

SECTION V

THE SEDIMENTARY ROCKS; THEIR CLASSIFICATION,
STRATIGRAPHY, PALAEONTOLOGY, AND STRUCTURE

Tabular Summary of the Formations.

River terraces, deltas, etc.	-----	Holocene	
Glacial deposits	-----	Pleistocene	
Quessnel River Series {	Brokenback Hill formation	-----	Early Lower Creta- ceous
	Peninsula formation	-----	Basal Lower Creta- ceous
Agassiz Series {	Agassiz Prairie formation	-----	Upper Jurassic
	Kent formation	-----	Upper Jurassic
	Mysterious Creek formation	-----	Late Mid. & early Upper Jurassic
Porphyrite Series {	Echo Island formation	-----	Middle Jurassic
	Harrison Lake formation	-----	Middle Jurassic
Camp Cove Series -- undivided	-----	Early Mesozoic	
(Conjectural Carboniferous limestone)	-----	Pennsylvanian	
Stollicum Series -- undivided	-----	Triassic	

The areas where these formations are best exposed are cut by faults, which however do not destroy the appearance of continuity of the major structure and are therefore presumably of small displacement. Consequently the possible errors which might be caused by these faults are not fundamental but are those of detail. On account of their structural relations these faults probably obscure small portions of the sections they cut. In order to eliminate as far as possible errors from this source, several sections have been compared and thicknesses have been thereby corrected. Finally, there are two results of fundamental stratigraphical importance, the second of which has not been previously attained in British Columbia, These are: description and complete measurement of Jurassic and lower

Cretaceous sedimentary series, and the delimitation of paleontologic zones in these series. The correlation of these zones in the several sections precluded the possibility of any fundamental error.

THE SLOLLICUM SERIES. The Slollicum is a thrust series: an immense translated sheet. It is separated from the autochthonous rocks by a thrust fault of great but unknown magnitude. Consequently its base can never be known in this area. What there is to be seen is a series over 15,000 feet thick of dynamically metamorphosed rocks occupying nearly the entire eastern shore of the lake, and much of the western in the northern half. The series is made up chiefly of slates and greenstones, the former predominating, interbedded and both strongly foliated. Rarely the foliation is weak, and in places where this is the case the slates appear as dark greenish or black argillites; the greenstones, as pyroclastics of fine grain usually, but occasionally coarse. In some places the foliation has proceeded to such a degree that the rocks are schists. A notable variation from the above types of sediment is a sandy phase occurring on the east shore near the north end of the lake and forming a zone about 3,000 feet thick. The Slollicum Series was studied much less minutely than were the less altered rocks, so no statements can be made in regard to detailed stratigraphy.

As might be expected this series yields few and poor fossils. Two faunas are discernable, but their composition and correlation

THE CAMP COVE SERIES. This series outcrops along the west shore of Harrison Lake from Camp Cove to a point about two miles south. These rocks are the oldest of the autochthonous series. They are brought to the surface by a dome structure of which they form the centre. The base of the series is not visible. The lowest beds seen are sandstones and black argillites, alternating with one another in thin beds for a thickness of about 2,000 feet along the shore from Camp Cove southward and on the hillside behind. These are overlain by several hundred feet of tuff. At Camp Cove this tuff is overlain by the basal agglomerates of the Porphyrite Series, but to the south the tuff is overlain by a chert member a hundred feet or so thick, followed by several hundred feet of conglomerate which forms the top of the series. This series has yielded no fossils of its own date but the conglomerate contains cobbles of Pennsylvanian limestone bearing fossils. This proves conclusively that the conglomerate is not older than Permian, and makes it seem probable that the date of its deposition is early Mesozoic. An additional reason for the latter conclusion is that palaeogeographic studies make it seem probable that no marine depositions took place in this region between Pennsylvanian and Middle Triassic time. The conglomerate contained well rounded cobbles of various sizes up to four inches in diameter of limestone; green, also black, chert; and green, altered igneous rocks of the extrusive type.

It is thought inadvisable to name the members of this

series because it is poorly exposed, the base is not seen, age not known, and therefore contributes but little toward geologic history.

THE PORPHYRITE SERIES. This series, on Harrison Lake so called because it is correlated with the Porphyrite Series of Tatlayeko Lake, outcrops along most of the west shore in the southern half of the lake, and westward as far as Chelalis Valley; also on Echo Island; in the southeast shore; and on both sides of Harrison River. The structure is that of strong but open folding. Cross faults are numerous and show a peculiar relationship. That area on the west shore occupied by the Camp Cove Series is domed up higher structurally than any other part. To the north of this area the normal faults are downthrown on the north side; to the east, on the east side; and to the south, on the south. Some of the faults classed as normal are really thrust faults, but the "fault plane" of none is far from vertical, the displacements are all small, and the general relations of all are so similar that they are classed together for the time being.

The Porphyrite Series is about 14,500 feet thick. It is made up in its lower part of the products of violent volcanic eruption; in its middle part, of pyroclastic materials deposited in the sea; and in its upper, principally of black

argillites of marine origin. On the basis of these three types of lithology it is possible to divide the series into three formations. The following names derived from localities are hereby applied:

- 3 Mysterious Creek formation
- 2 Echo Island formation
- 1 Harrison Lake formation

The Harrison Lake formation. This formation forming the lower part of the Porphyrite Series outcrops along the west shore of Harrison Lake from Camp Cove to Eagle Creek, this being considered the type section; also on the western three quarters of Echo Island; on west shore from the efflux two miles north; and on the mountain between Harrison and Fraser Rivers. The west shore outcrops continue westward as far as Chehalis Valley. The basal contact of the formation has not been seen, but occurs unexposed in Camp Cove where the Harrison Lake formation overlies the Camp Cove Series. On account of the structure it is believed to be an unconformity involving a perceptible discordance ~~.....~~. The main detail of the type section follows: --

Section, along the west shore of Harrison Lake from Camp Cove to Eagle Creek, in descending order.

_____ Top of formation, 200 yards north of the mouth of
Eagle Creek _____

Dark green, massive, vesicular rock (effusive or pyroclastic)-----	408
Chert and argillite-----	44
Dark green effusive rock-----	110

Pale green effusive rock-----	124
Coarse green tuff-----	300
Pale green effusive rock-----	220
Coarse green tuff-----	513
Pale green effusive rock-----	194
Coarse green tuff-----	293
Pale green effusive rock-----	194
Dark green effusive rock-----	271
Concealed-----	132
Coarse green tuff-----	609
Pale green effusive rock-----	176
Green tuff-----	315
Concealed-----	139
Reddish tuff-----	286
Green agglomerate-----	1320
Concealed-----	447
Coarse tuff-----	359
Black argillite-----	161
Fine red tuff-----	146
Green tuff-----	513
Pale green effusive rock-----	198
Green tuff-----	143
Pale green effusive rock-----	711
Red tuff-----	117
Pale green effusive rock (porphyritic)-----	495
Concealed-----	139
Green and red agglomerate-----	124
Concealed-----	44
Total-----	9240feet.

Base of formation, middle of Camp Cove

The following section on Echo Island shows the upper part of formation only. The sections are about six miles apart so a comparison will show the degree of stratigraphic correspondence to be expected.

Section on west and north shore of Echo Island, in descending order.

Top of formation, 1/4 mile south of the northeast corner of Echo Island, overlain by Echo Island formation

Grey massive tuff-----	560
Pale green effusive rock-----	100
Agglomerate-----	480

Pale green effusive rock	250
Black argillite	30
Pale green effusive rock	80
Fine green tuff	100
Pale green effusive rock	200
Agglomerate	350
Pale green effusive rock	300
Green tuff	160
Various tuffs	180
Pale green effusive rock	180
Black argillite	30
Agglomerate	100
Pale green effusive rock	100
Agglomerate	200
Green tuffaceous arkose	130
Total	3530 feet

_____ reposing on pale green effusive rock at the
point bounding Echo Bay on its north side _____

The great thickness of the whole is apt to surprise. Perhaps it is due to the kind of deposition -- mainly accumulation of volcanic ejecta. The flow rocks are peculiar in resembling intrusive porphyries in their occasional strongly porphyritic texture. In every case, however, these rocks are porphyritic only in their lower part. They grade upward into a non-porphyritic phase, and finally into a brecciated aa layer that was once, no doubt, the surface of the flow. There is therefore little doubt that they are contemporaneous flows of lava. On account of their being igneous rocks some authors would not include them in the section, but it is difficult to see how they could be separated. As regards occurrence and association they resemble the sedimentaries more than anything else, and they form a definite part of an epigene accumulation. They are therefore included.

The exact succession is uncertain since all the sections are broken by small faults. The detail of the type section is

therefore presented merely as a preliminary step toward the stratigraphy of this formation. Future work should locate and resolve the faults and enable missing portions of the section to be discovered and appreciated. The formation is overlain conformably by the Echo Island formation. No evidence of a time break between the two is to be found. The formations differ only in lithology not in origin. It is therefore believed that there is no hiatus in the deposition.

The formation has yielded few fossils, only one locality being known. This is on the southwestern shore of the lake, on the south side of a small bay, one mile north of the eflux. The fossils are found in coarse arkose beds, the relationship of which to the general section of the formation is at present unknown. The following species were collected:

Rhynchonella spp.
Pecten (Entolium) vulcanicus sp.nov.
Cylindrotenthis Themis sp.nov.

The date is probably Middle Jurassic.

The Echo Island formation. This formation is typically exposed on the southeast portion of Echo Island. It is also seen on Harrison River between Ingstrom's farm and Morris Creek; on the south side of Harrison River, opposite Morris Creek; and at other places. The formation rests conformably on the Harrison Lake formation, the basal contact, as well as a considerable sequence of strata, being excellently exposed on the south side of Echo Is-

land near the southeast corner. The uppermost part of this section occurs on the two islets off the southeast corner of Echo Island.

Section across the more easterly of the two islets, from east to west, in descending order:

Stratified tuffaceous arkose-----70

Section across the western islet from east to west, in descending order:

Concealed, between base of last section and top
of this, about-----10
Grey sandstone and argillite-----15
Coarse tuff-----11
Grey sandstone and argillite-----26
Coarse tuff-----16
Grey sandstone and argillite-----22
Concealed-----25
White tuff----- 2

_____reposing on the top of the fine stratified tuff which forms the top of the next section_____

Section on south shore of Echo Island, in descending order:

_____top of section, at little point on east side of Echo Island, 60 yards north of southeast corner_____

Fine stratified tuff----- 125
Coarse tuff----- 47
Tuff and chert interbedded----- 23
Fine tuff----- 20
Coarse tuff----- 23
Black tuff and chert----- 5
Concealed----- 13
Bluish tuff----- 21
Green tuff----- 29
Agglomerate----- 82
Fine green tuff with beds of coarser material----- 109
Massive tuff----- 51
Fine tuffaceous arkose----- 47
Coarse arkose----- 35

Chert with a few beds of arkose-----	39
Concealed-----	62
Chert-----	4
Tuff with interbeds of chert-----	58
Chert-----	15
Sandstone-----	31
Black tuff-----	27
Concealed-----	11
Dark argillite-----	31
Pale tuff, well bedded-----	64
Total-----	<u>1166 feet</u>

 base of formation, reposing on massive tuff of
the Harrison Lake formation on the south side of Echo
Island 670 yards from the southeast corner

This gives the thickness of that part of the Echo Island forma-
tion exposed at the type locality, the section being practically
continuous as far as it goes. At this locality the upper part
of the formation is concealed beneath the waters of the lake.
No complete continuous section could be found, but the total
thickness may be obtained from the section on Harrison River, the
base of which lies on Morris Creek; the top, on the south side
of the river. This section is severed in its middle part by the
presence of the Harrison River so no direct measurement can be
made. However, computation gives a total thickness of 2769 feet.
The detail of the upper part of the formation can be got from that
part of the section lying on the south side of the river, as
follows, in descending order:

 Top of formation in southwest corner of deep bay $\frac{1}{4}$
mile west of Macdonald's farm

Concealed near contact, about-----	45
Pale blue-grey arkose-----	100
Mainly pale and black argillites-----	303
Grey siliceous tuff-----	39
Various argillites and arkoses-----	211

Mainly stratified green tuffs-----501
Total----- 1199 feet

Base of section lies in small bay opposite
mouth of Morris Creek

This section is overlain conformably by the black argillites of the Mysterious Creek formation. Between the base of this section and the top of the type section there is about 400 feet of strata not measured, probably consisting of well stratified tuffs in the main such as are exposed on the north side of Harrison River west of Ingstrom's farm.

As far as can be judged from these and a few other measurements not published this formation maintains a fairly uniform total thickness but is very variable in individual beds which though they appear persistent to the eye have been found to be strongly lenticular. Most of the other occurrences of the formation add but little to what has been presented: they are unsatisfactory for the work of the stratigrapher in being too small, as that at the eflux of the lake; or broken by faults as that between Eagle and Deer Creeks. The essential characteristics of the formation are that it is well, and often minutely, stratified, and contains no intercalated flows, and very little really coarse pyroclastics. This means, of course, that the formation which marks a renewed marine invasion corresponds also to the decline and final cessation of the vulcanism of the Middle Jurassic.

The formation yields surprisingly few fossils. The type section including that on the east coast of Echo Island has yielded a few specimens at various horizons containing the following:

Pelecypoda, small fragments
"Belemnites" sp.

These are inadequate for correlation.

The Mysterious Creek formation. This formation is well exposed at two places -- along Deer Creek and over the divide into Mysterious Creek, and on the south side of Harrison River round Macdonald's farm, the former being considered the type locality since it yields the best fossils. The rocks which outcrop on the shore from the salmon hatchery to a point about a mile south of that are doubtfully referred to this formation. They are probably overturned. No detailed sections were measured since the formation consists almost entirely of black argillite. The total thickness computed from the section on Mysterious Creek is 2300 to 2900 feet; from that on Harrison River, 2300 to 2400 feet. Very rarely thin arkose or limestone beds are seen. At the top of the formation the argillite becomes slightly arenaceous but loses none of its black colour.

The palaeontology of this formation is important. About 300 feet above the base occurs a zone which yields the ammonoid Lilloettia exploratrix sp. nov. This species was obtained from both Deer Creek at 1275 feet and 1450 feet above the lake, and from a little point on the south side of Harrison River about 150 yards east of U. Macdonald's house. The genus Lilloettia is described for the first time in this report and consequently is not yet reported from other localities, but it occurs in southern Alaska: collections having been seen by the writer. The family to which it belongs is apparently confined to a small vertical

THE AGASSIZ SERIES. Since Bowen quoted the hills on the Agassiz flat as a fossil locality, it seems well to take that as a type section. But this section does not show the base, so recourse will be had to other localities also, to supply a more complete description. This series, entirely an Upper Jurassic one, is easily divided into two formations: the Kent, a thick mass of conglomerates; overlain by the Agassiz Prairie formation, a succession composed mainly of black argillites.

The Kent formation. The Kent formation, named after the municipality of Kent, is very meagrely exposed in what is considered the type section of the series to which it belongs. The exposure is at the west end of the more westerly of the two hills on the Agassiz flat. A better section is obtained on the mountain lying between Hammersley Prairie and the upper part of Harrison River. This gives the following section, descending order.

Top of section, at peak of mountain, 2930 feet

Fine grained, green, effusive rock, form and relations not determined-----	70
Conglomerate-----	160
Fine grained, green, effusive rock, form and relations not determined-----	60
Concealed-----	260
Conglomerate-----	485
Grey-green shale-----	500
Sandstone-----	25
Conglomerate-----	1075
Sandstone-----	150
Conglomerate-----	275
Total-----	3060 feet

Base of formation rests on black argillites of Mysterious Creek formation at altitude 1100 feet on north side of mountain

This section has yielded no fossils. The conglomerates show poor sorting. They contain pebbles of all sizes up to 8 inches in average diameter. The pebbles have been derived from the following rock types:

Micropegmatite
Porphyry, with quartz and white
feldspar phenocrysts, undoubtedly
from the Harrison Lake forma-
tion.
Tuffs, of all varieties
Quartzite
Pale chert
Black argillite.

The presence of the porphyry pebbles is especially important since it shows that by this time uplift and erosion had progressed sufficiently far in some part of the region to lay bare most of the volcanics of the Porphyrite Series. The micropegmatite is greatly altered. No original ferromagnesian minerals are preserved: their place is taken by chlorite, hematite and magnetite. This rock is quite unlike the granites of this area. It is possible that it came from the east, from the more ancient intrusives of the Gold Ranges.

The Kent formation is exposed also on Bear Mountain; on the west side of the Peninsula; and from a point just north of the mouth of Deer Creek, across Fossil Hill, to Mysterious Creek and beyond. The first two of these are composed of material of finer grain than the type sections but are not greatly dissimilar. The last needs special mention because it is quite atypical. Its composition differs markedly from all the others, and it is the only one which has yielded fossils. A section measured

along the shore of the lake gives the following detail, in descending order:

_____ Top of formation lies in a minute indentation of the shore 740 yards in a direct line north of the mouth of Deer Creek. Overlain by the Lower Cretaceous Peninsula Formation _____

Alternating sandstones, arkose and tuffs; with marine fossils-----	152
Agglomerate-----	29
Alternating sandstone and tuff-----	38
Coarse tuff-----	21
Sandstone-----	25
Arkose-----	10
Very fine sandstone-----	3
Arkose-----	32
Cherts and argillites-----	12
Coarse tuff-----	60
Green sandstone-----	50
Coarse tuff and arkose, interbedded-----	30
Coarse tuff-----	60
Sandstone-----	6
Coarse tuff-----	24
Arkose-----	15
Concealed-----	190
Arkose, with "Belemnites"-----	50
Coarse tuff-----	50
Concealed, 100' to 400', say-----	250
Total-----	125 feet

_____ Base of formation resting on the Mysterious Creek formation lies concealed 60 to 160 yards north of the first (lowest) rock outcrop on Deer Creek, which is $\frac{1}{4}$ mile from the mouth _____

The zone near the top of this section holding marine fossils yields the following species:

- "Arca" sp.
- Pecten (Entolium) sp.
- Lima sp.
- Meretrix ? sp.
- "Belemnites" sp.

These are of no value in correlation.

In its continuation northwestward the formation thickens but maintains the same general lithological character. Other fossils are found. On the southwest slope of Fossil Hill at 1850 feet above the lake, a fossil locality yields the following:

Trigonia dawsoni Whiteaves
Astarte harrisonensis sp. nov.
"Belemnites" sp.

It is very fortunate to find Trigonia dawsoni in this fauna because it has never before been dated. It was originally described from the Iltasyucco River, British Columbia, and has never been found anywhere else until discovered in the above association by the writer. While the Kent formation is not accurately dated yet it is tolerably certainly early Upper Jurassic, post-Cadoceras, pre-Cardioceras. This gives the approximate date of Trigonia dawsoni as Divesian, though it is possibly not entirely confined to that epoch.

The reasons for the lithological dissimilarity between this and the other sections are not clear. The differences are so great as to raise doubt as to the equivalence of this part of the formation with that in the type sections. Such a doubt is strengthened by the fact that only six miles away, on the west side of the Peninsula, the formation is fairly typical, being made up of conglomerates, sandstones, arkose, and grey-green shale, though poorly exposed. However, the several sections referred to this formation all occupy the same position in the general succes-

sion of geologic formations, and it is therefore believed that their inclusion in one formation is correct. The differences referred to above are regarded as the results of near shore deposition in a time of very various local conditions. If this view be correct, still greater differences may be expected in the exact equivalents of this formation at more distant localities. Those working in the region and suspecting they have strata of this general age should pay particular attention to this possibility, and remember that correlation in such a case is very difficult: almost impossible without palaeontological evidence.

The Agassiz Prairie formation. This formation is typically exposed on the two low hills and a little hillock on the Agassiz flat. Unfortunately sufficient time was not available to measure sections. However, it may be stated that the formation consists mainly of black argillite containing much gypsum. Interbedded with this are beds of various thickness of quartzite, arkose, tuffs, and limestone. The total thickness is about 3700 feet. The section dips to east. The base is seen near the west end of the most westerly of the hills where this formation rests conformably on the conglomerates of the Kent formation. The upper part of the formation is concealed beneath the valley filling so the top is not to be seen. The only other section is that forming the west end of Bear Mountain. It is probably inverted, and shows a somewhat less thickness.

Few fossils were obtained from this formation. One very

probably Argovian or early Kimmeridgian, which is quite in agreement with Bowen's unpublished opinion of 1912-13. So it is probable that the formation in question is contemporaneous with part of the Dewdney Series of the Coquihalla Area which has yielded Cardioceras, sensu lato.

THE QUESNEL RIVER SERIES. This series occurs in the form of a band averaging a mile wide lying between the autochthonous Jurassic and the exotic rocks. The series is entirely early Lower Cretaceous. The base rests on various Jurassic formations. The beds dip to the east and northeast. The top of the series is unknown since it is cut off at the thrust fault, where the Cretaceous rocks are overlain with fault relationship by the Stollicum Series. The basal unconformity must be considered. In the neighbourhood of Brokenback Hill, the series rests on the fossiliferous phase of the Kent formation; at the north end of the Peninsula it rests on the Mysterious Creek formation; at the south end of the Peninsula, on the typical Kent formation. At the south end of the lake no Cretaceous is known but the whole thickness of the Agassiz series overlies the Mysterious Creek formation. This means that folding and considerable erosion of the Jurassic sediments took place before the first Cretaceous deposition. However, it is to be noted that the utmost discordance demonstrable is only eight degrees; while for many miles in the country west of Brokenback Hill, in the close proximity of the batholith, the discordance between Jurassic and Cretaceous as shown by surface distribution of beds

is about two degrees. The unconformity is never sufficiently marked to be appreciated by the eye on an outcrop, and is in most places located only by the most critical studies of the sedimentation. The interpretation is, of course, that in this region the disturbance which closed the Jurassic was a gentle one. There is no doubt about this conclusion: it is one of the most obvious facts of the geology of the area. It is suggested that it will be well to re-examine the evidence in areas where a profound orogeny is reported.

The series is divisible into two formations: the Peninsula formation, of dark coloured sandstone with a basal conglomerate; overlain by the Brokenback Hill formation, of pyroclastics, arkoses, and argillites.

The Peninsula formation. This formation is exposed along the west side of the Peninsula, hence the name hereby given, and also on the west shore of the lake about half a mile north of the mouth of Deer Creek. The former section is rendered obscure by faulting so the latter will be regarded as the type. The detail follows, in descending order:

_____ Top of formation overlain by green, tuffaceous arkose of the Brokenback Hill formation, 235 yards from shore of lake, on left side of little brook which enters Harrison Lake 1450 yards in a direct line north of the mouth of Deer Creek _____

Dark green sandstone with <u>Aucella</u>	} Zone of <u>Tri-</u>	
<u>keyserlingiana</u> and <u>Trigonia aliciae</u>		<u>gonia aliciae</u> -----
Concealed-----		-----320

Very dark grey sandstone with <u>Aucella</u> <u>unschensis</u> , etc.	} Zone of -----440
Dark green sandstone with <u>Aucella un-</u> <u>schensis</u> , etc.	
Green arkose, with thin calcareous beds containing "Belemnites"-----	15
Green sandstone-----	40
Whitish arkose with occasional pebbles of granite, porphyry, chert, etc.-----	185
	Total----- 1260 feet

_____ Base of formation lies on tuffs of Kent forma-
tion on the west shore 740 yards in a direct line north
of the mouth of Deer Creek _____

The basal white arkose bears the following varieties of pebbles:

Granite-----	56%
Porphyry-----	19
Chert-----	13
Quartzite-----	12

The arkose undergoes a lateral transition toward the northwest
where it is gradually replaced by a basal conglomerate. This mem-
ber is about 200 feet thick where it crosses Mysterious Creek. It
is composed of well rounded pebbles of the following rocks:

Granite-----	37%
Porphyry-----	9
Chert-----	23
Black argillite-----	4
Sandstone-----	27

The pebbles are mostly of small size -- less than 4 inches in
greatest diameter. The matrix is of a pale sandstone and forms a
small proportion of the total bulk. The porphyry, chert, and black
argillite pebbles occur in the Jurassic conglomerates; but the
granite and sandstone occur in no conglomerates older than this.
The presence of these may be taken as a distinctive characteristic
of the early Cretaceous conglomerates of this district. The gran-

ite of the pebbles is composed mainly of orthoclase and quartz, with very small amounts of plagioclase occasionally, and hornblende as the only common accessory frequently largely altered to chlorite; and is exactly similar to the granite of the main body of the batholith seven miles west of Harrison Lake. This is the main evidence for dating the intrusion as Jurassic, and for presuming an unconformity between the granite and the Cretaceous sediments. But strong confirmatory evidence is supplied by the peculiar way in which the conglomerate thickens as the batholith is approached. The actual contact is located in country accessible only with great difficulty, and was not seen.

To return to the type section. Two important palaeontologic zones have been determined. The lower of these, the zone of Aucella unshensis has yielded:

- Aucella picchii Gabb. sp.
- A. picchii var. ovata Stanton
- A. picchii var. catamorphia var. nov.
- A. unshensis Pavlow
- Pecten (Entolium) sp.
- Palloceras knoxvillense Stanton
- Strophomena sp. nov.

Four of these species occur in the Knoxville of California, and one, Aucella unshensis in the early Eocene of Russia, zone of Craspedites stenomphalus. This indicates the probable correlation. The zone extends from the type section northwest and crosses the northeast slope of Fossil Hill. It also occurs on the northwest shore of the Peninsula, along the west side of the ridge of the Peninsula, and on the southwest side of the little bay on the southwest shore of the Peninsula.

The upper zone, that of Trigonia aliciae has been found only at the type locality, already indicated. It has yielded only three species:

Aucella keyserlingiana Trautschold
Trigonia aliciae sp. nov.
Arctica ? sp.

Of these, the Aucella is known in the early Neocomian of Russia, zone of Polyptychites keyserlingi. This helps to date the zone in British Columbia, but equally good is the evidence of its stratigraphic position between the zones of Aucella un-
schensis and that of A. crassicollis. The zone is named after the Trigonia because it is more distinctive and more easily recognized by field geologists than the Aucellae, the distinctions between which are very minute and occasionally quite baffling.

The Peninsula formation makes the base of the Cretaceous of this region. It represents a marine invasion of earliest Lower Cretaceous time. The most peculiar feature is not the lithologic development so much as the vast number of shells in the rocks, coupled with the poverty in species. This undoubtedly indicates that abnormal living conditions characterized these Aucella-bearing seas, but what these conditions were is still a problem.

The Brokenback Hill formation. This formation makes up the entire mass of the prominent feature known as Brokenback Hill, also much of the west shore of Long Island, and most of the east side of the Peninsula. The two former are regarded as the type sec-

late the zone, however it is tolerably certain that the fauna belongs to the upper Neocomian.

The noteworthy fact in regard to this formation is the presence of so much pyroclastic material -- not derived, but original. The discovery of this adds a hitherto unsuspected event to the recorded lower Cretaceous history of the region, namely a short period of volcanic activity between the hemerae of Trigonia aliciae and Aucella crassicollis. The sections show that about 2100 feet of material was accumulated in the time between these hemerae. The time involved is very short -- one fifteenth or less of the lower division of the Cretaceous period. This is valuable as an estimate of the rate of accumulation of pyroclastics. It shows that even for the building up of vast thicknesses like that of the Porphyrite Series, a great length of time is not required. Of course, this interpretation assumes, and the assumption is probably justified, that the accumulation of pyroclastics is not controlled, like that of other sediments, by the rate of upward movement of the base-level of erosion, at the site of deposition. It seems probable that the nature of much of the material of pyroclastics is such as to allow the deposit to be built far above the base-level and to preserve itself by exerting an influence through its own weight upon isostatic adjustment.

The following table shows the correlations of the two formations which make up the Quesnel River Series in this district.

SECTION VII

THE IGNEOUS GEOLOGY

Tabular Summary of the Igneous Rocks

Rock	Form	Date
Basalt	Small dikes	Miocene?
Quartz diorites	Stocks	Post-Laramide?
Hornblendite	Stocks	Post-Laramide?
Statlu granite	Large Batholiths	Jurasside
Granites	Small stocks	Jurasside ?
Quartz monzonites	Small stocks	Jurasside ?
The effusives of the Harrison Lake formation	Effusive flows	Middle Jurassic
Diorite porphyry	Small dikes	?

The Diorite Porphyry Dikes. Under this heading are included four or five small dikes, averaging less than ten feet wide, which cut the cherts of the Camp Cove Series a mile and three-quarters south of Camp Cove. The dikes strike roughly east and west. Andesine is the most abundant mineral. It occurs in large crystals enclosing pennine graphically; also in a second generation, in fine needles, making up much of the ground mass. Pennine, the next commonest constituent, occurs in crystals of very various sizes. All the pennine is an alteration of a ferromagnesian mineral none of which survives. Magnetite, apatite, and corundum are the commonest accessories. There is much secondary calcite.

Nothing is known of the date of the rock except that it is later than the Camp Cove Series. The extent to which alteration has progressed suggests that the age is near that of the group of rocks treated next.

The Effusives of the Harrison Lake Formation. These rocks oc-

occur as flows at various horizons in the Harrison Lake formation. They are of various types but are all notably acid in composition. The average is a dacite, most commonly porphyritic. A very few, notably those on Camp Cove Point, show marked flow texture. All are much altered, so that the groundmass is green to the unaided eye by reflected light on account of the presence of chlorite in the place of the original ferromagnesian minerals. Quartz and andesine occur in large phenocrysts, and also in a second generation, though quartz makes up most of the fine groundmass. Magnetite and apatite are minor accessories. There is much secondary calcite.

The best exposed occurrence is that at Camp Cove Point where there are several flows intercalated with pyroclastics. The flow on the easterly part of the point is about 300 feet thick. The basal part is strongly porphyritic. The middle part is without phenocrysts, and this grades upward into a brecciated layer which was once no doubt the surface of the lava flow. The flows are also well exposed on Echo Island and in the neighbourhood of Tennile Point.

The age of these extrusions is not accurately determined, but it is probable that they began about the end of the Lower Jurassic and continued well on through Middle Jurassic time.

The Statlu Granites. These are the Jurassic intrusions. They form large batholiths the eastern edge of which lies in the bottom of the Chehalis Valley, seven or eight miles west of Harrison Lake, in contact and cross-cutting relationship with the Porphyrite

Series. Most of this rock is a true granite. Orthoclase makes up slightly less than half the rock. Quartz is nearly the same in amount. Common hornblende, largely altered to pennine, is the chief accessory. There is about 1% of andesine present. Magnetite is a minor accessory. The texture is hypidiomorphic granular.

A variation from this type is found on the creek a few miles below Statlu Lake. This is a quartz monzonite of somewhat fine grain. The orthoclase and quartz are somewhat less in amount, while the andesine makes up more than a quarter of the total bulk. The hornblende is present in larger amounts than in the granite, making up about 10% of the whole. The latter is largely altered to pennine.

There are a number of other localities. Bosses of this granite occur: on the ridge between Harrison and Weaver Lakes where the composition is that of a true granite; on the same ridge, a mile and a half northwest of Camp Cove, where it is a granodiorite; and in a small creek, half a mile south of Doctor's Point where it is a much altered granite. Also, a large stock of coarse-grained granite borders the lake from Trethewey Creek to Tipella. An apophysis of this stock which crosses Trethewey Creek is a fine-grained granodiorite.

The chief characteristics of all these types is the presence of pale pink orthoclase, of common hornblende as the chief accessory, and the advanced alteration of the latter to pennine. These

three together with the total absence of biotite serve to identify the Statu granites in any situation and to distinguish them from the second group of intrusions, the quartz diorites.

The contact metamorphism is peculiar. There are few or no diaschistic dikes: none were seen. The contact phase of the intrusive is generally the fine-grained granodiorite type. The country rock, tuffs chiefly, is profoundly recrystallised and pyritized so that its original nature is unrecognisable in the first fifty to one hundred feet only. Beyond a few hundred yards the effects are imperceptible. Fossils collected within 300 yards of the batholith are well preserved except in cases where later compression has induced a mashing of the sediments against the more resistant igneous mass.

The batholiths have been dated as Jurassic from the facts that they intrude Jurassic sediments but supplied pebbles to the earliest Cretaceous.

In the northeast corner of the lake there are stocks and sills of a granitic intrusive cutting the Slollicum Series. The rocks partake of the same foliation which affects that series and so are probably "pre-compression" in age. Their relationships are not known.

The Quartz Diorites. These are the "post-compression" intrusives. There are two main occurrences and a number of smaller ones. The first of these is in the form of a long, narrow stock lying just north of Agassiz, and elongated in a NW--SE direction. One end of this crosses the Harrison River and terminates a mile or so be-

yond. The composition is similar throughout being that of a quartz diorite. Andesine, in zoned crystals, is the most abundant constituent, making up more than half the rock. Interstitial quartz forms about a quarter of the whole. Hornblende and biotite each make up about 10% of the total. Both of these show incipient alteration to chlorite. Magnetite and apatite are present in small amounts.

The contact metamorphism is slight. The intrusive shows no modification as the contact is approached, until at about 30 or 40 feet from it there is a sudden change to a fine-grained, micaceous rock which continues to the contact. The contact is generally very irregular on a small scale. The intruded rocks are strongly pyritized and micaceous near the contact, but beyond 100 yards they are not appreciably altered. Dikes are rare-- a few aplites were noticed on the south side of Bear Mountain.

The stock is dated tentatively as post-Laramide because it cuts the high-angled structures produced by the main compression. Possibly it is not later than the Miocene since it is cut by basalt dikes which are thought to belong to that period.

The other important occurrence of the quartz diorites is that which makes up Mount Douglas and extends across the lake at Doctor's Point. The composition is very similar to that of the quartz diorite at the south end of the lake. Andesine makes up more than half the rock. Hornblende and biotite the former usually predominating make up together about a quarter of the whole.

Both show slight alteration to various chlorites. Quartz rarely exceeds 15% of the total. The stock is intruded into the Slollicum Series. The contact metamorphism is similar to that of the other quartz diorite stock. The contact relations are important. The contact is frequently observed to cut across the foliation of the Slollicum Series. Occasionally minute apophyses invade the argillites along planes of foliation. Sometimes flat slabs of foliated rock and contorted masses of it are seen to have floated out into the intrusive. There is no evidence of differential movement between the intrusive and the intruded rocks. The meaning is obvious. The intrusion can be directly seen to have taken place subsequent to the induction of foliation. It can be shown indirectly to have taken place subsequent to the fault; because, had it not, the great compression would have caused differential movement between the soft argillites and the unyielding diorite mass, the effects of which could scarcely escape attention when they are persistently hunted for in good exposures.

There are several other occurrences. Castle Mountain is composed in part of a small stock of quartz diorite in which hornblende forms nearly one-third of the rock. Excellent exposures of the contact are seen on Stokke Creek showing that the intrusion occurred subsequent to the folding and the induction of foliation in the Slollicum Series. Another small boss occurs on Bear Creek where the relations are similar but the composition is more like that of the quartz diorite at the south end of the lake.

Also, on the west side of Chehalis Bay quartz diorite dikes occur intruding the old Jurassic granites. Contact metamorphism is very slightly developed, so that the relations are clear and striking.

A very peculiar type, which may be a phase of these intrusives, occurs on Seagull Island, one mile south of Twenty-mile Point. This is a hornblendite, made up mostly of hornblende but containing also, biotite, magnetite, and small amounts of plagioclase. The rock intrudes black argillites probably belonging to the Slollicum Series. The argillites are notably bleached at the contact.

The distinguishing characteristics of this group of rocks are: the abundance of andesine, the total absence of orthoclase, the presence of both biotite and hornblende as accessories, and the relative freshness of these two.

The Basalts. These rocks occur in the form of dikes cutting the quartz diorites, the Slollicum series, and all the Jurassic sediments. The dikes are very small, averaging two feet wide, and of comparatively short length. They were not studied in detail. They are tentatively placed as Miocene since they are possibly correlative with the Miocene intrusive and extrusive basalts of the interior.

SECTION VIII

SUMMARY OF THE STRUCTURAL GEOLOGY

This section is prepared chiefly for the convenience of those who wish to gain a comprehensive idea of the structural geology without wading through the entire report. For the purposes of analysis the entire area is divided into two main units. One of these is composed of the autochthonous rocks, sedimentary and intrusive, and occupies the southwestern quarter of the map area. This is composed of two Jurassic and one Cretaceous sedimentary series bearing gently discordant relationships to one another, and resting on a series of unknown age. The whole is compressed into strong though open folds. The best known of these is an anticline, the east limb of which forms the eastern boundary of the unit, and comprises all that is exposed on Harrison Lake. In the area lying from Camp Cove for two miles south the fold is domed up more than elsewhere, and here the oldest rocks are exposed. The whole mass is cut by numerous small faults. North of the area of upwarp at Camp Cove these faults are downthrown on the north side; to the east they are downthrown on the east side; and to the south, with one prominent exception, on the south. The sedimentary part of the unit is cut off on the west side by the main body of the coast range batholith, the contact roughly following the bottom of the Chehalis Valley. The relation to the Jurassic series is intrusive; to the Cretaceous, presumably unconformable. The Jurassic series in the southern part of the unit are cut by an intrusive stock of later date. On its east side this unit is bounded by a

steeply dipping thrust fault which has been called the Harrison Lake Overthrust in an earlier section of this report. It runs from the southeastern part of the area northwestward, so that it crosses the lake, passing longitudinally through Long Island and entering the west shore just south of Twentymile Point. The dip is steep -- about 57° to the northeast.

The other structural unit occupies the northeastern three-quarters of the area. It consists of a thick series of Triassic sediments dipping toward the northeast. The dip and strike vary from place to place corresponding to undulations at right angles to the general strike. In the neighbourhood of Stokke Creek the beds appear to be overturned. The details of the structure of this part of the area are, however, not yet well determined. This unit is intruded by stocks and sills of a granitic rock with a gneissic texture, the foliation of which parallels that of the intruded rocks. The whole unit has been compressed, folded, foliated, and finally thrust upward and westward, until it now no longer lies on its original basis but on the much younger Cretaceous rocks forming the top of the autochthonous unit. These movements were the result of by far the greatest disturbance which the area has suffered -- a veritable revolution, correlated tentatively with the Laramide Revolution of the eastern part of the Cordillera. Intrusive into the thrustsediments are quartz diorite stocks the contacts of which cut across the foliation. Also occasionally large slabs of the

foliated rocks are seen to have floated out a short distance into the intrusive. There is no evidence of differential movement between the intrusive and the intruded rocks. This is believed to mean that these intrusions are later than the compression. Of still later date are the small intrusive dikes of basalt which intrude these quartz diorites and both structural units. It is unfortunate for the cause of certainty that the direct relationships of these two latter igneous types toward the thrust fault have not been ascertained.