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III
THE OLIGOCENE OF KITSAP COUNTY.
WASHINGTON.

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INTRODUCTION

The purpose of this paper is to place upon record the results obtained from geologic and paleontologic studies made in Kitsap County, Washington, along the north and south shores of the entrance to the Bremerton Navy Yard. Because of the isolated occurrence of pre-glacial outcrops, it seems desirable to select small areas of importance and to investigate the geology of them in as much detail as possible. The area involved in this study is located six miles west of Seattle and is of special importance because of the occurrence there of the most complete and representative section of the Oligocene within the Puget Sound basin. With the exception of the exposures along the south side of the Strait of Juan de Fuca, it is the most complete within the state.

The surface rocks in the larger portion of the Puget Sound basin are composed of deposits of glacial drift. In a number of small and isolated areas the older pre-glacial bedrock formations project up through the drift. Such exposures are usually found in the form of low sea cliffs or in the canyons of certain streams. The region under investigation is one of such areas.

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PREVIOUS INVESTIGATIONS

At various times during the last 10 years reference has been made in the literature on west coast Geology to the presence of Oligocene and Miocene fossils at Restoration and Beans points on the north shores of Richs Passage. In 1904 Dr. Ralph Arnold, in his paper on the Tertiary and Quaternary Pectens of California, refers to certain "shales near Beans Point, King County¹," which contain a fauna of probable Oligocene age. Note is made concerning the occurrence of *Pecten peckhami* Gabb at U. S. G. S. localities 4112a and 4113, between Beans and Restoration points, King County. *Pecten clallamensis* Arnold is noted at Beans Point and "is associated with *Terebratula*, sp., *Turritella*, sp., *Marginella* or *Erato*, sp., *Natica* or *Lunatia*, sp., *Glycimeris*, sp., and *Astyris*, sp."

In 1909, Dr. W. H. Dall², in his paper on the Miocene of Astoria and Coos Bay, Oregon, mentions the occurrence of Oligocene strata at Port Blakeley and Restoration Point, opposite Seattle. The following species are listed from these localities: *Ampullina mississippiensis* Conrad, *Mioleionea indurata* Conrad, *Turricula washingtoniana* Dall and *Aturia angustata* Conrad.

In 1911, the writer³ in a preliminary paper on the Tertiary Palaeontology of Western Washington described the occurrence of lower Miocene strata and fossils in the Restoration Point and Blakeley Harbor area and provisionally referred to them as the Blakeley formation. These strata were recognized as a part of an extensive lower Miocene series involved in the north flank of a well-defined anticline trending from east to west across the Puget Sound basin.

The most recent report involving a discussion of the Restoration Point area is to be found in a paper by Arnold and Hannibal⁴ on the Marine Stratigraphy of the North Pacific Coast of America, published in 1913. A three-fold division of the Oligocene is recognized: The San Lorenzo or lower, the

¹Arnold, Ralph, The Tertiary and Quaternary Pectens of California. Professional Paper 47, U. S. Geological Survey, 1906.

²Dall, Dr. W. H., The Miocene of Astoria and Coos Bay, Oregon. Professional Paper 59, U. S. Geological Survey, 1906.

³Weaver, C. E., A Preliminary Report on the Tertiary Palaeontology of Western Washington. Bull. 13, Wash. State Geol. Surv., 1912.

⁴Arnold, Ralph, and Hannibal, Harold, The Marine Tertiary Stratigraphy of the North Pacific Coast of America, Proc. Am. Phil. Soc., vol. 52, pp. 573-579, 1913.

Seattle or middle, and the Twin River or upper. The lower and middle divisions are stated to occur at Restoration Point. The San Lorenzo formation is described as the "sandstones overlying the lower Astoria basalts west of Port Orchard Sound and forming the lower half of the Bainbridge Island section of the Seattle monocline." The Seattle formation is said to consist "of the upper beds of the northward dipping Seattle monocline extending from Restoration Point on Bainbridge Island across Admiralty Inlet." The Twin River formation is not believed to occur in the Puget Sound basin.

In none of the investigations so far undertaken has an attempt been made to work out the details of the stratigraphy.

GENERAL STATEMENT CONCERNING THE MARINE TERTIARY IN WESTERN WASHINGTON*

All of the pre-glacial areal outcrops in the western part of the state with the exception of the central and western portions of the Olympic Peninsula and the San Juan Islands are of Tertiary age. Both sedimentary and igneous rocks are present. They were formed during the Eocene, Oligocene and Miocene epochs. With the exception of possible marine sediments in the extreme western portion of Chehalis County, no rocks of definite Pliocene age are known to exist. The history of the Pliocene in western Washington must be sought in terms of diastrophism and erosion.

During the Eocene epoch there were formed deposits of marine, brackish and freshwater origin. Intercalated with these are lavas and tuff of andesitic character. These deposits attain a total maximum aggregate thickness of at least 10,000 feet. The marine invertebrate faunas occurring within these strata indicate that only the Tejon or upper Eocene is present in western Washington.

Five distinct marine faunal zones can be recognized in the post-Eocene formations of western Washington:

Yoldia strigata zone.....Upper Miocene
Arca montereyana zone.....Lower Miocene

*A detailed report on the "Tertiary Formations of Western Washington" by the writer will be issued as a bulletin of the publications of the Washington State Geological Survey. Accompanying this report are detailed areal and structural geological maps of the western portion of the state.

<i>Acila gettysburgensis</i> zone.....	Upper Oligocene
<i>Turritella porterensis</i> zone.....	Middle Oligocene
<i>Molopophorus lincolnensis</i> zone.....	Lower Oligocene

The strata in which these zones are contained are referred to in this paper as horizons, the term being used in the sense of a deposit formed during a certain time and identified by certain distinctive fossils.

The type locality for the *Molopophorus lincolnensis* zone occurs along the south bank of Chehalis River near the mouth of Lincoln Creek. This fauna possesses many characteristics in common with the underlying Tejon Eocene, but more with the *Turritella porterensis* zone above. The strata characterized by this fauna may be referred to as the Lincoln horizon.*

The *Turritella porterensis* zone is to be found well represented in the sandstone bluffs along the north bank of Chehalis River near the junction of Porter Creek. The sediments containing this fauna have been referred to as the Porter horizon. Among the more characteristic fossils occurring in this fauna are *Phacoides acutilineatus* (Conrad), *Thyasira bisecta* (Conrad), *Thracia trapezoidea* Conrad, *Cardium lorenzanum* (Arnold), *Turritella porterensis* Weaver, *Drillia stanfordensis* (Arnold) and *Malletia chehalisensis* Arnold. It is possible that the upper portion of this zone may be represented in the extreme lower portion of the section at Orchard Point.

The type section of the third or *Acila gettysburgensis* zone occurs within the strata exposed near the entrance to the Bremerton Navy Yard. Most of the faunas from the post-Tejon and pre-glacial strata in the Puget Sound basin belong to this zone. The sandstones and shales containing the fauna form the Blakeley horizon.

The fourth division, or *Arca montereyana* zone, is to be found in the sandstones outcropping along Alockaman River in Wahkiakum County, 12 miles north of Cathlamet. It also occurs in the sandstone and shale exposures along the south

*There is considerable doubt in the writer's mind as to the wisdom of using the term, horizon. In geological literature it is often used in a very loose sense. Sufficient geological field evidence is not available to warrant the term formation as yet. Without the introduction of an entirely new word to express the idea of an assemblage of varying types of rocks all of which are characterized by the same distinctive fauna, it becomes necessary to choose one which has been used most nearly in such a sense.

shore of the Strait of Juan de Fuca between Pysht and Clallam Bay. The strata are referred to as the Wahkiakum horizon.

Resting unconformably upon the Oligocene and lower Miocene sediments are shallow water deposits of upper Miocene age containing a distinctive fauna which may be referred to as the *Yoldia strigata* zone, or Montesano horizon.

STRATIGRAPHY

From the western spur of the Cascade Mountains in King County, a prominent spur extends nearly due west into the Puget Sound basin. This spur includes the Issaquah and Newcastle hills. From Lake Washington it trends westerly through Seattle as a pre-glacial and, in part, submarine topographic feature. It crosses the Sound a little to the south of Bainbridge Island and reappears in the Bald Hills of central Kitsap County. Structurally this ridge is of anticlinal origin. Sedimentary and volcanic rocks of Eocene and Oligocene age are involved within it. Extensive erosion has deeply cut into it so that the Oligocene strata have been completely removed from the axis. The core is largely composed of Eocene basalts together with brackish water and marine sediments. The coal measures at Issaquah and Newcastle, together with the sandstone and shales between Duwamish and Renton, belong to this phase. The basalts which outcrop on the shores of Sinclair Inlet, as well as those southwest of Bremerton in the Bald Hills, belong to the basaltic phase of the Tejon-Eocene. Resting unconformably upon the Eocene rocks and forming a part of the north flank of the anticline just mentioned, are sandstone and shales of Oligocene age. These strata are exposed in the north slopes of the Newcastle Hills, in the street cuts of Columbia City and Georgetown (both of which are within the city limits of Seattle), along the shores of Bailey Peninsula and at Alki Point. West from Seattle they outcrop at the water's edge at the south end of Bainbridge Island and along the south shores of Richs Passage. They appear for a distance of a mile along both shores of the narrow channel northwest of Bremerton near Tracyton. To the north of these Oligocene outcrops, the only formations within the county exposed at the

surface are deposits of glacial drift. Presumably they are involved in a broad synclinal basin beneath the glacial drift of northern Kitsap County. The evidence for such a suggestion is to be found to the northwest on the Quimper Peninsula between Quilcene and Port Townsend. In that region the same Oligocene strata resting unconformably upon the Eocene basalts exist in a broad synclinal fold whose axis trends southeasterly and passes beneath the glacial covering of northern Kitsap County. It can be seen from the foregoing statements that the Oligocene beds exposed at the entrance to the Bremerton Navy Yard are a representative part of the Oligocene formations of the Puget Sound basin and as such are worthy of detailed study.

In the investigation of this particular region transit surveys were made along the shore lines wherever pre-glacial formations were exposed. All observations taken on the strike and dip of the strata were tied in to these traverses. Stratigraphic sections were also made with the aid of the transit. The distribution of the Oligocene strata as exposed along the shore lines, as well as the structural data, may be seen by referring to Fig. 1.

The Oligocene strata of this region are entirely of sedimentary origin. The Eocene lavas upon which these sediments rest are exposed about two miles southwest of Bremerton on the west shore of Sinclair Inlet. The position on the surface of the contact between the Eocene andesites and the Oligocene sediments in this region is concealed beneath deposits of glacial drift. Many of the pebbles forming the basal conglomeratic phases of the Oligocene strata are composed in part of the older andesite.

The lowermost strata exposed in this area outcrop at Orchard Point. The highest occur along the north shore of the entrance to Blakeley Harbor. The total thickness of the deposits as exposed between the lower and uppermost beds is approximately 8900 feet. The following generalized stratigraphic column is constructed from observations taken along the section (B-B') :

TOP OF SECTION		Feet
Massive, coarse-grained conglomeratic sandstones containing numerous lenticular bands of conglomerate. Occasional narrow bands of clay shale are interbedded. The eastward continuation of the conglomerates appears in the outcrops at Blakeley Rocks. These strata persistently pitch to the north at very steep angles and extend as outcrops from the north shore of Blakeley Harbor northerly for 1500 feet....	1,300 (A)	
Sandy shales exposed beneath the waters of Blakeley Harbor..	1,400 (B)	
Brownish gray, massive to slightly bedded, sandy shales as exposed along the south shore of Blakeley Harbor for a distance of one-half mile northwesterly. Five hundred feet stratigraphically above the beds exposed at Restoration Point is an excellent fossil locality, No. 13.....	2,400 (C)	
Shaly sandstone grading in places into a sandy shale. Bedding planes are commonly well defined. The top of this belt is located at Restoration Point.....	1,200 (D)	
Shaly sandstone gradually becoming more sandy in depth. Bedding planes, very distinct.....	450 (E)	
Massive, sandy shales. Bedding planes, fairly distinct. Fossil locality No. 305.....	350 (F)	
Massive, brownish gray, coarse-grained conglomeratic sandstones with interbedded bands of coarse conglomerate, the pebbles of which attain a diameter of two feet. Many of the pebbles are composed of andesite and others of light colored shale and sandstone	1,800 (G)	
Total thickness	8,900	

The westerly continuation of the strata as exposed in the above section reappears in cross-section A A'. The upper beds as exposed at Point Glover appear to be the equivalent of those in belt (C). The extreme upper portion of belt (G) as exposed at Orchard Point is the westerly continuation of the narrow conglomeratic layers occurring just east of Beans Point on the south end of Bainbridge Island. The conglomerates outcropping at Quarry Point are the equivalent of those exposed at Middle Point. From Middle Point they cross Richs Passage and appear in the cliffs at Fort Ward on the south shore of Bainbridge Island. At this point they become less conglomeratic and more sandy. Near Restoration Point they are the equivalent of the upper portion of belt (D). The shales and sandstones exposed between Point Glover and Middle Point are to be correlated with the sandy shales in belt

(C). The conglomerates in belt (A) and the shales in belt (B) do not appear on the south side of Richs Passage. It is possible, however, that the conglomeratic sandstones and interbedded shales near Tracyton and Phinney Point are the equivalents of those in belts (A) and (B). The following stratigraphic section has been measured between the basal beds at Orchard Point and the higher beds exposed at Point Glover along section (A A') :

Top of Section at Point Glover		Feet
Massive, sandy shale with poorly defined bedding planes.....		150
Shaly sandstone		70
Brownish gray, sandy, clay shale.....		500
Massive, brown sandstone.....		100
Gray, sandy shale.....		45
Brown, massive, coarse-grained sandstone.....		60
Interbedded shale and sandstone, shale predominating.....		140
Massive sandstone		80
Thickly bedded shale		200
Alternating beds of thinly bedded shales and sandstones.....		520
Banded sandstone and shale, shale predominating.....		40
Banded shale and sandstone, shale predominating.....		20
Thinly bedded, gray shale		70
Massive, brownish gray sandstone		40
Thinly bedded shale		30
Massive, brown sandstone		300
Mainly shale with a few narrow bands of sandstone.....		200
Mainly sandstone with a few narrow bands of shale interbedded.		30
Mainly thin bedded, clay shale without distinct bedding.....		900
Massive, brown sandstone.....		65
Alternating layers of thinly bedded sandstones and shale with occasional bands of sandstones four to five feet in thickness		90
Massive, brown sandstone, slightly banded.....		75
Banded shale		10
Thinly bedded shaly sandstone.....		40
Alternating bands of thinly bedded shale and sandstone.....		75
Massive, brown sandstone		20
Massive, brown gritty sandstone.....		35
Gray shale possessing well-defined bedding		100
Massive, brown sandstone containing bands of shale.....		30
Mostly shale with a few bands of interbedded sandstone. Strata in part concealed		1,800
Thinly bedded shale somewhat massive in places and containing occasional bands of sandstones averaging one foot in thickness		320
Massive, brownish gray sandstone containing pebbly and conglomeratic bands		1,400
Massive conglomerates composed of pebbles ranging up to two feet in diameter and composed in part of altered andesite..		15
Massive, gritty sandstone		60
Conglomerate		15
Massive, gritty brown sandstone. These are the lowest strata exposed in the Bremerton Inlet area.....		70
Total thickness		8,715

FAUNAL RELATIONS

The invertebrate fauna occurring in the sedimentary rocks just described is entirely of marine origin. Altogether 42 species are present. In the lower beds outcropping at Orchard Point and represented by belt (G), the only species found are *Cardium lorenzanum* (Arnold), *Nucula*, sp., and *Tellina oregonensis* Conrad. In the following table the fauna listed from locality No. 13, comes from the sandy shales north of Restoration Point in belt (C). Locality No. 304 is located at the west end of Quarry Point and the fauna occurring there belongs to belt (C). Locality No. 305 occurs at Beans Point in the lower portion of belt (F).

The most characteristic species occurring in this region are *Acila gettysburgensis* Reagan, *Macrocallista vespertina* (Conrad), *Marcia oregonensis* (Conrad), *Modiolus inflatus* Dall, *Panope generosa* (Gould), *Phacoides acutilineatus* (Conrad), *Solemya ventricostata* Conrad, *Thracia trapezoidea* Conrad, *Eudolium petrosum* Conrad and *Turricula washingtoniana* Dall. The most fossiliferous portion of the formation is in belt (C). The fauna occurring in belt (F) except in the number of species does not differ greatly from that in belt (C). The conglomerates and coarse-grained sandstones composing the lowermost beds of the section as exposed at Orchard Point is almost entirely barren of fossils. This lower belt may correspond to the upper part of the Porter horizon or *Turritella porterensis* zone as exposed in the Chehalis Valley.

The fauna appearing in belt (C) at Restoration Point is almost identical with that occurring to the east within the city of Seattle, and in the sandy shales on the north slopes of the Newcastle Hills. It may also be correlated with that at Fiddlers Bluff about two miles south of the town of Snohomish. The shales and sandy shales outcropping between Pysht and Gettysburg are also to be referred to this horizon or faunal zone. The following table gives the distribution of the marine fauna occurring in the Bremerton Inlet area:

FAUNAL LIST

	13	304	305
<i>Acila gettysburgensis</i> Reagan.....	*	*	*
<i>Arca</i> , sp.....	*		
<i>Cardium lorenzanum</i> (Arnold).....	*	*	*
<i>Chione cathcartensis</i> Weaver.....	*		
<i>Crenella porterensis</i> Weaver.....	*		*
<i>Leda chehalisensis</i> Weaver.....	*		
<i>Macrocallista vespertina</i> (Conrad).....	*	*	*
<i>Marcia oregonensis</i> (Conrad).....	*	*	
<i>Modiolus directus</i> Dall.....	*	*	
<i>Modiolus inflatus</i> Dall.....	*		
<i>Mytilus sammammishensis</i> Weaver.....	*		
<i>Nucula conradi</i> Meek.....	*		*
<i>Ostraea</i> , sp.....		*	
<i>Panope generosa</i> (Gould).....	*	*	*
<i>Pecten peckhami</i> Gabb.....	*		
<i>Pecten</i> , sp.....		*	
<i>Phacoides acutilineatus</i> (Conrad).....	*	*	*
<i>Solen curtus</i> Conrad.....	*	*	*
<i>Solemya ventricostata</i> Conrad.....	*	*	*
<i>Spisula albaria</i> (Conrad).....	*	*	*
<i>Tellina obruta</i> Conrad.....	*	*	*
<i>Tellina oregonensis</i> Conrad.....	*	*	
<i>Thracia trapezoidea</i> Conrad.....	*	*	
<i>Thyasira bisecta</i> Conrad.....	*	*	
<i>Yoldia impressa</i> Conrad.....	*	*	
<i>Yoldia oregona</i> Shum.....	*		
GASTEROPODA			
<i>Ampullina oregonensis</i> Dall.....	*		
<i>Crepidula praerupta</i> Conrad.....	*	*	
<i>Epitonium</i> , sp.....	*		
<i>Eudolium petrosum</i> (Conrad).....	*	*	
<i>Fusinus</i> , sp.....	*	*	
<i>Miopteleona indurata</i> (Conrad).....	*	*	
<i>Natica oregonensis</i> Conrad.....	*	*	*
<i>Scaphander oregonensis</i> Dall.....	*	*	*
<i>Turricula washingtoniana</i> Dall.....	*	*	
<i>Turritella blakeleyensis</i> Weaver.....	*		
<i>Turritella newcombi</i> Merriam.....	*		
<i>Turris fresnoensis</i> (Arnold).....	*		
SCAPHOPODA			
<i>Dentalium conradi</i> Dall.....	*	*	*
CEPHALOPODA			
<i>Aturia angustata</i> Conrad.....	*		*
BRACHIOPODA			
<i>Hemithyris astoriana</i> Dall.....	*	*	*

CONDITIONS OF DEPOSITION

At the close of the Tejon epoch the Eocene deposits were differentially uplifted. Early in the Oligocene new embayments were formed. The seas of the northern part of the

Puget Sound region were disconnected from those to the south in the Grays Harbor area. The shore line of the present site of the Puget Sound embayment appears to have existed somewhere between Seattle and Tacoma and to have extended in an east to west direction from the present site of the Cascade Mountains to the present location of the Olympics. The present contact between the Eocene and Oligocene formations in the Bremerton Inlet, or Kitsap County, area is much farther north than the original southerly limits of the shore line. The strata have been tilted from their original horizontal position into a nearly vertical position and as a result those sediments which formerly extended to the south have been entirely removed by erosion. The lithologic character of the sediments and the faunas occurring within them indicate that they were deposited in shallow to moderately deep water. No products of direct volcanic origin were poured out in this region during the Oligocene epoch. This is in sharp contrast to the conditions of volcanic activity during the Tejon.

CONCLUSIONS

The area involved in this investigation is of special importance because within it occurs one of the most complete sections of Oligocene strata to be found in the state. There are approximately 8900 feet of conglomerates, shales and sandstones which are entirely of marine origin and rest unconformably upon older Tejon basalts and sediments. The contact in this area between the Tejon and Oligocene is obscured by deposits of glacial drift. The Oligocene strata form the north flank of an extensive east to west trending anticline, the axis of which has been deeply dissected by erosion. A marine fauna of 44 invertebrates is now known. The horizon represented is upper Oligocene. The fauna is a unit from base to top of section and is termed the *Acila gettysburgensis* zone.



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