THE GEOLOGY OF HORNBY ISLAND

by

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ABSTRACT

The thesis represents a stratigraphical, structural and paleontological study of the Upper Cretaceous strata exposed on Hornby Island. The stratigraphy and structure were studied in some detail, but the main part of the work is the faunal description, revision and illustration of 24 species of cephalopods, 15 species of pelecypods, 9 species of gastropods, 1 coral and 2 scaphopods.

The group of nostoceratids previously assigned to Anisoceras cooperi has been divided into five species, of which two are new ones.

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Date 20 September 1958.

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CHAPTER I

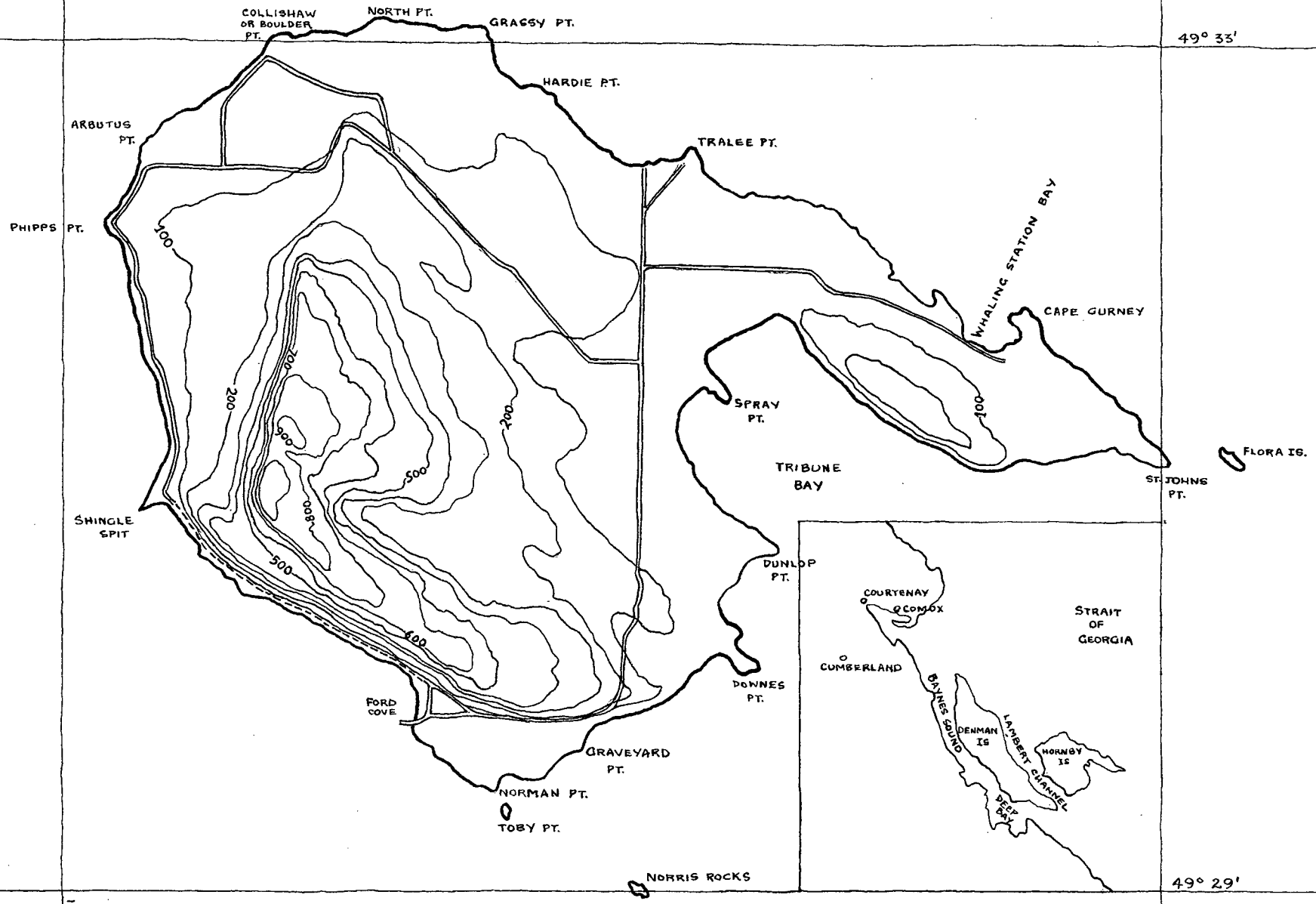
INTRODUCTION

General Statement

This thesis contains an account of the paleontologic and stratigraphic work done on Hornby Island, B. C. The writer arrived there on May 7th, and left on May 24th to compile the information gathered while in the field. An additional period from June 13th to June 16th was spent on the island to clarify some debatable points which had arisen during the writing of the thesis.

Hornby Island lies in the southern portion of the Comox basin; the stratigraphy and structure of the Nanaimo series exposed on the island were studied. A representative suite of fossils was collected and identified.

To reach Hornby Island one takes a nine-car ferry from Buckley Bay on Vancouver Island across Baynes Sound to the western side of Denman Island which sprawls out for a length of 12 miles completely hiding the smaller island from view.


COLLISHAW OR BOULDER PT.
NORTH PT.
GRASSY PT.
49° 33'
HARDIE PT.
ARBUTUS PT.
TRALEE PT.
PHIPPS PT.
100
200
300
400
500
600
WHALING STATION BAY
CAPE GURNEY
SPRAY PT.
FLORA IS.
TRIBUNE BAY
ST. JOHNS PT.
SHINGLE SPIT
DUNLOP PT.
COURTENAY
COMOX
STRAIT OF GEORGIA
CUMBERLAND
DOWNES PT.
BAYNES SOUND
DENMAN IS
LAMBERT CHANNEL
HORNBY IS
DEEP BAY
FORD COVE
GRAVEYARD PT.
NORMAN PT.
TOBY PT.
NORRIS ROCKS
49° 29'
124° 43'
124° 35'

A two-car ferry makes 7 daily trips from Hornby to the eastern side of Denman and back again.

The island has a good gravel road about 15 miles long, which winds almost completely around it except for a 2-mile section between Ford's Cove and Shingle Spit. A road does connect the two during the summer months but in winter the rains produce landslides which render it impassable. Above and below this road, huge conglomerate blocks from the Geoffrey formation rest upon the steep slopes of glacial till. Numerous deteriorating logging roads and trails form a network across the central part of the island. Private roads leading from the main road to farms along the coast make the beach easily accessible.

Hornby Island is situated off the east coast of Vancouver Island in Georgia Strait, 34 miles northwest of Nanaimo. As may be seen from the accompanying map the island lies between latitudes 49° 29' and 49° 33' and between longitudes 124° 35' and 124° 43'. Its maximum width is 4.2 miles and maximum length 6 miles.

Physical Features

Topography and Coastline

The main topographic feature on Hornby Island is an arcuate mountain consisting of the resistant cliff-forming Geoffrey formation. Near Shingle Spit about half a mile in

from the coast is Mt. Geoffrey's 920 foot peak; from there the mountain gradually drops in elevation to the southeast and to the north. It consists of a structurally simple 700 foot conglomerate homocline striking N 20° W and dipping to the northeast at a shallow angle of about 6°. The apex of the arcuate mountain belt points to the southwest. Behind the mountain and almost enclosed by it is fertile, green Strachan valley. On the large peninsula which extends in a southeast direction from the north of the island towards St. John's Point the Hornby formation outcrops forming cliffs on the east side of Tribune Bay; the highest of these is about 200 feet. The argillaceous Lambert and Spray formations form the subdued lowlands of the island.

The coast of Hornby is probably a rising shoreline, as indicated by the almost perpendicular cliffs along its periphery. A 100 foot cliff of Lambert shale extends from Shingle Spit to Phipps Point, while from the latter to Boulder Point, the cliffs are not as steep and are covered in many places by vegetation. One can walk out 500 yards to the low-tide mark at Boulder Point; this is due to the extremely shallow dip of the Lambert formation. The area from Boulder or Collishaw Point to St. John's Point is on the downdip side of the island so that there are almost no cliffs although the main level land is about 50 feet above sea level. The steep sandstone and conglomerate cliffs of the Hornby formation which reach from St. John's Point to Tribune Bay are so perpendicular in places that there is no beach at all. Tribune Bay itself

PLATE I

Beach Between Spit and Phipp's Point

Stations 1,2 and 3

North of Phipp's Point

Stations 4 and 5

Low Tide at Boulder Point

Station 6

has a mile-long beach of white sand.

From Spray Point at the west end of Tribune beach, to Downes Point where the massive Geoffrey conglomerates begin, lies the Spray formation. Its low topography consists of a monotonously regular interbedding of sandstone and shale which forms flat shelves stretching out to sea. In some places the almost horizontal beds can be traced along the bank for a fair distance. Between Downes Point and Graveyard Point, however, the bank is quite uniformly concealed and the beach rendered almost impassable at high tide by the enormous chunks of Geoffrey conglomerate. Along this coastline, which is very similar to that from Ford's Cove to the Spit, the massive blocks reach a diameter of 50 feet or more. The Lambert sandstone and shale which appears from Graveyard Point to Ford's Cove is almost flat lying.

Climate and Drainage

Hornby Island has an early spring; vegetation begins to grow in March and is well advanced by April. Summer, which lasts from April to September, is very dry; sometimes there is no rainfall whatsoever during these months. The heat never becomes excessive as the island is small enough to be exposed everywhere to the tempering sea breezes. The winters are mild and moist; however, the overall rainfall is still much less than in surrounding areas. Severe frosts are rare.

A few small streams carry a fair amount of water in winter, but dry up almost completely in the summer. Several springs of good drinking water have been found, although most of the islanders rely upon wells for their clean water. The water from these two sources if used sparingly is sufficient to last them through the summer months. The shortage of water is of course due to the fact that there is no reservoir on the island; one solution would be to dam Strachan valley.

Flora and Fauna

The island is well forested. In places the trees are so numerous as to form a thick closed canopy above; here there is little underbrush, and the forest floor is dry and covered with pine needles. Where the trees are less concentrated a dense almost impenetrable underbrush occurs. It consists of blackberry vines, oregon grape, salal and ferns. Cacti, wild roses and horsetails are plentiful, especially on Flora Island near St. John's Point.

The dominant tree species is Douglas fir, which attains a height of over 150 feet. Other lesser conifers are hemlock, white pine, black pine, spruce, red cedar, yew and grand fir. The main deciduous trees are the maples, alders, arbutus, willows and Garry oaks.

In addition to the densely forested areas there are areas of open parkland, especially noticeable at St. John's Point, where the original stand of Douglas fir, hemlock and oak

is untouched. Here grass and wildflowers are the only ground cover.

The abundance of animal life on the island is remarkable. Deer are prolific probably because no cougars have reached Hornby, although some exist on Denman Island. Notorious chicken-killers are the numerous mink and raccoons. The island is well known for its large cormorant and heron populations; many other water birds also seek refuge here. Land bird species are plentiful.

The Effects of Man

History and Culture

The earliest people on Hornby were of course a peaceful Coast Indian tribe; there is an old Indian graveyard on the south of the island where the last descendant of the Ford family is yet to be buried. Many Indian relics have been found in the various "kitchen middens" on Hornby, one of which was on the site of an old lumber mill near Shingle Spit. The discovery of some finely-made obsidian arrowheads has led to the belief that raiding parties of the warlike Haida Indians came all the way from the Queen Charlottes. According to the islanders, the last Indian massacre took place on what is now Chrome Island, just south of Denman.

Place names are interesting keys to the past. Early families were responsible for Ford's Cove and Strachan valley. However, the island itself was named after "Rear Admiral Phipps

Hornby, C. B. Commander-in-chief on this station, flagship Asia, 84 guns, Capt. R. F. Stafford, 1847-1851." Geoffrey mountain is so called after his son Geoffrey Thomas Phipps Hornby, Captain of "HMS Tribune" after which Tribune Bay is named. These names were given by Hudson's Bay Company officers about 1850. St. John's Point, Norris Rocks, Downes Point, Norman Point and Dunlop Point were named in 1860 by Captain Richards of the survey ship "HMS Plumper" after other officers of "HMS Tribune."

In the early days Hornby Island was a hive of activity; the first pile driven wharf north of Nanaimo was built at Whaling Station Bay to accomodate the whaling fleets on their way through Georgia Strait. Even in 1913 there were just trails where the roads are now, although the lumbering business was already flourishing.

Principal Industries

From 1908 when lumbering was first started on Hornby Island, until 1956 when island loggers had to go elsewhere to look for jobs, the total amount of lumber removed from there was approximately 100 million feet. Until about 1939, the companies logged mainly around the shoreline. Later work was done on the slopes of the mountain. The Union Logging Company took about 30 million feet of lumber from the island; it was in operation from 1939-1949, sending logs down to the Selkirk mills in Victoria.

The two most important trees in Hornby's logging industry were Douglas fir and red cedar. Some of the lumber was sent to the small mills on the island for local use; the remainder went to Courtenay, Nanaimo or Vancouver. Balsam and white fir logs were used in the pulp and paper industry at Vancouver and Powell River. Alder and maple were sent from Hornby to the Western Hardwood Company and the Hammond Furniture Company in Vancouver.

Generally where it is underlain by the Geoffrey and Hornby formations, the surface of the island is rocky. Underlying the land suitable for agriculture are the Lambert and Spray formations, which because of their less-resistant nature have the thickest glacial deposits. These form the best soils and are the most heavily timbered. The light sandy loam becomes somewhat boggy or peaty in the low-lying flats. Vegetables, grains and fruits are successfully grown.

Several of the islanders have fairly large flocks of sheep, and others have up to 50 head of ranch cattle. These flourish if their number is restricted; each animal needs a larger grazing area on Hornby than elsewhere, because of the usual summer drought.

Perhaps the newest industry on Hornby is the tourist trade; a motel, several guest farms, a lodge and a campsite exist for the convenience of summer visitors.

Previous Work

The study of the Nanaimo series exposed along the southeast coast of Vancouver Island began well over a century ago and is still continuing today. This study was stimulated by the existence of extensive coal deposits, some of which were known as early as 1834. Actual mining was started in the fall of 1852 by the Hudson's Bay Company. Up to the present these coalfields have produced about one-half of B. C.'s total output. The two main coal horizons in the Nanaimo Group are the Wellington coal seam which is 700 feet above the base and low in the series, and the Newcastle-Douglas seam which is 1000 feet above the Wellington. These together produce about 90 per cent of the total output from the Nanaimo coal basin.

Early paleontological work was carried out by Bauerman 1860, Meek 1861, Newberry 1863, Gabb 1864 and Whiteaves 1893-1903, each adding to the list of species for the Nanaimo area. The regional geology was done by James Richardson, who made the first extensive investigation of the Vancouver Island coalfields during the years 1871-1876. G. M. Dawson also studied the coalfields; his findings were released in publications on the mineral wealth of B. C. in 1878 and again in 1889. In 1908 C. H. Clapp began the next detailed investigation, not only of Nanaimo series, but also of all the rocks exposed in his chosen map areas. He named the formations in the Nanaimo series, these being equivalent to Richardson's subdivisions, except that Clapp divided the "productive coal measures" or formation A, into six formations.

During 1921 and 1922 J. D. Mackenzie, one-time assistant to Clapp, studied the stratigraphy of the Comox coal basin. His assistant was T. B. Williams, who later wrote his Ph. D. thesis on the area. More recent work was done by A. F. Buckham who did surveys of the coalfields between the years 1939 and 1948. Under his guidance J. L. Usher studied the ammonite faunas of southeast Vancouver Island.

On Hornby Island, the main geological work was done by James Richardson in 1872-1873 and by Usher in 1945 and 1948.

CHAPTER II

STRATIGRAPHY AND STRUCTURE

General Geology

During the Upper Cretaceous period when the Nanaimo series was laid down, a major depression undoubtedly existed which is now occupied by Georgia Strait. In 1899 Bailey Willis suggested that the Georgia depression was part of his Pacific coast downfold which extended from the Gulf of California to north of the Queen Charlotte Islands. This feature is now believed to be much more recent, probably Pleistocene in age.

Ten years ago, Bostock stated that the Georgia depression forms the southern part of a coastal trough most of which is submerged beneath the epicontinental sea of the Pacific coast. Parts of the depression rise above sea level forming islands in the Strait of Georgia and lowlands on Vancouver Island and the mainland. During the Cretaceous the depression was evidently much larger than is indicated now by the limits of the Upper Cretaceous strata exposed on Vancouver Island and the mainland. Much erosion has since taken place. It is likely

that an arm of the depression extended southeast into Washington State, and that a whole series of depressions stretched northward to Alaska paralleling the Coast Range mountains. Through the Triassic and Jurassic periods the mountains on either side of the Georgia Strait depression were gradually worn down to a subdued lowland; during the late Jurassic or early Cretaceous they were uplifted again. However, in the Upper Cretaceous a lowland still existed between the uplifted ranges and the Georgia depression. It is believed that the Nanaimo series was deposited upon the eroded surface of this lowland, which according to Clapp still had considerable relief--in places as much as 2,000 feet. The lowland upon which the series was unconformably laid down consists mainly of volcanic and sedimentary rocks of the Vancouver group; these are of Triassic and Jurassic age. The lowland is also made up of igneous rocks of irregular batholitic and dyke intrusions which metamorphosed and deformed the Vancouver group.

The first pronounced deformation of the Nanaimo series took place after the close of Eocene sedimentation and vulcanism. As Buckham said in 1947, both folding and faulting occurred, the latter often being determined by the attitude and position of the coal seams in the Nanaimo basin. During the late Tertiary the area was again uplifted and eroded, removing much of the Upper Cretaceous sediments.

The Nanaimo Series

The Nanaimo series consists of a thick sequence of alternating conglomerates, sandstones and predominantly silty shales. Some coal occurs in the lower part of this series which in the Nanaimo basin has been subdivided into eleven formations on fairly well-defined lithological grounds. Unfortunately the fauna is too uniform and too scarce in many of the formations to be used for subdividing the series. Although generally the lithology and fauna are similar in the Nanaimo and Comox basins, a separate set of names has been given to the succession of rocks in the latter. This was done because in the Comox basin there are no formations equivalent to the lowest in the Nanaimo area. Also the coal seams occur at different horizons and there are distinctions between the faunas of the two basins. The facies changes and vertical variations are so pronounced that formational names cannot be applied over such a wide area.

The Nanaimo series has a northwest-southeast strike with a prevailing dip to the northeast. It has been correlated with the Chico of California and with the Pierre of the Great Plains. The series was deposited in several different environments on a surface with considerable relief. This is shown by the rapid lateral and vertical gradation of the strata which consists essentially of a group of overlapping lenses with few beds that persist for any distance. To the southeast the series has a thickness of 10,000 feet and there the Nanaimo

basin was probably deepest; the average is approximately 7,500 feet.

As Buckham pointed out, the six lower formations of the series, which total 1,900 feet, were not deposited north of the Qualicum River. The four lowest of these reach only to Nanoose Bay. The five upper formations on the other hand were probably continuous over most of the Georgia depression. This is an idication then that as the sediments were laid down on the uneven floor the first beds had very irregular outlines, while those deposited after the depressions had filled up were most persistent laterally. There was a progressive overlap, a northward migration of the north shore of the Cretaceous seas as deposition continued. Sediments from the south first filled the hollows of the irregular pre-Upper Cretaceous surface, becoming thinner northward as they transgressed inland.

Rapid erosion of the granitic, metamorphic and sedimentary rocks exposed on the mountains bordering the Georgia depression was supplying a large volume of material which was spread over the lowland and the depression. In 1913 Clapp showed that the sandstones, chiefly composed of angular to subangular fragments and containing a large percentage of easily decomposed minerals like feldspar, indicated a rapid accumulation and deposition in relatively small basins where the detritus was not subject to severe wave action.

While rapid erosion of the uplifted mountain ranges took place the depression area was also sinking in relation to

sea level. The elevation, as a result of new deposition and of the sinking of the depression, did not maintain a constant balance. Therefore at times the sediments were deposited by the action of streams above sea level and at other times by wave and current action below sea level. As shown by its fauna, part of the series is definitely estuarine. Rain imprints and mudcracks indicate very shallow near shore environments such as beaches or lagoons. In other areas the sediments were laid down by fresh water. These terrestrial deposits are denoted by the presence of land plant remains and coal beds. According to Clapp, the lack of marine fossils in the upper formations may well mean an entirely terrestrial environment.

TABLE OF UPPER CRETACEOUS FORMATIONS OF NANAIMO GROUP

After Usher, 1952, p. 7

Nanaimo Basin

Age	Formation	Thickness in Feet	Lithology
Maastrichtian	Gabriola	2,000-3,000	Sandstone
	Northumberland	2,000-2,700	Shale Sandstone Shale
Campanian	De Courcy	800-1,000	Sandstone
	Cedar District	700-1,000	Shale
	Protection	650	Sandstone
	Newcastle	215- 400	Sandstone, Shale, Newcastle and Douglas Coal Seams
	Cranberry	200- 600	Sandstone, Conglomerate
Lower Campanian or (?) Santonian	Extension	600- 800	Conglomerate, Sandstone
	East Wellington Member	35	Sandstone, Wellington Coal Seam
	Haslam	600-1,500	Shale
	Benson	100	Conglomerate

TABLE OF UPPER CRETACEOUS FORMATIONS OF NANAIMO GROUP

Cont'd.

Comox Basin

Age	Formation	Thickness in Feet	Lithology
Maastrichtian	Hornby	600- 800 * 500- 600	Sandstone Conglomerate
	Spray	800- 830 * 700	Shale, Sandstone
	Geoffrey	1,100-1,300 * 600- 700	Conglomerate
	Lambert	800 *1,000+	Shale
Campanian	Denman	900-1,000	Sandstone Conglomerate
	Trent River	1,000	Shale
	Comox	600	Sandstone, Coal Deposits
	Qualicum	(?)1,800	Shale, Sandstone
Lower Campanian or (?) Santonian			

* Writer's measurements

The Five Basins

The Nanaimo series found on the east coast of Vancouver Island exists only in five sedimentary basins. These are the Nanaimo, Comox, Cowichan, Alberni and Suquash basins; unfortunately the work done on them has not been extensive enough to determine their exact origin. Little except the approximate size and location is known of the Suquash and Alberni basins. James F. Fyles found that the Cowichan basin appears to be almost wholly controlled by structure. Of the five, the Nanaimo basin has been studied most because of the large deposits of coal located in it. The Comox basin is also known in considerable detail.

Formerly, the Nanaimo and Cowichan basins were believed to be distinct and separated from one another by a narrow ridge of the crystalline Sicker series which strikes in a northwesterly direction just south of Crofton across Saltspring Island. Recent writers have incorporated much of the Cowichan basin with the Nanaimo basin, reducing the former to a lowland or a side arm of the main Nanaimo basin. The lowest formations of the Nanaimo series are exposed around Cowichan Lake which covers almost all of the 30 by 8 mile lowland.

The Nanaimo basin stretches from Departure Bay south to Orcas Island, its maximum length being about 75 miles and maximum width 25 miles. Approximately 700 square miles in area, it is bounded on the east by Georgia Strait and on the west by the ranges of Vancouver Island. To the north of it lies the Comox basin which is separated from the Nanaimo basin by an

axis of Vancouver volcanics near Nanoose Harbour.

The Alberni basin parallels the southern half of the Comox basin from which it is separated by the Beaufort Range. The former has a length of 35 miles and a width of 6 miles. The largest single area of Upper Cretaceous rocks on southern Vancouver Island outside the Comox-Nanaimo-Cowichan basins occurs in this district. The sediments laid down here definitely belong to the Nanaimo series and have been tentatively correlated with the basal formations in the Comox basin. J. D. Mackenzie believes that although the Comox and Alberni basins are now separated by an axis of Pre-Cretaceous rocks, originally they were probably a single basin. The Alberni basin is thought to be an elongated syncline complicated by one major anticline and other lesser folds; the principal elongation is in a northwest direction.

In the Suquash basin the conditions are in many respects similar to those in the Comox basin. Clapp has correlated the sediments here with the Comox and Protection formations of the Comox and Nanaimo basins respectively. The basin is believed to be a broad syncline striking N 60° E and pitching slightly to the northeast; the strata dip less than 10 degrees. Much of the Suquash is drift-covered therefore knowledge of it is meagre. It includes Malcolm and Cormorant Islands, possibly extending southwest to Quatsino Sound.

The Comox basin extends from Campbell River south to Nanoose Bay, where it is separated from the Nanaimo basin by a

ridge of metamorphic and igneous rocks. To the east is Georgia Strait, to the west, Beaufort Range. The basin is 75 miles long and 10 miles wide. Its continuity is almost broken at Wolf Lake by a granite intrusion and at Deep Bay by a ridge of volcanic rocks reaching almost to the sea.

The sedimentary rocks in the Comox basin are an alternating succession of conglomerates, sandstones and shales, which exceeds 5,000 feet in thickness. The succession has been divided into eight formations on lithological grounds. As in the Nanaimo basin, the pre-Upper Cretaceous surface of the Comox area was irregular, with a total relief of at least 440 feet (Buckham). Here again the deeper hollows were filled first, as the irregular surface was gradually submerged. Thus, the Qualicum formation is restricted to the area between Deep Bay and Nanoose Bay. The Comox sandstone overlying the Qualicum is the lowest formation elsewhere in the Comox basin and rests unconformably on the Vancouver volcanics. Within this formation are the productive Cumberland coal seams; at the end of 1954 they had produced 29 million tons of coal. No coal of economic importance is found above the Comox formation although there are many small lentils.

The formation names used are those proposed by Buckham and Usher in 1952. Fossils are almost wholly restricted to the Trent River and Lambert shales which are both marine. Clapp has suggested that the uppermost formations may be terrestrial. Buckham and Usher both mention that only small normal faults

with a displacement of less than 20 feet could be detected in the Comox basin. On Hornby Island the writer observed two faults with a very much greater displacement. However, the structure of the Comox basin is more regular than that of the Nanaimo basin; the stratigraphy of the former indicates that sedimentation took place during more uniform conditions.

Stratigraphy: General and Detailed

On Hornby Island the four uppermost formations of the Nanaimo series in the Comox basin are exposed. They constitute the southwest limb of a broad open syncline, the axis of which plunges gently to the southeast. A general description of each formation follows, as well as a detailed description of both the Lambert and Spray formations.

Difficulties in measuring were mainly due to concealed strata. In addition, dip and strike readings varied considerably because of the shallowness of the regional dip, the irregularities of the strata and the weathered nature of the rocks, many of which are exposed only at low tide. The Geoffrey and Hornby formations produced a further difficulty as they consist of conglomerate and sandstone lenses, few of which persist for any distance. Therefore, apart from actual measurements a fair amount of estimating was necessary. This was accomplished by pacing, Brunton readings, and measurements taken from the Provincial Government's map of Hornby Island.

The Lambert Formation

The lower part of this formation outcrops on the northeast side of Denman Island where it overlies the Denman formation. There is a gradational contact between the two. The middle part is concealed by the waters of 1½ mile wide Lambert Channel.

The upper Lambert formation is exposed on the northwest side of Hornby Island where it grades from nodular, dark gray, reddish-weathering, silty shales to dark gray, blocky to fissile, gray weathering, silty shales. These non-calcareous shales have numerous red to light gray weathering limestone nodules which are gray, dense, micro-grained, hard and often concentrically layered. Some nodules are fossiliferous, containing well preserved ammonites and inoceramids. Interbedded in the shales are sandstone beds up to 4 feet thick. These are brown, fine-grained and calcareous; in some places they contain whitish-weathering fossiliferous limestone nodules. Because of their resistance to erosion, the interbedded silty and mud-cracked limestone horizons form the tops of the beds extending out to sea.

In the lower part of the upper Lambert formation numerous sandstone dykes occur, varying from a fraction of an inch to over a foot in thickness. These were probably formed when local disturbances pushed the underlying unconsolidated sand into the jointed shales above, or conversely, when overlying sand filled the cracks in the consolidated shales

PLATE 2

Figs. 1 and 2
Sandstone Dykes. Lambert Shale

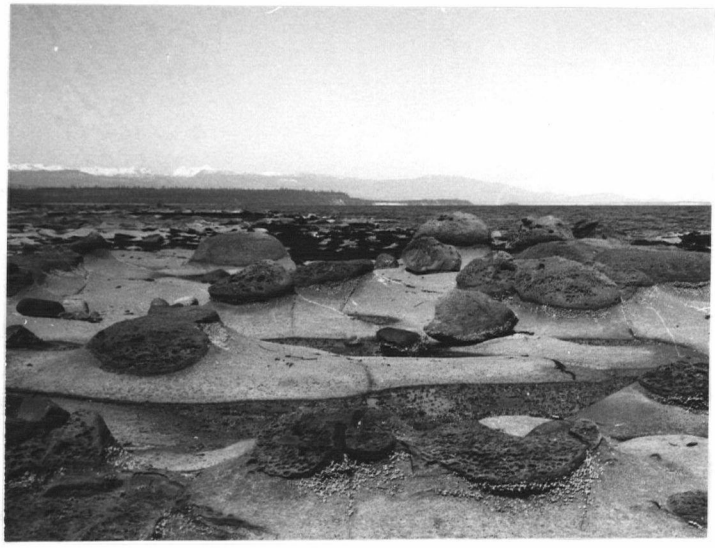


Fig. 3
Upper Lambert Sandstone

below. Towards the top of the Lambert, two sandstone beds pinch and swell along strike. Both average 40 feet in thickness and are separated from each other by 43 feet of shale. These sandstones are brown, fine to medium grained, thickly bedded, and friable. In the upper sandstone layer are thinly bedded argillaceous and carbonaceous sandstones, containing plant remains and thin veinlets of jet black, highly lustrous coal. Also in this layer are very large calcareous sandstone nodules which weather dark brown, and occasionally exceed 10 feet in diameter. They exhibit the characteristic "lace" weathering.

The strike of the Lambert formation varies from N 25° W between Shingle Spit and Phipps Point to N 65° W between Phipps Point and Boulder Point. At the Grassy Point contact between the Lambert and Geoffrey formations, the strike is again N 20° W. This great variance is due to faulting.

In 1872 James Richardson estimated that his "middle shales" or the Lambert formation was 76 feet thick. He measured the upper part of the formation at Norman point where 47½ feet are exposed. Then he concluded that the concealed interval under Lambert Channel would be an additional 28½ feet because the dip was approximately 1 or 2 degrees. Richardson did his measurements on the down-faulted block of a huge hinge fault, not realizing that the regional dip was 5 to 6 degrees. Later in 1952 Usher gave a total thickness of 800 feet for the Lambert formation; he did not mention the distribution of footage between Denman Island, Lambert Channel and Hornby Island.

PLATE 3

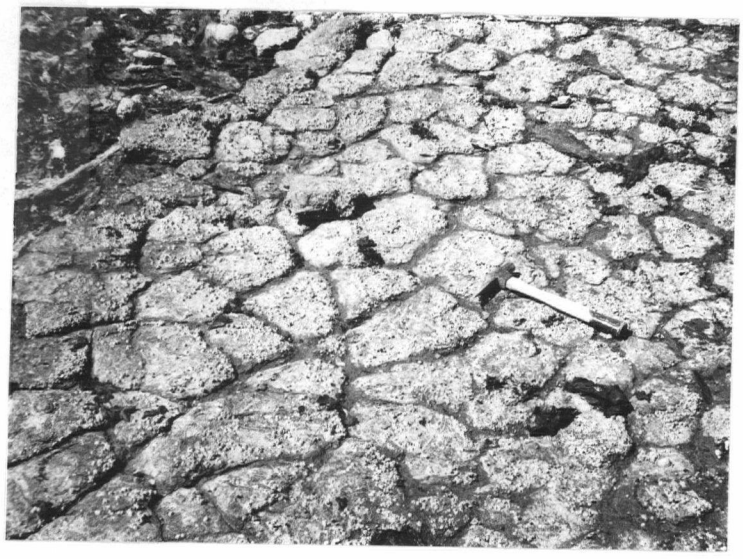


Fig. 1

Mudcracked Limestone Horizon in Lambert Formation

Fig. 2

Sandstone with Limestone Nodules Lambert Formation

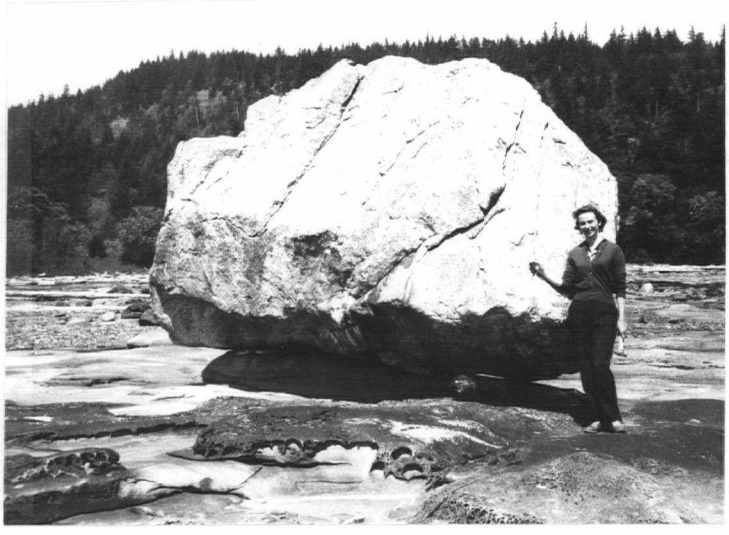


Fig. 3

Glacial Erratic on beach near Toby Island

The present writer believes that a minimum of 350 feet of Lambert shale is exposed on the island; however, if the concealed interval between Arbutus and Collishaw Points is similar in structure to the strata on either side of it, then the thickness would be about 500 feet. The normal fault with a throw of ± 100 feet half-way between these points has been taken into consideration. A further 500 feet would exist between Denman and Hornby if a monoclinal dip of 5 degrees was assumed. The total thickness would thus be at least 1,000 feet, including the lower Lambert on Denman. The writer believes that Usher's 8 degree dip is excessive and that his estimated thickness of 800 feet is insufficient.

The formation was measured in ascending order from the lowest part of the formation exposed on Hornby Island just north of Shingle Spit.

Interval	Remarks
0' - 105'	Shale, gray, silty, non-calcareous, nodular, reddish weathering, containing gray, micro-grained, red weathering fossiliferous limestone nodules. The biggest have a diameter of 20 inches but a thickness of only 7 inches. Large poorly preserved ammonite and inoceramid remains were found in these nodules, but were not collected. Numerous sandstone dykes occur in this interval; these range from less than an inch to more than a foot in thickness. There is a four foot thick lens of sandstone as well as several non-continuous, irregular, nodular limestone beds up to four inches in thickness.

PLATE 4

Fig. 1

Calcareous Nodules
in Lambert Sandstone

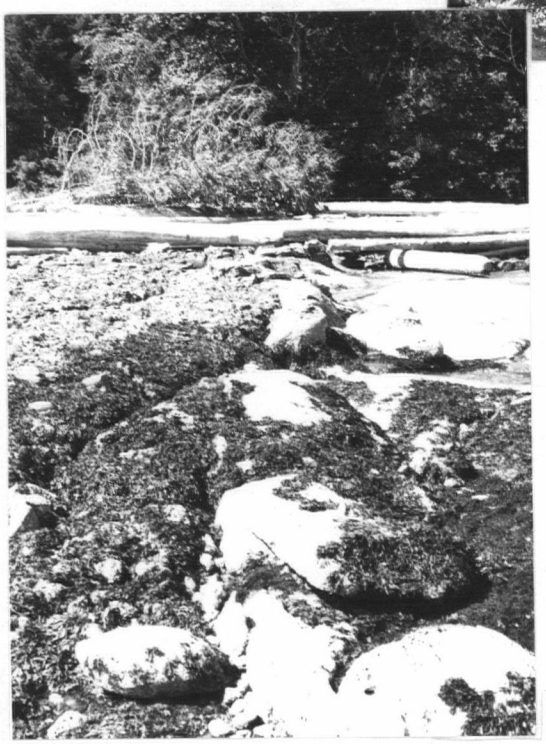


Fig. 2

Contact Between Lambert
and Geoffrey Formations
on North Shore Near
Grassy Point

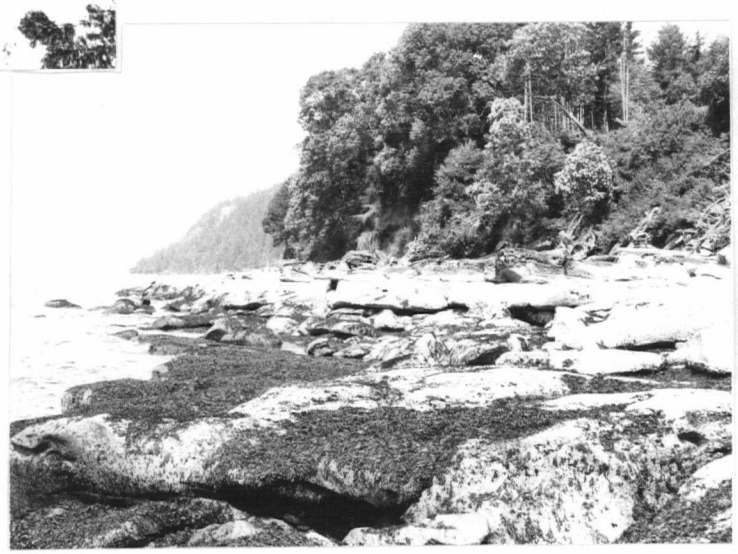


Fig. 3.

Upper Lambert
Sandstone Near
Ford's Cove

Interval	Remarks
105' - 115' (10') Sample 1A	Sandstone, brown, fine to medium grained with some coarser fragments; angular to sub-angular, poorly sorted, low sphericity. Composition: calcareous cement 40%, quartz 20%, plagioclase 16%, orthoclase 4%, chert and other rock fragments 19%, pyrite, magnetite and hematite 1%. Within the sandstone numerous light gray, micro-grained, whitish-weathering, fossiliferous limestone nodules occur which disappear laterally.
115' - 160' (45')	Shale, black, silty, non-calcareous, fissile, with numerous interbedded medium-gray, micro-grained, light gray weathering, pure limestone nodules which are fossiliferous and up to 3 feet in diameter. There are also concentrically layered limestone nodules or "cannon-balls" which are rarely fossiliferous.
160' - 190' (30') Sample 2A	Shale, black, non-calcareous, platy when pure, fissile when silty; with interbedded limestone horizons which are argillaceous, silty, and a few inches thick. Because of their greater resistance the latter form the tops of the beds that shelve out to sea. These limy layers are brown-gray in colour, micro-grained, banded and mud-cracked. This interval was measured during low tide.
190' - 210' (20')	Mainly concealed, shale, dark gray, silty, blocky to fissile, limestone nodules more abundant than in previous interval.
210' - 230'	Shale, medium gray, blocky to fissile with interbedded gray, micro-grained, light gray weathering, fossiliferous, limestone nodules and mud-cracked, silty limestone horizons.
230' - 350' (120')	Concealed. This interval was estimated from the map and may not be accurate. In places the strata are contorted, especially in the vicinity of a major fault, the displacement of which was taken into consideration.

Interval	Remarks
350' - 380' (30')	Shale, medium gray, silty, blocky, containing haphazardly oriented brown-gray, micro-grained, dense, limestone nodules.
380' - 420' (40') Sample 3A	Sandstone, light-brown, medium to coarse grained, massive bedding, friable. Thickness varies from 30 to 80 feet. Interbedded are thin fissile argillaceous and carbonaceous sandstone beds which contain plant remains and veinlets of vitrain. Some shale nodules also present.
420' - 463' (43')	Shale, gray, thinly bedded, reddish weathering, containing gray, micro-grained, fossiliferous limestone nodules.
463' - 503' (40') Sample 4A	Sandstone, brown, medium grained, non-calcareous, angular to sub-angular, sphericity (.7), porous, friable, well-sorted, thickly bedded, containing large calcareous "lace"-weathered, flattened sandstone nodules, many in excess of 10 feet in diameter. Squeezed between these sandstone beds are thin, brownish-gray, silty, blocky, shale horizons from 6 to 12 inches in thickness. They in turn contain irregular argillaceous limestone nodules. Also interbedded are some silty, fissile, shale beds. Composition of sandstone, chert and rock fragments 50%, quartz 30%, feldspar mainly plagioclase 10%, fine grained matrix plus traces of biotite, chlorite and hematite 10%.

The Geoffrey Formation

The Geoffrey formation consists of a thick series of massive conglomerate lenses with minor interbedded lenses of sandstone. This formation produces the main relief on the island in the form of an obtusely-triangular mountain, which slopes gently to the northeast and drops for a sheer 250-300 feet on its west and southwest sides. Mt. Geoffrey's peak is 920 feet high near the steep cliffs at the Spit; from here the

mountain ridge gradually loses elevation towards the north and southeast. Thus the Geoffrey formation is exposed on the coast in the Grassy Point area and near Downes Point.

The formation overlies the Lambert with a sharp almost conformable contact. Because of the uniformity of the conglomerates, which vary in size from granule to boulder variety, and because of the formation's lenticular nature, detailed descriptions of it will not be given. Throughout the Geoffrey cobble conglomerates containing occasional boulders alternate with pebble and granule conglomerates. Interbedded with them are sandstone lenses which vary greatly in thickness but generally persist only for short distances. The conglomerates are composed mainly of aphanitic, basaltic rocks but also contain chert, quartzite, quartz, porphyries, granitic rocks, schist, argillite, sandstone and sometimes large limestone nodules. The coarser pebble-cobble conglomerates are usually well-rounded and exhibit a fair sphericity. On the other hadn, the granule conglomerates tend to be sub-angular.

The sandstone matrix of the conglomerate is:

> gray, fine to coarse grained, angular to sub-angular, exhibits low sphericity and poor sorting. Composition: quartz 35%, calcareous and ferruginous cement 30%, feldspar 10%. Rock fragments account for 25% and consist largely of chert with grains of biotite, chlorite, muscovite, carbonaceous material and pyrite.

The sandstone in the lenses is:

> medium to coarse grained, poorly sorted, sub-angular, fairly spherical and often contains cherty granules up to 6.5 mm. in diameter. Composition: feldspar 40%, quartz 35%, calcareous cement 15%. Chert, biotite, muscovite, carbonaceous material, hematite, chlorite and myrmekite account for the other 10% in order of abundance.

In the Geoffrey formation facies changes are extremely rapid. A thick conglomerate bed was traced along strike where it changed gradually from a conglomerate with a 20% sandstone matrix to a sandstone with 40% conglomerate. The bed then changed to pure sandstone and back to conglomerate again. The contacts along strike between conglomerate and sandstone lenses are often perpendicular.

Towards the top of the Geoffrey formation near Grassy Point, there is a thick interval of granule conglomerate overlain by a coarser conglomerate with pebbles and cobbles up to 8 inches in diameter. These decrease in size and abundance upward as the Geoffrey grades into the Spray formation sandstone. Thus the area of overlap between the two is characteristically a sandstone with scattered pebbles. On the other side of the island the contact is much sharper.

The thickness of the Geoffrey formation has been generally accepted to be 1,100 to 1,200 feet. Richardson first suggested this figure in 1872-73. In 1952 Usher again gave a thickness of from 1,100 to 1,300 feet for the formation. The present writer believes that the maximum thickness does not exceed 800 feet. It would seem that Richardson measured the

Geoffrey formation on the downthrow side of the hinge fault, half-way between Ford's Cove and Shingle Spit. He thus went over the upper part of the Geoffrey formation twice.

The Spray Formation

This formation is almost completely exposed, outcropping on the south side of the island from Downes Point to the northern end of Tribune Bay. On the north coast it extends from east of Hardie Point to Tralee Point. The Spray formation conforms closely with the arcuate nature of the Geoffrey formation which it overlies with a gradational contact.

On the south shore the formation is composed of thinly interbedded sandstones and shales. The sandstones are brown to gray, fine grained and partly calcareous. They show crossbedding and structures of soft rock deformation. Some interbedded red-weathering marcasite nodules exist. Between the thin-bedded and occasionally thick-bedded sandstones are dark gray, blocky to fissile, silty, non-calcareous, greenish-gray weathering shales. The latter contain limestone nodules which are gray, dense, micro-grained and weather light-gray. Higher in the formation there are thicker sandstone horizons, especially at Spray Point. Here light-brown, fine-grained, non-calcareous, friable, massive, slightly undulatory sandstone beds occur. These enclose large hemispherical calcareous sandstone nodules, the surfaces of which are weathered to a lacy network. The thick beds are separated by thin beds of shale and grade

laterally into thinly-bedded sandstones.

The Spray formation on the north shore is very much more arenaceous and thickly bedded. The sandstones are gray, fine to medium grained, and brown weathering; they are composed of angular quartz feldspar and mica flakes. The beds which here again have large lace-weathering calcareous nodules, are separated from each other by silty to sandy shales. Also interbedded are some pebble conglomerate lenses. Crossbedding is well displayed; the strata here form a steplike coastline. No fossils were found in the Spray formation.

The exposed thickness was measured as 346+ feet, while the intervals concealed by the Little and Big Tribune Bays were estimated to be 353 feet thick. The 5 degree dip was quite uniform. The fault running through the island may account for a loss of between 40 and 100 feet. Richardson's total of 776 feet agrees closely.

The Spray formation was measured in ascending order from the Geoffrey contact in the bay south of Dunlop Point.

Interval	Remarks
0' - 17' (17')	Concealed
17' - 28' (11')	Sandstone, brown to dark gray, very fine to fine grained, fissile, pure to very argillaceous. Some interbedded black silty shale.

PLATE 5

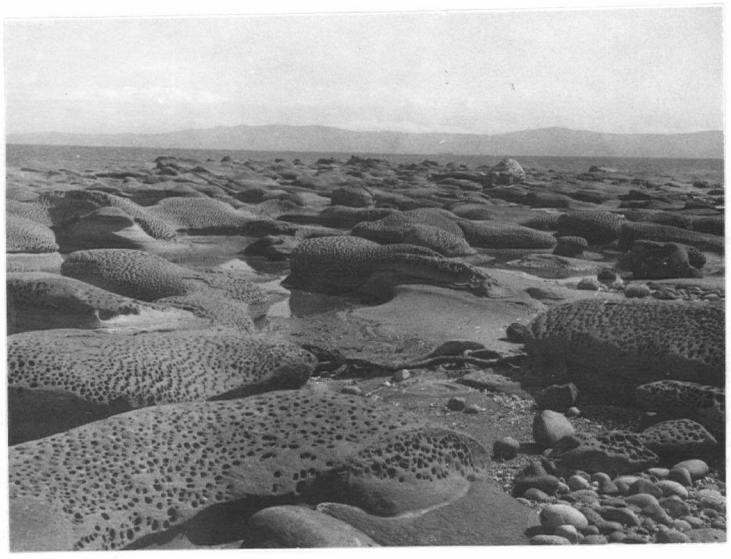
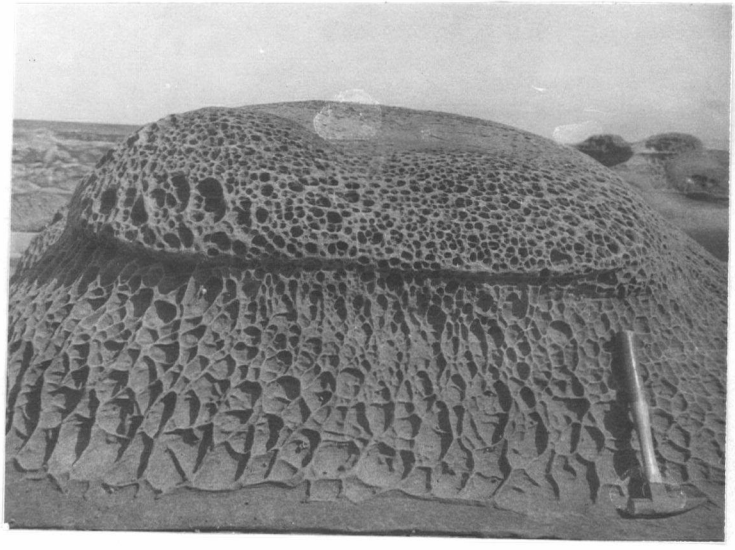
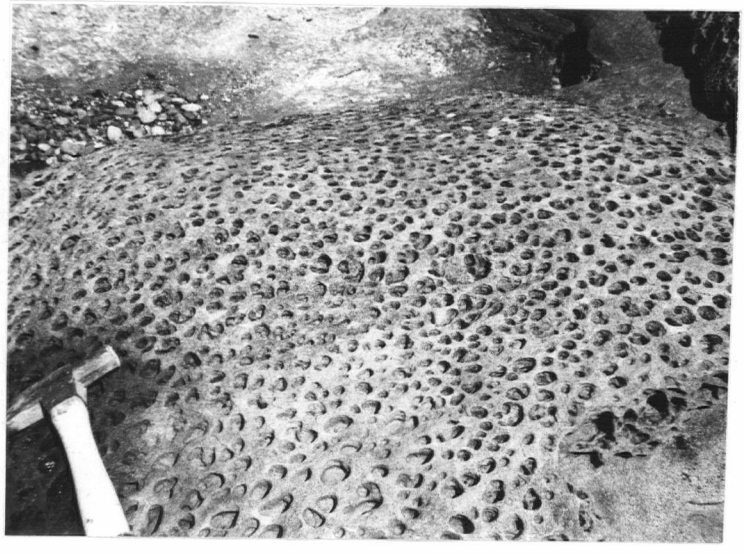


Fig. 1

Hornby Formation
East of Tralee
Point





Honeycombed
Calcareous Nodules
Figs. 2 and 2.

Interval	Remarks
28' - 45' (17')	Sandstone, brown to light gray, fine grained, calcareous, with interbedded dark gray to black, fissile to blocky, silty to pure shale. In the upper part of this interval dark gray, micro-grained, argillaceous limestone nodules one foot in diameter and three inches thick occur.
45' - 79' (34') Sample 1C	Interbedded sandstone and shale. Sandstone brownish to greenish gray, very fine to medium grained, porous, friable, angular to sub-angular, fairly high sphericity (.7), well sorted. Composition: calcareous cement 40%; quartz 35%; chert 10%; feldspar 6%; biotite 2%; carbonaceous material, chlorite, hematite, magnetite and pyrite 2%. Shale, dark gray, slightly silty, fissile to blocky.
79' - 85' (6')	Concealed
85' - 92' (7')	Interbedded black, platy, silty shale and dark gray, very fine grained, calcareous, fissile to thinly-bedded, argillaceous sandstone.
92' - 97' (5')	Sandstone, whitish brown, very fine to coarse grained, calcareous and friable. Interbedded are dark gray, silty, platy shales.
97' - 108' (11')	Thinly interbedded very argillaceous siltstones and very silty shales.
100' - 115' (5')	Interbedded whitish-gray calcareous sandstone and silty shale.
113' - 136' (23')	Thinly interbedded dark gray, pure, platy shale and brownish-green, medium grained, fissile sandstone containing reddish weathering marcasite nodules. Joint pattern N 35° E occurs, dipping at a high angle.

Interval	Remarks
136' - 142' (6')	Sandstone, greenish brown, medium to coarse grained, calcareous, thickly bedded, containing large flattened honey-combed nodules and some wood fragments. Interbedded are dark gray, silty to pure shales.
142' - 151' (9')	Interbedded whitish to greenish-brown, fine grained, fissile to thinly bedded, calcareous sandstone containing plant fragments and dark gray shale with limestone nodules.
151' - 174' (23')	Interbedded dark gray, silty, platy, greenish weathering shale and medium grained sandstone containing honeycombed nodules.
174' - 231' (57')	Interbedded light brown, fine to medium grained, calcareous sandstone with dark gray, silty to pure, platy shales. Joint pattern strikes N 55° E and dips at a high angle.
231' - 248' (17')	Thinly interbedded, platy, calcareous sandstone containing marcasite nodules and dark gray silty shale.
248' - 295' (47')	As above with some limestone nodules. The strata is warped in this interval due to a major fault. Accurate measurements could not be taken.
295' - 423' (128')	Concealed by beach of Little Tribune Bay.
423' - 440' (17')	Interbedded light brown to light gray, medium grained, calcareous, thinly bedded, cross-bedded, somewhat undulatory sandstone and dark gray, silty to pure, platy, reddish weathering shale.
440' - 452' (12')	Sandstone, light brown, fine to medium grained, non-calcareous, undulatory, slightly cross-bedded, friable, thinly to mediumly bedded. Interbedded are some dark gray silty shales.
452' - 458' (6')	Thinly interbedded sandstone and shale.

Interval	Remarks
458' - 474' (16')	Sandstone, light brown, medium to coarse grained, non-calcareous, thickly bedded, friable, porous, sub-angular, fair sphericity (.7), generally well sorted with some poorly sorted intervals. Interbedded are some dark gray, fine grained carbonaceous sandstones containing small coal veinlets. At the top of this interval there are numerous calcareous lace-weathered sandstone nodules. Composition of main sandstone: Quartz 65%; chert 20%; plagioclase 5%; rock fragments 4%; muscovite 1%; hornblende, hematite and chlorite ±2%.
474' - 700'	Concealed by the beach of Big Tribune Bay.

The Hornby Formation

The Hornby formation is the youngest of the Nanaimo series in the Comox basin and corresponds to the Gabriola formation in the Nanaimo basin. It outcrops along precipitous 200 foot cliffs between Tribune Bay and St. John's Point, and underlies the whole peninsula. The formation has a NNW strike and a dip of about 6-8 degrees. Its 500 to 600 feet of sandstone and conglomerate can be divided into three members: a basal massive sandstone member, a middle massive conglomerate member, and a topmost member of interbedded sandstone and conglomerate.

The lowest sandstone member conformably overlies the Spray formation; the contact can be seen on the north-east side of Tribune Bay where this massive member forms a perpendicular 100 foot cliff. The sandstone is:

Fig. 1 and 2

"Lacework" Weathering in Spray Formation Sandstone

Fig. 3

Erosion Channels in Spray Sandstone

brown, medium grained, non-calcareous, medium to thickly bedded, angular, porous, cross-bedded and friable. In places it is well sorted, elsewhere poorly sorted. Generally its particles have a low sphericity. Composition: quartz 65%; plagioclase 10%; matrix 15%; rock fragments 4%; biotite 3%; muscovite, hematite, chlorite and carbonaceous material 3%.

Within the sandstone there are stringers of granule conglomerate and calcareous lace-weathered sandstone nodules. Although they extend for some distance, laterally towards St. John's Point the massive beds become medium-bedded and then thin-bedded. Near the top of the sandstone member conglomerate pebbles occur, becoming more abundant towards the gradational contact with the overlying massive conglomerate member.

The middle member consists of well-rounded to sub-rounded pebble-cobble, and less frequently, boulder conglomerates. It is at least 150 feet, possibly 200 feet thick. Sandstone stringers and lenses become more abundant towards the top.

Chert, basalt, limestone, greenstone, porphyries, quartz, shale and granitic fragments make up the conglomerate. Fine grained to aphanitic igneous rocks are most common. The sandstone matrix is greenish-brown, coarse-grained, calcareous, sub-angular, is well sorted and has a high sphericity. Composition: quartz 50%; calcareous cement 25%; plagioclase 10%; chert and rock fragments 10%; hematite, carbonaceous material and unidentified fragments 2%.

Overlying the massive conglomerate conformably is a series of interbedded sandstone and conglomerate beds and lenses. The sandstone horizons are greenish-brown, medium to coarse grained, medium-bedded, and contain calcareous honeycombed nodules as well as very large shale nodules. Some of the

Fig. 1

Little Tribune Bay.
Looking at Spray Pt.
and St. John's Pt.

Fig. 2

Sandstone Lense
in Lower Hornby
Conglomerate.
Cormorant Nesting
Grounds

Fig. 3.

Spray Sandstone
at Tralee Point

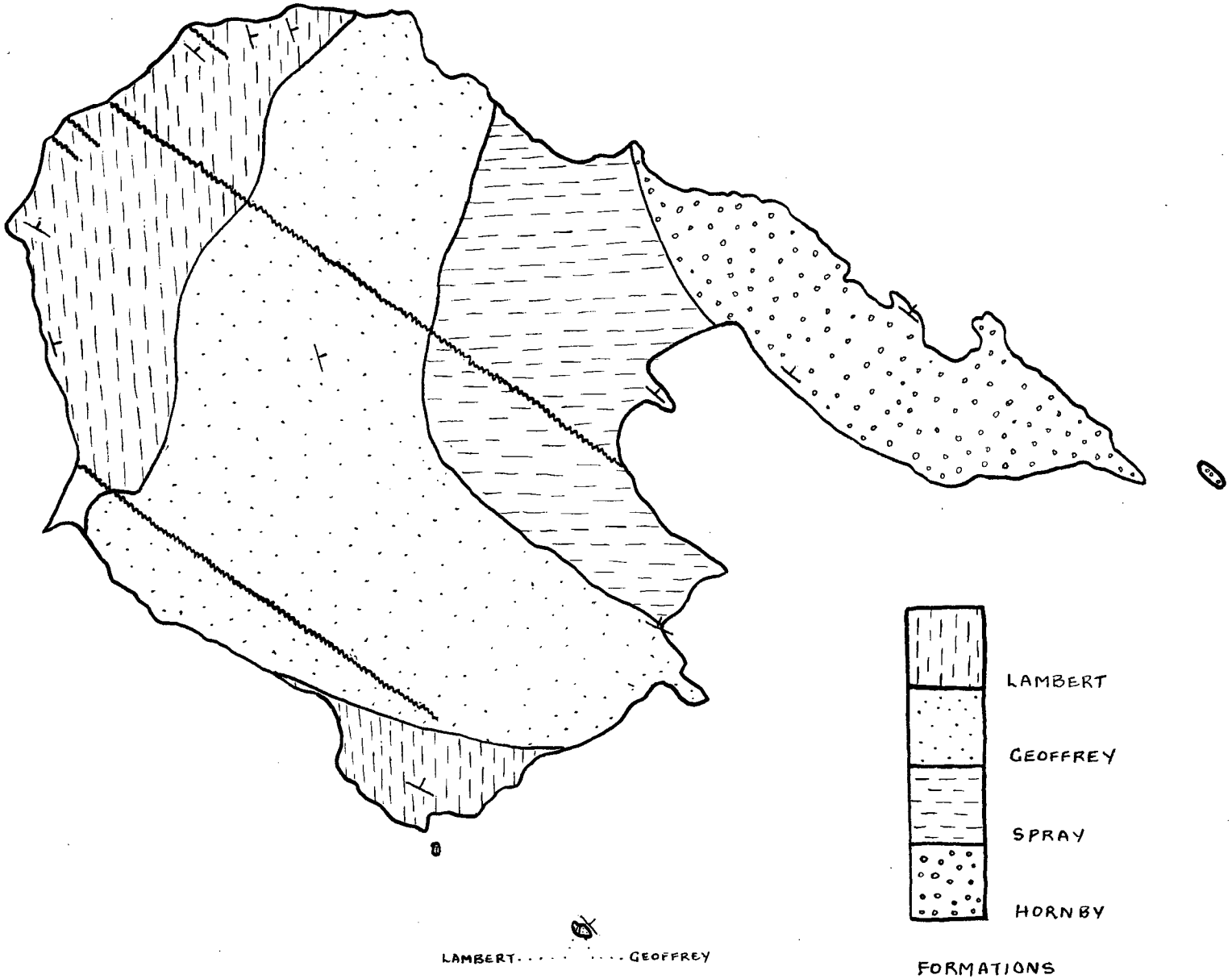
nodules exposed along the cliffs have been weathered out to form caves 10 feet in diameter. The shales are gray, silty, blocky, contorted and weathered a reddish brown.

The conglomerate beds are very similar to the main second member conglomerate. The pebbles and cobbles are well rounded. Noticeable are the many limestone pebbles and nodules, some of which are two feet in diameter. Interbedded in the conglomerate are numerous, small pebbly sandstone lenses; also interbedded are occasional beds of black, pure to silty, platy shales. The third member is probably the thickest of the three at about 280 feet.

Structural Geology

The structural geology of the island appears to be relatively simple; to prove this is quite difficult. The bedrock is almost completely concealed except for the intertidal portion along the coast and the cliffs of Mt. Geoffrey. As was mentioned previously, strike and dip readings were complicated by the eroded nature of the rocks, the shallowness of the true and apparent dips and the undulatory nature of the strata. On the island two major normal faults appear which parallel one another and strike N 55° W, dipping at a high angle to the southwest.

The longer of the two faults, which traverses the whole island, can be seen along the coast at the south side of Little Tribune Bay. Here the strata are contorted and have


LAMBERT
GEOFFREY
SPRAY
HORNBY
FORMATIONS
LAMBERT . . . . . GEOFFREY

different strikes on either side of the fault. It cuts across the island to a point half-way between Arbutus and Boulder Points. The beds here are folded but a fault is not apparent. On the northern limb of Mt. Geoffrey a 70 foot fault or fault-line scarp occurs. No actual slickinslides, mullion or other fault features are noticeable on the scarp so that a close estimate of the displacement cannot be given. Probably the displacement is the height of the scarp because the fault is sharply defined and the fault line straight. A valley exists along the scarp.

The second major fault paralleling the first is a large hinge fault which originates about 500 feet up on the mountain midway between Ford's Cove and Graveyard Point. From the hinge point a section of the homocline has slipped down to form a horizontal bench extending to Shingle Spit. The displacement at the dropped end of the fault near the Spit is about 400 feet. This hinge fault which was not observed by previous workers perhaps accounts for the excessive thicknesses quoted by Richardson and Usher for the Geoffrey formation.

Minor faults and fault zones, with a similar strike and dip as the major faults, exist at Arbutus and Boulder Points. These have small displacements of about 20 feet; associated with them are numerous auxiliary or branch faults.

CHAPTER III

SYSTEMATIC PALEONTOLOGY

Phylum . . . . COELENTERATA

Class . . . . ANTHOZOA

Subclass . . . HEXACORALLA

Order . . . . MADREPORARIA

Family . . . . TURBINOLIDAE

Genus: Smilotrochus (Edwards and Haime)

SMILOTROCHUS (?) cf. vancouverensis (Whiteaves)

Plate 8, fig. 1

1879 Smilotrochus (?) vancouverensis Whiteaves, Mesozoic Fossils, v. 1, pt. 2, p. 178, pl. 20, figs. 7, 7a.

1903 Smilotrochus (?) vancouverensis Whiteaves, Mesozoic Fossils, v. 1, pt. 5, p. 406.

A solitary, curved, trochoid hexacoral was collected from the same locality where Richarson, and later Harvey each found one specimen. For these, Whiteaves proposed the name Smilotrochus (?) vancouverensis. The description is based on Richardson's specimen which was imperfect and poorly preserved;

Harvey's specimen was intact.

The writer found only the upper portion of a corallum, which is almost circular in cross-section with a diameter of 19 mm. and a height of 8 mm. Around the periphery there are numerous septa; major ones alternate with three minor ones. In all there are about 48 which have small nodes along the peripheral stereozone. Calyx is concealed but appears to be quite deep and wide with a possible diameter of 11 mm.

Whiteaves believed the calyx to be shallow but he was dealing with a much smaller specimen.

Occurrence: Locality 6.

Hypotype: K 58-6-1

Phylum . . . . MOLLUSCA

Class . . . . GASTROPODA

Order . . . . ASPIDOBRANCHIA

Suborder . . . DOCOGLOSSA

Family . . . . ACMAEIDAE

Genus: Acmaea Eschscholtz 1830

Type Species: Acmaea mitra Eschscholtz

> "like Patella, but shell having generally a differentiated marginal band inside; externally smooth, finely striated, or radially ribbed. Beak anterior to middle."

ACMAEA (?) sp. undet.

Plate 8, fig. 2

Shell small, thin, conical, elevated; outline elliptical, apex sub-central, situated slightly in front of the middle, conical and straight.

Surface ornamented by regular, nearly equidistant concentric growth-lines, which are cut at right angles by much finer radial striae not visible to the naked eye. Internal features not uncovered.

Dimensions: Length 17 mm., width 15 mm., height 7 mm.

Occurrence: Locality 3.

Hypotype: K 58-3-1.

Family . . . . TURBINIDAE

Genus: Turbo (Linne)

Type Species: Turbo Petholatus (Linne)

> "Turbinate to conical; aperture, nearly circular. Operculum calcareous, thick, flat internally, externally convex, multispiral with sub-central nucleus."

TURBO s.l. sp. A

Plate 8, fig. 3

Shell of medium size, turbinate, spiral angle about 60°. Protoconch broken away. Whorls three, possibly four, gently convex on the sides, expanding very rapidly. The largest

whorl bears four strong, narrow, sharp, tuberculate costae on the side; these are separated by much wider interspaces. Suture partly concealed, weak. Growth-lines not strong, crossed by faint revolving lines which parallel the costae, producing a finely reticulated pattern. Diameter of body whorl 17 mm.; height of shell (est.) 27 mm.

Occurrence: Locality 4.

Hypotype: K 58-4-23.

TURBO s.l. sp. B

A small, much distorted, very fragile shell has also been tentatively assigned to this genus as it closely resembles the previous specimen in shape and ornamentation. Whorls four, angulated, squarely ovate in section. Suture more strongly impressed. Costae sharp and tuberculate separated by wider interspaces. On this shell the costae are not restricted to the body whorl but also occur on the lower whorls of the spire. Diameter of body whorl 9 mm.; height of test, 13 mm.

Occurrence: Locality 6.

Hypotype: K 58-6-8.

Suborder . . . . RHIPIDOGLOSSA

Family . . . . . PLEUROTOMARIIDAE

Genus: Pleurotomaria Sowerby.

> "Shell broadly conical or turbinate; spire sometimes high, in other cases depressed. Umbilicus present or absent. Outer lip with slit; growth lines strongly recurved, meeting in the slit-band."

PLEUROTOMARIA sp. undet.

Plate 8, fig. 4

A large Pleurotomaria type gastropod was collected from the beach of Hornby Island south of Phipps Point. Much of the original shell material has worn off. Shell turbinate-conical, wider than high, spire about as high as body whorl; umbilicus deep, less than one third the diameter of base, filled almost completely with shell material. Whorls probably four or five, squarely-ovate in section, angulated; two raised ridges revolve around the shell, the upper halfway, the lower at the base of the whorls.

Shell ornamented by revolving, raised lines especially noticeable on the base. The grooves between are about equal to the lines in width. Faint vestiges of nodes are discernible on the upper part of the spire whorls. The specimen may possibly be identical with P. skidegatensis Whiteaves, but its poor state of preservation does not permit definite correlation. Diameter of body whorl 55 mm.

Occurrence: Locality 2.

Hypotype: K 58-2-1.

Order . . . . . CTENOBRANCHIATA

Suborder . . . PLATYPODA

Superfamily . . TAENIOGLOSSA

Family . . . . NATICIDAE

Genus: Gyrodes (Conrad)

Type Species: Natica (Gyrodes) crenata (Conrad)

"Naticoid shells with broad and deep umbilicus generally surrounded by an angulation; and a flattened or concave band at suture in later whorls." -- Conrad

GYRODES cf. conradiana (Gabb)

Plate 8, figs. 5, 6, 7

1861 Natica infracarinata (Gabb), Proc. Acad. Nat. Sci., Philadelphia, vol. 13, p. 319.

1861 Gyrodes spillmanii (Gabb). Idem., p. 320.

1864 Lunatia (Gyrodes?) conradiana (Gabb). Paleont. Calif., v. 1, p. 107, pl. 29, fig. 219.

1869 Lunatia (Gyrodes?) conradiana (Gabb). Paleont. Calif., v. 2, p. 222.

1879 Gyrodes excavata (Michelin) (Whiteaves). Mesozoic Fossils, v. 1, pt. 2, p. 124, pl. 16, fig. 2.

1889 Gyrodes conradiana (Gabb) (White). Bull. U. S. Geol. Surv. No. 51, p. 45.

1903 Gyrodes canadensis (Whiteaves). Mesozoic Fossils, v. 1, pt. 5, p. 365.

1926 Gyrodes conradiana (Gabb) (Stewart). Acad. Nat. Sci., Philadelphia, Proc., Vol. 78, p. 329, pl. 22, fig. 2.

1958 Natica (Gyrodes) conradiana (Gabb) (Anderson). Geol. Soc. Am. Men. 71, p. 149, pl. 21, figs 2, 3.

Shell depressed, subglobose; spire short, about one fifth of entire length; whorls four or five, rounded. Aperture narrow above rounded below, somewhat elongated. Outer lip simple, thin, expanded in the center; inner lip simple, nearly straight, but curved concavely below. The umbilicus which is concealed in all the specimens, is as Gabb says,

". . . broadly-open, perspective forming about half of the diameter of the lower aspect of the shell; margin subangular."

The surface in most specimens is almost smooth, ornamented only by numerous very fine growth lines which continue into the umbilicus.

The dozen poorly preserved examples are all small, the largest measuring about 9 mm. These might be considered to be young specimens of G. conradiana. However, more likely they belong to a different species. Differences were noted even between the various specimens, some of which closely resemble Whiteaves' G. canadensis while others resemble Stephenson's G. fluvianus.

The specimens collected were too poor to define the species, but they closely resemble G. conradiana sensu lato, which is common in the Nanaimo series.

Occurrence: Localities 6 and 7.

Hypotype: K 58-6-7.

Family . . . . XENOPHORIDAE

Genus: Xenophora (Fischer)

Type Species: Trochus conchyliophorus (Born)

> "Shell conical or pyramidal; whorls slightly convex or flat; base angular at the periphery. Inner lip often truncated anteriorly, thickened or with teeth."
> -- Linne

XENOPHORA (?) sp. undet.

Plate 8, fig. 8

Shell small, trochiform, spire higher than body whorl,

composed of two broad whorls excluding the protoconch. Whorls slightly convex, increasing slowly in size. Test ornamented by numerous revolving costae bearing small blunt nodes. Aperture subrounded, incomplete.

Occurrence: Locality 6.

Hypotype: K 58-6-3.

Family . . . . APORRHAIDAE

Genus: Anchura (Conrad)

Type Species: Anchura abrupta (Conrad)

> "Shell fusiform turreted or conical ovate. Aperture produced anteriorly in a canal. Outer lip expanded in a wing-like or digitiform fashion, or thickened. Operculum horny."

ANCHURA s.l. sp. undet.

Plate 8, figs. 9, 9a

The poorly preserved shells of this genus could not be given specific names although undoubtedly more than one species were obtained. Some of the specimens have well developed axial ribs, others are almost smooth resembling A. modesta (Cragin) as figured by Stephenson. All possess the conspicuous long siphonal canal. The long slender spur-like projection of the upper lip was not preserved in any of the shells.

The smallest specimen measured a little less than 8 mm., the largest 35 mm. with a body whorl diameter of 18 mm.

Occurrence: Localities 6, 7.

Hypotype: K 58-6-5.

Genus: Lispodesthes

Type Species: Anchura nuptialis (White) 1877

LISPODESTHES sp. undet.

Plate 8, fig. 10

Only the body whorl of this shell was found. It resembles Geinitz's species Aparrhais (Lispodesthes) reussi, as figured by Zittel, p. 551, fig. 991.

Growth lines pronounced, sinuous, forming a smooth forward curve on the body whorl but slanting strongly backward on the siphonal canal, crossed by faint revolving striae.

Length of body whorl and part of siphon 14 mm., width of body whorl 9 mm.

Occurrence: Locality 6.

Hypotype: K 58-6-6.

Genus: Tessarolax (Gabb)

> "Shell fusiform, spire and aperture about equal; spire incrusted by a thin body whorl bearing two (or more) varix-like processes. Aperture broad above, continued below in a long curved canal. A posterior canal continues for some distance up the spire. Columella incrusted, but without folds or teeth. Outer lip produced in two long spine-like canals."

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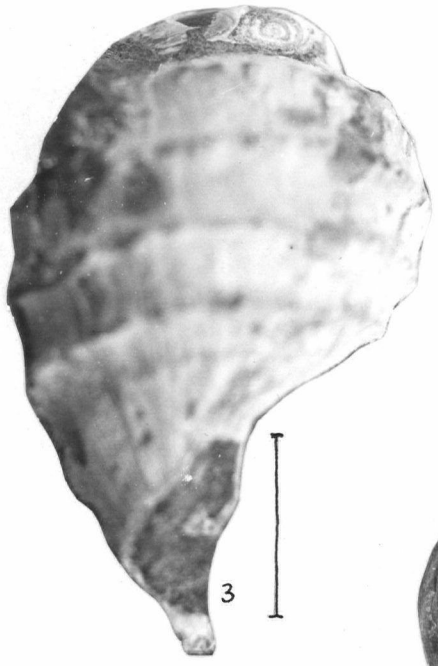
PLATE 8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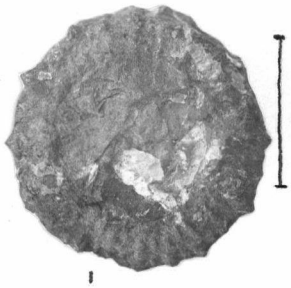
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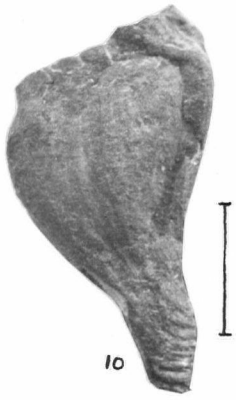
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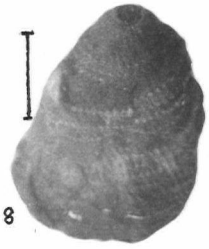
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TESSAROLAX distorta (Gabb)

Plate 9, fig. 1

1864 Tessarolax distorta (Gabb). Geol. Surv. Calif. Paleont. vol. 1, p. 126, pl. 20, fig. 82.

1879 Tessarolax distorta (Gabb) (Whiteaves). Mesozoic Fossils, v. 1, pt. 2, p. 123.

1896 Tessarolax distorta (Gabb) (Whiteaves). Trans. Roy. Soc. Canada, 2nd ser., vol. 1, sect. 4, p. 127.

1903 Tessarolax distorta (Gabb) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 358.

> "Shell elongated; spire high; whorls five or six (from casts), slightly convex in middle, so as to produce a faint undulation on the smooth surface of the spire. Apex usually flattened and somewhat twisted; at other times bluntly rounded. Surface of body bicarinate bearing on the upper carina at a point about a third of the circumference of the mouth, a short clavate process, abruptly truncated at the end and flattened on the sides. On the lower carina is another process, flattened above and below, prominent and angular at the extremity. This is placed about half-way between the first and outer lip. Aperture small, broad above, rapidly narrowed and prolonged below into a canal, which curves obliquely forward and to the left. Above, the mouth is continued into a canal, which runs beside the spire for about two-thirds of its height and then curves off obliquely backwards and to the right. The outer lip is prolonged into two long, slender, channelled spires, continuations of the carinae on the whorl, which diverge rapidly, and which are not in the same plane, the lower one being directed much in advance of the upper." -- Gabb 1864.

The writer found only part of an outer whorl or body chamber, which had three varix-like processes intact as well as the two long spine-like anterior and posterior canals.

Occurrence: Locality 5.

Hypotype: K 58-5-1.

Order . . . . OPISTHOBRANCHIA

Suborder . . TECTIBRANCHIATA

Family . . . RINGICULIDAE

Genus: Oligoptychia (Meek) 1876

Type Species: Acteon concinnus (Hall and Meek)

> "Shell with spire much depressed and obtuse; outer lip smooth within, and very slightly sinuous at the base of the aperture; inner lip bearing a single, very prominent, nearly transverse plication, or tooth, at the base of the columella." -- Meek.

OLIGOPTYCHIA obliqua (Gabb)

Plate 9, figs. 2, 2a, 3, 4

1864 Cinulia obliqua (Gabb). Paleont. Calif., vol. 1, p. 111, pl. 19, figs. 64-64c.

1879 Cinulia obliqua (Gabb) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 131.

1884 Cinulia pusilla (?) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 3, p. 217, pl. 28, figs. 5, 5a.

1889 Cinulia obliqua (Gabb) (White). U. S. Geol. Surv. Bull. 51, p. 44.

1958 Oligoptycha obliqua (Gabb) (Anderson). Geol. Soc. Am. Mem. 71, p. 67.

Numerous shells were found at various localities on Hornby Island. According to Whiteaves this appears to be one of the commonest and most abundant gastropods in the Nanaimo series. Usually these are well preserved, retaining all their ornamentation.

Gabb describes the species:

> "Shell subglobose, obliquely truncated below; whorls four, rounded; suture distinct. Surface ornamented by numerous fine revolving ribs, with deep interspaces, which are divided into minute, square compartments by crossbars which do not rise to the level of the ribs. Outer lip heavy, smooth, a little notched or sinuous anteriorly. Columella coated by heavy callus, which unites at both ends with the lip, and bears a large fold anteriorly, with a slight intumescence in advance of it."

Whiteaves mentions a species which he names C. pusilla. However, his description and figure are very similar to Gabb's C. obliqua and in the present writer's opinion are not sufficiently different to warrant a new species name. Whiteaves says,

> "On the last volution and near the mouth, there are fifteen or sixteen rows of spiral punctures, the latter are about one half as broad as the smooth flat bands between them. Under an anchromatic microscope. . . these spiral punctations are seen to be transversely oval or somewhat rectangular in outline."

These oval punctations are like those produced by the intersection of the revolving ribs with the crossbars mentioned in Gabb's description. Whiteaves also says that the length and breadth of C. pusilla are almost equal. This is the case with C. obliqua. He specifies the supposed adult specimen's length to be short of five millimeters. Possibly he had either immature specimens or a smaller variety of C. obliqua.

Occurrence: Localities 3, 4, 5, 6, 7.

Hypotype: K 58-6-2.

Family . . . . ACTEOCINIDAE

Genus: Haminea (Leach)

Type Species:

"Oval, thin-shelled, brittle; the spire concealed."
-- Leach.

HAMINEA hornii (Gabb)

Plate 9, figs. 5, 6

1864 Bulla hornii (Gabb). Mesozoic Fossils, Paleont. Calif., v. 1, p. 143, pl. 29, fig. 235.

1879 Haminea hornii (Gabb) (Whiteaves). Mesozoic Fossils, v. 1, pt. 2, p. 132, pl. 16, figs. 8, 8a.

Shell small, very thick, subovate, widest one-third from top. Sides curve downwards towards anterior and where they curve rapidly inwards. Upper end slightly oblique, truncated, rounded and umbilicated marking position of sunken spire. Aperture longer than shell, arcuate, upper end projecting a short distance beyond the summit; anterior end wider. Outer lip simple and thin. Entire surface ornamented by very fine impressed revolving striae as well as finer less numerous transverse striae.

Occurrence: All stations.

Hypotype: K 58-6-4.

Class . . . . SCAPHOPODA

Family . . . DENTALIIDAE

Genus: Dentalium (Linne)

Type Species: Dentalium elephantinum (Linne)

> "Shell tusk-like, tubular, curved and regularly tapering, with circular cross-section and open ends; surface bearing strong large longitudinal ribs or striae, or smooth; apex entire or with notch or slit."
> -- Shimer and Shrock.

DENTALIUM nanaimoense (Meek)

Plate 29, fig. 7

1857 Dentalium nanaimoense (Meek). Trans Albany Inst., vol. 4, p. 44.

1864? Dentalium stramineum (Gabb). Pal. Cal. v. 1, p. 139, pl. 21, fig. 101.

1876 Dentalium koomooksense (Meek). Bull. Geol. & Geog., Surv. of terr., v. 2, no. 4, p. 364, pl. 3, fig. 6.

Meek described the species from a fragment of the anterior portion of the shell not much more than half an inch in length. Since then the shell has been found to taper much more gradually than is shown by Meek's partly restored drawing. Mr. Richardson collected some specimens over an inch in length; these if restored would probably give the entire shell a length of approximately two inches or more. The present writer found some fragments measuring up to 30 mm. in length. The total reconstructed length would be at least 60 mm.

The shell is slightly curved, long in relation to diameter, and in cross-section almost circular. It is much

more fragile and slender than D. whiteavesi. It is ornamented by parallel transverse lines which are quite faint; these are crossed at right angles by more pronounced longitudinal lines producing a reticulated pattern as on D. whiteavesi. However, in the latter species the transverse lines are more pronounced and the longitudinal ones very faint.

Near the apex about 16 lines or costae occur with very fine smaller costae between them. The latter become major costae near the middle of the shell with further thin costae between them. At the large end there are over 80 fine costae.

Whiteaves points out that Gabb's D. stramineum and Meek's D. gracile may well be the same as D. nanaimoense because their differences are probably varietal rather than specific. All may be just geographical forms of Sowerby's D. decussatum.

Occurrence: Locality 6.

Hypotype: K 58-6-17.

DENTALIUM (ENTALIS) whiteavesi (Anderson and Hanna)

Plate 9, figs. 8, 9

1879 Entalis cooperi (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 134, pl. 16, fig. 10.

1903 Entalis cooperi (Whiteaves). Mesozoic Fossils, vol. pt. 5, p. 372.

1935 Dentalium (Entalis) whiteavesi (Anderson and Hanna). Proc. Calif. Acad. Sci. 4th Ser. vol. 23, p. 27, pl. 6, fig. 5.

Whiteaves gave the name Entalis cooperi to the specimens found on Hornby Island by J. Richarson referring them to Gabb's Eocene species, Dentalium cooperi.

Shell slightly curved, long, tapering and circular in cross-section. Original shell material very thick especially toward the smaller end. The surface is ornamented mainly by parallel transverse grooves which are just visible to the naked eye; these in turn are crossed at right angles by very faint longitudinal lines. The reticulated pattern is only visible under a binocular microscope in most specimens.

Whiteaves measured a maximum length of approximately 4½ inches on a specimen from the Trent River formation. The specimens collected by the writer on Hornby were considerably smaller as the largest, if complete, would measure about 2½ inches. The largest fragment measures 28 mm. with a maximum diameter of 7 mm.

Occurrence: Localities 6 and 7.

Hypotype: K 58-6-16.

Class . . . . . PELECYPODA

Order . . . . . PRIONODESMACEA

Superfamily . . NUCULACEA

Family . . . . NUCULIDAE

Genus: Nucula (Lamarck)

Type Species: Arca nucleus (Linne)

NUCULA s.l. sp. undet.

Plate 9, fig. 10

From a fragile shale horizon on the northwest side of Hornby, about a dozen very poorly preserved nuculid shells were collected. On most the original shell material broke off when an attempt to collect them was made. Their outline and dentition indicate a close affinity to the genus Nucula.

Occurrence: Locality 6.

Hypotype: K 58-6-15.

Genus: Acila (Adams)

Type Species: Nucula divaricata (Hinds)

> "Shell nuculid, with posterior ventral margin of valves produced into a short rostrum and set off from the rest of shell by shallow sinus extending from near umbos to ventral margin; surface sculpture of fine radial plications bifurcating along a lateral axis, sometimes with more than one axis of bifurcation."
> -- Shimer and Shrock.

ACILA (Truncacila) demessa (Finlay)

Plate 9, fig. 11

1864 Nucula truncata (Gabb). Paleont. Calif., v. 1, p. 198, pl. 26, fig. 184.

1869 Nucula (acila) truncata (Gabb). Paleont. Calif., v. 2, p. 197 and p. 250.

1879 Nucula (acila) truncata (Gabb) (Whiteaves). Mesozoic Fossils, v. 1, pt. 2, p. 162.

1884 Nucula (acila) truncata (Gabb) (Whiteaves). Mesozoic Fossils, v. 1, pt. 2, p. 232.

1903 Nucula (acila) truncata (Gabb) (Whiteaves). Mesozoic Fossils, v. 1, pt. 5, p. 389.

1927 Acila demessa (Finlay). Tr. Proc. N. Zealand, v. 57, p. 522.

1930 Acila demessa (Finlay) (Stewart). Acad. Nat. Sci., Philadelphia, p. 45, pl. 3, fig. 6.

1958 Acila (Truncacila) demessa (Finlay) (Anderson). Geol. Soc. Am. Mem. 71, p. 68.

Stoliczka pointed out that the name proposed by Gabb for this species was a homonym. The species was indiscriminately renamed by Finlay as Acila demessa although it was without a designated type. This practice of indiscriminately renaming homonyms is condemned by many paleontologists.

The Hornby Island specimens fit Gabb's original description.

> "Shell moderate in size, oblique, anterior end abruptly truncated; posterior end produced, rounded, cardinal and basal margins subparallel, convex, beaks small, anterior, terminal and nearly touching. Surface marked by divaricating ribs; these ribs separate along an imaginary line, drawn from the beaks to the posterior basal margin; near the beaks they are regular, but towards the base, especially near the posterior end, they become irregular, sometimes becoming dichotomous, and at times presenting a "hacked" appearance, from the crossing of small impressed lines at acute angles. Anterior end almost entirely occupied by a large, sunken, subcordate lunule, faintly marked by minute ribs."

The hinge line was not described by Gabb. Possibly it was not exposed on his specimens. Those collected from Hornby show a short somewhat obtuse hinge line. Many were collected from shale horizons, as a result they are compressed and fragile. On these shells the ribs are regular all the way to the basal margin. Only a few ribs near the anterior dorsal region are dichotomous.

Occurrence: Localities 4, 5 and 7.

Hypotype: K 58-6-12.

Superfamily . . TELLINACEA

Family . . . . DENACIDAE

Genus: Protodonax (Vokes)

Type Species: Protodonax elongatus (Vokes)

PROTODONAX sp. undet.

Plate 9, fig. 12

Shell slender, elongated anteriorly, small, extremely inequilateral. The shell as a whole thins wedge-like to the front. Umbonal ridge well rounded. Beaks, hinge and interior not exposed.

Surface marked by very fine concentric growth lines and gentle, faint growth undulations.

Dimensions of single left valve: length 12 mm., height 5.5 mm., convexity could not be measured.

Occurrence: Locality 6.

Hypotype: K 58-6-13.

Superfamily . . ARCACEA

Family . . . . ARCIDAE

Genus: Parallelodon (Meek)

Type Species: Macrodon rugosus (Lycett)

"Elongate to sub-quadrate; anterior end angular at cardinal line and rounded below; posterior rounded or obliquely sub-truncate; beaks anterior to middle; hinge line long and straight; concentric striae often lamellose, hinge with several small, diverging teeth beneath the beak and two or four long, lateral teeth near posterior extremity; ligament external; pallial line simple." -- Shimer and Shrock.

PARALLELODON (Nanonavis) nanaimoensis (Anderson)

Plate 9, figs. 13, 14

1879 Nemodon vancouverensis (Meek) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 163, pl. 19.

1930 Parallelodon (Nanonavis) brewerianus (Gabb) (Stewart) (in part) Acad. Nat. Sci., Philadelphia, Special Pub. no. 3, p. 69.

1935 Nemodon vancouverensis (Meek) (Anderson & Hanna). Proc. Calif. Acad. Sci., 4th ser., v. 23, p. 28.

1937 Parallelodon (Nanonavis) vancouverensis (Reinhart). Jl. Palaeont., v. 11, no. 3, pl. 27, fig. 4.

1943 Parallelodon (Nanonavis) vancouverensis (Reinhart). Geol. Soc. Am., Special Paper, no. 47, p. 85.

1958 Parallelodon (Nanonavis) nanaimoensis (Anderson). Geol. Soc. Am. Mem., 71, p. 94.

These specimens are exceptionally well preserved although brittle; in some the original shell material is completely intact. The largest is 40 mm. in length; the smallest 20 mm. Some slightly larger, ± 50 mm., were observed in the field but could not be collected because of excessive fragility. Some of Mr. Richarson's specimens have a length of over 3 inches and a height of 1.85 inches.

The shell has a height-length ratio of 3 to 5; it is roughly rectangular in outline with the anterior end curved.

In most the hinge line is almost parallel to the basal margin and the posterior end is more or less squarely truncated.

The shell is ornamented by both growth lines and plications. The latter are much more obvious than the growth lines in the younger specimens.

The dentition of the hinge line is very uniform; the hinge plate, which is nearly as long as the shell itself, is straight, and widens out at each end. The writer found the dentition on his specimens rather obscure. Mr. Whiteaves says,

> "Opposite to the beaks or a little behind them, are a few minute, crowded, granular denticles, arranged obscurely in three obliquely ascending but nearly transverse rows. The whole of the teeth proper are large, elongated, horizontal, and nearly parallel with the cardinal margin, but at their inner terminations they curve distinctly downwards. In the adult shell there are three or four anterior and five posterior teeth in the right valve, while in the left there are three anterior and four posterior. The anterior teeth of both valves are grooved transversely, but the posterior teeth are smooth. The nearer the teeth are to the inner margin the shorter they are, and vice versa. The upper posterior tooth is more than half the length of the hinge line."
>
> -- Whiteaves 1879.

Occurrence: Locality 6

Hypotype: K 58-6-11.

Superfamily . . . OSTRACEA

Family . . . . . OSTREIDAE

Genus: Ostrea (Linne)

Type Species: Ostrea edulis (Linne)

PLATE 9

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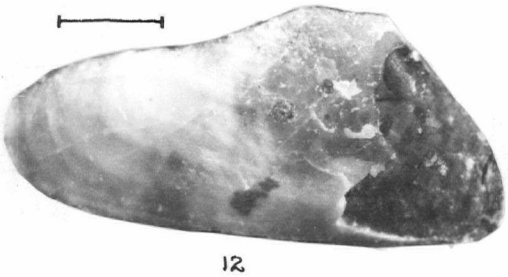
PLATE 9



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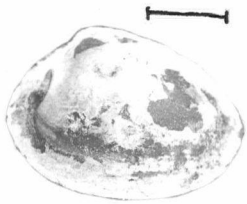

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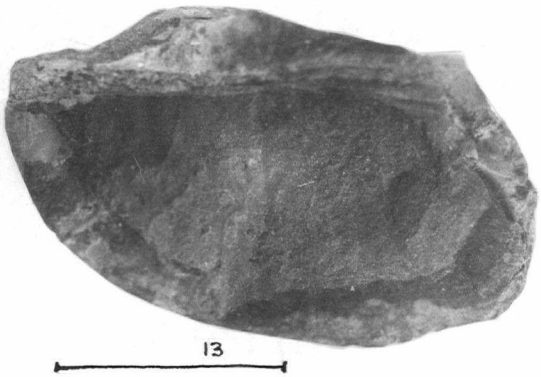

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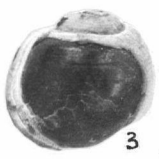

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"Shell distorted by adherence to extraneous objects; structure lamellar; inequivalve, fixed by left or larger valve; beaks terminal; left valve convex often marked by radiating ribs; right valve flat or concave, often smooth; sculpture usually different on the two valves; teeth generally absent, anterior muscle impression absent, posterior nearly central, ligament cavity conspicuous, triangular or elongate, pallial line distinct." -- Shimer and Shrock.

OSTREA sp. undet. cf. O. skidegatensis (Whiteaves)

Plate 10, fig. 1

The shells are highly irregular in shape and outline, ranging from high narrow shells to those longer than high. Some are shallowly convex, others almost flat. The hinge line is very short; in this area all the shells are narrowest, flaring out below it. Muscle scars are large and sometimes almost circular. The surfaces are marked by distinct irregular growth lines.

Occurrence: Localities 6 and 7.

Hypotype: K 58-6-14.

Superfamily . . . PTERIACEA

Family . . . . . PEDALIONIDAE

Genus: Inoceramus (Sowerby)

Type Species: Inoceramus cuvieri (Sowerby)

Shell rounded, ornamented with more or less prominent concentric undulations and striations; umbos prominent, somewhat anterior; hinge line long, straight, without teeth, but with numerous small ligament pits.

INOCERAMUS chicoensis (Anderson)

Plate 10, figs. 2 and 3

1958 Inoceramus chicoensis (Anderson). Geol. Soc. Am. Mem. 71, p. 103, pl. 55, figs. 1, 2.

> "Shell large at maturity, subcircular in outline, equivalve, somewhat lenticular in form; hinge line straight, beaks subterminal, small, forming the apex of an angle of about 95° or more between the hinge line and the anterior margin of the shell; surface marked by concentric ridges, or undulations; the spaces between the ribs widening rapidly with growth; surface otherwise smooth."

This species has not previously been recorded from the Nanaimo series. Two well preserved specimens were found in the Upper Lambert shales.

Dimensions of incomplete hypotype K 58-3-9: length 31 mm.; height 26 mm.; thickness of right valve 5 mm.

Dimensions of hypotype K 58-4-1, also incomplete: length 110 mm.; height 130 mm.

Occurrence: Localities 3 and 4.

Hypotype: K 58-3-9.

K 58-4-1.

INOCERAMUS subundatus (Meek)

Plate 10, figs. 4, 5, 6

1861 Inoceramus subundatus (Meek). Acad. Nat. Sci. Philadelphia, Proc., vol. 13, p. 315.

1876 Inoceramus cripsii var. subundatus (Meek). Geol. and Geog. Surv., vol. 2, no. 4, p. 358, pl. 1, fig. 6; pl. 3, figs. 1, 3.

1895 Inoceramus subundatus (Meek) (Whiteaves). Trans. Roy. Soc., Canada, vol. 1, sec. 4, p. 112.

1958 Inoceramus subundatus (Meek) (Anderson). Geol. Soc. Am. Mem. 71, p. 101, pl. 22, figs. 1, 2, 3; pl. 26, fig. 4.

Meek's description is as follows:

> "Shell (right valve) subovate or truncato-sub-circular, rather gibbous, anterior and posterior margins rounded more or less regularly into the base so as to form with the latter three-fourths of a circle; hinge equalling a little more than two-thirds of the entire length of the shell; beak small, rather obtuse near the anterior margin, and rising above the hinge. Surface ornamented by regular concentric undulations, separated by concave spaces of nearly uniform size, and obscure concentric striae. Length, 2.23 inches; height 1.95 inches; convexity of right valve, .70 inch."

Several well preserved inoceramids closely resembling Meek's description and figures were found on Hornby Island.

The largest specimen K 58-3-13 (incomplete) has the following dimensions: length 115 mm.; height 93 mm.; thickness left valve 30 mm. The following hypotypes could be identified accurately:

K 58-3-4	K 58-3-2	K 58-3-7
K 58-3-8	K 58-3-13	K 58-7-1

An additional seven specimens were tentatively identified as I. subundatus. These were hypotypes:

K 58-2-2	K 58-2-3	K 58-4-3
K 58-5-2	K 58-5-3	K 58-3-3
K 58-7-1		

Occurrence: Localities 2, 3, 4, 5 and 7.

INOCERAMUS duplicostatus (Anderson)

1958 Inoceramus duplicostatus (Anderson). Geol. Soc. Am. Mem. 71, p. 100, pl. 17, figs. 3, 4.

> "Shell is small or medium size, narrowly ovate in outline, inequilateral, and slightly curved, umbonal ridge curving gently upward toward anterior end. Beaks terminal narrowly acuminate. Surface characteristically marked by narrow, concentric folds (undulations) that show a decided disposition to duplication, appearing as doubles or triplets."

The specimen from Hornby distinctly exhibits fold duplication. The shell is not complete and does not show the position and nature of the beaks; it does have the narrowly ovate outline.

Occurrence: Station 4.

Hypotype: K 58-4-2.

INOCERAMUS sp. A

Plate 10, fig. 7

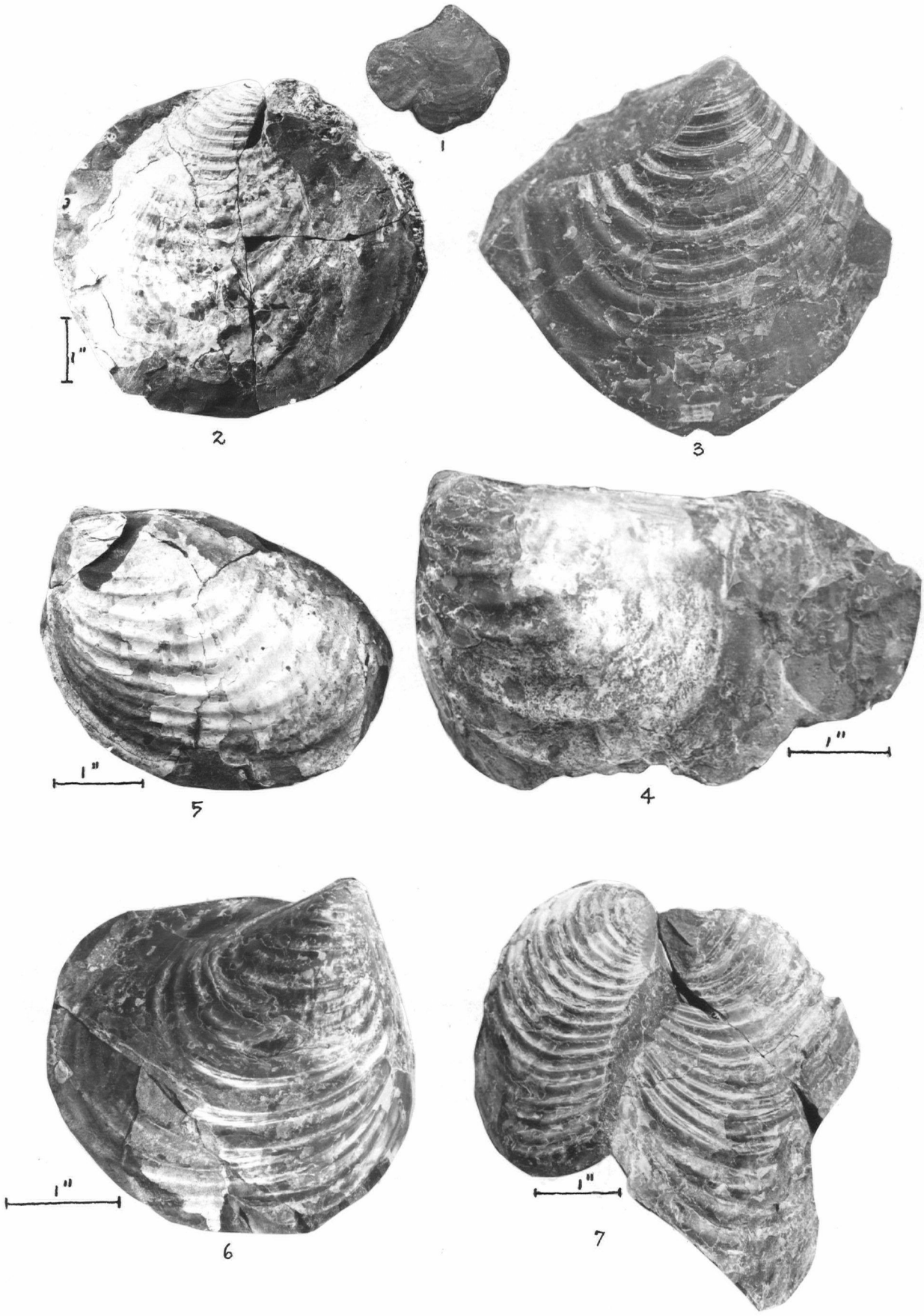
Shell of medium size, narrowly ovate in outline, margin elliptical. Umbonal region convex, anterior region somewhat compressed; concentrically costate, ribs narrow, ridge-like and very numerous, separated by concave inter-costal grooves of equal width.

Dimensions of sepcimen K 58-2-7: left valve: length 105 mm., height 55 mm., thickness approximately 24 mm.; right valve: length 115 mm., height 65 mm., thickness not available.

PLATE 10

		Page
Fig. 1	Ostrea sp. undet. One of many specimens collected. Natural size. K 58-6-14	58
Fig. 2	Inoceramus chicoensis (Anderson) K 58-4-1	59
Fig. 3	Inoceramus chicoensis (Anderson). Ornamentation of young specimen. Twice natural size. K 58-3-9	59
Fig. 4	Inoceramus subundatus (Meek) Left valve. K 58-3-13	59
Figs. 5, 6	Inoceramus subundatus (Meek) K 58-3-2 and K 58-4-3	59
Fig. 7	Inoceramus sp. A K 58-2-7	61

PLATE 10



Dimensions of incomplete specimen K 58-2-8: length 65 mm.; height 38 mm.

Occurrence: Locality 2.

Hypotype: K 58-2-7.

K 58-2-8.

INOCERAMUS sp. B

Plate 11, fig. 1

Shell medium in size, subcircular in outline; moderately inflated; anterior and posterior margins rounded, forming a continuous semicircular outline with the basal margin. Hinge line straight; beak small, about level with the hinge.

Surface ornamented by regular costae, which become more pronounced and ridge-like with age; the costae on the umbonal region are quite fine; bifurcation occurs midway on shell.

Dimensions of specimen K 58-3-10: length 72 mm.; height 54 mm.; estimated convexity of single valve 15 mm.

Occurrence: Locality 3.

Hypotype: K 58-3-10

K 58-3-5.

INOCERAMUS sp. C

Plate 11, fig. 2

Shell medium sized, subcircular, compressed. Anterior, basal and posterior margins form a continuous smooth circular outline. Hinge line straight, more than three-fourths length of shell; beaks small. Shell ornamented by well developed rarely bifurcating concentric costae, each tracing a semicircle and paralleling outline of shell.

Dimensions: length 96 mm.; height 73 mm.

Occurrence: Locality 2.

Hypotype: K 58-2-6.

INOCERAMUS sp. D

Two small imperfectly preserved shells appear to be different from the other inoceramids. They are narrowly ovate in outline and ornamented by numerous alternating major and minor costae which are essentially concentric.

Dimensions: length 23 mm.; height 45 mm.

Occurrence: Locality 5.

Hypotype: K 58-5-5.

INOCERAMUS (Endocostaea) stanislausensis (Anderson)

Plate 11, figs. 3, 4, 5, 6

1958 Inoceramus (Endocostaea) stanislausensis (Anderson). Geol. Soc. Am. Mem. 71, p. 105, pl. 74, figs. 3-6.

This species does not appear to have been recorded previously for the Nanaimo series.

Anderson's description is as follows:

> "Shell of medium size, subovate as viewed laterally, slightly compressed behind, somewhat inflated before, especially in umbonal region, concentrically costate, ribs narrow and ridge-like, separated by rather broad concentric inter-spaces, which become broader with growth of shell, especially near its basal border. . . These specimens were found in the upper part of the Moreno formation and therefore are of Maastrichtian (and Danian?) age."

Dimensions of hypotype K 58-4-4: left valve: (incomplete) length 85 mm.; height 50 mm.; thickness 25 mm. Right valve (incomplete): length 80 mm.; height 50 mm.

These two valves were touching one another in a single nodule. Whether they belong to the same organism or whether a left and right valve were coincidentally preserved together cannot be determined. The shells were not touching in a life-like position.

Dimensions of hypotype K 58-3-11: incomplete right valve: length 75 mm.; height 50 mm.

Occurrence: Localities 2 and 3.

Hypotype: K 58-2-4.

K 58-3-11, K 58-3-6.

Order . . . . . TELEODESMACEA

Superfamily . . VANERACEA

Family . . . . VENERIDAE

Genus: Flaventia (Jukes-Brown)

Type Species: Clementia (Flaventia) ovalis (Sowerby)

FLAVENTIA hornbyensis (Gabb)

1879 Cyprimeria lens (Gabb) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 152, pl. 17, fig. 15.

1889 Cyprimeria lens (Gabb) (White). U. S. Geol. Surv. Bull. 51, p. 42.

1895 Cyprimeria lens (Gabb) (Whiteaves). Trans. Roy. Soc. Canada, vol. 1, sec. 4, p. 126.

1903 Cyprimeria lens (Gabb) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 379.

1930 Flaventia? lens (Whiteaves) (Stewart). Acad. Nat. Sci. Philadelphia, Special Pub. no. 3, p. 247, 248.

1937 Flaventia lens (Gabb) (Popenoe). Jour. Geol., vol. 11, no. 5, p. 393, pl. 48, fig. 4.

1958 Flaventia hornbyensis (Gabb) (Anderson). Geol. Soc. Am. Mem. 71, p. 134.

These shells were extremely fragile and the writer succeeded in collecting only one complete right valve.

Whiteaves describes them:

> "Shell compressed, convex, moderately inflated, ovately circular in marginal outline and nearly as high as long; posterior side a little longer, and in some specimens rather more, narrowly rounded than the anterior; basal margin broadly convex; superior border descending rapidly and obliquely in front of the beaks, gently convex and slightly prominent immediately behind them, thence curving gradually downward to the posterior end, beaks placed a little in advance of the midlength, small,

depressed, appressed and curved forward. No definite nor distinctly margined lunule, and apparently no well defined escutcheon."

Shell ornamented with numerous crowded concentric striae as well as several coarser grooves paralleling the growth line.

The hinge line was only partially preserved on the collected specimen from Hornby. What was there fitted Popenoe's description and figure.

"Right anterior and median cardinals set close together, diverging ventrally, directed obliquely anteriorly; right posterior cardinals long, heavy, deeply bifid, the anterior element being short."

Dimensions: length 19 mm.; height 15 mm.; thickness 5 mm.

Occurrence: Locality 6.

Hypotype: K 58-6-21.

Superfamily . . . MACTRACEA

Family . . . . . MACTRIDAE

Genus: Cymbophora (Gabb)

Type Species: Mactra asburnerii (Gabb)

CYMBOPHORA cf. C. schucherti (Stephenson)

Plate 11, fig. 8

"Shell large, thick walled, subtrigonal in outline, inflated, inequilateral, equivalve. Beaks of moderate prominence, strongly in-curved. Antero and postero dorsal slopes steep, making wide obtuse angles with the main surface. Lunule wide and long, taking up nearly all the area of the antero dorsal slope, circumscribed by a weakly impressed line and rising gently along the marginal contact to form a low keel."

The only ornamentation on the shell consists of fine crowded growth lines. Interior not uncovered.

Occurrence: Locality 3.

Hypotype: K 58-3-12.

Superfamily . . . MYACEA

Family . . . . . CORBULIDAE

Genus: Corbula (Lamarck)

Type Species: Corbula sulcata (Lamarck)

"Shell ovate, very inequivalve, close rounded in front, contracted behind, umbos prominent; right valve convex, the larger with a strong cardinal tooth; pallial line slightly sinuous posteriorly, marine to fresh water."
-- Shimer and Shrock.

CORBULA sp. undet.

About half a dozen natural internal casts of this genus were found. On some fragments of the original shell still exist. Possibly as differences of ornamentation occur, more than one species was collected.

One specimen ornamented by five crowded concentric growth lines closely resembles C. hornii (Gabb) as shown by Stewart. Another resembles C. primorsa (Gabb).

Shells small to medium, thick-walled, inflated, inequilateral. Beaks prominent, in-curved, situated in some about one-third the length of the shell from the anterior extremity, in others almost centrally. The umbonal ridge is obtusely subangular in cross-section. The marginal outline varies considerably being sub-triagonal in some, oval in others.

Surfaces marked generally by five concentric growth lines. In some radial striations are apparent. Hinge and internal features not uncovered.

Dimensions: maximum length, width and convexity: 18 mm., 13 mm., and 4.5 mm. respectively.

Occurrence: Localities 6 and 7.
Hypotype: K 58-6-10.

Class . . . . . CEPHALOPODA
Order . . . . . AMMONOIDEA
Suborder . . . EXTRA SIPHONATA
Family . . . . DESMOCERATIDAE

Genus: Joaquinites (Anderson)

Anderson has proposed the genus name Joaquinites for a small group of ammonites found in the upper part of the Panoche formation on the western border of the San Joaquin Valley. He mentions that two species have been recognized. Only one of these, J. fascicostatum, was sufficiently well preserved for diagnostic use. The suture line, although

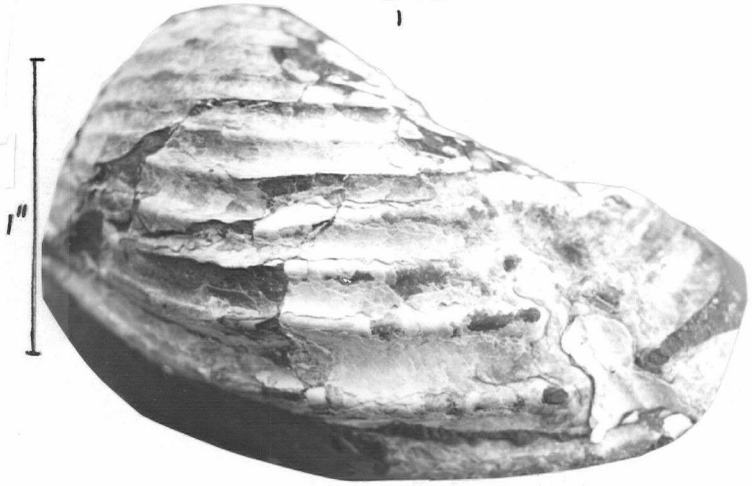
PLATE 11

		Page
Fig. 1	Inoceramus sp. B K 58-3-10	62
Fig. 2	Inoceramus sp. C K 58-2-6	63
Fig. 3	Inoceramus (Endocostea) stanislausensis (Anderson). Note the depression which extends from behind the beak obliquely downward to the posterior margin. K 58-2-4	64
Fig. 4	Inoceramus (Endocostea) stanislausensis (Anderson) K 58-3-6	64
Fig. 5	Inoceramus (Endocostea) stanislausensis (Anderson). Left valve. Natural size shown. K 58-3-11	64
Fig. 6	Inoceramus (Endocostea) stanislausensis (Anderson) K 58-2-4	64
Fig. 7	Cymbophora sp. undet. Consists of a fragment of the right valve magnified one and a half times. K 58-3-12	66

PLATE 11

1

2



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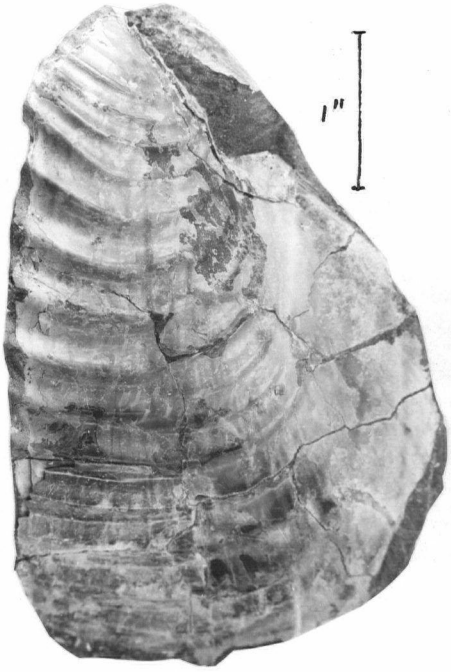

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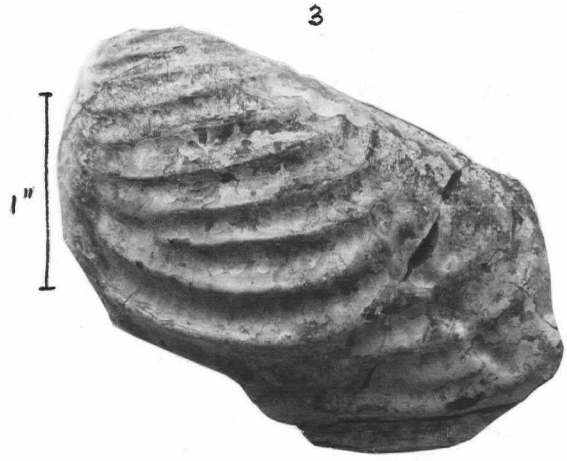

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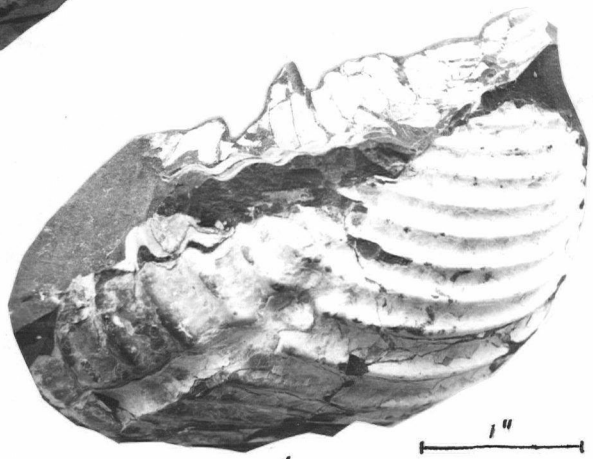


6

imperfectly exposed, is desmoceratid; he unfortunately does not illustrate it.

JOAQUINITES cf. fascicostatum (Anderson)

Plate 12, figs. 1, 1a, 1b, 2, 3

1958 Joaquinites fascicostatum (Anderson). Geol. Soc. Am. Mem. 71, p. 219, pl. 9, figs. 3, 3a, 4.

He describes the Maastrichtian species as:

> "Shell of medium size, discoidal or somewhat lenticular in section, of desmoceratid aspect, having a moderately broad and deep umbilicus, neatly rounded on shoulder; sides but little inflated, sloping gently to periphery which is slightly flattened on ventral zone; sides of whorl marked by rather fine sinuous costal threads arising on small bullae on umbilical border, forming bundles of four or more, some of which subdivide near the middle of the side into minor groups, but tend to disappear before reaching ventral border; suture line showing only strong lateral lobe and elevated saddles deeply cut by minor elements."

Dimensions of Hornby Island specimens: hypotype K 58-5-19: greater diameter 165 mm.; width of umbilicus 38 mm.; height of whorl 71 mm.; breadth of whorl 48 mm.

Hypotype K 58-5-20: greater diameter 190 mm. (est.); width of umbilicus 36 mm.; height of whorl 91 mm.; breadth of whorl 60 mm.

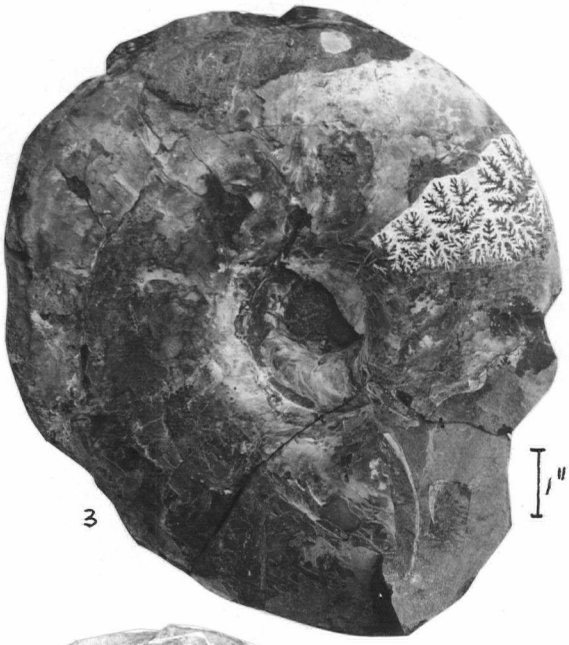
Hypotype K 58-4-20: greater diameter 230 mm.; width of umbilicus 46 mm.; height of whorl 110 mm.; breadth of whorl not available.

Whether these specimens are identical with Anderson's will depend on further collections in the type locality.

PLATE 12

		Page
Figs. 1, 1a, 1b	Joaquinites fascicostatum (Anderson) Suture pattern and external ornamentation. K 58-5-19	69
Fig. 2	Joaquinites fascicostatum (Anderson) K 58-5-20	69
Fig. 3	Joaquinites fascicostatum (Anderson) K 58-4-20	69
Fig. 4.	Pachydiscus ootacodensis (Stolixzka) Note pattern. Natural size shown. K 58-3-26	70

PLATE 12



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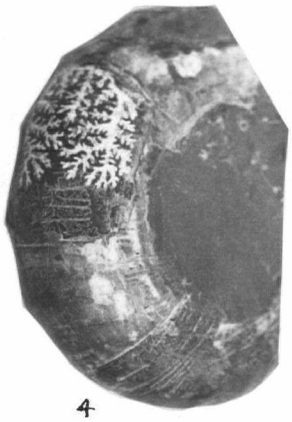

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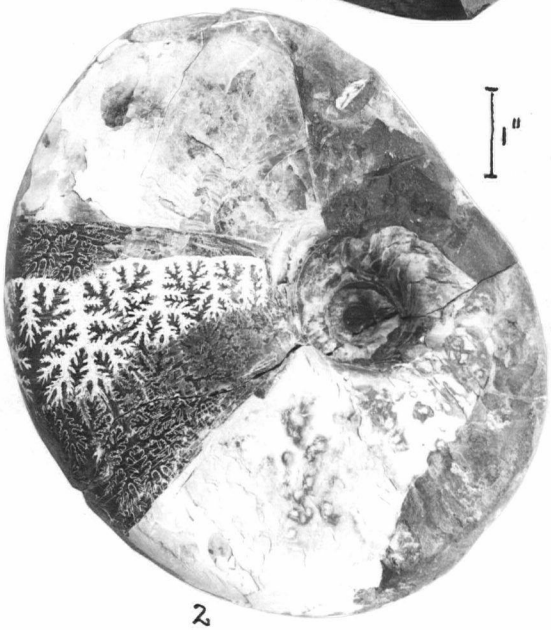

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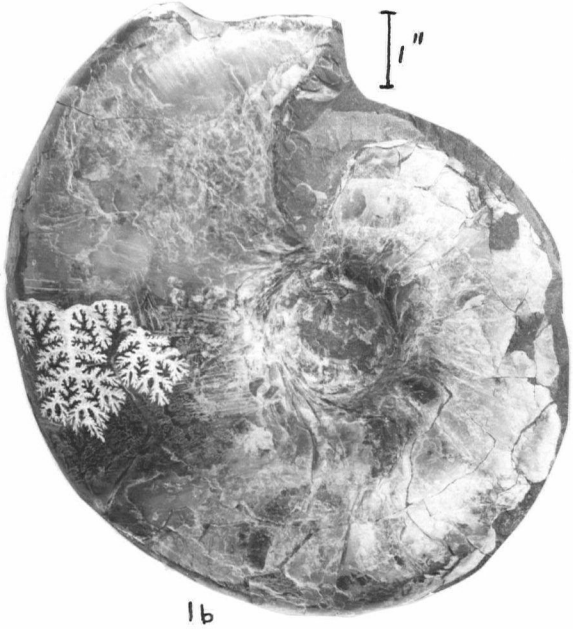
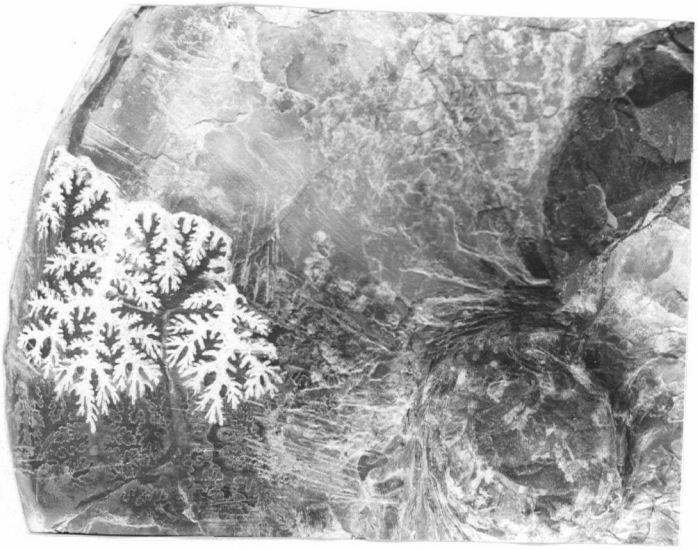
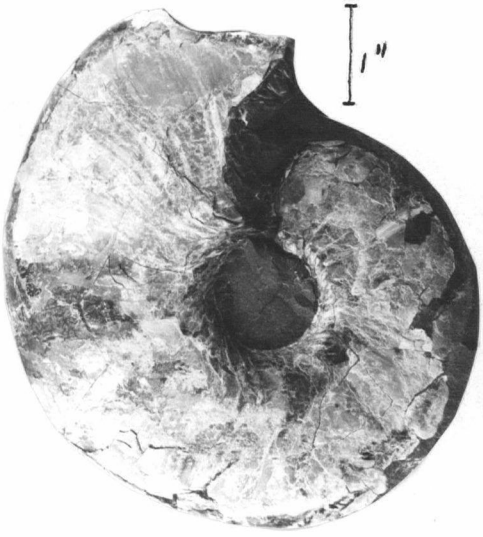


1b



1



1a

Anderson's description is based on a small imperfect specimen with a greater diameter of only 58 mm. Morphologically they are very similar, but the greater size of the Hornby Island specimens may indicate a different species.

Occurrence: Localities 4, 5.

Hypotype: K 58-4-20

K 58-5-19

K 58-5-20.

Genus: Pachydiscus (Zittel)

Type Species: Ammonites neubergicus (von Hauer)

> "Compressed to moderately stout shell, with relatively small umbilicus, gently rounded umbilical shoulder, rounded external margin; surface costate, no ventral nodes; costae generally flexuous, including both umbilical and intercalated costae; late stages mostly smooth. Suture much dissected, crowded, with long slender elements; first lateral lobe the longest, tops of saddles in nearly straight lines."
>
> -- Reeside 1947.

PACHYDISCUS ootacodensis (Stoliczka)

Plate 12, fig. 4; pl. 13, figs. 1, 1a, 2, 2a

1862 Ammonites colligatus (Binkhorst). Mon. des Gasteropodes et des Cephalopodes du Limbourg, pars II, p. 25, non idem Hoeninghaus.

1865 Ammonites ootacodensis (Stoliczka). Cret. Rocks of S. India, Pal. Indica, vol. 1, p. 109, pl. LIV, figs. 3, 4, pl. LVI.

1894 Pachydiscus otacodensis (Stoliczka) (Kossmat, Jahrb). K. K. Geol. Reich Wien, vol. 44, p. 472.

1895 Pachydiscus otacodensis (Stoliczka) (Whiteaves). Trans. Roy. Soc., Canada, 2nd ser., vol. 1, sec. 4, p. 131.

1903 Pachydiscus otacodensis (Stoliczka) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 340, pl. 46, fig. 1.

1922 Parapachydiscus aff. ootacodensis (Stoliczka) (Spath). Trans. Roy. Soc. S. Africa, vol. 10, pt. 8, p. 132, pl. vii, fig. 6.

1935 Parapachydiscus ootacodensis (Stoliczka) (Anderson and Hanna). Proc. Calif. Acad. Sci., 4th ser., vol. 23, no. 1, p. 20, pl. 6, figs. 1 and 2.

1952 Pachydiscus ootacodensis (Stoliczka) (Usher). Geol. Surv. Can., Bull. 21, p. 85, pl. 17, 18, 19 and 20.

1958 Parapachydiscus ootacodensis (Stoliczka) (Anderson). Geol. Soc. Am. Mem. 71, p. 229.

Shell smooth and rounded in youth, becoming discoidal and costate with age; whorls increase rapidly in size, higher than wide, convex, with an involution of about two-thirds; umbilicus deep, steplike, smooth, less than one-fourth diameter of shell; umbilical wall steep, rounded, overhanging; umbilical shoulder smooth, rounded; flanks flattened, slightly convex; venter broadly rounded.

Ornamentation consists of ribs and striae. The former do not appear until the adolescent stage and disappear almost completely in the gerontic stage. They are restricted to the venter and ventro-lateral sides where they are bent forward. The striae continue, almost to the umbilicus. The original shell material is covered with fine pustules.

Suture line was well preserved. External lobe is broad stemmed with two principal lobules on each side of the siphon; the small broad siphonal saddle has lobate anterior corners. First lateral lobe broad, trifid, deeper than external lobe; first auxiliary lobe on umbilical shoulder; remaining lobes decrease rapidly in size to umbilical suture. First

lateral saddle, broad, much larger than second lateral saddle; remaining saddles decrease gradually in size towards umbilicus.

Dimensions of hypotype K 58-4-17: greater diameter 160 mm.; width of umbilicus 33 mm.; height of whorl 78 mm.; breadth of whorl (est.) 70 mm.

Occurrence: Localities 2, 3 and 4.

Hypotype: K 58-2-16 K 58-3-16
K 58-4-17 K 58-3-14
K 58-3-26

PACHYDISCUS suciaensis (Meek)

Plate 13, figs. 3, 4; pl. 14, figs. 1, 1a

1861 Ammonites complexus var. suciaensis (Meek). Proc. Acad. Nat. Sci., Philadelphia, vol. 13, p. 317.

1876 Ammonites complexus var. suciaensis (Meek). Bull. U. S. Geol. & Geog. Surv. Terr., vol. 2, no. 4, p. 369, pl. 5, fig. 2.

1879 Ammonites complexus var. suciaensis (Meek) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 106.

1898 Pachydiscus suciaensis (Meek) (Kossmat).

1903 Pachydiscus suciaensis (Meek) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 344.

1921 Canadoceras suciaensis (Meek) (Spath). Trans. Roy. Soc. S. Africa, vol. XI 2, pt. 3, p. 125.

1952 Pachydiscus suciaensis (Meek) (Usher). Geol. Surv. Canada, Bull. 21, p. 68, pl. 9, figs. 1-11; pl. 10, figs. 1-3; pl. 31, figs. 2-3.

1958 Eupachydiscus? suciaensis (Meek) (Anderson). Geol. Soc. Am. Mem. 71, p. 223.

Shell smooth, round and inflated in youth becoming discoidal and costate with age. Whorls higher than wide in older specimens with greatest width just above the umbilical shoulder. Flanks somewhat flattened, slightly convex, meeting umbilical wall at a sharply rounded curve. Venter broad, rounded and convex. Umbilicus about one-quarter of total diameter, concealing two-thirds of all inner whorls; umbilical wall almost vertical.

Shell ornamented by about eleven major costae which originate just over the edge of the umbilicus from raised sharp radially elongated bullae. Costae strongest near umbilicus and across venter, decreasing in height and width toward mid-flank. Between the major or primary costae there are secondary ribs which extend from the venter over half to three-quarters of the flanks. One or two minor ribs occur between the major ribs. On the venter primary and secondary ribs are indistinguishable. In old specimens the secondaries become of equal strength as the primaries and extend down to the umbilicus. On the gerontic examples the ribs become almost obsolete. In addition to the ribs, fine crowded radiating lines cover all of the outer shell. Very fine pustules were preserved on one specimen. It is uncertain whether the latter are peculiar to the individual or common to all.

The suture pattern is excellently preserved. External lobe not as deeply cut as the first lateral lobe. The former consists of two bifid branches one on each side of the siphon.

First lateral lobe trifid; second lateral lobe smaller reproduction of the first; first auxiliary lobe bifid and situated on umbilical shoulder. First lateral saddle narrow, bifid, outer branch larger; second lateral saddle much smaller than first, bifid, inner branch larger. Remaining lobes and saddles similar to first, rapidly decreasing in size passing obliquely backward into the umbilicus.

Occurrence: Localities 2 and 3.

Hypotype: K 58-2-9 K 58-2-10 K 58-2-11
K 58-2-12 K 58-2-13 K 58-3-17
K 58-3-19 K 58-3-20 K 58-3-23

PACHYDISCUS sp. A

Plate 14, figs. 2, 2a

Shell discoidal, costate, about two-thirds involute; whorls rounded, higher than wide in older specimens, with greatest width just above the umbilical shoulder. Flanks flattened, meeting umbilical wall at a rather sharp but well rounded dorso-lateral angle. Venter broadly rounded. Umbilicus broad, deep; umbilical wall short. Aperture squarely ovate, about two-thirds emarginate by preceding whorl.

About 35 sharp, well defined costae cross the flanks and venter. The major costae arise at the umbilical shoulder. From two to four minor costae occur between the major ones. The former arise between the umbilical shoulder and mid-flank.

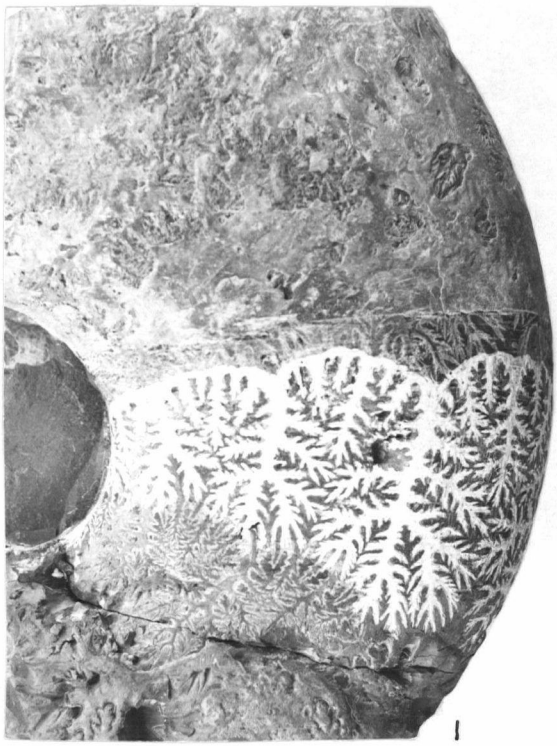
PLATE 13

		Page
Fig. 1, 1a	Pachydiscus ootacodensis (Stoliczka) K 58-3-14	70
Fig. 2	Pachydiscus ootacodensis (Stoliczka) K 58-4-17	70
Fig. 2a	Internal whorl of K 58-4-17	70
Fig. 3	Pachydiscus suciaensis (Meek) K 58-3-19	72
Fig. 4	Pachydiscus suciaensis (Meek) Note smooth inner whorl. K 58-2-12	72

PLATE 13

1a

1"



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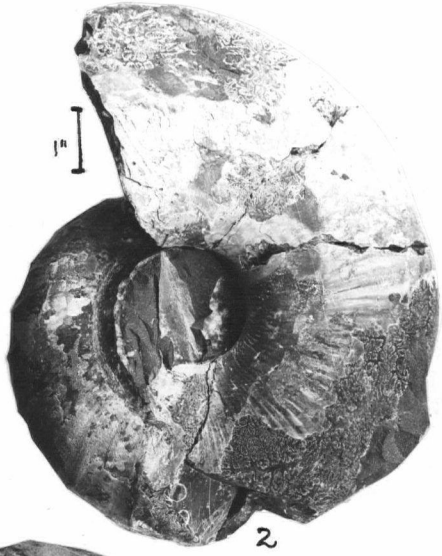

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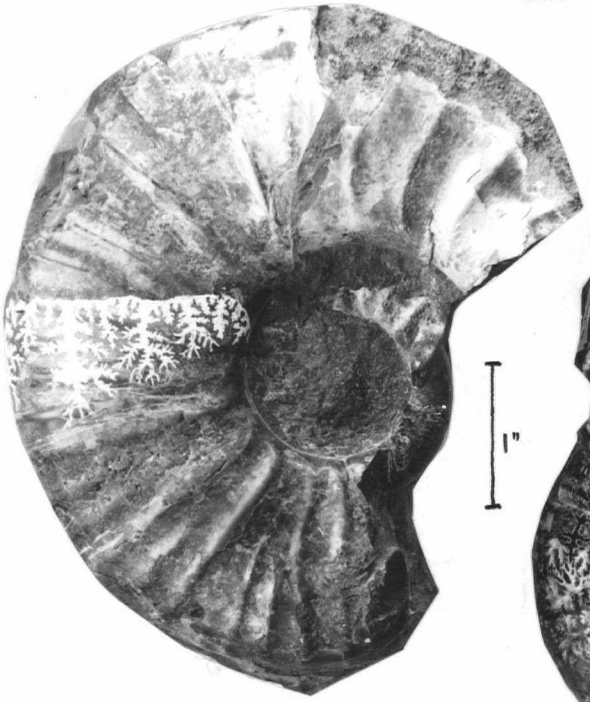

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The costae are rather sinuous, describing a forward arcuity on the dorso-lateral flanks and a backward arcuity on the ventro-lateral flanks. On the venter they again display a slight forward arcuity. With age the minor costae become fewer but equal in strength to the major ones; then both lose their sharpness and appear as undulations separated by concave grooves of equal width.

External lobe broad, bifid, lanceolate; first lateral lobe deeper than external lobe, trifid, with a strong stem; second lateral lobe like the first only smaller. First auxiliary lobe unequally trifid; remaining auxiliary lobes decrease rapidly in size as they recede backward into the umbilicus. First lateral saddle narrow, bifid, outer branch larger than inner; second lateral smaller than first, bifid, inner branch larger; first auxiliary saddle like second but smaller.

Dimensions: greater diameter 73 mm.; width of umbilicus 20 mm.; height of whorl 29 mm.; breadth of whorl 23 mm.

Occurrence: Locality 4.
Hypotype: K 58-4-15.

PACHYDISCUS sp. B

Plate 14, figs. 3 and 4; pl. 20, fig. 4

Shell discoidal, somewhat compressed, costate in youth becoming smooth with age; whorls two-thirds involute, high, narrow, thickest at umbilical shoulder; flanks flattened, very

slightly convex, converging gradually to the narrow, broadly rounded venter; umbilicus deep with sharply rounded shoulders and steep walls, one-fourth of total shell diameter. Within the umbilicus one-third of all the whorls are exposed forming a steplike arrangement. These specimens closely resemble Joaquinites cf. fascicostatum except for their wider umbilicus.

Shell ornamented by numerous fine, flexuous striations. On the dorso-lateral flanks and on the venter the striations curve forward. They curve backward at mid-flank. The costae on the inner whorls closely resemble those of P. ootacodensis.

The deeply cut and ramified suture is well preserved on one of the two specimens collected; it is almost identical with the suture of J. cf. fascicostatum. External lobe broad with two bifurcated terminal branches almost equal in length to the first lateral lobe, which is as deep as the external lobe and unequally trifid. Central lobule trifid, two lateral lobules unequally bifid. Second lateral lobe very similar to first, only shorter. First auxiliary lobe situated on umbilical shoulder, unequally bifid, smaller than second lateral lobe. Remaining lobes are slanted, decreasing very little in length to umbilical suture. First lateral saddle straight, unequally bifid, outer branch larger, each branch again bifid; second lateral saddle narrower and shorter, nearly equally bifid, inner branch larger; first auxiliary saddle unequally bifid, shorter than second lateral saddle. Remaining saddles short and oblique.

Dimensions: hypotype K 58-4-12: greater diameter 185 mm.; width of umbilicus 46 mm.; height of whorl 81 mm.; breadth of whorl 62 mm. Hypotype K 58-5-24: greater diameter 112 mm.; width of umbilicus 26 mm.; height of whorl 51 mm.; breadth of whorl 40 mm.

Occurrence: Localities 4 and 5.

Hypotype: K 58-4-12

K 58-5-24.

PACHYDISCUS species C

Plate 15, figs. 1, 1a

Shell discoidal, costate, increasing rapidly in size, involution not exposed, whorls higher than wide, slightly convex, greatest width between umbilical wall and mid-flank, umbilicus small and deep, about one-fifth of total shell diameter. Umbilical shoulder narrowly rounded; umbilical walls steep and apparently quite smooth.

Ornamented by numerous shallow rounded costae, major alternating with several minor ones. These cross from the umbilicus to the venter in a straight line and are separated by shallow concave grooves about twice the width of the costae. Finer striae lie between, paralleling the costae. Ventral region worn off.

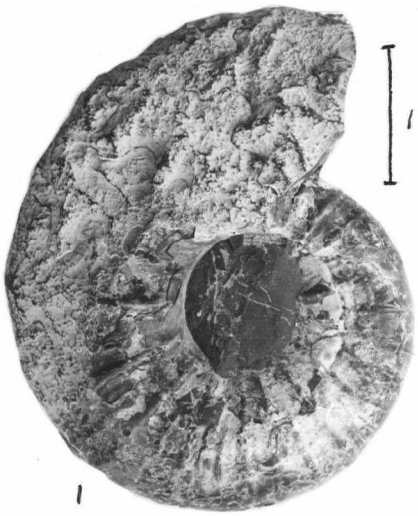
Suture lines complex but characteristic. External lobe as high or higher than first lateral lobe; the latter is

PLATE 14

		Page
Fig. 1	Pachydiscus suciaensis (Meek) K 58-2-13	72
Fig. 1a	Pachydiscus suciaensis (Meek) Inner whorl Magnified of specimen K 58-4-3 K 58-2-13	72
Figs. 2, 2a	Pachydiscus sp. A Note distinct suture pattern and ornamentation. K 58-4-15	74
Fig. 3	Pachydiscus sp. B K 58-5-24	75
Fig. 4	Pachydiscus sp. B K 58-4-12	75

PLATE 14

1a



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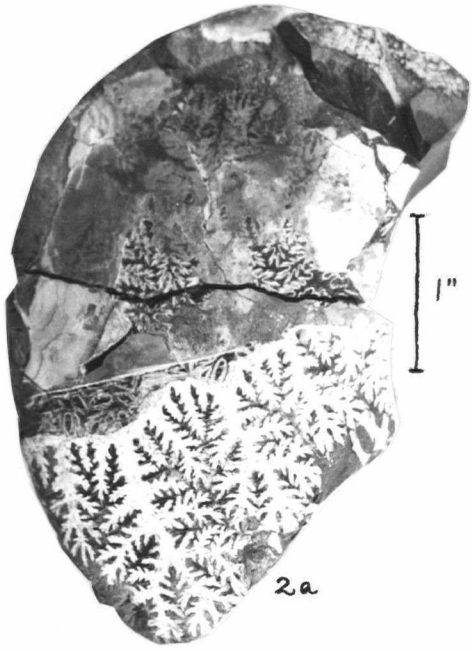

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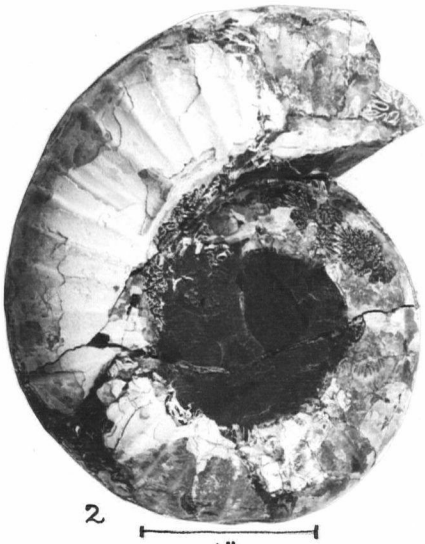

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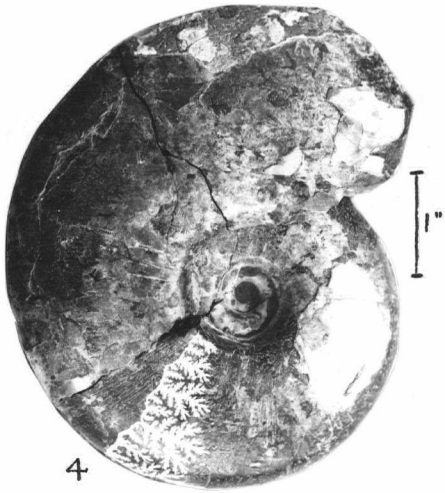

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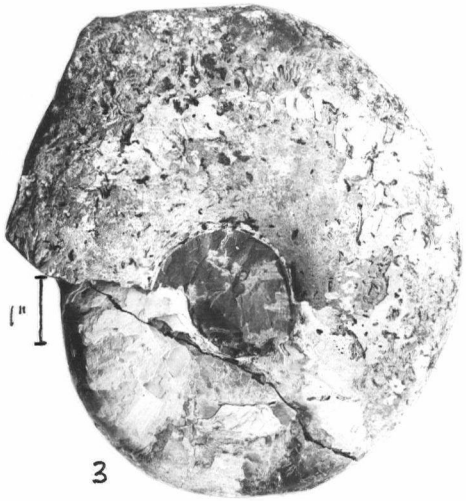


1"

3

broadstemmed and unequally trifid. First lateral saddle largest, bifid, external branch most developed. Second lateral saddle as first, inner branch more developed. Remaining auxiliary lobes and saddles not exposed.

Dimensions: diameter (est.) 250 mm.; width of umbilicus 50 mm.; height of whorl 120 mm.; breadth of whorl not available.

Occurrence: Locality 5.

Hypotype: K 58-5-25.

PACHYDISCUS (?) sp. D

Plate 15, fig. 2

Shell of desmoceratid aspect, discoidal, smooth, about two-thirds involute; whorls much higher than wide, with greatest width on dorso-lateral flanks. Flanks flattened, slightly convex, meeting umbilical wall at an 85°-95° angle. Ventrolateral angle more smoothly rounded. Umbilicus broad but deep, equal to one-quarter of shell diameter; umbilical wall steep, smooth. Aperture narrow, about two-thirds emarginate by preceding whorl.

No ornamentation exists on the thick shell material except for very faint undulations. Suture pattern not exposed.

Dimensions: hypotype K 58-4-21: (est.) greater diameter 350 mm.; width of umbilicus 89 mm.; height of whorl 140 mm.; breadth of whorl not available.

Hypotype K 58-5-26: (est.) greater diameter 230 mm.; width of umbilicus 60 mm.; height of whorl 90 mm.; breadth of whorl 70 (?) mm.

Occurrence: Localities 4 and 5.

Hypotype: K 58-4-13

K 58-4-21

K 58-5-26.

Genus: Desmophyllites (Spath)

Type Species: Desmoceras larteti seunes

Desmophyllites is a smooth, deeply involute, constricted desmoceratid, with well rounded whorls and deep umbilicus. Suture line similar to Desmoceras.

DESMOPHYLLITES selwynianus (Whiteaves)

Plate 15, fig. 3

1879 Ammonites selwynianus (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 104, pl. 13, fig. 1.

1903 Desmoceras selwynianum (Whiteaves), (Kossmat).

1952 Schulteria selwyniana (Whiteaves) (Usher). Geol. Surv. Canada Bull. 21, p. 63, pl. 5, figs. 3, 4; pl. 6, figs. 1-3, pl. 31, fig. 20.

1958 Desmophyllites selwynianus (Whiteaves) (Anderson). Geol. Soc. Am. Mem. 71, p. 215, pl. 40, fig. 2.

The specimen collected from Hornby Island does not show the finer surface ornamentation nor the suture pattern but is morphologically perfect and appears to be identical with Whiteaves' species.

Shell discoidal, highly involute, somewhat compressed at the sides, rounded on the periphery. Whorls higher than wide with greatest width at mid-flank, moderately inflated. Flanks flattened or slightly convex, meeting smooth rounded venter with gentle contour. Umbilicus very narrow, about one-fifteenth of the greatest diameter of the shell, deep with vertical walls; umbilical shoulder sharply rounded.

Test is ornamented by faint and very delicate, crowded, flexuous striations which trace sigmoidal curves, beginning radially on the umbilical wall, then sweeping obliquely forward to mid-flank. On the outer flank they bend slightly backward and then forward again. Passing over the venter they form a series of beak-like processes with concave sides.

Five to seven deep constrictions or grooves occur underneath the shell material. These parallel the striae on the outer whorl at periodic intervals and are believed to be the remains of former lips. Cross-sections of the constrictions show them to be asymmetric, with the steepest part of the groove on the leading edge.

> "Suture line complex, almost identical with S. diphylloides Kossmat sp. External lobe broad, as deep as the first lateral, with a short median, siphonal saddle and long, well developed, secondary lateral saddles cutting each branch, on either side of the siphon, into two equal parts (a feature that distinguishes it from Desmoceras latidorsatus); first and second lateral lobes symmetrically trifid; 5 auxiliary lobes decreasing regularly in size to the umbilical shoulder. First lateral saddle, bifid both branches projecting an equal distance forward; second lateral saddle narrower, bifid, 6 auxiliary saddles." -- Usher, p. 63.

Occurrence: Usher believes it to be restricted to the Cedar district and Trent River formations in the Nanaimo series. This is the first recorded from the Maastrichtian. Locality 3.

Hypotype: K 58-3-18.

Family . . . LYTOCERATIDAE

Genus: Epigoniceras (Spath)

Type Species: Lytoceras (Tetragonites) epigonum (Kossmat)

> "Epigoniceras is mainly a senonian lytoceratid, with a rounded whorl, a smooth shell and a suture line in which the auxiliary elements decrease rapidly in an oblique direction into the umbilicus; the internal suture has two large saddles." -- Usher, p. 54.

EPIGONICERAS epigonum (Kossmat), 1895

Plate 15, fig. 14

1865 (pro parte) Ammonites timotheanus (Pictet and Roux) (Stoliczka). Cret. Rocks S. India, Pal. Indica, vol. 1, p. 146, pl. 73, figs. 4, 5.

1903 Tetragonites timotheanus (?) (Pictet and Roux) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 329.

1908 Lytoceras tetragonites epigonum (Kossmat) (sic) (Kilian and Reboul). Schwed. Sudpolar-Exped., vol. 3, pt. 6, p. 14.

1926 Epigoniceras epigonum (Kossmat) (Marshall). Trans. N. Zealand Inst., vol. 56, p. 149, pl. 29, figs. 6, 7.

1952 Epigoniceras epigonum (Kossmat) (Usher). Geol. Surv. Canada Bull. 21, p. 55, pl. 2, figs. 6, 7; pl. 3, fig. 1; pl. 31, fig. 13.

1958 Lytoceras (Tetragonites) epigonum (Kossmat) (Anderson). Geol. Soc. Am. Mem. 71, pl. 65, p. 187, figs. 4, 5; pl. 67, figs. 3, 3a.

Shell discoidal, whorls rapidly increasing in size with an involution of about one-half to two-thirds. Whorls wider than high, with the greatest width just above the umbilical shoulder. Umbilicus fairly deep, small, steplike, showing one-half of all inner whorls; umbilical wall steep, meeting flattened flanks with a smooth sharply rounded curve.

Shell ornamented by fine striations which rise obliquely forward up the umbilical wall from the umbilicus. On the umbilical shoulder they point more forward, continuing across the flank as straight striae. They cross the venter with a smooth slightly forward convexity.

Suture pattern closely resembles Stoliczka's. External lobe wide, deep, with a prominent, narrow, blunt siphonal saddle. First lateral lobe bifid, broad, not as deep as the external lobe; second lateral lobe much smaller, trifid; four auxiliary lobes decrease rapidly in size and pass obliquely backward into the umbilicus.

The Hornby Island specimen is similar to the example figured by Stoliczka.

Occurrence: Locality 4.

Hypotype: K 58-4-9.

Genus: Pseudophyllites (Kossmat)

Type Species: Ammonites indra (Forbes)

"Pseudophyllites is a very involute form, with a small, deep umbilicus; the whorls are rounded in youth, becoming more elliptic at maturity, with a large, convex venter and somewhat flattened flanks. Ornament consists of fine striae inflected forward and passing radially across venter; faint spiral bands appear at maturity. The suture consists of bifid lobes and saddles; first lateral lobe deeper than external lobe; first lateral saddle with large external branch whereas internal branch of second lateral saddle is the larger."
-- Usher, p. 56.

PSEUDOPHYLLITES indra (Forbes), 1845

Plate 15, fig. 5; pl. 16, figs. 1, 2, 3, 4, 5

1845 Ammonites indra (Forbes). Trans. Geol. Soc. London, 2nd ser., vol. 6, p. 105, pl. 11, fig. 7.

1865 Ammonites indra (Forbes) (Stoliczka). Cret. Rocks S. India, Pal. Indica, vol. 1, p. 112, pl. 58, figs. 2, 2a, 2b.

1879 Ammonites indra (Forbes) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 105, pl. 13, figs. 2, a, b.

1895 Pseudophyllites indra (Forbes) (Kossmat).

1895 Phylloceras indra (var.) (Forbes) (Whiteaves). Trans. Roy. Soc. Canada, 2nd ser., vol. 1, sec. 4, p. 219.

1903 Pseudophyllites indra (Forbes) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 331.

1906 Pseudophyllites indra (Forbes) (Woods). Ann. S. African Museum, vol. 4, p. 334, pl. 41, figs. 6, 6a.

1908 Pseudophyllites indra (Forbes) (Kilian and Reboul). Schwed. Sudpolar-Exped. Geol. U Pal. vol. 3, pt. 6, p. 14.

1926 Pseudophyllites indra (Forbes) (Marshall). Trans. N. Zealand Inst. vol. 56, p. 152, pl. 20, fig. 1; pl. 29, figs. 3-5.

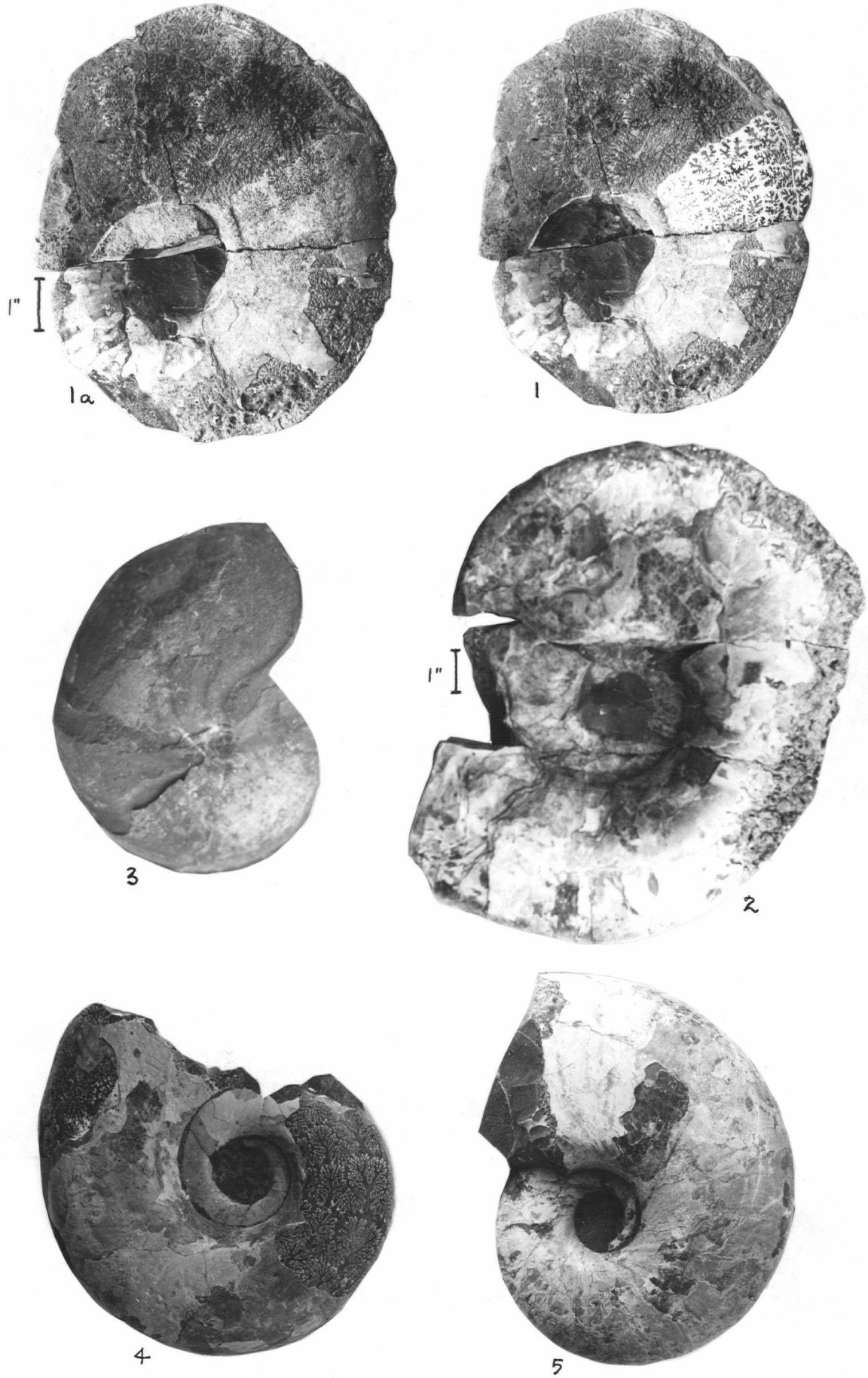
1938 Pseudophyllites indra (Forbes) (Roman). Les Ammonites Jurassiques et cretacees; p. 44, pl. 5, figs. 42, 42a.

1952 Pseudophyllites indra (Forbes) (Usher). Geol. Surv. Can. Bull. 21, p. 57, pl. 3, figs. 2-13.

PLATE 15

		Page
Fig. 1, 1a	Pachydiscus sp. C K 58-5-25	77
Fig. 2	Pachydiscus (?) sp. D K 58-4-21	78
Fig. 3	Desmophyllites selwynianus (Whiteaves) Note constrictions. K 58-3-18	79
Fig. 4	Epigoniceras epigonum (Kossmat) Natural size. K 58-4-9	81
Fig. 5	Pseudophyllites indra (Forbes) Note smaller umbilicus than epigoniceras epigonum. Natural size shown. K 58-5-13	83

PLATE 15



> "Shell discoidal, whorls increasing rapidly in size, with an involution of about two-thirds in the early stages, increasing to about three-quarters at maturity. Except in the larval stage, where the whorls are nearly round and slightly wider than high, the whorls are higher than wide, the greatest width being at the umbilical shoulder." -- Usher, p. 57.

Umbilicus small, deep, steplike, showing between one-third to one-quarter of inner whorls; umbilical wall steep, high, meeting somewhat flattened flank with a smooth sharply rounded curve.

Ornamentation consists of numerous very fine striations. These are particularly well developed in the younger specimens but almost disappear with age. The largest specimen collected was practically smooth. The striae rise perpendicularly up the umbilical wall; swing strongly forward on the umbilical shoulder and sweep across the flanks in a broad forward arcuity. They straighten out and then form an almost imperceptible backward arcuity across the venter.

The suture pattern was not easy to expose on the specimens collected but is essentially the same through all stages. External lobe a little deeper than first lateral lobe, which is wide and unequally bifid, with a long median secondary saddle, second lateral lobe much smaller. First and second lateral lobes unsymmetrically bifid.

Occurrence: Localities 2, 3, 5 and 7.

Hypotype: K 58-2-17 K 58-2-18 K 58-5-17
K 58-3-27 K 58-5-14 K 58-7-2
K 58-5-18 K 58-5-15 K 58-5-16

Family . . . PHYLLOCERATIDAE

Genus: Neophylloceras (Shimizu)

Type Species: Phylloceras subramosum (Shimizu)

Neophylloceras s.s. differs from Phylloceras s.s. in having a more finely incised suture line which lacks the strong phylloidal endings of the saddles. The former is more compressed and stratigraphically more recent. Neophylloceras is typically a coniacian or later form, while Phylloceras rarely extends beyond the Turonian.

NEOPHYLLOCERAS ramosum (Meek)

Plate 16, fig. 6; pl. 17, fig. 1

1857 Ammonites (scaphites?) ramosus (Meek). Trans. Albany Inst., vol. 4, p. 45.

1876 Phylloceras ramosum (Meek). Bull. U. S. Geol. & Geog. Surv. Terr., vol. 2, no. 4, p. 371, pl. 5, figs. 1, a,b,c.

1879 Ammonites velledae (Michelin) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 2, p. 103.

1895 Phylloceras ramosum (Meek) (Whiteaves). Trans. Roy. Soc. Canada, 2nd ser., vol. 1, sec. 4, p. 128.

1902 Phylloceras ramosum (Meek) (Anderson). Proc. Calif. Acad. Sci., 3rd ser., vol. 2, p. 58, 61, 86, 99.

1903 Phylloceras ramosum (Meek) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 32.

1920 Phylloceras ramosum (Meek) (Gignoux). Contr. a Etude des Ceph. Paleocret. du S. E. de la Fr. Mem. Expl. Carte Geol., France, p. 93.

1921 Phylloceras ramosum (Meek) (Spath). Ann. Durban Mus. vol. 3, pt. 2, p. 40.

1927 Phylloceras cf. ramosum (Meek) (Yabe). Tohuku. Imp. Univ. Sci. Rpts., 2nd ser., vol. 11, p. 31, pl. 9, figs. 30, 36.

1928 Phylloceras aff. ramosum (Meek) (Collignon). Paleont. vol. 17, p. 7, pl. 1, figs. 2-4.

1942 Neophylloceras ramosum (Meek) (Matsumoto). Proc. Imp. Acad. Tokyo, vol. 18, no. 133, p. 674.

1952 Neophylloceras ramosum (Meek) (Usher). Geol. Surv. Canada, Bull. 21, p. 49, pl. 1, figs. 4, 5.

1958 Phylloceras ramosum (Meek) (Anderson). Geol. Soc. Am. Mem. 71, p. 81, pl. 40, figs. 4, 4a.

Shell compressed, narrow, umbilicus very small, deep, with short steep walls; volutions increase rapidly in diameter but not as much in thickness; flanks strongly flattened, rounding towards the umbilicus and venter.

On these ammonites the costae were well preserved, extending from the umbilical region across the venter. These, as Usher pointed out, are more flexuous than described and figured by Meek. Usher's description of the ribs fits closely.

> "They rise out of the umbilicus with a slight forward inclination and extend thus along about one-third of the flank. Here they bend forward even more and on the middle third of the flank they trace a well marked sigmoidal curve, bending first forward, then backward, and again slightly forward. Thence to and across the venter they are inclined almost imperceptibly forward."

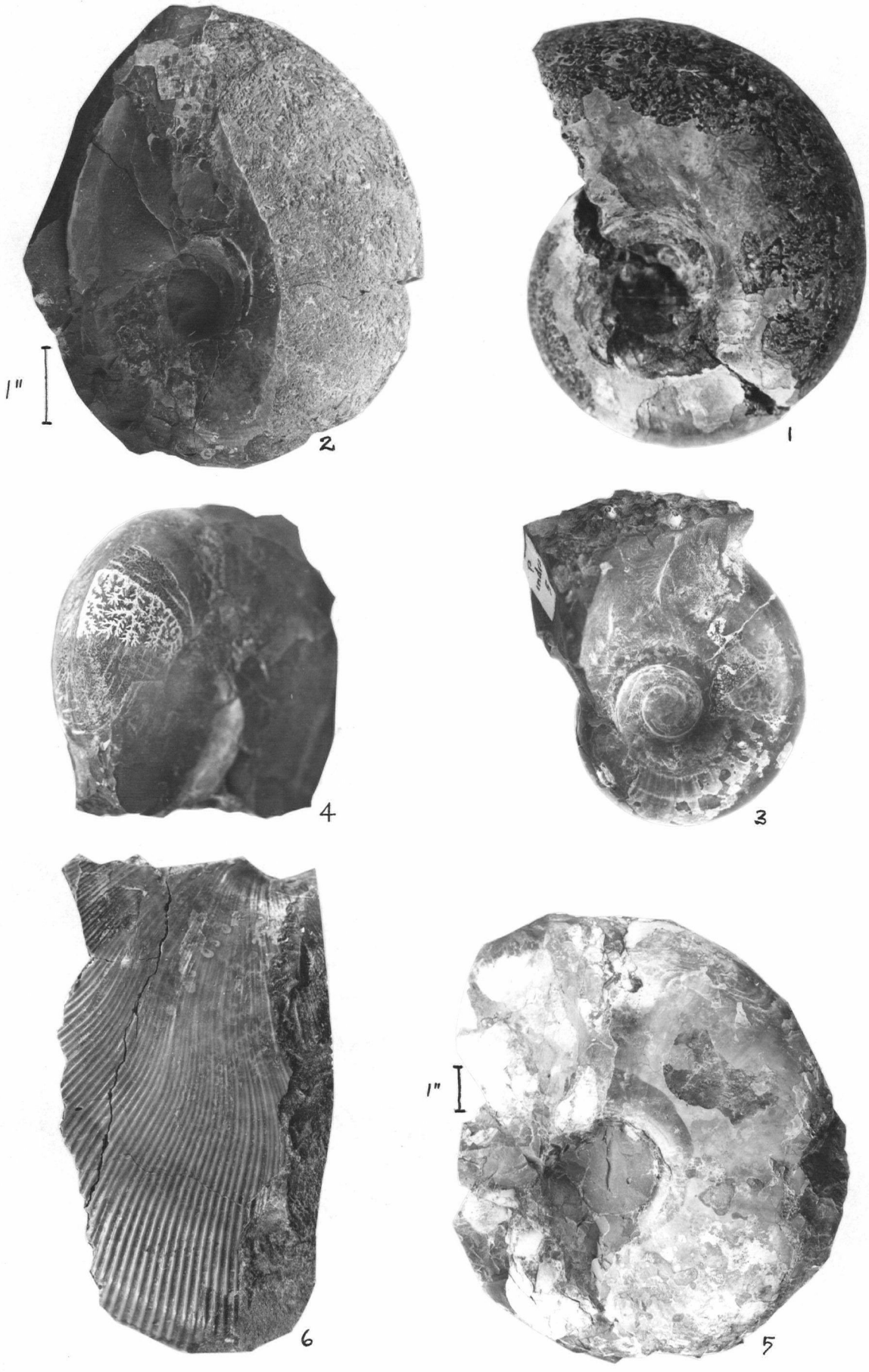
The costae or ribs are distinct on the flanks and venter, but toward the umbilical region they become much finer and tend to coalesce. Suture complex, not uncovered on Hornby Island specimens.

Usher proposes a new species Neophylloceras lambertense as distinct from N. ramosum, because the former has more sinuous ribs, a deeper umbilicus and more flattened

PLATE 16

		Page
Fig. 1	Pseudophyllites indra (Forbes) Inner whorl of larger specimen magnified three times. K 58-5-17	83
Fig. 2	P. indra (Forbes) K 58-3-27	83
Fig. 3	P. indra (Forbes) Natural size shown. K 58-5-15	83
Fig. 4	P. indra (Forbes) Natural size shown. K 58-5-14	83
Fig. 5	P. indra (Forbes) K 58-5-18	83
Fig. 6	Neophylloceras ramosum (Meek) Magnified 1.6 times. K 58-2-15	85

PLATE 16



flanks. Possibly the larger specimen K 58-2-4 may be N. lambertense. The present writer believes the difference between the two to be variable rather than specific.

Occurrence: Locality 2.

Hypotype: K 58-2-14

K 58-2-15.

Family . . . BACULITIDAE

Genus: Baculites (Lamarck)

Type Species: Baculites anceps (Lamarck)

> "Shell with minute, closely coiled initial stage but quickly becoming straight and assuming the form of a staff, which with increasing age increases slowly in diameter; transverse section subtrigonal to oval, or subcircular, though usually compressed laterally, living chamber large, aperture with long, straight, rounded extension on siphonal side and lateral sinuses; surface smooth or with low rounded ribs parallel to aperture and as a rule distinct only on flanks, or with low rounded nodes on flanks; suture generally has six saddles and six lobes, bifid except for the antisiphonal." -- Shimer and Shrock.

BACULITES occidentalis (Meek)

Plate 17, figs. 2, 3, 4

1857 Baculites ovatus (Say?) (Meek). Trans. Albany Inst. vol. 4, p. 48.

1861 Baculites occidentalis (Meek). Proc. Acad. Mat. Sci. Philadelphia, vol. 13, p. 316.

1876 Baculites occidentalis (Meek). Bull. U. S. Geol. & Geog. Surv. Terr., vol. II, no. 4, p. 366, pl. 4, fig. 1.

1879 Baculites occidentalis (Meek) (Whiteaves). Mesozoic Fossils, vol. 1, pt. II, p. 115.

1895 Baculites occidentalis (Meek) (Whiteaves). Trans. Roy. Soc. Canada, 2nd ser., vol. 1, sec. 4, p. 117.

1935 Baculites occidentalis (Meek) (Anderson & Hanna). Proc. Calif. Acad. Sci., 4th ser., vol. 23, no. 1, p. 24, pl. 8, figs. 3, 4.

1952 Baculites occidentalis (Meek) (Usher). Geol. Surv. Canada, Bull. 21, p. 98, pl. 28, fig. 1; pl. 31, fig. 19, text fig. 4.

Shell very long, straight, tapering gradually. Section ovate in youth, subtrigonal in adolescence, almost triangular in maturity. Flanks slightly convex, converging abruptly to acute rounded venter; flanks meet the broad flattened dorsum with rounded dorso-lateral angles.

> "Surface ornamented with flexuous parallel growth lines and costae. Growth lines cross dorsum with a smooth semi-circular, forward convexity, then pass backwards on the dorso-lateral flanks tracing there a deep forward concavity. At mid-flank they bend forward again and sweep in an oblique straight line towards the venter and cross the latter in an abruptly rounded angle. Costae, varying from smooth narrow ribs to broad, deep, fold-like corrugations are confined mostly to the dorso-lateral flanks where they parallel the growth lines and where they are strongest on the forward concavity described above. Spacing of the costae varies with the specimens and with change in size." -- Usher.

Suture pattern much the same as shown by Meek. External lobe is broad, bifid with a broad squarish siphonal saddle; first lateral lobe deeper than external lobe, bifid, broad stemmed, containing a short median secondary saddle; antisiphonal lobe short, dividing the large bifid antisiphonal saddle. First and second lateral saddles broad, bifid, equal in size; each branch ending in three shorter branches.

B. occidentalis was at one time grouped with B. chicoensis; it differs markedly from the latter in its trigonal cross-section with broad flattened dorsum and acute venter. Also B. occidentalis possesses fold-like costae that appear at an early stage and persist into the latest stages of maturity. Generally speaking the suture of B. occidentalis has longer saddles, deeper lobes and is more digitated than B. chicoensis.

Occurrence: Localities 4, 5 and 6.

Hypotype: K 58-4-10 K 58-4-16 K 58-5-11
K 58-5-12 K 58-6-18 K 58-6-19

BACULITES chicoensis (Trask)

Plate 17, fig. 5

1856 Baculites chicoensis (Trask). Proc. San Francisco Acad. Nat. Sci., vol. I, p. 85, pl. II, fig. 2.

1857 Baculites ovatus (Say) (Meek). Trans. Albany Inst., vol. 4, p. 48.

1861 Baculites inornatus (Meek). Proc. Acad. Nat. Sci. Philadelphia, vol. 13, p. 316.

1864 Baculites chicoensis (Trask) (Gabb). Paleont. Calif. vol. 1, p. 80, pl. 14, figs. 27, 29a; pl. 17, figs. 27, 27a.

1876 Baculites chicoensis (Trask?) (Meek). Bull. U. S. Geol. & Geog. Surv. Terr., vol. II, no. 4, p. 364, pl. 4, fig. 2.

1879 Baculites chicoensis (Trask) (Whiteaves). Mesozoic Fossils, vol. 1, pt. II, p. 114.

1889 Baculites chicoensis (Trask) (White). Bull. U. S. Geol. Surv. no. 51, p. 47.

1895 Baculites chicoensis (Trask) (Whiteaves). Trans. Roy. Soc., Canada, 2nd ser., vol. 1, sec. 4, p. 116.

1903 Baculites chicoensis (Trask) (Whiteaves). Mesozoic Fossils, vol. 1, pt. V, p. 339.

1935 Baculites inornatus (Meek) (Anderson and Hanna). Proc. Calif. Acad. Sci., 4th ser., vol. 23, no. 1, p. 24, pl. 8.

1940 Baculites chicoensis (Trask) (Taff, Hanna and Cross). Bull. Geol. Soc. Am., vol. 51, no. 9, p. 1321, pl. 1.

1952 Baculites chicoensis (Trask) (Usher). Geol. Surv. Canada, Bull. 21, p. 96, pl. 26, 31.

1958 Baculites chicoensis (Trask) (Anderson). Geol. Soc. Am. Mem. 71, p. 190, pl. 48, 60.

Shell long and straight, tapering very gradually. In transverse section the species is egg-shaped throughout its history, changing only slightly in outline. Dorsum well rounded becoming broader in later stages; flanks convex; venter rounded but narrower than dorsum. With age the maximum width shifts from the dorso-lateral region to mid-flank. Although costae are lacking the shell surface is ornamented by closely spaced growth lines. These cross the dorsum with a smooth semi-circular forward convexity bending backward in a similar convexity on the dorso-lateral flanks. The lines straighten in mid-flank, proceed obliquely forward in a straight line across the ventro-lateral flanks, and meet on the venter in another forward convexity.

> "Suture line not as deeply cut as Meek's illustration; external lobe very broad, bifid with a broad, short, siphonal saddle; first lateral lobe same depth as external, not as perfectly bi-symmetrical as the first lateral lobe of B. occidentalis; second lateral lobe broader than first, almost as deep but with a much shorter, narrower, dividing secondary saddle; antisiphonal lobe short but deeper than of B. occidentalis. First lateral saddle broad, bifid, shorter than that of B. occidentalis; second lateral saddle higher than the first; antisiphonal saddle much as in B. occidentalis, but not as deeply cut and with thicker branches." -- Usher, p. 97.

Occurrence: Locality 5.

Hypotype: K 58-5-6 K 58-5-7 K 58-5-9

BACULITES sp. undet.

Two very small smooth immature specimens were found. The larger has a diameter just short of 5 mm., the smaller about 2 mm. On both the suture is well preserved but bears no relation to adult specimens of B. occidentalis or B. chicoensis. They may be immature specimens of either. Since known immature specimens of these are not available for comparison, no identification has been made.

Occurrence: Locality 5.

Hypotype: K 58-5-23.

Family . . . . NOSTOCERATIDAE

Hyatt placed a number of later cretaceous phylogerontic ammonoid types in this family. The following genera are referable: Nostoceras (Hyatt), Didymoceras (Hyatt) (Meek's Heteroceras); Emperoceras (Hyatt), Diplomoceras (Hyatt), Exiteloceras (Hyatt), Bostrychoceras (Hyatt) (Whitfield's Ptychoceras); Oxybeloceras (Hyatt), and Solenoceras (Conrad).

Variations in the forms, spirals, retroversal loops and ornamentations of Pacific Coast Nostoceratids make it difficult to separate any of the genera unless the specimens are complete. For example a turricone type with its apical portion missing could be assigned to either Nostoceras or

Didymoceras. Similar difficulties are encountered with other genera.

Genus: Diplomoceras (Hyatt)

Type Species: Hamites cylindraceum (d'Orbigny)

> "Loose helicoid spire followed by two or three sub-parallel straight or curved shafts; section circular to oval; fine, dense, rather subdued ribbing; weaker on inside than outside of shell; collared construction at aperture. Suture very florid." -- Moore.

DIPLOMOCERAS jimboi (Anderson)

Plate 17, figs. 6, 6a, 7

1958 Diplomoceras jimboi (Anderson). Geol. Soc. Am. Mem. 71, p. 199, pl. 68, fig. 5.

The holotype consists of a fragment from the proximal limb of the shell, which is subcircular in section and slightly flattened on the dorsal side. The species appears to be closely related to Whiteaves' Diplomoceras notabile group.

> "The ribs are without nodes and are slightly oblique to the axis of the limb; suture lines as shown on the holotype are lytoceratid in character, with bifid lobes, much divided and somewhat crowded." -- Anderson.

Dimensions of hypotype K 58-4-14: length 185 mm.; lateral diameter 40 mm.; ventro-dorsal diameter 58 mm. Hypotype K 58-4-8 has a length of 40 mm.; its diameters cannot be measured accurately as the specimen is crushed.

In the middle of the smaller specimen K 58-4-8, a constriction occurs which is about twice as wide and deep as the normal concave grooves between the ribs.

Occurrence: Locality 4.

Hypotype: K 58-4-8

K 58-4-14.

DIPLOMOCERAS notabile(Whiteaves)

Plate 18, fig. 1

1903 Diplomoceras notabile (Whiteaves). Mesozoic Fossils, vol. 1, pt. V, p. 335, pl. 44, figs. 4, a, b.

1908 Anisoceras notabile (Whiteaves) (Kilian & Reboul). Schwed. Sudpolar-Exped. vol. III, pt. 6, p. 15, pl. II, fig. 1; pls. III, IV, V; pl. VI, fig. 1.

1952 Diplomoceras notabile (Whiteaves) (Usher). Geol. Surv. Can., Bull. 21, p. 109, pl. 29 and 30.

Whiteaves describes the species as follows:

"Shell very large when perfect, sub-cylindrical and transversely ribbed, ribs simple, leaving no impress upon the cast. The only specimen known to the writer is a nearly straight piece of the prolonged portion from Hornby Island, about ten inches and three-quarters long, and septate for by far the greater portion of its length. It is slightly compressed at the sides, broadly oval and not far from circular in transverse section. Near the smaller end it measures forty-seven millimetres in its diameter from the siphonal to the antisiphonal side and thirty-eight millimetres in its lateral diameter. Near the larger end the corresponding measurements are fifty-five millimetres by forty-six.

"The ribs are numerous, closely and regularly disposed, nearly transverse, but slightly oblique, rounded, and about as wide as the shallowly concave grooves between them. On the middle of each side there are about eight and a half ribs to the inch near the smaller end, and seven at the larger. In addition to the ribs there are two widely distant narrow, transverse constrictions, running parallel with them.

". . . the septation of this specimen is essentially similar to that of Hamites cylindraceus, as figured by d'Orbigny on plate 136, fig. 4, of the Atlas to the first volume of the 'Terrains cretaces' which is the type of

> Hyatt's recently proposed genus Diplomoceras. In both there are six lobes, viz., two large laterals (the 'lateral superieur' and the 'lateral inferieur' of d'Orbigny) on each side; one siphonal lobe and one antisiphonal. In both, also, the two lateral lobes, on each side, are very nearly equal in size. But the lobes and saddles of the Hornby Island specimen are still more numerously incised than are those of the French fossil, and this may be easily seen by comparing the siphonal saddle, the largest of the three accessory saddles between the first and second laterals, and the antisiphonal lobe, of both. The figure of the siphonal saddle of H. cylindraceus in the Atlas to the Terrains cretaces, for example represents it as entire at the summit and only twice incised on each side, whereas in the Hornby Island specimen, the same saddle is twice incised at the summit and four times on each side."
>
> -- Whiteaves 1903, p. 335.

In the specimen collected by the writer the suture cannot be seen; in other respects Whiteaves' description fits closely.

Dimensions: buccal limb 240 mm. in length; dorso-ventral height 105 mm.; length of smaller limb 90 mm.; height 88 mm.; diameter across loop 210 mm.; lateral diameter was not measured as the shell is slightly compressed.

Occurrence: Locality 5.

Hypotype: K 58-4-11

K 58-5-21.

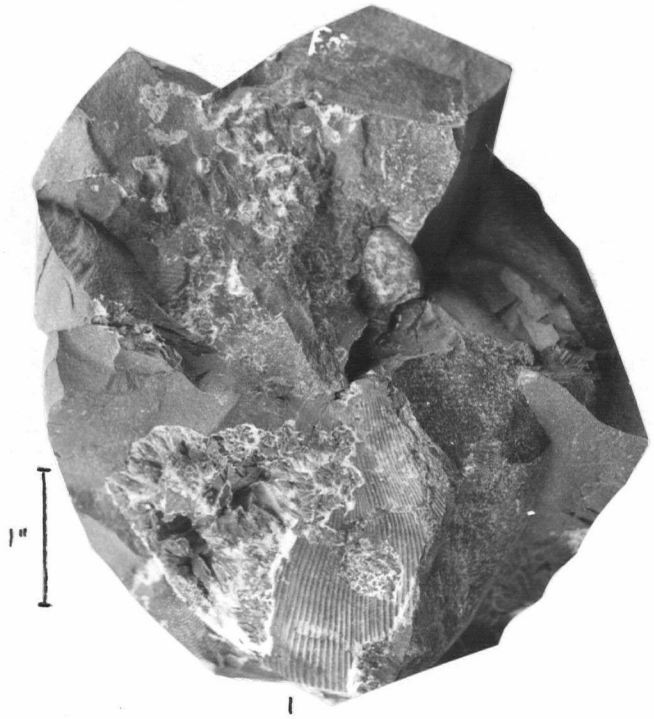
Genus: Didymoceras (Hyatt)

Whiteaves identified various types of nostoceratids as Anisoceras cooperi. He believed these to be identical with Gabb's Ammonites cooperi, which the latter proposed for two or three very much compressed fragments from Point Loma near San Diego, California.

PLATE 17

		Page
Fig. 1	Neophylloceras ramosum (Meek) K 58-2-14	85
Fig. 2	Baculites occidentalis (Meek) Natural size. K 58-5-12	87
Fig. 3	Baculites occidentalis (Meek) K 58-5-10	87
Fig. 4	Baculites occidentalis (Meek) K 58-6-19	87
Fig. 5	Baculites chicoensis (Trask) K 58-5-9	89
Fig. 6	Diplomoceras jimboi (Anderson) K 58-4-14	92
Fig. 6a	Diplomoceras jimboi (Anderson) External ornamentation. K 58-4-14	92
Fig. 7	Diplomoceras jimboi (Anderson) Natural size. K 58-4-8	92

PLATE 17



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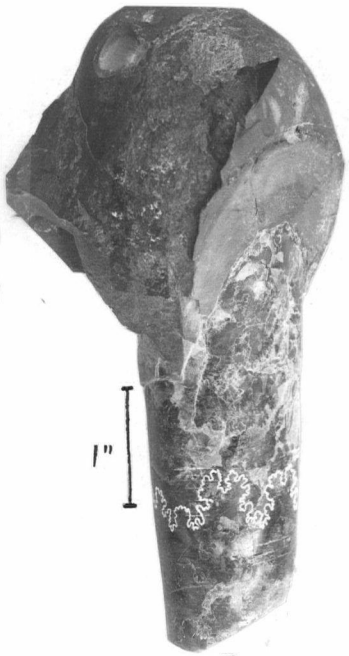

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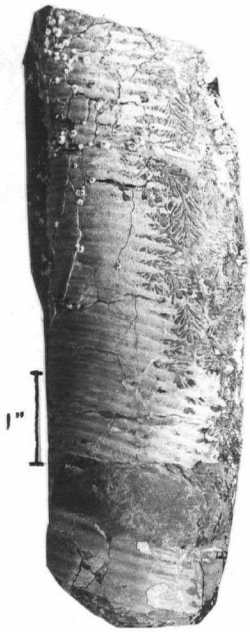


6a

7

The writer feels certain that at least four different species of nostoceratids occur which have been previously lumped together as Anisoceras cooperi. These are Didymoceras kernense (Anderson), Didymoceras hardiensis, n. sp., Nostoceras lambertense n. sp., Anisoceras (Didymoceras) vancouverense (Whiteaves), and Exiteloceras sp. undet. Didymoceras hardiensis may be identical with Whiteaves' D. hornbyense.

DIDYMOCERAS cf. kernense (Anderson)

Plate 18, figs. 2, 3

Genus: Didymoceras (Hyatt)

1958 Didymoceras kernense (Anderson). Geol. Soc. Am. Mem. 71, p. 196, pl. 65, figs. 1, 1a, 2.

> "The holotype is large, strongly costate, and tuberculate; section of limbs subquadrate, or subcircular in different parts; ribs strong, elevated, branching irregularly, or single, and accordingly of two sorts: on smaller limb, ribs are strongly oblique, extending sharply backward on approaching dorsal border, but suppressed on dorsum itself; on buccal limb ribs cross the sides nearly at right angles to its axis; ribs on the upper portion of the loop-like body chamber, branching into four smaller ribs, more or less tuberculate; the tubercles are in two rows on ventral border; through these ribs pass, branching from them in alternate manner, branches from each row crossing the ventral area obliquely. On the holotype only the last septum is visible, but not clearly. The single ribs rarely pass through more than one tubercle; the others pass through two.
>
> "The holotype is rather large, having the following dimensions: length of large limb 112 mm.; greatest width across the loop 81 mm.; greatest ventro-dorsal diameter of buccal limb, 38 mm.; diameter of smaller limb 32 mm." -- Anderson.

The one example of D. kernense consists of part of the retroversal loop which was slightly compressed by rock pressure. It does not exhibit the antisiphonal side. The ornamentation on the venter and flanks is well preserved and identical with Anderson's description and figure 2 on plate 65.

A complete retroversal loop was also found; it closely resembles Anderson's figure 1, plate 65 of D. kernense except that the ribs do not bifurcate as much. It too has been tentatively assigned to this species as its dimensions, form and ornamentation are very similar.

Dimensions of complete retroversal loop: K 58-2-21: length of buccal limb 80 mm.; width of loop 82 mm.; diameter of buccal limb 39 mm.; diameter of proximal limb 35 mm.

Occurrence: Localities 2 and 3.

Hypotype: K 58-2-21
K 58-3-15.

DIDYMOCERAS hornbyense (Whiteaves)

Plate 18, figs. 4, 4a, 5

1895 Heteroceras hornbyense (Whiteaves). Can. Rec. Sci., vol. 4, no. 6, p. 316.

1903 Heteroceras hornbyense (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 332, pl. 42, figs. 1-4.

1921 Didymoceras hornbyense (Whiteaves) (Spath). Ann. S. Africa Mus., vol. 12, no. 16, p. 251.

1943 Nostoceras hornbyense (Whiteaves) (Usher). Geol. Surv. Canada, Bull. 21, p. 103, pl. 27, figs. 1, 2; pl. 28, fig. 2.

1958 Nostoceras hornbyense (Whiteaves) (Anderson). Geol. Soc. Am. Mem. 71, p. 195.

Whiteaves' original description was based on a small dextral coil:

> "Shell dextral, depressed, turbinate, much broader than high, and composed, so far as is known, of five or six rounded, ventricose volutions, which are incclose contact but without embracing, spire moderately elevated; umbilicus broad and deep, exposing the whole of the inner volutions.
>
> "Surface marked with simple and not very flexuous transverse ribs."

The ribs are separated by deep smooth concave furrows and are inclined forward from the top to the bottom of the whorl. The ribs flex sharply forward at the impressed zone forming a deep, forward convexity on the inner part of the whorl.

Usher discusses the detailed ornamentation:

> "At sparse intervals in the mature stages, deep constrictions, bordered on each side by a high, thick rib, are well marked. Two rows of high, sharp, commonly elongated tubercles appear at early maturity, the upper row located about mid-whorl and the lower row a short distance below on the lower, outer part of the volution. Between the two rows is the siphuncle. As the whorls become larger, the tubercles migrate lower on the shell to where the upper rows spring from the shell directly over the siphuncle and then pass over it. At a whorl diameter of 1 inch, both rows are on the lower, outer part of the volution. At their first appearance, the nodes occur on every other third or fourth rib, and at later stages on every other second or third rib. Where costae bifurcate they do so at the nodes. Rarely fibulation of the ribs between the two rows of nodes may be observed."

Anderson does not agree that Whiteaves' dextrally and sinistrally coiled examples represent the same species.

He calls the sinistral types D. perversum. Anderson regards only the dextrally coiled examples as D. hornbyense.

Two dextral specimens were found. The larger one with a diameter of 33 mm. exhibits an unsymmetric suture line, while the smaller one has long extended nodes.

Occurrence: Locality 4.

Hypotype: K 58-4-4

K 58-4-6.

DIDYMOCERAS perversum (Whiteaves)

Plate 19, fig. 1

1895 Heteroceras perversum (Whiteaves). Can. Rec. Sci. vol. 4, p. 35.

1903 Heteroceras hornbyense (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 332, pl. 42, figs. 2, 3.

1958 Didymoceras perversum (Whiteaves) (Anderson). Geol. Soc. Mem. 71, p. 197.

The examples collected by the writer are too fragmentary to add new information.

Occurrence: Localities 3 and 4.

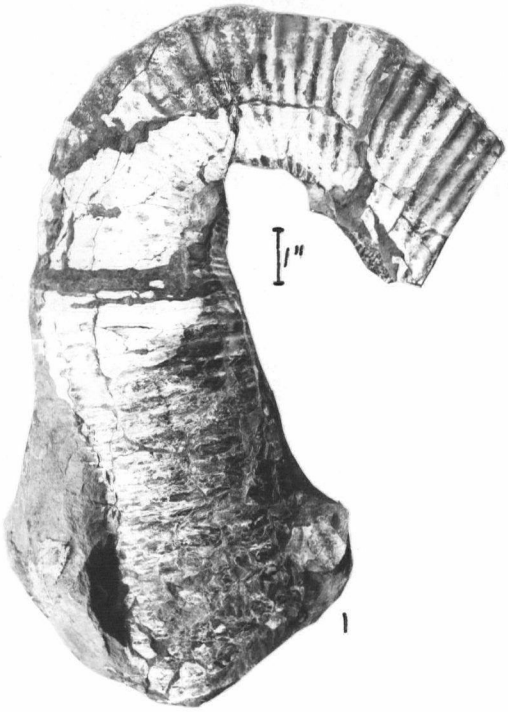
Hypotype: K 58-3-24

K 58-4-5.

PLATE 18

		Page
Fig. 1	Diplomoceras notabile (Whiteaves) K 58-5-21	93
Fig. 2	Didymoceras kernense (Anderson) k 58-3-15	95
Fig. 3	Didymoceras cf. kernense (Anderson) K 58-2-21	95
Figs. 4, 4a	Didymoceras hornbyense (Whiteaves) Consisting of part of the dextral coil, slightly magnified. K 58-4-6	96
Fig. 5	Didymoceras hornbyense (Whiteaves) Twice natural size. K 58-4-4	96

PLATE 18



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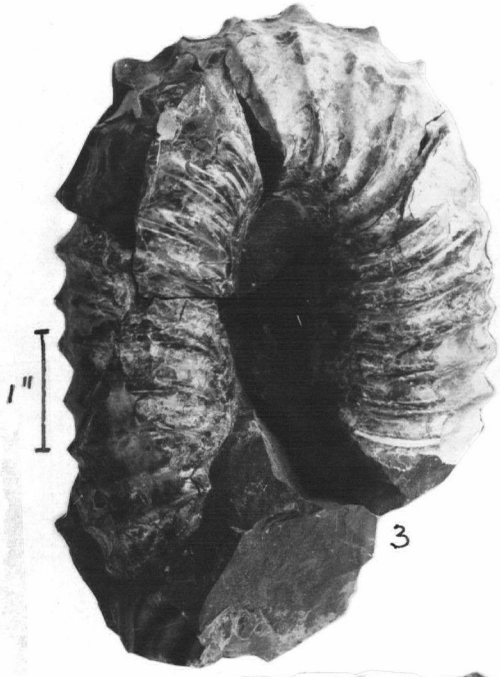

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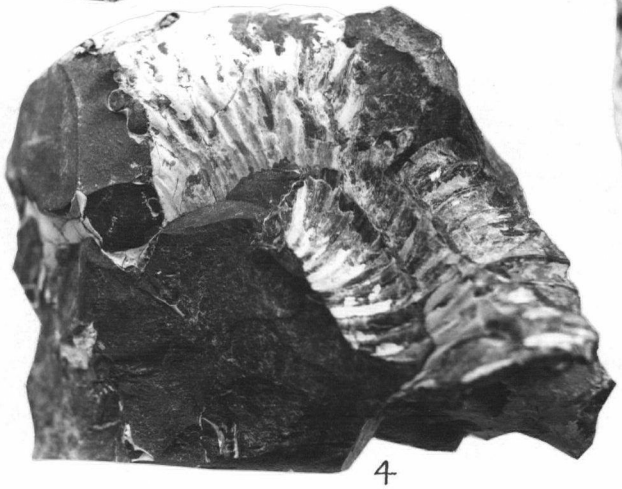

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4a

DIDYMOCERAS hardiensis N. sp.

Plate 19, figs. 2, 3, 4

Three beautifully preserved examples were collected. On these, the ornamentation and form is so unique that a new species is proposed. One fragment of a large buccal limb and two retroversal loops were found. On one of the latter the smaller limb is complete and begins to curve at the proximal end.

Shell costate and tuberculate; flanks on buccal limb stronger flattened, meeting dorsum and broad venter with sharply rounded contours; section sub-quadrate. On smaller limb flanks and venter more convex, section sub-rounded.

The shell is ornamented by flexuous costae, and by two rows of small sharp nodes, one on each side of the siphon. The costae slant towards the retroversal loop from the dorsum to mid-flank on both the larger and smaller limb. At mid-flank they slant away from the retroversal loop. At the bend the costae cross at right angles to the periphery and are straight. Bifurcating ribs are common, especially in the curved portion. On the holotype (K 58-5-27) the smaller limb is complete; at its proximal end the costae curve towards the apical portion.

Dimensions of holotype: length of buccal limb 40 mm.; ventro-dorsal diameter 45 mm.; lateral diameter 42 mm.; length of smaller limb 160 mm.; loop diameter 110 mm. Distance between limbs 25 mm.

The ornamentation and suture are similar to D. hornbyense, which may be the apical portion of D. hardiensis. Whether this is the case will depend on further collections. Certainly D. hornbyense is not the apical portion of Anisoceras vancouverense as suggested by Whiteaves.

Occurrence: Localities 2 and 5.

Holotype: K 58-5-27

Paratype: K 58-2-20

K 58-5-22.

NOSTOCERAS lambertense N. sp.

Plate 19, fig. 5

This species is represented by various almost complete retroversal, U-shaped loops. Some of these, then called Anisoceras cooperi were collected by Harvey in the late 19th century and are now kept in the Provincial Museum at Victoria. The writer found one complete loop and some fragments. The species is common and distinctive, but so far only the retroversal loop has been collected.

Shell ornamented by numerous strong sharp ridge-like costae; on the smaller limb they are simple, annular, and at right angles to the periphery. On the buccal limb the costae slant strongly backward from the antisiphonal side toward the loop. They cross the flanks in a smooth backwardly directed arcuity. Near the venter minor costae develop between the major ones and extend halfway down the flanks. On the limbs

there are 5 costae to the inch; these rarely bifurcate. On the curved portion the numerous ribs are much finer, less distinct, more rounded and bifurcate regularly. In addition to the costae N. lambertense is ornamented by two rows of large blunt nodes, one on either side of the siphon. On the holotype the nodes are preserved only in the bent portion but may well extend along the full length of the loop. This species closely resembles N. mexicanum (Anderson) except for its ornamentation. In N. mexicanum the costae are straight and single; secondary costae do not develop between primary ones.

Dimensions of holotype K 58-2-19: maximum length of buccal limb 71mm.; length of smaller limb 88 mm.; maximum diameter of smaller limb 43 mm.; diameter of loop 113 mm.; maximum space between limbs 23 mm.

Occurrence: Locality 2.

Holotype: K 58-2-19.

ANISOCERAS (DIDYMOCERAS) vancouverense (Whiteaves)

Plate 20, fig. 1

1895 Anisoceras vancouverense (Whiteaves). Can. Rec. Sci. vol. 4, no. 6, pp. 313-318.

One specimen was collected from Hornby which fits Whiteaves' description of A. vancouverense. He incorporated this species with Meek's Heteroceras cooperi and Gabb's Ammonites cooperi. The last two appear to be distinct from A. vancouverense.

PLATE 19

		Page
Fig. 1	Didymoceras perversum (Whiteaves) Slightly magnified. K 58-4-5	98
Fig. 2	Didymoceras hardiensis n. sp. K 58-5-22	99
Fig. 3	Didymoceras hardiensis n. sp. K 58-5-27	99
Fig. 4	Didymoceras hardiensis n. sp. K 58-2-20	99
Fig. 5	Nostoceras lambertense n. sp. K 58-2-19	100

PLATE 19

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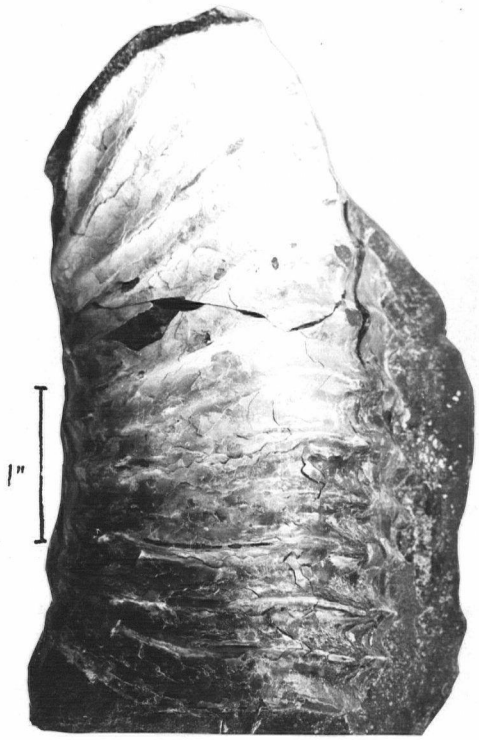

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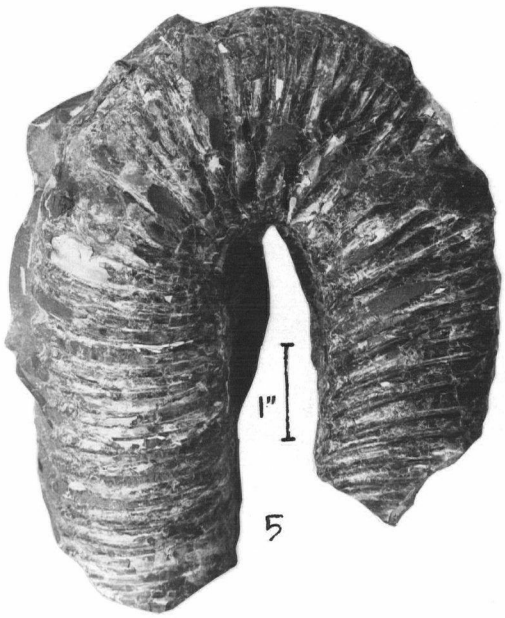

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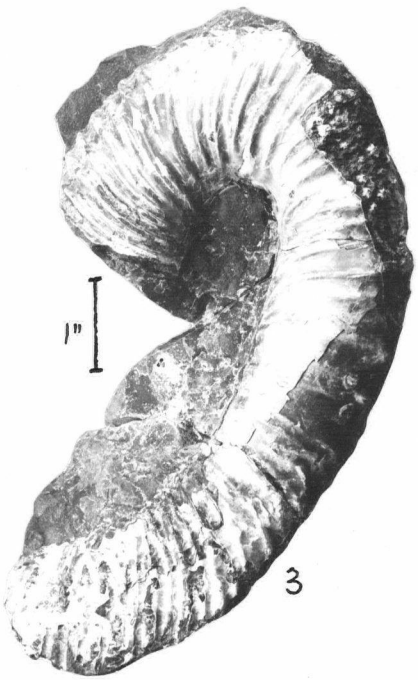

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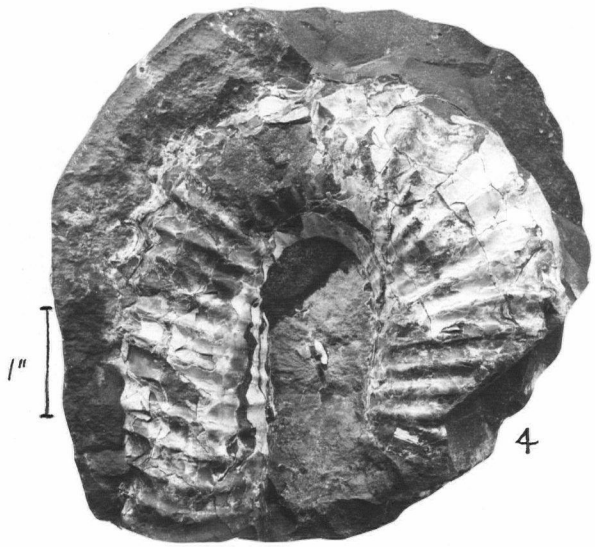

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> "The surface is strongly ribbed, and many of the ribs bear a large conical tubercle on each side of the periphery, but there is much irregularity in the disposition of the ribs and tubercles. On the sides of the shell the ribs are usually simple and disposed with comparative regularity, but they occasionally bifurcate, or a short rib is intercalated between two larger ones, and two ribs frequently coalesce on both sides, at one of the tubercles on the outer margin of the periphery." -- Whiteaves.

Both limbs seem to have the same diameter on either side of the loop. This feature distinguishes the species from Didymoceras hardiensis where the buccal limb is much larger than the limb on the other side of the loop. The suture, spines and ornamentation are also very different in A. vancouverense and D. hardiensis.

The specimen from Hornby is almost completely preserved except for parts of the venter which were not preserved by the enclosing nodule. In shape the shell is almost ellipsoidal, one limb passing beneath the other. The shell is slightly contorted.

The uncrowded sharp ridge-like nature of the ribs with the wider concave grooves between, and the strong, well developed conical nodes are distinctive.

Occurrence: Locality 3.

Hypotype: K 58-3-21.

Genus: Exiteloceras (Hyatt)

> "Hyatt included in this genus in addition to the type, the more regularly coiled symmetrical 'Ancycloceras' jenneyi (Whitfield), which is more complete and less eccentric in its form and ornamentation, and more correctly represents a number of species occurring in the Upper Cretaceous of California and Oregon."
> -- Anderson.

EXITELOCERAS sp. undet.

Plate 20, fig. 2

This is the most regular and most simply ornamented of the Nostoceratids of Hornby Island. Like all the others it was previously referred to as Anisoceras cooperi. The costae are simple; they bifurcate rarely and only in the curved portion of the shell; they are strongest on the flanks which they cross in a forward direction. Nodes occur but are not well preserved on the specimen. Both limbs are almost equal in diameter.

Occurrence: Locality 4.

Hypotype: K 58-4-19.

Genus: Hamites (Parkinson)

Type Species: Hamites attenuatus (Sowerby)

> "The uncoiled ammonites within this genus consist of two or three straight or slightly curved, nearly parallel arms connected to one another by elbows or bends of 180 degrees. The surface of the shell is usually ornamented with numerous, simple costae that are continuous all around; tubercles are for the most part absent. The suture consists of nearly equal bifid lobes, a small antisiphonal lobe and five strong bifid saddles." -- Usher, p. 100.

"HAMITES" obstrictus (Jimbo)

Plate 20, figs. 3, 3a, 3b

1894 Hamites obstrictus (Jimbo). Paleon. Abh. Nem., vol. 2, pt. 3, p. 38, pl. 7, figs, 2, a, b.

1895 Hamites obstrictus (Jimbo) (Whiteaves). Trans. Roy. Soc., Canada, 2nd ser., vol. 1, sec. 4, p. 130.

1903 Hamites obstrictus (Jimbo) (Whiteaves). Mesozoic Fossils, vol. 1, pt. 5, p. 334, pl. 44, fig. 3.

1908 Anisoceras obstrictum (Jimbo) (Kilian and Reboul). Schwed. Sudpolar-Exped., Geol. & Pal., vol. 3, pt. 6, p. 17, pl. 4.

1921 Diplomoceras obstrictus (Jimbo) (Spath). Ann. S. African Mus., vol. 12, no. 16, p. 256.

1927 Hamites (Polyptychoceras) obstrictum (Jimbo) (Yabe). Tohoku Univ. Sci. Repts., 2nd ser., vol. 11, p. 44.

1943 Polyptychoceras obstrictum (Jimbo) (Matsumoto). Mem. Fac. Sci. Kyusyu Imp. Univ., vol. 2, no. 1, pl. 2, p. 113, fig. 24.

1952 "Hamites" obstrictus (Jimbo) (Usher). Geol. Surv. Canada Bull. 21, p. 100, pl. 27, fig. 7.

Three fragments were collected from a single nodule; one hooked portion with a constriction on the larger end, and two straight sections, one with a constriction. Whether the three sections belong to the same animal is not certain; all are slightly crushed and show no suture.

The specimen has an estimated diameter of 12 mm. and is ornamented by fine, sharp, transverse ribs. There are about seven of these to a centimeter; they are separated by much wider concave grooves.

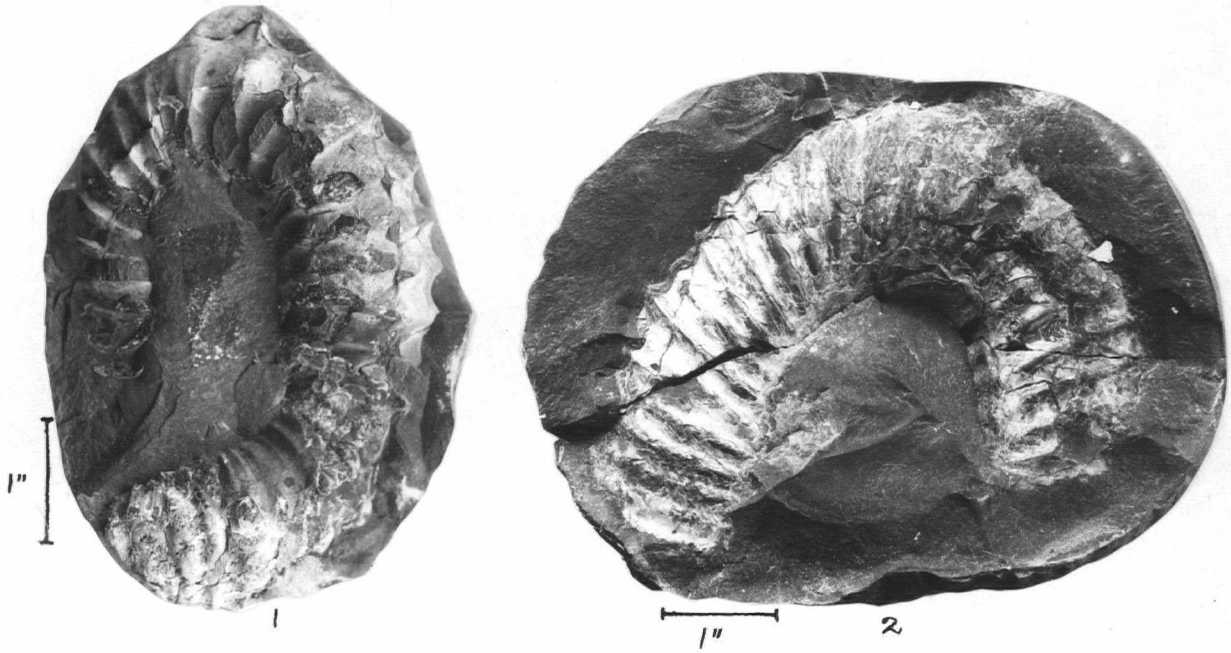
Occurrence: Locality 3.

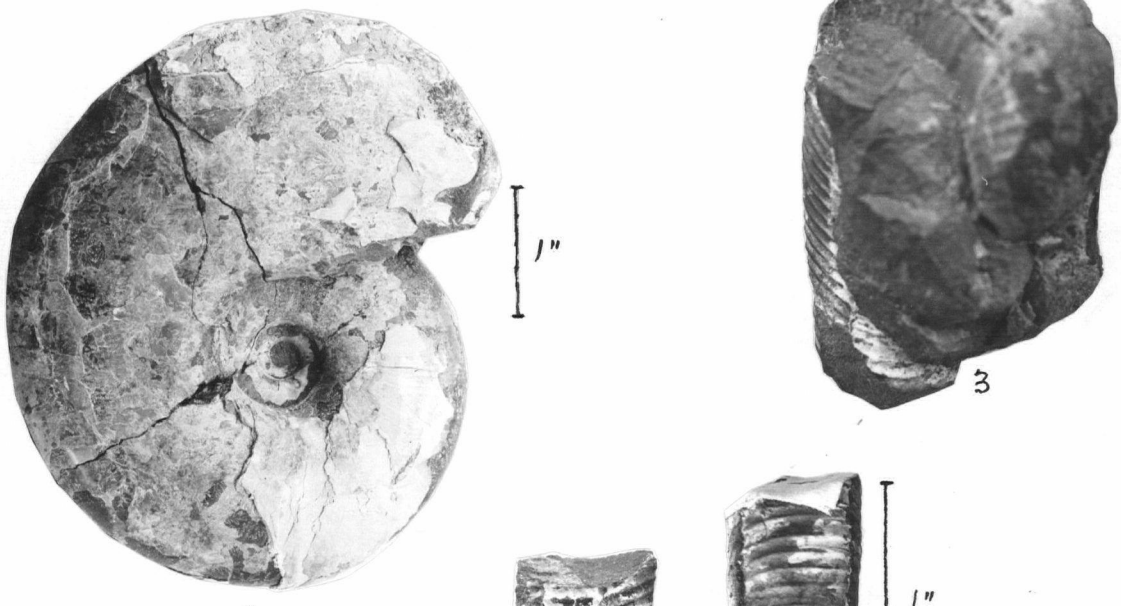
Hypotype: K 58-3-22.

PLATE 20

		Page
Fig. 1	Anisoceras vancouverense (Whiteaves) K 58-3-21	101
Fig. 2	Exiteloceras sp. undet. K 58-4-19	103
Figs. 3, 3a, 3b	Hamites obstrictus (Jimbo) K 58-3-22	104
Fig. 4	Pachydiscus sp. B K 58-4-12	75

PLATE 20





CHAPTER IV

CONCLUSION

The fauna of the Nanaimo series is imperfectly understood mainly because of the lack of good fossil collections. The literature, although plentiful, is fragmentary and often inadequately illustrated. Many species have been named from poorly preserved fossils; others have been described but not illustrated. The ones that are illustrated often do not show enough characteristic details. Suture drawings are perhaps the most inadequate of all. Suture drawings by Meek, Gabb, Usher and others vary tremendously for the same species. The main reason for this may be free hand drawing or tracing of sutures; both methods are inaccurate. Sutures can be shown correctly only on photographs of perfect specimens. Inking in the suture helps when it is too obscure to stand out sufficiently in a photograph.

In the Upper Lambert formation some ammonite species appear to be restricted to definite zones but again not enough collecting has been done in the area to determine the zonal

limits. The abundance of Pseudophyllites indra, Pachydiscus suciaensis and Pachydiscus ootacodensis as well as the occurrence of Neophylloceras ramosum, Baculites occidentalis and Baculites chicoensis indicate a Maastrichtian age for the Lambert formation. Typical Upper Cretaceous species such as Diplomoceras, Didymoceras and Nostoceras are also recorded.

Apart from the above mentioned fossils, many other single species were collected; this lack of duplication suggests a very much larger fauna than is yet known. Some species once believed to be restricted to other formations lower in the series have now been discovered in the Lambert; examples are Desmophyllites selwynianus and Epigoniceras epigonum.

The writer believes that a compilation of all the paleontological work done in the Nanaimo series is essential. A revision of nomenclature, descriptions and illustrations would much improve the understanding of the Upper Cretaceous marine life along the West Coast of North America.

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