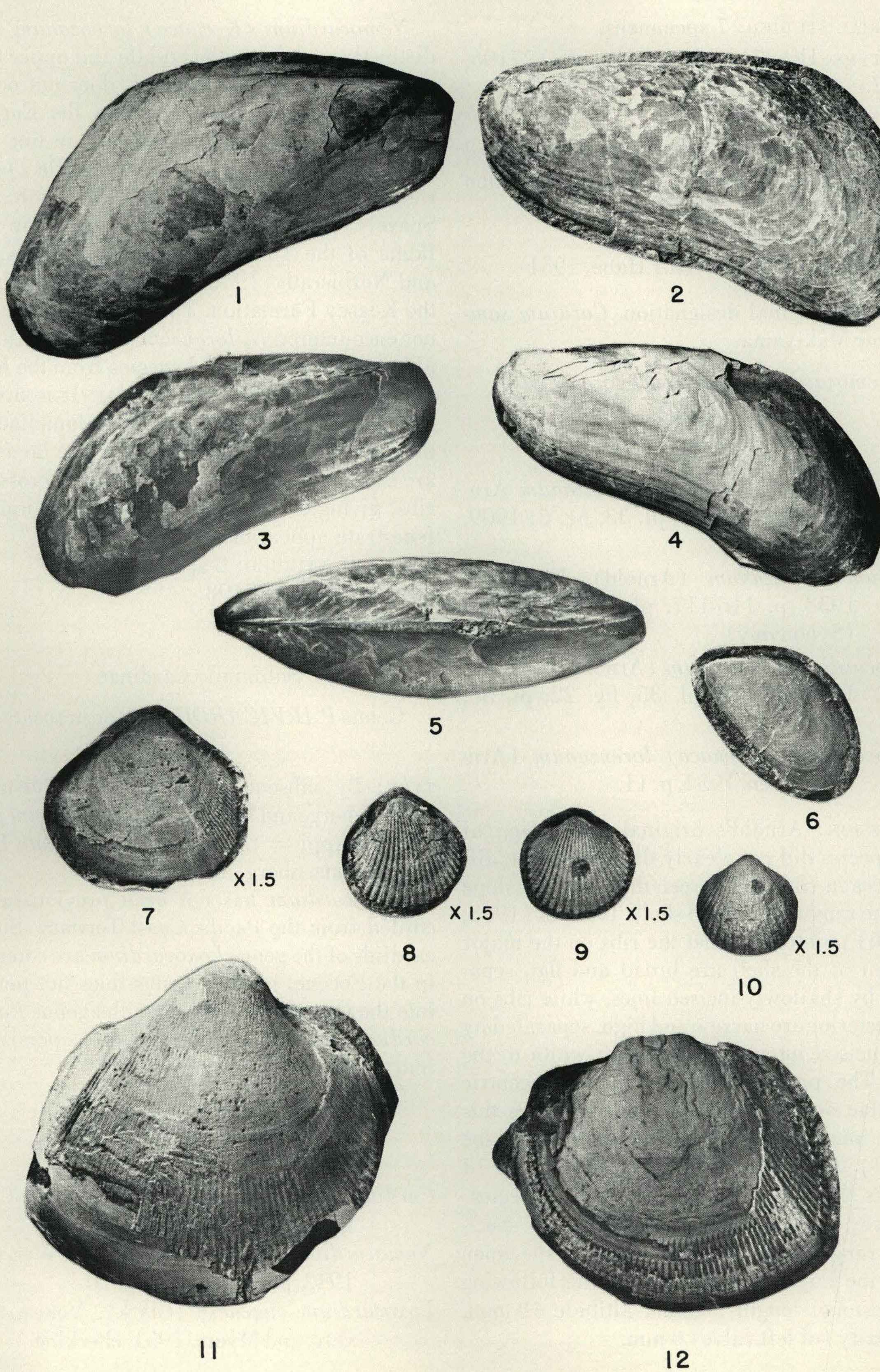
9. Length 9 mm, altitude 9 mm. Loc. 20. UO 27201.

10. Length 10 mm, altitude 10.5 mm, convexity (both valves) 8 mm. Loc. 28. UO 27200.

Figure 11, 12. *Nemocardium (Nemocardium) formosum* Hickman, n. sp.

11. Holotype. Right valve, length 56 mm, altitude 51 mm. Loc. 19. UO 27195.

12. Paratype. Left valve, length 49 mm, altitude (incomplete) 42 mm. Loc. 19. UO 27196.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12

MATERIAL STUDIED: 7 specimens.

HOLOTYPE: UO 27195. PARATYPES: UO 27196, 27197.

TYPE LOCALITY: 19.

OTHER LOCALITIES: A single poorly-preserved specimen was collected higher in the formation at locality 40.

Subgenus *KEENAEA* Habe, 1951

TYPE: By original designation, *Cardium samarangae* Makiyama.

Nemocardium (Keenaea) lorenzanum (Arnold)

Pl. 2, fig. 7

Cardium cooperi Gabb var. *lorenzanum* Arnold, 1908, p. 366, pl. 33, fig. 6; 1909, p. 4, fig. 17.

Cardium lorenzanum (Arnold). Tegland, 1933, p. 116-117, pl. 7, figs. 16, 17 (Synonymy)

Nemocardium lorenzanum (Arnold). Weaver, 1942, p. 160, pl. 35, fig. 22, pl. 36, figs. 3, 5.

Nemocardium (Keenaea) lorenzanum (Arnold). Keen, 1954, p. 11.

DISCUSSION: Arnold's original description of this species did not clearly distinguish the differences in ribbing between the posterior slope and the remainder of the shell. Tegland (1933, p. 116) pointed out that the ribs on the major portion of the shell are broad and flat, separated by shallowly-incised lines, while ribs on the posterior are narrow and high, separated by well-incised interspaces equal in width to the ribs. The presence of prominent concentric lamellae on the posterior ribs segregates this form into the subgenus *Keenaea* of Habe (1951). Arnold's original description cites 14 mm as the maximum length for the species; however, Tegland states that Blakeley specimens range up to 19 mm. The largest specimen from the Eugene Formation has the following dimensions: length 20 mm, altitude 18 mm, convexity (of left valve) 6 mm.

Nemocardium (Keenaea) lorenzanum is a distinctive species in the middle and upper Oligocene of the Pacific Coast. It does not occur in the Eugene Formation within the Eugene area, but it is moderately common in fine tuffaceous siltstones in the McMinnville Quadrangle north of Salem. Vokes, Norbisrath, and Snavely (1949) list *N. lorenzanum* in the fauna of the Toledo Formation, and Warren and Norbisrath (1946, p. 227) record it from the Keasey Formation. The present author has not encountered *N. lorenzanum* in the Keasey, although an undescribed species from the Keasey is superficially quite similar. It is distinguished by prominent concentric lamellae on the posterior portion of the shell. The lamellae are confined to the interspaces and not cross the ribs, giving this portion of the shell a unique fenestrate appearance.

MATERIAL STUDIED: 8 specimens.

HYPOTYPE: UO 27198.

LOCALITY: 50.

Subfamily Cardinae

Genus *PARVICARDIUM* Monsterosato, 1884

TYPE: By subsequent designation (Bucquoy, Dautzenberg, and Dollfus, 1886) *Cardium parvum* Philippi = *C. exigiuum commutata* Bucquoy, Dautzenberg, and Dollfus.

Parvicardium has not been previously recorded from the Pacific Coast Tertiary. Small cardiids of the genus *Loxocardium* are common in the Eocene, but this genus does not persist into the Oligocene. In Europe the genus *Parvicardium* appears in the Oligocene, persisting into the Recent.

Parvicardium eugenense (Clark)

Pl. 2, figs. 8, 9, 10

Cardium eugenense Clark, 1925, p. 91, pl. 22, fig. 6; Schenck, 1923, p. 66.

Nemocardium eugenense (Clark). Weaver, 1942, p. 162, pl. 36, fig. 10.

Loxocardium eugenese (Clark). Vokes, Snavely, and Myers, 1951, checklist.

DISCUSSION: Although Clark's *Cardium eugenense* is based on a single specimen from an unknown locality in the Eugene Formation, the holotype is fairly typical of the species. Measurements of 68 specimens from various localities in the Eugene Formation indicate that altitude and length are equal or that length slightly exceeds altitude. The 26 to 27 radial ribs are broad and flat-topped and wider than the interspaces. Beaks are centrally located and slightly prosogyrous. There is no umbonal ridge or differentiation of the posterior portion of the shell. The hingeplate and dentition are weakly developed, and hingelines were difficult to obtain for the species. In the right valve the posterior cardinal is moderately well developed, but the anterior cardinal is apparently lacking. The cardinal teeth are situated midway between the laterals or slightly nearer to the anterior laterals. Dimensions of average specimen: length 11 mm, altitude 11 mm, convexity (both valves) 8 mm. Dimensions of largest specimen: length 17 mm, altitude 16 mm. Dimensions of smallest specimen: length, 6 mm; altitude 6 mm, convexity (both valves) 2.5 mm.

Parvicardium eugenense is one of the most common and distinctive species in the Eugene Formation, although it is generally not well preserved. It occurs in the coarser tuffaceous units as well as the fine silty units. Valves are usually disarticulated, although whole specimens are not uncommon at some localities. Many specimens show evidence of predation by naticoid gastropods.

P. eugenense is probably endemic to the Eugene Formation. It is present both in the Eugene and Salem areas. The small cardiids of the Pacific Coast Tertiary need further study with particular attention to hinge characters. Most of these forms were originally lumped into *Cardium* or *Nemocardium*, and few of the type specimens have hinges exposed.

MATERIAL STUDIED: 72 specimens.

HYPOTYPES: UO 27199, 27200, 27201, 27202, 27203, 27204, 27205, 27206.

LOCALITIES: 2, 5, 7, 8, 12, 18, 19, 20, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 39, 40, 42, 46.

Superfamily LUCINACEA

Family Lucinidae

Genus *LUCINOMA* Dall, 1901

TYPE: By original designation, *Lucina filosa* Stimpson.

Lucinoma acutilineata (Conrad)

Pl. 3, figs. 1, 4

Lucina acutilineata Conrad, 1849, p. 725, pl. 18, figs. 2, 2a, 2b; Weaver, 1942, p. 143-144, pl. 34, figs. 8, 11, 16.

Pectunculus patulus Conrad, 1849, p. 726, pl. 18, figs. 8, 8a.

Cyclas acutilineata (Conrad). Conrad, 1865, p. 153.

Phacoides acutilineatus Conrad. Dall, 1909, p. 116-117, pl. 12, fig. 6.

Lucina (Myrtea) acutilineata Conrad. Grant and Gale, 1931, p. 286-287, pl. 14, figs. 22a, 22b (Synonymy).

Lucinoma acutilineata (Conrad). Moore, 1963, p. 70-71, pl. 15, figs. 7-10, 12.

DISCUSSION: This well-known and widespread lucinid has a characteristic shape and regularly-occurring, sharp, concentric lamellae separated by interspaces in which fine growth lines are situated.

Lucinoma acutilineata is rare in the Eugene Formation. It occurs primarily as internal molds on which the prominent, elongate, anterior muscle scar is free of the pallial line, distinguishing it as a lucinid from internal molds of *Diplodonta*. A single external mold from Hall's Ferry (locality 41) southwest of Salem exhibits the characteristic sharp concentric lamellae of *L. acutilineata*. Better-preserved specimens were collected by the author in the Pittsburg Bluff Formation (pl. 3, fig. 4), where the species is somewhat more common.

L. acutilineata was apparently widespread during the Oligocene and Miocene, although it is always a minor faunal element. Pliocene and Quaternary forms belonging to this lineage of *Lucinoma* are generally referred to *L. annu-*

PLATE 3

Figure 1, 4. *Lucinoma acutilineata* (Conrad)

1. Length 32 mm, altitude 30 mm, convexity 12 mm. Loc. 41. UO 27207.

4. Length 27 mm, altitude 24.5 mm, convexity (left valve) 5 mm. Pittsburg Bluff Fm. UO 27210.

Figure 2, 3, 5-7. *Diplodonta parilis* (Conrad)

2. Length 22.5 mm, altitude 21 mm, convexity (right valve) 5 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27211.

3. Length 25 mm, altitude 23 mm, convexity 11 mm. Loc. 28. UO 27212.

5. Length 19 mm, altitude 17.5 mm, convexity 6 mm. Loc. 12. UO 27213.

6, 7. Length 18 mm, altitude 17 mm, convexity 8 mm. Loc. 28. UO 27214.

Figure 8-14. *Macrocallista pittsburgensis* (Dall)

8. Left hinge. Pittsburg Bluff Fm. UO loc. 2567. UO 27222.

9. Length 25.5 mm, altitude 16.5 mm, convexity 11 mm. Loc. 35, UO 27224.

10. Length (incomplete) 23.5 mm, altitude 16 mm, convexity 8 mm. Loc. 46. UO 27226.

11. Left valve, length 28 mm, altitude 19 mm, convexity 5 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27222.

12. Right hinge. Pittsburg Bluff Fm. UO loc. 2567. UO 27223.

13, 14. Length 28 mm, altitude 18.5 mm, convexity 12 mm. Loc. 35, UO 27225.

Figure 15. *Macrocallista* n. sp.

Length 52 mm, altitude 31 mm, convexity 25 mm. Loc. 26. UO 27228.

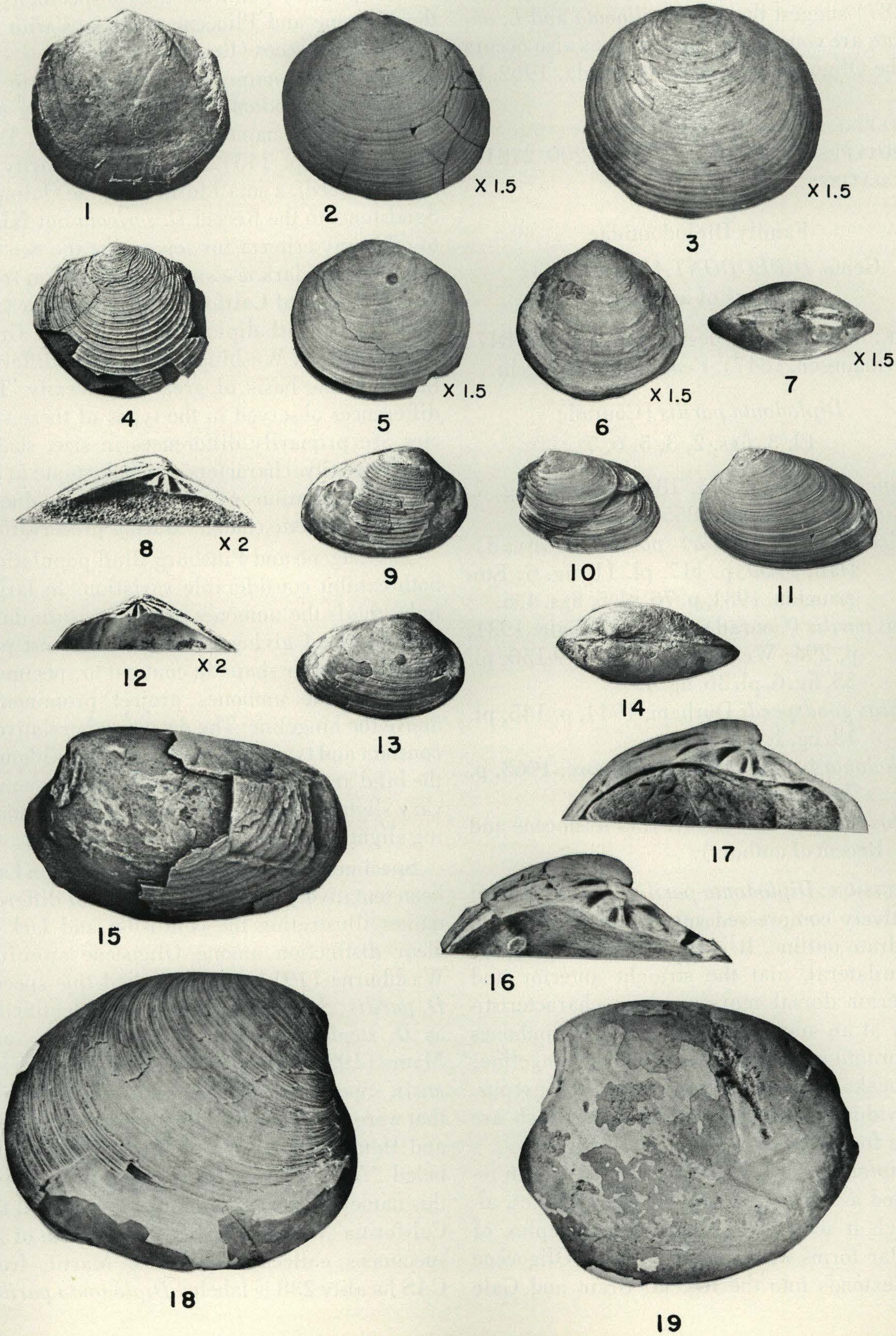
Figure 16-19. *Pitar (Pitar) dalli* (Weaver)

16. Left hinge. Loc. 12. UO 27234.

17. Left hinge. Loc. 28. UO 27235.

18. Length 56 mm, altitude 47 mm, convexity 30 mm. Loc. 28. UO 27232.

19. Length (incomplete) 53 mm, altitude 45 mm, convexity 29 mm. Loc. 28. UO 27233.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lata (Reeve), although Grant and Gale (1931, p. 287) suggest that *L. acutilineata* and *L. annulata* are conspecific. This species also occurs in the Oligocene of Japan (Kamada, 1962, p. 97).

MATERIAL STUDIED: 5 specimens.

HYPOTYPES: UO 27207, 27208, 27209, 27210.

LOCALITIES: 27, 41.

Family Diplodontidae

Genus *DIPLODONTA* Bronn, 1831
(*Taras* of authors)

TYPE: By subsequent designation (Gray, 1847; Herrmannsen, 1847), *Venus lupina* Brocchi.

Diplodonta parilis (Conrad)
Pl. 3, figs. 2, 3, 5, 6, 7

Loripes parilis Conrad, 1848, p. 432, fig. 7.
Mysia parilis Conrad, 1865, v. 1, p. 153.
Diplodonta *(Felaniella) parilis* (Conrad). Dall, 1909, p. 117, pl. 11, fig. 6; Etherington, 1931, p. 76, pl. 5, figs. 4, 6.
Taras parilis (Conrad). Grant and Gale, 1931, p. 294; Weaver, 1942, p. 149-150, pl. 35, fig. 6, pl. 36, fig. 4.
? *Taras goodspeedi* Durham, 1944, p. 145, pl. 13, fig. 1.
Diplodonta parilis (Conrad). Moore, 1963, p. 71, pl. 23, fig. 6, 9.
Diplodonta sericata (Reeve). (Pleistocene and Recent of authors).

DISCUSSION: *Diplodonta parilis* is a thin-shelled relatively compressed species of orbicular to quadrate outline. It is equivalved but slightly inequilateral, and the straight anterior and posterior dorsal margins slope characteristically at an angle of about 35°. The umbones are prominent and project above the hingeline; the beaks are small and slightly prosogyrous. Individuals commonly attain sizes which are large for the genus.

Diplodonta parilis has traditionally been regarded as a Miocene and Pliocene species, although it seems to be part of a complex of similar forms which appears in the Oligocene and extends into the Recent. Grant and Gale (1931, p. 294) point out the conspecificity of the Miocene and Pliocene specimens with the Recent *D. sericata* (Reeve).

A variety of names has been applied to the Oligocene diplodontids, but the validity and value of these names are questionable. Durham (1944, p. 145) noted the similarity of *D. goodspeedi*, a small form from the Quimper Sandstone, to the Recent *D. sericata* but failed to offer any criteria for separating the two. *D. stephensoni* Clark is a similar small form from the Oligocene of California. *D. griesensis* (Effinger), a small diplodontid from the Gries Ranch Beds of Washington, has been differentiated on the basis of greater convexity. The differences observed in the types of these species are primarily differences in size, shape, and convexity, characters which fluctuate in the Recent populations or which may vary due to minor diagenetic changes during preservation.

The Eugene and Pittsburg Bluff populations both exhibit considerable variation. In larger individuals the umbones are often worn down or broken off giving the shell an almost perfectly orbicular shape in contrast to specimens in which the umbones project prominently above the hingeline. The detention is relatively constant and typical of modern forms, although the bifid anterior cardinal in the left valve may vary slightly in position from vertical to slanting slightly posteriorly.

Specimens from the Eugene Formation have been tentatively assigned a number of different names illustrating the confusion and lack of clear distinction among Oligocene species. Washburne (1914, p. 25) called this species *D. parilis*; Schenck (1923, p. 69) identified it as *D. stephensoni*; and Vokes, Snavely, and Myers (1951, checklist) assigned it to *D. griesensis*. Specimens in the Stanford collection that were obtained at Smith's quarry by Arnold and Hannibal between 1909 and 1913 are labeled "*Diplodonta willamettensis* n. sp.," but this name was never formally proposed. At the California Academy of Sciences a suite of 23 specimens collected by Bruce Martin from CAS locality 238 is labeled *Diplodonta parilis*.

D. parilis occurs throughout the Eugene Formation in the coarser buff siltstone as well as the fine gray siltstone units. It usually occurs as double-valved specimens except in lenses of concentrated shell material where the valves are typically disarticulated. In the Pittsburg Bluff Formation valves are almost always found singly.

MATERIAL STUDIED: 139 specimens.

HYPOTYPES: UO 27211, 27212, 27213, 27214, 27215, 27216, 27217, 27218, 27219, 27220, 27221.

LOCALITIES: 3, 7, 11, 12, 13, 23, 24, 25, 26, 28, 30, 35, 37, 41, 42, 46, 47, 49.

Superfamily VENERACEA

Family Veneridae

Subfamily Pitarinae

Genus *MACROCALLISTA* Meek, 1876

TYPE: By monotypy, *Venus gigantea* Gmelin.

Macrocallista pittsburgensis (Dall)

Pl. 3, figs. 8, 9, 10, 11, 12, 13, 14

Meretrix pittsburgensis Dall, 1900, pl. 36, fig. 22, pl. 43, fig. 15.

Macrocallista pittsburgensis (Dall). Dall, 1903, p. 1253; Clark, 1925, p. 92, pl. 18, fig. 9, pl. 19, figs. 4-5; Clark, 1932, p. 816, pl. 19, figs. 1-2; Weaver, 1942, p. 175, pl. 32, fig. 7, pl. 41, figs. 4, 7, 10, 14.

DISCUSSION: *Macrocallista pittsburgensis* is a small species with a characteristically ovate-elongate outline. The beaks are situated about one-fifth of the distance from the rounded anterior end. The posterior end is markedly attenuate and the posterior dorsal margin broadly convex. The external ligament is prominent and extends about one-third of the total length of the shell. The lunule is long and narrowly cordate. Sculpture consists of irregularly-spaced concentric grooves in which the brownish periostracum is often preserved in specimens from the type locality.

The hinge of each valve contains three cardinal teeth. In the right valve the posterior cardinal is long, slender, and bifid. The central and anterior cardinals are both extremely slender and are set vertically. An anterior lateral in the left valve fits into an anterior socket on the right valve, which is defined by sharp ridges above and below.

M. pittsburgensis is relatively longer and more compressed than any of the other West Coast Tertiary species. It is a characteristic species in a number of beds of middle Oligocene age in Oregon and Washington. In the course of preparing this report, specimens were collected at a number of localities in the Pittsburg Bluff and Tunnel Point Formations as well as the Eugene Formation. The species is most abundant in the upper portions of the Eugene, and it is present in both the Salem and Eugene areas. It usually occurs with the valves articulated and tightly closed.

At Holmes Gap (locality 46) *M. pittsburgensis* occurs in a fauna which is intermediate in character between the type Pittsburg Bluff fauna and faunas typical of the upper part of the Eugene Formation within the Eugene area. Measurements of specimens from one population from the Eugene area indicate a greater relative convexity than populations from the type Pittsburgh Bluff, but this character alone is not of sufficient importance to warrant taxonomic differentiation of the Eugene form.

In addition to the formations mentioned above, *M. pittsburgensis* is also present in the Lincoln Formation and Marrowstone Shale in Washington and the Toledo Formation in Oregon. It has been reported from the Oligocene of California (Zimmerman, 1944, p. 964).

MATERIAL STUDIED: 30 specimens.

HYPOTYPES: UO 27222, 27223, 27224, 27225, 27226, 27227.

LOCALITIES: 12, 34, 35, 42, 46.

Macrocallista n. sp.

Pl. 3, fig. 15

DISCUSSION: A number of poorly-preserved specimens of a *Macrocallista* that is apparently

PLATE 4

Figure 1-4. *Pitar (Lamelliconcha) clarki* (Dickerson)

1. Left hinge. Loc. 12. UO 27244.

2. Right hinge. Loc. 12. UO 27245.

3. Length 48.5 mm, altitude 41 mm, convexity 25.5 mm. Loc. 28. UO 27242.

4. Length 47 mm, altitude 43 mm, convexity 26 mm. Loc. 28. UO 27243.

Figure 5-9. *Pitar (Pitar)* n. sp.

5, 7. Length 26.5 mm, altitude 22 mm, convexity 10 mm. Loc. 12. UO 27237.

6. Length 21.5 mm, altitude 18 mm. Loc. 25. UO 27239.

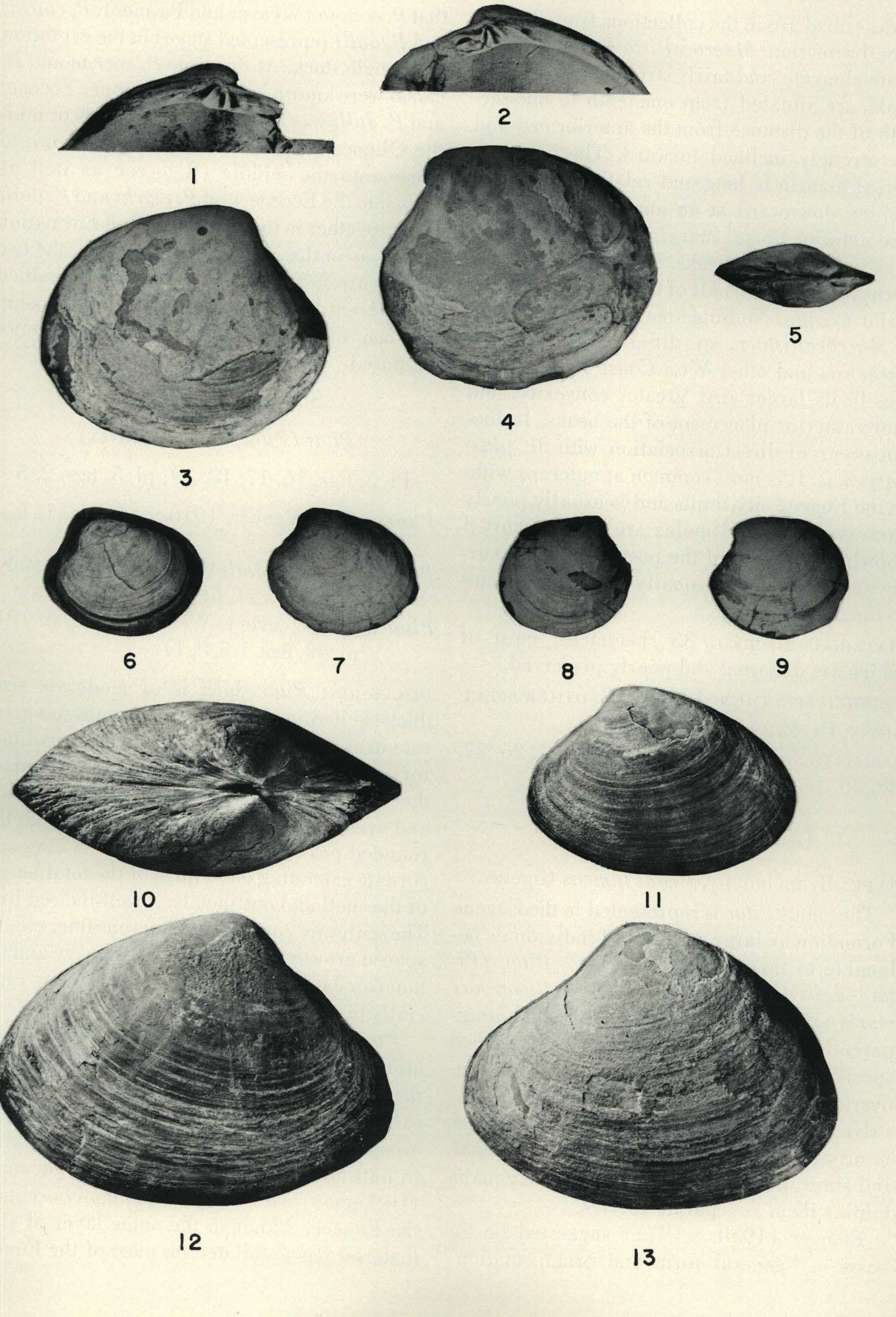
8, 9. Length 22 mm, altitude 20 mm, convexity 9 mm. Loc. 12, UO 27238.

Figure 10-13. *Spisula eugenensis* (Clark)

10, 12. Length 66 mm, altitude 45 mm, convexity 29 mm. Loc. 4. UO 27247.

11. Length 46 mm, altitude 33 mm, convexity 21 mm. Loc. 28. UO 27249.

13. Length 62 mm, altitude 48 mm, convexity 27 mm. Loc. 15. UO 27248.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undescribed are in the collections from the Eugene Formation. *Macrocallista* n. sp. is large, ovate-elongate, and fairly strongly convex. The beaks are situated from one-tenth to one-seventh of the distance from the anterior end and are strongly inclined forward. The posterior dorsal margin is long and relatively straight, sloping downward at an angle of about 20°. The anterior dorsal margin is a short, convex area in front of the beaks. The ligament groove occupies about one-half of the length of the posterior margin. No hinge material is available.

Macrocallista n. sp. differs from *M. pittsburgensis* and other West Coast Tertiary species in its larger size, greater convexity, and more anterior placement of the beaks. It does not occur in direct association with *M. pittsburgensis*. It is most common at outcrops within the Eugene city limits and is usually poorly preserved. Internal molds are often distorted showing flattening of the posterior dorsal surface and creasing diagonally from the umbones to the posterior end.

MATERIAL STUDIED: 35 specimens, most of which are distorted and poorly preserved.

FIGURED SPECIMEN: UO 27228. OTHER SPECIMENS: UO 27229, 27230, 27231.

LOCALITIES: 11, 12, 13, 14, 15, 20, 21, 26, 27, 28, 35, 37, 40.

Genus *PITAR* Römer, 1857

TYPE: By montoypy, *Venus tumens* Gmelin.

The genus *Pitar* is represented in the Eugene Formation by large numbers of individuals belonging to three different species: *Pitar (Pitar) dalli* (Weaver), *Pitar (Lamelliconcha) clarki* (Dickerson), and a species which is apparently new. The two previously described species show a great range of variation and overlap in general form and outline of the valves. Were it not for differences in the hinge, in ornamentation, and in the shape of the pallial sinus, it would be difficult to justify maintaining them as separate species.

Effinger (1938, p. 371) suggested on the basis of "general form and ornamentation" that *P. eocena* (Weaver and Palmer), *P. clarki*, and *P. dalli* represented stages in the evolution of a single stock. At this time *P. eocena* and *P. clarki* were known only from the upper Eocene, and *P. dalli* was known only from beds of middle Oligocene age. *P. clarki* is now known to range into the middle Oligocene as well as back into the Eocene, and *P. clarki* and *P. dalli* occur together in the Pittsburg Bluff Formation as well as in the Eugene. Furthermore, the two species are sufficiently different to be classified in different subgenera. Thus the relationship between the two is not as simple as once supposed.

Subgenus *PITAR s. s.*

Pitar (Pitar) dalli (Weaver)

Pl. 3, figs. 16, 17, 18, 19; pl. 5, figs. 2, 5

Pitaria dalli Weaver, 1916, p. 41, pl. 1, figs. 1-4.

Pitaria (Pitaria) dalli Weaver. Tegland, 1929, p. 278, pl. 21, figs. 4-9.

Pitar dalli (Weaver). Weaver, 1942, p. 181, pl. 43, figs. 1-5, 8, 11.

DISCUSSION: *Pitar dalli* is of moderate size, thick-shelled, and typically elongate-subquadrate in outline. The beaks are strongly inclined forward and located near the anterior end of the shell. The posterior dorsal margin is long and evenly convex, merging gradually into the rounded posterior end. The lunule is long and cordate extending one-fourth of the total length of the shell and outlined by a well-incised line. The sculpture consists of numerous fine, evenly-spaced growth lines. The hinge is heavy and the anterior lateral tooth in the left valve is especially thick and strongly developed.

Pitar dalli shows a much wider range of variation in the Eugene Formation than in specimens observed by the author from the type locality in the Lincoln Formation. It overlaps almost completely with the range of variation in outline found in specimens of *Pitar clarki* (Dickerson) with which it commonly occurs in the Eugene. Although the outer layer of shell material has exfoliated on most of the Eugene specimens of *P. clarki*, topotypes from the Cowlitz Formation indicate that it belongs in the subgenus *Lamelliconcha* while *P. dalli* with its relatively smooth shell is a true *Pitar*. The shell of *P. dalli* is also considerably thicker. The lunule in *P. dalli* is more prominent and the beaks are higher and more prominent. The hinge of *P. dalli* is heavier and the anterior lateral is large and stout while in *P. clarki* it is thin and blade-like. The pallial sinus in *P. dalli* is short and pointed, not reaching the middle of the shell. In *P. clarki* the pallial sinus extends to the center of the valve cavity and is rounded.

P. dalli is one of the most abundant forms in the Eugene Formation and is present in coarse as well as fine units both in the Eugene and Salem areas. At some horizons it occurs with *P. clarki*, and at others it is the only *Pitar* represented. It is commonly the dominant element in an assemblage and usually occurs with both valves articulated and tightly closed. There is no stratigraphic significance to the above-noted variations in outline and convexity.

In addition to its occurrence in the Lincoln and Eugene Formations, *P. dalli* has been recorded from the Tumey Sandstone in California (Zimmerman, 1944, p. 963), the Toledo Formation in Oregon (Vokes, Norbisrath, and Snavely, 1949, checklist), the Pittsburg Bluff Formation (Warren, Norbisrath, and Grivetti, 1945, checklist), the Tunnel Point Formation (Weaver, 1945, p. 51), and the Marrowstone Shale in Washington (Durham, 1944, p. 147).

MATERIAL STUDIED: 80 specimens.

HYPOTYPE: UO 27232, 27233, 27234, 27235, 27236.

LOCALITIES: 12, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 26, 27, 28, 31, 33, 34, 35, 37, 39, 42, 43, 46, 50.

Pitar (Pitar) n. sp. ?

Pl. 4, figs. 5, 6, 7, 8, 9

DISCUSSION: A number of specimens collected from six localities in the Eugene Formation may represent a new species of *Pitar*. It is a small, laterally compressed, nearly smooth species with beaks placed one-fifth of the distance from the anterior end of the shell. The lunule is faintly impressed, but the area beneath the beaks is deeply depressed on either side of the sharp keel-like ridge formed by the convex anterior dorsal valve margins. The ascending pallial sinus is short and pointed. The hinge plate is relatively heavy and the dentition similar to that of *P. dalli*.

Pitar n. sp. ? is differentiated from *P. dalli* primarily on the basis of size. Specimens of intermediate size between the two species do not exist in the collections. The small size cannot be attributed to sorting, since the small form occurs with large shells of other species. It might represent a dwarfed, genetically distinct variety of *P. dalli* or an ecotypic varient capable of attaining sexual maturity and reproducing iteslf at this size. The compressed form of the valves and the keel-like ridge through the lunule serve to further distinguish the small form from *P. dalli*.

Pitar n. sp. ? occurs primarily in fine-grained siltstones within the Eugene city limits. It is never directly associated with *P. dalli* or *P. clarki* and occurs commonly in local concentrations of specimens ranging from disarticulated valves through partially disarticulated valves to entire specimens.

MATERIAL STUDIED: 47 specimens.

FIGURED SPECIMENS: UO 27237, 27238, 27239. OTHER SPECIMENS: UO 27240, 27241.

LOCALITIES: 12, 25, 26, 27, 28, 29.

Subgenus *LAMELLICONCHA* Dall, 1902

TYPE: By original designation, *Cytherea concinna* Sowerby.

Pitar (Lamelliconcha) clarki (Dickerson)

Pl. 4, figs. 1, 2, 3, 4

Pitaria clarki Dickerson, 1917, p. 169, pl. 28, figs. 4a-c.

Pitaria (Lamelliconcha) clarki Dickerson. Tegland, 1929, p. 279, pl. 22, figs. 1-4.

Pitar (Lamelliconcha) clarki (Dickerson). Ef-

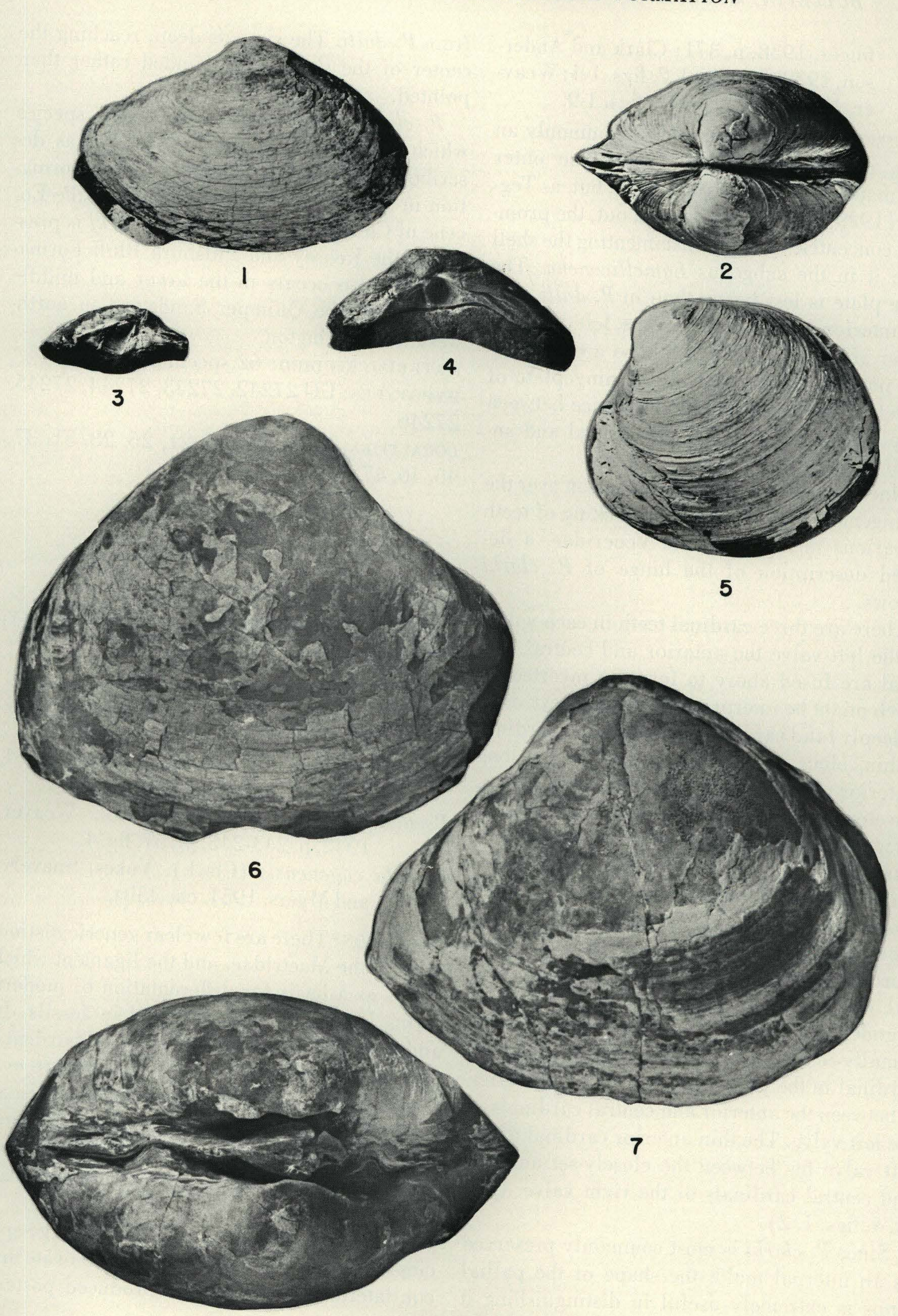
PLATE 5

Figure 1. *Spisula pittsburgensis* Clark
Left valve, length 52 mm, altitude 35 mm, convexity 7 mm. Loc. 42. UO 27252.

Figure 2, 5. *Pitar (Pitar) dalli* (Weaver)
Length 48 mm, altitude 44 mm, convexity 28.5 mm. Loc. 28. UO 27236.

Figure 3, 4. *Spisula eugenensis* (Clark)
3. Left hinge. Loc. 25, UO 27250.
4. Right hinge. Loc. 25. UO 27251.

Figure 6-8. *Pseudocardium* n. sp.
6, 8. Length 84.5 mm, altitude 72 mm, convexity 49 mm. Loc. 28. UO 27253.
7. Length 88.5, altitude 70 mm, convexity 52 mm. Loc. 28. UO 27254.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finger, 1938, p. 371; Clark and Anderson, 1938, p. 947, pl. 2, figs. 1-4; Weaver, 1942, p. 183, pl. 42, figs. 1-9.

DISCUSSION: *Pitar clarki* is most commonly an ovate, moderately inflated form. The outer shell material is usually exfoliated, but, as Tegland (1929, p. 279) has pointed out, the prominent concentric lamellae ornamenting the shell place it in the subgenus *Lamelliconcha.* The hinge plate is less heavy than in *P. dalli,* and the anterior lateral tooth in the left valve is longer and thinner. There is also a characteristic notch or indentation in the hingeplate of the left valve of *P. clarki* in the space between the posterior cardinal and the central and anterior cardinals.

Since there has been some confusion over the arrangement and order of interlocking of teeth in various members of the Veneridae, a detailed description of the hinge of *P. clarki* follows.

There are three cardinal teeth in each valve. In the left valve the anterior and central cardinal are fused above to form an inverted V, which might be interpreted as a single extremely deeply bifid cardinal. The posterior cardinal is thin, elongate, and subparellel to the long posterior ridge which is present in both valves. The elongate anterior lateral tooth is set closely adjacent and perpendicular to the anterior cardinal, and might be considered a modified anterior cardinal tooth. In the right valve the strong, bifid, posterior cardinal is joined above with the thin anterior cardinal to form a broad inverted V over the freestanding central cardinal. The anterior lateral socket is bounded above and below by prominent horizontally-set lamellae. The middle free-standing cardinal in the right valve fits into the inverted V between the anterior and central cardinals of the left valve. The thin anterior cardinal of the left valve fits between the closely-set anterior and central cardinals of the right valve. (See pl. 4, figs. 1, 2)

Since *P. clarki* is most commonly preserved as an internal mold, the shape of the pallial sinus is extremely useful in distinguishing it from *P. dalli.* The sinus is deep, reaching the center of the shell, and rounded rather than pointed.

P. clarki is one of the few Eugene species which persisted from the Eocene. It was described from the late Eocene Cowlitz Formation in Washington and also occurs in the Eocene of California. In Oregon *P. clarki* is present in the Keasey and Pittsburg Bluff Formations. It also occurs in the lower and middle portions of the Quimper Sandstone in northwestern Washington.

MATERIAL STUDIED: 62 specimens.

HYPOTYPES: UO 27242, 27243, 27244, 27245, 27246.

LOCALITIES: 3, 12, 19, 20, 21, 26, 28, 31, 37, 45, 46, 47.

Superfamily MACTRACEA

Family Mactridae

Genus *SPISULA* Gray, 1837

TYPE: By subsequent designation (Gray, 1847) *Mactra solida* (Linné).

Spisula eugenensis (Clark)

Pl. 4, figs. 10, 11, 12, 13; pl. 5, figs. 3, 4

Mulinia eugenensis Clark, 1925, p. 104, pl. 14, figs. 1, 2.

Pseudocardium eugenense (Clark. Weaver, 1942, p. 244-245, pl. 57, fig. 4.

Spisula eugenensis (Clark). Vokes, Snavely, and Myers, 1951, checklist.

DISCUSSION: There are few clear generic distinctions in the Mactridae, and the ligament which serves as a basis for differentation of modern forms is seldom well-preserved in fossils. In addition, the Tertiary literature is burdened with specific names for mactrids that are evidently based on such variable characters as shell outline, general proportions, and position of the beaks. Well-preserved specimens of *Spisula eugenensis* facilitate a more precise treatment of this taxon.

Spisula eugenensis is a relatively large species which varies in outline from sub-ovate and equilateral to elongate and produced posteriorly. The small triangular crack between the valve margins just posterior to the umbones indicates that an external ligament was present in the living animal and removes it from the genus *Mulinia* where Clark originally placed it. The ligament and chondrophore are distinct, but there is no sign of a shelly ridge separating the two as in *Mactra*. There is a prominent posterior ridge extending from the umbones to the posterior extremity, bordered on either side by a shallow depression. The growth lines change direction along the ridge and are more prominent there than anywhere else on the shell. There is a similar but somewhat less prominent ridge between the umbones and the anterior margin of the shell. The pallial sinus is deep and rounded and points horizontally. The cardinal teeth are thin but fairly prominent. The lateral teeth are relatively long and prominent, and the chondrophore is oblique and moderately deep.

The holotype of *S. eugenensis* is a large and poorly-preserved specimen 103 mm long and 82 mm high. The paratype is a smaller double-valved specimen from a different locality in the formation. Clark (1925, p. 104) suggested that the two specimens might represent distinct forms, but subsequent collections do not support his view.

S. eugenensis can be distinguished from other Tertiary species primarily by the presence of the anterior umbonal ridge in addition to the posterior one. More than 200 specimens were collected during the preparation of this report, and the ridge is a constant feature in spite of a broad range of variation in shell proportions. *S. pittsburgensis*, which occurs in the Salem area, lacks the ridge. The shell is also thinner in *S. pittsburgensis* and the beaks are not as prominently prosogyrous.

S. eugenensis is one of the most abundant species in the Eugene Formation, commonly occurring in local concentrations of double-valved specimens with an average length of 65 mm. Larger single-valved specimens comparable to Clark's holotype are common in coarser units in the formation. This species is apparently restricted to the Eugene Formation.

MATERIAL STUDIED: 238 specimens.

HYPOTYPES: UO 27247, 27248, 27249, 27250, 27251.

LOCALITIES: 1, 2, 3, 4, 5, 7, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 31, 32, 33, 34, 35, 37, 38, 40, 49.

Spisula pittsburgensis Clark

Pl. 5, fig. 1

Spisula pittsburgensis Clark, 1925, p. 101-102, pl. 17, figs. 2, 4; Tegland, 1933, p. 120; Weaver, 1942, p. 235, pl. 54, fig. 9.

DISCUSSION: Thirty-two specimens of this form were collected at two localities in the Salem area. The hinge is not accessible on any of these specimens, but external shell characters compare closely with specimens from the type locality in the Pittsburg Bluff Formation.

S. pittsburgensis does not occur in collections from the Eugene area. It can be distinguished from *S. eugenensis* by the lack of a prominent anterior umbonal ridge, less prosogyrous beaks, a straight posterior-dorsal margin, and a thinner, more delicate shell. The shell outline is also more constant in this species, the average adult size is much smaller, and the valves are more compressed.

S. pittsburgensis has been reported from the Tunnel Point and Toledo Formations of the Oregon coast as well as from the Pittsburg Bluff and Eugene Formation. *S. pittsburgensis* subsp. *frustra* was described by Tegland (1933, p. 121) from the Blakeley Formation in Washington. This form was distinguished on the basis of slight differences in proportions, but there are no significant differences in hinge characters. *S. pittsburgensis* also occurs in the middle part of the Quimper Sandstone in northwestern Washington.

MATERIAL STUDIED: 32 specimens.

HYPOTYPE: UO 27252.

LOCALITIES: 42, 44.

Genus *PSEUDOCARDIUM* Gabb, 1866

TYPE: By monotypy, *Pseudocardium gabbi* (Rémond) = *Mulinia densata* Conrad.

PLATE 6

Figure 1, 2. *Tellina eugenia* (Dall)

1. Right valve, length 54 mm, altitude 22 mm, convexity 3 mm, distance from beaks to posterior end 26 mm. Loc. 24. Stanford Univ. NP 94.

2. Right valve, length 57 mm, altitude 22 mm, convexity 2 mm, distance from beaks to posterior end 27 mm. Loc. 24. Stanford Univ. NP 94.

Figure 3-6. *Tellina pittsburgensis* Clark

3-5. Length 16 mm, altitude 10 mm, convexity 3 mm. Loc. 19. UO 27257.

6. Length 17.5 mm, altitude 10.5 mm, convexity 3 mm, distance from beaks to posterior end 6 mm. Loc. 12. UO 27258.

Figure 7-12. *Tellina aduncanasa* Hickman, n. sp.

7. Holotype. Left valve, length 38 mm, altitude 19 mm, convexity 3.5 mm, distance from beaks to posterior end 18 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27262.

8-10. Paratype. Length 32 mm, altitude 17 mm, convexity 7 mm, distance from beaks to posterior end 14 mm. Loc. 28. UO 27263.

11. Paratype. Length 20 mm, altitude 15 mm, convexity 6.5 mm. Loc. 28. UO 27264.

12. Paratype. Length 27.5 mm, altitude 15 mm. Loc. 25. UO 27265.

Figure 13, 18, 19, 21, 22. *Tellina* ? n. sp.

13. Length 27.5 mm, altitude 30 mm, convexity 15 mm. Loc. 19. UO 27276.

18, 21, 22. Length 34.5 mm, altitude 33 mm, convexity 18 mm. Loc. 12. UO 27274.

19. Length 33 mm, altitude 33 mm, convexity 18 mm. Loc. 12. UO 27275.

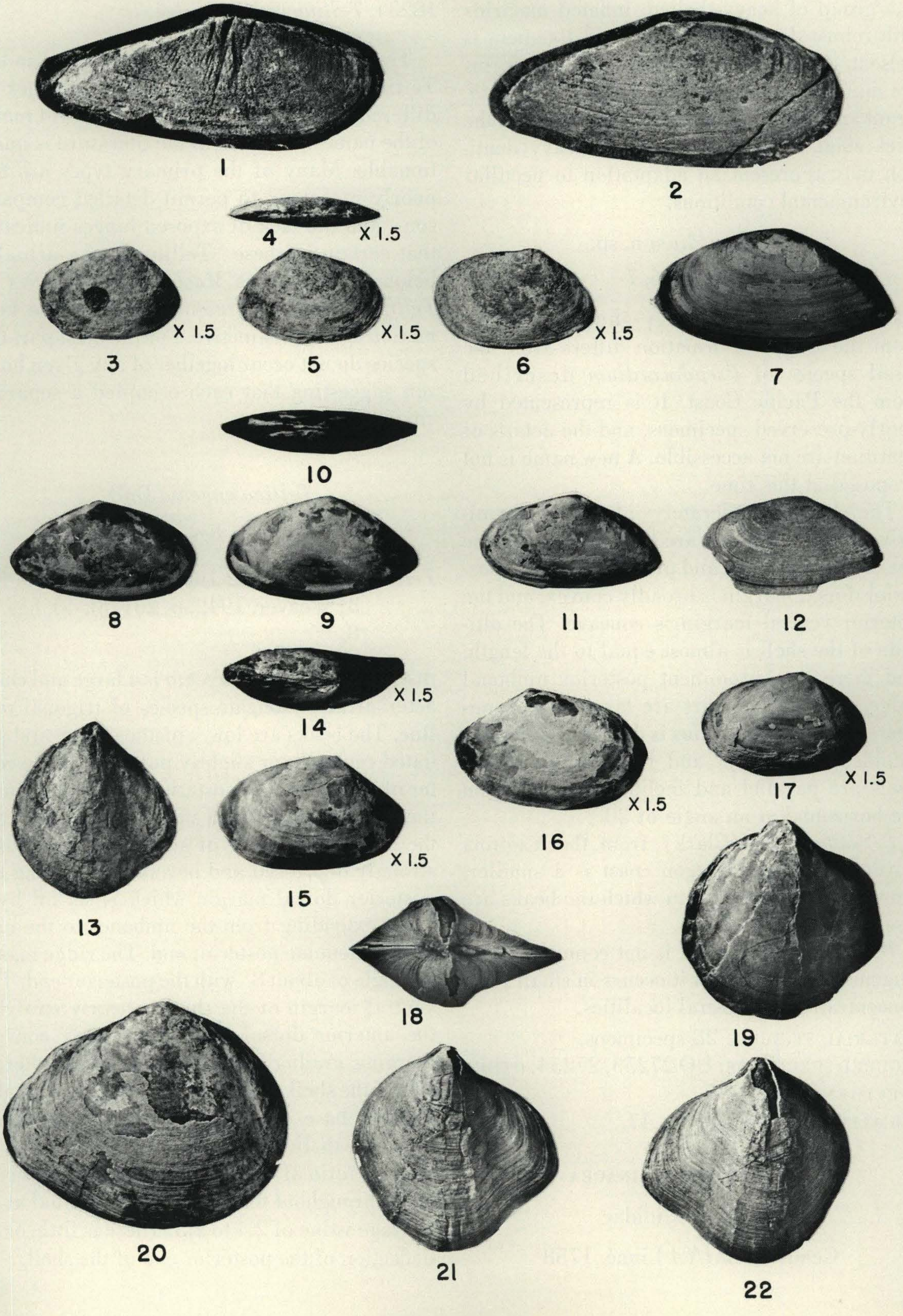
Figure 14-17. *Tellina (Moerella) lincolnensis* (Weaver)

14-16. Length 21 mm, altitude 13 mm, convexity 6.5 mm, distance from beaks to posterior end 7.5 mm. Loc. 28. UO 27277.

17. Length 19 mm, altitude 12 mm, convexity 6.5 mm. Loc. 28. UO 27278.

Figure 20. *Macoma* aff. *M. inquinata* (Deshayes)

Length 44 mm, altitude 36 mm, convexity 14 mm. Loc. 15. UO 27286.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The name *Pseudocardium* has been applied to a group of heavy-shelled, inflated mactrids with robust dentition. An external ligament is present, but it is not clear whether these forms are more closely related to *Spisula* or *Mactra.* Grant and Gale (1931, p. 403) suggest that the thick shell and correspondingly heavy dentition may represent an adaptation to peculiar environmental conditions.

Pseudocardium n. sp.

Pl. 5, figs. 6, 7

DISCUSSION: A large heavy-shelled mactrid from the Eugene Formation differs from the fossil species of *Pseudocardium* described from the Pacific Coast. It is represented by poorly-preserved specimens, and the details of dentition are not accessible. A new name is not proposed at this time.

The shell is moderately inflated and equivalved, and the beaks are almost central. The beaks are prominent and prosogyrous. The posterior dorsal margin is broadly convex, and the anterior ventral margin is concave. The altitude of the shell is almost equal to the length, and there is a prominent posterior umbonal ridge. The muscle scars are large and prominent, and the pallial sinus is deep and narrowly rounded. The upper and lower limbs of the sinus are parallel and inclined upward from the horizontal at an angle of 30°.

P. yaquinense (Clark) from the Yaquina Formation on the Oregon coast is a smaller, more compressed form in which the beaks are less prosogyrous.

Pseudocardium n. sp. is not common in the Eugene Formation, but it occurs in small local concentrations at several localities.

MATERIAL STUDIED: 28 specimens.
FIGURED SPECIMENS: UO 27253, 27254. OTHER SPECIMEN: UO 27255.
LOCALITIES: 2, 24, 28, 31, 47.

Superfamily TELLINACEA

Family Tellinidae

Genus *TELLINA* Linné, 1758

TYPE: By subsequent designation (Children, 1823), *Tellina radiata* Linné.

The genus *Tellina* is well represented in the Tertiary of the Pacific Coast by a number of different lineages. However, the status of many of the names proposed in the literature is questionable. Many of the primary types are too poorly preserved to permit detailed comparisons, and the lack of exposed hinges indicates that certain of these "Tellinas" may actually belong in the genus *Macoma.* The species of *Tellina* which are present in the Eugene Formation are all distinctive. For the most part the species do not occur together at any given horizon suggesting that each occupied a separate environment.

Tellina eugenia Dall

Pl. 6, figs. 1, 2

Tellina eugenia Dall, 1909, p. 124, pl. 19, fig. 3; Weaver, 1942, p. 201, pl. 48, figs. 5, 8.

DISCUSSION: *Tellina eugenia* is a large and characteristically elongate species of trigonal outline. The beaks are low, opisthogyrate, and situated centrally or slightly posterior to the center of the shell. The posterior dorsal margin of the shell is straight and slopes downward from the beaks at an angle of about 20°. There is a strongly depressed and beveled area along the posterior dorsal margin which is set off by a ridge extending from the umbones to the narrowly attenuate posterior end. The ridge makes an angle of about 8° with the posterior end. The ventral margin of the shell is nearly straight; the anterior dorsal margin is gently convex, merging gradually into the rounded anterior end of the shell which in turn merges gradually with the base. Sculpture consists of numerous fine growth lines with a growth pattern such that the ratio of length to altitude remains constant throughout the life of an individual at an average value of 2.4 to 2.5. There is little or no deflection of the posterior end of the shell.

T. eugenia is not common in the Eugene Formation, although it is a striking species in its large size and long attenuate posterior end. Dall's holotype and the majority of specimens collected subsequently came from a single locality, Smith's quarry in Eugene. It appears to have been endemic to the southern portion of the Eugene sea. Other species of *Tellina* are absent in the layers bearing *T. eugenia.* The valves are almost always disarticulated but unfragmented, although surrounding material on the same bedding plane may consist exclusively of unidentifiable angular fragments of bivalve shells.

T. eugenia is unique among Oligocene species, although it might be confused with *T. townsendensis* Clark. The latter species is most easily distinguished by its smaller average size, by the slightly concave outline of the posterior dorsal margin, and by the less markedly rostrate posterior end.

MATERIAL STUDIED: 11 specimens.

TOPOTYPES: The figured topotypes are both unnumbered specimens from Stanford Univ. loc. NP 94. HYPOTYPE: UO 27256.

LOCALITIES: 16, 23, 24, 30, 34, 35.

Tellina pittsburgensis Clark

Pl. 6, figs. 3, 4, 5, 6

Tellina pittsburgensis Clark, 1925, p. 95, pl. 12, figs. 8, 9; Weaver, 1942, p. 200, pl. 48, fig. 14.

DISCUSSION: *Tellina pittsburgensis* is a small, thin-shelled, laterally compressed tellen with an ovate outline. The beaks are inturned but not twisted and are located two-thirds of the length of the shell from the anterior end. The anterior dorsal margin is straight and slopes away from the beaks at an angle of about 15° merging into a broadly rounded anterior end. The posterior dorsal margin is much steeper, sloping downward from the beaks at an angle of about 40° into a moderately rostrate posterior end. The flattened posterior portions of the valves are deflected slightly to the right. The posterior umbonal ridge is faintly developed, and there is a relatively prominent beveled area between the ridge and the posterior dorsal margin.

The holotype of *Tellina pittsburgensis* (Stanford Univ. Pal. Type Coll. no. 46) is imbedded in matrix and the hinge is not exposed, although Clark illustrated the specimen as if it was free of matrix. The hinge is also inaccessible on the paratype (CAS no. 705) which is likewise imbedded in matrix. Hypotypes from the Eugene Formation show well-developed lateral teeth, confirming Clark's generic identification.

T. pittsburgensis is probably more common in the Eugene than in the Pittsburg Bluff Formation. It occurs abundantly in the fine tuffaceous siltstone units, usually with both valves together and tightly closed, although commonly somewhat distorted. This species is readily distinguished from *T. (Moerella) lincolnensis* by its compressed form and from other tellens in the Eugene by its small size.

Zimmerman (1944, p. 963) recorded *T. pittsburgensis* from the Tumey Sandstone of California, but it is otherwise unknown from the California faunas. Durham (1944, p. 148) collected it in the lower portion of the Quimper Sandstone in Washington. According to Warren, Norbisrath, and Grivetti (1945, checklist) it is also present in the Gries Ranch Beds of Oregon.

MATERIAL STUDIED: 36 specimens.

HYPOTYPES: UO 27257, 27258, 27259, 27260, 27261.

LOCALITIES: 11, 12, 18, 19, 20, 25, 26, 27, 28, 29, 36, 44, 46.

Tellina aduncanasa Hickman, n. sp.

Pl. 6, figs. 7, 8, 9, 10, 11, 12

DESCRIPTION: Shell of moderate size, elongate and trigonal in outline; ratio of length to altitude 2.0 ;umbones low, beaks slightly posterior and opisthogyrate; valves slightly inequilateral, left valve larger and more convex, right valve smaller and flattened or depressed across the middle; both valves produced and flattened posteriorly, slightly deflected toward the right; posterior dorsal margin straight to slightly convex, sloping downward from beaks at angle of about 30°, meeting base abruptly to form a markedly attenuate posterior end; anterior dorsal margin convex and merging gradually into the evenly-rounded anterior end; conspicuous beveled area present along posterior dorsal margin, set off by prominent umbonal ridge which slopes downward from beaks at an angle of 35° and makes an angle of 5° with the posterior dorsal margin; valves slightly depressed just anterior to umbonal ridge, the depression increasing in prominence toward the ventral margin of the shell; sculpture consists of fine, closely-spaced, lightly-incised growth lines which change direction abruptly at the posterior umbonal ridge, crossing the angulation to the dorsal margin of the shell at an angle of 90°; sculpture more prominent on posterior dorsal angulation than on remainder of shell; pallial sinus deep and broadly U-shaped but not touching anterior adductor muscle scar; lower end of sinus confluent with pallial line; external ligament prominent, about 6 mm long; bifid posterior cardinal tooth in right valve, bifid anterior cardinal tooth in left valve, anterior portion of tooth thicker than posterior portion; posterior cardinal in left valve thin and not well developed, anterior cardinal in right valve not exposed; laterals present but not well exposed.

DISCUSSION: The holotype of *Tellina aduncanasa* is from the Pittsburg Bluff Formation, and the paratypes come from the Eugene and Pittsburg Bluff Formations. Shell material and details of sculpture are generally better preserved in the Pittsburg Bluff specimens while details of the shell interior are better preserved on the Eugene specimens. This species is common at outcrops in the Eugene area, particularly in the fine-grained tuffaceous siltstone units. It also occurs in Eugene beds in the Salem area. Valves are generally still articulated and tightly closed, although shell material is often chalky or absent.

T. aduncanasa has apparently been lumped by previous workers with *Tellina eugenia* Dall. *T. eugenia* attains a much larger size and is relatively longer. No overlap in size was observed in these two species. They do not occur at the same horizons in the Eugene Formation and probably occupied different habitats.

T. aduncanasa may be distinguished from the Recent *T. bodegensis* Hinds by the less broadly rounded anterior end and more central beaks. *T. aduncanasa* shows a general similarity to *T. bodegensis* Hinds, subsp.? Clark and Arnold from the upper Oligocene Sooke Formation of Vancouver Island. The types are incomplete specimens, however, and there is no additional material available for comparison.

T. townsendensis Clark is relatively longer and has a prominent convex area along the posterior dorsal margin that is absent in *T. aduncanasa*. In *T. woodmanensis* Durham from the lower Oligocene Quimper Sandstone of Washington the anterior dorsal margin is broadly rounded and the beaks less prominent. *T. emacerata* Conrad and *T. kincaidi* Weaver, both Miocene species, are relatively shorter than *T. aduncanasa*.

The name given to this species is compounded from the Latin *aduncus* (crooked or curved) and *nasus* (nose).

MATERIAL STUDIED: 45 specimens.

HOLOTYPE: UO 27262. PARATYPES: UO 27263, 27264, 27265, 27266, 27267, 27268, 27269, 27270, 27271, 27272, 27273.

TYPE LOCALITY: UO 2567.

OTHER LOCALITIES: 3, 25, 26, 27, 28, 42, 44.

Tellina ? n. sp.

Pl. 6, figs. 13, 18, 19, 21, 22

DISCUSSION: One of the most common species in the Eugene Formation is a *Tellina* ? which is previously unrecorded from the Pacific Coast Tertiary. The shell is of moderate size, thin, and trigonal-ovate with distinct anterior and posterior portions. Altitude and length are almost equal. The beaks are prominent, inturned, and slightly opisthogyrate. The valves are equilateral with a slight deflection toward the right of the flattened, produced posterior extremity. The anterior dorsal margin is convex and continuous with the evenly rounded anterior end, and the posterior dorsal margin is straight to gently convex behind a slight concavity posterior to the beaks. A prominent umbonal ridge extends from the beaks to the posterior end of the shell. The ridge is bordered anteriorly by a broad sulcus dividing the shell into two portions which are emphasized by a prominent indentation of the ventral margin where it meets the sulcus. The shell is ornamented by numerous fine concentric growth lines of somewhat unequal prominence. The external ligament is prominent and the pallial sinus is broad and deep, almost confluent with the pallial line. Adductor impressions are large and distinct, and the groove on the internal mold indicates the presence of an internal anterior umbonal rib. The hinge is poorly preserved, which makes it difficult to make a positive generic assignment. There may be lateral teeth in one poorly-preserved right valve, but the presence of this diagnostic feature is questionable. The posterior cardinal tooth in the right valve is longer than the anterior cardinal but is apparently not bifid. The posterior cardinal in the left valve is small, and the anterior cardinal is not exposed.

Tellina ? n. sp. is recognized by its unique trigonal-ovate outline and the division of the shell into an inflated anterior portion separated by a broad umbonal sulcus from the flattened auricle-like posterior portion. Many of the characters suggest the genus *Tellina*, although the hinge is not well enough known to confirm this identification. The overall shape of the species is not characteristic of the genus.

Tellina ? n. sp. is abundant at several localities in the Eugene area, although it is usually distorted and the shell material is seldom preserved intact. Previous workers have overlooked this form, perhaps because of the poor state of preservation of most specimens.

MATERIAL STUDIED: 48 specimens, most of which are distorted internal molds.

FIGURED SPECIMENS: UO 27274, 27275, 27276.

LOCALITIES: 12, 13, 14, 16, 19, 20, 26, 28, 37.

Subgenus *MOERELLA* Fischer, 1887

TYPE: By monotypy, *Tellina donacina* Linné.

Tellina (Moerella) lincolnensis (Weaver)

Pl. 6, figs. 14, 15, 16, 17

Tellina lincolnensis Weaver, 1916, p. 42, pl. 3, fig. 30; Weaver, 1942, p. 199, pl. 48, fig. 2.

Tellina (Moerella) lincolnensis (Weaver). Effinger, 1938, p. 371-372; Durham, 1944, p. 149.

DISCUSSION: *Tellina lincolnensis* is a small, convex species with an ovate outline. The beaks and umbones are relatively prominent and are situated slightly more than one-third of the distance from the posterior end of the shell. The rounded anterior end is larger and more convex than the flattened, attenuate and flexed posterior end. The anterior dorsal slope is straight to slightly convex; the posterior dorsal slope is steeper and slightly concave. Both ends of the broadly arcuate ventral margin. The right valve is less convex than the left. The area of greatest convexity on both valves is located about midway between the beaks and the anterior end of the shell. There is a narrow, inconspicuous beveled area along the posterior margin of the shell set off by a low, narrow ridge that is visible only on specimens on which shell material is well preserved. The pallial sinus is deep and broadly U-shaped, almost touching the anterior muscle scar. Sculpture consists of fine, evenly-spaced, concentric growth lines.

Specimens of *T. lincolnensis* in the Eugene Formation attain a greater average size than those from the Lincoln Formation. *T. lincolnensis* is distinguished from *T. pittsburgensis* by the marked convexity of the valves and from other tellens in the Eugene by its small size.

T. lincolnensis is common throughout the Eugene area. It occurs with both valves tightly closed in the gray tuffaceous siltstone units associated primarily with *Parvicardium eugenense* (Clark) and *Nuculana washingtonensis* (Weaver). It is also abundant in lenses of concentrated shell material where it occurs as single disarticulated valves.

In addition to its occurrence in the Lincoln and Eugene Formations, *T. lincolnensis* is present in the Toledo Formation in Oregon according to Vokes, Norbisrath, and Snavely (1949, checklist).

MATERIAL STUDIED: 47 specimens.

HYPOTYPES: UO 27277, 27278, 27279,27280, 27281, 27282, 27283, 27284.

Genus *MACOMA* Leach, 1819

TYPE: By monotypy, *Macoma tenera* Leach.

Although the genus *Macoma* is abundantly represented in Miocene and younger formations, it is not well known from the Oligocene. Modern representatives of the genus are most abundant in boreal and temperate seas.

Macoma aff. *M. inquinata* (Deshayes)

Pl. 6, fig. 20; pl. 7, figs. 1, 2

DISCUSSION: This compressed *Macoma* may be a new species, although it is comparable to the Recent *Macoma inquinata* (Deshayes) [*Macoma irus* (Hanley) of authors] of the West Coast of North America. The shell is of medium size and rounded trigonal shape. It is compressed laterally, essentially eqivalve, and exhibits little or no deflection of the posterior end. The anterior end of the shell is broadly and evenly rounded, and the posterior end is somewhat rostrate and bluntly truncated. The beaks are situated anterior to the middle of the shell. The posterior umbonal ridge is wide and low, sloping downward from the beaks at an angle of about 30°. Sculpture consists of numerous, fine, irregularly-spaced growth lines of varying prominence. Lateral teeth are wanting. Two prominent and well-developed bifid cardinal teeth occur in the right valve, and the hinge of the left valve is not known.

The Recent *Macoma inquinata* (Deshayes) ranges from the Bering Sea south to the Los Angeles area. It rests vertically in the substrate and lacks the "bent nose" adaptation found in *Macoma nasuta* Conrad, the other common West Coast species which typically lies horizontally with the left valve on the bottom. *M. inquinata* has not been reported from beds older than Pliocene age, although Dall's variety *arnheimi* may extend as far back as the Miocene according to Grant and Gale (1931, p. 368).

M. aff. *M. inquinata* is abundant at localities in the Eugene area, although the genus *Macoma* is absent from all earlier species lists for the Eugene Formation. It is labeled as *Thracia condoni* Dall in many of the early collections from the Eugene and was evidently lumped with this taxon on the basis of a superficially similar outline. Vokes, Snavely, and Myers (1951, checklist) list specimens that may be referrable to *M.* aff. *M. inquinata* as "*Apolymetis* ?".

This species appears to be endemic to the Eugene Formation. It occurs as far north as locality 46 in the McMinnville Quadrangle where the fauna shows marked affinities to that of the Pittsburg Bluff Formation. It does not occur, however, in the Pittsburg Bluff fauna.

MATERIAL STUDIED: 83 specimens.

FIGURED SPECIMENS: UO 27285, 27286. OTHER SPECIMENS: UO 27287, 27288. RECENT SPECIMEN UO 27289.

LOCALITIES: 11, 12, 13, 15, 17, 18, 19, 20, 21, 26, 27, 28, 36, 37, 46.

Subgenus *HETEROMACOMA* Habe, 1952

TYPE: By monotypy, *Tellina irus* Hanley

Macoma (Heteromacoma) vancouverensis (Clark and Arnold)

Pl. 7, figs. 3, 5, 7,

Metis vancouverensis Clark and Arnold, 1923, p. 150, pl. 22, figs. 3, 4.

Apolymetis vancouverensis (Clark and Arnold). Weaver, 1942, p. 221, pl. 50, fig. 17.

Macoma sespeensis Loel and Corey, 1932, p. 228-229, pl. 43, figs. 10-12.

Poromya n. sp. Tegland, 1933, p. 92.

Poromya teglandi Weaver, 1942, p. 121-122, pl. 25, fig. 23.

Apolymetis twinensis Durham, 1944, p. 150, pl. 13, fig. 7.

Macoma (Heteromacoma) vancouverensis (Clark and Arnold). Addicott, 1966, p. 644-645, pl. 76, figs. 1, 4 (Synonymy).

DISCUSSION: Addicott (1966, p. 644-645) discusses this species in some detail. It is typically equivalved, thick-shelled, and unusually inflated for a *Macoma*. The beaks are located well anterior to the middle of the shell and are inturned and slightly opisthogyrate. The posterior umbonal ridge is bordered anteriorly by a broad shallow sulcus which separates the shell into anterior and posterior portions. This division is accentuated by a prominent indentation of the ventral margin of the shell where it meets the posterior sulcus. The ligament is prominent and heavy and lies in a deeply-incised groove. The pallial sinus is broadly U-shaped. Its lower limb coincides in part with the pallial line and does not reach the moderately elongate anterior adductor scar. The presence of a pseudo-lunule anterior to the beaks along with the deeply-incised ligament groove constitute a large portion of the basis for placing this form in *Heteromacoma*.

Specimens from the Eugene Formation show a wide range of variation in the outline of the valves. Addicott (1966, p. 644) noted this same range, from suborbicular to elongate, in the specimens he examined. Shells of this general outline have posed a problem to Pacific Coast paleontologists for many years, and workers have placed them in a wide variety of taxa. Specimens in early collections from the Eugene Formation were identified as *Thracia* or *Thyasyra*. They have also been placed in *Poromya*, *Mya*, and *Apolymetis (Metis)* as well as in *Macoma*. The above synonymy is by no means complete, and it is probable that reexamination of many of the Oligocene and Miocene collections will reveal its presence.

According to Keen (1962, p. 161) *M. (Heteromacoma)* does not occur on the West Coast of North America today, although the common West Coast *Macoma inquinata* (Deshayes) has been referred to by many authors as *Macoma irus* (Hanley), Habe's type species for *Heteromacoma*. *Heteromacoma irus* is apparently restricted to Japanese waters. Present evidence suggests that *Heteromacoma* was rather widely distributed on the West Coast in the Oligocene and Miocene, although the overall distribution of the taxon needs further study.

In the Eugene Formation specimens invariably occur with the valves articulated and tightly closed, although the shell material is often completely exfoliated. Specimens are commonly distorted.

MATERIAL STUDIED: 36 specimens. Many distorted specimens in the collections may also be referable to this species.

HYPOTYPES: UO 27290, 27291, 27292, 27293, 27294, 27295.

LOCALITIES: 2, 12, 13, 14, 15, 16, 17, 19, 20, 28, 33.

Family Sanguinolariidae

Subfamily Sanguinolariinae

Genus *SANGUINOLARIA* Lamarck, 1799

TYPE: By monotypy, *Solen sanguinolentus* Gmelin.

Sanguinolaria townsendensis Clark

Pl. 7, figs. 4, 6

Sanguinolaria (Nuttallia) townsendensis Clark, 1925, p. 97, pl. 18, fig. 7.

Sanguinolaria townsendensis Clark. Weaver, 1942, p. 220, pl. 50, fig. 8.

DISCUSSION: *Sanguinolaria townsendensis* is of medium size, thin-shelled, and ovate in outline. The valves are compressed laterally and unequal. The left valve is more inflated than the almost flat right valve. The beaks are small and pointed, slightly opisthogyrate, and set off by a

PLATE 7

Figure 1, 2. *Macoma* aff. *M. inquinata* (Deshayes)

1. Length 49.5 mm. altitude 37.5 mm, convexity (distorted) 10 mm. Loc. 12. UO 27285.

2. Left valve, length 52 mm, altitude 37 mm, convexity 9 mm. Recent specimen. Vancouver Island, B.C. UO 27289.

Figure 3, 5, 7. *Macoma (Heteromacoma) vancouverensis* (Clark and Arnold)

3, 5. Length 51.5 mm, altitude 38 mm, convexity 22.5 mm. Loc. 28. UO 27290.

7. Length 49 mm, altitude 37 mm, convexity 23 mm. Loc. 28. UO 27291.

Figure 4, 6. *Sanguinolaria townsendensis* Clark

Length (incomplete) 50 mm, altitude 45 mm, convexity 13 mm, ratio of length to altitude 1.4. Loc. 24. Stanford Univ. NP 94.

Figure 8-10. *Semele willamettensis* Hickman, n. sp.

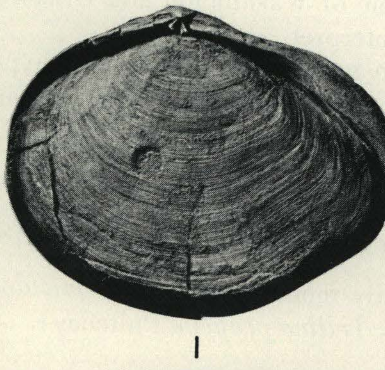
8. Holotype. Length 39 mm, altitude 36 mm, convexity 18 mm. Loc. 20. UO 27296.

9. Paratype. Length (incomplete) 34.5 mm, altitude 33 mm, convexity 16.5 mm. Loc. 20. UO 27297.

10. Paratype. Length (incomplete) 34 mm, altitude 34.5 mm, convexity 15 mm. Loc. 21. UO 27298.

Figure 11, 12. *Solena (Eosolen) eugenensis* (Clark)

Length 68 mm, altitude 17 mm, convexity 14 mm. Loc. 12. UO 27299.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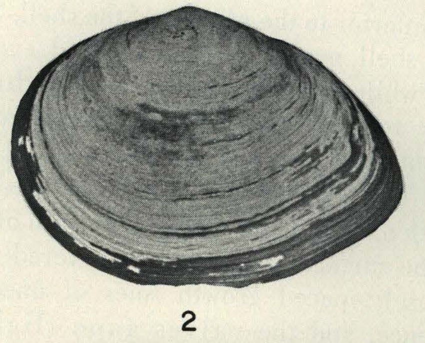
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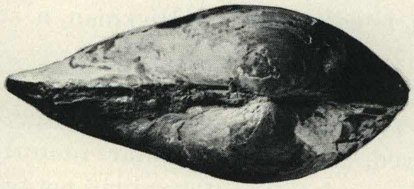
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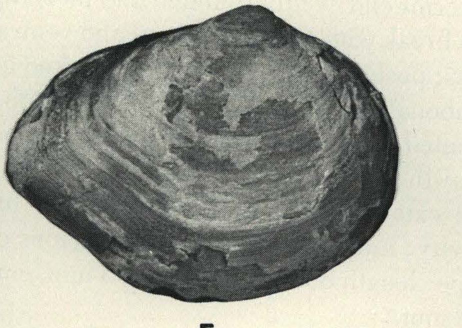
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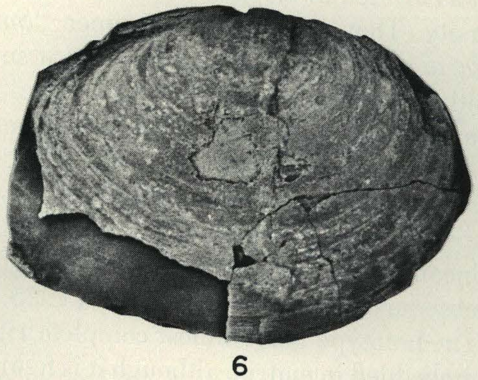
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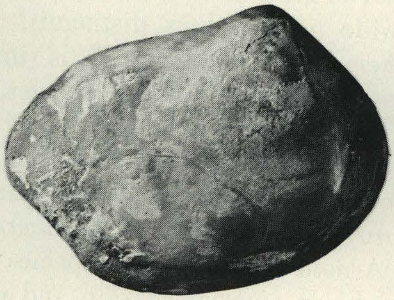
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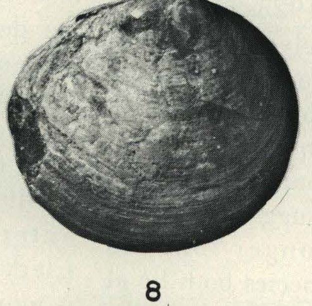
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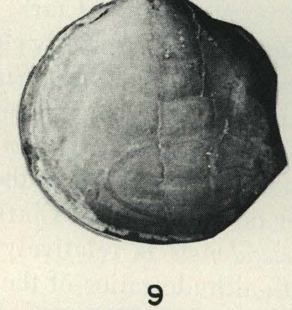
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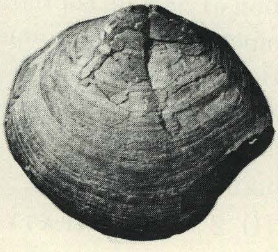
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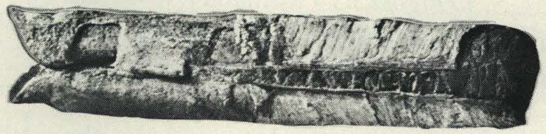
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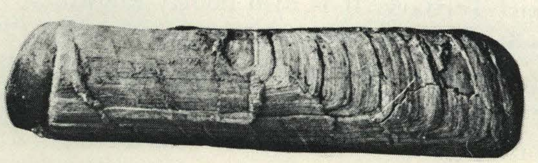
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small posterior notch or convexity. They are located anterior to the middle of the shell. The anterior shell margin is broadly and evenly rounded while the posterior end is more drawn out and angular. The external ligament is prominent and seated on relatively long nymphs. The ligament extends almost one-half the length of the posterior dorsal margin of the shell. The surface of the shell is covered with fine, closely-spaced growth lines of unequal prominence, and the valves gape slightly posteriorly.

A single specimen of *S. townsendensis*, collected by Arnold and Hannibal sometime between 1909 and 1913 at Smith's quarry in Eugene, was located in the collections at Stanford University. They labeled the specimen "*Sanguinolaria* n. sp." but did not describe it subsequently. Washburne (1914, p. 25, 34, 35) collected several specimens from the Eugene Formation which Dall tentatively identified as *Sanguinolaria* n.sp., but these also were never described. This same species was later found in the Lincoln Formation of western Washington and subsequently described by Clark (1925, p. 97). The holotype is an almost complete right valve imbedded in matrix, although it is figured as free of matrix.

As pointed out by Clark, (1925, p. 97), *S. townsendensis* is probably closely related to the Miocene to Recent *S. nuttallii* Conrad. The main differences lie in the greater length of the external ligament in *S. townsendensis* and the greater convexity of both the anterior and posterior dorsal margins. Clark suggested that *S. townsendensis* is relatively longer, but the length-altitude ratios of the species both lie at about 1.5. *S. uchigoensis* (Kamada) from the Oligocene of Japan, a somewhat more quadrate and elongate species, may also be closely related to *S. townsendensis*.

Sanguinolaria is poorly known from the West Coast Tertiary. It is also poorly known from the Tertiary of East Asia. It is presently found along the southern California coast and does not range north of Monterey Bay. Its rare occurrence in the relatively cool seas of the Oligocene of Washington and Oregon is difficult to interpret.

FIGURED HYPOTYPE: The figured hypotype is an unnumbered specimen from Stanford Univ. loc. NP 94.

Family Semelidae

Genus *SEMELE* Schumacher, 1817

TYPE: By monotypy, *Tellina reticulata* Spengler (=*Tellina proficua* Pulteney).

Semele willamettensis Hickman, n. sp.

Pl. 7, figs. 8, 9, 10

DESCRIPTION: Shell moderately large, thin, equivalved, almost subcircular in outline; beaks inconspicuous, inturned but not twisted; anterior end evenly rounded and merging without break with rounded dorsal and ventral margins; posterior portion of shell marked by faint umbonal ridge; surface nearly smooth, ornamented by numerous fine concentric lines of growth; pallial sinus deep and broadly rounded, extending far anterior to center of valve cavity; hinge not exposed. Dimensions of holotype: length 39 mm, altitude 36 mm, convexity 18 mm.

DISCUSSION: The general form of the shell and the deep wide pallial sinus distinguish this form as a *Semele*. *S. willamettensis* is similar in outline to several of the Recent species, but it is entirely distinct from other forms recorded from the Oligocene. *S. reagani* Dickerson is a smaller species with a marked convexity in the anterior dorsal margin. *S. vancouverensis* Clark and Arnold is also a small species with a more produced anterior margin and ovate outline.

The distribution of *Semele* is presently tropical to warm temperate. It is not common in the Eugene Formation. The shell is thin and fragile, however, and shell destruction may account for its infrequent preservation.

MATERIAL STUDIED: 10 specimens.

HOLOTYPE: UO 27296. PARATYPES. UO 27297, 27298.

TYPE LOCALITY: 20.

OTHER LOCALITIES: 6, 7, 15, 21, 28.

Superfamily SOLENACEA

Family Solenidae

Genus *SOLENA* Mörch, 1853

TYPE: By subsequent designation (Stoliczka, 1871), *Solen obliquus* Spengler.

Subgenus *EOSOLEN* Stewart, 1930

TYPE: By original designation, *Solen obliquus* Deshayes = *Solena plagiaulax* (Cossmann).

Solena (Eosolen) eugenensis (Clark)

Pl. 7, figs. 11, 12

Solen eugenensis Clark, 1925, p. 98, pl. 22, fig. 1.

Solena eugenensis (Clark). Weaver, 1942, p. 230, pl. 53, figs. 14, 15.

SUPPLEMENTARY DESCRIPTION: Shell large and long; valves moderately inflated; ratio of length to altitude 4.0; dorsal and ventral margins subparallel, valves increasing slightly in height posteriorly; posterior end squarely truncate; anterior umbonal sulcus or constriction deep and strongly developed, sloping from dorsal margin at an angle of 120°; shell material twice as thick on expanded semicircular area anterior to sulcus as on remainder of shell; surface of valves covered with numerous fine growth lines extending parallel to dorsal and ventral margins, turning abruptly at right angles to meet dorsal margin of shell; anterior muscle scar narrow and elongate, extending one-fourth of the length of the entire shell; posterior muscle scar short, sub-triangular; pallial sinus deep; external ligament heavy, about same length as anterior adductor scar. Dimensions of average specimen: length 68 mm, altitude 17 mm, convexity 14 mm. Dimensions of largest specimen: length 117 mm, altitude 23 mm, convexity 14 mm. Dimensions of smallest specimen: length 46 mm, altitude 23 mm.

DISCUSSION: Clark's original description of *Solen eugenensis* was based on a single incomplete and poorly-preserved specimen. The holotype falls well within the range of variation in specimens in subsequent collections, however. The species is common throughout the Eugene Formation, particularly in fine-grained siltstone beds. It may occur in one of three ways: (1) in the living position with both valves tightly closed, vertical to the bedding with the posterior or siphonal end up; (2) clustered on a bedding plane as a thin layer of disarticulated or partially articulated valves; or (3) as occasional disarticulated to fragmented specimens in lenses of concentrated shell material.

Specimens of *S. eugenensis* are relatively higher and shorter than the type specimens of *S. lorenzana* Wagner and Schilling and *S. lincolnensis* Weaver, but until entire populations can be compared no conclusions can be reached regarding their affinities.

MATERIAL STUDIED: 111 specimens.

HYPOTYPES: UO 27299, 27300, 27301, 27302, 27303, 27304, 27305.

LOCALITIES: 6, 11, 12, 14, 15, 16, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 34, 35, 37, 42, 44, 45, 46, 47, 48, 49, 50.

Genus *SOLEN* Linné, 1758

TYPE: By subsequent designation (Schumacher, 1817), *Solen vagina* Linné.

Solen sicarius Gould

Pl. 8, figs. 5, 7, 9

Solen sicarius Gould, 1850, p. 214; Arnold, 1909b, p. 164, pl. 29, fig. 4; Keep, 1911, p. 104, fig. 81; Oldroyd, 1924, p. 188, pl. 49, fig. 1, pl. 18, fig. 4; Grant and Gale, 1931, p. 385-386, pl. 21, fig. 4 (Synonymy).

Solen perrini Clark, 1915, p. 420, 477-478, pl. 44, fig. 2.

Solena sicarius (Gould). Weaver, 1942, p. 229, pl. 53, fig. 16.

DISCUSSION: From the Oligocene onward, small jackknife clams occur as minor elements in many of the Pacific Coast Tertiary faunas. They have been assigned by various authors to *Solen sicarius* Gould and *Solen rosaceus* Carpenter, both of which are living today. There are a number of additional closely-related Recent species which are distinguished primarily by coloration of the periostacum and geographical distribution. *Solen townsendensis* Clark is a poorly-defined fossil species which also falls into this complex. At present the affinities of the fossil species are impossible to determine, and a careful review of this genus on the Pacific Coast is in order.

The Recent *S. sicarius* is an occasional species in mudflats from Vancouver Island to Lower California, reaching a length of little more than 80 mm. It is higher in proportion to length than *S. rosaceus* and shows a slight convexity in the ventral edge and slight concavity in the dorsal margin. Specimens in the Eugene Formation are small for the species. They exhibit length-altitude ratios of 4.0 with lengths of 38-40 mm and altitudes of 9-10 mm. The species occurs in the fine-grained tuffaceous siltstone units in the Eugene area associated with the more abundant *Solena eugenensis*. It is also common as single disarticulated valves or fragments in layers of densely-packed shell material. *S. sicarius* is readily distinguished from *Solena eugenensis* by its small size and the absence of an umbonal furrow and differentiated anterior end.

MATERIAL STUDIED: 25 specimens.

HYPOTYPES: UO 27306, 27307, 27308, 27309.

LOCALITIES: 9, 12, 16, 19, 21, 25, 26, 28, 29, 30, 35, 42, 49.

Superfamily MYACEA

Family Myidae

Genus *MYA* Linné, 1758

TYPE: By subsequent designation (Children, 1822), *Mya truncata* Linné.

The evolution and Tertiary distribution patterns of the genus *Mya* have been discussed in detail by MacNeil (1965). The origin and early portion of the evolution of the genus took place during the late Eocene in East Asia, and *Mya* did not reach the West Coast of North America until sometime in the Oligocene. It is not well known from the Oligocene, however, since the major differentiation and evolution of myan species did not begin until the Miocene.

Subgenus *?ARENOMYA* Winckworth, 1930

TYPE: By monotypy, *Mya arenaria* Linné.

Mya (?Arenomya) kusiroensis (Nagao and Inoue)

Pl. 8, figs. 1, 2, 3

Mya grewingki var. *kusiroensis* Nagao and Inoue, 1941, p. 150, pl. 32, figs. 2-6.

Mya (?Arenomya) kusiroensis (Nagao and Inouie). MacNeil, 1965, p. 27, pl. 1, figs. 5, 6, 8-10 (Synonymy).

DISCUSSION: *Mya (?Arenomya) kusiroensis* is a moderately elongate species with an evenly-rounded anterior end and an attenuate, weakly-inflated posterior end.

In the collections from the Eugene Formation it was possible to expose the chondrophore on the left valve of a single specimen. The spoon is rounded rather than triangular suggesting closer affinities to *Mya (Arenomya)* than to *Mya* s. s.

This species is the first *Mya* to occur in North America and is recorded by MacNeil (1965, p. 27) from the *Acila shumardi* Zone in Alaska. The presence of this *Mya* in the Eugene Formation extends the known geographic distribution of the genus farther south along the Pacific Coast during the Oligocene, and may represent an earlier occurrence of the genus.

Specimens from the Eugene Formation are generally distorted and decorticated and difficult to recognize due to a superficial similarity in external form to the species of *Macoma* with which it is often associated. It occurs primarily in fine-grained tuffaceous siltstone units in the Eugene area.

MATERIAL STUDIED: 8 specimens.
HYPOTYPES: UO 27310, 27311.
LOCALITIES: 16, 26, 27, 28.

Family Hiatellidae

Genus *PANOPEA* Menard, 1807

TYPE: By subsequent designation (Schmidt, 1818), *Mya glycimeris* Gmelin.

Subgenus *PANOPEA s. s.*

Panopea has undergone very little modification in overall form during its history, and species from the Cretaceous of the Gulf Coast look very much like the Recent forms. This fact, combined with the wide range of aberrations of form within a given species, makes it extremely difficult to define fossil species. *Panopea* s. s. did not appear on the West Coast until the Oligocene, but Oligocene and Miocene species rarely reached the large average sizes (over 100 mm in length) of the Recent *Panopea abrupta* (Conrad). This size difference has also been noted in the Japanese species (Kamada, 1962, p. 136), although little attempt has been made to relate the Japanese and Pacific Coast forms. Kamada (1962, p. 136) and other Japanese authors have considered the specific name *generosa* (= *abrupta*) to be preoccupied by *japonica* for the large living species. It is possible that the small Japanese Tertiary species *P. nomurae* Kamada is the same as the North American *P. ramonensis* Clark.

Panopea (Panopea) abrupta (Conrad)
Pl. 8, fig. 15

Mya abrupta Conrad, 1849, p. 723, pl. 17, fig. 5; not *Pholadomya abrupta* Conrad, 1832, p. 21, pl. 12.
Panopaea generosa Gould, 1850, p. 215.
Panopea estrellana (Conrad). Dall, 1909, p. 133.
Panope generosa (Gould). Clark, 1915, pl. 62, fig. 1; Etherington, 1931, p. 88; Tegland, 1933, p. 121, pl. 9, fig. 13; Weaver, 1942, p. 262, pl. 60, figs. 2, 4.
Panope (Panope) generosa (Gould). Grant and Gale, 1931, p. 424-425, pl. 21, figs. 12a, 12b (Synonymy).
Panope (Panope) abrupta (Conrad). Moore, 1963, p. 83-84, pl. 30, figs. 3, 4, pl. 31, figs. 4, 7 (Synonymy).

DISCUSSION: This well-known Recent species [*Panope generosa* (Gould) of authors] needs no further description. A single large specimen of *P. abrupta*, collected by Arnold and Hannibal at Smith's quarry in Eugene, was located in the collections at Stanford University. The specimen is a left valve imbedded in a gray siltstone. A portion of the posterior end is missing, but enough remains to tell that it was truncate rather than rounded. The beaks are somewhat more anteriorly located than in a typical modern specimen, and the anterior and posterior dorsal margins are less horizontal; but there is so much variation in Recent specimens that it would be difficult to justify a new name for this form. Dimensions of hypotype: length 109 mm, altitude 71 mm.

P. abrupta is well known from Miocene and younger formations, but it is virtually unknown from older rocks. Its occurrence in the Eugene Formation extends the range of the species back into the Oligocene. The large size of the specimen from Smith's quarry is particularly interesting, since the Miocene specimens show maximum lengths of about 65 mm.

P. snohomishensis Clark, a closely-related Oligocene species, is smaller and relatively longer, and the posterior end is rounded rather than truncate. *P. ramonensis* Clark is also smaller and more elongate with more prominent inturned and prosogyrous beaks and a characteristic sinus extending from the umbo to the truncate posterior end.

FIGURED HYPOTYPE: The figured hypotype is an un-numbered specimen from Stanford Univ. loc. NP 94.

Panopea (Panopea) ramonensis Clark

Pl. 8, figs. 8, 12

Panope ramonensis Clark, 1925, p. 106, pl. 10, figs. 2, 3.

PLATE 8

Figure 1-3. *Mya (Arenomya) kusiroensis* (Nagao and Inoue)

1, 2. Length 42 mm, altitude 27 mm, convexity (distorted, 18 mm. Loc. 27. UO 27310.

3. Length 39.5 mm, altitude 24 mm, convexity 13 mm. Loc. 27. UO 27311.

Figure 4, 6. *Martesia* sp.
Length 16.5 mm, altitude 8 mm, convexity 8 mm. Loc. 27. UO 27320.

Figure 5, 7, 9. *Solen sicarius* Gould

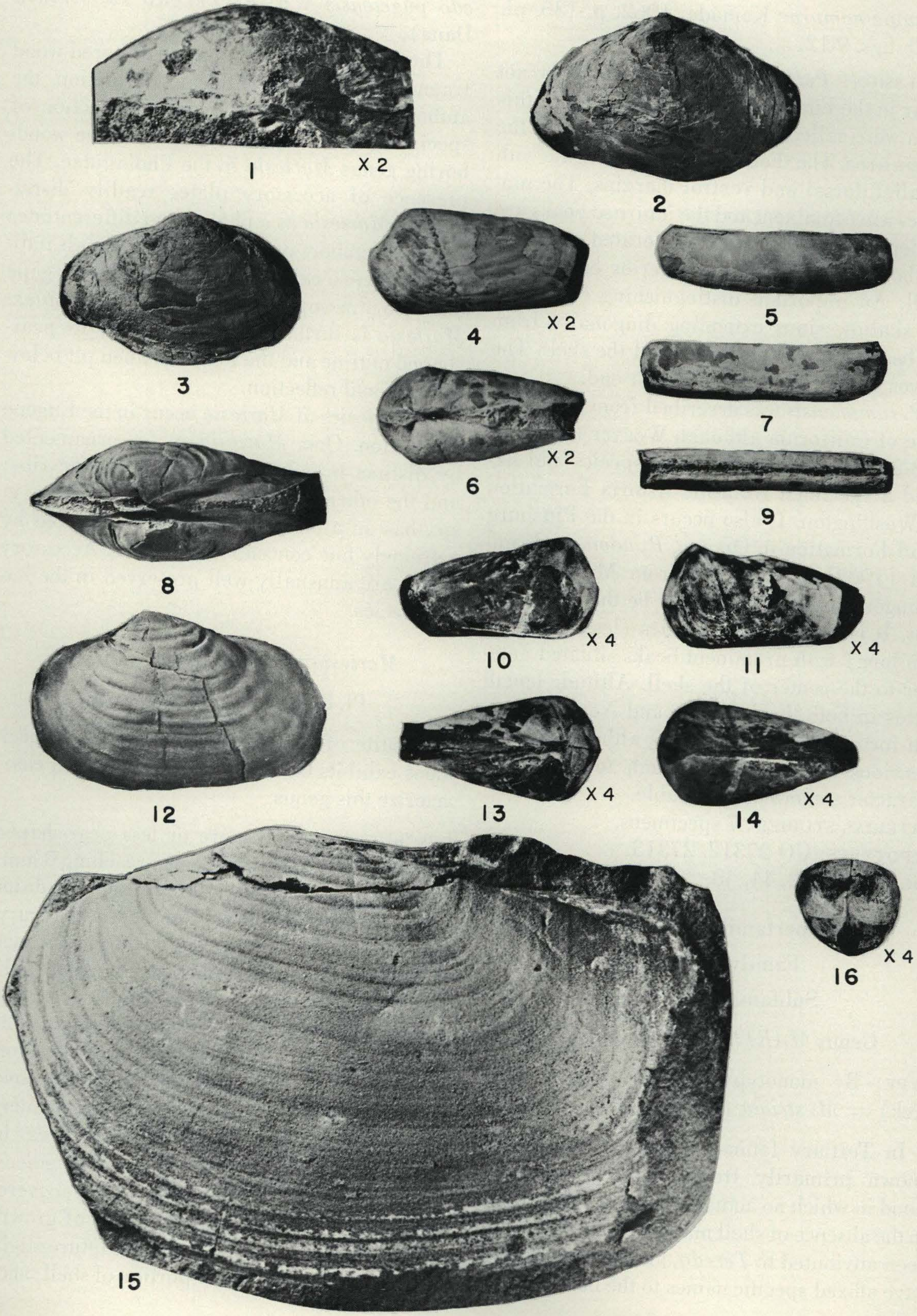
5. Length 38 mm, altitude 10 mm, convexity 6 mm. Loc. 28. UO 27307.

7, 9. Length 40 mm, altitude 9 mm, convexity 6 mm. Loc. 28. UO 27306.

Figure 8, 12. *Panopea (Panopea) ramonensis* Clark
Length 48.5 mm, altitude 29 mm, convexity 18 mm. Loc. 48. UO 27312.

Figure 10, 11, 13, 14, 16. *Martesia turnerae* Hickman, n. sp.
Holotype. Length 8.5 mm, altitude 4.5 mm, convexity 4.5 mm. Loc. 28. UO 27314.

Figure 15. *Panopea (Panopea) abrupta* (Conrad)
Left valve, length 109 mm, altitude 71 mm. Loc. 24. Stanford Univ. NP 94.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13 X 4
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16 X 4

?*Panope nomurae* Kamada, 1962, p. 135, pl. 16, figs. 9-12.

DISCUSSION: *Panopea ramonensis* does not occur in the Eugene area, but specimens of this form were collected from three outcrops in the Salem area. The shell is typically elongate with parallel dorsal and ventral margins. The umbones are prominent and the inturned beaks are moderately prosogyrous and located one-third of the distance from the anterior end of the shell. An important distinguishing feature is the shallow sinus extending diagonally from the beaks to the posterior end of the shell. The valves gape only at the posterior end.

P. ramonensis was described from the Oligocene of California although Weaver (1942, p. 263-264) called it a Miocene species and figured a specimen from the Astoria Formation of Washington. It also occurs in the Pittsburg Bluff Formation in Oregon. *P. nomurae* Kamada (1962, p. 135-136) from Miocene and younger rocks in Japan may be the same species. It is also a small species (less than 100 mm long) with prominent beaks situated anterior to the center of the shell. Altitude-length ratios in both the Japanese and North American forms average about 0.6, although the dimensions are variable enough to make this character somewhat unreliable.

MATERIAL STUDIED: 7 specimens.

HYPOTYPES: UO 27312, 27313.

LOCALITIES: 42, 44, 48.

Superfamily PHOLADACEA

Family Pholadidae

Subfamily Martesiinae

Genus *MARTESIA* Sowerby, 1824

TYPE: By monotypy, *Pholas clavata* (Lamarck) = *M. striata* (Linné).

In Tertiary faunas boring pelecypods are known primarily from fragments of bored wood in which no actual specimens are present. In the absence of shell material these tubes have been attributed to *Teredo*, and several workers have affixed specific names to the borings (*Teredo pugetensis* White; *Teredo substriata* Dana).

Through careful examination of bored wood fragments from the Eugene Formation the author has recovered a sizeable collection of specimens which can be assigned to the wood-boring genus *Martesia* in the Pholadidae. The presence of accessory plates readily distinguishes *Martesia* as a pholad and differentiates it from members of the Teredinae. Adult individuals have a callum closing the anterior gape and also a mesoplax, metaplax, and hypoplax. *Martesia* is further characterized by its pear-shaped outline and the funnel-shaped pit below the umbonal reflection.

Two species of *Martesia* occur in the Eugene Formation. One, *Martesia* sp., is ornamented by distinct broad undulating concentric ribs; and the other, *Martesia turnerae* Hickman, n. sp., has an almost smooth surface marked by extremely fine concentric sculpture. Accessory plates are unusually well preserved in the latter species.

Martesia turnerae Hickman, n. sp.

Pl. 8, figs. 10, 11, 13, 14, 16

A suite of unusually well-preserved specimens exhibits the accessory plates which characterize this genus.

DESCRIPTION: Shell more or less pear-shaped and small, the largest specimen reaching 9 mm; twice as long as high; callum present in adults, unsculptured; umbones prominent and recurved, forming funnel-shaped pits anteriorly; metaplax and hypoplax thin and elongate, undivided, pointed anteriorly and bluntly rounded posteriorly; protoplax lacking; mesoplax unusually small and subrectangular, divided longitudinally into two parts by median groove, notched posteriorly, somewhat pointed anteriorly; valves divided into two distinct areas by moderately incised umbonal-ventral sulcus; surface without raised concentric ribs, covered with extremely fine concentric lines of growth, over 100 counted on holotype; sculpture slightly denticulate on anterior portion of shell; shell interior not exposed. Dimensions of holotype: length 8.5 mm, altitude 4.5 mm, convexity 4.5 mm.

DISCUSSION: This small *Martesia* is characterized by the absence of raised concentric ribs and the extremely fine pattern of concentric sculpture which differentiate it from the three living American species and the questionable fossil species in which accessory plates are not preserved.

Forty-eight specimens of *M. turnerae* were found in a single small piece of fossil wood. The specimens are extremely crowded, and crowding evidently led to stenomorphy. The callum is nearly completed in most of these small specimens. The closure of the callum indicates that boring has ceased. None of the specimens exhibits the teredo-like shell characteristic of the juvenile stage. The small size of the mesoplax and the longitudinal division of this plate in the holotype are probably youhful characters since the callum is not completely closed on this specimen. In *Martesia* the mesoplax is characteristically a single plate, but Turner (1955, p. 106) has pointed out that it is divided by a median groove in young specimens of the Recent *M. striata.*

Fragments of bored wood, commonly enclosed in concretions, are present at many localities in the Eugene Formation; but specimens assignable to *M. turnerae* have been collected at only one locality in the formation.

This species is named in honor of Dr. Ruth Turner in recognition of her definitive work on the Pholadidae.

MATERIAL STUDIED: 48 specimens.
HOLOTYPE: UO 27314. PARATYPES: 27315, 27316, 27317, 27318, 27319.
TYPE LOCALITY: 28.

Martesia sp.

Pl. 8, figs. 4, 6

DISCUSSION: A second species of *Martesia* in the Eugene Formation is distinguished by the presence of 10 to 12 prominent concentric ribs or undulations on both portions of the shell as opposed to the numerous fine striations on the shell of *M. turnerae.* These undulations are denticulate anterior to the umbonal-ventral sulcus. The umbones are strongly reflected with funnel-shaped pits below, and a callum is present in the adult forms. In the absence of accessory plates, however, it is not possible to give this form a specific designation. The largest specimen from the Eugene Formation is 24 mm long, but most are considerably smaller, averaging 15 mm in length. Stenomorphy is commonly seen in small specimens. One specimen 4 mm long shows the teredo-like juvenile form with a large pedal gape.

Thin sections of a number of samples of bored wood all indicate that the plants were dicotyledonous angiosperms. The burrows are generally parallel and apparently never intersect, although they may wind sinuously through the wood. The burrows show various orientations with respect to the grain of the wood. Both the burrows and the fossils are commonly filled with ingrowths of crystalline calcite, micrite, or micrite recrystallized as sparry calcite.
MATERIAL STUDIED: 42 specimens.
FIGURED SPECIMEN: UO 27320. OTHER SPECIMENS: UO 27321, 27322, 27323, 27324, 27325, 27326.
LOCALITIES: 19, 27, 28, 29.

Superfamily PANDORACEA

Family Pandoridae

Genus *PANDORA* Chemnitz, 1795

TYPE: By subsequent designation (Children, 1825), *Tellina inaequivalvis* Linné.

Subgenus *PANDORA* s. s.

Pandora (Pandora) laevis Hickman, n. sp.

Pl. 9, figs. 7, 8, 9

DESCRIPTION: Shell small and thin, inequivalved, compressed; left valve convex, right valve slightly concave; right valve smaller and strongly overlapped on the ventral margin by the left valve; beaks situated one-third of dis-

PLATE 9

Figure 1-6. *Dentalium (?Fissidentalium) laneensis* Hickman, n. sp.

1. Paratype. Length (incomplete) 96 mm, maximum diameter (distorted) 16 mm. Loc. 12. UO 27335.

2. Holotype. Length (incomplete) 84 mm, maximum diameter (distorted) 14 mm. Loc. 12. UO 27332.

3. Paratype. Length (incomplete) 71 mm, maximum diameter (distorted) 13 mm. Loc. 12. UO 27333.

4. Paratype. Length (incomplete) 79.5 mm, maximum diameter (distorted) 13.5 mm. Loc. 12. UO 27334.

5. Paratype. Loc. 28. UO 27338.

6. Paratype. Loc. 28. UO 27339. (Note thickness of shell)

Figure 7-9. Pandora *(Pandora) laevis* Hickman, n. sp.

7. Paratype. Length 14 mm, altitude of right valve 7.5 mm. Loc. 12. UO 27328.

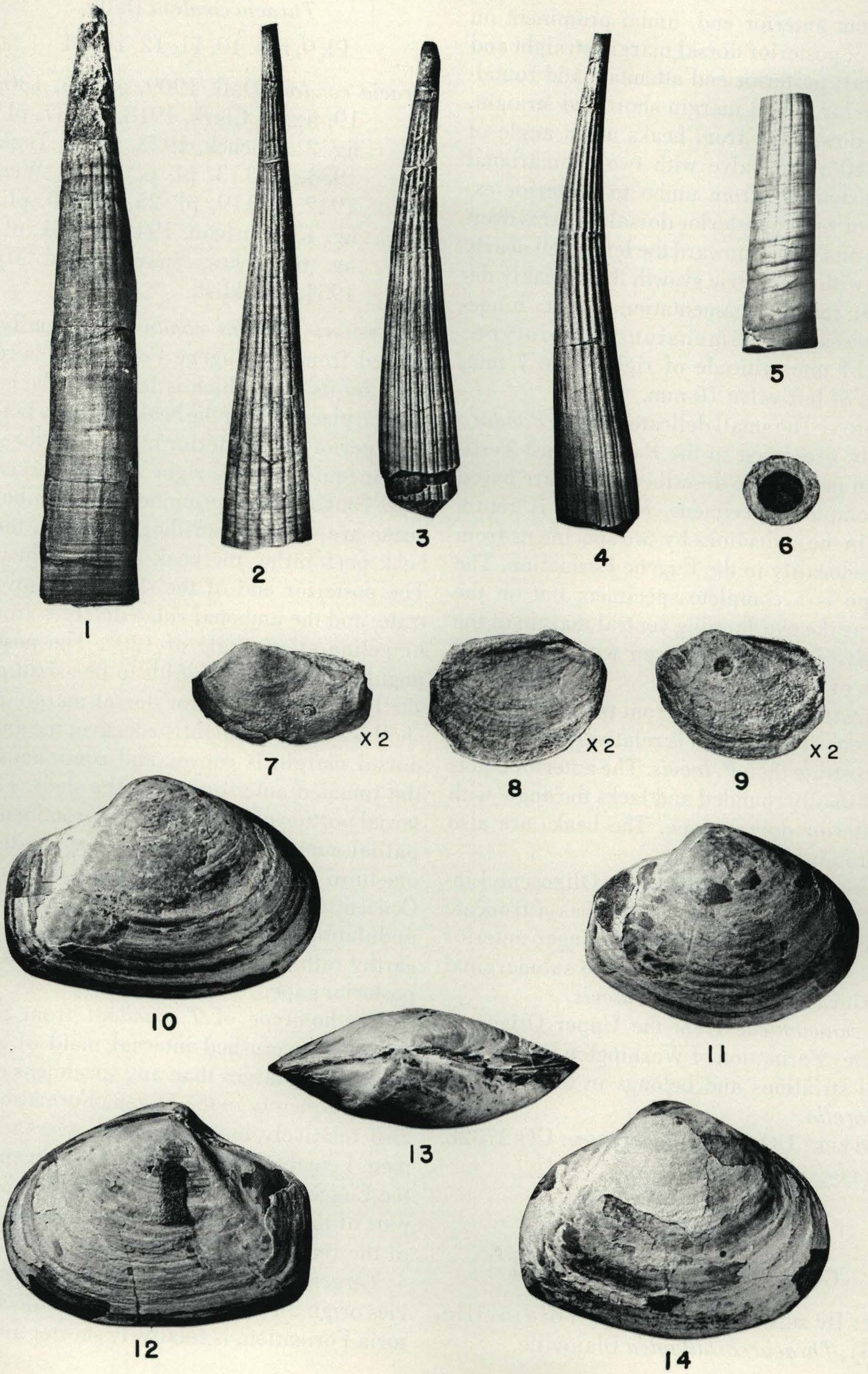
8, 9. Holotype. Length 14 mm, altitude of left valve 10 mm, altitude of right valve 7 mm. Loc. 12. UO 27327.

Figure 10-14. *Thracia condoni* Dall

10, 12, 13. Length 49 mm, altitude 35 mm, convexity 19 mm. Loc. 28. UO 27329.

11. Length 42.5 mm, altitude 32 mm, convexity 17 mm. Loc. 28. UO 27331.

14. Length 49 mm, altitude 37 mm, convexity 19 mm. Loc. 28. UO 27330.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tance from anterior end, umbo prominent on left valve; posterior dorsal margin straight and horizontal; posterior end attenuate and rounded; anterior dorsal margin short and straight, sloping downward from beaks at an angle of 35° to 40°; left valve with two submarignal ridges extending from umbo to posterior extremity of valve; posterior dorsal margins overlapping and curved toward the left; shell nearly smooth with concentric growth lines weakly developed; radial ornamentation absent; hingeline inaccessible. Dimensions of holotype: length 14 mm, altitude of right valve 7 mm, altitude of left valve 10 mm.

DISCUSSION: The small delicate shell of *Pandora* is rarely preserved in the Pacific Coast Tertiary, and most of the described forms are based on incomplete specimens. *P. laevis* is represented in the collections by two specimens from a single locality in the Eugene Formation. The holotype is a complete specimen, but on the paratype the overlapping ventral margin of the left valve is broken off even with the ventral margin of the right valve.

P. acutirostrata Clark from the San Lorenzo Oligocene of California is relatively longer and more rostrate than *P. laevis*. The anterior end is more broadly rounded and lacks the angle with the anterior dorsal slope. The beaks are also less prominent.

P. washingtonensis from the Oligocene Lincoln Formation of Washington has a truncate posterior end and a relatively longer anterior dorsal slope. It also lacks the two submarginal posterior ridges found in *P. laevis*.

P. vanwinkleae from the Upper Oligocene Blakeley Formation of Washington has marked radial striations and belongs in the subgenus *Pandorella*.

HOLOTYPE: UO 27327. PARATYPE: UO 27328. TYPE LOCALITY: 12.

Family Thraciidae

Genus *THRACIA* Leach, 1824

TYPE: By subsequent monotypy (Blainville, 1825), *Thracia corbuloidea* Blainville.

Thracia condoni Dall

Pl. 9, figs. 10, 11, 12, 13, 14

Thracia condoni Dall, 1909, p. 135, 136, pl. 19, fig. 5; Clark, 1918, p. 137, pl. 12, fig. 2; Schenck, 1923, p. 66; Tegland, 1933, p. 113, pl. 6, fig. 5; Weaver, 1942, p. 119, pl. 25, fig. 10, pl. 29, fig. 15; Durham, 1944, p. 141, pl. 13, fig. 6; Vokes, Snavely, and Myers, 1951, checklist.

DISCUSSION: *Thracia condoni*, originally described from the Eugene Formation, is recognized by its size, which is large for the genus, and the placement of the beaks midway between the anterior and posterior margins of the shell. It is inequivalve: the right valve is larger and more convex with a prominent high umbo. The beaks are strongly opisthogyrate with the left beak perforating the beak on the right valve. The posterior end of the shell is bluntly rostrate, and the umbonal ridge diverges from the hingeline at an angle of 120°. The posterior angulation covers one-fifth to one-sixth of the shell area. The posterior dorsal margin of the shell is straight to slightly concave; the anterior dorsal margin is convex and continuous with the rounded anterior end of the shell. The external portion of the ligament is prominent. The pallial sinus is wide but not deep, extending one-third of the distance into the shell cavity. Concentric growth lines are even rather than undulating, and the surface of the shell is earthy rather than granulose. There is a slight posterior gape.

The holotype of *T. condoni* from Smith's quarry is a crushed internal mold of a right valve and is larger than any specimens collected subsequently in the Eugene Formation. It is also relatively longer than the average specimen. Length-altitude ratios of specimens from the Eugene Formation cover a wide range, but part of this variation may be due to distortion of the relatively thin shells.

Thracia trapezoides Conrad, a Recent species originally described from the Miocene Astoria Formation, is relatively shorter and has a narrower and less prominent posterior rostration than *T. condoni.* It also attains a smaller average size than *T. condoni.*

Thracia schencki Tegland from the Blakeley Formation of Washington is also smaller than *T. condoni* and relatively shorter. Two small specimens from the Eugene compare closely with Tegland's types, but they are considered here as extremes in variation in *T. condoni* since they are not well enough preserved to permit detailed comparison.

Thracia dilleri Dall from the Coaledo Formation of Oregon is relatively longer and has a more prominent posterior rostration. It is also a smaller species than *T. condoni.*

Kamada (1962, p. 78) suggests that *T. kidoensis* from the Oligocene Asagai Formation of Japan is closely related to *T. condoni.* He differentiates it from the American species on the basis of a less distinct posterior ridge and lower umbonal region.

T. condoni occurs in the Salem area as well as throughout the Eugene area, and as a species it is apparently restricted to the Oligocene. Within the formation it is restricted to the fine-grained siltstone units where it is almost always found with the valves articulated. It is conspicuously absent in layers of transported shell material, where only the heavier shells are generally represented.

Durham (1944, p. 141) reported *T. condoni* from the Quimper Sandstone of Washington. Vokes, Norbisrath ,and Snavely (1949) reported it from the Toledo Formation in Oregon and questionably identified it from the Yaquina Formation in Oregon. Clark (1918, p. 137) recorded it from the "San Lorenzo Series" of California. Martin (1916, p. 254) referred a specimen from the Etchegoin (Pliocene) to *T. condoni*, but it is unlikely that it is the same species. This species also occurs in the author's collections from the Pittsburg Bluff Formation.

MATERIAL STUDIED: 27 specimens.

HYPOTYPES: UO 27329, 27330, 27331.

LOCALITIES: 12, 15, 19, 20, 23, 24, 25, 27, 28, 30, 33, 35, 41, 46, 48.

Superfamily MYACEA

Family Myadesmidae

Genus *MYADESMA* Clark, 1922

TYPE: By original designation, *Myadesma dalli* Clark.

Myadesma howei Clark

Myadesma howei Clark, 1922, p. 117-118, pl. 13, fig. 1, pl. 14, figs. 1-2; Weaver, 1942, p. 251, pl. 58, fig. 2.

DISCUSSION: In 1922 Bruce Clark proposed a new pelecypod family and genus related to the Myidae and characterized by elongate-quadrate shape and the presence of a large and distinctive anteriorly-directed myaform chondrophore on the left valve with a sunken resilifer on the right. Accompanying his description of the genus are descriptions of three species, one of which is presumably from the Eugene Formation.

There is some confusion, however, regarding the localities of Clark's specimens. The type species is designated in the text of the paper as *M. sookensis* from the Upper Oligocene Sooke Formation of southern Vancouver Island. In his description of the species, however, this same form is designated as *M. dalli. M. howei* is cited in the text of the paper as coming "from the vicinity of Eugene, Oregon, where it is associated with a typical lower Oligocene fauna." Two of the three type specimens bear UC locality no. 3626. The original description of this locality is missing, and the information given on the type card is "Tunnel Point Sandstone ?, Coos County, Oregon." The holotype is cited as having come from UC locality no. 3622, which is described as Smith's quarry in Eugene; but this specimen is apparently missing from the type collection. All three specimens were originally collected by H. V. Howe, for whom the species was named.

Myadesma does not appear in any of the collections made or examined in the course of preparing this report ,and its presence in the Eugene Formation is questionable.

SCAPHOPOD

Family Dentaliidae

Genus *DENTALIUM* Linné, 1758

TYPE: By subsequent designation (Montfort, 1810), *Dentalium elephantium* Linné.

Subgenus *FISSIDENTALIUM* Fischer, 1885

TYPE: By monotypy, *Dentalium ergasticum* Fischer.

Dentalium (? Fissidentalium) laneensis Hickman, n. sp.

Pl. 9, figs. 1, 2, 3, 4, 5, 6

DESCRIPTION: Shell large and heavy, very elongate, conical; early half moderately curved, remainder nearly straight; sculpture of 16-35 longitudinal ribs separated by narrow impressed grooves; multiplication of rib number by intercallation of secondary ribs common; ribs narrow and rounded near apex, becoming broad and flattened in the middle of the shell and obsolete near the aperture in older individuals; concentric growth striae strongest near aperture; aperture oblique and nearly circular (in specimens which have not been distorted by flattening); apex small, circular, without slit; shell thin at aperture; maximum recorded length 105 mm; maximum recorded diameter 15 mm; color of shell yellowish to brownish white (unless this represents discoloration after death). Dimensions of holotype: length (incomplete) 84 mm, maximum diameter (distorted) 14 mm.

DISCUSSION: This species is unusually large and robust and unique among the few species of *Dentalium* which have been described from the Pacific Coast Tertiary. *D. porterensis*, the common Oligocene species in Washington and Oregon, is smaller with more numerous but weakly-developed longitudinal ribs which leave the surface nearly smooth.

D. laneensis is abundant in the fine-grained units in the Eugene Formation within the Eugene area and is one of the most characteristic elements of the fauna. At some localities specimens are fragmentary with only a chalkly film of shell material remaining, while at other localities the shell is completely intact and appears to preserve the original coloration. Specimens of all sizes are particularly abundant in lenses of concentrated shell material where they show striking parallel orientation by currents.

MATERIAL STUDIED: 225 specimens. Fifty-eight of these specimens preserve original shell material intact and 26 are almost complete specimens.

HOLOTYPE: UO 27332. PARATYPES: UO 27333, 27334, 27335, 27336, 27337, 27338, 27339.

LOCALITIES: 4, 9, 12, 14, 16, 17, 18, 19, 20, 21, 25, 26, 27, 28, 29, 30, 32, 37, 45.

GASTROPODS

Family Epitoniidae

Genus *EPITONIUM* Bolten, 1798 (*SCALA* of authors; *SCALARIA* Lamarck, 1801)

TYPE: By subsequent designation (Suter, 1913), *Turbo scalaris* Linné.

Subgenus *BOREOSCALA* Kobelt, 1902 (*ARCTOSCALA* Dall, 1908)

TYPE: By original designation, *Epitonium greenlandicum* (Perry).

Boreoscala is a typically boreal to cool temperate subgenus of unusually large and heavy epitoniids.

Epitonium (Boreoscala) condoni (Dall)

Pl. 10, figs. 7, 8, 9, 10, 12

Epitonium (Arctoscala) condoni Dall, 1909, p. 53, pl. 3, figs. 1, 12.

Epitonium (Boreoscala) condoni (Dall). Weaver, 1916, p. 30; Grant and Gale, 1931, p. 856; Durham, 1937, p. 494, pl. 57, fig. 4; Weaver, 1942, p. 314-315, pl. 65, figs. 12, 13, 16, 17.

DISCUSSION: *Epitonium condoni* is characterized by a large shell with moderately convex whorls bearing 10 to 16 prominent varices. Callus deposits are absent or minimally developed. Spiral ribs are well developed. There are five or six prominent ribs on the lower half of the whorl and three to five narrower and more closely-spaced ribs on the upper half of the whorl. Fine secondary ribs are seldom preserved. The varices bear nodes where crossed by primary spirals. The basal disk is set off by a moderately prominent keel. The aperture is ovate.

As pointed out by Durham (1937, p. 494), *E. condoni* s. s. represents a portion of the range of variation in a highly plastic species represented by two other "varieties" in the Eugene Formation. Durham does not use variety in the normal sense of a genetically and ecologically distinct form, but rather as a category for describing extremes in continuous variation within a population. The "varieties" co-occur at the same localities and exhibit a great deal of overlap with respect to a number of independently varying characters.

E. condoni occurs primarily in the upper portion of the Eugene Formation, and it is not known from beds in the Salem area. Outside of the Eugene Formation the pattern of variation in *E. condoni* becomes more complex. In the lower and middle Oligocene formations of Washington and Oregon certain "varieties" of this species have definite stratigraphic restrictions and different patterns of association with one another. Some of these forms probably represent good subspecies. Thus present evidence suggests that the *E. condoni* complex consists of geographically and stratigraphically distinct subspecies, morphologically distinct but stratigraphically and geographically co-occurring varieties, and populations such as the Eugene population in which there is completely continuous morphological variation, indicating a lack of ecological or genetic differentiation.

Durham's "varieties" will be treated separately here as a matter of convenience.

MATERIAL STUDIED: 23 specimens.
HYPOTYPES: UO 27340, 27341, 27342, 27343.
LOCALITIES: 12, 16, 26, 27, 28, 30, 31, 34, 35, 37.

Epitonium (Boreoscala) condoni (Dall) "var. *eugenense*" *Durham*

Pl. 10, figs. 11, 13

Epitonium (Boreoscala) condoni (Dall) var. *eugenense* Durham, 1937, p. 494-495, pl. 57, fig. 1; Weaver, 1942, p. 315, pl. 65, figs. 14, 20, pl. 66, figs. 1, 2.

DISCUSSION: In this "variety" the number of varices is typically high, ranging from 17 to 21. The whorls are almost straight-sided, and the callus deposit covers two-fifths of the preceding whorl. The callus deposits are more convex than the whorls of the upper part of the shell and stand out as convex rings. The spiral ribbing is extremely fine and does not produce nodes at the varices which are thin and low.

This "variety" occurs in the upper portion of the formation within the Eugene area. It has not been reported from any other Oligocene formations on the Pacific Coast.

MATERIAL STUDIED: 10 specimens.
HYPOTYPES: UO 27344, 27345, 27346, 27347, 27348.
LOCALITIES: 28, 33, 34, 35.

Epitonium (Boreoscala) condoni (Dall) "var. *oregonense*" Dall

Pl. 10, fig. 14

Epitonium (Catenoscala) condoni Dall, 1909, p. 54, pl. 3, fig. 3.

Epitonium oregonense Dall. Schenck, 1928, p. 11, 14, 15.

Epitonium (Boreoscala) condoni Dall var. *oregonense* Dall. Durham, 1937, p. 495, pl. 57, fig. 5; Weaver, 1942, p. 316, pl. 65, figs. 18, 19, pl. 66, fig. 4.

DISCUSSION: As noted above this "variety" represents an extreme of continuous variation with *E. condoni* s. s. The number of varices and the number and distribution of spiral

PLATE 10

Figure 1, 2. *Acrilla (Ferminoscala) becki* Durham

1. Height (incomplete) 23 mm, diameter 8.5 mm. Loc. 23. UO 27350.

2. Height (incomplete) 19 mm, diameter 8 mm. Loc. 28. UO 27351.

Figure 3-6. *Acrilla (Ferminoscala) dickersoni* Durham

3. Height 14.5 mm, maximum diameter 5 mm. Loc. 28. UO 27352.

4, 5. Height (incomplete) 9.5 mm, maximum diameter 4.5 mm. Loc. 27 UO 27353.

6. Height (incomplete) 12 mm, maximum diameter 5 mm. Loc. 12. UO 27354.

Figure 7-10, 12. *Epitonium (Boreoscala) condoni* (Dall)

7. Height 62 mm, diameter 21 mm. Loc. 35. UO 27340.

8. Height (incomplete) 54 mm, maximum diameter 20 mm. Loc. 35. UO 27342.

9, 10. Height (incomplete) 54 mm, maximum diameter 22 mm. Loc. 35. UO 27341.

12. Height (incomplete) 45 mm, maximum diameter 20 mm. Loc. 35. UO 27343.

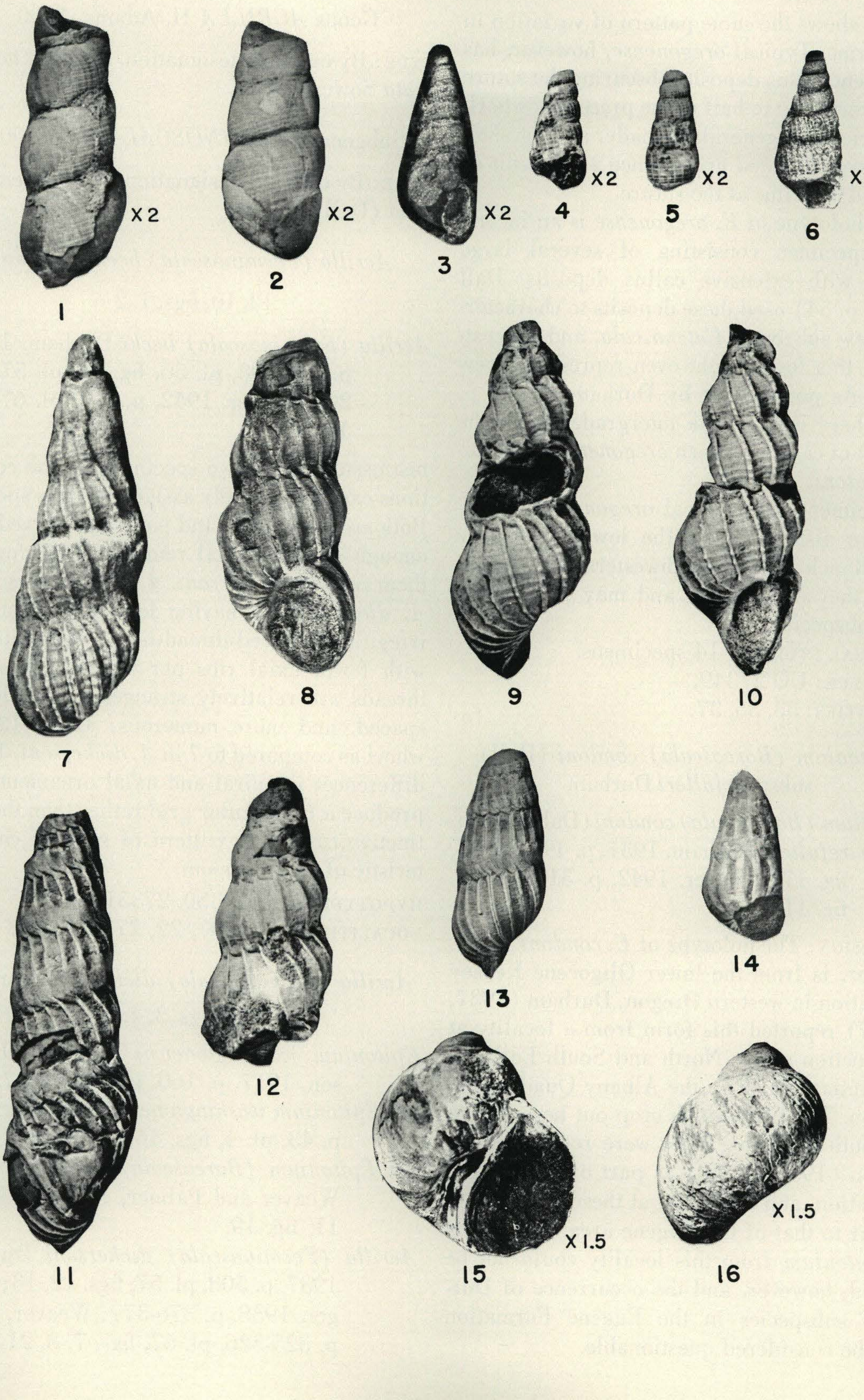
Figure 11, 13. *Epitonium (Boreoscala) condoni* "var. eugenense" (Durham)

11. Height (incomplete) 67 mm, maximum diameter 22 mm. Loc. 35, UO 27344.

13. Height (incomplete) 36 mm, maximum diameter 14 mm. Loc. 35. UO 27345.

Figure 14. *Epitonium (Boreoscala) condoni* "var. oregonense" (Dall)
Height 26.5 mm, maximum diameter 13 mm. Loc. 35. UO 27349.

Figure 15, 16. *Natica (Natica)* n. sp. ?
Height 23.5 mm, diameter 21 mm. Loc. 28. UO 27365.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X1.5
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X1.5
16

threads shows the same pattern of variation in both forms. Typical *oregonense*, however, has prominent callus deposits obscuring the suture and covering up to half of the preceding whorl. The varices are generally broader and the shell has a straight-sided appearance as a result of the band of callus at the suture.

The holotype of *E. oregonense* is an incomplete specimen consisting of several large whorls with extensive callus deposits. Dall (1909, p. 54) used these deposits to characterize a new subgenus, *Catenoscala*, and suggested that this form might even represent a new genus. As pointed out by Durham (1937, p. 494) there is complete intergradation in the amount of callus between *oregonense* and typical *condoni*.

Specimens with typical *oregonense* characters are also found in the lower Oligocene Gries Ranch Beds of southwestern Washington where they occur alone and may represent a true subspecies.

MATERIAL STUDIED: 14 specimens.
HYPOTYPE: UO 27349.
LOCALITIES: 33, 35, 37.

Epitonium (Boreoscala) condoni (Dall)
subsp. *refulleri* Durham

Epitonium (Boreoscala) condoni (Dall) subsp. *refulleri* Durham, 1937, p. 498, pl. 57, fig. 17; Weaver, 1942, p. 319, pl. 66, fig. 11.

DISCUSSION: The holotype of *E. condoni* subsp. *refulleri* is from the lower Oligocene Keasey Formation in western Oregon. Durham (1937, p. 497) reported this form from a locality at the junction of the North and South Forks of the Santiam River in the Albany Quadrangle, Oregon. The beds which crop out here and to the south on Knox Butte were recognized by Allison (1953, p. 7-8) as part of the Eugene Formation, and the fauna at these localities is similar to that of the Eugene area. Specimens of *Epitonium* from this locality could not be located, however, and the occurrence of Durham's subspecies in the Eugene Formation must be considered questionable.

Genus *ACRILLA* H. Adams, 1860

TYPE: By original designation, *Scalaria acuminata* Sowerby.

Subgenus *FERMINOSCALA* Dall, 1908

TYPE: By original designation, *Acrilla ferminiana* (Dall)

Acrilla (Ferminoscala) becki Durham

Pl. 10, figs. 1, 2

Acrilla (Ferminoscala) becki Durham, 1937, p. 507-508, pl. 56, fig. 26, pl. 57, fig. 20; Weaver, 1942, p. 327, pl. 67, fig. 14.

DISCUSSION: Only two specimens in the collections can be positively assigned to this species. Both are incomplete and poorly preserved, but enough shell material remains to distinguish them from *A. dickersoni*. *A. becki* differs from *A. dickersoni* in having less prominent and irregularly spaced thread-like axial sculpture, with fewer axial ribs per whorl. The spiral threads are relatively stronger, more closely spaced, and more numerous: 10 to 12 per whorl as compared to 7 in *A. dickersoni*. These differences in spiral and axial ornamentation produce a rectangular grid rather than the distinctive cancellate pattern of squares characteristic of *A. dickersoni*.

HYPOTYPES: UO 27350, 27351.
LOCALITIES: 12?, 19?, 22, 27?, 28, 29?

Acrilla (Ferminoscala) dickersoni Durham

Pl. 10, figs. 3, 4, 5, 6

Epitonium washingtonensis Weaver. Dickerson, 1917, p. 160, pl. 31, figs. 7a, 7b.

not *Epitonium washingtonensis* Weaver, 1916, p. 43, pl. 4, figs. 46, 47.

not *Epitonium (Boreoscala) washingtonensis* Weaver and Palmer, 1922, p. 30, pl. 11, fig. 19.

Acrilla (Ferminoscala) dickersoni Durham, 1937, p. 508, pl. 57, figs. 12, 13; Effinger, 1938, p. 376-377; Weaver, 1942, p. 325-326, pl. 67, figs. 7, 8, 21.

DISCUSSION: *Acrilla (Ferminoscala) dickersoni* is characterized by equally prominent spiral ornamentation and thread-like axial ribs which cross to give the shell a distinctly cancellate appearance. The shell is of moderate to small size, slender, and high-spired with up to 10 whorls. There are 25 to 30 varix-like axial ribs and 7 spiral ribs on each whorl. The number of spiral ribs seems to be constant and diagnostic for this species. The distance between axial ribs is equal to the distance between spiral ribs on the upper whorls so that they intersect to form perfect squares. On lower whorls the spiral ribs are closer together and intersect with axial ribs to produce more rectangular spaces. The basal keel is somewhat more prominent than the spiral ribs above. The axial ribs continue across the keel onto the basal disk; the spiral ribs become finer and more closely spaced on the basal disk where there may be as many as 13 ribs. The aperture is oval and the inner and outer lips are both extremely thin.

A. dickersoni is readily distinguished from members of the genus *Epitonium* in the Eugene Formation by its small size, the presence of true axial ribs rather than varices, and the thin outer lip. *A. becki*, which also occurs in the Eugene Formation, is easily differentiated by the greater prominence, closer spacing, and greater number of spiral ribs per whorl as well as greater overall size. *A. lincolnensis* is similar in outline to *A. dickersoni* but is distinguished by more numerous and almost obscure axial ribs as well as a greater number of spiral threads.

A. dickersoni is common in certain of the gray, fine-grained, tufaceous siltstone units in the Eugene Formation where it ranges in height from 9.5 mm to 27 mm. The shell material is usually decorticated, and only occasional specimens preserve details of ornamentation.

This species was described from the lower Oligocene Gries Ranch Beds of southwestern Washington. It is also reported by Durham (1937, p. 508) from the San Emigdio Formation of California.

MATERIAL STUDIED: 26 specimens.

HYPOTYPES: UO 27352, 27353, 27354, 27355, 27356.

LOCALITIES: 5, 11, 12, 18, 19, 26, 27, 28, 29, 47.

Superfamily CALYPTRACEA

Family Calytraeidae

Genus *CALYPTRAEA* Lamarck, 1799

TYPE: By monotypy, *Patella chinenis* Linné.

The fossil species of *Calyptraea* are poorly defined and differentiated because many workers have failed to appreciate the kinds of variability and the distortions of shape which typically occur in such sedentary forms.

Calyptraea diegoana (Conrad)

Pl. 11, figs. 7, 8

Trochita diegoana Conrad, 1855, p. 7,17; 1857, p. 319, 327, pl. 5, fig. 42.

Galerus excentricus Gabb, 1864, p. 136,228, pl. 20, fig. 95, pl. 29, figs. 232, 232a.

Calyptraea washingtonensis Weaver, 1916, p. 44, pl. 3, fig. 44; Tegland, 1933, p. 137, pl. 14, fig. 25; Weaver, 1942, p. 352-353, pl. 71, figs. 19, 22.

Calyptraea diegoana (Conrad). Stewart, 1926, p. 340, 341, pl. 27, fig. 19, (Synonymy); Turner, 1938, p. 89, 90, pl. 20, figs. 1, 2; Effinger, 1938, p. 378; Weaver, 1942, p. 351, 352, pl. 71, figs. 16, 20, pl. 103, fig. 3; Durham, 1944, p. 161.

DISCUSSION: *Calyptraea diegoana* is a highly-variable conical species of nearly circular outline in which the apex varies from central to slightly excentric in position. Some specimens are high-spired with slightly convex whorls while others are low and flattened with flat-sided whorls. The surface of the shell is thin and smooth except for lines of growth. The internal lamina is not exposed on any of the specimens from the Eugene Formation.

PLATE 11

Figure 1, 3, 6, 11. *Crepidula ungana* Dall

1, 3. Height 36.5 mm, height of aperture 27.5 mm, maximum diameter 20 mm. Loc. 28. UO 27363.

6, 11. Chain of three individuals. Loc. 28. UO 27364.

Figure 2, 4, 5. *Calyptraea sookensis* Clark and Arnold

2, 5. Height 13 mm, maximum diameter 25 mm. Loc. 47. UO 27362.

4. Height 13 mm, maximum diameter 33 mm. Loc. 47. UO 27361.

Figure 7, 8. *Calyptraea diegoana* (Conrad)

7. Height 12 mm, maximum diameter 30 mm. Loc. 15. UO 27357.

8. Height 10 mm, maximum diameter 28 mm. Loc. 28. UO 27358.

Figure 9, 10. *Sinum obliquum* (Gabb)

9. Height 6 mm, maximum diameter 10.5 mm. Loc. 12. UO 27383.

10. Height 10 mm, maximum diameter 12 mm. Loc. 12. UO 27382.

Figure 12-19. *Polinices washingtonensis* (Weaver)

12. Loc. 46. UO 27376.

13. Loc. 46. UO 27377.

14-16. Height 20 mm, maximum diameter 18 mm. Loc. 28. UO 27373.

17, 18. Height 21.5 mm, maximum diameter 19 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27375.

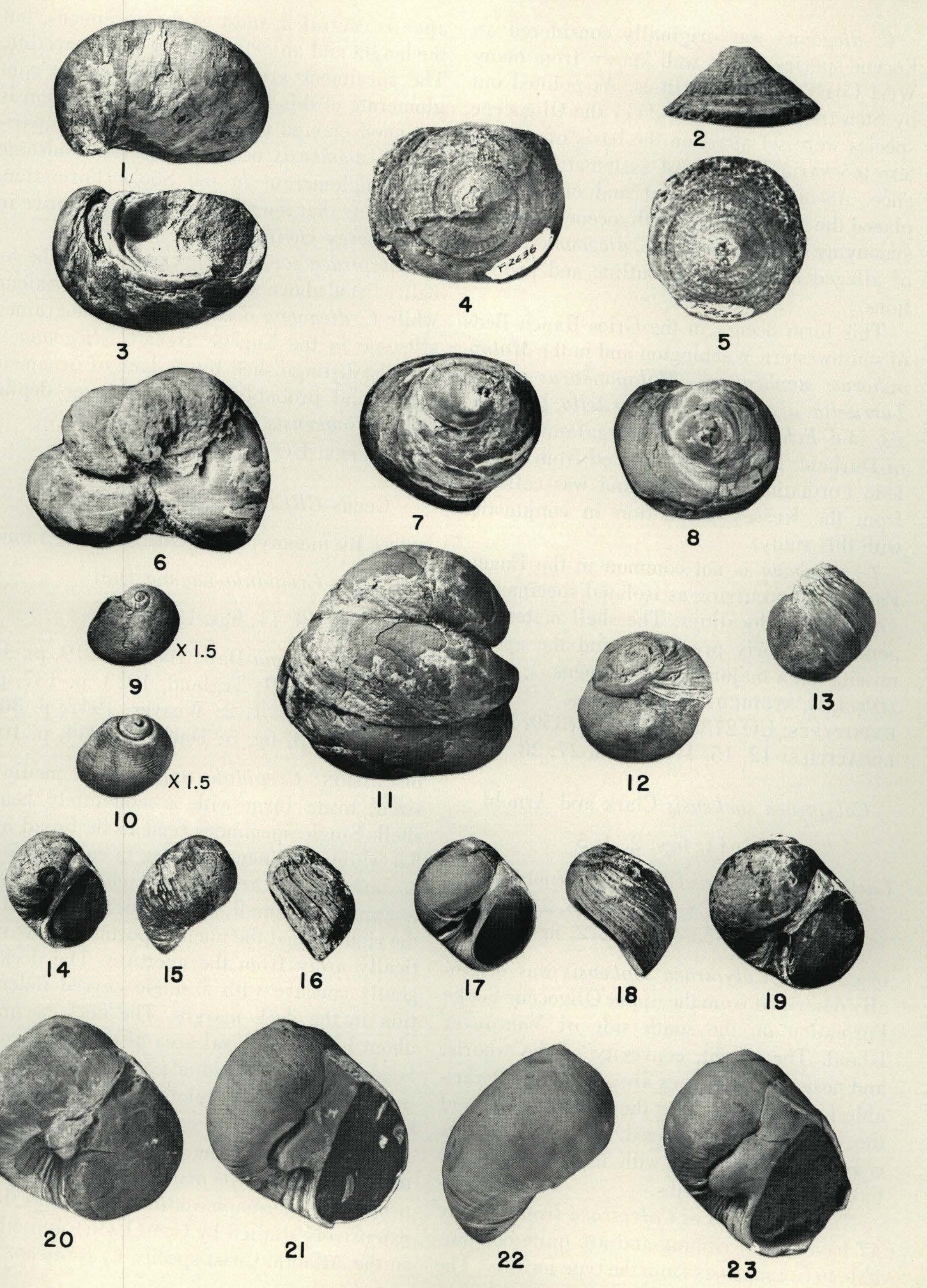
19. Height 26.5 mm, maximum diameter 25 mm. Loc. 27. UO 27374.

Figure 20-23. *Neverita thomsonae* Hickman, n. sp.

20. Paratype. Height 35 mm, maximum diameter (distorted) 40 mm. Loc. 28. UO 27368.

21. Paratype. Height 34.5 mm, maximum diameter 33 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27367.

22, 23. Holotype. Height 34 mm, maximum diameter 31 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27366.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C. diegoana was originally considered an Eocene species and is well known from many West Coast Eocene localities. As pointed out by Stewart (1926, p. 340-341) the Oligocene species were set apart on the basis of characters too variable to be of systematic importance. Accordingly, Stewart and others have placed the smooth-shelled Oligocene species in synonymy with the Eocene *C. diegoana* in spite of alleged differences in outline and proportions.

This form occurs in the Gries Ranch Beds of southwestern Washington and in the *Molopophorus stephensoni, Molopophorus gabbi, Turritella olympicensis, Turritella porterensis,* and *Echinophoria rex* megafaunal zones of Durham. It has been reported from the Toledo Formation in Oregon and was collected from the Keasey Formation in conjunction with this study.

C. diegoana is not common in the Eugene Formation, occurring as isolated specimens at a number of localities. The shell material is generally poorly preserved, and the apex is missing on a majority of specimens.

MATERIAL STUDIED: 11 specimens.

HYPOTYPES: UO 27357, 27358, 27359, 27360.

LOCALITIES: 12, 15, 17, 20, 26, 27, 28.

Calyptraea sookensis Clark and Arnold

Pl. 11, figs. 2, 4, 5

Calyptraea sookensis Clark and Arnold, 1923, p. 168, pl. 36, figs. 1a, 1b, 2; Weaver, 1942, p. 353-354, pl. 72, figs. 1, 3, 4.

DISCUSSION: *Calyptraea sookensis* was originally described from the upper Oligocene Sooke Formation on the south side of Vancouver Island. The height, convexity of the whorls, and position of the apex are all somewhat variable in specimens from the type locality, and the species is recognized primarily by its coarse radial ribbing with interspaces equal to the width of the ribs.

Nine specimens of *Calyptraea* from locality 47 have radial ribbing and are quite comparable to *C. sookensis* from the type locality. The apex is central in most of the specimens, but the height and apical angle are quite variable. The specimens are imbedded in a fine conglomerate at this locality, and preservation is not good enough to permit detailed comparison. *C. sookensis* occurs in coarse sandstone and conglomerate in the Sooke Formation, suggesting that the ribbing may be adaptive in high energy environments.

Calyptraea sookensis occurs only at the locality listed above which is northwest of Salem, while *C. diegoana* occurs only in fine-grained siltstone in the Eugene area. *C. diegoana* is readily distinguished by its lack of ornamentation and probably lived at greater depths than *C. sookensis.*

HYPOTYPES: UO 27361, 27362.

Genus *CREPIDULA* Lamarck, 1799

TYPE: By monotypy, *Patella fornicata* Linné.

Crepidula ungana Dall

Pl. 11, figs. 1, 3, 6, 11

Crepidula ungana Dall, 1904, p. 119, pl. 10, figs. 8, 9; Tegland, 1933, p. 137, pl. 14, figs. 1, 2; Weaver, 1942, p. 360, pl. 73, fig. 5; Durham, 1944, p. 162.

DISCUSSION: *Crepidula ungana* is a medium-sized, ovate form with a moderately heavy shell. Single specimens tend to be broad and flat while specimens growing in colonial form on one another are highly arched. The apex is appressed, small, and strongly recurved to the right so that the nuclear portion points vertically away from the aperture. The deck is gently concave with a single curved indentation in the deck margin. The deck occupies about half of the oval area of the aperture. It is common for individuals of *C. ungana* to aggregate in chain-like colonies. One colony from the Eugene Formation contains 11 individuals.

The build up of chains of individuals in *C. ungana* is evidently a manifestation of the same protandric hermaphoroditism that has been extensively studied by Coe (1936) and others in the Atlantic Coast species *C. fornicata.* An individual functions first as a male and passes through a bisexual stage to become a female. Only the old individuals (females) in these chains become permanently attached to each other by calcareous secretions of the foot, explaining why small individuals (males) are not preserved with the fossil chains but are commonly found as isolated specimens.

Schenck (1936, p. 4) cited the *Crepidula* "reefs" in the Eugene Formation as evidence of the proximity of the Oligocene shore. These "reefs" are layers two to three inches thick of individuals and chains which have been concentrated by current action. The layers occur at irregular intervals throughout the Eugene area, most notably at localities 5, 11, 13, 14, and 37.

The upper Oligocene *C. sookensis* Clark and Arnold may be distinguished from *C. ungana* by its broader, flatter form and less conspicuous apex which is twisted laterally rather than upward. In *C. pileum* (Gabb), which ranges into the lower Oligocene, the apex is lower, lying along the margin of the body whorl. *C. praerupta* Conrad, a predominantly Miocene species, is distinguished by a blunter and less coiled and closely-appressed apex.

The holotype of *C. ungana* was collected by Dall on Ungana Island, Alaska, from a concentrated layer of *Crepidula* which is probably similar to its occurrence in the Eugene Formation. *C. ungana* is also reported from the Blakeley Formation in Washington and the Toledo and Yaquina Formations in Oregon.

MATERIAL STUDIED: 150 specimens. Most of the specimens are poorly-preserved internal molds although many are in chain form. Large slabs from locality 14 contain many additional chains and individuals.

HYPOTYPES: UO 27363, 27364.

LOCALITIES: 2, 4, 5, 7, 11, 12, 13, 14, 15, 16, 19, 23, 24, 25, 26, 28, 30, 37, 40, 41.

Family Naticidae

Subfamily Naticinae

Genus *NATICA* Scopoli, 1777

TYPE: By subsequent designation (Harris, 1887), *Nerita vitellus* Linné.

Subgenus *NATICA s. s.*

Natica (Natica) n. sp. ?

Pl. 10, figs. 15, 16

DISCUSSION: A single specimen from Eugene Formation locality 28 exhibits well-preserved umbilical features which place it in the genus *Natica.* The umbilicus is partially open and the funicle is a low, broad, central rib which extends up the umbilical wall. The parietal callus is moderately well developed above and does not invade the umbilicus. The shell is globose with abutting sutures and a relatively prominent spire. Since the details of the umbilical area are not preserved in most of the Eugene naticoids, this form may have been more abundant than suggested by the single specimen described above. Because of insufficient material and confused taxonomy within the genus a new name is not proposed.

The subgeneric distinctions in the genus *Natica* are confused in the literature. Specimens from the West Coast Tertiary have been traditionally referred to the subgenus *Tectonatica* Sacco or to *Cryptonatica* Dall. In the type species of both these subgenera the umbilicus is completely filled with callus deposit, and many workers have considered the names synonymous. The type of *Cryptonatica* is, however, a large boreal species while the type of *Tectonatica* is a small tropical species, leading Woodring (1957-59, p. 88) to suggest that both names may be valid.

Both *Cryptonatica* and *Tectonatica* have been applied improperly to West Coast Tertiary specimens in which the umbilicus is not completely filled with callus. In these specimens and in the specimen from the Eugene Formation the funicle is a low ridge typical of the subgenus *Natica* s. s. Even the importance of this feature is debatable, however, since Woodring (1928, p. 377) has pointed out gradations from virtually no funicle to funicle completely filling the umbilicus.

FIGURED SPECIMEN: UO 27365.

Genus *NEVERITA* Risso, 1826

TYPE: By monotypy, *Neverita josephina* Risso.

Subgenus *GLOSSAULAX* Pilsbry, 1929

TYPE: By original designation, *Neverita reclusiana* (Deshayes).

Neverita (Glossaulax) thomsonae
Hickman, n. sp.
Pl. 11, figs. 20, 21, 22, 23

DESCRIPTION: Shell large for fossil members of genus, heavy and globose with low spire and large, broadly convex body whorl; sutures tangential, profile smooth without shoulders; whorls four to five; aperture elliptical, narrower above, strongly inclined; parietal callus large and prominent, extending downward as a tongue from juncture of outer lip and body whorl, overriding and coalescing with a heavy funicle which covers umbilicus completely in most specimens; parietal callus and funicle separated by moderately impressed arcuate groove; entire callus bounded by impressed groove; surface smooth except for lines of growth which are generally thickened around the umbilical area. Dimensions of Holotype: height 34 mm, maximum diameter 31 mm.

N. thomsonae is closely related to the Recent *N. reclusiana* which has been reported from numerous Tertiary localities ranging in age from Oligocene to Recent. *N. thomsonae* may be distinguished by its smooth, flattened profile and broader body whorl which overlaps a greater portion of the spire. *N. thomsonae* is typically larger than any of the fossil specimens of other species of *Neverita* examined in the course of this study, commonly attaining diameters of 45 mm.

Schenck used the name *Natica reclusiana* for a large specimen of this species from Eugene Formation locality 27. He labeled two smaller specimens from the same locality as *Natica oregonensis* (Conrad).

N. thomsonae is common throughout the Eugene area and also in the Pittsburg Bluff Formation. In both these formations this large naticoid commonly occurs with *Polinices washingtonensis* (Weaver) as part of an abundant naticoid fauna. *N. thomsonae* is easily distinguished from *Polinices* and other naticoids in the Eugene Formation by the large grooved umbilical callus. Specimens are commonly distorted by flattening, and the umbilicus is seldom completely intact. Specimens from the Pittsburg Bluff Formation are extremely well preserved.

This species is named in honor of the late Harriet W. Thomson, a meticulous collector who contributed several large collections of Eugene fossils to the University of Oregon.

MATERIAL STUDIED: 62 specimens from the Eugene Formation. 28 specimens from the Pittsburg Bluff Formation.

HOLOTYPE: UO 27366. PARATYPES: UO 26367, 27368, 27369, 26370, 27371, 27372.

TYPE LOCALITY: UO locality 2567 (Pittsburg Bluff Formation).

OTHER LOCALITIES: 3, 4, 5, 11, 12, 13, 14, 15, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 35, 42.

Subfamily Polinicinae

Genus *POLINICES* Montfort, 1810

TYPE: By original designation, *Polinices albus* Montfort (= *Natica mamillaria* Lamarck = *Natica brunea* Link).

Polinices washingtonensis (Weaver)
Pl. 11, figs. 12, 13, 14, 15, 16, 17, 18, 19

Natica washingtonensis Weaver, 1916, p. 44, pl. 5, figs. 73, 74, 75, 76.

Natica lincolnensis Weaver, 1916, p. 44, 45, pl. 5, figs. 71, 72.

Polinices washingtonensis (Weaver). Clark and Anderson, 1938, p. 954, pl. 3, figs. 16, 17; Durham, 1944, p. 160.

Polinices lincolnensis (Weaver). Effinger, 1938, p. 377.

Polinices (Polinices) washingtonensis (Weaver). Weaver, 1942, p. 337, pl. 68, figs. 18, 23.

Polinices (Polinices) washingtonensis (Weaver) var. *lincolnensis* (Weaver). Weaver, 1942, p. 337, pl. 68, fig. 22, pl. 65, figs. 4, 7.

DISCUSSION: *Polinices washingtonensis* is a medium-sized species with a large, smooth body whorl and a small, evenly-rounded spire. The parietal callus is well developed along the upper edge of the inner lip, leaving the umbilical area partially open below. There is no funicle present.

The holotype of *P. washingtonensis* is from the Lincoln Formation of southwestern Washington. Specimens from this locality are generally smaller than specimens from the Eugene Formation, but there are no other significant differences. Many of the Eugene specimens have the widely open umbilicus which Weaver originally used to characterize *P. lincolnensis*. Clark and Arnold (1938, p. 954) pointed out the continuous variation between *P. lincolnensis* and *P. washingtonensis* in the Lincoln Formation. Since this same range of variation occurs in the Eugene specimens, it seems appropriate to consider the prior name, *P. washingtonensis,* valid for the entire complex.

P. washingtonensis is abundant throughout the Eugene Formation and is the most common of the four naticoids comprising the large carnivorous gastropod population of the formation. It can be readily distinguished from other naticoids in the formation by the open umbilicus and absence of a funicle, coupled with a well-developed parietal callus. Specimens exhibit a wide range of sizes (from 3 to 27 mm maximum diameter); and signs of their activity in the form of drill holes are common throughout the Eugene fauna. Small specimens are particularly abundant in layers of concentrated shell material.

At locality 46 many specimens are partially enclosed in small calcareous concretions (pl. 11, figs. 12, 13). The concretion occurs around the aperture, suggesting that pH changes surrounding the large foot as it decayed may have initiated local precipitation and acted as a nucleus for formation of the concretion.

This species is common in the Oligocene of Washington and Oregon, occurring in the Lincoln, Quimper ,and Blakely Formations as well as the Gries Ranch Beds in Washington and the Pittsburg Bluff, Toledo, and Tunnel Point Formations in Oregon.

MATERIAL STUDIED: 132 specimens. This many specimens have been worked out of matrix. Hundreds of additional specimens are present in slabs of concentrated shell material. Forty-four specimens from the Pittsburg Bluff Formation were examined.

HYPOTYPES: UO 27373, 27374, 27375, 27376, 27377, 27378, 27379, 27380, 27381.

LOCALITIES: 4, 5, 11, 12, 13, 14, 15, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 36, 40, 42, 46, 47.

Subfamily Sininae

Genus *SINUM* Röding, 1798

(*SIGARETUS* Lamarck, 1799)

TYPE: By subsequent designation (Dall, 1915), *Helix haliotoidea* Linné.

Sinum obliquum (Gabb)

Pl. 11, figs, 9, 10

Naticina obliqua Gabb, 1864, p. 109, 225, pl. 21, fig. 112; Dickerson, 1915, figs. 5a, 5b.

Sinum obliquum (Gabb). Arnold and Hannibal, 1913, p. 569, 570, 572; Stewart, 1926, p. 327, pl. 30, fig. 7a; Clark, 1938, p. 704, pl. 3, figs. 32, 37; Weaver, 1942, p. 350, 351, pl. 71, fig. 13, pl. 103, fig. 6; Durham, 1944, p. 161.

Sinum occidentis Weaver and Palmer, 1922, p. 32, pl. 11, figs. 8, 26; Weaver, 1942, p. 351, pl. 71, fig. 15.

DISCUSSION: *Sinum obliquum* is a small moderately-flattened species with a short spire and a large inflated body whorl sculptured with fine spiral grooves crossed by less prominent

PLATE 12

Figure 1-4. *Olequahia schencki* Durham

1. Height 79 mm, maximum diameter 55.5 mm. Loc. 28. UO 27389.

2. Height (incomplete) 58 mm, maximum diameter 58.5 mm. Loc. 28. UO 27390.

3. Height (incomplete) 44 mm, maximum diameter 39 mm. Loc. 28. UO 27391.

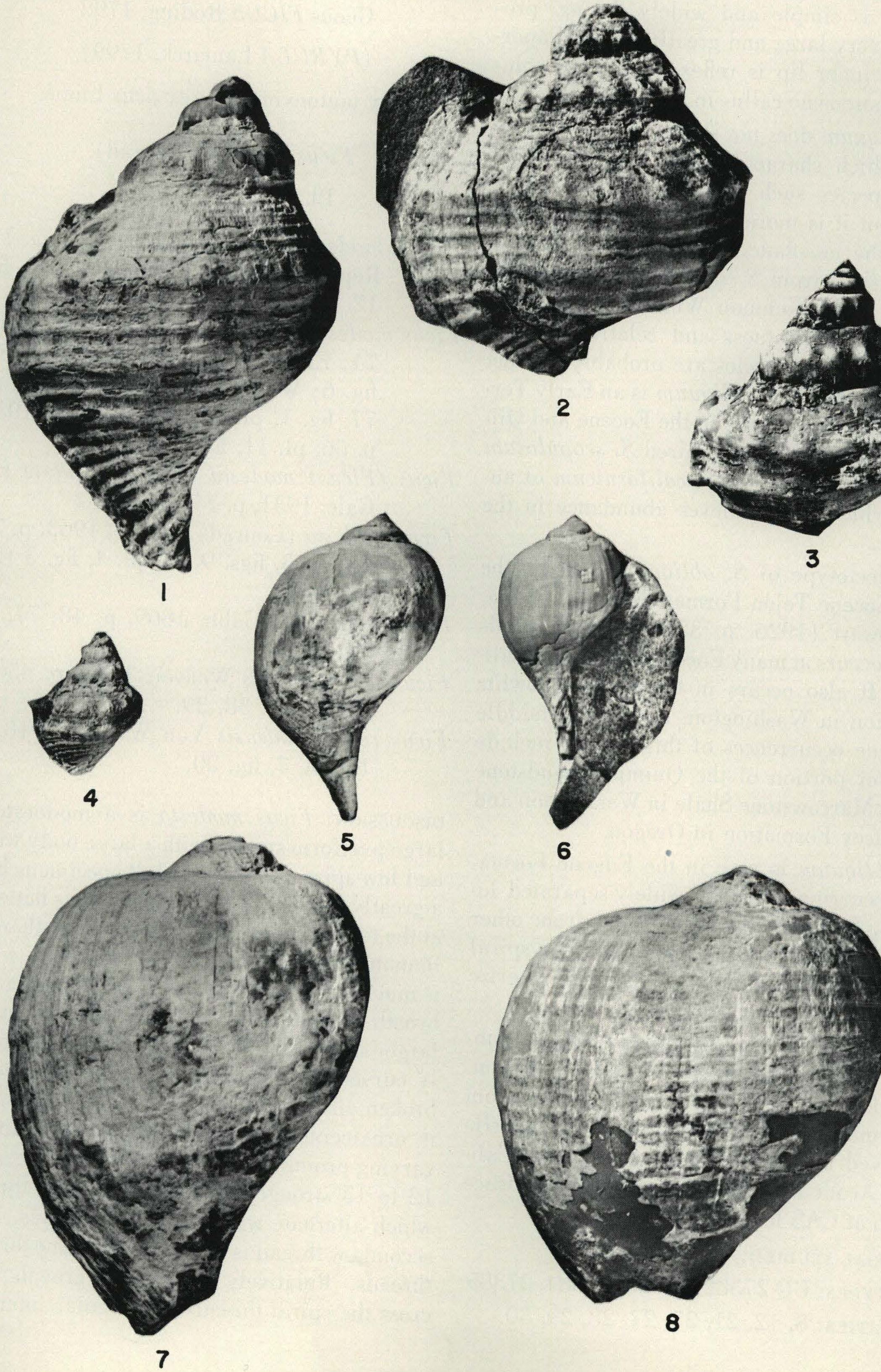
4. Height (incomplete) 23 mm, maximum diameter 18 mm. Loc. 28. UO 27393.

Figure 5-8. *Ficus modesta* (Conrad)

5, 6. Height 48.5 mm, diameter 29 mm. Loc. 15. UO 27387.

7. Height (incomplete) 78.5 mm, diameter 54 mm. Loc. 28. UO 27388.

8. Height (incomplete) 69.5 mm, diameter 60 mm. Loc. 4. UO 27386.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and irregularly-spaced lines of growth. The outer lip is simple and widely flaring, producing a very large and greatly-inclined aperture; the inner lip is reflexed over the columella. There is no callus in the umbilicus.

S. obliquum does not show the extreme flattening which characterizes a number of the Recent species such as *Sinum perspectivum* (Say), but it is more similar to these species than to the less-flattened forms. It is readily distinguished from *S. scopulosum* (Conrad), the only other common West Coast Tertiary species, by its flatness and relatively lower spire. These two species are probably distinct stratigraphically. *S. obliquum* is an Early Tertiary species, occurring in the Eocene and Oligocene while the higher-spired *S. scopulosum* is a Recent species (= *S. californicum* of authors) which first achieves abundance in the Miocene.

The lectotype of *S. obliquum* is from the upper Eocene Tejón Formation of California, and Stewart (1926, p. 327) states that this species occurs at many Eocene horizons in California. It also occurs in the Eocene Cowlitz Formation in Washington. Lower and middle Oligocene occurrences of this species include the lower portion of the Quimper Sandstone and the Marrowstone Shale in Washington and the Keasey Formation in Oregon.

S. obliquum is rare in the Eugene Formation, occurring singly in widely-separated localities. It is easily distinguished from other naticoids in the fauna by the trough-like spiral grooves on the body whorl which characterize the genus.

Sinum does not appear on any of the published species lists for the Eugene Formation. It is also absent from early collections from the formation with the exception of two poorly-preserved uncataloged specimens at the California Academy of Sciences, collected by Bruce Martin at CAS loc. 238.

MATERIAL STUDIED: 12 specimens.
HYPOTYPES: UO 27382, 27383, 27384, 27385.
LOCALITIES: 8, 12, 21, 25, 27, 28, 29, 30.

Family Ficidae

Genus *FICUS* Röding, 1798

(*PYRULA* Lamarck, 1799)

TYPE: By tautonymy, *Murex ficus* Linné.

Ficus modesta (Conrad)

Pl. 12, figs. 5, 6, 7, 8

Pyrula modesta Conrad, 1848, p. 433, fig. 12; Reprinted by Dall, 1909, p. 151, fig. 12.

Ficus modestus (Conrad). Dall, 1909, p. 12, 74; Etherington, 1931, p. 96, pl. 11, fig. 6; Weaver, 1942, p. 395-396, pl. 77, fig. 1, pl. 103, fig. 1; Hall, 1958, p. 56, pl. 11, fig. 3.

Ficus (Ficus) modesta (Conrad). Grant and Gale, 1931, p. 742.

Ficus modesta (Conrad). Moore, 1963, p. 32-33, pl. 3, figs. 9, 10, pl. 4, fig. 3 (Synonymy).

Ficus pyriformis Gabb, 1869, p. 48, 77, pl. 14, fig. 4.

Ficus wynoochensis Weaver, 1916, p. 45-46, pl. 3, figs. 38, 39.

Ficus restorationensis Van Winkle, 1918, p. 88, pl. 7, fig. 20.

DISCUSSION: *Ficus modesta* is a moderate to large pyriform species with a large body whorl and low spire. The large adult specimens have a greatly-inflated body whorl which is flattened at the top with a relatively lower spire than the immature specimens in which the body whorl is much less tumid and the upper shoulder less broad. The aperture is also broader in the larger specimens. The canal is elongate, broadly curved, and slightly twisted. The canal is broken off in most specimens. The body whorl is ornamented by rounded spiral threads of varying prominence. Typically there are about 12 to 15 strongly-developed primary threads which alternate with secondary threads. Each secondary thread is flanked by two fine tertiary threads. Relatively prominent growth lines cross the spiral threads at irregular intervals.

The holotype of *F. modesta* is missing, but large collections of the species are available from the Astoria Formation where Conrad first collected it. Moore (1963, p. 32-33) has pointed out the extreme range of variation in tumidity from young to adult specimens in the Astoria Formation. The same pattern is typical of Eugene specimens. Large specimens are more common in the Eugene while those from the Astoria are typically smaller.

F. restorationensis Van Winkle from the upper Oligocene Blakeley Formation of Washington and *F. wynoochensis* Weaver from the Astoria Formation of Washington fall within the range of variation in *F. modesta* as it is now understood. The holotype of *F. chehalisensis* Weaver from the Astoria Formation of Washington was never figured and was subsequently lost. The name must be considered a *nomen dubium*, but the description strongly suggests *F. modesta.*

Numerous authors have pointed out the similarity between *F. modesta* and *F. dussumieri*, a Recent species living off the coast of China, but there is no basis at present for evaluating the relationship between the two. The genus *Ficus* is tropical in its distribution, and its occurrence with more typically temperate forms in the Oligocene and Miocene suggests either that it was a relictual faunal element or that the genus as a whole had a wider range of tolerance during this time.

F. modesta is not abundant in the Eugene Formation, but owing to its large size it is one of the most striking elements of the gastropod fauna. It occurs primarily at localities within the Eugene city limits.

MATERIAL STUDIED: 23 specimens.

HYPOTYPES: UO 27386, 27387, 27388.

LOCALITIES: 4, 5, 12, 13, 15, 19, 20, 28.

Family Bursidae

Genus *OLEQUAHIA* Stewart, 1926

TYPE: By original designation, *Cassidaria washingtoniana* Weaver.

Olequahia is an endemic Pacific Coast genus which occurs in the Eocene and lower to middle Oligocene. This genus is placed in the Bursidae primarily on the basis of the prominent posterior siphonal canal and the nodose, angulated body whorl, although varices are not developed on all the forms which have been placed in the genus.

Olequahia schencki Durham

Pl. 12, figs. 1, 2, 3, 4

Olequahia schencki Durham, 1944, p. 168-169, pl. 15, fig. 15.

DISCUSSION: The holotype of *Olequahia schencki* was collected by Schenck in the Keasey Formation and later described by Durham (1944, p. 168-169). It is a large incomplete specimen with a broken anterior canal and missing outer lip. The ornamentation is well preserved and compares closely with the ornamentation on specimens from the Eugene Formation.

A wide range of sizes is represented in the collections, and specimens are smaller than the holotype. The spire is moderately high with a spiral angle of about 75°. There are two prominent noded angulations on the body whorl with a flat to slightly concave surface between. These heavy nodes are not always aligned vertically from one row to the other, and the number of nodes on the body whorl varies from 12 on the smallest specimen to 18 on the largest. There are four wide, rounded spiral ribs on the sloping surface between the suture and the posterior angulation and three ribs separating the two angulations. Below the anterior angulation and separated from it by a single rib is a prominent rib which does not bear nodes, although on the larger specimens it tends to form a third faint angulation on the whorl. The suture is appressed against the posterior row of nodes on the whorls of the spire producing an undulating line.

Details of the canal and outer lip are preserved on a number of specimens from the Eugene Formation. The spiral ribbing continues onto the canal, and there are 10 ribs present below the third faint angulation described above. The canal is moderately long and open. The outer lip is crenulated at the edge and expanded outward to make the aperture and body whorl very wide. There is a prominent sinuation or slot in the outer lip for the posterior siphon.

This is the first record of *O. schencki* outside the Keasey Formation, although *O. lorenzana* (Wagner and Schilling) from the middle Oligocene of California is very closely related and may be the same species. Durham (1944, p. 169) differentiated the two on the basis of differences in the height of the spire and the number and prominence of the nodes and spiral ribs, but more material of *O. lorenzana* must be examined to determine the proper relationship of these two names. *O. washingtoniana*, the type of the genus, is differentiated by the presence of axial varices.

O. schencki is not abundant in the Eugene Formation, but it is a striking element of the gastropod fauna, occurring as single specimens at a number of horizons both in the Eugene and Salem areas.

MATERIAL STUDIED: 18 specimens.
HYPOTYPES: UO 27389, 27390, 27391, 27392, 27393.
LOCALITIES: 2, 26, 27, 28, 39, 41.

Superfamily BUCCINACEA

Family Buccinidae

Genus *MOLOPOPHORUS* Gabb, 1869

TYPE: By monotypy, *Bullia (Molopophorus) striata* Gabb.

Molopophorus is an extinct, endemic, Pacific Coast genus which is best represented in the Oligocene of Washington, Oregon, and California. Several distinct lineages of *Molopophorus* are present in the Oligocene: a group of relatively high-spired smooth forms typified by *M. fishii* (Gabb), a group of high-spired forms with spiral and longitudinal ornamentation such as *M. newcombei* (Merriam), and a lineage of low-spired broad forms with markedly nodose sculpture typified by *M. gabbi* Dall. Although species of *Molopophorus* have been used extensively by Durham (1944) and others to subdivide and correlate the West Coast Oligocene, the relationships among species and the range of variation within species is poorly understood.

Molopophorus fishii (Gabb)

Pl. 13, figs. 2, 3, 4, 5

Ancillaria fishii Gabb, 1869, p. 9, pl. 2, fig. 15.
Bullia buccinoides Merriam, 1899, p. 179, pl. 23, fig. 5.
Ancilla fishii (Gabb). Clark and Arnold, 1923, p. 161, pl. 31, figs. 9a, 9b, 10a, 10b.
Molopophorus fishii (Gabb). Weaver, 1942, p. 470, pl. 90, figs. 9, 10, 11; Durham, 1944, p. 170.

DISCUSSION: *Molopophorus fishii* is a distinctive smooth-shelled species which occasionally shows faint longitudinal ribbing. The canal is short and deeply notched. The well-developed anterior siphonal fasciole is characteristic of the genus. The spire is moderately elevated, and the suture is not collared.

M. fishii was originally described from the upper Oligocene Sooke Formation on Vancouver Island, and Durham (1944, p. 170) has reported it from beds of late Oligocene age in northern Washington. A smooth species also occurs in the upper Oligocene Yaquina Formation in Oregon which Vokes, Norbisrath, and Snavely (1949, checklist) assigned to *M. fishii.*

This species is not common in the Eugene Formation, although local concentrations of poorly-preserved specimens are sometimes found in layers of fragmented and closely-packed shell material. *M. fishii* is easily distinguished from *M. dalli* by the smooth unornamented shell which lacks a sutural collar.

M. clarki (Weaver) from the upper Eocene Cowlitz Formation of Washington is closely related to *M. fishii.* The holotype of *M. clarki* appears to fall within the broad range of variation observed in specimens of *M. fishii* from the Sooke Formation, but more material must be examined before clear species definitions can be made in this lineage of smooth forms.

MATERIAL STUDIED: 25 specimens.

HYPOTYPES: UO 27394, 27395, 27396, 27397, 27398.

LOCALITIES: 3, 5, 10, 13, 22, 23, 24, 27, 28, 31, 34, 35.

Molopophorus dalli Anderson and Martin

Pl. 13, fig. 1

Molopophorus dalli Anderson and Martin, 1914, p. 78, pl. 6, figs. 7a, 7b; Wagner and Schilling, 1923, p. 259, pl. 50, fig. 1; Weaver, 1942, p. 469, pl. 90, fig. 8; Durham, 1944, p. 170.

DISCUSSION: Only a few specimens of this species have been collected in the Eugene Formation. The best-preserved specimen is one collected by H. V. Howe at locality 2. The body whorl is large and robust, and the sutural collar is well developed. Ornamentation of the body whorl consists of longitudinal ribs crossed by spiral sculpture to produce a cancellate or beaded pattern. The Eugene specimen exhibits the same prominent constriction beneath the sutural collar that is seen on the holotype.

M. dalli is not a well-known species although Durham (1944, p. 116) considered it a characteristic species of his *M. gabbi* Zone in western Washington. The holotype was collected in middle Oligocene beds near Clatskanie, Oregon, and Durham collected the species at a single locality in the middle portion of the Quimper Sandstone. *M. dalli* may be a subspecies of *M. gabbi,* although the ornamentation and relative proportions of the available material are sufficient to distinguish the two.

MATERIAL STUDIED: 3 specimens.

HYPOTYPE: UO 27399.

LOCALITIES: 2, 31, 47.

Family Neptuneidae

Genus *BRUCLARKIA* Trask, 1926

TYPE: By original designation, *Clavella gravida* Gabb.

Bruclarkia is one of a number of genera which appeared suddenly on the Pacific Coast during the Oligocene. The group underwent rapid speciation and is represented in many formations by large numbers of individuals. *Bruclarkia* is present to a limited extent in the Miocene, becoming extinct before the end of the epoch.

Bruclarkia vokesi Hickman, n. sp.

Pl. 13, figs. 6, 7, 8, 9, 10,11

DESCRIPTION: Shell moderately large with an elevated spire of five to six whorls in mature individuals; spiral angle averages 60°; body whorl large and characteristically ornamented by three spiral rows of about 15 prominent nodes which are aligned vertically; middle row of nodes situated closer to anterior row than to posterior row; spiral ornamentation of fine threads in several ranks, varying from specimen to specimen; sutural collar broad and overlapping, covering two anterior node rows leaving posterior row barely exposed on whorls of spire; sides of whorls merge evenly with upper portion of body whorl to produce smooth profile in most specimens; some specimens have concave area between suture and first node row on body whorl; growth lines moderately prominent and irregularly spaced with marked sinuousity where they cross sutural collar; canal relatively short, wide, and slightly recurved, broken on most specimens; outer lip thin, inner lip smooth and lightly callused. Dimensions of holotype: height 40.5 mm, maximum diameter 24 mm.

B. vokesi resembles *B. columbianum* (Anderson and Martin). *B. columbianum* typically has a shorter spire with a wide spiral angle, about 80°, and a stouter body whorl. The sculpture pattern and arrangement of nodes is great-

PLATE 13

Figure 1. *Molopophorus dalli* Anderson and Martin
Height 33 mm, maximum diameter 20 mm. Loc. 2. UO 27399.

Figure 2-5. *Molopophorus fishii* (Gabb)
2. Height 28 mm, maximum diameter 15 mm. Loc. 23. UO 27394.
3. Height 22 mm, maximum diameter 13.5 mm. Loc. 3. UO 27395.
4, 5. Height 19 mm, maximum diameter 13.5 mm. Loc. 5. UO 27396.

Figure 6-11. *Bruclarkia vokesi* Hickman, n. sp.
6. Holotype. Height (incomplete) 40.5 mm, maximum diameter 24 mm. Loc. 28. UO 27400.
7, 8. Paratype. Height (incomplete) 32 mm, maximum diameter 22 mm. Loc. 28. UO 27401.
9, 10. Paratype. Height (incomplete) 36 mm, maximum diameter 24.5 mm. Loc. 28. UO 27402.
11. Paratype. Height (incomplete) 30 mm, maximum diameter 21.5 mm. Loc. 29. UO 27403.

Figure 12, 13. *Bruclarkia columbianum* (Anderson and Martin)
12. Height (incomplete) 30 mm, maximum diameter 23 mm. Loc. 12. UO 27415.
13. Height (incomplete) 26 mm, maximum diameter 20.5 mm. Loc. 28. UO 27416.

Figure 14, 15. *Perse lincolnensis* (Van Winkle)
Height 34.5 mm, maximum diameter (incomplete) 19 mm. Loc 28. UO 27417.

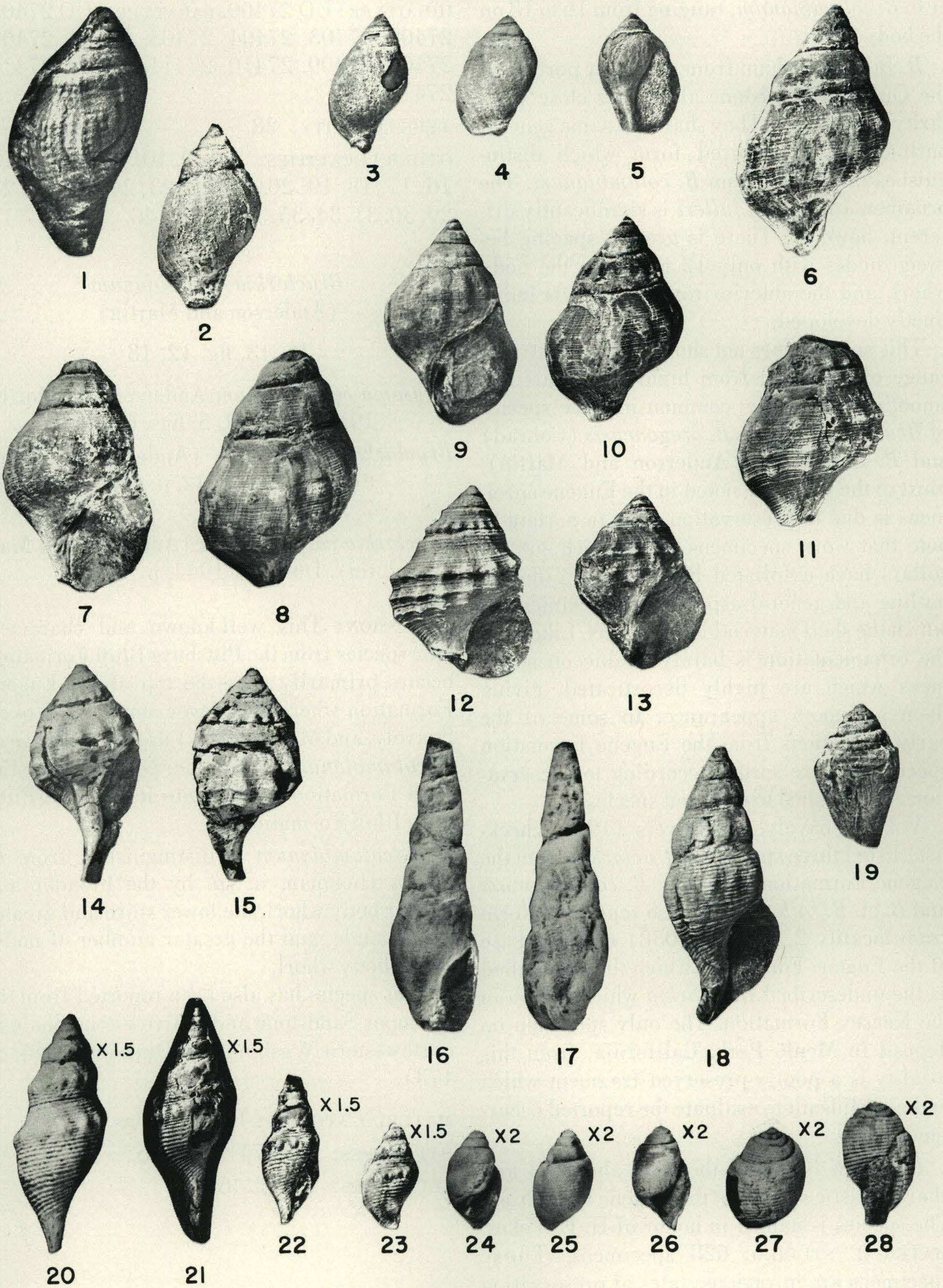
Figure 16, 17. *Exilia lincolnensis* (Weaver)
Height 46 mm, maximum diameter 14 mm. Loc. 12. UO 27418.

Figure 18. *Priscofusus* n. sp.?
Height 46 mm, maximum diameter 19 mm. Loc. 26. UO 27419.

Figure 19. *Conus* ? sp.
Height (incomplete) 22 mm, maximum diameter 13.5 mm. Loc. 11. UO 27420.

Figure 20-23. *Gemmula bentsonae* Durham
20. Height 25 mm, maximum diameter 9.5 mm. Keasey Fm. UO 27424.
21. Height 23.5 mm, maximum diameter 8 mm. Loc. 28. UO 23421.
23. Height (incomplete) 10.5 mm, maximum diameter 6 mm. Loc. 29. UO 27423.

Figure 24-28. *Acteon parvum* Dickerson
24, 25. Height 7.9 mm, maximum diameter 4.5 mm. Loc. 29. UO 27232.
26. Height 8 mm, maximum diameter 4.5 mm. Loc. 29. UO 27233.
27. Height (distorted) 6 mm, maximum diameter (distorted) 6 mm. Loc. 12. UO 27234.
28. Height 8.5 mm, maximum diameter (distorted) 6 mm. Loc. 12. UO 27235.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er in *B. columbianum*, ranging from 16 to 18 on the body whorl.

B. fulleri Durham from the lower portion of the Quimper Sandstone also bears close similarity to *B. vokesi*. They share the same general outline and high-spired form which distinguishes them both from *B. columbianum*. The ornamentation in *B. fulleri* is significantly different, however. There is greater spacing between nodes with only 12 nodes on the body whorl, and the anterior row of nodes is indistinctly developed.

This species does not show the same extreme range of variation from highly sculptured to smooth forms that is common in some species of *Bruclarkia* such as *B. oregonensis* (Conrad) and *B. barkeriana* (Anderson and Martin). Most of the variation noted in the Eugene specimens is due to preservation. It is important to note that worn specimens from which sutural collars have exfoliated have a very different outline and general aspect from specimens in which the shell material is still intact. Likewise, the ornamentation is barely visible on specimens which are highly decorticated, giving them a smooth appearance. In some of the early collections from the Eugene Formation specimens were sorted according to preservation and assigned to different species.

Vokes, Snavely, and Myers (1951, checklist) listed three species of *Bruclarkia* from the Eugene Formation including *B. columbianum* and *B.* cf. *B. fulleri*. They also reported a form from locality 2 (USGS 17038) near the base of the Eugene Formation which they identified as the undescribed *Bruclarkia* which occurs in the Keasey Formation. The only specimen on deposit in Menlo Park, California, from this locality is a poorly-preserved fragment which makes it difficult to evaluate the reported occurrence.

B. vokesi is one of the most abundant and characteristic species in the Eugene Formation. The species is named in honor of H. E. Vokes.

MATERIAL STUDIED: 628 specimens. These specimens are in various states of preservation as described above.

HOLOTYPE: UO 27400. PARATYPES. UO 27401, 27402, 27403, 27404, 27405, 27406, 27407, 27408, 27409, 27410, 27411, 27412, 27413, 27414.

TYPE LOCALITY: 28.

OTHER LOCALITIES: 3, 5, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 34, 35, 37, 38, 39, 40.

Bruclarkia columbianum
(Anderson and Martin)

Pl. 13, fig. 12, 13

Agasoma columbianum Anderson and Martin, 1914, p. 73, pl. 5, figs. 6a, 6b.

Bruclarkia columbiana (Anderson and Martin). Weaver, 1942, p. 443, pl. 87, figs. 7, 8.

Bruclarkia columbianum (Anderson and Martin). Durham, 1944, p. 173.

DISCUSSION: This well-known and characteristic species from the Pittsburg Bluff Formation occurs primarily near the top of the Eugene Formation where it is never abundant. Vokes, Snavely, and Myers (1951) use the presence of *B. columbianum* in the upper portion of the Eugene Formation to correlate it with the Pittsburg Bluff Formation.

B. columbianum is distinguished from *B. vokesi* Hickman, n. sp. by the broader and stouter body whorl, the lower spire and greater spiral angle, and the greater number of nodes on the body whorl.

This species has also been reported from the Quimper Sandstone and Marrowstone Shale in northwestern Washington (Durham, 1944, p. 173).

MATERIAL STUDIED: 14 specimens.

HYPOTYPES: UO 27415, 27416.

LOCALITIES: 12, 28, 46, 47.

Family Fasciolariidae

Genus *PERSE* Clark, 1918
(= *WHITNEYELLA* Stewart,1927)

TYPE: By original designation, *Perse corrugatum* Clark.

Perse lincolnensis (Van Winkle)
Pl. 13, figs. 14, 15

Hemifusus lincolnensis Van Winkle, 1918, p. 89, 90, pl. 7, fig. 10.

Whitneyella lincolnensis (Van Winkle). Tegland, 1933, pl. 12, fig. 13; Weaver, 1942, p. 476-477, pl. 91, figs. 6, 13, 14, pl. 103, fig. 20.

Perse lincolnensis (Van Winkle). Clark, 1938, p. 719; Durham, 1944, p. 174.

DISCUSSION: *Perse lincolnensis* is a distinctive species which is well known from abundant well-preserved specimens from the Lincoln Formation. The shell is fusiform with an acute spire and a moderately long and slightly reflexed anterior siphonal canal. The ornamentation consists of a series of about 12 longitudinal ribs on the central portion of the body whorl. The ribs are crossed by fine spiral threads of several strengths. Three particularly prominent threads produce nodes where they cross the longitudinal ribs. The callus on the inner lip is well developed in this species and obscures a portion of the sculpture on the body whorl.

The pattern of nodes on the body whorl in *P. lincolnensis* is similar to the pattern on *Bruclarkia vokesi* Hickman, n. sp. *P. lincolnensis* has a much narrower form, and the longer narrower canal which is characteristic of the genus. Moore (1963, p. 35) noted this same similarity of ornamentation in the highly sculptured form of *Bruclarkia oregonensis* (Conrad) and *Perse washingtonensis* Weaver.

P. lincolnensis is not common in the Eugene Formation, although decorticated specimens with broken canals could not be separated from similarly-preserved specimens of *Bruclarkia*. Vokes, Snavely, and Myers (1951, checklist) reported this species from several localities in the Eugene Formation. It has also been recorded from the Toledo and Tunnel Point Formations in Oregon.

MATERIAL STUDIED: 6 specimens.
HYPOTYPE: UO 27417.
LOCALITIES: 26, 28.

Family Fusinidae

Genus *EXILIA* Conrad, 1860

TYPE: By monotypy, *Exilia pergracilis* Conrad.

Exilia lincolnensis Weaver
Pl. 13, figs. 16, 17

Exilia lincolnensis Weaver, 1916, p. 5, 30, 51, pl. 4, figs. 49, 50; Van Winkle, 1918, p. 76; Tegland, 1933, p. 126, pl. 10, figs. 15-17; Bentson, 1940, p. 217-218, pl. 1, fig. 20, pl. 3, figs. 2, 7, 13; Weaver, 1942, p. 514-515, pl. 96, fig. 30; Durham, 1944, p. 187.

Fusinus (Exilia) lincolnensis (Weaver). Clark, 1918, p. 178, pl. 23, fig. 10.

Fusinus (Exilia) aff. *lincolnensis* (Weaver). Wagner and Schilling, 1923, p. 260.

Exilia sp., Schenck, 1936, p. 71.

DISCUSSION: Three fragmentary and badly decorticated specimens of an *Exilia* from the Eugene Formation are comparable to *E. lincolnensis*. One specimen retains several patches of shell material on which the faint spiral ribbing and dominant axial ribbing are preserved. The axial ribs are enlarged to nodes on the posterior half of the whorls, which according to Bentson (1940, p. 217) differentiates *E. lincolnensis* from all other West Coast species of *Exilia*.

A fourth specimen from the Eugene Formation is in the Schenck collection at Stanford University in his lot number 659 from the junction of the North and South Forks of the Santiam River in the Albany Quadrangle. Bentson (1940, p. 218) tentatively identified this specimen as *E. lincolnensis* on the basis of "a faint suggestion of nodes on the body whorl."

Exilia is nowhere abundant in the Pacific

Coast Tertiary, and the fragmentary material from the Eugene Formation is typical of the occurrence of this poorly-known genus. Although it is not abundant, *Exilia lincolnensis* is a widespread species, occurring in a number of lower and middle Oligocene formations in Washington, Oregon, and California.

HYPOTYPE: UO 27418.

LOCALITIES: 12, 27, 28.

Genus *PRISCOFUSUS* Conrad, 1865

TYPE: By subsequent designation (Cossmann, 1901), *Fusus geniculus* Conrad.

Priscofusus is an endemic Pacific Coast genus which occurs in the Oligocene and Miocene of Washington, Oregon, and California. There has been much confusion over the designation of the type species and the characteristics and family affinities of the genus, and the species which belong in this taxon were originally described under a variety of generic names. Grant and Gale (1931, p. 490-492) and Moore (1963, p. 39-40) present helpful discussions and resolutions of some of these problems.

Priscofusus n. sp. ?

Pl. 13, fig. 18

DISCUSSION: *Priscofusus* n. sp. ? is represented by a single specimen from locality 26. The elongate fusiform shell has a height of 46 mm and a maximum diameter of 19 mm. The spire is moderately elevated, and anterior canal is strongly recurved. The shell is sculptured by well-developed spiral ribs of varying prominence with a tendency toward alternation of strong and weak ribs on the canal. The axial sculpture consists of elongated, somewhat irregular nodes which give the upper portions of the body whorl a wrinkled appearance. The nodes are more regular on the whorls of the spire and are most prominent below the midpoint of the whorl. It is probable that this form represents a new species, but is seems best to withhold a name until additional material is available.

P. chehalisensis (Weaver), the well-known middle and late Oligocene species, is larger and more slender with a higher spire, a longer but less recurved anterior canal, and more pronounced axial nodes which tend to form slightly curved ridges. *P. stewarti* (Tegland), a late Oligocene species, is typically smaller with a straighter canal and more prominent axial sculpture on the body whorl. *P. hannibali* (Clark and Arnold), another late Oligocene species, is differentiated by the regular alternation of primary and secondary spiral ribs.

FIGURED SPECIMEN: UO 27419.

Family Conidae

Genus *CONUS* Linné, 1758

TYPE: By subsequent designation (Children, 1823), *Conus marmoreus* Linné.

Conus ? sp.

Pl. 13, fig. 19

DISCUSSION: A single poorly-preserved biconical shell collected at locality 11 is probably a *Conus*. The outer lip and base of the specimen are missing, and there is no shell material remaining; but there is some suggestion of a slit-like aperture, and the elongate straight-sided body whorl tapers evenly from the shoulder toward the anterior extremity. *Conus* was one of the first of the characteristically tropical genera to disappear during the Oligocene. It is common in the Eocene, and in Oregon it persisted in the Keasey seas of the early Oligocene. Although its occurrence would be noteworthy, it is not unlikely that small populations could have survived in the Eugene seas.

FIGURED SPECIMEN: UO 27420.

Family Turridae

Subfamily Turrinae

Genus *GEMMULA* Weinkauff, 1876

TYPE: By subsequent designation (Cossmann, 1896), *Pleurotoma gemmata* Hinds.

Gemmula is best represented today in warm waters of the Indo-Pacific. It is not common in the Pacific Coast Tertiary.

Gemmula bentsonae Durham

Pl. 13, figs. 20, 21, 22, 23

Gemmula bentsonae Durham, 1944, p. 184, pl. 14, figs. 14, 17.

DISCUSSION: *Gemmula bentsonae* has an elongate fusiform shell with a tall spire of five to six whorls and a long, narrow, straight anterior canal which is usually broken off. The peripheral keel is beaded or gemmate as in all members of the genus, imparting a distinct angulation to the whorls. There are generally 12 prominent nodes on the keel of the body whorl. The posterior anal sinus is shallow for the genus and V-shaped as indicated by the incurving of growth lines as they cross the peripheral keel. The whorls are sculptured with spiral ribs alternating with interspaces of about equal width. The five ribs on the peripheral keel are narrower and more closely spaced than elsewhere on the shell and persist across the nodes. There are three or four spiral ribs between the keel and the suture. The sutural collar is faintly beaded.

G. bentsonae was described from the lower portion of the Quimper Sandstone in northwestern Washington. Specimens from the Eugene Formation agree closely with the holotype except for the number and prominence of the nodes on the peripheral keel. There are 15 nodes on the holotype as compared to 12 on the majority of Eugene specimens, but this difference may not be significant.

The author has collected large numbers of *G. bentsonae* in the Keasey Formation which contains an unusually rich fauna of turrid gastropods. This species is abundant and exceptionally well preserved in the Keasey and is figured here for comparison (pl. 13, fig. 20). As in the Eugene Formation, specimens typically have 12 nodes on the body whorl.

G. bentsonae is most abundant in the layers of concentrated shell material in the Eugene area. Specimens are typically small in these layers and evidently have been overlooked by previous collectors since no turrid gastropod appears on any of the species lists for the formation. Poorly preserved fragments of larger specimens are occasionally found at other localities in the formation.

MATERIAL STUDIED: 39 specimens.

HYPOTYPES: UO 27421, 27422, 27423, 27424, 27425, 27426, 27427, 27428, 27429, 27430, 27431.

LOCALITIES: 11, 12, 13, 14, 25, 27, 28, 29, 40.

Superfamily SCAPHANDRACEA

Family Acteonidae

Genus *ACTEON* Montfort, 1810

TYPE: By monotypy, *Voluta tornatilis* Gmelin.

Acteon parvum Dickerson

Pl. 13, figs. 24, 25, 26, 27, 28

Acteon parvum Dickerson, 1917, p. 172, pl. 29, figs. 12a, 12b; Effinger, 1938, p. 387, pl. 47, fig. 2; Weaver, 1942, p. 543-544, pl. 99, figs. 30, 31; Durham, 1944, p. 190.

DISCUSSION: *Acteon parvum* is a small ovate species with a large, cylindrical body whorl and short spire. The suture is distinct and slightly channeled. The aperture is long and narrow, widening below. The inner lip is lightly callused, and the columella bears a small plication which is characteristic of the genus; the outer lip is thin and simple. The surface of the body whorl bears an average of 19 or 20 low flat spiral ribs separated by fine, lightly incised grooves.

A. parvum is probably closely related to *A. chehalisensis* (Weaver) from the Washington Oligocene. *A. parvum* is distinguished by a relatively wide body whorl and lower spire as well as fewer spiral ribs. *A. parvum* seems to occur in older beds than *A. chehalisensis*.

A. parvum occurs in the fine-grained tuffaceous siltstone units in the Eugene area. It is most abundant in layers of concentrated small shell

PLATE 14

Figure 1-3. *Scaphander stewarti* Durham

1. Height 12 mm, maximum diameter 7 mm. Pittsburg Bluff Fm. UO loc. 2567. UO 27446.
2. Height 7 mm, maximum diameter 4 mm. Loc. 29. UO 27443.
3. Height 9 mm, maximum diameter 5 mm. Loc. 29. UO 27444.

Figure 4-6. *Cylichnina turneri* Effinger

4. Height 9 mm, maximum diameter 3.5 mm. Loc. 29. UO 27439.
5. Height 7 mm, maximum diameter 3 mm. Loc. 29. UO 27440.
6. Height 5 mm, maximum diameter 2 mm. Loc. 29. UO 27442.

Figure 7. Terebratulid brachiopod

Maximum preserved length 18.5 mm. Loc. 34. Stanford Univ. NP 93.

Figure 8, 9, 11. *Balanus* sp. (p. 166)

8. Loc. 27. UO 27450.
9. Loc. 27. UO 27454.
11. Loc. 12. UO 27456.

Figure 10. *Aturia angustata* (Conrad)

Specimen from private collection of Clifford Davis, Springfield, Oregon.

Figure 12. Galeoid shark tooth

Loc. 27. UO 27449.

Figure 13. Hexanchoid shark tooth

Loc. 27. UO 1260.

Figure 14. Kewia n. sp. ?

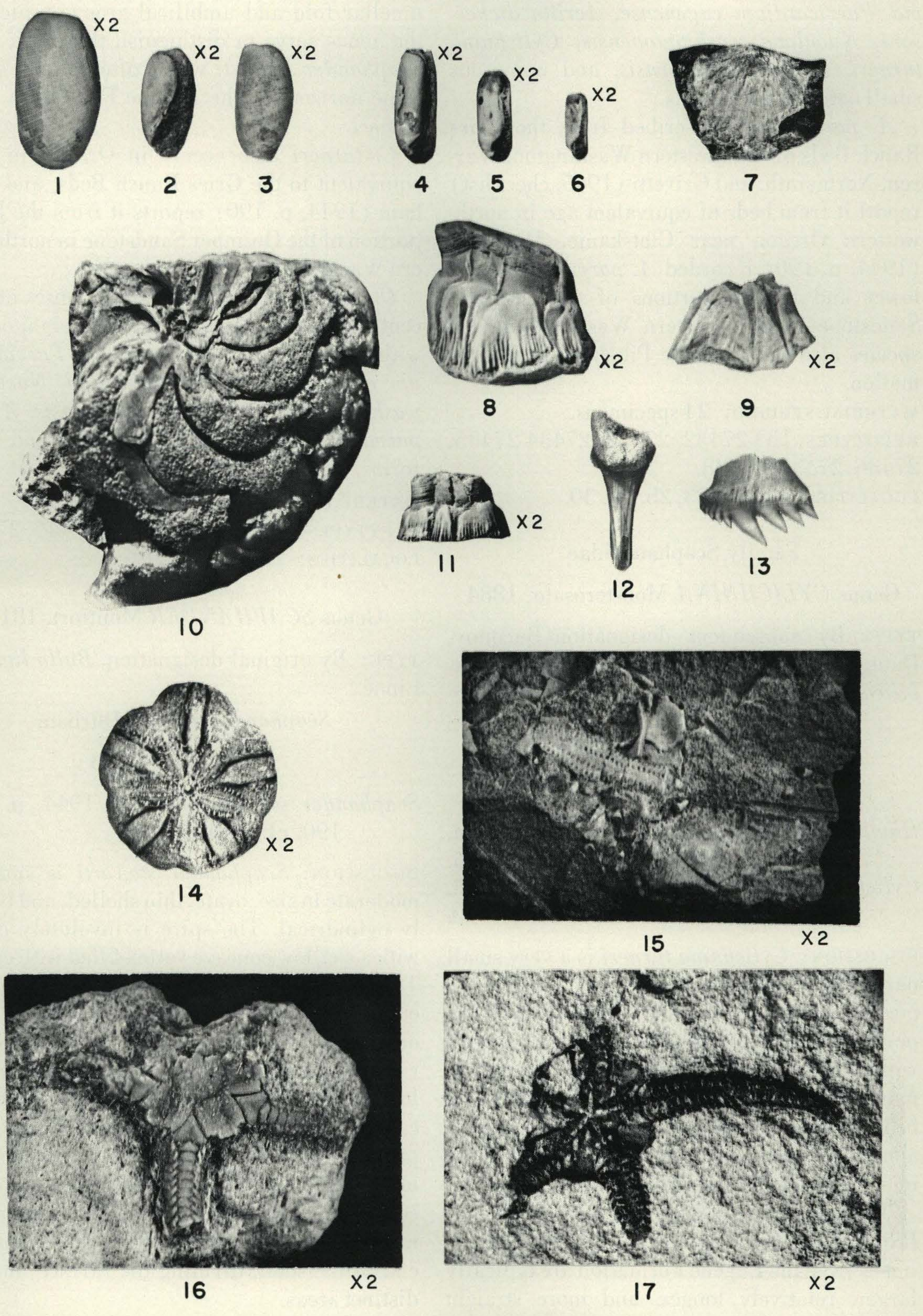
Maximum diameter 14 mm. Loc. 10. UO 27453.

Figure 15. Echinoid fragments—*Salenia schencki* Kaar?

Loc. 19. UO 27451-a.

Figure 16, 17. Ophiuroids

16. Loc. 42. UO 27455.
17. Specimen from private collection of L. W. Staples, Eugene, Oregon.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material along with *Acila nehalemensis minima*, *Parvicardium eugenense*, *Acrilla dickersoni*, *Nuculana washingtonensis*, *Cylichnina turneri*, *Dentalium laneensis*, and numerous small naticoid gastropods.

A. parvum was described from the Gries Ranch Beds of southwestern Washington. Warren, Norbisrath, and Grivetti (1945, checklist) report it from beds of equivalent age in northwestern Oregon near Clatskanie. Durham (1944, p. 190) recorded *A. parvum* from the lower and middle portions of the Quimper Sandstone in northwestern Washington. This species also occurs in the Pittsburg Bluff Formation.

MATERIAL STUDIED: 24 specimens.

HYPOTYPES: UO 27432, 27433, 27434 27435, 27436, 27437, 27438.

LOCALITIES: 12, 18, 23, 25, 29, 30.

Family Scaphandridae

Genus *CYLICHNINA* Monsterosato, 1884

TYPE: By subsequent designation(Bucquoy, Dautzenberg, and Dollfus, 1886), *Bulla umbilicata* Montagu.

Cylichnina turneri Effinger

Pl. 14, figs. 4, 5, 6

Haminea cf. *petrosa* (Conrad). Dickerson, 1917, p. 160; Van Winkle, 1938, p. 76.
Cylichnina turneri Effinger, 1938, p. 387-388, pl. 47, fig. 3; Durham, 1944, p. 190.

DISCUSSION: *Cylichnina turneri* is a very small narrowly-cylindrical species with a truncate posterior end and involute spire. The apex is perforate. The aperture is long and narrow with a small anterior dilation. The columella is marked by a basal fold with a conspicuous umbilical groove and partially open umbilicus above. The almost smooth shell is marked by numerous fine, lightly-incised, spiral striae.

This species was described from the Gries Ranch Beds of southwestern Washington. Specimens from the Eugene Formation are typically larger, relatively longer, and more straight sided, but they agree in other details. The columellar fold and umbilical groove typical of the genus serve to distinguish this form from *Scaphander stewarti* which often occurs at the same horizons in the Eugene Formation as *C. turneri.*

C. turneri also occurs in Oregon in beds equivalent to the Gries Ranch Beds, and Durham (1944, p. 190) reports it from the lower portion of the Quimper Sandstone in northwestern Washington.

C. turneri occurs primarily in lenses of concentrated small shells. In these layers it occurs with *Acila nehalemensis minima*, *Parvicardium eugenense*, *Acrilla dickersoni*, *Nuculana washingtonensis*, *Dentalium laneensis*, *Acteon parvum*, small naticoid gastropods, and other forms.

MATERIAL STUDIED: 32 specimens.

HYPYTYPES: UO 27439, 27440, 27441, 27442.

LOCALITIES: 25, 27, 28, 29.

Genus *SCAPHANDER* Montfort, 1810

TYPE: By original designation, *Bulla lignaria* Linné.

Scaphander stewarti Durham

Pl. 14, figs. 1, 2, 3

Scaphander stewarti Durham, 1944, p. 189-190, pl. 14, fig. 15.

DISCUSSION: *Scaphander stewarti* is small to moderate in size, ovate, thin shelled, and broadly cylindrical. The spire is involutely coiled with a shallow concave vertex filled with callus. The aperture is narrow above, gradually widening until broadly expanded anteriorly. The outer lip is slightly carinate at the apex and rises upward from the depressed spire; the lower portion of the inner lip bears a thin rim of callus which disappears posteriorly under the parietal wall. The ornamentation consists of low, flat, spiral ribs separated by alternating coarse and fine incised grooves. On some specimens the fine grooves occur only on the anterior end of the shell, dividing the surface into two distinct areas.

S. stewarti was described from the Quimper Sandstone in northern Washington, and Durham (1944, p. 190) cites it from his *Molopophorus stephensoni, Molopophorus gabbi,* and *Turritella olympicensis* Zones. It is closely related to *S. washingtonensis* Weaver from the type Lincoln Formation of southwestern Washington and differs chiefly in the marked upward flair of the outer lip above the apical depression.

S. stewarti has also been reported from the Keasey and Pittsburg Bluff Formations in northwestern Oregon as well as from the Gries Ranch Beds of Oregon (Warren, Norbisrath, and Grivetti, 1945, checklist). A number of well-preserved specimens were collected in the Pittsburg Bluff Formation in conjunction with the preparation of this report (pl. 14, fig. 1).

This species is not common throughout the Eugene Formation, but it is locally abundant in lenses of concentrated small shell material. *S. stewarti* is readily distinguished from *Cylichnina turneri* by its broader form, lack of apical perforation, and lack of both columellar fold and umbilical groove.

MATERIAL STUDIED: 18 specimens from the Eugene Formation. 14 specimens from the Pittsburg Bluff Formation.

HYPOTYPES: UO 27443, 27444, 27445, 27446, 27447.

LOCALITIES: 25, 28, 29, 35, 39, 42. UO locality 2567.

CEPHALOPOD

Family Nautilidae

Subfamily Aturinae

Genus *ATURIA* Bronn, 1838

TYPE: By tautonymy, *Nautilus aturi* Basterot.

Aturia angustata (Conrad)

Pl. 14, fig. 10

Nautilus angustatus Conrad, 1849, p. 728, pl. 20, figs. 5, 6.

Aturia angustata (Conrad). Schenck, 1931, p. 457-462, pl. 69, figs. 1-3, pl. 70; figs. 1-5, pl. 71, figs. 1, 3-8, pl. 72, figs. 1, 2, 5, 6, text figs. 4, 5, 7, 9, 20-23, 30, 33 (Synonymy); Miller, 1947, p. 85-88, pl. 48, figs. 5, 6, pl. 88, fig. 1, pl. 90, figs. 1-3, pl. 91, figs. 1 ,2, pl. 92, figs. 1, 2, 8, 9, pl. 93, figs. 3, 4 (Synonymy).

DISCUSSION: Because post-Triassic nautiloids are extremely rare this species has attracted a great deal of interest. *Aturia angustata* has been described and discussed in detail by Schenck (1931, p. 457-462) and Miller (1947, p. 85-88).

A. angustata was originally described more than a century ago from the Astoria Formation in Oregon. It has been collected since that time from a number of Oligocene and Miocene localities in Washington and California as well as Oregon. Dall (1909, p. 8-9) considered *A. angustata* an Oligocene species and referred the "Aturia bed" at Astoria to the Oligocene. Schenck (1923, p. 68) used the occurrence of a single specimen of *A. angustata* in the Eugene Formation as one of the strongest points in his circular argument to prove that the Oligocene did exist in Oregon.

Schenck later assigned all Oligocene and Miocene representatives of *Aturia* from strata on the Pacific Coast to *A. angustata* in his monograph of the genus (1931). At this time he described and figured the specimen from the Eugene Formation, a well-preserved juvenile individual which is now apparently lost. The specimen, Condon Museum plesiotype no. 50, UO locality 80, could not be located either at the University of Oregon or at Stanford University where Schenck made the study. A topotype of *A. angustata,* which was figured in the same report (1931, pl. 69, fig. 3), as UO neotype no. 77, is also missing.

A fragmentary specimen of *A. angustata* in the general collections at the University of Oregon is probably from the Eugene Formation. The locality for the specimen, UO 1420, is documented as follows: "Basal Astoria Formation, Miocene, College Crest Reservoir." College Crest Reservoir, also known as College

Hill or Reservoir Hill, is a well-known locality within the Eugene city limits, and the matrix on the specimen appears to be the same as that adhering to other fossils from that locality.

A. angustata has been reported by a number of amateur collectors from outcrops of the Eugene Formation in the Eola Hills northwest of Salem. The specimens are preserved as opalized internal molds which are found in freshly-plowed fields along with opalized molds of *Pitar*. One such specimen of *A. angustata* from the collection of Clifford Davis of Springfield, Oregon, is figured in this report (pl. 14, fig. 10). A subsequent search of several localities in the Salem area has yielded four poorly-preserved fragments.

MATERIAL STUDIED: 6 specimens, all of which are incomplete.

HYPOTYPE: UO 1420.

LOCALITIES: 4, 27, 44.

FOSSILS OTHER THAN MOLLUSKS

Although the purpose of this paper is to describe and analyze the molluscan fauna of the Eugene Formation, there are a number of nonmolluscan elements in the fauna which deserve some discussion in the interest of completeness.

FORAMINIFERA

The Foraminifera of the Eugene Formation are being collected and studied by W. N. Orr, and I am indebted to him for the following information.

Samples have been processed from a number of horizons at locality 27 near the top of the Eugene and from outcrops at and in the vicinity of localities 12 and 13 farther down in the formation. A sample has also been processed from locality 40 south of Salem. The samples contain a diverse but poorly-preserved fauna of benthonic Foraminifera with a predominance of miliolids, arenaceous forms, and certain of the Nonionidae, notably *Elphidium*. All specimens have completely filled tests, and in forms which have the test wall intact as unaltered calcite, there are usually signs of wear or abrasion. The diversity and composition of this fauna as well as its mode of preservation are in keeping with the interpretations of the overall ecological setting at the time of deposition which is discussed earlier in this report.

The following benthonic Foraminifera have been identified in samples from the Eugene Formation: *Ammobaculites* spp., *Bathysiphon* sp., *Bolivina* spp., *Bulliminella* spp., *Cibicides* sp., *Discorbis* sp., *Elphidium* spp., *Eponides* sp., *Glandulina* sp., *Globobulimina* sp., *Guttilina* sp., *Gryodina* sp., *Lenticulina* spp., *Nodosaria* sp., *Nonion* spp., *Nonionella* spp., *Planulina* sp., *Quinqueloculina* spp., *Virgulina* sp.

The benthonic fauna listed above is similar to the fauna contained in portions of the lower Oligocene Bastendorf Formation which underlies the middle Oligocene Tunnel Point Formation at Coos Bay, Oregon. This similarity does not necessarily imply synchrony of the units, however, so much as it indicates similarity of dept or climate

BRACHIOPODS

Two poorly-preserved terebratulid brachiopods are in the collections of Arnold and Hannibal from Locality NP 93 at Stanford University. One of the specimens (pl. 14, fig. 7) is similar in appearance to the subspecies of *Terebratalia transversa* (Sowerby) figured by Clark and Arnold (1923, pl. 32, fig. 4) from the Sooke Formation, but it is not well enough preserved for positive identification.

DECAPODS

The Eugene Formation contains a diverse fauna of well-preserved decapod crustaceans which were originally described and figured by Rathbun (1926). Of the 11 species which she reported 9 were described as new. The following seven species were based on holotypes from the Eugene Formation: *Zanthopsis hendersonianus*, *Persephona bigranulata*, *Calapa lanensis*, *Palehomola gorelli*, *Rani-*

noides washburnei, Raninoides eugenensis, and *Raninoides fulgidus. Zanthopsis vulgaris* and *Portunites alsakensis* were both based on material from a variety of Oligocene localities on the West Coast in addition to the Eugene Formation. *Callianassa oregonensis* Dana and *Graptocarcinus* (?) sp. were also reported from the Eugene Formation.

J. Dale Nations at the University of California is presently reexamining the fossil decapods of the Pacific Coast and has kindly supplied the following tentative identifications of specimens collected at locality 27 where crab-bearing concretions are particularly abundant: *Plagiolophus weaveri* Rathbun, *Portunites insculpta* Rathbun, *Raninoides fulgidus* Rathbun, *Callianassa oregonensis* Dana, and *Callianassa* sp. (not *C. oregonensis*).

BARNACLES

A number of small barnacles of the genus *Balanus* are in the collections from the Eugene Formation (pl. 14, figs. 8, 9, 11). A specimen consisting of 23 individuals crowded together in honeycomb fashion was collected at locality 47 northwest of Salem. Fragments of wood adhere to the bases of a number of the individuals, suggesting that they were cemented to floating wood in life. All other specimens were found singly and unattached. Although balanid barnacles are commonly thought of as inhabitants of the high intertidal zone, some species are adapted to life at great depths, and the presence of *Balanus* in the Eugene fauna does not necessarily have any ecological significance.

OSTRACODS

W. N. Orr (personal communication, 1968) reports that ostracod carapaces are rare but scattered throughout the samples he has prepared from the Eugene Formation.

ECHINOIDS

Identifiable echinoids are not common in the Eugene Formation, although the occurrence of spines indicates that they were present in the fauna. Associated plates and spines of a crushed stirodont echinoid were collected at locality 19. Carol Wagner Allison at the University of California has examined these fragments and believes that they are probably referrable to *Salenia schencki* Kaar (in Zullo, Karr, Durham, and Allison, 1964, p. 343). This species was described from exposures of the Keasey Formation along the west bank of the Nehalem River near Mist, Oregon, where large numbers of crushed specimens with articulated spines are associated with the well-known Keasey crinoids of the genus *Isocrinus*. *S. schencki* is the only representative of this genus known from the Tertiary of the Pacific Coast of North America. The five living members of the genus are widely spaced geographically and occur at depths ranging from 50 to 250 fathoms (Zullo, Kaar, Durham, and Allison, 1964, p. 331-332). The Eugene specimen is figured on plate 14, figure 15.

Small scutellinid echinoids of the genus *Kewia* (Nisiyama) were reported from the Eugene Formation by Durham (1957, p. 630) as *Kewia* sp. indet. The specimen figured by Durham (pl. 72, fig. 3) was collected by Thomas Condon from near the top of the Eugene Formation, and 3 other specimens examined by Durham came from lower in the formation. None of these specimens was well-enough preserved to compare with other species in the genus.

A number of specimens of this form were collected recently at locality 10 (pl. 14, fig. 14). Carol Wagner Allison is currently working on this group of echinoids of the Pacific Coast and has kindly supplied the following information on several specimens from locality 10: "This little sand dollar is reminiscent of *Kewia newcombei* (Kew) in some respects but is not strikingly similar. . . . I suspect it should be considered a new species."

OPHIUROIDS

Ophiuroids are rare in the Tertiary of the Pacific Coast and are seldom well-enough preserved to classify. Two brittle stars have been collected in the Eugene Formation. One specimen comes from locality 42 in the Salem Quadrangle (pl. 14, fig. 16) and preserves most of the aboral surface of the disk and portions of the arms. The other specimen (pl. 14, fig. 17) is from the property of L. W. Staples in the upper portion of the same light-colored tuff that crops out at locality 12. This specimen consists of both the negative and positive impressions of the oral surface of the disk and portions of the arms.

FISH REMAINS

Shark teeth are occasionally found in the Eugene Formation. The teeth represent two major groups of sharks. The single cusps are typical of the modern galeoid type of shark (pl. 14, fig. 12) and the saw-like teeth typical of the primitive hexanchoid genus *Hexanchus* (*Notidanus*) (pl. 14, fig. 13). Both of these groups are abundantly represented by teeth in Tertiary marine deposits, although they are not well known from the Pacific Coast.

FOSSIL PLANTS

Fragments of carbon and fossil wood are common throughout the Eugene Formation, and leaves and leaf fragments are occasionally associated with marine fossils. The most common occurrences of fossil wood are those which have been bored by clams of the genus *Martesia.*

The Eugene Formation interfingers to the south with non-marine tuffaceous beds which have yielded several floras of somewhat different ages. The best known of these floras is the Goshen flora. Chaney and Sanborn (1933, p. 4) suggest that the Goshen flora lies stratigraphically below the Eugene Formation, although subsequent workers (Turner, 1938, p. 25-26; Vokes and Snavely, 1948, p. 39-40) indicate that the two may be contemporaneous. Tuffaceous beds north of the Goshen plant locality contain a flora which Brown (in Vokes, Snavely, and Myers, 1951) considers late Oligocene and younger than the Eugene Formation and Goshen flora.

Clarification of the relationship of the Eugene Formation to the non-marine plant-bearing beds has been complicated by the paucity of outcrops and cover of alluvium and post-Eocene basalt flows in the area south of Eugene. It is beyond the scope of the present work to evaluate the stratigraphic relationship of the Eugene Formation and the Fisher or Fisher-like beds to the south, but it is important to note that the question has become controversial among stratigraphers and paleobotanists. Marine molluscan faunas and Tertiary floras have not been correlated successfully, and clarification of the problem awaits the discovery of some fossil group such as pollen which migh occur in both formations.

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APPENDIX A

Appendix A is a list of the localities from which material has been examined during the course of this study. The following abbreviations have been used: UO, University of Oregon; UC, University of California; CAS, California Academy of Sciences; USGS, United States Geological Survey Cenozoic locality; and NP, Stanford University Northern Pacific locality. Locality descriptions are general and do not include the dates of the collections or names of the collectors, which in many cases are not known. For more detailed information about these localities the reader may consult the locality catalogs at the institutions where collections are housed. An asterisk (*) indicates localities which are still accessible at the time of this writing.

No. used in this report	Corresponding localities	Locality description
		Eugene Quadrangle
1	UO 172, 173 UC A-1338 USGS 17044	Outcrops on Oak Hill, SE 1/4 sec. 25, T. 17 S., R. 5 W., NE 1/4 sec. 36, T. 18 S., R. 5 W.
2	UO 17, UC 4091 USGS 17038	*Outcrops on Crabtree Hill, S 1/2 sec. 19, T. 17 S., R. 4 W.
3	UO 2530	Temporary excavation, Lorane Rd. at Em Ray Dr., Eugene, E. 1/2 sec. 12, T. 18 S., R. 4 W.
4	UO 12, 29, 127 164, 128, 129 UC 4080-4084 USGS 5425a-d, 17015, 17041, 17942	College Crest Reservoir and various localities on the flanks of College Hill, Eugene, sec. 6, T. 8 S., R. 3 W.
5	UO 2531	*Roadcut, NE corner of intersection, 26th Ave. and Washington St., Eugene, SW 1/2 sec. 6, T. 18 S., R. 3 W.
6	UO 2532	Temporary excavation, 18th Ave. and Olive St., Eugene, on section boundary between sec. 31, T. 17 S., R. 3 W. and sec. 6, T. 18 S., R. 3 W.
7	UO 2533	*South bank of Willamette River at Skinner Butte Park, Eugene, E. 1/2 sec. 30, T. 17 S., R. 3 W.
8	UO 2534 USGS 17019	*Outcrops on Gillespie Butte, Eugene, SW 1/2 sec. 19, T. 17 S., R. 3 W.
9	UO 2535	Temporary excavation, 21st Ave. and Patterson St., Eugene, NW 1/2 sec. 5, T. 18 S., R. 3 W.
10	UO 2536	Temporary cuts at 28th Ave. and Amazon Pky., Eugene, SW 1/4 sec. 5, T. 18 S., R. 3 W.
11	UO 2537	Roadcut, 38th Avenue and University St., Eugene, NW 1/4 sec. 5, T. 18 S., R. 3 W.
12	UO 2538	*Roadcut, 30th Ave. and Agate St., Eugene, NW 1/4 sec. 8, T. 18 S., R. 3 W.

13	UO 2539	*Roadcuts along southwest side of 30th Ave. NW ¼ sec. 9, T. 18 S., R. 3 W.
14	UO 2540	Excavation for Co-Op Store, 13th Ave. and Kincaid St., S. ½ sec. 32, T. 17 S., R. 3 W.
15	UO 2541	Excavation for UO Library, UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
16	UC A-980	Excavation for Murray Warner Art Museum, UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
17	UO 2542	Temporary excavation, N. side Villard Hall, UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
18	UO 2543	Excavation for Geology wing of science complex, NE corner 13th Ave. and University St., UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
19	UO 2544	Excavation for Science II Annex, UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
20	UO 2545	Excavation for Erb Memorial Student Union, UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
21	UO 2546	Excavation for Carson Hall, 13th Ave. and Emerald St., UO Campus, S. ½ sec. 32, T. 17 S., R. 3 W.
22	UO 2549	Excavation for Lew Williams Chevrolet, Franklin Blvd. and Orchard St., Eugene, SW ¼ sec. 33, T. 17 S., R 3 W.
23	UO 2550	*Beds exposed at low water, south bank Willamette River, SW ¼ NW ¼ sec. 33, T. 17 S., R. 3 W.
24	UO 10, UC 3622 CAS 237 NP 94	Smith's Quarry, Eugene, Between Millrace and Franklin Blvd., O. 7 mi. E. of BM 449, sec. 33, T. 17 S., R. 3 W.
25	UO 2551	*Outcrop beneath E. end of overpass of Franklin Blvd. over Southern Pacific Railroad tracks, SW ¼ sec. 33, T. 17 S., R. 3 W.
26	UO 2552	*Roadcut on E. side of Eugene Exit off Interstate 5, SW ¼ sec. 33, T. 17 S., R. 3 W.
27	UO 80	*Prominent cut on main line of Southern Pacific Railroad, beneath cemetery in SW ¼ sec. 34, T. 17 S., R. 3 W.
28	UO 2553	Roadcuts along Interstate 5 in NW ¼ sec. 3, T. 18 S., R. 3 W.
29	UO 2554	Layers of concentrated fossil shells in gray tuffaceous siltstone at base of hill on E. side of Interstate 5, NW ¼ sec. 3, T. 18 S., R. 3 W.
30	CAS 238	Small rock quarry at entrance to Hendrick's Park, Eugene, sec. 4, T. 18 S., R. 3 W.
31	UO 2555	Excavations for Lane Community College, SW ¼ sec. 34, T. 17 S., R. 3 W.
32	UO 24, 125 UC 64087 USGS 5422	Outcrops on S side Kelly Butte, NW ¼ sec. 34, T. 17 S., R. 3 W.

33	CAS 239	Bluff along E. side of Willamette River, 1/2 mi. S. of Springfield Butte, SW 1/4 sec. 35, T. 17 S., R. 3 W.
34	NP 93	Bluffs along Willamette River 1/2 mi. from Springfield, SW 1/4 sec. 35, T. 17 S., R. 3 W.
35	UO 37, 38	Outcrops along Willamette River near site of present Springfield bridge, SW 1/4 sec. 35, T. 17 S., R. 3 W.
36	UO 19	*Outcrops on S. side of Lenon Hill, 2 mi. N. of Coburg, sec. 21, T. 16 S., R. 3 W.
37	UO 2556	Exposures on top of Lenon Hill, sec. 21, T. 16 S., R. 3 W.
38	UO 170 USGS 17025	Outcrops on E. side of Rock Hill, 3 mi. N. of Coburg, NW 1/4 NW 1/4 sec. 15, T. 16 S., R. 3 W.
		Salem Quadrangle
39	UO 2557	Outcrops on Looney Butte, sec .22 and 23, T. 9 S., R. 3 W.
40	UO 2558	*Roadcut on frontage road, 10 mi. S. of Salem on Highway 99, SE 1/4 NE 1/4 sec. 16, T. 9 S., R. 3 W.
41	UO 148	Halls Ferry, a little N. of center of NE 1/4 sec. 14, T. 8 S., R. 4 W.
42	UO 2559	*Exposures at Finzer Station on Oregon Electric Railroad, 5 mi. SW of Salem, 100 ft. S. of Overpass, NE 1/4 SW 1/4 sec. 6, T. 8 S., R. 3 W.
43	UO 2560	*Exposures in fields of Freeman Ranch, Eola Hills, NE 1/4 SW 1/4 sec. 3, T. 7 S., R. 4 W.
44	UO 2561	*Outcrops in stream bank, McMahn Branch, SE 1/4 SE 1/4 sec. 3, T. 7 S., R. 4 W.
45	UO 2562	Roadcut .4 mi. S. of RR crossing at Holmes Gap, W. side of road, NW 1/4 NW 1/4 sec. 6, T. 7 S., R. 4 W.
		McMinnville Quadrangle
46	UO 2563	Cut on E. side of new road, just N. of RR crossing at Holmes Gap, boundary between sec. 32, T. 6 S., R. 4 W. and sec. 5, T. 7 S., R. 4 W.
47	UO 39	Outcrop 1/4 NE of RR crossing at Holmes Gap, S. 1/2 sec. 32, T. 6 S., R. 4 W.
48	UO 2564	Outcrops in NE 1/4 sec. 9 and NW 1/4 sec. 10, T. 6 S., R. 4 W.
49	UO 2565	Outcrops in NW 1/4 sec. 4, T. 6 S., R. 5 W.
50	UO 2566	Outcrops in NW 1/4 sec. 21, T. 5 S., R. 4 W.

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