CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

PAPER 53-17

TERTIARY ROCKS OF THE HESQUIAT-NOOTKA AREA, WEST COAST OF VANCOUVER ISLAND, BRITISH COLUMBIA

By

J. A. Jeletzky

OTTAWA

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Price, 50 cents

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(With Brief Comments on Adjacent Mesozoic Formations)

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<u>Illustration</u>

Preliminary map - Hesquiat-Nootka area, Vancouver Island, B. C. .... In pocket

TERTIARY ROCKS OF THE HESQUIAT-NOOTKA AREA, WEST COAST OF VANCOUVER ISLAND, BRITISH COLUMBIA

INTRODUCTION AND ACKNOWLEDGMENTS

This report presents the preliminary results of a survey of part of the west coast of Vancouver Island, between Ferrer Point, on the northwest end of Nootka Island, southeast across Hesquiat Peninsula to Kutcous Point on the southeast shore of Flores Island.

The field work, which occupied parts of the summers of 1951 and 1952, was greatly facilitated by the assistance and co-operation of the residents of the area. To those residents, and in particular to Mr. E. Redford, manager of the Estevan Point Lighthouse, goes the writer's express gratitude for courteous and generous help. Special thanks are given to Dr. H. C. Gunning, Chairman of the Department of Geology and Geography of the University of British Columbia, and to Dr. Charles E. Weaver, University of Washington (retired), for helpful and stimulating discussions of the problems involved. Grateful acknowledgment is made to Mr. A. F. Buckham, Chief Geologist of the Nanaimo Colleries, Limited, for providing the writer with a photostat copy of a report by Mr. S. M. Robins,formerly manager of the New Vancouver Coal Company, Nanaimo, on an early prospecting trip to Estevan Point, and for other valuable advice.

Thanks are due to Messrs. A. N. Nichols, Th. M. Kozminchuk, and H. C. Okabe for able assistance in the field during the season of 1951, and to Messrs. J. D. Campbell, R. C. Moore, and G. D. Pollock during the 1952 season.

PHYSICAL FEATURES OF THE AREA

Topography and Vegetation

The area studied lies almost entirely within the narrow coastal plain situated between the steep slopes of the mountain ranges and the Pacific Ocean. This plain is divided into sections split up by Nuchatlitz Inlet, Nootka Sound, Hesquiat, Inner, and Rae Basins, Sydney Inlet, and Russell Channel of Clayoquot Sound. Its broadest part is on Hesquiat Peninsula, where it reaches a width of some 6 to 8 miles. Elsewhere it does not exceed 2 1/2 to 3 miles in width (e.g., at Bajo Point on Nootka Island), and most of it is less than a mile wide.

Much of the coastal plain lies between 100 and 150 feet above sea-level and is interrupted in places by variously shaped hills and island-like knolls not more than 800 feet high. Most of these do not exceed 200 to 250 feet above sea-level.

There is an obvious relation between the character of the bedrock and the relief of the coastal plain. Wherever the latter is underlain by less disturbed and relatively soft Tertiary rocks or by Pleistocene and Recent deposits, its surface is almost featureless and flat, interrupted here and there by gently rounded hills; much of it is swampy, and many of the creeks and small rivers that cross it have sluggish, meandering courses.

Wherever, on the other hand, the bedrock consists of the harder, strongly faulted, intensely folded, sheared, and contorted rocks of the Vancouver group, of the Coast intrusions, or of the more resistant Tertiary rocks, the coastal plain, though low lying as elsewhere presents a somewhat different aspect. It is much more uneven, and is dotted with precipitous bluffs, cliffs, and protruding high rocks. Steep, precipitous, rocky gullies, ravines, and deep crevices form an irregular criss-cross pattern, and the numerous irregular depressions and pits between the positive elements of "micro-relief" are commonly occupied by small lakes or swamps. The drainage system has on the whole a highly irregular pattern: creeks and small rivers have numerous rapids and water-falls, and most of them begin and end in lakes or swamps. These conditions are believed to be caused primarily by the complex tectonic history of this coastal region, the drainage system being partly controlled by innumerable criss-crossing faults and shear zones.

The character of the shoreline presents similar diversity of relief, apparently caused by the same factors. Wherever the relatively undisturbed and softer Tertiary rocks occupy the shore, it is featureless and is commonly marked by sandy or pebbly beaches for long distances. Outcrops of bedrock are generally scarce or lacking between the high-tide mark and the fringe of the forest, but below high tide the shore is almost invariably marked by broad rocky flats accessible at low tide, or in places at half tide. These flats are commonly from 150 to 250 yards wide, and some of them may extend offshore for 300 to 500 yards or more. Though commonly more or less overgrown with seaweeds or covered by sand, gravel, or huge boulders and blocks (probably derived from the boulder clay), these rocky flats present many excellent outcrops from which much of the geological information was obtained.

All other kinds of rocks, including the resistant sandstone-conglomerate of Divisions A and C of the Tertiary section, produce a bolder and much more rugged shoreline, and stretches occupied by these rocks commonly project far into the sea. Particularly on the west side of Hesquiat Peninsula, where shale, clayey sandstone, and resistant sandstone-conglomerate members of Division C of the Tertiary System alternate along the shore at short intervals, the alternation of flat and rugged stretches of the coast strikingly coincides with the lithological changes of the rocks.

Wherever intensely faulted, sheared, and contorted, these resistant rock types generally produce a precipitous, bluffy shoreline, deeply cut with numerous steep-sided gullies, blow-holes, caves, subterranean passages, and natural arches. All these forms of relief are mainly a result of powerful marine erosion along the structural lines of weakness in the rocks, and are usually associated with the type of dissected coastal plain already described.

All the land areas above the high-tide mark, or the level reached by waves during winter gales, including all hills and island-like knolls of the plain and the slopes of the mountains landward of this plain are densely wooded. Within the coastal plain itself the forest is nearly everywhere infested with extremely dense underbrush, which consists of salal, rose-bushes, ferns, various berry bushes, and sparse devil's club. A few patches of the open, grassy, or park-like land were noted around Bajo Point and on the west coast of Flores Island southeast of Rafael Point; these were apparently cultivated during the earlier part of the century. On the mountain slopes above the 200- to 300-foot contours the underbrush mostly thins out or is largely replaced by various ferns, and is far more passable than that of the coastal plain, which, as the local inhabitants remark, is not quite thick enough to walk upon but is almost too thick to be penetrated in any other way. Heavy windfall covers the coastal plain and much of the mountain slopes and valleys of the creeks and rivers.

Climatic Conditions

The average annual precipitation at Estevan Point during the last 27 years is estimated at 109.32 inches, but is undoubtedly higher farther inland and at the heads of the inlets. Much of it falls in the period between October and March. Southeasterly storms and gales are rare during the summer months, and weather forecasts proved a great help in avoiding them. Much more inconvenience, and sometimes even danger, was caused by strong westerly to northwesterly winds, which commonly reached 20 to 35 miles an hour and raised very rough seas. Such winds may persist for days and weeks, and whenever in excess of 10 to 15 miles an hour prevented any navigation in open water by launch. These winds commonly subsided during the night and early forenoon, but increased to full power during each afternoon. However, the strongest and steadiest winds of this type often continue with equal force around the clock and are usually accompanied by sunny, clear weather.

Dense fog is another hazard that must always be taken into account in these parts. Fogs usually accumulate during the quiet, cloudy days, when it would be otherwise easy to travel across the open water. They may lift or return within short intervals, but in August and September commonly persist for days and even weeks, with only short intervals of clear weather.

Accessibility and Transportation

At present, the area can only be reached by air, but has no regular transportation service.

Passable trails are all but wanting within the area, with the exception of the telephone-line trail that follows the shoreline around Hesquiat Peninsula and from there along the eastern side of Hesquiat Harbour to Hesquiat Point, and along its western shore to Kanim Lake and from there to Stewardson Inlet. This trail, though neglected for years as a result of the discontinuation of the telephone service, is still in fair condition. A trapping trail leads up the northwest shore of Beano Creek for several miles, and another connects Beano Creek with Yuquot village. Both are in poor condition owing to the decline of trapping during the last few seasons. An equally poor trail leads along the western shore of Flores Island from Siwash Bay to the southern base of Rafael Point. Its further course was not investigated. A good trail leads from the head of Rae basin along the eastern shore of the outlet of Hesquiat Lake to this lake and thence for an unknown distance along its eastern shore. The party did not use it, however, as it is always possible to bring a dinghy in and out of Hesquiat Lake whenever tides are more than 11.5 feet high. A plank road connects the Estevan Point lighthouse with Hesquiat village; this is used by trucks carrying supplies for the lighthouse and is well maintained.

Channels of larger creeks and rivers are commonly fair to good routes of travel where they are cut in Quarternary deposits or in the relatively soft and less disturbed Tertiary rock types, or otherwise where their channels are mature, as indicated by low and wide shores. In resistant Tertiary sandstones and conglomerates, and in badly faulted and metamorphosed Mesozoic rocks the streams are apt to occur in precipitous gorges, very picturesque but mostly impassable. Both Beano and Calvin Creeks flow in canyons that contain numerous waterfalls above where they cross the belt of Tertiary shales. Some 1 1/2 to 2 miles farther upstream, however, their valleys become wide and low, with but little bedrock showing from beneath an alluvial sheath of boulders and gravel. Escalante River is easily accessible for about 1 1/2 miles above its mouth, and Satchie Creek is flanked by low shores on either side of a broad alluvial channel for at least a mile above its mouth. The creeks on the west coast of Flores Island seem to be slow, partly stagnant streams resembling those of the low part of Hesquiat Peninsula.

For transportation along the coast the party used a shallow-draft, round-bottomed launch 20 feet long and 6 feet wide powered with a 25 h.p. inboard engine. A low, lid-like cabin occupied the forward two-thirds of the boat, and a narrow cockpit, with glass windows for the pilot, was constructed behind it. So equipped, this launch was found satisfactory for cruising everywhere within the area mapped. Over open water it was found to be seaworthy in calm weather and even during northwesterly winds not exceeding 10 to 15 miles an hour. The launch was capable of carrying more than a 1-ton load, consisting of three to four persons, with all necessary equipment and supplies. The crew could not, however, sleep on board.

OBJECTIVE AND FIELD PROCEDURE

The writer's survey of the west coast of Vancouver Island between Clayoquot and Quatsino Sounds was originally planned as a detailed palaeontological and stratigraphical study of the areas of the Lower Cretaceous sedimentary, marine rocks shown on Geological Survey maps of that district. It was hoped that it might be possible to establish a type section, and a succession of that uppermost Jurassic and lowermost Cretaceous faunas that would serve as a standard of reference for strata of these ages elsewhere in the Canadian Cordillera. It soon became apparent, however, that most of these rocks were of Tertiary age (Jeletzky, 1950, pp. 47-48) though the remainder were found to include a considerable thickness of the uppermost Jurassic (Portlandian) marine beds and others of Lower Cretaceous (Neocomian) age. Furthermore, sedimentary, fossiliferous rocks of Upper Triassic, early Jurassic, and Tertiary age were found to be present in many parts of the coast hitherto believed to be built mainly or entirely of Coast intrusions or of unfossiliferous volcanic and pyroclastic rocks of the Vancouver group. As a result of these findings the writer was instructed to broaden his survey to include all fossiliferous strata of Mesozoic and Tertiary age outcropping along this part of the coast, and to pay particular attention to the marine Tertiary formations.

In the light of this objective it was decided to first undertake a relatively detailed examination of this stretch of the coast so as to locate all sizable areas occupied by the fossiliferous sedimentary rocks and to define their structural and stratigraphic relations with the adjacent volcanic and pyroclastic rocks of the Vancouver group and with the Coast intrusions. This survey was then to be supplemented by a more detailed palaeontological and stratigraphic study of the exposed fossiliferous Mesozoic and Tertiary sections.

The geological mapping required for this study was conducted on various scales. Most of the terrain occupied by sedimentary rocks was mapped on 2 to 3 inches to the mile, whereas smaller scales were employed in areas of intrusive, pyroclastic, and volcanic rocks. Considerable stretches of the coast were reconnoitred only at intervals spaced sufficiently closely to avoid the omission of any substantial bodies of sedimentary rocks. Some stretches of the shore were traversed during high tide and, as no opportunity arose to recross them during low tide, considerable geological and palaeontological information may have been missed in these places. Finally, stretches of very rough, partly inaccessible shoreline had to be mapped on a relatively small scale regardless of their geological nature.

In the field, the geological information was plotted directly on the vertical air photographs of the Royal Canadian Air Force, or on the Admiralty Charts of the west coast. In the office these data were transferred to a prepared topographic base on a scale of 1 inch to the mile.

PREVIOUS GEOLOGICAL WORK

So far as the writer is aware, the first geological investigation of the Hesquiat-Nootka area was undertaken by Mr. S. M. Robins of the New Vancouver Coal Company, Nanaimo. He made at least one reconnaissance and prospecting trip to Hesquiat Peninsula in search of coal prior to the year 1902, and produced a remarkably accurate geological map of the Hesquiat area. The map differentiates the allegedly coal-bearing sedimentary rocks from the volcanic rocks of the Vancouver group, and correctly indicates the lithology and synclinal structure of the former.

Clapp (1913) visited Sharp Point at the entrance to Sydney Inlet, and investigated the hot spring situated near its tip on the west side. He has also left a description of the granitic and dioritic rocks in its vicinity.

Brewer (1921) examined the southwest corner of Flores Island southeast of Rafael Point in connection with an alleged discovery of a coal seam at that place. He found some sandstone and shale, "apparently of the Cretaceous period", both on the shore below high-tide mark and in the shores of Cow Creek farther inland. No commercial coal was found.

Dolmage (1921) spent part of one season mapping the west coast of Vancouver Island within the Hesquiat-Nootka area. He was the first to differentiate the rocks of the Vancouver group from those of Coast intrusions along the west coast of the island between Quatsino and Barkley Sounds. The sedimentary rocks of the coastal plain of the Hesquiat-Nootka area were mapped as of Lower Cretaceous age on the basis of their lithological similarity to beds of that age outcropping on Grassy and Clark (One Tree) Islands in the Kyuquot-Esperanza area.

The results of Gunning's mapping (1930, 1932, 1933) of

Quatsino and Nimpkish areas are of fundamental importance, and even though he did not include the Hesquiat-Nootka area his basic conclusions are as valid for that area as they are for those mapped by him.

Bancroft (1937) spent part of one season investigating the mining properties and the geology of the Hesquiat-Nootka area. His most important contribution is the recognition of the Tertiary (Oligocene) age of the less disturbed, sedimentary rocks of the coastal plain of that area, which were hitherto considered to be of Lower Cretaceous age.

Slocomb (1946) made a topographical survey of the Muchalat and Hesquiat map-areas, and in addition to important topographical, climatological, and industrial information, provided some data on the mineral occurrences and prospects of these areas.

Hoadley (1950, 1953) has recently mapped Zeballos map-area and was able to prove that the basic conclusions of Gunning are also fully valid for that area.

All petrographic descriptions and definitions of rock types presented in this report are based on megascopic examinations only. The following is a tabular summary of the various formations encountered in the Hesquiat-Nootka area, arranged in chronological order.

STRATIGRAPHY

TABLE OF FORMATIONS

AGE	GROUP OR FORMATION	LITHOLOGY AND THICKNESS		FAUNAS
RECENT	None	Beach deposits, recent alluvial deposits; 10 to ± 100 feet		None seen
PLEISTOCENE	None	Boulder clay, stratified sands, gravels, and clays; 10 to ± 150 feet		None seen
Major unconformity				
		NOOTKA ISLAND	HESQUIAT PENINSULA TO FLORES ISLAND	
EARLY MIOCENE(?)	None	Division D Marine, greenish to bluish grey, limy sandstone grading locally into sandy shell-limestone; gritty, limy sandstone; minor grit and pebble-conglomerate; 150 to 200 feet or more, top not exposed	Missing(?) apparently eroded	Sooke(?)fauna with *Bruclarkia* cf. *acuminata* Anderson and other forms
- ? - ? -	- - ? - ? - - - -	- - - -	- - ? - ? - ? - - - -	- - - ? - ? - ? - - - - -
OLIGOCENE	None	Erosional disconformity Division C The same lithology as on Hesquiat Peninsula and Flores Island; visible thickness not in	Division C Very irregular but distinctly cyclical alternation of: (1)marine	Typical Blakeley (=Lower Twin River) fauna with *Acila gettisburgensis* Reagan and other forms -

TABLE OF FORMATIONS (cont'd)

AGE	GROUP OR FORMATION	LITHOLOGY AND THICKNESS		FAUNAS
OLIGOCENE		excess of 1,000 feet; poorly exposed; base not exposed	to continental members consisting of coarse, commonly gritty, resistant sandstone and conglomerate; pebbly shale and siltstone; medium-grained sandstone; minor sandy siltstone and shale; a little coal; with (2) prevailingly marine members consisting of multicoloured laminated or grey shale and siltstone (partly sandy); fine- to medium-grained, weak, clayey sandstone; pebbly shale and siltstone; minor resistant sandstone, grit, and conglomerate; locally includes a little coal; contacts between (1) and (2) mostly disconformable; minor angular unconformities observed locally; 4,000-7,000 to (?) 10,000 feet (est.)	
	None	Division B: Marine, ash-grey, fissile to massive shale, with concretions and beds of impure limestone; minor sandy shale and siltstone; minor sandstone; 2,000 to 3,000 feet (est.)		Plant fossils and marine animal fossils (locally) ----------- Lincoln fauna: Zone of *Portunites alaskensis* Rathbun and of *Eumorphocorystes naselensis* Rathbun; present all over the area and beyond its boundaries. Crabs are locally associated with rich molluscan fauna and a few plants

TABLE OF FORMATIONS (cont'd)

AGE	GROUP OR FORMATION	LITHOLOGY AND THICKNESS	FAUNAS
OLIGOCENE	Escalante formation	Division A: marine, coarse, resistant, partly limy sandstone and pebble-to boulder-conglomerate; gritty sandstone; medium- to fine-grained, partly concretionary, sandstone; minor sandy shale and siltstone; 100 to 400-500 feet (est.)	Lincoln fauna (cont'd)
Major unconformity			
MIDDLE JURASSIC(?)	Coast intrusions	Granitic, dioritic, and gabbroic intrusive bodies and associated minor dyke-and sill-like intrusions of the same composition	None
Intrusive contact			
UPPER TRIASSIC - ?LOWER JURASSIC; Vancouver group	Bonanza group	Volcanic division: intermediate to basic lavas, tuffs, and breccias; minor tuffaceous strata; slaty and schistose metamorphic rocks; thickness in order of a few thousand feet; top not exposed within the area Sedimentary division: mainly argillitic and slaty rocks; greywacke and impure limestone; minor, intercalated, intermediate to basic lavas, tuffs, and breccias; some slates and schists of uncertain origin; thickness uncertain; at least a few hundred to 1,000 feet thick	None seen

TABLE OF FORMATIONS (cont'd)

AGE		GROUP OR FORMATION	LITHOLOGY AND THICKNESS	FAUNAS
UPPER TRIASSIC	Vancouver group	Quatsino formation	Pure, tuffaceous, and shaly, crystalline to unmetamorphosed limestones; variable, but mostly minor, volcanic rocks; thickness in order of a few hundred feet or (?) more	None seen
UPPER TRIASSIC AND(?) EARLIER		Karmutsen group	Basic to intermediate, porphyritic to amygdaloidal lavas, tuffs, and breccias; schistose rocks of uncertain origin; and, locally, whitish masses of cherty rock; minor, intercalated limestone beds and members; thickness in order of a few thousand feet or(?) more. Bottom not observed within the area	

MESOZOIC COMPLEX OF VOLCANIC, PYROCLASTIC, AND SEDIMENTARY ROCKS (VANCOUVER GROUP)

Karmutsen Group

The Karmutsen group of rocks is correlated with the "Karmutsen volcanics" of Zeballos and Nimpkish map-areas (Gunning, 1932, 1933; Hoadley, 1950, 1953) on the basis of their lithology and stratigraphical relationships with the overlying Quatsino formation.

No fossils were found in the rocks of the Karmutsen group within the area studied, but collections obtained farther north along the coast and at Buttle Lake in central Vancouver Island indicate that the upper part of the group at least is of Upper Triassic age. In the Zeballos area some ammonites were found by Hoadley (1950, p. 2) in the minor intercalated sedimentary beds near the top of the group, which were determined by F. H. McLearn (Geological Survey of Canada, retired) as fairly certainly of an Upper Triassic age.

In the Esperanza-Kyuquot area the writer found some ammonites in the lenses of impure limestone in volcanic rocks of the Karmutsen group just below its contact with the Quatsino limestone. These ammonites were tentatively identified by him as Tropites (Paratropites) sp. indet., which determination was later confirmed by F. H. McLearn (personal communication). An Upper Triassic, specifically Karnian, age is thus indicated for the uppermost beds of the Karmutsen group in Kyuquot-Esperanza area, and as there does not seem to be any doubt that the Karmutsen rocks of the Hesquiat-Nootka area are equivalent to those of the Zeballos and Esperanza-Kyuquot map-areas, the same age is also postulated for them.

Quatsino Formation

The limestone formation of the Hesquiat-Nootka area is correlated with the Quatsino formation of the Zeballos-Nimpkish areas (Gunning, 1930, 1932, 1933; Hoadley, 1950, 1953) on the basis of its lithology and its stratigraphic position between the volcanic and pyroclastic rocks of the Karmutsen group and the sedimentary division of the Bonanza group.

No fossils were found in the rocks of the Quatsino formation within the area mapped, but the occurrence of the Karnian (lower Upper Triassic) Tropites (Paratropites) fauna in the uppermost beds of the Karmutsen group in the Esperanza-Kyuquot area dates the lower age limit of the formation in that area. The Tropites fauna was also found in the lower part of the Quatsino formation in the same area. The upper age limit of the Quatsino limestone is dated by the discovery of late Norian (mid-Upper Triassic) Monotis subcircularis fauna, which occurs within the overlying sedimentary division of the Bonanza group, both in the Nimpkish-Zeballos and in Esperanza-Kyuquot areas. Thus, at least in these areas, the Quatsino formation includes rocks of Karnian (? late Karnian) and ? early Norian ages of the Upper Triassic Epoch.

As the Quatsino formation of the Hesquiat-Nootka area represents an immediate southeastern extension of the Quatsino formation of the Esperanza-Kyuquot area and occupies the same stratigraphic position within the Vancouver group, its age limits are thought to be the same in both areas.

Bonanza Group

No fossils were found in the sedimentary or volcanic rocks of the Bonanza group within the area studied, and their age can only be determined from evidence obtained elsewhere. Work in the Kyuquot-Esperanza area (Jeletzky, 1950) has shown that the sedimentary rocks comprising the lower part of the group in that area are mostly or wholly of Upper Triassic age, and it is, therefore, assumed that the lower, sedimentary division of the Bonanza in the Hesquiat-Nootka area is of the same age. In neither area, however, is it certain whether this sedimentary division includes any uppermost Triassic (Rhaetian) or lowermost Jurassic rocks in addition to those of early Upper Triassic (Norian) age, which form the bulk of it.

In the Kyuquot-Esperanza area northwest of the mouth of Tatchu Creek, the upper volcanic division of the Bonanza group is apparently conformably overlain by a thick succession of sedimentary rocks, which, at least in their upper part, are of a late Lower Jurassic (Toarcian) age, as such index ammonites as Harpoceras (Grammoceras) sp. indet., and Fanninoceras sp. indet. were determined by the writer from this part of their succession. Their older beds, though devoid of index ammonites, carry Trigonia ex gr. costata fauna for which a probable late Lias age was indicated by Hans Frebold of the Geological Survey. The basal beds, grading upwards into those with T. ex gr. costata Sowerby, carry the following fauna, determined by Hans Frebold of the Geological Survey: Trigonia sp. indet. allied to T. beesleyana Lycett, Pseudomonotis sp. indet., Pecten sp. indet., Parallelodon sp. indet., Gervillia ? sp. indet., Modiolus sp. indet., Mytilus sp. indet., Perna? sp. indet. Though new for Canada, this fauna suggests a Lower Jurassic age for the basal beds of the above group of sedimentary rocks. It appears logical, therefore, to consider the volcanic division of the Bonanza group, which underlies these sedimentary Lower Jurassic rocks with apparent conformity, as of Lower Jurassic age rather than to group it with the underlying Upper

Triassic sedimentary strata from which it is separated by an erosional interval of unknown duration. It may also be mentioned that Gunning (1930, p. 105A) found fossils, which were determined by F. H. McLearn (Geological Survey of Canada, retired) to be of probable Jurassic age, in the volcanic rocks of the Bonanza group in the vicinity of Port Alice, Quatsino Sound.

COAST INTRUSIONS

The Coast intrusions of Vancouver Island have generally been considered to be of late Jurassic or early Cretaceous age. To the writer's knowledge the presence of more than one major period of intrusive activity during the Mesozoic era has never been established.

Neither the upper nor the lower age limit of Coast intrusions could be closely determined within the Hesquiat-Nootka area. All that can be said is that they are intrusive into the youngest rocks of the Vancouver group outcropping there, namely, the volcanic division of the Bonanza group. As these have been shown to be probably of Lower Jurassic age, the Coast intrusions of the area are, therefore, not older than Jurassic. Further, as they are overlain unconformably by the Tertiary rocks of the area, which date back to Oligocene time, they are probably all of pre-Tertiary age.

These rather wide age limits can, however, be narrowed, using the more definite evidence available elsewhere on the island. In the adjacent Esperanza-Kyuquot area, the writer has found that granitic intrusions of the same type have invaded the fossiliferous sedimentary rocks of latest Lower Jurassic (Toarcian) age, but were nowhere observed to cut the fossiliferous strata of the earliest Upper Jurassic (Callovian) age. The latter, negative evidence is to some extent strengthened by the discovery of pebbles of acidic intrusive rocks resembling those of the Coast intrusions in the conglomerate beds of the Callovian rocks at Tatchu Creek. A Middle Jurassic age is, therefore, indicated for the Coast intrusions of the Esperanza-Kyuquot area.

TERTIARY ROCKS

General Statement

A thick succession of shale, siltstone, sandstone, conglomerate, pebbly shale, and grit, with minor intercalations and concretions of impure limestone, occupies considerable parts of the coastal plain within the Hesquiat-Nootka area. These rocks were all found to be of Tertiary age, with both Oligocene and Miocene Epochs apparently represented.

These sedimentary rocks were previously assumed to be of Cretaceous age on the basis of lithology (Brewer, 1921; Dolmage, 1921) and mapped accordingly. Later, Bancroft (1937) discovered invertebrate and vertebrate fossils in these rocks at Escalante Point, which indicated their Tertiary, probably Oligocene, age. The same Tertiary strata occur in the Esperanza-Kyuquot area (Jeletzky, 1950, pp. 44-48).

Distribution

Tertiary sedimentary rocks occupy all of the western shore of Nootka Island between a point about 4 miles southeast of Ferrer Point and another 2/5 mile northwest of the mouth of Marble Creek. Farther northwest and southeast they plunge beneath the ocean to reappear at Tatchu Point (Jeletzky, 1950, pp. 44-45) and on the west side of Hesquiat Peninsula. Tertiary strata occupy the greater part of Hesquiat Peninsula; they appear on the northern side of Escalante Point on the west side of the peninsula and outcrop uninterruptedly to the northern side of a point about 1 1/4 miles northeast of Leclaire Point on its east side. About 3/4 mile northeast of Leclaire Point, however, a small, wedge-like block of volcanic and pyroclastic rocks of the Karmutsen group, some 350 yards wide along the shoreline, is faulted in between two monoclinally tilted bodies of Tertiary beds. Farther north the more northeastern of these two Tertiary-Karmutsen contacts crosses the peninsula on a general northwesterly trend towards Escalante Point. Its course in the interior of the peninsula is mostly obscured by a thick cover of Pleistocene deposits and by the lush vegetation. Isolated outcrops of Tertiary sandstones and conglomerates were, nevertheless, observed near the base of the peninsula at 1,200 to 1,300 feet above sea-level, and may occur even higher.

On the eastern side of Hesquiat Harbour, an area of Tertiary shales occupies the shore around Hesquiat Point for about 3 miles, extending inland for about 1 mile midway of its length. Another, smaller outlier occupies about 1 1/2 miles of the shore just east of Kanim Lake; its extension inland is not known.

On the west coast of Flores Island, Tertiary rocks of the same Oligocene age occupy most of the shore between a small bay, locally known as Siwash Bay, about 2 1/4 miles southeast of Rafael Point, and the southeast base of a pronounced point about 1 1/2 miles north of Rafael Point. On Flores Island, the areas of Tertiary sedimentary rocks are interrupted in two places by narrow, wedge-like blocks of the volcanic and pyroclastic rocks of the Karmutsen group faulted in between the monoclinally tilted blocks of Tertiary strata, but it was not established how far inland these Tertiary rocks extend.

Lithology, Subdivision, Thickness, and Structure

The Tertiary rocks of the Hesquiat-Nootka area present a great diversity of facies both vertically and laterally. The pronounced change of facies midway of their succession is especially remarkable, and has necessitated a separate discussion of lithology, subdivision, and succession on the west coast of Nootka Island as opposed to the areas lying between the west coast of Hesquiat Peninsula and the southeast part of Flores Island.

Tertiary Rocks of the West Coast of Nootka Island

Division A

At the base of the Nootka Tertiary succession there are from 100 to 400 feet of predominantly resistant, mostly light-coloured sandstones, pebble- and boulder-conglomerates, grits, concretionary sandstones, and arenaceous siltstones. Although the common occurrence of strong strike faults of uncertain amplitude has prevented an accurate estimate of their thickness, these rocks form a mappable lithological unit, which is here designated as Division A.

In the lower part of Division A, sandstones are mostly coarse grained, gritty or pebbly, poorly sorted, and ill rounded. Lenses, nests, and concretions of strongly calcareous sandstones occur locally in this part of the succession, and beds, lenses, and nests of pebble-conglomerates formed of volcanic, pyroclastic, and igneous rocks, and including small to large boulders and blocks of the same rocks, are interbedded with the sandstones. Most of the sandstone and conglomerate beds are strongly lenticular. Both the lithology and thickness of the beds of this part of Division A undergo rapid and drastic changes along and across the strike. Sandstone beds generally predominate, but locally the conglomerates increase to become the predominant rock, as is well illustrated in sections between Beano and Marble Creeks. An increase in the relative amount of conglomerate is usually accompanied by an increase in total thickness of Division A. In contrast, sections with only a little conglomerate are relatively thin, as at Beano and Calvin Creeks. The section on the northwest side of the body of Tertiary rocks of Nootka Island appears to be similar to that between Beano and Marble Creeks on the southeastern side of the same body. It was, however, imperfectly studied due to the flooding tides at the time of traverse. The thickness of this lower part of Division A on Nootka Island seems to vary from 30 to 50 feet in some places to 150 to 250 feet in others.

The upper part of Division A includes highly variable amounts of rocks of the above types, but these are interbedded with thick members and beds of medium- to fine-grained, partly calcareous, concretionary sandstones; others of shale-like, clayey sandstones; and still others of arenaceous siltstones and shales. The relative amounts of rocks of these types gradually increase upward in all sections to where but little coarse-grained sandstone and conglomerate remain. The thickness of this part of Division A appears to vary, locally, from 100 to 250 feet.

The rocks of Division A everywhere overlie, with a pronounced angular unconformity, the surface of the deeply eroded rocks of the Vancouver group or of the Coast intrusions, and a basal conglomerate of variable thickness and composition everywhere overlies this surface.

The strata of Division A are fossiliferous throughout, but in the lower part of the Division rarely carry well-preserved and abundant fossil remains, except in interbeds of calcareous, honeycombed sandstones or in concretions in these sandstones. Index crab species Portunites alaskensis Rathbun and Eumorphocorystes naselensis Rathbun were collected among other fossils. In the upper part of the Division, however, calcareous sandstone or siltstone concretions are regularly distributed at various horizons in fine- to medium-grained, concretionary sandstones, siltstones, and sandy shales, and in places carry a rich fauna of molluscs, some plants, and the above index species of crabs. The molluscs seem to be quite similar to the fauna determined by Dr. Ralph B. Stewart of the United States Geological Survey from the rocks of Division A in the vicinity of Tatchu Point, Esperanza-Kyuquot area (Jeletzky, 1950, p. 46), and at Escalante Point on Hesquiat Peninsula (Bancroft, 1937, p. 9). There does not seem to be any stratigraphically important faunal differences between the rocks of the lower and upper parts of Division A.

Division B

Upwards, the rocks of Division A of the Tertiary System appear to grade everywhere into a thick section of mainly massive to fissile, dark to ash-grey shale, containing numerous horizons of similarly coloured, yellowish weathered, shaly or limy concretions and beds of impure, mostly concretionary limestone. Near the base of the section are a few minor beds and members of siltstone, hard sandy shale, and sandstone, and, in its middle and upper parts, local, minor beds and members of sandy shales, siltstones, and clayey fine-grained sandstone. These rocks are designated as Division B, and the boundary between it and Division A was drawn more or less arbitrarily at the horizon where shales become strongly predominant.

Division B, as a mappable, lithological unit, is restricted to the west coast of Nootka Island and to areas to the northwest, as in the Kyuquot-Esperanza area. Farther southeast on the west coast of Hesquiat Peninsula, it is replaced by a lithologically different assemblage of rocks. Its total thickness on Nootka Island is difficult to estimate; but is assumed to be in the order of 2,000 to 3,000 feet.

The base of the division is well exposed at the northeast end of the Tertiary area on Nootka Island and in the canyons of Calvin and Beano Creeks, but southeast of Beano Creek it is concealed by a broad strip of gravelly beach, probably representing the site of a major, northwest trending fault.

Division B is fossiliferous in its lower and middle parts, where the diagnostic species of crabs Portunites alaskensis Rathbun and Eumorphocorystes naselensis Rathbun are locally common in the rows of limy concretions. In the coarser sedimentary beds these crabs may be accompanied by pelecypods, gastropods, brachiopods, shark teeth, and plants, as yet undetermined. About midway of Skuna Bay, the arenaceous zone assumed to be near the base of Division B carries the same crab species together with a rich marine fauna of pelecypods and gastropods, including Epitonium cf. condoni Dall, Acila sp. indet. (cf. shumardi Dall), Dentalium sp. indet., Pectunculus sp. indet., and other forms. This fauna is very similar to that collected in the upper beds of Division A.

The apparent restriction of all fossils other than crabs to the coarser silty to sandy members or beds seems to suggest stagnant, sulphurous conditions at the bottom of the Tertiary sea during the deposition of the dark grey shales of Division B, and the fact that these shales are locally rich in concretions of marcasite and that both crab species are swimming forms supports this suggestion.

The top, or what appears to be the top, of Division B is imperfectly exposed at low tide in the tidal trough immediately southeast of the tip of Bajo Point and between this point and the broad, rocky tidal flat off its tip. Here the massive, ash-grey shale appears to be overlain conformably by multicoloured, laminated, partly sandy shale, lithologically similar to that outcropping on the tidal flat, at the base and within Division C. Only a few feet of these shales were observed, however, their top being either concealed beneath the sea or cut off by a series of strong, northwesterly trending faults.

The Tertiary Divisions A and B form a homocline wherever they outcrop on the west coast of Nootka Island. This homocline has a persistent strike of north 40 to 60 degrees west and an average dip of 15 to 35 degrees southwest. Dips from 40 to 60 degrees southwest were, however, observed locally in the vicinity of major faults or near the contact of Division A with older rocks.

The rocks of both divisions are moderately broken by high-angle normal and reverse faults of prevailing northwesterly and northeasterly strikes. The larger northwesterly faults are believed to be mainly tear faults, as strikes deviate so considerably in their vicinity as to suggest strong drag along the fault planes. There is also a considerable amount of supplementary folding, shearing, and crushing in the proximity of the larger northwesterly trending faults, wherever the strikes of the rocks begin to deviate markedly from normal.

The amount of displacement along the faults is commonly obscured by the lithological monotony of both divisions, and in the case of the larger faults by a cover of beach or alluvial deposits. Their approximate position had, therefore, to be inferred in many places from the changes in relief, from the character of the supplementary faulting, and from that of other dislocations of the surrounding rocks.

The largest displacements actually observed along the faults cutting the rocks of Divisions A and B are in the order of 100 to a few hundred feet. Major faults of northeasterly trend at the northwestern end of the Nootka Tertiary outlier cut the Coast intrusions and rocks of Division A causing horizontal displacements of from 150 to 300 feet. Another group of major faults of the same strike, on both sides of Skuna Bay, crosses the tidal shelf and causes horizontal displacements, of from 100 to 200 feet. Even larger faults are believed to be concealed under beach deposits within Skuna Bay and around Calvin Creek.

A group of northwesterly trending, high-angle major faults was observed about 1,100 yards east of the mouth of Beano Creek. On the southwestern side of this fault zone the conglomerates of the lower part of Division A are brought into contact with the silty to concretionary sandstones of the uppermost part of the division on the northeastern side of the fault zone. Though the relative downthrow of these sandstones could not be accurately determined, it is believed to be in order of at least 100 to 200 feet. These faults probably cut into the shore east of Beano Creek and cross the bed of the creek higher upstream, as indicated by the crumpling of the Tertiary shales along the canyon of Beano Creek.

Several, large, northwesterly and northeasterly trending tear faults cut into the shore at the base of Bajo Point, at its tip, and between the tip and the tidal flat beyond. Their horizontal displacement seems to be in order of a few hundred feet or more, but could not be more accurately estimated. This zone of tear faults is accompanied by an exceptionally strong supplementary faulting, as evidenced by the crushed and sheared appearance of the rocks, and by a pronounced steepening of their dips all around Bajo Point.

Most of the other faults observed in the Tertiary rocks of Nootka Island (See map) show displacements of from 10 to 50 feet.

Division C

The broad, rocky, tidal flat off the tip of Bajo Point, Nootka Island, and a group of larger reefs adjoining it from the east, expose a succession of Tertiary rocks that is quite dissimilar lithologically to those of Division B. These rocks, here designated as Division C, are believed to be younger than any part of Division B outcropping on the mainland at the tip of Bajo Point. It seems probable that the multicoloured, laminated shales overlying the ash-grey, massive shales of Division B at the tip of Bajo Point represent the basal beds of Division C. Beyond the zone of tear faults the upward stratigraphic succession of the younger rocks of Division C appears to be as follows. The eastern end of the southeasternmost reef exposes 20 to 25 feet of multicoloured, laminated, sandy shale interbedded with similar sandstone, the base of which was not seen. These rocks are apparently disconformably overlain by a succession of pebble-conglomerates and coarse, gritty sandstones some 30 to 35 feet thick. The conglomerate pebbles include rocks of volcanic and intrusive types, but some 40 to 50 per cent of the pebbles are composed of dark to light grey, sandy and calcareous shale with tawny or rusty red crust. Pebbles of tawny or brick-red sandstone are also common. These sedimentary pebbles are believed to be derived from the underlying beds of shale and sandstone, as they resemble the concretions occurring in the underlying laminated shale and the lithologically similar shale members of Division C on Hesquiat Peninsula. The conglomerate member is conformably overlain by some 60 to 70 feet of multicoloured, laminated shales, interbedded with sandy siltstones and minor beds and layers of coarse- to medium-grained, resistant sandstone. These rocks, in turn, are overlain, apparently disconformably (an angular unconformity of 10 to 15 degrees may also be represented), by a bed of pebble-conglomerate of the above type, 5 to 6 feet thick, above which are 75 to 85 feet of multicoloured, laminated, sandy siltstones, shales, and sandstones. The top of this section was not observed, and is probably cut off by faults.

The rocks of Division C exposed on the southeasternmost reef off Bajo Point are very badly faulted, crushed, and sheared. They also form a complicated and, as yet, little understood tectonic structure, which appears to be superficially similar to a small dome badly broken and partly obliterated by strong tear faults in several directions. In spite, however, of the exceeding complexity of this structure and the intensity of the faulting, few dips exceed 10 degrees and none greater than 15 degrees was observed.

Westward along the shore toward the tip of Bajo Point, for 400 to 450 yards, are small, isolated tidal flats and reefs, which, apparently, represent fault blocks of a major fault zone of northeasterly trend separating the above described flat reef from the large tidal flat just off the tip of Bajo Point. So far as could be observed, these reefs and flats are built of badly faulted and crushed sandy siltstone, sandstone, and shale; they continue on the southeastern half of the large tidal flat off the tip of Bajo Point, where some 220-250 feet are exposed. The shaly rocks of the southeastern half of Bajo Point tidal flat contain numerous horizons of mostly irregular shaped shaly to limy concretions with a bright brick-red, orange, or tawny crust. The concretions usually do not exceed a few inches in diameter and are restricted to certain beds and zones. A few poorly preserved marine shells were found in the above concretions. Beds up to 10 or 12 feet thick composed of resistant, buff to light brown, coarse- to medium-grained sandstone occur at intervals in the succession, being more abundant near the visible base of these shaly beds. On this part of the large tidal flat the rocks of Division C form a gently dipping monoclinal succession with a general strike of north 50 to 70 degrees east and predominant dips of 10 to 15 degrees northwest. They are traversed by strong cross and strike faults, some of which seem to be tear faults to judge by the local deviations of the strikes of the beds in their vicinity. The faulting is, however, much less severe than that on the eastern tidal flat where the lower sandy to conglomeratic part of Division C outcrops.

Division D

Some 225 to 250 yards to the west of the eastern side of the large tidal flat at Bajo Point, Nootka Island, the sandy siltstones and shales of Division C are capped by a succession of lithologically distinct rocks herewith designated as those of Division D. The boundary between the rocks of the two divisions is one of pronounced erosional disconformity, the upper contact of the laminated, multicoloured siltstones of Division C being uneven and abrupt. Above the contact lie some 25 to 30 feet of light-coloured, buff to dull green, coarse, partly gritty and pebbly sandstones. Thin layers of pebble-conglomerate with calcareous matrix occur among these sandstones.

This basal, coarse-grained member of Division D is succeeded by light grey to bluish green, mostly strongly calcareous, medium- to fine-grained sandstone, which is partly concretionary and grades locally into sandy shell-limestone. Only minor layers and beds of siltstone, grit, and pebble-conglomerate occur in it. Altogether, the rocks of Division D outcropping in this vicinity have an estimated visible thickness of 150 to 200 feet. Their top is not exposed.

Near their lower contact, the rocks of Division D have the same general attitude as the underlying rocks of Division C on the eastern third of the large flat. In the western two-fifths of their exposed area, however, they first flatten to 5 degrees west, or even become almost horizontal; then, farther west, they gradually acquire dips up to 5 degrees southeast, and finally, on the western end of the tidal flat, their strike changes to north 10 degrees west to north, with average dips of 10 to 15 degrees east. Thus the structure of the rocks of Divisions C and D appears to be that of a widely open, gently dipping syncline, with its westerly limb largely concealed beneath the ocean. The rocks of Division D are faulted in much the same way as the underlying rocks of Division C to the west, and their uppermost beds represent the visible top of the Tertiary succession of Nootka Island.

Rocks of Division D are fossiliferous throughout. Some beds carry an exceedingly rich, marine fauna of molluscs, including Bruclarkia cf. acuminata (Anderson and Martin); Bruclarkia sp. indet. aff. acuminata (Anderson and Martin); Fusinus (Priscofusus) cf. hannibali Clark and Martin, Mactra (Spisula) cf. sookensis Clark and Arnold, Mytilus cf. mathewsoni Gabb, Polinices cf. victoriana Clark and Arnold, Natica (in a broad sense) sp. indet., Yoldia sp. indet. (cf. Y. cooperi Gabb), Cardium cf. sookensis Clark and Arnold, Solen sp. indet. (cf. S. clallamensis Clark and Arnold); Lucina (in a broad sense) sp. indet., Nucula (in a broad sense) sp. indet., and Acila sp. indet.

Tertiary Rocks of Hesquiat Peninsula

On Hesquiat Peninsula, Tertiary rocks occupy an area of 5 by 8 miles or more, with an imperfectly known northeastern boundary. This is the largest body of Tertiary rocks in the Hesquiat-Nootka area, and the one where they reach their maximum thickness. The strata are gently folded into a wide, open syncline, whose axis trends northwesterly from a point about 1/4 mile northeast of Matlahaw Point to a point about 1 mile southwest of the inner part of Barchester Bay. This major structure will be referred to in the following pages as the Hesquiat syncline. Severe dislocation by high-angle faults and, locally, by low-angle thrust faults is characteristic of the Tertiary rocks of Hesquiat Peninsula.

Division A

The basal division (A) of the Tertiary group of rocks has about the same lithology on Hesquiat Peninsula as on the west shore of Nootka Island. It exhibits the same wide range of variation in the relative amount of conglomerate and sandstone beds over very short distances, and its thickness is equally variable. It appears, however, that its thickness on Hesquiat Peninsula increases locally to 500 or 550 feet, and possibly even to 600 or 650 feet.

At Escalante Point, the base of Division A is concealed by beach deposits on the northern side of the point, and its lowermost beds are probably cut off by a major strike fault. Those actually exposed at Escalante Point are represented almost exclusively by coarse-grained, resistant, partly calcareous and honeycombed sandstones, with lenses and concretions of calcareous sandstone. These sandstones are mostly gritty and pebbly in the lower 250 to 300 feet of their exposed section. A few beds and lenses of conglomerate composed of pebbles and boulders of the volcanic and pyroclastic rocks of the Vancouver group and of those of the granitic and dioritic rocks of the Coast intrusions occur in this part of the succession; none of these beds exceeds 10 to 12 feet in thickness.

A poorly preserved molluscan fauna, including Dentalium sp. indet., Mactra (in a broad sense) sp. indet., and Epitonium sp. indet., occurs locally in this part of the succession, which may be correlated with the lower part of Division A on Nootka Island.

At the tip of Escalante Point, and on its southwestern side, the coarse, gritty sandstones grade upward into light-coloured, strongly calcareous, medium- to coarse-grained, strongly concretionary sandstones. These show marked differential weathering and honeycombing, and contain nests and lenses of strongly calcareous sandstone grading into sandy limestone. Lime concretions at the tip of Escalante Point have provided a few molluscs and the index species of crab Portunites alaskensis Rathbun, together with a little fossil wood. The visible thickness of these upper sandstones, which may be correlated with the upper part of the Division A on Nootka Island, is estimated at 200 to 250 feet; their top is concealed beneath the ocean.

The observed thickness of Division A at Escalante Point is estimated at 450 to 550 feet, but the total thickness probably exceeds this figure by 100 feet or more, as neither top nor bottom is exposed.

The name 'Escalante formation' was introduced by Bancroft (1937, p. 4) for the Tertiary rocks exposed at Escalante Point, south of Nootka Sound. These rocks are described by him (1937, p. 8) as follows:

"The oldest Tertiary sediments thus far found on Vancouver Island underlie the Nootka coastal plain. Coarse conglomerates with rounded pebbles of crystalline rocks of the Vancouver group outcrop at the shore at Escalante Point; stratigraphically upward these give place to finer conglomerates, sandstones, calcareous sandstones, and shales containing an abundance of plant remains, shells, and rounded pebbles of jet."

Though neither the upper nor lower limit of the 'Escalante formation' was defined by Bancroft, it seems apparent from its geographical location and lithology that most of the rocks included in it belong to Division A of the present report, although it would probably also include the lowermost shales and sandstones of Division C of Hesquiat Peninsula. This formational name could, therefore, be easily redefined to correspond with Division A of the present report, and could be extended laterally to include all its outcrops within the Hesquiat-Nootka area. However, its use is not recommended by the writer, as the type locality is inadequate, both bottom and top of Division A being concealed by beach deposits at Escalante Point. No new formational name is proposed for rocks of Division A at this stage of the writer's research.

In the exposed section of Division A on the east side of Hesquiat Peninsula, about 3/4 mile northeast of Leclaire Point, the lithology differs from that presented by the section at Escalante Point. There its lower part, some 350 to 400 feet thick, is essentially conglomeratic with the beds and members of coarse-grained, resistant sandstones greatly reduced in thickness. Beds, lenses, and nests of tightly packed pebble- to boulder-conglomerate from a few inches to 10 or 15 feet thick comprise some 35 to 40 per cent of this part of the division, and are more or less evenly distributed throughout. Beds, layers, lenses, and nests of mostly coarse-grained, resistant sandstones interfingered with the conglomerates are for the most part gritty and pebbly; they commonly grade into impure conglomerates rich in gritty and sandy matrix. Sandstones and conglomerates interfinger rather irregularly, forming a very complex pattern. No fossils were encountered in this part of Division A in this section.

The uppermost conglomerate bed, at the top of the lower part of Division A on the east side of the peninsula, is conformably overlain by 2 to 3 feet of coarse-grained, calcareous sandstone, which exhibits a differentially weathered and honeycombed surface. This sandstone is succeeded by some 20 feet of siltstone and sandy shale, thinly interbedded with clayey, fine- to medium-grained sandstone. In the numerous concretions in these beds, well-preserved molluscs, plant leaves, and crab remains were found, including those of the index fossil Portunites alaskensis Rathbun. Within the next 50 feet, the fossiliferous sandy shales, siltstones, and clayey sandstones grade into hardened, fissile to massive, dark grey shale, which is assigned to the basal part of Division C. In this section, the upper part of Division A is thus greatly reduced, being apparently partly replaced by the conglomerate-sandstone facies.

About 1,000 yards north of the place where the base of Division A is exposed in the shore bluffs on the east side of Hesquiat Peninsula, the rocks of this division reappear within the Tertiary area occurring on the northern side of the fault block of the rocks of the Karmutsen group. This section of Division A differs lithologically from the one just described. Here the conglomerate-sandstone member, lithologically similar to the above-described lower part of Division A, is reduced to some 150 to 200 feet in thickness, and is overlain conformably by about 200 feet of sandstones. The sandstones resemble those comprising the upper part of Division A at Escalante Point, and are interrupted by only two or three minor conglomerate beds. The sandstones of this upper member contain, in contrast with those of the section at Escalante Point, only rare calcareous, sandy concretions, and perhaps for this reason not a single specimen of fossil crabs was collected here, though a few fossil molluscs were found in the sandstones.

The lower contact of Division A has the same character in both sections on the east side of Hesquiat Peninsula, being marked by a basal conglomerate, which varies greatly in colour, thickness, and size of pebbles and boulders. The basal conglomerate rests with a profound angular unconformity on highly contorted and strongly sheared volcanic and pyroclastic rocks of the Upper Triassic Karmutsen group.

Division C

On both sides of Hesquiat Peninsula the rocks of Division A grade upward into a very thick succession of lithologically diverse rocks. On the northeastern limb of the Hesquiat syncline, these rocks have a maximum exposed thickness of more than 7,000 feet, and, barring any major repetition by the numerous, strong, strike faults, may well be nearly 10,000 feet thick. These rocks are all indistinguishable lithologically from those of Division C outcropping on the tidal shelves and reefs off Bajo Point on Nootka Island.

According to palaeontological evidence, to be discussed later, the apparent lack of anything lithologically similar to Division B of Nootka Island in the Tertiary succession of Hesquiat Peninsula is because sediments characteristic of the rocks of Division C began to accumulate much earlier in southeasterly parts of the Hesquiat-Nootka area and only later spread over its northwesterly parts. It seems evident that only minor lentils and tongues of shales lithologically similar to those of Division B were deposited in the southeastern parts of the Hesquiat-Nootka area at intervals during the period of uninterrupted deposition of the shales of Division B on the west coast of Nootka Island. Owing to the entire lithological dissimilarity of these shales to the variable rocks of Division C, it appeared to be necessary to map these two divisions separately, even though the rocks of Division B of Nootka Island are probably an exact time equivalent of the lower part of Division C of Hesquiat Peninsula.

On the other hand, as these diverse rock types of Division C are lithologically indistinguishable from those of this division on Nootka Island and are known to be contemporary with them, at least in their upper part, the writer considers it possible to map the two rock groups as one unit.

The rocks of Division C that immediately overlie those of Division A are everywhere represented by a thick zone of shaly to fine-grained sandy rocks that in places may be similar to those of the basal part of Division B of Nootka Island. In these rocks, however, pure shales, both multicoloured, laminated, and uniformly grey coloured, are reduced to members, tongues, and beds interfingered with an even larger proportion of predominantly thinly bedded to laminated, multicoloured, sandy siltstones, clayey, shaly sandstones, and sandy shales. Rocks of these shaly and sandy types are overlain by coarse-grained, resistant, rusty, buff, or grey-yellowish, mostly honeycombed, commonly gritty to pebbly sandstones (mostly subgreywackes), and pebble- to boulder-conglomerates, which are rather similar lithologically to those of Division A. The sandstones and conglomerates are in turn overlain by shaly and fine-grained rock types. This alteration of both principal rock types continues in a distinctly cyclical fashion throughout the succession of Division C on Hesquiat Peninsula to its visible top, which is exposed in the axial part of the Hesquiat syncline. Both principal rock types form beds and members of variable thickness and of pronounced lenticular character. They are, herewith, designated respectively as Shale-clayey sandstone and resistant Sandstone-conglomerate members of Division C.

It was noted that the resistant, sandstone-conglomerate members almost everywhere rest on the eroded, uneven surface of the underlying shale-clayey sandstone members and grade imperceptibly into the overlying shale-clayey sandstone members. In two instances, minor angular unconformities were observed at their lower contacts.

Owing to the great thickness of strata referable to Division C on Hesquiat Peninsula, an attempt has been made at subdivision into smaller mappable units, although the extreme diversity of rock types within the succession and their rapid lithological changes along and across the strike has made this task extremely difficult. The subdivision attempted is based on the cyclical repetition of resistant, sandstone-conglomerate and shale-clayey sandstone members, and, accordingly, all such members of sufficient thickness and lateral extent are shown separately on the accompanying geological map.

However, as none of these observed members appears to persist far along strike, it was found necessary to treat them all as merely distinctive, local lithological phases of Division C devoid of regional stratigraphical importance. Accordingly, all resistant sandstone-conglomerate members have been represented on the map by the one symbol and all shale-clayey sandstone members by another symbol. All lesser intercalations of the rocks of one member within those of another have been mapped with the latter, although several of them, visible on air photographs, could have been shown separately on a map of larger scale.

It was found impossible to correlate the seven, major, resistant sandstone-conglomerate members outcropping on the west side of Hesquiat Peninsula, on the northeastern limb of the Hesquiat syncline, with only two such members on the southwestern limb of the syncline on the same side of the peninsula. Nor do these members seem to persist across the peninsula, where only one such member occurs on the northeastern limb, at Leclaire Point, and one, relatively thin member on the southwestern limb, at the tip of Matlahaw Point. The only seemingly complete section of the rocks of Division C on Hesquiat Peninsula was measured on its western side of the northeast limb of the Hesquiat syncline. In view of the fact that all individual beds, lithological zones, and major mappable lithological phases of this division are strongly lenticular, the thicknesses given may be considered as only roughly approximate. The circumstance that the rocks of Division C are often badly faulted, sheared, and locally strongly contorted in this section has further reduced the precision of the measurements made.

The lowermost part of Division C appears in outcrops within the broad, open bay behind Escalante Island. There, at the fringe of the forest, above the high-tide mark, sandstones of the uppermost part of Division A are exposed locally in small patches. A covered interval, 20 to 50 feet wide, conceals their contact with the overlying rocks of Division C, which outcrop on the broad, rocky tidal shelf inside of the bay and present the following upward succession.

Bed or Zone	Description	Thickness
		Feet
	First Shale-Clayey Sandstone Member (Bed No. 1 represents the base of Division C)	
1	Shale, ash-grey to dark grey, fissile to massive, with rows of septaria-like, limy concretions up to 10-15 feet in diameter, and of small, variously shaped, sandy, shaly, and limy concretions; in the lowermost 15 to 25 feet, the latter carry well-preserved index species of crabs: Portunites alaskensis Rathbun and Eumorphocorystes naselensis Rathbun, together with some molluscs and plant remains; base not exposed	± 175 (visible)
2	Shale, ash-grey, sandy, grading into sandy siltstone, fissile to massive; rich in variously shaped, small, calcareous, sandy concretions, which carry well-preserved crab remains of Portunites alaskensis Rathbun and Eumorphocorystes naselensis Rathbun	30 to 40
3	Sandstone, fine- to medium-grained, clayey, shale-like; mostly thinly bedded to laminated and multicoloured, with light yellow, light green, and tawny laminae and layers alternating throughout most of the succession	250 to 300
	First Resistant Sandstone-Conglomerate Member	
4	Pebbly shale, dark grey, fissile, grading into pebbly siltstone, rich in small to large pebbles and rounded to irregularly shaped sandstone and shale concretions; overlies Zone 3 with an uneven and sharp contact indicating an erosional disconformity; upwards becomes more and more sandy and grades imperceptibly into Zone 5	30 to 35

Bed or Zone	Description	Thickness
		Feet
5	Pebble-conglomerate, relatively well-bedded; in addition to pebbles derived from rocks of the Vancouver group and the Coast intrusions, contains numerous pebbles of sandstone, rolled up shaly concretions, and angular pieces of these rocks, which were apparently derived from the underlying Tertiary rocks; pebbles vary widely in size and are embedded in sandy or gritty matrix, their size decreasing markedly upwards and, apparently, to the southwest; top concealed beneath the ocean	30 to 35 (visible)
6	Interval covered by beach deposits or by the water of the bay; believed to be the site of a major, northwesterly trending fault zone	1,500 to 2,550
	Second Shale-Clayey Sandstone Member	
7	Shale, dark grey, very sandy; occurs in isolated patches within a strip of beach deposits; very badly contorted and crushed	$\pm$ 50
8	Shale, dark grey, sandy; interbedded with similar sandstone; includes at least one bed of pebble-conglomerate similar to Bed 5; badly contorted and crushed. The following fossils were collected from concretions in a shale bed: *Portunites alaskensis* Rathbun, fossil leaves, twigs and needles of *Sequoia* (in a broad sense) sp. indet., top not exposed	$\pm$ 50 (visible)
9	Interval covered by beach deposits (? a fault). .	$\pm$ 50
10	Shale, dark grey, sandy, fissile, interbedded with beds and layers of the laminated, shale-like sandstone and siltstone; fossil leaves, small pieces of coal, *Dentalium* sp. indet, and pelecypods (genus and species indet.) were collected from midway of this zone; top not exposed	$\pm$ 75 (visible)

Bed or Zone	Description	Thickness
		Feet
11	Covered by beach deposits (? a fault with northwesterly trend)	± 30
12	Rocks entirely similar to those of Zone 10....	± 20
13	Sandstone, buff-coloured, coarse-grained, resistant	6 to 8
14	Sandstone, fine- to medium-grained, shale-like, clayey, thinly bedded to laminated; includes some beds and layers of similar looking, laminated, sandy to pure shale and siltstone up to 5-10 feet thick........	300 to 350
15	Sandstone, similar to that of Bed 13, but with a honeycombed surface and thinly bedded ..	20 to 25
16	Sandstone, similar to that of Zone 14	± 100
17	Sandstone, similar to that of Beds 13 and 15 ..	9 to 10
18	Sandstone, similar to that of Beds 14 and 16..	100 to 150
19	Sandstone, brownish grey, coarse-grained, calcareous, with dispersed pebbles and gritty particles; in the lower part contains concretions of shale with rough surfaces, which are apparently in place; these concretions carry crab remains of <u>Portunites alaskensis</u> Rathbun .... (Bed 19 and all the rocks in its vicinity are very irregularly and strongly contorted, heavily faulted, and apparently thrust upon the underlying rocks in the northerly direction. The estimated displacement of the overthrust rocks amounts to 15-20 feet or more.)	10 to 15
20	Shale, grey, sandy, fissile, with numerous concretions of calcareous shale; nests and lenses of grit, and dispersed small and large pebbles occur commonly in this zone. Index crab species <u>Portunites alaskensis</u> Rathbun and <u>Eumorphocorystes</u>	

Bed or Zone	Description	Thickness
		Feet
	naselensis Rathbun were collected in the calcareous concretions; this is the highest recorded occurrence of these fossils in Division C on Hesquiat Peninsula	12 to 14
21	Pebble-conglomerate, coarse, lithologically similar to that of Bed 5; forms a lenticular bed	Fluctuates from almost nil to some 2 or 3 feet within short distances
22	Sandstone, brownish grey, coarse-grained, heavily bedded, resistant	15 to 20
23	Shale, dark grey, fissile; at certain levels carries large, calcareous, septaria-like concretions and small, rounded, calcareous, grey concretions; overlies Bed 2 conformably	± 150
24	Shale, multicoloured, laminated; with large, calcareous, septaria-like concretions and small, rounded, calcareous, grey concretions, covered with a red or tawny crust; overlies Zone 23 conformably	250 to 300
25	Sandy shale and siltstone interbedded with shaly, fine-grained, clayey sandstone; conformably overlies Zone 24; top cut off by a major fault zone of westerly to northwesterly trend	35 to 40 (visible)
26	Shale, dark grey, brownish weathered, partly laminated and sandy; interbedded with beds 1 foot to 5 feet thick of resistant, coarse-grained, brownish weathered, grey sandstone and grit, which occur at intervals of from 3 to 20 feet; bottom and top cut off by major faults of westerly to northwesterly trend. .	100 to 120 (visible)
27	Sandstone, dull green to light grey, coarse-grained, gritty, resistant; occurs in	

Bed or Zone	Description	Thickness
		Feet
	beds from 1 foot to 5 feet thick; bottom of this zone is cut off by a major fault of westerly to northwesterly trend	30 to 35 (visible)
28	Shale, grey, laminated; interbedded with superficially similar, fine-grained, shale-like, clayey sandstone; rocks are badly faulted and sheared; top of the zone cut off by a major fault of northwesterly trend	30 to 35 (visible)
	Second Resistant Sandstone-Conglomerate Member	
29	Sandstone, bluish grey, coarse-grained, resistant; bottom concealed under the topsoil at the fringe of the forest	$\pm$ 20
30	Sandstone, fine- to coarse-grained, laminated, impure	15 to 20
31	Shale, grey, thinly bedded to laminated, sandy; interbedded with superficially similar, fine-grained sandstone; both are rich in dispersed pebbles in the upper 8 or 10 feet; poorly exposed in part; contact with Bed 32 is poorly exposed but seems to be disconformable	$\pm$ 40
32	Pebble-conglomerate, coarse to medium, similar to Bed 5; forms lenticular beds from 3 to 7 feet thick interfingered with the similarly thick lenticular beds, lenses, and nests of coarse-grained, resistant sandstone, grit, and, in one or two places, of light grey, partly sandy, fissile shale; grades into Bed 33 imperceptibly; shattered into fault blocks from several square yards to several scores of square yards by a dense net of minor faults	90 to 100

Bed or Zone	Description	Thickness
		Feet
33	Shale, light grey to ash-grey, sandy; locally containing numerous dispersed pebbles and nests of grit; lower beds contain lenses and layers of pebble-conglomerate	35 to 40
34	Sandstone, grey, mostly thinly bedded, partly shale-like, fine- to coarse-grained; interbedded with layers and nests of coarse grit and fine pebble-conglomerate	50 to 60
35	Pebble-conglomerate, coarse to fine; interbedded with beds and lenses of brownish grey grit and coarse-grained resistant sandstone	25 to 30
36	Sandstone, greenish grey to greenish yellow, resistant, coarse-grained, gritty; top not exposed	15 to 20 (visible)
37	Covered interval occupied by beach deposits; assumed to represent the site of a major fault or of a fault zone	$\pm$ 50
	<u>Third Shale-Clayey Sandstone Member</u>	
38	Sandstone, brownish grey, resistant, slabby, coarse-grained, in beds from 0.3 to 1.0 foot; interbedded with beds 2 to 3 feet thick of finely grained, laminated sandstone; base not exposed ...	30 to 35 (visible)
39	Shale and siltstone, dark grey, superficially similar lithologically to the overlying shale-clayey sandstone members	270 to 300
40	Sandstone, dark grey, shale-like, laminated to thinly bedded, fine-grained; inter-bedded with considerable thin beds and layers of resistant, coarse-grained, brownish grey sandstone	200 to 210
41	Shale, brownish grey to tawny, laminated ...	60 to 65

Bed or Zone	Description	Thickness
		Feet
42	Pebble-conglomerate, tightly packed, hard; the lowermost pebbles embedded in the underlying shale	0.5 to 1.0
43	Sandstone, buff-coloured, coarse-grained, poorly sorted; carries numerous, small to large pebbles up to 4 to 6 inches in diameter, irregularly dispersed in sandy matrix	10 to 12
	Third Resistant Sandstone-Conglomerate Member	
44	Pebble- to boulder-conglomerate, in beds from 5 to 12 feet thick, which form from 70 to 80 per cent of the total thickness of the zone; large boulders and blocks up to several feet in diameter occur in beds of fine to coarse pebble-conglomerate; interfingered with conglomerate beds are several lenticular beds of coarse-grained, resistant, brownish grey sandstone and grit, rich in dispersed, small and large pebbles, and from 5 to 8 feet thick; beds of sandy, grey shale rich in dispersed pebbles also occur in this conglomerate zone; in some conglomerate, beds abundant in rounded fragments of light grey shale were observed; the conglomerate zone rests on an uneven and apparently eroded surface of Bed 43 with a sharp, erosional contact	100 to 150
45	Sandstone, yellowish grey, coarse-grained, gritty; grades downward into conglomerates of Zone 44..................	4 to 6
	Fourth Shale-Clayey Sandstone Member	
46	Sandstone, grey, fine- to coarse-grained, weak to resistant; interfingered with minor beds and layers of sandy shale, and with a few thin beds and layers of coarse grit and fine pebble-conglomerate; fine-grained, shale-like, clayey sandstone	

Bed or Zone	Description	Thickness
		Feet
	and sandy shale, some locally rich in dispersed pebbles and nests of grit; grades downward into Zone 45	30 to 35
47	Shale, dark grey to tawny, laminated; interbedded with similarly coloured, fine-grained, shale-like, clayey sandstone; beds of coarse-grained, partly gritty, resistant, dark to light grey sandstone from 1/2 foot to 2 feet thick occur in this zone at intervals ranging from 1 foot to 10 feet; small (mostly only up to a few inches in diameter), rounded or irregularly shaped, marcasitic, shaly, and limy concretions, with a red to tawny crust (? limonitic crust) occur commonly both in shale and in clayey sandstone beds; a few, grey, light yellowish weathered, septaria-like concretions were observed in shale beds. Beds of coarse-grained sandstones are commonly rich in small lenses, nests, and pieces of coal, in pieces of fossil wood, and in poorly preserved fragments of plants and bark. Determinable fossils were found only in one zone of laminated, grey shale some 15 to 20 feet thick and including five to six beds of coarse-grained, resistant sandstone, which occurs some 120 feet above the base of the zone; here the rocks commonly contain abundant fragments and small nests of coal, disintegrated plant remains, and marine shells, which include among others _Dentalium_ sp. indet., _Acila_ sp. indet. (? cf. _shumardi_ Dall), and _Nucula_ sp. indet.; fossils occur both in shale and in sandstone; in the former, however, they mostly do not occur in the same layers with plant remains and coal	380 to 400

Bed or Zone	Description	Thickness
		Feet
	Fourth Resistant Sandstone-Conglomerate Member	
48	Sandstone, greenish to yellowish grey, light-coloured, coarse-grained, partly gritty, resistant, interfingered throughout with a considerable, but locally variable, amount of lenses and lenticular beds of grit and pebble-conglomerate; at the base, a bed of coarse pebble-conglomerabe 15 to 20 feet thick persists across the outcrop of this member; overlies the uneven, apparently eroded surface of the fourth shale-clayey sandstone member (i.e., Zone 47) with a sharp, erosional contact; strongly faulted	Varies locally from 70 to 150, possibly owing to faulting
	Fifth Shale-Clayey Sandstone Member	
49	Shale, dark grey, fissile, laminated, with small marcasitic and limy shale concretions, which are covered with a red to tawny (? limonitic) crust; thin beds of resistant, coarse-grained sandstone occur at more or less regular intervals (as in overlying and underlying shaly zones and members); the upper 45 feet are built almost exclusively of pure shale, whereas the lower 55 feet consist of sandy shale, interbedded with considerable thinly bedded to laminated, shale-like, clayey sandstone and coarse-grained, resistant sandstone	$\pm$ 100
	Fifth Resistant Sandstone-Conglomerate Member	
50	Boulder- to cobble-conglomerate; most beds carry blocks up to 10 by 50 feet square, or more, of slates and volcanic and pyroclastic rocks of the Vancouver group, granitic rocks of the Coast intrusions,	

Bed or Zone	Description	Thickness
		Feet
	and greenish sandstones, apparently derived from the older Tertiary members; cobbles and boulders are of the same composition as the blocks; only a few minor lenticular beds and lenses of fine pebble-conglomerate, grit, and coarse-grained, gritty sandstone were observed in the upper part of this conglomerate zone; the lowermost conglomerate bed rests with a very sharp contact on the deeply eroded, uneven surface of the fifth shale-clayey sandstone member; an angular unconformity of 5 to 10 degrees at the contact	300 to 350
51	Sandstone, light yellow to greenish grey, coarse-grained, heavily bedded, resistant; interfingered with numerous beds, lenses, and nests of grit, and pebble-conglomerate; relative amount of sandstone and conglomerate beds varies widely along strike, and conglomerate may predominate locally; grades downward into conglomerates of 50; top concealed beneath the sea	25 to 35 (visible)
52	Covered by the waters of a deep, narrow bay; at the head of the bay, and in the mouth of a small creek, are poor outcrops of sandstones and sandy shales	200 to 250
	<u>Sixth Shale-Clayey Sandstone Member</u>	
53	Sandstone, grey, thinly bedded, fine- to coarse-grained, partly shale-like, interbedded with minor layers and beds of dark grey shale; base concealed beneath the sea	250 to 300 (visible)
54	Shale, dark grey, thinly interbedded with fine- to medium-grained, dark grey to brownish grey sandstone	45 to 50
55	Shale, dark grey, laminated, mostly pure; interbedded with thin layers and beds of fine- to coarse-grained, partly resistant sandstone; shale rich in irregularly	

Bed or Zone	Description	Thickness
		Feet
	shaped, shaly and marcasitic concretions from 1/2 inch to 4 inches in diameter, covered with a brick-red to tawny crust; grades upward into Bed 56	350 to 400
56	Sandy shale, dark grey, laminated, rich in dispersed small pebbles and in grit particles; small nests of grit	10 to 15
	Sixth Resistant Sandstone-Conglomerate Member	
57	Pebble-conglomerate, coarse to fine, interfingered with highly variable amounts of beds, lenses, and nests of coarse, resistant sandstone, grit, and pebbly to gritty shale and siltstone; conglomerate beds predominate in this zone on both sides of Split Cape and thin gradually toward the southeast to be replaced by gritty sandstones, pebbly shales, and other rocks; within Barchester Bay this resistant sandstone-conglomerate member disappears beneath the sea to reappear on the southeastern side of the bay in its full thickness. On the northwestern side of Split Cape, at least 300 to 350 feet of this resistant sandstone-conglomerate member is exposed above the top of the sixth shale-clayey sandstone member, but its top is concealed beneath the sea. The basal beds of the member at Split Cape carry abundant sandstone pebbles, which are apparently locally derived; contact with the underlying sixth shale-clayey sandstone member is very sharp and uneven, and evidently represents an erosional disconformity.	

The inner northeastern shore of Barchester Bay again exposes the rocks that underlie the sixth resistant sandstone-conglomerate member; the succession there is as follows:

Bed or Zone	Description	Thickness
		Feet
	Fifth Resistant Sandstone-Conglomerate Member	
51	Sandstone, light yellow to yellowish green, massive to heavily bedded, coarse-grained, partly gritty; some plant remains occur in the lower beds; base not exposed	20 to 25 (visible)
	Sixth Shale-Clayey Sandstone Member	
52 to 56	Regular interbedding of clayey, partly shale-like sandstones and sandy, laminated, partly multicoloured shales, interrupted at irregular intervals by several zones of coarse-grained, resistant sandstones, with lenticular beds, layers, and nests of pebble-conglomerate some 5 to 15 feet thick. This succession is stratigraphically equivalent to Beds 52 to 56 of the section north of Split Cape, but it is not possible to compare them bed by bed	700 to 750 (? or more)
	Beyond a covered interval of several hundred feet across the predominant strike of the rocks, the following, upper part of the sixth shale-clayey sandstone member reappears on the southeast side of Barchester Bay:	
56	Sandstone, brownish grey, medium-grained, resistant; with interbeds of softer, grey, clayey sandstones and sandy siltstones; base not exposed	150 to 200 (visible)
	Sixth Resistant Sandstone-Conglomerate Member	
	The following succession of this resistant sandstone-conglomerate member is exposed on the southeastern shore of Barchester Bay and to the southwest:	

Bed or Zone	Description	Thickness
		Feet
57a	Pebble-conglomerate, coarse to fine, hard; with interbeds, lenses, and nests of various sandstones; overlies Bed 56 with a sharp contact suggestive of an erosional disconformity........................	± 50
57b	Sandstone, soft, friable, clayey, grading into siltstone	± 50
57c	Sandstone, yellowish grey to rusty coloured, partly honeycombed, resistant, coarse-grained; with minor beds, lenses, and nests of soft or hard pebble-conglomerate	75 to 85
57d	Sandstone, soft, fine- to medium-grained; with numerous pebbles; interbedded with sandy shale containing abundant pebbles or with hard pebble-conglomerate	70 to 80
57e	Pebble-conglomerate, coarse; interbedded with minor lenticular beds and lenses of softer pebble-conglomerate, with an abundant sandy matrix, and with minor beds or lenses of coarse-grained, gritty or pebbly sandstone	180 to 200
57f	Sandstone, light grey, coarse-grained, resistant to soft; interbedded with similar looking, pebbly sandstone and shale, minor beds of soft or hard pebble-conglomerate, and some fine-grained, clayey sandstone	180 to 200
57h	Shale, dark grey, sandy; abundant pebbles; overlies Zone 57f with a sharp, uneven contact suggestive of an erosional disconformity	± 100
	Seventh Shale-Clayey Sandstone Member	
58	Shale, multicoloured, laminated; with variously shaped limy concretions; grades downward into Zone 57h................	500 to 550

Bed or Zone	Description	Thickness
		Feet
	Seventh Resistant Sandstone-Conglomerate Member	
59	Pebble-conglomerate, coarse to medium; with lenses of coarse-grained, partly honeycombed, brownish weathered sandstone; contact with Zone 58 is poorly exposed, but appears to be conformable although sharp	16 to 17
60	Shale, grey; with abundant pebbles and sandy grains; contains irregular nests and lenses of solidly packed, hard conglomerate; contact with Bed 59 is indistinct, but it appears to be gradual ...	± 75
61	Sandstone, grey, rusty to buff weathered, coarse-grained, heavily bedded; contains loaf-like, rusty weathered concretions up to 12 feet in maximum diameter and 4 or 5 feet thick	± 10
62	Sandstone, grey, thinly bedded to laminated, fine- to coarse-grained, soft and friable..	± 20
63	Pebble-conglomerate, coarse to fine; with nests and lenses of grit and sandstone resembling those of Bed 61; contains high, "castle-like" sandstone concretions similar to those of Bed 61 in their dimensions; nests and lenses of light grey to whitish, calcareous sandstone also occur in this bed; the relative amount of sandstone and conglomerate beds and lenses varies greatly within short distances along the strike, so that one or other rock type may predominate locally; Bed 63 overlaps unconformably Beds 58 to 62 inclusive, its base truncating their tops within some 150 yards along strike; an angular unconformity of some 15 to 30 degrees was measured at the contact of Bed 63 with the underlying beds	20 to 50 +

From the top of Bed 63 to the axis of the Hesquiat syncline, which crosses the tidal shelf about 2/5 mile farther south, the shore is occupied by rocks that are apparently younger than Bed 63. These rocks are, however, so badly contorted and faulted that the succession could not be determined. Several major, low-angle thrust faults of predominantly northwesterly strike and northeasterly dip combined with numerous, major, northeasterly striking tear faults transform this uppermost part of the succession of Division C into a maze of fault blocks of various dimensions locally thrust upon one another for at least 100 to 200 feet. Actually observed horizontal displacements of the major tear faults amount to some 200 to 300 feet. Bed 63 is, in particular, locally folded synclinally and thrust southwesterly upon the overlying shaly rocks. The succession of the youngest rocks of Division C is probably repeated several times on the tidal shelf between the secondary point where Bed 63 outcrops at the axis of the Hesquiat syncline.

Despite the complex tectonic pattern, it is assumed that at least 400 to 500 feet of the predominantly shaly and fine-grained sandy rocks, with some beds and members of coarse-grained, resistant sandstone, and at least a few beds of pebble-conglomerate, comprise the uppermost part of Division C between the top of Bed 63 and the axis of the Hesquiat syncline.

Most of the axial part of the Hesquiat syncline lies within the above-described zone of intense faulting and low-angle thrusting, which is accompanied in many places by extreme shearing and crushing of the rocks. Farther south, however, the southwestern limb of the syncline exposes a reasonably good, though locally strongly faulted and sheared, succession of the variegated rocks of Division C more or less uniformly dipping to the northeast and striking northwest. The southwestern limb of the Hesquiat syncline exposes, in descending order, the following lithological units of the uppermost, predominantly shaly beds of Division C; seventh resistant sandstone-conglomerate member, seventh shale-clayey sandstone member, and the sixth resistant sandstone-conglomerate member. Within Homeis Cove, however, the base of the last-mentioned member appears to be cut off by what is believed to be a strong, northeasterly trending tear fault, or a major shear zone.

On the southwestern side of this fault zone a thick, resistant sandstone-conglomerate member may represent a horizontally displaced continuation of the sixth resistant sandstone-conglomerate member; it thins out markedly in a southwesterly direction on the broad tidal shelf just south of Homeis Cove, where it is underlain by a thick succession of dark grey to brownish grey, partly laminated and thinly bedded shales and siltstones. These latter rocks outcrop continuously to the tip of Estevan Point and occupy some 300 to 400 yards of the broad tidal shelf to the southwest; their base is concealed beneath the ocean. This shale-siltstone succession, whose visible thickness amounts to some 2,000 to 2,300 feet, has yielded marine fossils and plants at several levels. As the crab species characteristic of the lower part of Division C appear to be lacking among these fossils, it is assumed that these rocks are all relatively high in the succession of Division C and are-only a facies of the rocks between the second and sixth resistant sandstone-conglomerate members on the northeastern limb of the Hesquiat syncline.

Only a very few beds and layers of grey, shale-like, fine- to medium-grained sandstone were observed within the aforementioned shale-siltstone succession between Homeis Cove and its visible base on the tidal flat off Estevan Point.

Tidal flats between Estevan Point and Matlahaw Point are occupied by rocks that according to attitude and stratigraphic position are the southeasterly continuation of the Homeis Cove-Estevan Point shale-siltstone succession of beds. They exhibit, however, a much more diversified lithology. In the vicinity of Smokehouse Bay the upper part of the section includes numerous lenticular beds, lenses, and nests of resistant, coarse-grained sandstone, and even some grit and pebble-conglomerate. None of these beds and lenses was, however, thick or extensive enough to be shown on the map. These, still predominantly shaly rocks underlying the resistant sandstone-conglomerate member of Matlahaw Point, were, therefore, lumped together with the shale-siltstone succession outcropping between Homeis Cove and Estevan Point. The facies replacement and intertonguing of shaly with sandy and conglomeratic rocks seems to be evident in the vicinity of Smokehouse Bay.

On the east side of Hesquiat Peninsula, the following section of the lower part of Division C was measured on the northeastern limb of the Hesquiat syncline above the top bed of Division A (in ascending order):

Bed or Zone	Description	Thickness
		Feet
	First Shale-Clayey Sandstone Member	
1	Shale, light grey, fissile, hardened; with only a few concretions	± 80
2	Gap in outcrops (? site of a major strike fault)	60 to 70
3	Shale, multicoloured, laminated	± 160
4	Gap in outcrops occupied by beach deposits (? site of a major strike fault)	50 to 60
5	Shale, grey, laminated to uniformly coloured, fissile; interbedded with numerous beds of sandy siltstone, fine-grained, laminated, clayey sandstone, and coarse-grained, resistant, greywacke-sandstone; the beds of resistant sandstone occur at intervals from 2 to 8 feet and are from 1/2 foot to 3 feet thick; the lowermost 10 to 20 feet of this zone are composed almost exclusively of these coarse-grained sandstones, with only insignificant layers of shale and siltstone; base not exposed ...	120 to 130 (visible)
6	Shale, multicoloured, laminated to thinly bedded, carries numerous variously shaped (mostly lens-like and rounded) concretions of rusty weathered sandstone and siltstone; about 20 to 30 feet above the base of the zone these concretions are rich in fossil wood and in generally poorly preserved fossil leaves; marine shells were also found in this zone; a few minor beds and layers of sandy siltstone and fine-grained, shale-like, clayey sandstone occur in this zone at irregular intervals	320 to 350

Bed or Zone	Description	Thickness
		Feet
	First Resistant Sandstone-Conglomerate Member	
7	Conglomerate, coarse pebble to boulder, in beds up to 20 feet thick; interfingered with an about equal amount of similarly thick beds of fine to medium pebble-conglomerate and grit; all beds are strongly lenticular; minor lenticular beds and lenses of coarse-grained, gritty, resistant sandstone occur in this conglomerate zone; all rocks are rather badly jointed, sheared, and broken into fault blocks relatively displaced for distances ranging from a few to 50 or 60 feet; a strong, almost flat thrust fault with (?) low southerly dip cuts off the base of Zone 7 across most of its outcrop; elsewhere the contact with Zone 6 appears to be sharp and erosional; this conglomerate zone forms the crest of Leclaire Point	280 to 300
8	Sandstone, grey, coarse- to medium-grained; interbedded with sandy siltstone; grades downward into the conglomerates of Zone 7	± 60
	Second Shale-Clayey Sandstone Member	
9	Shale, dark grey, partly sandy, fissile; grades downward into Zone 8	45 to 50
10	Sandstone, grey, laminated, fine-grained, clayey; grades into sandy siltstone or shale	15 to 20
	Second Resistant Sandstone-Conglomerate Member	
11	Pebble-conglomerate, coarse to fine, contains minor lenses and nests of coarse to fine grit; rests with a sharp, erosional contact on the uneven surface of Bed 10	5 to 6

Bed or Zone	Description	Thickness
		Feet
12	Pebble-conglomerate, fine; interfingered with beds, layers, and nests of grit and coarse-grained, gritty sandstone	7 to 10
13	Sandstone, grey-yellow, resistant, coarse-grained, calcareous, partly honeycombed; interbedded with some 10 per cent of lenticular beds of coarse to fine grit grading into fine pebble-conglomerate; the amount of coarse grains and pebbles decreases gradually upward	± 120
14	Sandstone, grey, fine- to medium-grained, thinly bedded to laminated; interfingered with beds and layers of clayey, laminated to thinly bedded, fine-grained sandstone and superficially similar, very sandy siltstones	40 to 45
15	Pebble-conglomerate, coarse; with some cobbles and boulders up to 2 or 3 feet in diameter; thickness seems to vary considerably along strike; this conglomerate bed forms the crest of the unnamed secondary point immediately south of Leclaire Point	15 to 20
16	Sandstone, grey, coarse-grained; carries small, dispersed pebbles in some beds; is interfingered with layers and beds up to 12 inches thick of fine to medium pebble-conglomerate	± 40
	<u>Third Shale-Clayey Sandstone Member</u>	
17	Siltstone, grey, sandy; top concealed beneath the beach deposits in the mouth of a larger creek	4 to 6 inches (visible)

Farther south along the shore only rare, isolated, small outcrops of predominantly shaly rocks occur among the long stretches of beach deposits; these are represented either by grey, fine- to medium-grained, shale-like, clayey sandstone or by sandy, grey siltstone and shale. No outcrops were observed between the northwestern base of a long point of land with a sandspit, known locally as Anton's Place, and the southern part of Hesquiat Indian village.

Tertiary rocks, with the same attitude as before, reappear from underneath the pebble and boulder beach about 400 yards south of the mouth of Purdon Creek on the broad, muddy, tidal flat opposite the southern end of Hesquiat village, and in the shore bluffs on which the village houses stand. From this point they outcrop continuously to the southwest along the shore for about 7/8 mile. These rocks, which are believed to represent the shaly facies of the upper part of Division C, present the following succession (in ascending order):

Bed or Zone	Description	Thickness
		Feet
1	Shale, dark grey, fissile, mostly somewhat sandy; carries numerous rows of irregularly shaped, mostly small, shaly and limy concretions and some large, septaria-like concretions; shales are badly broken by a dense net of minor faults, and their strikes vary considerably within short distances; they grade upward into Zone 2; base concealed beneath the sea	300 to 400 (visible)
2	Shale and siltstone, multicoloured, laminated to thin-bedded; interbedded with thin (from fractions of an inch to 2 inches thick) layers and laminae of grey, medium- to fine-grained sandstone, which occur at intervals from 1/10 foot to 3 feet; in the shore bluffs as at the southern part of Hesquiat village, several beds of fine- to coarse-grained, resistant sandstone occur in the lower part of this zone; on the broad tidal shelf, some 400 to 450 yards south of the bluffs, these beds were not observed, but rows of discoidal, concretion-like lenses of medium- to fine-grained, clayey sandstone, or coarse-grained, calcareous sandstone occur commonly	

Bed or Zone	Description	Thickness
		Feet
	throughout the succession of Zone 2; they are rich in marine fossils, which include among others: shark teeth; Dentalium sp. indet.; the following gastropods: cf. Echinophora rex Tegland, cf. Ancistrolepis clarki Tegland, Fusinus (Priscofusus) cf. chehalisensis (Weaver), (?) Turcicula cf. washingtoniana Dall (?) cf. Astrea (Pomaulux) gradata Grant and Gale; and the following numerous and well-preserved pelecypods: Acila gettisburgensis Reagan, Nuculana sp. indet., Yoldia sp. indet., and a pelecypod, genus and species indet. This fauna also occurs in sandy shales and siltstones between the sandstone lenses; the zone grades upwards into Zone 3....................	200 to 250
3	Shale, grey, laminated in the lower part of the succession and fissile, uniformly coloured in its upper part; slightly to very sandy, but for the most part almost devoid of sandstone beds and lenses; in the upper part of this zone the rocks are very strongly faulted, sheared, contorted, and locally folded; top concealed beneath the pebble to boulder beach some 700 yards to northeast of the tip of Matlahaw Point; some 200 to 300 feet below the visible top of Zone 3 the hardened shale varieties are rich in fossils, which represent the Acila gettisburgensis fauna, occurring in Zone 2	± 1,000 (visible)
4	Interval; pebble and boulder beach occupies a small open bay just northeast of the base of Matlahaw Point; it is believed to be the site of a major shear zone of a general northwesterly trend, which occupies the axial part of the Hesquiat syncline	1,050 to 1,200
5	Siltstone and shale, dark grey, almost black, very sandy, fissile, soft; grade locally into clayey, fine-grained sandstone;	

Bed or Zone	Description	Thickness
		Feet
	occur in beds from 1 foot to 5 feet thick, and are interbedded with brownish grey, coarse- to medium-grained, resistant sandstone in beds from 1/2 foot to 3 feet thick; rocks are very strongly faulted, badly sheared and crushed, complexly folded, and commonly overturned to south; succession of beds could not be determined; the rocks of Zone 5 appear first from underneath the beach deposits some 250 to 300 yards northeast of the tip of Matlahaw Point and seem to overlie conformably Zone 6 at its northeast side; they are believed to form the southwestern fringe of the major shear zone of Zone 4	No estimate could be made
	<u>Resistant Sandstone-Conglomerate Member</u>	
6	Shale, dark grey, sandy, soft; abundant pebbles, which are mostly from 1/2 inch to 1 1/2 inches in diameter; interbedded with lenses and lenticular beds of fine to coarse pebble-conglomerate from 2 to 5 feet thick; the beds of Zone 6, although badly faulted, sheared, and locally folded, have in general a persistent strike of about north 20 degrees west and a dip of 15 to 25 degrees northeast, on the southwesterly limb of the Hesquiat syncline	$\pm$ 100
7	Pebble-conglomerate, fine to coarse, strongly lenticular; interbedded with beds and lenses of pebbly shale and coarse-grained, resistant sandstone; attitude as for Zone 6, which it underlies conformably and without any apparent erosional disconformity; forms the tip of Matlahaw Point and a pronounced hogback on the tidal shelf to the southeast	20 to 25

The Matlahaw Point resistant sandstone-conglomerate member rests, apparently with a sharp, erosional contact, on a thick, predominantly shaly succession of rocks.

Tertiary Rocks of Hesquiat Point

The Tertiary rocks of Hesquiat Point consist almost entirely of shales lithologically similar to those of shale-clayey sandstone members of Division C of Hesquiat Peninsula. They are tilted at an average angle of 20 degrees to the southwest, and strike about north 40 degrees west, suggesting that they represent a southeasterly continuation of a part of the northeastern limb of the Hesquiat syncline of Tertiary rocks. Except in adjoining areas to the northeast, these Tertiary rocks are almost undisturbed by larger faults, minor folds, and shear zones. In their structural relationships they resemble the rocks of Division B of Nootka Island and differ markedly from the much more strongly dislocated Tertiary rocks of Hesquiat Peninsula.

On both sides of Hesquiat Point the rocks of Division A are apparently missing between the shales of Division C and the Mesozoic rocks, probably owing to faulting. About a mile up the creek that enters the sea 1 1/4 miles east of the tip of Hesquiat Point a few score feet of badly faulted and sheared rocks of Division A were observed at the base of the shaly succession of Division C and in fault contact with the dark-coloured border facies of the Coast intrusions; these intrusive rocks seem to be thrust upon the rocks of Division A from the east. One fragmentary specimen of Portunites cf. alaskensis Rathbun was collected from the upper sandstones of Division A at this locality.

On the west side of Hesquiat Point, the succession of shales of Division C is more nearly completely exposed, and is represented by multicoloured, laminated shales, with numerous shaly, limy, and sandy concretions of various sizes and shapes in their lower 250 to 300 feet. Only a very few thin beds and layers of a sandy siltstone and fine-grained, clayey sandstone occur in thin shaly zones. At their visible base, and for the first 50 to 100 feet south, the shales are intersected by a dense net of minor, high-angle faults, mainly north 30 to 50 degrees west and north 40 to 80 degrees east, directions varying considerably within distances. Farther south these dislocations become much less numerous.

The overlying shales are uniformly coloured, ash-grey to light grey, are commonly brownish tinged, contain a few concretions, and their top is concealed beneath the ocean. Their visible aggregate thickness to the southern end of the tidal flat off the tip of Hesquiat Point is estimated to be about 2,700 feet. These shales are also exposed on the south side of Hesquiat Point and along the shore farther east. At a point about a mile east of the tip of Hesquiat Point a few fragmentary specimens of fossil crabs, one of which possibly belongs to Portunites sp. indet., and fragments of fossil leaves were found in some of the rare shaly concretions. About 1 1/2 miles east of the tip of Hesquiat Point the uniformly tilted dark grey shales are intersected by an increasing number of faults, are more steeply dipping locally, and in one place are involved in a small anticlinal fold.

Tertiary Rocks East of Kanim Lake

The 1 1/2 miles of shore just east of Kanim Lake are occupied by Tertiary rocks, which, like those of Hesquiat Point, have an average strike of north 30 to 50 degrees west and southwesterly dips of 20 to 40 degrees, and are thought to represent the most easterly extension of the northeastern limb of the Hesquiat syncline. In contrast with the rocks of Hesquiat Point these rocks are badly faulted, strongly sheared, and in places completely crushed. This, together with the fact that there is no evidence of strong faulting between the Tertiary rocks and those of the underlying Karmutsen group, suggests that the eastward extension of the major fault limiting the Hesquiat Point beds on the east lies beneath the sea in front of the Kanim Lake strata.

The Kanim Lake rocks consist almost entirely of rocks of Division A, which is estimated to reach some 600 to 700 feet in thickness. Their lithological characters are essentially similar to those of the section at Escalante Point on Hesquiat Peninsula, though the relative amount of conglomerate beds appears to be somewhat greater. The basal beds of Division A on both sides of the Tertiary area consist of the thick beds of coarse pebble- to boulder-conglomerate, which always includes some large boulders and blocks of the older intrusive and volcanic rocks. The basal conglomerate is 5 to 7 feet thick on the east end of the outlier but at its west end reaches 80 feet in thickness. It overlaps, with pronounced angular unconformity, the deeply eroded surface of the volcanic and pyroclastic rocks of the Karmutsen group, the contacts being entirely similar in their character to those described earlier on the east side of Hesquiat Peninsula and on the west coast of Nootka Island.

The younger beds of Division A are represented mainly by coarse-grained, resistant sandstones of the usual type. In the upper beds of the division, these are interbedded with medium- to fine-grained, calcareous, concretionary sandstones, sandy siltstones, and minor beds of sandy shale. Midway of the section these have yielded a well-preserved crab specimen of *Eumorphocorystes naselensis* Rathbun and a few molluscs.

The gradational contact of Divisions A and C and the lowermost shale beds of Division C are well exposed in the lower part of the sea bluffs and on the tidal shelf offshore midway of the Kanim Lake section. The shales of Division C do not seem to differ from those observed elsewhere in the Hesquiat-Nootka area; they lie, for the most part, well below the high-tide mark, and no more than a few hundred feet of shales and siltstones of Division C could be represented between high- and low-tide marks.

Tertiary Rocks of the West Coast of Flores Island

On the west coast of Flores Island, Tertiary rocks form relatively narrow bodies separated from one another by narrow wedges of the volcanic and pyroclastic rocks of the Vancouver group believed to form a part of the Karmutsen group. The occurrence of three such bodies of Tertiary rocks was established on the seashore between Siwash Bay and a point about 1 1/2 miles north of Rafael Point. Tertiary rocks of all three bodies are tilted monoclinally, striking north 20 to 60 degrees west and dipping 15 to 40 degrees southwest. It is obvious that the separation of these Tertiary bodies from one another was caused by major strike faults with a vertical displacement of at least several hundred feet. The manner in which Tertiary rocks are dislocated by minor faults in the proximity of the major faults suggests that the latter may in part be tear faults. In no case was the extension inland of these Tertiary bodies traced.

Within each fault block the Tertiary rocks are intersected by a more or less dense net of high-angle, normal and reverse faults of predominantly northwesterly and northeasterly trends. The overall lithological monotony of the Tertiary rocks on Flores Island tends to conceal the actual amount of displacement along the faults, but it is believed that in most instances the displacement is between 10 and 50 feet. Only a few of these lesser faults could be shown on the accompanying map. Strong shearing and jointing occur in their proximity, but there is no evidence of supplementary folds, owing probably, to the predominantly incompetent character of the beds.

The southern fault block of Tertiary rocks occupying the shore between the southwestern side of Siwash Bay and the southeastern base of Rafael Point consists entirely of rocks of Division A, very similar to those at Escalante Point, Hesquiat Peninsula, and on both sides of the Kanim Lake Tertiary body. Within this fault block the visible thickness of Division A was estimated at 400 feet.

On both sides of the southern fault block the basal beds of Division A, represented by an interfingering of lenticular beds and lenses of coarse pebble- to boulder-conglomerate with those of fine pebble-conglomerate, grit, and pebbly to gritty, coarse-grained sandstone, overlie with pronounced angular unconformity the deeply eroded surface of volcanic and pyroclastic rocks of the Vancouver group. They are succeeded by coarse-grained, commonly gritty and pebbly sandstones, with minor beds and layers of pebble-conglomerate, reaching 150 to 200 feet in thickness. The upper 150 to 200 feet of Division A is mainly coarse- to medium-grained, grey-yellow to brownish grey, resistant, calcareous sandstone, with numerous concretions of calcareous sandstone; the concretions yielded well-preserved crab specimens, including Portunites alaskensis Rathbun and Eumorphocorystes naselensis Rathbun.

The middle fault block of Tertiary rocks occupies all the southern side of Rafael Point and extends northward to the northeastern base of Dagger Point. At the base of the southern side of Rafael Point the Tertiary rocks are separated from the volcanic and pyroclastic rocks of the Vancouver group by a covered interval some 300 to 400 feet wide, believed to be the site of the major fault separating the middle and southern fault blocks of Tertiary rocks. The Tertiary rocks on the northern side of this interval appear to be comparable lithologically with those of Division C of Hesquiat Peninsula, and wholly unlike the sandstones of Division A outcropping in the direct line of their strike on the southern side of this covered interval. The base of the rocks of Division C is concealed in the forest at the base of Rafael Point and the lower 400 to 450 feet of their visible thickness is represented by thin interbeds of dark grey, laminated, fine- to medium-grained, clayey, commonly shale-like sandstone with ash-grey to dark grey, more or less sandy shale, comparable with the shale-clayey sandstone member of Division C. A few layers and beds of coarse to fine grit, and of fine to coarse pebble-conglomerate occur at irregular intervals in this succession of sandstones and shales. These latter, and also some of the sandstones beds, contain abundant shell detritus and many complete marine shells. Beds of sandy shale contain many variously shaped sandstone and shale concretions, some of which are fossiliferous.

Perhaps the most striking feature of this sandstone-shale member is the occurrence of a zone 5 to 6 feet thick of thin beds and lenses of a peculiar, breccia-like rock some 200 feet above the visible base of the section. This rock consists of fine to coarse pebbles and fragments of coal (?bituminous variety) intermixed with pebbles and fragments of shale and with nests and lenses of calcareous grit and pebble-conglomerate. It is very rich in shells of marine molluscs and so must have been formed below the level of the sea. The fossils include a poorly preserved fragment of a crab probably belonging to Eumorphocorystes sp. indet., gastropods ? Turcicula sp. indet., and ?Argobuccinum sp. indet., a scaphopod Dentalium sp. indet., and indeterminate brachiopods, spines of cidaroid echinoids, etc.

The above sandstone-shale member is apparently conformably overlain by a thick succession of coarse-grained, calcareous, resistant sandstones, commonly rich in fragments of marine shells, spines of echinoids, etc. These sandstone beds, mostly 1 foot to 3 feet thick, are interbedded with numerous thin and thick beds of calcareous coarse grit and fine to coarse pebble-conglomerate. Minor beds and members of fine-grained, dark grey, shaly looking sandstone, and of sandy, dark grey shale are interbedded with coarser rocks at certain levels, and in particular near the top and the base of this member, which is referable to the resistant sandstone-conglomerate members of Division C of Hesquiat Peninsula; its visible thickness amounts to 300 or 350 feet, the top being concealed beneath the sea off the tip of Rafael Point.

A collection of fossils from a zone of coarse, gritty sandstone about 60 feet thick, midway of this resistant sandstone-conglomerate member, includes: Epitonium cf. condoni Dall, Pecten sp. indet., Dentalium sp. indet., spines of cidaroid echinoids, etc.

The above described succession of Tertiary rocks is believed to represent a part of Division C, as developed on Hesquiat Peninsula; its occurrence in line with the strike of the rocks of the upper part of Division A indicates that the fault (or a fault zone) separating the southern and middle fault blocks of Tertiary rocks of Flores Island is in the nature of a tear fault, but the displacement along it could not be determined.

The northwestern end of the middle fault block of Tertiary rocks of Flores Island is situated at the northeastern base of Dagger Point. At this point a thick succession of brownish to rusty coloured, fine to coarse pebble-conglomerates, interfingered with lenses, nests, and layers of coarse-grained, poorly sorted sandstone and fine to coarse grit, overlaps unconformably the uneven, deeply eroded surface of dark grey, volcanic rock of the Vancouver group. Only about 25 feet of this volcanic rock is exposed below the contact with Tertiary conglomerates of Division A, and the writer believes that the covered interval separating its outcrop from the south end of the northern Tertiary fault block conceals a major strike fault.

Conglomerates of Division A occupy all of Dagger Point; they become finer upwards, in which direction the relative amount of nests, lenses, and beds of coarse-grained, pebbly or gritty sandstone also increases. Within the first 50 to 60 feet above the base of Division A the sandstone lenses and nests are fossiliferous, but no determinable fossils were found, and no fossils were seen in the overlying beds. The thickness of Division A at Dagger Point was tentatively estimated at about 370 feet.

On both sides of Dagger Point the rocks of Division A are intersected by many high-angle, normal and reverse faults of predominant northwesterly and northeasterly trends, along which the maximum observed horizontal displacement was about 250 feet. From the northeastern side of Dagger Point to its extreme tip the rocks dip from 35 to 40 degrees southwest; on the southwest side the dips lessen to 25 to 30 degrees southwest.

The rocks of Division A are conformably overlain at the southwestern base of Dagger Point by a succession of brownish grey, fine to coarse grit and coarse-grained, calcareous sandstone, interbedded with considerable pebble-conglomerate and fine- to medium-grained, shale-like, laminated sandstone. This grit-sandstone member, accepted as the base of Division C, is 400 to 450 feet thick. Its top is marked by a 10- to 20-foot bed of pebble-conglomerate, which carries blocks of the volcanic rocks of the Vancouver group up to 15 or 20 feet in diameter and forms a bluffy secondary point of the shoreline. It is succeeded by 150 to 200 feet of sandstones, similar lithologically to those underlying the conglomerate bed, but almost devoid of grit and conglomerate; these in turn are overlain by 200 to 250 feet of medium- to fine-grained, shale-like, partly laminated, grey sandstones interfingered with a few beds and minor members of sandy siltstones.

Some 90 to 100 feet of coarse-grained, gritty sandstones, interbedded with layers of grit and fine pebble-conglomerate, overlie the laminated, grey sandstones and are succeeded by about 50 feet of coarse-grained, gritty, resistant, brownish grey sandstone interbedded with layers of grit and fine pebble-conglomerate. Fossils, including Epitonium condoni Dall, Pecten sp. indet., Dentalium sp. indet., indeterminate brachiopods, and spines of cidaroid echinoids, were collected from this zone, which occupies the entire width of another secondary rocky and bluffy point to the southwest of Dagger Point.

The rocks occupying the shore and the tidal flat between the second rocky point and the tip of Rafael Point are entirely similar lithologically to the resistant sandstone-conglomerate member of Division C, which occurs on the southern side of Rafael Point above the top of the sandstone-shale member, and appears to have a thickness of 600 to 650 feet. Some 150 yards northeast of the tip of Rafael Point, Acila cf. shumardi (Dall), ?Mactra sp. indet., Nucula sp. indet., indeterminate gastropods, spines of cidaroid echinoids, and a few other fossils were found in large blocks of calcareous pebble-conglomerate lying on the shore above high-tide mark; these fossils are believed to be locally derived.

The dips of the Tertiary rocks between the first rocky point southwest of Dagger Point and the tip of Rafael Point lessen to 15 to 25 degrees southwest.

It appears to be evident that no lithological equivalents of the sandstone-shale member of the southern side of Rafael Point are represented in the Tertiary section of the northwest side of the point. In so far as this latter section of Division C is complete in its lower part, and as no major strike faults were observed within it, the disappearance of the sandstone-shale member must be due to facies changes that take place in the intervening interior part of Rafael Point, and seems to be yet another example of the rapid lateral lithological changes characteristic of these Tertiary rocks.

The northern fault block of Tertiary rocks of Flores Island occupies the entire length of the broad open bay between the southwestern base of a point about 1 1/2 miles north of the tip of Rafael Point and the northwest base of Dagger Point. At the base of Rafael Point, dark to light grey, massive, volcanic rocks of the Karmutsen group are disconformably overlain by 70 to 80 feet of coarse to medium pebble-conglomerate, which is believed to be the basal conglomerate of Division A. The top of this conglomerate zone, which has a visible dip of 10 to 15 degrees southwest, is concealed beneath the thick mantle of Pleistocene deposits extending from the top of the cliff to the level of the beach just southwest of the visible top of the conglomerate zone. The writer believes that these Pleistocene deposits, which cover the shore for the next 300 to 350 yards, conceal the site of a major strike fault (? or of a major shear zone), which separates the conglomerates of Division A from the dark grey shales outcropping farther southeast. The remainder of the bay, up to the covered interval at the northeast base of Dagger Point, seems to be occupied by dark grey to ash-grey, fissile shales, with large, septaria-like concretions; their strike averages north 40 degrees west, and they have an average dip of about 30 degrees southwest. These shales outcrop only below the half-tide mark, and were mostly covered by water at the time of the traverse; no detailed study of them was possible and no fossil collections were made. The writer assigns them tentatively to the shale-clayey sandstone phase of Division C.

It seems probable that the outcrops of dark grey shales observed by Brewer (1921, pp. 195-196) about 1 1/2 miles up Cow Creek southeast of Siwash Bay could be the direct continuation of the above-described shale zone of the northern fault block, as they lie almost directly on the strike of this zone, and pure shales of such type were not observed in other fault blocks of Tertiary rocks of Flores Island. Should this assumption be correct, the Tertiary shales of the northern fault block must extend southeasterly entirely across the inner part of the coastal plain of Flores Island to the bed of Cow Creek, behind the strips of Karmutsen group rocks and the body of Coast intrusions occupying the shoreline southeast of Siwash Bay, to reappear between fault blocks of Tertiary rocks at the southeastern base of Rafael Point and at the northeast base of Dagger Point. The writer was, however, unable to visit Brewer's (1921) shale localities or to investigate the inland extension of the northern fault block of Tertiary rocks.

Age and Correlation

The following account of age and correlation of the Tertiary rocks of the Hesquiat-Nootka area is necessarily only of a preliminary nature, and more thorough study of the fossil collections may result in some readjustment of opinions presently held.

The work of Dr. Charles E. Weaver (1937, 1942, 1944) on the stratigraphy and palaeontology of the Tertiary formations of the northwestern part of the Pacific coast of North America, and specifically the correlation chart of these formations (Weaver et al., 1944) has provided the writer with an invaluable stratigraphic standard. All European stage and series names used throughout this report are employed in the sense of these authors without any attempt at a critical appraisal of their correlations.

The rocks of Division A seem to be all of the same general age in the Hesquiat-Nootka area, as they everywhere contain the same invertebrate, marine fauna of the Lincoln (mid-Oligocene) Stage. The Lincoln age of this fauna was originally suggested by Dr. Ralph B. Stewart of the United States Geological Survey, who has studied the invertebrate fossils collected by Bancroft (1937) at Escalante Point on Hesquiat Peninsula and concluded that (quoted in part from Bancroft, 1937, p. 9): "The six species of gastropods are not sufficiently well preserved to be identified with certainty, but they belong to an Oligocene fauna, that is, near the Lincoln horizon of western Washington . . . If the correlation with the Oligocene is correct, the fauna is probably earlier than the Sooke fauna, which although erroneously called Oligocene, seems better referred to the Miocene".

The specimen of a whale found at the same spot by Bancroft (1937), was determined by Dr. Remington Kellogg of the United States National Museum; it supports, in a general way, the conclusions derived from the study of invertebrate fossils, as Dr. Kellogg states (quoted from Bancroft, 1937, p. 9): "I am inclined to believe that an upper Eocene or at most a lower Oligocene age is indicated".

The writer studied the fossil crabs, which are the most numerous and ubiquitous element of the fauna of Division A. The hitherto determined crabs belong to Portunites alaskensis Rathbun and Eumorphocorystes naselensis Rathbun. Both species were so far found only in rocks of earlier Oligocene age (Rathbun, 1928, pp. 74, 100), approximately equivalent to the Lincoln horizon of the Pacific coast Tertiary standard(Weaver et al., 1944). Weaver (1942, p. 588) also allots a mid-Oligocene (Lincoln) age as the stratigraphic range of Eumorphocorystes naselensis Rathbun.

Among the gastropods collected from the rocks of Division A, Epitonium condoni Dall (in a broad sense) and its varieties seem to be stratigraphically important. This species (in a broad sense) is considered characteristic of rocks of the Lincoln Stage (mid-Oligocene) of the Pacific coast of North America (Weaver, 1942, pp. 314-319), though some of its numerous varieties range downward into early Oligocene. Epitonium condoni Dall (in a broad sense) and var. were found in almost all sections of Division A within the area studied, and range throughout the division.

The above palaeontological evidence is considered sufficient for the correlation of Division A with the mid-Oligocene Lincoln Stage of the Pacific coast Tertiary standard.

The lower and middle parts of Division B of Nootka Island are also of Lincoln (mid-Oligocene) age, as they carry Portunites alaskensis Rathbun, Eumorphocorystes naselensis Rathbun, and Epitonium condoni Dall (in a broad sense) in almost all sections. No stratigraphically important faunal differences between Division A and the lower and middle parts of Division B have yet been recognized by the writer.

The age of the upper part of Division B, which is about 1,000 feet thick, is uncertain, as no determinable fossils were found there. The upper beds of the shaly Tertiary succession of the Hesquiat Point section provided only a few fragmentary specimens of fossil crabs; it is believed, however, that they still represent the crab fauna of the Lincoln Stage. The rocks of Division C outcropping midway of the Kanim Lake body of Tertiary rocks are also believed to be of a Lincoln age. The rocks of the lower sandstone-shale member of Division C within the middle fault block of Flores Island carry poorly preserved crab remains apparently belonging to Eumorphocorystes naselensis Rathbun. The overlying resistant sandstone-conglomerate member of the same division yielded no crab remains, but readily determinable specimens of Epitonium cf. condoni Dall (in a broad sense) were found in it. On the northwest side of Rafael Point, Epitonium condoni Dall (in a broad sense) was also found midway of the sandstone succession assigned to Division C. Furthermore, Acila cf. shumardi (Dall) was found in a loose block of pebble-conglomerate, which is apparently locally derived, near the tip of Rafael Point; this species is an index form of the Lincoln fauna, and is not known in the upper Oligocene rocks (Blakeley Stage) of the Pacific coast of North America (Weaver, 1942, p. 26).

The above palaeontological evidence indicates that all the rocks of Division C outcropping within the above-mentioned areas of Tertiary rocks, however distinct lithologically, belong to the mid-Oligocene Lincoln Stage and are contemporary with the lower and middle parts of Division B of Nootka Island.

On the west side of Hesquiat Peninsula, the highest occurrence of Eumorphocorystes naselensis Rathbun, about 1,400 feet above the bottom of Division C, is tentatively accepted as representing the top of the Lincoln Stage within its succession. On the east side of Hesquiat Peninsula, the index crabs were only found at the base of Division C.

The age of the middle part of Division C on both sides of Hesquiat Peninsula cannot as yet be reliably determined. A rather vague indication that they may be of Lincoln age is given by the presence of a form of Acila possibly conspecific with A. shumardi (Dall) in the rocks of the fourth shale-clayey sandstone member on the western side of Hesquiat Peninsula.

The upper 700 to 800 feet of rocks of Division C on the east side of Hesquiat Peninsula carry a rich molluscan fauna, which is definitely younger than the Lincoln fauna. The general composition of this fauna, and specifically the abundant occurrence of the typical and well-preserved Acila gettisburgensis Reagan, dates this fauna as of the Blakeley Stage of the North American Pacific standard, which is accepted as corresponding with late Oligocene and early Miocene in terms of the European series (Weaver et al., 1944, Correlation Table). Acila gettisburgensis Reagan is, indeed, accepted as the zonal index of the Blakeley fauna by most modern North American authors (Clark and Arnold, 1923, pp. 135-136; Weaver, 1942, pp. 33-34; and others). Although it is possible that this species ranges upward into the rocks of later Miocene age, it has never yet been known to range downwards into rocks of mid-Oligocene (Lincoln) age in the northwestern part of the Pacific coast of North America. The rest of this fauna, though not yet completely studied, fully supports the proposed Blakeley age of the Acila gettisburgensis fauna of Hesquiat Peninsula. This fauna ranges into the highest beds of Division C outcropping on the northeastern limb of the Hesquiat syncline between Hesquiat village and Matlahaw Point, and the writer considers that elsewhere on Hesquiat Peninsula the upper 700 to 800 feet of this division are also of Blakeley age.

The Blakeley Stage is now customarily subdivided into two faunal zones that are designated respectively as lower (or typical) and upper Blakeley faunas, or as lower and upper Twin River faunas. Echinophora rex Tegland is used as the zonal index of the lower Blakeley, whereas Echinophora apta Tegland is recognized as the index fossil for the upper Blakeley fauna (Weaver et al., 1944, Correlation Table). The lower Blakeley fauna is dated as late Oligocene and the upper Blakeley fauna as of early Miocene age; the latter fauna is accepted as the time equivalent of the Sooke fauna of southern Vancouver Island.

The specific composition of the Blakeley fauna of the east side of Hesquiat Peninsula favours its correlation with the lower (or typical) Blakeley fauna. The presence of ornate gastropods comparable with Echinophora rex Tegland, Turcicula washingtoniana Dall, and Fusinus (Priscofusus) chehalisensis (Weaver), taken together with the lack of gastropods comparable with Agasoma (Bruclarkia) acuminata Clark and Arnold and Fusinus (Priscofusus) hannibali Clark and Arnold in the Hesquiat Peninsula fauna, is the main argument supporting this conclusion, and the writer proposes correlation of this fauna with the lower (i. e., typical) Blakeley fauna of the State of Washington.

The age of the rocks of Division C on the tidal flats and reefs at the tip of Bajo Point on Nootka Island can only be appraised from their stratigraphic position, as they have not yielded any determinable fossils. On the one hand, they overlie the beds of Division B containing the Lincoln fauna, and are separated from these latter by a considerable succession of shales that do not carry any determinable fossils, but on the other hand they are immediately overlain by rocks of Division D, which contain a fauna, which, although undoubtedly of a general Blakeley (late Oligocene-early Miocene) age, is believed to be younger than the lower Blakeley fauna of Hesquiat Peninsula. In consequence, it is virtually certain that the rocks of Division C of Nootka Island can only be equivalent to the middle and upper parts of the same division of Hesquiat Peninsula and cannot include the lower, crab-bearing part of this division, which was shown to be contemporary with the lower and middle parts of Division B (mid-Oligocene or Lincoln) of Nootka Island.

It is not yet possible to say how much of the older part of Division C of Hesquiat Peninsula corresponds with the unfossiliferous upper part of Division B on Nootka Island, so that the precise dating of the facies change from the shales of Division B to the variegated rocks of Division C on Nootka Island is impossible. Nevertheless, it is quite evident that the deposition of the rocks of Division C on Nootka Island was begun much later than on Hesquiat Peninsula and in the area to the southeast. This conclusion is of considerable stratigraphic and palaeogeographical significance.

The previously mentioned, rich molluscan fauna of Division D of Nootka Island appears to be rather different in composition from the Blakeley fauna of the upper part of Division C of Hesquiat Peninsula, which in the writer's opinion may be correlated with the lower or typical Blakeley (-Lower Twin River formation) fauna.

All molluscan species hitherto determined by the writer from the rocks of Division C are so similar to those of the upper Blakeley fauna (*Echinophora apta* Zone) that the writer proposes its correlation with this fauna. The upper Blakeley fauna (Upper Twin River fauna) correlates with the lower Miocene series (Aquitanian Stage) of Europe and is thus younger than the upper Oligocene (Chattian Stage of Europe) typical (or lower) Blakeley fauna (Weaver *et al.*, 1944, Correlation Table). There seems to be little doubt that the Sooke fauna of southern Vancouver Island is an exact equivalent of the upper Blakeley fauna (=Upper Twin River fauna) of the northwestern United States (Weaver *et al.*, 1944, Correlation Table).

The above conclusion as to the age of the upper Blakeley (=Upper Twin River) fauna of Division D of Nootka Island is, however, subject to one reservation. This fauna is a typical shallow water (littoral) fauna, whereas the *Acila gettisburgensis* fauna (=typical or lower Blakeley fauna) of the upper part of Division C of Hesquiat Peninsula is a fauna of deeper and quieter waters (facies of clayey sandstone and shale). There still remains, therefore, the possibility that both faunas are only extreme faunal facies of one and the same general age; such a possibility is all the more feasible as the lower Blakeley fauna is immediately followed in time by the upper Blakeley (or upper Twin River, or Sooke) fauna and the age difference between the two cannot be very great. Furthermore, Clark and Arnold (1923, p. 136) have actually observed an interfingering of the typical Blakeley and Sooke (=Upper Twin River) faunas corresponding to changes of facies in beds lying between the Carmanah and Sooke formations in the vicinity of Carmanah Point in the southern part of Vancouver Island.

The writer admits in principle the possibility of at least a partial time overlap of the upper part of Division C of Hesquiat Peninsula with the rocks of Division D of Nootka Island, and it is indicated in the table of formations. Nevertheless, the dissimilarity of both faunas with one another and their respective similarity with the lower and upper Blakeley faunas seems to rule out the possibility of their complete contemporaneity. This conclusion is also supported by the northwesterly plunge of the axis of the Hesquiat syncline on the west side of the peninsula. This would naturally favour the appearance of younger rocks in the axial part of the syncline off the tip of Bajo Point, which may be considered a continuation of the axial part of the Hesquiat syncline. Furthermore, the presence of a pronounced erosional disconformity between rocks of Divisions C and D on Nootka Island speaks against a time overlap between the two divisions, as no such disconformity was observed in the upper part of Division C on Hesquiat Peninsula.

In spite of the fact that the outlines of the correlation of the lithological divisions of the Tertiary rocks of the Hesquiat-Nootka area with the standard Tertiary stages of the northwestern part of the Pacific coast of North America appear to be sufficiently clear, their correlation with the Tertiary formations of the southern part of Vancouver Island (Clapp, 1912, 1917) presents considerable difficulties. This is mainly due to the fact that very little reliable information about the age limits and correlation of the Carmanah formation is available. The prolonged controversy about the age relations of the Carmanah and Sooke formations was reviewed by Clark and Arnold (1923, pp. 135-136) and by Weaver (1937, pp. 115-116, 142-144). Weaver et al. (1944, Correlation Table), however, did not include the Carmanah formation in their table of Cenozoic formations of the Pacific coast of North America, and have not discussed it in the body of the paper, though at an earlier date Weaver (1942, Correlation Table) tentatively correlated the Carmanah beds with the mid-Oligocene, Lincoln Stage.

The present writer accepts as valid the conclusions of Clark and Arnold (1923, pp. 135-136) that both the Lincoln and lower (typical) Blakeley Stages are represented within the limits of the Carmanah formation, with some beds equivalent to the lower part of the Sooke formation forming its uppermost beds. Whether or not any older(Keasey Stage) rocks are represented in its lower part is not known, although this does not seem probable in view of the statement by Clark and Arnold (1923, p. 136) that the Lincoln fauna characterizes the lower part of the Tertiary succession in the vicinity of Carmanah Point.

For the time being at least, the writer includes in the Carmanah formation all Tertiary rocks of southern Vancouver Island that lie between the bottom of the Sooke formation and the top of the Metchosin volcanic rocks (including upper beds correlated with the Crescent formation of Washington), which are believed to be of late Eocene age (Clapp, 1913, p. 107; 1917, pp. 290-292; Weaver *et al.*, 1944, pp. 596-597).

There is not enough lithological information available to decide whether the rocks of the Carmanah formation, as above defined, are further subdivisible or whether its lithological subdivisions would correspond to those of the contemporary Tertiary rocks of the Hesquiat-Nootka area. Clapp (1912, pp. 140-141; 1917, p. 336) has stated that the separation of the Carmanah and Sooke formations on lithological grounds is not possible, and does not mention any lithological subdivisions for the Carmanah formation.

Clark and Arnold (1923, p. 136) mention that in the vicinity of Carmanah Point heavy conglomerates separate the beds containing the typical Lincoln and Blakeley faunas. The conglomerates between Lincoln and Blakeley (=lower Twin River) parts of the Carmanah formation could perhaps be used for their lithological separation. Any such subdivision would, however, be impractical without thorough reinvestigation of the whole Tertiary body around Carmanah Point. For the time being the writer limits himself to the conclusion that the Carmanah formation apparently corresponds with all the Tertiary divisions of the Hesquiat-Nootka area with the sole exception of Division D of Nootka Island; this is apparently an equivalent of the Sooke formation. It would seem, therefore, at least in the present state of our knowledge, that the Tertiary sedimentary succession of southern Vancouver Island has the same general time limits as that of the Hesquiat-Nootka area.

ECONOMIC POSSIBILITIES

The presence of sizable areas and considerable thicknesses of Tertiary marine sedimentary rocks in the Hesquiat-Nootka area is of some interest in relation to possible occurrences of oil and natural gas. Similar marine strata occur elsewhere along the west coast of Vancouver Island, and both in age and lithology resemble formations farther south, on the west coasts of Washington and Oregon, where numerous oil seepages and gas "shows" are known to occur, and in the coastal region of California, where they have yielded large quantities of oil and gas. Farther north, again, the oil-bearing Oligocene strata of the Katalla and Yakutaga districts in Alaska resemble those of Vancouver Island.

Investigations of the oil and gas possibilities of these marine Tertiary strata within the limited confines of the present area have, however, not proved encouraging. No authentic oil or natural gas seepages were observed, though several have been claimed by local residents. So far as these were investigated they proved to be a result either of the misidentification of mineral film on the water for oil film, or caused by oil-bearing sludge discharged from ships. Alleged gas "shows" in swamps and ponds appeared to be produced by recent decaying vegetation, though no thorough study of the occurrences was made and no samples of the gas taken.

No structures obviously favourable for the accumulation and preservation of gas or oil were recognized in the Tertiary rocks of the Hesquiat-Nootka area, which in the main are badly disrupted by faults and shear zones. In fact, the apparent lack of seepages along these natural channelways might in itself be regarded as unfavourable to the occurrence of oil at depth in these rocks. The minor anticlinal fold of the shales of Division C on the east side of the Hesquiat Point area of Tertiary rocks may deserve some consideration as a potentially favourable structure, but probably does not involve a thickness of more than a few hundred feet of beds. Again, the peculiar, "dome-like" structure on the easternmost reef of Bajo Point on Nootka Island may deserve some consideration, but is badly faulted and sheared. Further, the occurrence of numerous major faults and the characteristically lenticular nature of the sandy and shaly beds of Tertiary rocks within the area might be expected to provide oil and gas traps either against the planes themselves or within the sandy and conglomeratic lenses; however, no evidence favouring the presence of such accumulations was seen in this area.

Before the turn of the century, the sedimentary rocks of Hesquiat Peninsula, and those of the west coast of Flores Island, had attracted the attention of prospectors in connection with the reported occurrence of coal measures in these areas, and some land was staked for coal. The investigations made by Mr. S. M. Robins of the New Vancouver Coal Company, Nanaimo, on Hesquiat Peninsula prior to 1902 had, however, failed to discover any economic occurrences of coal. Nor was the examination of claims on Flores Island by Brewer (1921) any more successful, though layers of carbonaceous shales were encountered locally at Siwash Bay.

The writer found small lenses and nests of bituminous(?) coal at several localities in sandstones and shales of Division C, on both sides of Hesquiat Peninsula. None of these occurrences can, however, have any commercial value. Most of them are in marine rocks and the coal itself is probably of marine origin.

Of more potential interest is the occurrence of numerous fragments and pebbles of coal in the zone of breccia-like rock on the southern side of Rafael Point. The rock itself is definitely marine, as marine shells are associated with fragments and pebbles of coal; the occurrence may, however, suggest the presence of coal measures somewhere in the vicinity. It seems, indeed, fairly certain from the lithological changes of the rocks of Division C within the Hesquiat area that the shoreline of the Oligocene sea was situated to the southeast and east of the coastal plain now occupied by Tertiary marine sediments. Therefore, it appears not unlikely that these fragments and pebbles of coal were originally derived either from coal seams of continental facies and Oligocene age, or from older rocks originally present in the interior of Flores Island. This consideration seems to lend some support to the older claims of coal seams in the interior of this island, discounted by Brewer (1921), but it seems improbable that any such coal seams could have survived the subsequent great uplifts of the coastal plain and the mountainous interior of Flores Island.

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