67-54

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 67-54

UPPER JURASSIC AND CRETACEOUS ROCKS OF TASEKO LAKES MAP-AREA AND THEIR BEARING ON THE GEOLOGICAL HISTORY OF SOUTHWESTERN BRITISH COLUMBIA

(Report and 14 figures)

J. A. Jeletzky and H. W. Tipper

Price, $3.50

1968

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ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1968

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ABSTRACT

The tectonically complex, predominantly argillaceous Callovian to Barremian rocks of Tyaughton Lake map-area are 5,000 to 9,000 feet thick; they were named Relay Mountain Group. This group lacks lithological horizon markers and exhibits extremely strong and irregular lateral facies changes. Its subdivision, correlation and structural interpretation are therefore only possible on a palaeontological basis. A number of palaeontological zones based on Buchia (=Aucella), ammonites and Inoceramus species was recognized in the predominantly marine, often fossil-rich rocks of Relay Mountain Group. Most of these zones are recognizable all over Western Canadian Cordillera. The base of the group is invariably faulted. A regional unconformity appears to separate it from the overlying Jackass Mountain and Taylor Creek Groups.

The Jackass Mountain Group comprises as much as 15,000 feet of greywacke, shale, and coarse boulder conglomerate of Aptian and (?)lower Albian age. The group is essentially non-marine and fossil flora occurs in places. The French Bar Formation of this group is a coarse boulder conglomerate apparently deposited at the base of an essentially granitic mountain range; it grades rapidly westward into finer marine basal conglomerates of the Taylor Creek Group.

The Taylor Creek Group is essentially marine Aptian and Albian black shale over 10,000 feet thick. It is interbedded locally with thick chert pebble conglomerate and with tuffs and volcanic breccias to the west. The group is believed to be the marine equivalent of much of the Jackass Mountain Group.

The Kingsvale Group, over 15,000 feet thick, overlies the Taylor Creek Group conformably. This group is subdivided into four units: Division A of pebble and cobble conglomerate, greywacke, shale and siltstone; Division B of andesitic and basaltic tuffs and breccias; Division C of volcanic conglomerate, greywacke and shale; and Division D also of andesitic and basaltic tuffs and breccias. Fossil flora in Division A indicates that the group is essentially of Cenomanian and (?)later age.

Late Middle Jurassic to Cretaceous rocks of Taseko Lakes map-area were deposited in a long, narrow, northwest trending Tyaughton Trough (new name) limited by cordillera-like tectonic lands in southwest and northeast. These were intermittently uplifted and supplied sediments to the Tyaughton Trough, which extended southeastward beyond international boundary. A sublatitudinal seaway connected Tyaughton Trough with the Vancouver Island-Queen Charlotte Islands Trough (new name) across northwestern Washington.

Tyaughton Trough apparently was connected with the Vancouver Island-Queen Charlotte Islands Trough northwest of Taseko Lakes map-area. Two more seaways must have been connecting the northwestern end of Tyaughton

Trough respectively with the late Upper Jurassic and Lower Cretaceous seas of Northern Yukon and those of northeastern British Columbia. These two seaways were permanently closed by the regional Aptian orogeny.

The two above mentioned seaways across the present Coast Mountains were apparently closed permanently in the latest Albian time. Thereafter, only non-marine volcanic and sedimentary rocks were deposited in Tyaughton Trough.

UPPER JURASSIC AND CRETACEOUS ROCKS OF TASEKO LAKES MAP AREA AND THEIR BEARING ON THE GEOLOGICAL HISTORY OF SOUTHWESTERN BRITISH COLUMBIA

INTRODUCTION

Early geological reconnaissance of the southern half of Taseko Lakes map-area by McCann (1922), MacKenzie (1921) and Dolmage (1929), revealed the presence of abundant Mesozoic fossils at many localities, but few collections were made and no attempt was made to study the area in detail. In 1937 and 1939 C.E. Cairnes (1943) and C.H. Crickmay mapped an area around Tyaughton Creek and southward, and many excellent fossil collections were obtained. It became obvious that one of the most complete and fossiliferous Mesozoic sections in Canada was exposed there. However, insufficient knowledge of the fauna and the structural complexities of the area hindered a satisfactory explanation of its stratigraphical and structural history.

In 1961 Tipper began a 4 miles to 1 inch mapping of the Taseko Lakes map-area (51°-52° Lat., 122°-124° Long.), and in the southern half of this area encountered the problems already faced by Cairnes and Crickmay, as well as additional stratigraphic problems in the southwestern quarter. The Upper Jurassic and Cretaceous strata in particular presented problems that were incapable of solution on the scale of mapping being attempted because: (a) most of these rocks are a monotonous succession of shale, siltstone, and greywacke with a few lithologic markers, (b) many thick sections are only sparingly fossiliferous, (c) the faunal succession was imperfectly known, and (d) the strata are complexly deformed by thrust faulting, normal faulting, and intrusion. To assist in the unravelling of the stratigraphic problems, Jeletzky visited the area for a month in 1963, and again in 1964, and made a detailed study of the Buchia-bearing Upper Jurassic strata above the lower Oxfordian Stage and of the Lower Cretaceous strata below the Aptian Stage. In view of the key role of the Taseko Lakes map-area in the understanding of the Upper Jurassic and Lower Cretaceous history of the southwestern part of the Canadian Cordillera, an attempt has been made to correlate the rock units of this period with those of adjacent areas and to outline the sequence of some important structural and palaeogeographical events apparently common to much of the region. Although the interpretations offered appear to be reasonable and satisfactory to the authors in the light of available information, they may well be subject to considerable adjustment and reappraisal in the future. The authors' names are listed alphabetically and their respective contributions to this report are briefly outlined below. Initials in brackets after headings throughout the report indicate authorship and main responsibility.

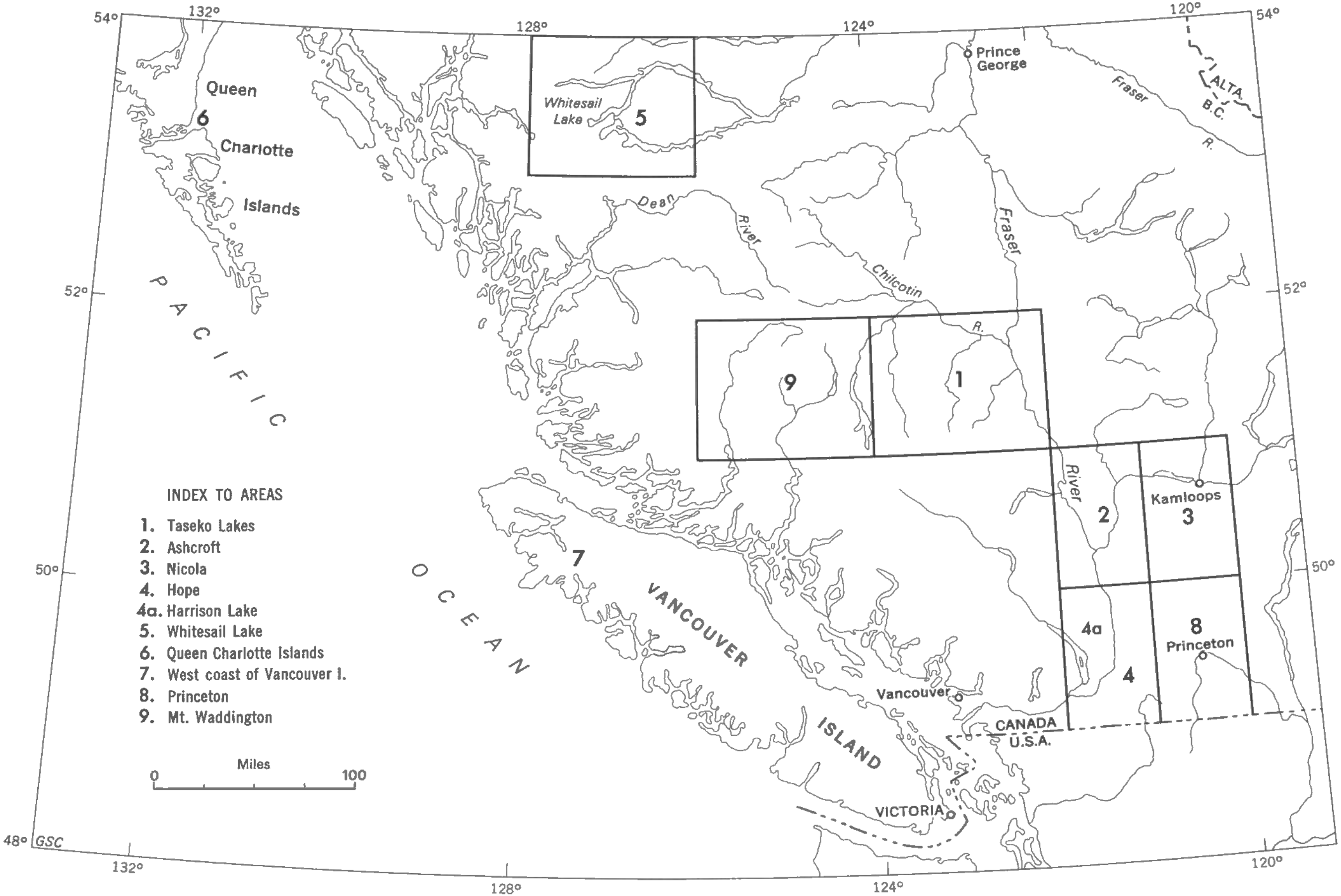

Figure 1. Location of areas.

The strata discussed in this paper span the time from the middle(?) Callovian Stage of the Middle Jurassic to the middle part of the Upper Cretaceous. All the stratigraphic sections included in the appendix were not investigated in the same detail, Sections 1 to 20 contributed by Jeletzky were studied in much greater detail than Sections 21 to 30 contributed by Tipper. The correlation charts based on the respective sections also differ in amount of detail.

The sections of Oxfordian to Barremian age were first examined by Tipper as part of the general mapping but these were subsequently measured and studied in detail by Jeletzky. These strata, for the most part, contain abundant fossils and provide excellent palaeontological control in an otherwise lithologically repetitious rock unit consisting of interbedded shale, siltstone, and greywacke. This unit is readily distinguished from the earlier Jurassic and Triassic rocks as well as from most of the younger groups. In part it was previously included in the Eldorado Group. The name Relay Mountain Group is proposed for these rocks largely on the basis of information provided by Jeletzky.

The rocks of Aptian, Albian, and early to (?) mid-Upper Cretaceous age presented different problems. The sections are extremely thick (see Table of Formations; p. 4), reasonably distinct lithologically, contain few fossils and are complexly faulted. Several groups of rocks are recognizable in this part of the column in Taseko Lakes map-area which are correlative to groups in adjoining areas. In only one of these groups are marine faunal zones recognized and the other groups are dependent for palaeontologic control on fossil flora. It was found that of these groups, few were dated correctly by previous workers. These groups will be discussed, described, and, in some cases, redefined, based on information obtained largely by Tipper. The information in general is much less detailed than in the case of Relay Mountain Group because of the lack of precise control and rapid examination of formations inherent in a regional study.

Except where otherwise indicated, invertebrate fossil identifications, relative age determinations of strata concerned, and other biostratigraphical comments have been provided by Jeletzky. All these data are based on preliminary study of the fossils and may be subject to change in the final stratigraphical and palaeontological reports by Jeletzky. The sections of the report dealing with the problems of depositional history, palaeogeography, Aptian tectonic movements and regional correlation have been written jointly.

TYAUGHTON TROUGH

All of the upper Oxfordian to (?) mid-Upper Cretaceous marine and non-marine rocks of the Taseko Lakes map-area apparently were deposited

TABLE OF FORMATIONS

<table>
<tr><th colspan="2">System and Series</th><th>Stage</th><th colspan="2">Formation</th><th>Lithology</th><th>Thickness</th></tr>
<tr><td rowspan="10">CRETACEOUS</td><td rowspan="4">Upper Cretaceous</td><td rowspan="4">Cenomanian and later</td><td rowspan="4">Kingsvlae Group</td><td>Division D</td><td>Andesitic and basaltic tuffs and breccias.</td><td>4,000'+</td></tr>
<tr><td>Division C</td><td>Volcanic conglomerate, greywacke, conglomerate, and shale.</td><td>200'-
600'+</td></tr>
<tr><td>Division B</td><td>Andesitic and basaltic tuffs and breccias, minor lavas.</td><td>6,000'+</td></tr>
<tr><td>Division A</td><td>Pebble and cobble conglomerate, greywacke, shale, siltstone.</td><td>5,400'+</td></tr>
<tr><td rowspan="6">Lower Cretaceous</td><td rowspan="2">Upper (?), Middle, and Lower Albian</td><td colspan="2">Taylor Creek Group</td><td>Chert pebble conglomerate, black banded limy shale, green tuffs, volcanic breccias, andesite and basalt.</td><td>10,600'+</td></tr>
<tr><td rowspan="3">Jackass Mountain Group (in part)</td><td>Division C</td><td>Greywacke, shale, thin pods and lenses of conglomerate, arkose.</td><td>8,000'+</td></tr>
<tr><td rowspan="2">Aptian</td><td>French Bar Formation (division B)</td><td>Boulder conglomerate, minor lenses of pebble and cobble conglomerate, greywacke, arkose.</td><td>2,000'-
3,000'+</td></tr>
<tr><td></td><td>Greywacke, shale, thin beds of conglomerate; similar to division C.</td><td>4,000'+</td></tr>
<tr><td colspan="5">Probable major unconformity with Jackass Mountain Group; possible disconformable relation with Taylor Creek Group</td></tr>
<tr><td>Barremian
Hauterivian
Valanginian
Berriasian</td><td colspan="2" rowspan="3">Relay Mountain Group</td><td rowspan="3">Argillaceous clastic sediments (shale, siltstone, mudstone), fine to coarse-grained greywacke, fine to coarse pebble and boulder conglomerate, minor volcanic rocks and impure limestone. <u>See</u> Fig. 14 for lithology and facies changes of individual subdivisions of the group.</td><td rowspan="3">From 5,000' to 9,000'+ depending on facies and location. <u>See</u> Fig. 14 for thicknesses of individual subdivisions of the group.</td></tr>
<tr><td rowspan="2">JURASSIC</td><td>Upper Jurassic</td><td>Upper Tithonian
Portlandian s. str.
Kimmeridgian
Oxfordian</td></tr>
<tr><td>Middle Jurassic</td><td>Middle (?) to Upper Callovian</td></tr>
</table>

in a long, narrow, northwest trending, subsiding trough which was limited by landmasses on the southwest and northeast. These provided sediments to the trough and are interpreted as cordillera-like tectonic lands which were intermittently uplifted and eroded. The geographical extent of these tectonic lands varied considerably throughout their geological history. However, their relative positions remained approximately the same. The depositional trough extended southeastward beyond the international boundary but its northwestward continuation is not well known. It is believed that the trough extended to the northwest across the area of the present Coast Mountains and was connected with the upper Oxfordian to mid-Upper Cretaceous marine trough that occupied the western side of Vancouver Island and Queen Charlotte Islands (Jeletzky, 1965b). The name Tyaughton Trough is proposed for this depositional trough of the British Columbia mainland.

RELAY MOUNTAIN GROUP

Introduction and Nomenclature

The presence of fossiliferous Upper Jurassic and Cretaceous rocks within the area was recorded by several early workers. Drysdale (1916, p. 79) introduced the name "Eldorado series" for a group of Lower Cretaceous sedimentary rocks along Eldorado Creek and on Eldorado Mountain. This usage was continued by Mackenzie (1921, pp. 74-76) and McCann (1922, pp. 34-35). Dolmage (1929, pp. 81-83) extended the age limits to include Upper Jurassic and Lower Cretaceous and Cairnes (1943, p. 7) accepted this extension but referred to it as the Eldorado Group. None of the reports by these geologists, however, described these rocks in detail. Tipper (1963) used the name Eldorado Group essentially in the same sense as Cairnes (1943, p. 7) in restricting it to the Upper Jurassic and Lower Cretaceous predominantly argillaceous and arenaceous rocks of the area. The authors are unable to continue the usage of Eldorado Group because in the type area of Drysdale's (1916) unit on Eldorado Mountain or in the valley of Eldorado Creek, the rocks exposed were found to be Triassic by Cairnes (1943) and late Lower Cretaceous (Albian) by Tipper (this report). Therefore, the authors have proposed the name Relay Mountain Group for the latest Middle Jurassic?, Upper Jurassic and Lower Cretaceous (mid-Callovian? to Barremian) strata found in the Taseko Lakes map-area and adjacent areas and have chosen as the type area the well exposed sections occurring on the northern and northeastern slopes of Relay Mountain and its unnamed northern spur (summit 8222). The combined Sections 11, 12, 13, 14 and 15 of the Appendix are proposed as the type section of the Relay Mountain Group. Neither the top nor the base of the group is exposed in the type section but all other known sections are less satisfactory and the possibility of a better type section appears remote.

Exposures of the Relay Mountain Group are apparently restricted to the southern half of the Taseko Lakes map-area (Tipper, 1963). South in the Pemberton map-area they are exposed along Yalakom River but have not been studied in detail. Other known but poorly studied outcrops of the Relay Mountain Group occur west of the area in the Chilko Lake area.

The Relay Mountain Group consists of a thick sequence of predominantly argillaceous clastic sediments containing many interbeds of fine to coarse greywacke and relatively few interbeds of grit and pebble conglomerate. Insignificant interbeds, bands or concretions of impure limestone and interbeds of volcanic rocks occur locally. All coarser rocks are characteristically poorly sorted and rounded; quartzose sandstones are not found. In spite of the abundance of well exposed sections above the tree-line, it was, for the most part, found impossible to subdivide the group into thinner lithologically distinct mappable units because of: (1) the extreme lithological monotony of the rocks with the apparent absence of distinctive and persistent lithological markers; (2) the pronounced and rather irregular lateral facies changes occurring throughout the group and commonly within short distances; (3) common repetition of lithologically similar argillaceous to greywacke units (commonly as recurrent pairs of rock units) at irregular intervals within the group; and (4) the extremely complex tectonics commonly resulting in the overturning of sections and their transformation into a series of "schuppen" separated by thrust fault planes, recognizable only because of the reversal or repetition of sequences of fossil zones.

The interpretation of sequence of beds within the individual sections of the Relay Mountain Group depends on the determination of their relative age by means of a set of invertebrate fossil zones worked out in this and other areas of the western Canadian Cordillera by Jeletzky (1950, 1954a, b, 1964a, 1965a, and this report). Similarly, the interpretation of the structure of the group and correlations of its sections with one another depend on the same set of fossil zones. This time-consuming task was greatly facilitated by the availability of reasonably well known and commonly closely similar successions of fossil faunas in adjacent parts of the western United States Cordillera (Anderson, 1938, 1945; Popenoe et al., 1960; Imlay, 1959, 1960) and in the Canadian Arctic (Jeletzky, 1964b, 1964c, 1965a).

The correlation of the regional fossil zones of the Relay Mountain Group with the international standard stages, based on the European fossil standard zones, is based exclusively on the index fossils.

Fossil Zones of the Relay Mountain Group

The fossil zones listed in Table I have been identified in the Relay Mountain Group of the Taseko Lake map-area. Probably this zonal sequence

TABLE I

Fossil Zones of the Relay Mountain Group

<table>
<tr><th>System</th><th>Stage</th><th colspan="2">Regional Fossil Zone</th></tr>
<tr><td rowspan="10">LOWER CRETACEOUS</td><td>BARREMIAN</td><td colspan="2">Poorly fossiliferous rocks containing indeterminate crioceratids (Hoplocrioceras?), inocerami and belemnites (unzoned).</td></tr>
<tr><td rowspan="5">HAUTERIVIAN</td><td colspan="2">Craspedodiscus cf. discofalcatus and Simbirskites cf. broadi</td></tr>
<tr><td colspan="2">Unfossiliferous rocks of a general mid-Hauterivian age (unzoned).</td></tr>
<tr><td>Inoceramus colonicus beds</td><td>Poorly fossiliferous rocks which contain only Inoceramus colonicus.</td></tr>
<tr><td colspan="2">Simbirskites (Hollisites) lucasi, Speetoniceras cf. agnessense and Simbirskites (Simbirskites) spp. indet.</td></tr>
<tr><td colspan="2">Homolsomites oregonensis and Inoceramus nov. sp. aff. quatsinoensis</td></tr>
<tr><td rowspan="4">VALANGINIAN</td><td colspan="2">Buchia crassicollis s. str. (including B. c. var. solida and B. c. var. gracilis Lahusen 1888 non Sokolov, 1908)</td></tr>
<tr><td colspan="2">Homolsomites quatsinoensis and Olcostephanus pecki</td></tr>
<tr><td colspan="2">Buchia pacifica s. lato</td></tr>
<tr><td colspan="2">Buchia tolmatschowi s. lato</td></tr>
</table>

System	Stage	Regional Fossil Zone
LOWER CRETACEOUS	BERRIASIAN	Buchia uncitoides s. lato and Spiticeras (Spiticeras) sp. indet.
		Buchia okensis s. lato (predominant) and B. uncitoides s. lato (more or less rare)
		Berriasella n. sp. aff. gallica Berriasella spp. indet.
UPPER JURASSIC	UPPER TITHONIAN (=UPPER VOLGIAN)	Buchia terebratuloides s. lato (including B. t. var. subuncitoides, var. subinflata and var. occidentalis). Early forms of B. okensis s. lato, and B. ex aff. fischeriana may be common locally.
		Buchia fischeriana s. lato. Late forms of Buchia lahuseni and var. tenuicollis and B. ex aff. terebratuloides s. lato are common locally.
	?	
	PORTLANDIAN S. STR. (=LOWER VOLGIAN)	Buchia piochii f. typ. (=B. russiensis f. typ.) and B. p. var. mniovnikensis. Buchia lahuseni and var. tenuicollis common in the upper part.
		Buchia cf. blanfordiana. Buchia piochii f. typ. and var. and Buchia n. sp. aff. piochii are common locally.
		Buchia n. sp. aff. piochii. Early forms of Buchia piochii f. typ. and Buchia ex aff. mosquensis s. lato are common locally.
	KIMMERIDGIAN	Buchia mosquensis s. lato and several insufficiently understood allied forms possibly characterizing fossil zones of their own (e.g. B. tschernyschewi, B. volongensis, B. lindstroemi) in the lower (upper Kimmeridgian) part of the zone.
	KIMMERIDGIAN / OXFORDIAN	Buchia concentrica s. lato (= ? B. bronni Rouillier) and insufficiently understood, allied forms.
	OXFORDIAN	Cardioceras spp. (Hans Frebold's identifications)

will be found to be essentially valid through most or all of the western Canadian Cordillera, although additional zones may be found in the presently unzoned intervals represented by poorly fossiliferous or unfossiliferous rocks, or in intervals which are probably faulted out.

The principles underlying the use of fossil zones by the writer have been outlined by Jeletzky (1956, 1965c). Unlike some other workers (e.g. Teichert, 1958), the writer does not hesitate to assign completely unfossiliferous rocks occurring between well established fossil zones in an apparently uninterrupted section to the appropriate intervening zones known to occur elsewhere in the area. A case in point is the Homolsomites oregonensis zone which is only known in the Tchaikazan River basin but is inferred to occur in Section 16 and elsewhere in the eastern part of the area although not confirmed by its index fossils.

The following remarks are intended to elucidate the age and correlation of fossil zones and their index fossils employed in this paper pending the publication of descriptions and figures of the species concerned.

The Hauterivian fossil zones of the area are essentially the same as those recognized by Imlay (1960) and Popenoe et al. (1960) in Washington, Oregon and California. The uppermost Hauterivian zone of Craspedodiscus cf. discofalcatus, etc. is believed to be equivalent to the Herteinites aguila zone of the Pacific slope of the United States. However, it seems more convenient to use the former name because of the apparent absence of H. aguila in Canada and the exceptional value of Craspedodiscus cf. discofalcatus for the purposes of intercontinental correlation.

In the United States (Popenoe et al., 1960, pp. 1506-1508) and outside of the Taseko Lakes map-area in the western Canadian Cordillera (Quatsino Sound; Jeletzky, unpublished) Inoceramus colonicus (= I. ovatoides) is known to range through most or all of the Hauterivian (possibly with the exception of the Homolsomites oregonensis zone) and into the lower Barremian (Shasticrioceras pontiente zone). In the Taseko Lakes map-area, however, it is almost confined to the middle part of the Hauterivian stage between the Speetoniceras-Simbirskites (Hollisites) zone below and the unfossiliferous middle Hauterivian rocks directly underlying the Craspedodiscus cf. discofalcatus, etc. zone above. This part of the Hauterivian is herein informally designated the Inoceramus colonicus beds (not zone) in view of the apparent regional usefulness of this species and the absence of any better index fossils in these beds.

All beds between the base of the Speetoniceras-Simbirskites (Hollisites) zone and the top of the Buchia crassicollis s. str. zone are included tentatively in the Homolsomites oregonensis zone. The unique occurrence of Homolsomites packardi in these beds (GSC loc. 62452) and those west of the area on Homathko River in the Mount Waddington map-area (GSC loc. 30389) suggest the possibility of the subdivision of these beds into Homolsomites packardi zone above and Homolsomites oregonensis zone below. More work must be done, however, to establish the zonal usefulness of H. packardi both in Canada and the United States (compare Popenoe et al., 1960, p. 1506).

The sequence of the Valanginian and Berriasian fossil zones of the Taseko Lakes map-area is the same as that recently established by Jeletzky (1964a, 1965a) for other parts of the western Canadian Cordillera. These zones and their index fossils are used here exactly as they were proposed by him.

The upper Tithonian (= upper Volgian) rocks of Taseko Lakes map-area are unique for the Pacific slope of North America in their apparently complete development and in their connection by transitional beds with the basal Berriasian Buchia okensis zone. It is expected that Sections 14 and 15 will form a standard section for rocks of that age in this region. The upper Tithonian zonal sequence already worked out by the writer clarifies a number of hitherto unsolved problems of the stratigraphy and biochronology of the Jurassic-Cretaceous transition beds throughout the Pacific slope of North America.

The Buchia terebratuloides s. lato (including B. t. var. subinflata and var. occidentalis) zone is obviously an important interregional uppermost Jurassic (=late upper Volgian or late upper Tithonian) zone corresponding to the little known Buchia fauna occurring in the topmost beds of the Knoxville series of California (Anderson, 1945, pp. 940, 942, pl. 12, figs. 1-2, 5-6; pl. 13, fig. 4, foss. loc. CAS 28037; Imlay, 1960, p. 159) on the one hand, and to the Craspedites (Taimyroceras?) canadensis and Buchia unschensis zone of the Canadian Arctic Archipelago (Jeletzky, 1964c, p. 105) on the other. The palaeozoogeographical and biostratigraphical importance of the Buchia terebratuloides var. subinflata fauna of California has already been stressed by Bodylevsky (1936, pp. 130-131).

Beds in California containing Buchia terebratuloides var. subinflata and var. occidentalis have been correctly placed in the Tithonian stage by Anderson (1945, p. 940) and Imlay (1959, p. 159) in spite of the recorded presence of Buchia okensis and B. subokensis. The zonal value of Buchia terebratuloides s. lato fauna was not recognized by these workers who have amalgamated it with the Buchia fischeriana zone. Sections in Taseko Lakes map-area reveal the independence of this fauna (see Section 14, unit 12; Section 15, unit 1) and its occurrence between the zones of Buchia fischeriana and Buchia okensis s. str. The common presence of the early variants of Buchia okensis (Pavlow) and forms transitional between B. fischeriana var. trigonoides and B. okensis in the Buchia terebratuloides s. lato zone of the

Taseko Lakes map-area explains and verifies the records of this species (Pavlow, 1907, p. 40, pl. 1, figs. 10a-10c; Anderson, 1945, pp. 940, 942) in the top part of the Knoxville series of California which have greatly puzzled Imlay (1959, pp. 159-160).

The appearance of Buchia okensis in the late upper Tithonian of North America confirms its time range observed in U.S.S.R. (see Jeletzky, 1965a); it stresses, at the same time, once more the unreliability of single Buchia specimens for exact age determinations. A reliable differentiation of the Buchia okensis zone proper from the next older Buchia terebratuloides s. lato zone depends, therefore, on the strong prevalence of typical and giant B. okensis forms in the former zone and on the apparently complete absence of B. terebratuloides var. subinflata, var. subuncitoides and var. occidentalis there. The reverse is true of the Buchia terebratuloides s. lato zone, which is, furthermore, rich in more typical forms of B. terebratuloides and in Buchia aff. lahuseni (Pavlow). Anderson's (1945, pl. 12, figs. 1, 5) determination of Buchia fischeriana from the Buchia terebratuloides s. lato zone is erroneous, the forms concerned being transitional between B. fischeriana var. trigonoides and B. okensis. Typical B. fischeriana (d'Orbigny) occurs rarely, however, in this zone in the Taseko Lakes map-area. Buchia forms allied to B. lahuseni Pavlow apparently account for Anderson's (1945, p. 940) records of B. piochii (Gabb) from the Buchia terebratuloides s. lato zone.

The underlying Buchia fischeriana zone proper appears to lack completely B. okensis, B. terebratuloides var. subinflata, and B. terebratuloides var. occidentalis, except possibly in its topmost beds. Even B. fischeriana var. trigonoides Lahusen, 1888 non Pavlow, 1907 is rare there. The lack of these forms and the predominance of large and typical representatives of B. fischeriana d'Orbigny in most sections permits the recognition of this early upper Tithonian (=early upper Volgian) zone and its differentiation from the overlying and underlying Buchia zones. The writer cannot agree with Anderson (1945) and Imlay (1959) that Buchia piochii (Gabb) is common in the Buchia fischeriana and Buchia terebratuloides s. lato zones. In Taseko Lakes map-area only closely related but nevertheless distinguishable descendants of B. piochii, such as Buchia lahuseni (Pavlow), and B. lahuseni var. tenuicollis Pavlow, and forms transitional between this species and B. terebratuloides s. lato (inclusive of B. terebratuloides var. subuncitoides Bodylevsky, 1936) are common in the Buchia fischeriana zone. These forms, which recently have been excellently described and figured by Gerassimov (1955, p. 95, pl. XIV, figs. 4-8), have been apparently lumped with B. piochii s. str. by Imlay (1959). Only relatively rare Buchia specimens, apparently indistinguishable from B. piochii s. str. have been seen by the writer in the lower part of the Buchia fischeriana zone in association with more common B. fischeriana and B. lahuseni.

The next older, presumably latest upper Portlandian s. str. (=latest lower Volgian) to (?) earliest upper Tithonian (=earliest upper Volgian) Buchia piochii zone is characterized by the strong predominance of B. piochii s. str. over all other buchias occurring in it. However, early, small to medium-sized forms of Buchia fischeriana and similar forms of B. lahuseni and its variants may be fairly common locally in the upper part of the zone. Contrary to Anderson (1945, pp. 964-965, 968) and Jeletzky (1965a), the writer now believes B. gabbi (Pavlow) and B. russiensis (Pavlow) as figured by Gerassimov (1955, pl. XIV, figs. 1-3) to be indistinguishable from the type specimens of B. piochii (Gabb) as figured by Anderson (1945, pl. 3, figs. 1-5) even on the infraspecific level. So restricted, B. piochii s. str. is common only in the beds occurring between the Buchia cf. blanfordiana and Buchia fischeriana zones, so far as the writer knows (see below).

The Buchia cf. blanfordiana zone (Jeletzky, 1964a, 1965a) was found to underlie immediately the restricted Buchia piochii zone in all sections studied. This confirms its late Portlandian s. str. (=late lower Volgian) age favoured by Jeletzky (1965a), while indicating that it can hardly correspond to the top part of that stage. In the Taseko Lakes map-area the Buchia cf. blanfordiana zone contains more variable populations of B. cf. blanfordiana as compared with those studied elsewhere by Jeletzky (1964a, 1965a). It often contains, furthermore, smaller or greater admixtures of B. n. sp. aff. piochii, B. piochii s. str., and other closely allied but insufficiently understood Buchia forms.

As on the west coast of Vancouver Island (Jeletzky, 1965a), the Buchia cf. blanfordiana zone is underlain by a sequence of beds characterized by predominance of small to medium-sized buchias closely allied to Buchia piochii (Gabb) s. str. These forms were previously identified as B. piochii var. russiensis (Pavlow), B. piochii var. mniovnikensis (Pavlow) and early forms of B. piochii (Gabb) (Jeletzky, 1965a). However, they appear to be specifically distinct, ancestral forms of Buchia piochii s. str. possibly synonymous with Buchia elderensis Anderson (1945, pl. 4, figs. 1-4), in part at least. Their best distinguishing features from B. piochii s. str. consist in the more or less marked left-handed incurvature of the strongly pinched and long left beak. This beak is more strongly coiled than that of B. piochii s. str. and, unlike the latter, tends to overhang the right valve. The shell of these forms is, furthermore, thicker than that of B. piochii s. str. and is more irregularly shaped. For the time being the forms concerned are designated as Buchia n. sp. aff. piochii. B. piochii s. str., and other forms, apparently indistinguishable from B. piochii s. str., have been seen in the upper part of the Buchia n. sp. aff. piochii zone and in the Buchia cf. blanfordiana zone. Buchia forms allied or transitional to B. mosquensis s. lato, and others resembling B. cf. blanfordiana but actually specifically identical with Anderson's (1945, pl. 12, fig. 3) Aucella cf. A. mosquensis, are other diagnostic elements of the Buchia n. sp. aff. piochii zone. They are especially common in its middle and lower parts. Beds with a mixed Buchia fauna including B. n. sp. aff. piochii and late forms of B. mosquensis s. lato occur between the zones concerned.

A more or less thick sequence of beds underlying the Buchia n. sp. aff. piochii zone is characterized by the predominance of typical Buchia mosquensis (Buch non Lahusen, 1888 nec Sokolov, 1908) and B. mosquensis var. rugosa Fischer, such as were described and figured by Gerassimov (1955, pp. 91-94, pl. XII, figs. 4-11), and several insufficiently understood, closely related forms possibly characterizing fossil zones of their own. The top part of this early Portlandian s. str. (=early lower Volgian) to mid(?)-Kimmeridgian zone is dominated by late, small to medium-sized and relatively thick-shelled Buchia ex gr. mosquensis (Buch) such as occur in the lower part of Division B on Grassy Island (Jeletzky, 1965a). These forms include B. mosquensis var. gracilis (Pavlow), B.m. var. rouillieri (Pavlow) and probably B. subpallasi Krumbeck. Typical large representatives of B. mosquensis (Buch) and its var. rugosa (Fischer) are rare or absent in these beds; they appear to be characteristic of the middle part of the Buchia mosquensis s. lato zone and become again largely replaced by other related forms, such as B. mosquensis var. polita (Keyserling), B. tschernyschewi Sokolov, B. volongensis Sokolov, and B. lindstroemi Sokolov in the lower (i.e. late to mid(?)-Kimmeridgian) part of the zone. So far as the writer knows, only the late phase of the Buchia mosquensis fauna has so far been recorded on the Pacific slope of North America by Jeletzky (1965a) and Anderson (1945, p. 965, pl. 3, figs. 8-11; pl. 2, figs. 9-10; under the name of Aucella sollasi Pavlow). It seems likely that the apparent absence of its two older phases in this region is due to a widespread hiatus caused by the Nevadan orogenic movements. It is also possible, however, that the typical representatives of B. mosquensis and its late to mid(?)-Kimmeridgian representatives (or ancestors?) only penetrated into the relatively unexplored northern parts of the Cordilleran geosyncline and thus have escaped discovery until now.

The oldest representatives of the Buchia mosquensis species group such as B. tschernyschewi, B. volongensis and B. lindstroemi, seem to be immediate descendants of the Buchia concentrica (=?Buchia bronni Rouillier) stock (Jeletzky, 1965a, Fig. 3).

The late Oxfordian to early Kimmeridgian Buchia concentrica zone directly underlies the oldest phase of the Buchia mosquensis zone in all sections studied. This zone is here interpreted in the conventional sense (Imlay, 1959, etc.).

The oldest fossil zone known in the Relay Mountain Group is characterized by Cardioceras sp. of early Oxfordian age, dated and identified by H. Frebold. This zone immediately underlies the Buchia concentrica zone in

Section 3 and seems to be devoid of any Buchia species. The underlying basal shales of the group are unfossiliferous and so can only be recognized because of their stratigraphic position and a rather characteristic lithology.

Stratigraphy, Age, Palaeogeography, and Origin

The subdivisions of the Relay Mountain Group proposed and described below are believed to be sufficiently distinctive to be recognizable in thick, well exposed sections. However, most of them are not distinctive enough from lithologically similar rock units present elsewhere in the underlying and overlying parts of the group to be safely recognizable on lithology alone. The same is, furthermore, true of most recurrent pairs of rock units (e.g. shale and greywacke units) within the group. Recognition of all such "lithological" subdivisions of the Relay Mountain Group depends explicitly on their fossil content which is reflected in most of the names introduced for them in this report (see Fig. 14 and below).

This type of stratigraphic unit is a combination of biochronological units in the sense of Jeletzky (1956) with the rock-stratigraphic units. It is introduced experimentally for lithologically monotonous and structurally complex but richly fossiliferous rock sequences of the western Canadian Cordillera where it is impossible to use successfully the ordinary rock-stratigraphic units of formational and member rank. It is expected that field geologists would find it easier to map these "lithological" units than the biochronological units (fossil zones and stages) proper.

The admittedly long names given to the individual "lithological" subdivisions of the Relay Mountain Group purport to elucidate the highlights of their age limits and lithology at a glance.

Mid-Callovian(?) to lower Oxfordian shale

A thick succession of shale with some siltstone interbeds and inclusions forms the basal unit of the Relay Mountain Group and it is designated as the mid-Callovian(?) to lower Oxfordian shale.

The rocks comprise a relatively uniform succession of soft, pure to silty, dark grey to black shale interbedded in places with lighter coloured, grey to dark brown shale (compare Section 16). Minor interbeds of similarly coloured, harder, occasionally splintery siltstone and shale occur in most sections studied; but they seem to be more common in the upper 100 to 150 feet of the unit. Loaf-like concretions 4 to 5 feet long and 2 to 3 feet thick of moderately hard to hard, grey to black shale and siltstone occur scattered or in rows in some sections (see Section 16, unit 3). No sandy siltstone or sandstone interbeds were seen. Many members and beds of the unit tend to weather brownish grey or dark brown but for the most part they retain their dark grey to black colouring in the weathered state. Near intrusive bodies or fault zones all rocks of the unit tend to become harder, splintery and weather orange- to rust-coloured (see Section 3, units 1, 3). Elsewhere the rocks of the unit weather earthy and recessively, producing poorly exposed, relatively gentle slopes.

Most of the known outcrops are restricted to the southwestern flank of Tyaughton Trough (Section 3) and its axial part (Sections 2, 16). It is only doubtfully recognized on the northeastern flank of the trough (Section 13), which is due almost certainly to the paucity of exposures. Unlike most of the younger subdivisions of the group, the sequence retains its characteristic lithology over its entire exposure area.

The contact with the overlying upper Oxfordian to lower Kimmeridgian variegated rocks is abrupt and possibly disconformable in three out of four suitable sections of the unit. In these sections a few feet of pebbly greywacke with lenses and inclusions of pebble conglomerate and "belemnite battle fields" overlie shales or siltstones of the top part of the unit with an abrupt and possibly uneven contact. Section 13 does not seem to exhibit this basal conglomerate. However, it is not certain that the unfossiliferous shales and siltstones tentatively assigned to the mid-Callovian(?) to lower Oxfordian shale in this section really belong there, instead of representing the unfossiliferous phase of the upper Oxfordian to lower Kimmeridgian variegated rocks. The lower contact of the unit is not exposed in any of the sections studied by Jeletzky. In some sections studied by Tipper its lowermost beds exposed occur in proximity to the apparently next older, fossiliferous lower Callovian rocks, however, in all such cases faults appear to separate the rocks of these two units. Elsewhere in Taseko Lakes map-area a thick succession of Callovian grits, pebble conglomerate and greywacke grade upward into unfossiliferous greywacke and shale strata possibly representing the lower part of the mid-Callovian(?) to lower Oxfordian shale unit faulted out in other sections. The base of this section containing a lower Callovian (according to H. Frebold) fauna rests unconformably on lower Bajocian rocks. Middle and late Callovian fossils have not been found but the thickness of section and the gradation upward toward a more shaly facies suggest that rocks of middle and late Callovian age and correlatives of the mid-Callovian(?) to lower Oxfordian shale may occur in one unbroken conformable section above the lower Callovian rocks. If this can be substantiated there may be justification eventually in extending the lower contact of the Relay Mountain Group to a natural break, the unconformity below the lower Callovian rocks.

The mid-Callovian(?) to lower Oxfordian shale apparently is more than 1,000 feet thick and may possibly reach 2,000 feet (it was not measured, however, in any of the longest sections studied because of poor exposures and structural complications).

The uppermost beds of the unit contain the early Oxfordian fossil Cardioceras sp. in two of the sections studied (identified and dated by H. Frebold). The older beds did not yield any diagnostic fossils and are believed to be of earliest Oxfordian to mid-Callovian age because of assumed superposition on lower Callovian rocks (see above).

Upper Oxfordian to lower Kimmeridgian variegated rocks

A moderately thick rock unit characterized by the presence of Buchia concentrica (=?B. bronni Rouillier) has a fairly distinctive lithology which does not seem to vary much within the area. This unit consists typically of beds 10 to 60 feet thick of dark grey to brown-grey, commonly weathering brown to rust-coloured, soft to medium hard siltstone and silty shale. These are interbedded with less common 3-inch to 15-foot thick beds, layers and inclusions of fine (predominantly) to coarse grained, poorly sorted, often gritty and pebbly, dark green, or yellowish green greywacke. A few, mostly lenticular 1/2 to 5-foot thick beds and pods of fine to coarse, pebbly grit and fine to medium pebble conglomerate are irregularly distributed in most sections studied. One of these beds commonly forms the base of the unit. These grit or conglomerate interbeds often have abundant broken and abraded guards of Cylindroteuthis-like belemnites forming the so-called "belemnite battle fields". These guards were probably locally derived and redeposited by waves or currents. Granitic pebbles were noted in these interbeds in addition to various sedimentary and metamorphic pebbles. This is the oldest known occurrence of granitic pebbles in Taseko Lakes map-area.

The best, essentially complete section of the upper Oxfordian to lower Kimmeridgian variegated rocks (Section 16), is situated in the axial zone of Tyaughton Trough (Fig. 14) and has a minimum measured thickness of about 454 feet. However, the true thickness of this section is almost certainly greater; it may approach 800 feet if the present width (across general strike) of the tectonic breccia of unit 13 of this section is fairly close to its original true thickness. The almost unfaulted, apparently complete section situated on the northeast flank of the trough has a minimum measured thickness of fossiliferous upper Oxfordian to lower Kimmeridgian variegated rocks of about 464 feet (Section 13). The underlying unfossiliferous shale-siltstone unit, 159 feet thick, could, however, be an unfossiliferous phase of these beds rather than the upper part of the mid-Callovian(?) to lower Oxfordian shale to which it is tentatively referred. Other sections (Nos. 2, 3, 8) only expose partial successions of the upper Oxfordian to lower Kimmeridgian variegated rocks.

Buchia concentrica first appears only a few feet above the top of the mid-Callovian(?) to lower Oxfordian shale which does not appear therefore to include any upper Oxfordian rocks. The contact between the two units concerned corresponds therefore approximately with the lower-upper Oxfordian boundary. The upper boundary of the upper Oxfordian to lower Kimmeridgian unit was drawn between the Buchia concentrica and Buchia mosquensis zones as there are no suitably situated lithological markers, and the rocks of these two zones are difficult to distinguish on lithology alone. These lithologically variegated beds are of late Oxfordian to early Kimmeridgian age in terms of the international standard stages. The complete lack of identifiable zonal ammonites makes it, however, impossible to correlate these beds with the standard ammonite zones of other North American regions.

The ratio of greywacke and coarser clastic rocks to the always predominant shale and siltstone varies strongly in the sections studied. However, this lithological variation appears to lack any regularity that would suggest the differentiation of facies of the axial zone of Tyaughton Trough from that of its marginal parts, such as is clearly perceptible for the younger phases of its existence (beginning with Buchia mosquensis time). This lack of differentiation is believed to be a real feature characteristic of the mid-Callovian(?) to lower Oxfordian and upper Oxfordian to lower Kimmeridgian phases of development of the trough. It is not certain whether this lack of differentiation is due to the existence of a wider trough during Buchia concentrica time than in the subsequent phases of the trough's development, to lack of subsidence in its axial zone or other causes. The current interpretation may be subject to revision in view of the small number of sections studied and the fact that only one of them is situated on the northeastern flank of the trough (Section 13).

Mid(?)-Kimmeridgian to Portlandian s. str. beds

A lithologically diversified succession of rocks immediately and apparently gradationally overlying the upper Oxfordian to lower Kimmeridgian variegated rocks, comprises 1,400-1,500 feet of predominantly fine to coarse grained greywacke in most sections studied. In at least one section (Section 16), situated in the axial zone of the trough, the exactly equivalent rocks are only about 150 feet thick and are represented almost exclusively by siltstone. These beds form three distinct facies belts shown in Figures 2 and 12. Because of these far reaching facies changes the mid(?)-Kimmeridgian to Portlandian s. str. rocks of the area can only be recognized by their fossil content and are named accordingly. The boundaries of the mid(?)-Kimmeridgian to Portlandian s. str. rocks cannot be closely dated either in terms of the international standard stages or in those of the standard ammonite zones of the boreal and Tethyan provinces because of a total lack of identifiable ammonites in this area. It seems likely, however, that this unit

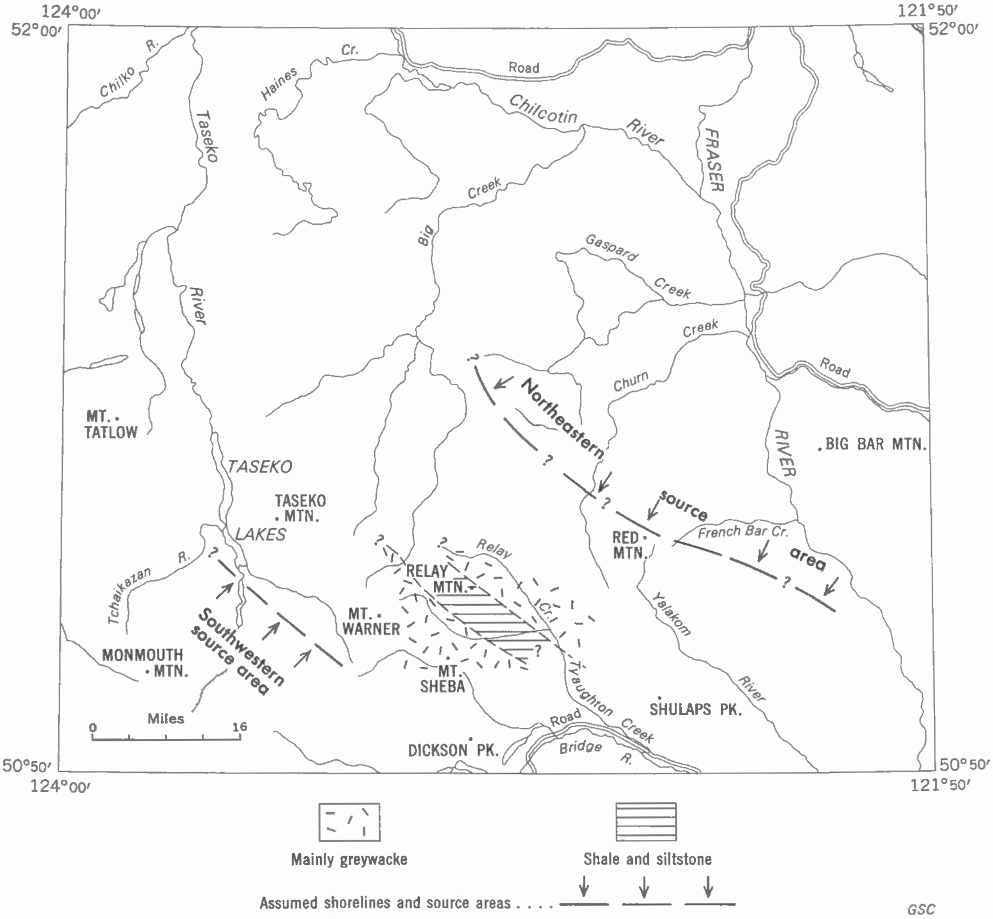

Figure 2. Facies of Portlandian s. str. rocks in southern part of Taseko Lakes map-area

includes rocks ranging from mid(?)-Kimmeridgian to late but not the latest Portlandian s. str. (=lower Volgian) of the international standard. It includes the following zones of the regional standard (Jeletzky, 1964a, 1965a and this paper pp. 7-8): Buchia mosquensis zone, Buchia n. sp. aff. piochii zone, and Buchia cf. blanfordiana zone.

Although the lower boundary of the unit is best defined palaeontologically, the strong predominance of siltstone and shale in the upper Oxfordian to lower Kimmeridgian variegated rocks and the almost equally strong predominance of greywacke in the mid(?)-Kimmeridgian to Portlandian s. str. beds permit their differentiation on lithology in most of the long and well exposed sections. The upper boundary is characterized by an abrupt change from dark grey greywacke to dark grey siltstone or shale of the latest Portlandian s. str. to late Berriasian shale unit in some sections (e.g. Section 14). However, in several other sections no lithological change occurs at this level (Section 16) whereas in some other sections situated on the southwestern flank of the trough (Section 3), siltstone of the Buchia cf. blanfordiana zone grades upward into a variegated siltstone-greywacke-pebble conglomerate sequence of latest Portlandian s. str. to late Berriasian age. Therefore, the upper boundary of the mid(?)-Kimmeridgian to Portlandian s. str. rocks is best defined palaeontologically; it is drawn between the Buchia cf. blanfordiana and Buchia piochii s. str. zones.

The mid(?)-Kimmeridgian to Portlandian s. str. rocks of the Taseko Lakes map-area exhibit a facies and thickness pattern (Fig. 2) that differs markedly from that of the underlying beds of the Relay Mountain Group and is essentially similar to that observed in most or all of its younger beds.

One of the three contrasting facies belts of the mid-Kimmeridgian to Portlandian s. str. rocks shown in Figures 2 and 14 is typified by Section 16 which is believed to be situated in the axial part of Tyaughton Trough for the reasons given below. This facies is characterized by a predominance of dark grey, mostly pure siltstone and shale. Sandy siltstone, greywacke and coarser clastic types are absent, except for a few interbeds and lenses of sandy siltstone and fine, silty greywacke not exceeding 6 inches in thickness. This facies is, furthermore, characterized by an exceptionally small thickness of the unit concerned which is only about 150 feet thick in Section 16. It is, however, possible that the rocks are tectonically thinned out in this critical section. The lower part of the mid(?)-Kimmeridgian to Portlandian s. str. rocks corresponding to the Buchia mosquensis s. lato and Buchia n. sp. aff. piochii zones is unfossiliferous in Section 16; it is, however, possible to date it indirectly as it is connected by transitions with the underlying and overlying fossiliferous rocks of the Buchia concentrica and Buchia cf. blanfordiana zones.

The second contrasting facies belt is situated to the northeast of the first. It is represented by Sections 1, 13 and 14, which are characterized by alternation of mostly thick beds of dark grey to greenish grey or dull green, fine to coarse grained greywacke with considerably less common and mostly thinner beds of dark to green-grey often rust- to orange-weathering siltstone. Minor interbeds of dark to bluish grey shale, grit, and pebble conglomerate occur at irregular intervals in some sections. Siltstone and shale beds are characteristically concentrated near the base and top of the unit whereas its considerably thicker middle part is built predominantly of various greywackes. These greywackes are commonly poor in marine fossils and carry some plant remains and carbonaceous specks. The complete sections of this facies belt are from 1,400 to 1,500 feet thick (see Section 13). The lateral replacement of the siltstone facies by the greywacke facies of the mid(?)-Kimmeridgian to Portlandian s. str. rocks must be rapid as Sections 13 and 14, which are situated close to its axial part represented by Section 16, differ strongly from the latter in lithology and thickness (see Fig. 11). Further lateral changes are apparent within the greywacke facies itself as the greywacke becomes for the most part coarser and gritty between Sections 13 and 14 on the one hand and the northeasternmost Section 1 on the other, as shown in Figures 11 and 14. Furthermore, considerable interbeds of fine to coarse grit and some conglomeratic interbeds lacking in Sections 13 and 14 appear in Section 1.

The third contrasting facies belt is found southwest of the first and is represented by Sections 3, 7, and 8 (see Figs. 2, 14). The lithology of the rocks found in the southwestern facies belt is essentially the same as that of the rocks in the second (northeastern) facies belt, which suggests that they both represent the marginal zones of Tyaughton Trough whereas the intervening siltstone facies represents the axial part of the same trough (Fig. 2). The only apparent difference between the northeastern and southwestern marginal belts of the mid(?)-Kimmeridgian to Portlandian s. str. rocks consists in the development of the Buchia cf. blanfordiana zone in Section 3. In spite of its apparently almost complete development in this section, the Buchia cf. blanfordiana zone is represented almost exclusively by siltstone (Section 3, unit 16) and lacks any traces of the thick greywacke beds of Sections 13 and 14. However, the underlying beds of the mid(?)-Kimmeridgian to Portlandian s. str. rock unit in Section 3 appear to be similar lithologically to the corresponding parts of this unit on the northeastern flank of the trough. This is true of Sections 7 and 8 and of the southwesternmost known outcrop of the Buchia mosquensis zone which occurs about 3 miles northwest of Section 3 on the northwestern side of Tosh Creek at a point about 1 3/4 miles up from its confluence with Big Creek. This outcrop consists of about 200 feet of fine- to coarse-grained greywacke similar to that of unit 1 of Section 7. The fine-grained character of the Buchia cf. blanfordiana zone in its only known, extensive section on the southwestern flank of the trough may possibly indicate its gradual widening toward the southwest during this part of mid(?)-Kimmeridgian to Portlandian s. str. time. It could, however, reflect the gradual decrease of the relief of the tectonic land situated southwestward of the trough during the same period of time. It is difficult to choose between these possibilities in the present state of our knowledge as the facies relationships prevailing during Buchia n. sp. aff. piochii time on this flank are completely unknown and those of Buchia mosquensis time are rather imperfectly understood.

No complete sections of the mid(?)-Kimmeridgian to Portlandian s. str. rocks are known on the southwestern flank of Tyaughton Trough. Their thickness there must be in the order of 500 to 600 feet at the very least and could well be comparable to that measured on the northeastern flank. It is remarkable that all the thick sections of the mid(?)-Kimmeridgian to Portlandian s. str. rocks known to date consist of medium to coarse clastics and are restricted to the marginal parts of Tyaughton Trough (Figs. 2, 14).

Latest Portlandian s. str. to late Berriasian shale

A moderately thick shale-siltstone unit of the latest Jurassic to earliest Cretaceous age overlies conformably and gradationally the mid(?)-Kimmeridgian to Portlandian s. str. greywackes in Sections 13 and 14 and the siltstone facies of these rocks in Section 16. This shale-siltstone unit is characterized by a strong prevalence of medium to dark grey shale, usually soft, with numerous 1/2 to 3-foot thick bands and concretions of grey, hard, calcareous shale, impure, cryptocrystalline limestone, and rust-weathering clay ironstone. Considerable interbeds of mostly dark grey to blackish grey, pure to sandy, occasionally more or less glauconitic siltstone occur in various parts of the division. These siltstone interbeds are rich in the same bands and concretions as occur in the shale. The glauconitic siltstone, commonly sandy, appears to be restricted to a narrow belt of rocks just beneath the Jurassic-Cretaceous boundary (e.g. Section 14, units 9, 10, 12). Only rare and thin interbeds or inclusions of sandy siltstone, fine grained, silty greywacke and (?) volcanic tuff have been noted in the Jurassic part of the division. No coarser rock types have been seen in it.

The latest Portlandian s. str. to late Berriasian shale unit is about 854 feet thick on the northeastern slopes of the Relay Mountain massif (see Sections 12, 14, 15). In these sections its Jurassic part is about 518 feet and the Cretaceous part is about 336 feet thick. Elsewhere (e.g. Section 16), only partial sections of the unit have been seen but its thickness seems to be about the same as on Relay Mountain.

The shales of the latest Portlandian s. str. to late Berriasian shales extend farther northeastward than the shale facies (Section 16) of the mid(?)-

Kimmeridgian to Portlandian s. str. rocks as they overlap the greywacke facies of the latter rocks in Sections 13 and 14 (Fig. 14). This facies change reflects a considerable northeastward expansion of the axial part of Tyaughton Trough in the latest Jurassic and earliest Cretaceous time which was probably caused by a subsidence of its northeastern flank. The full extent of this subsidence is not known as no outcrops of the corresponding rocks have been found anywhere northeast of the Relay Mountain massif. Oddly enough, no traces of a corresponding subsidence are present on the southwestern flank of the trough where contemporary rocks are represented for the most part by fine to coarse, commonly pebbly greywacke with some interbeds of pebble conglomerate. This marginal facies of the latest Portlandian s. str. to late Berriasian time appears at the headwaters of Tyaughton Creek (Section 4, unit 1; Section 8, units 7-9) and on Elbow Mountain (Section 3, units 18-32).

The latest Portlandian s. str. to late Berriasian shale unit spans the Jurassic-Cretaceous boundary. No erosional disconformity, let alone an unconformity, is present at this boundary which occurs within an apparently uninterrupted shale sequence. The Buchia fauna changes gradually across the boundary. The only possible suggestion of shallowing of the sea at the Jurassic-Cretaceous boundary consists in the appearance of interbeds of glauconitic and sandy siltstone in the upper part of the Buchia fischeriana zone and in the Buchia terebratuloides s. lato zone (see Section 14, units 9, 10, 12).

The boundaries of the latest Portlandian s. str. to late Berriasian shale unit cannot be closely dated either in terms of the international standard stages or in those of the standard ammonite zones of the boreal and Tethyan provinces because of the absence of well preserved zonal ammonites. The age of the Buchia piochii s. str. zone is, however, reasonably well known and has already been discussed in this report. The position of the Jurassic-Cretaceous boundary within the unit can be determined with considerable precision as the Buchia terebratuloides s. lato zone is known to be of upper Volgian (=upper Tithonian) age and the next younger Buchia okensis f. typ. zone has been reliably correlated with the early Berriasian (=Ryasanian) stage (Jeletzky, 1965a). In all outcrops studied the latest Portlandian s. str. to late Berriasian shale unit includes the regional zones of: Buchia piochii f. typ., Buchia fischeriana s. lato, Buchia terebratuloides s. lato and Buchia okensis f. typ. (including its overlap beds; see Jeletzky, 1965a, pp. 17, 18); it includes, furthermore, the lower part of the Buchia uncitoides s. lato zone proper.

White-weathering coquinoid member

The latest Portlandian s. str. to late Berriasian shale unit is conformably and gradationally overlain by 100 to 150 feet of calcareous, light coloured siltstone interbedded with impure coquina limestone. The known deposition area of this characteristically white-weathering member is the same as that of the underlying latest Portlandian s. str. to late Berriasian shale unit. Like this unit the white-weathering coquinoid member is restricted to the considerably expanded (as compared to mid(?)-Kimmeridgian to Portlandian s. str. time) axial part of Tyaughton Trough as it is flanked by belts of essentially contemporary arenaceous sediments from the southwest (Sections 3, 12) and northwest (Section 18). The white-weathering coquinoid member appears to represent, however, a time of relative shallowing of the axial part of the trough. The flourishing of Buchia colonies during its time of deposition is hard to understand otherwise, especially if one compares it with the relative paucity of the same or closely allied Buchia species in the underlying and overlying shale and siltstone units of the same sections.

The white-weathering coquinoid member is best developed on the northern and northeastern slopes of Relay Mountain (Sections 12, 15). It seems likely, furthermore, that this member extends also to the southern and southwestern slopes of this massif which is on strike with the Cardtable Mountain sections (Section 16, etc.). Where examined on Relay Mountain the white-weathering coquinoid member includes lenticular, 1 to 5-foot thick beds, of dark grey, brownish grey or light grey, soft, somewhat sandy to pure siltstone commonly rich to very rich in buchias. These rocks are more or less regularly interbedded with similarly thick, lenticular beds of harder, light grey weathering, white to whitish grey, strongly calcareous siltstone or impure coquina limestone replete with buchias. The alternation of these two rock types results in the characteristically white striped appearance of the outcrops of the member, which is accordingly a good horizon marker whenever present. Where studied on Relay Mountain the white-weathering coquinoid member is about 150 feet thick and embraces the upper part of the Buchia uncitoides s. lato zone proper, all of the Buchia tolmatschowi zone and the basal part of the Buchia pacifica zone. The age of this member ranges accordingly from latest Berriasian to basal mid-Valanginian.

Closer to the trough's axis on the northern and northeastern slopes of Cardtable Mountain the white-weathering coquinoid member decreases to about 100 feet (Section 16, etc.) and it includes fewer beds of impure coquina limestone. It does not include any part of the Buchia pacifica zone which is restricted to the overlying mid- to late-Valanginian shale unit. The deposition of sediments making up the white-weathering coquinoid member in the trough's axis was accordingly restricted to latest Berriasian and early Valanginian time (Fig. 14). This apparent wedging out of the member (shallower water facies) southwestward suggests that the Tyaughton Trough's axis was situated between Cardtable Mountain and Castle Peak in the latest Berriasian to basal mid-Valanginian time. On the other hand, the presence of the marginal, largely arenaceous contemporary facies at the headwaters of Tyaughton Creek (Section 8) and on Elbow Mountain (Section 3) suggests that the trough's axis went through the top part of Relay Mountain and a point about halfway between Castle Peak and Cardtable Mountain (see Figs. 3, 11).

Latest Portlandian s. str. to (?)early Valanginian arenaceous rocks of the southwestern flank

The rocks contemporary with the latest Portlandian s. str.(?) to late Berriasian shale unit and the white-weathering coquinoid member of the axial part of the trough outcrop in several places on the southwestern flank. They appear to form a northwest-trending belt extending at least from the headwaters of Tyaughton Creek (Section 4, units 1-4; Section 8, units 7-11) to the northern shoulder of Elbow Mountain (Section 3, units 18-32). The middle part of the Buchia piochii s. str. zone in Section 3 (unit 23) consists largely of more or less strongly baked and discoloured siltstone and shale lithologically similar to the corresponding parts of the uppermost Portlandian s. str. to late Berriasian shale unit. Otherwise, the arenaceous unit is represented largely by fine (predominantly) to coarse grained, locally gritty and pebbly greywacke. This greywacke is interbedded with lesser sandy siltstone and minor grit, pebble conglomerate, and gritty to pebbly coquina limestone. A member of green-coloured, basic(?) volcanic rocks forms the visible top of the unit in Section 8 (unit 11). This shallow water to (?)non-marine marginal facies can only be correlated with the uppermost Portlandian s. str. to late Berriasian shale unit and white-weathering coquinoid member on a palaeontological basis (Fig. 14). It grades downward in the greywacke facies of the mid(?)-Kimmeridgian to Portlandian s. str. rocks. The contact with the overlying variegated mid- and (?)late Valanginian rocks was not observed.

The maximum thickness of the latest Portlandian s. str. to (?)early Valanginian arenaceous rocks on the southwestern flank was measured in Section 3 where it amounts to about 308 feet. This section is, however, rather incomplete as there are several faulted out intervals and possibly some erosional gaps (e.g. all of the Buchia fischeriana and Buchia terebratuloides s. lato zones, parts of the Buchia uncitoides zone, and all of the Buchia tolmatschowi zone proper). Some of the missing beds are, however, present in other sections (e.g. Sections 4, 8) where they are relatively thin. This suggests that the total thickness of the unit does not exceed 450 feet and so is considerably smaller than that of the contemporary deeper water facies (latest Portlandian s. str. to late Berriasian shale unit and white-weathering coquinoid member) occupying the axial part of Tyaughton Trough.

The age limits of the latest Portlandian s. str. to (?) early Valanginian arenaceous rocks are believed to be about the same as those of the previously discussed contemporary deeper water facies except that they do not include either the "overlap beds" between the Buchia tolmatschowi and Buchia pacifica zones or the basal beds of the latter zone which form part of the overlying mid- and (?)late Valanginian variegated rocks. No fossiliferous rocks of the Buchia tolmatschowi zone proper have been found within the area. However, in Sections 4 and 8 the fossiliferous rocks of the Buchia uncitoides zone are overlain conformably and gradationally by unfossiliferous greywacke, pebble conglomerate, and green-coloured, basic(?) volcanic rocks up to 84 feet thick. These rocks are tentatively correlated with the Buchia tolmatschowi zone proper and assumed to correspond to the faulted out interval between units 32 and 33 of Section 3. If this assumption is correct, Buchia tolmatschowi time was characterized by a considerable uplift and some volcanic activity on the southwestern flank of Tyaughton Trough. The sea may have completely left this part of the trough at that time, which would explain the apparent absence of the fossiliferous rocks of the Buchia tolmatschowi zone proper in all the sections studied there (Fig. 14). This assumed early Valanginian uplift could easily have a regional significance, because in the Harrison Lake area, about 2,000 feet of unfossiliferous (non-marine?) agglomerates, tuffs, and subgreywacke (Crickmay, 1962, p. 8) were deposited between the time of deposition of the Buchia uncitoides and Buchia crassicollis s. str. zones. More field work is needed to elucidate the nature, intensity and areal extent of these early Valanginian events in Taseko Lakes map-area.

Late Berriasian(?) to (?)mid-Valanginian arenaceous rocks of the northeastern flank

Some downfaulted areas of predominantly sandy early Lower Cretaceous rocks occur on Yalakom River near its confluence with Shulaps Creek. According to Leech (1953, p. 21, geol. map) these rocks: "consist chiefly of impure sandstone (greywacke) and shale, possibly both tuffaceous in part, accompanied by lesser but important amounts of conglomerate and minor quantity of chert and limestone." These rocks were not mapped in any detail and the writer was only able to measure one short, unfossiliferous section (Section 18) during his brief visit to the area. This section probably represents the upper part of the sequence. No estimate of the total thickness of these rocks is possible at present.

A poorly preserved Buchia fauna apparently representing the Buchia uncitoides s. lato zone, but including rare forms of Buchia okensis s. lato and Buchia ex aff. volgensis Lahusen (GSC loc. 15995) occurs in fine-grained greywacke on Yalakom River at approximately Lat. 50°57'N.; Long. 122°15'W. This fauna was found in the basal 200 to 300 feet of the unit in a section exposing its contact with Triassic(?) volcanics (written communication of H.M.A. Rice of February 2nd, 1961). This suggests that the unit does not include rocks older than late Berriasian. The mid-Valanginian Buchia pacifica s. lato fauna (previously identified as Buchia cf. and aff. crassicollis by the writer) has, furthermore, been found by Leech (1953, p. 21; GSC loc. 17009) in another section. The stratigraphic position of this fauna within the unit is uncertain. Section 18 is tentatively assumed to extend from late Berriasian to mid-Valanginian and not to include any younger rocks. For comments based on field work in 1966, see Jeletzky 1967. Whatever the upper age limit of this early Lower Cretaceous unit may be, it seems to reflect a transgressive overlap of the late Berriasian sea on the folded Triassic or (?)Jurassic volcanics along the northeastern margin of Tyaughton Trough (Fig. 14). It seems likely that the older rocks of the Relay Mountain Group were not deposited in this part of the trough; they could, however, have been removed by the late Berriasian transgression. The relationship of the arenaceous early Lower Cretaceous rocks of the Yalakom River to those of the axial part of the trough has already been discussed (see also Fig. 3).

Mid- to late Valanginian shale

In the axial part of the trough on the northeastern slopes of Cardtable Mountain (Section 16, etc.) and presumably just south of the top of Relay Mountain the white-weathering coquinoid member is conformably and gradationally overlain by a thick succession of dark grey to black, mostly soft shales with considerable interbeds of similarly coloured, soft, mostly pure siltstones. Variously shaped, large and small concretions of dark grey, hard, commonly more or less calcareous shale and siltstone or impure limestone are common locally; they are irregularly scattered or occur in rows. Minor interbeds of fine-grained greywacke or sandy coquinoid limestone may be present near the top and base of the unit. Fossils are rare, except in the coarser grained, calcareous interbeds and concretions. Lenticular masses of sandy siltstone and fine-grained, silty, richly fossiliferous greywacke occur locally close to typical exposures of the unit (Section 16, units 22a-22d). These little understood rocks could perhaps represent underwater banks on the sea bottom where the sediments have been winnowed out by currents but it is equally possible that they represent thin wedges of the silty to arenaceous facies of the mid- to late-Valanginian rocks. This unit is similar lithologically to the latest Portlandian s. str. to late Berriasian shale unit and, like the latter, is believed to reflect a phase of subsidence of the axial part of Tyaughton Trough. It seems to be distinguishable from the latest Portlandian s. str. to late Berriasian shale in the well exposed sections because of the distinctly darker, more uniform colouring of the rocks, relative paucity in concretions and interbeds of hard, calcareous shale and siltstone, and apparently complete absence of glauconitic rocks. None of these lithological criteria is believed to be reliable.

The mid- to late Valanginian shale unit appears to grade imperceptibly into arenaceous and calcareous early Hauterivian rocks everywhere. This is in contrast with the contact relationships of the other contemporary rock units in the marginal parts of the trough (see below). The apparently complete succession of the mid- to late Valanginian shale unit in Section 16 is about 600 feet thick. Buchia crassicollis zone is at least 425 feet thick in this centrally located section which is in contrast with its thin to very thin development on both flanks of the trough. The strata of the mid- to late Valanginian shale unit may possibly be even thicker in another, only cursorily studied section on the northeastern slope of Cardtable Mountain. Only discontinuous sections of the unit have been found in the southern part of the Relay Mountain massif.

In the sections studied, the mid- to late Valanginian shale unit comprises all of the Buchia pacifica and Buchia crassicollis zones as defined by Jeletzky (1964a, 1965a). The upper part of Buchia pacifica zone contains Homolsomites cf. giganteus (Imlay). The Buchia crassicollis zone has yielded a new Polyptychites (Euryptychites)? sp. indet. and Homolsomites quatsinoensis - Olcostephanus pecki auna in its midddle part (180 to 185 feet above base). The overlying 200 to 225 feet of the zone have only yielded Buchia crassicollis s. str. and its variants. The Valanginian-Hauterivian boundary was placed tentatively 80 feet above the highest occurrence of Buchia crassicollis s. str. (i.e. Section 16, between units 23, 24). So placed, the boundary coincides with an apparently persistent lithological change occurring at that level in rocks that did not yield any diagnostic fossils. The overlying part of the unit must correspond to the Homolsomites oregonensis zone of lower Hauterivian age.

Mid- to late Valanginian siltstones and sandstones of the northeastern flank

The mid- to late Valanginian shale is laterally replaced by silty to arenaceous, commonly more or less calcareous rocks on the northeastern flank of Tyaughton Trough. The predominant rock of this facies is a dark grey, light green-grey to whitish grey weathering, soft, sandy siltstone containing inclusions, lenses of lighter grey, commonly white-grey to white weathering, hard, calcareous sandy siltstone or impure (arenaceous) limestone rich in Buchia and other fossils. These inclusions and lenses are commonly rich enough in buchias to be called coquina limestone. Thick and continuous beds and members of coquina limestone, such as occur in the Buchia pacifica zone on the southwestern flank of the trough or in the underlying white-weathering coquinoid member are rare in the siltstone. The siltstone represents the bulk of the unit in all sections studied; it is about 200 feet thick at the most (Section 12, units 3, 4) and grades downward into the white-weathering coquinoid member through a gradual increase of the number and thickness of lenticular coquina beds. In the uppermost part of the unit, invariably corresponding to the upper part of the Buchia crassicollis zone only, the dark grey siltstone gradually becomes sandier through a zone a few feet thick until it is finally transformed into a light green-grey, calcareous, mostly pebbly and gritty but always fine-grained greywacke rich in Buchia crassicollis s. str. This 1/4 to 4-foot thick greywacke bed forms the top of the unit in all sections studied (Section 10, unit 2; Section 11, unit 3; Section 12, units 5-7). In some sections (Section 12, unit 6) it may include interbeds or lenses of fine to coarse pebble conglomerate. The contact with the overlying basal Hauterivian rocks is abrupt everywhere but apparently even.

The silty to arenaceous facies of the mid- to late Valanginian rocks outcrops extensively on the northern and northeastern slopes of Relay Mountain massif (Sections 11, 12, etc.) forming an apparently northwesterly trending belt (Fig. 3). On the eastern and southeastern slopes of the massif this facies appears to grade laterally into the previously described mid- to late Valanginian shale (Section 10, etc.). The thickness of the silty and arenaceous facies is considerably smaller than that of the shale facies of the mid- to late Valanginian rocks which is illustrated by the presence of about 204 feet of these rocks in Section 12 as compared with at least 600 feet of their shale equivalents in Section 16. The time extent of the silty and arenaceous facies is, however, somewhat smaller than that of the shaly facies. The former does not include the basal part of the Buchia pacifica zone and may well include a hiatus corresponding to the upper part of the Buchia crassicollis zone at the top (see below). The rate of deposition of the mid- to late Valanginian sediments must therefore have been considerably less on the northeastern flank of the trough than in its axial part and the latter must have been subsiding more rapidly during that time interval.

Mid- and (?)late Valanginian variegated rocks of the southwestern flank

The shallow water, largely arenaceous mid- and (?)late Valanginian rocks are widespread southwest of the axial part of Tyaughton Trough (see Fig. 14 and Sections 3, 6); they appear to form a northwest-trending facies belt paralleling that of the silty to sandy mid- to late Valanginian rocks occurring on the northeastern flank of the trough (Fig. 3).

The mid- and (?)late Valanginian rocks of the southwestern flank are insufficiently understood, being invariably poorly exposed and commonly poorly fossiliferous to unfossiliferous. However, they differ markedly from their equivalents on the northeastern flank in being represented by an alternation of arenaceous to pebbly coquina limestone, fine to coarse grained greywacke, and dark grey to black arenaceous mudstone and siltstone in

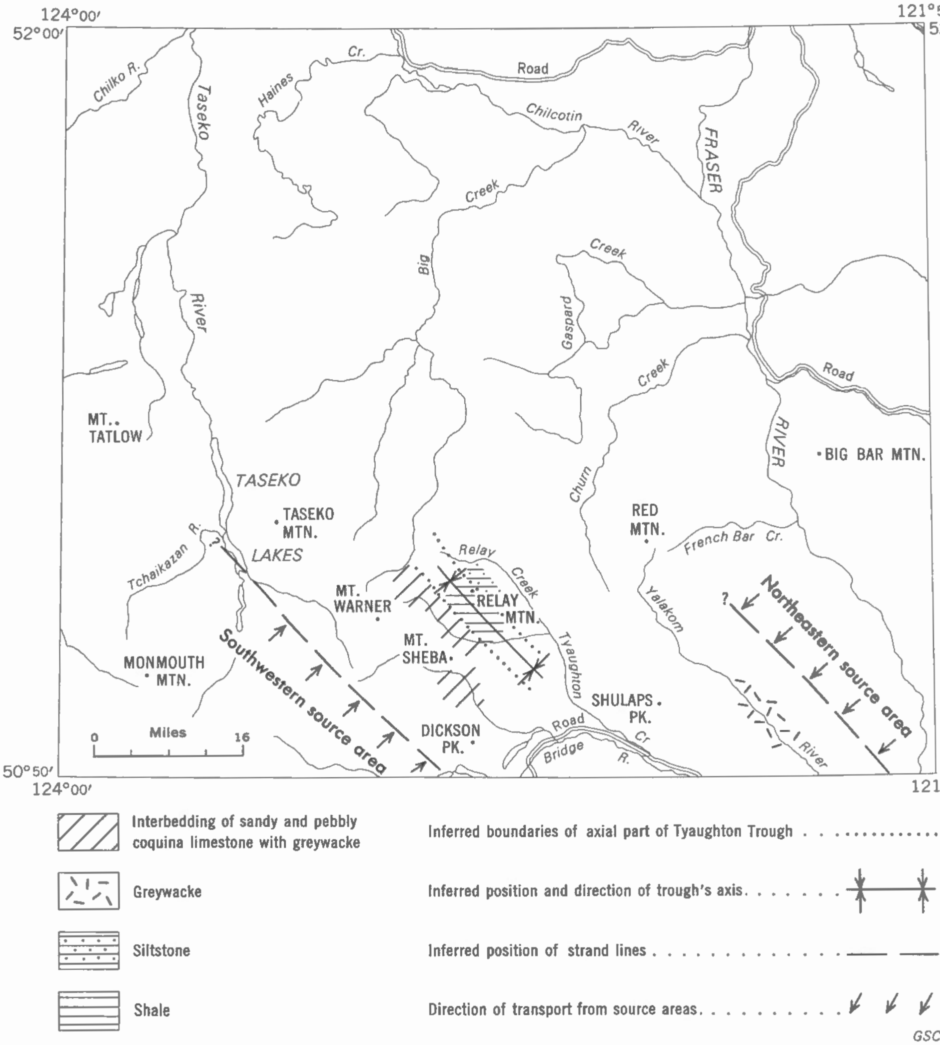

Figure 3. Facies of mid-Valanginian (Buchia pacifica zone) rocks of the southern part of Taseko Lakes map-area.

about equal amounts with minor inclusions and interbeds of grit and pebble conglomerate. The arenaceous to pebbly coquina seems to form an 80 to 100 feet thick member in the middle part of the succession and to be overlain and underlain by 30- to 40-foot thick beds of greywacke with minor interbeds of other rocks. The 40- to 45-foot thick bed of dark greenish grey to black mudstone and siltstone forms the top of the sequence. The inferred total thickness of the unit is 150 to 185 feet. This tentative estimate was achieved by a somewhat arbitrary combination of several partial sections. The complete thickness of the basal greywacke is especially uncertain as this unit was not seen in normal contact with either the underlying latest Portlandian s. str. to (?)early Valanginian arenaceous rocks or with the overlying Buchia pacifica coquina limestone.

The best section (130 to 140 feet thick) of the variegated mid- and (?)late Valanginian rocks occurs at the northwestern end of Spruce Lake (Section 6). It exhibits a virtually complete succession of the middle and upper parts of the unit. The basal part of the Buchia pacifica coquina is, however, covered in this section and the underlying greywacke is not exposed. These basal beds have been seen only in other badly faulted sections (e.g. Section 3).

The lower contact of the variegated rocks concerned was not observed. The upper contact was only seen in Section 6 (units 4, 5) where the dark grey to black arenaceous siltstone and mudstone believed to represent the Buchia crassicollis zone is overlain abruptly (but apparently not even disconformably) by a thick unit of tuffaceous (?)greywacke, which is believed to be the shallow water early Hauterivian facies (see below).

The relatively coarse-grained character of the variegated rocks of mid- and (?)late Valanginian age on the southwestern flank suggests that they have been deposited in much shallower and more agitated water than their equivalents on the northeastern flank, some non-marine rocks may be included. No interfingering of the variegated rocks with the shale facies of the axial part of the trough has been observed in any of the sections studied on the southwestern flank which suggests that these rocks represent a more marginal facies of mid- to late Valanginian time than the equivalent silty to sandy rocks of the northeastern flank. The fact that the variegated rocks are somewhat farther away from the outcrops of the shale facies than are the silty to sandy rocks of the northeastern flank supports this conclusion. Only the mid-Valanginian part of the Yalakom River section (Figs. 3, 14) appears to be a facies equivalent to this marginal facies.

The lower and middle beds (coquina and greywacke) of the variegated rocks are known to include all of the Buchia pacifica zone. The relationships observed in Section 3 suggest that their basal beds include the "overlap beds" between the Buchia pacifica and Buchia tolmatschowi zones as well. The

Buchia tolmatschowi zone proper was not observed anywhere on the southwestern flank and it is not known whether it forms part of the variegated rocks or of the underlying latest Portlandian s. str. to (?)early Valanginian arenaceous rocks. The Buchia crassicollis s. str. zone was not found in any of the studied sections, it may, however, be represented by the 40-to 45-foot thick member of dark grey to black, arenaceous siltstones and mudstones conformably overlying Buchia pacifica beds in Section 6. This suggestion finds support in the presence of Buchia crassicollis f. typ. et var. solida in association with Homolsomites quatsinoensis 3 miles south of Spruce Lake on the southern side of the ridge between Gun and Leckie Creeks at an altitude of 6,300 feet (GSC locs. 19167, 19168). These fossils are enclosed in a dark bluish grey arenaceous siltstone closely resembling unit 4 of Section 6. No Hauterivian index fossils have been found in unit 5 of Section 6 and the tentative placement of the Valanginian-Hauterivian contact between these units lacks palaeontological support.

Pre-Hauterivian uplift and its palaeogeographical significance

In the axial part of the trough unfossiliferous dark grey siltstone tentatively placed in the top part of the Buchia crassicollis zone rather than in the basal part of the Homolsomites oregonensis zone (Section 16, unit 23) is conformably and apparently gradationally overlain by very fine grained, silty sandstones, sandy siltstones, calcareous, fine-grained greywacke, and arenaceous coquina limestone of the Homolsomites oregonensis? and Speetoniceras-Simbirskites (Hollisites) zones, which pass upward into unfossiliferous Hauterivian siltstone. These lithological changes indicate only a moderate shallowing of the axial part of the trough at the end of Valanginian time. However, on the northeastern flank of the trough (see Sections 10-12) the siltstone of the upper part of the Buchia crassicollis zone rapidly passes upward into fine-grained but gritty and pebbly greywacke with irregularly shaped pods and thin interbeds of grit and fine to coarse pebble conglomerate. This gritty and pebbly greywacke contains the Buchia crassicollis fauna and is separated from the overlying impure, locally gritty and pebbly limestones of the basal Hauterivian by an abrupt boundary. These relationships indicate the occurrence of an uplift in the latest Valanginian time on the northeastern flank of the trough, which was apparently accompanied by an interruption of sedimentation and some erosion of the older rocks. However, it is not known whether the northeastern flank was uplifted above sea level or the observed relationships were caused only by submarine erosion supplemented by an influx of coarse clastic particles from more northeasterly parts of the area where no early Lower Cretaceous rocks are known to exist now. The strong thinning out of the Buchia crassicollis zone between Sections 10 (minimum thickness of 49 1/2 feet) and 12 (complete thickness of only 15 3/4 to 17 feet), which are situated almost across the strike of the trough (<u>see</u> Figs. 11, 14), is at any rate suggestive of subaerial erosion possibly accompanied by an overlap of different parts of the *Buchia crassicollis* zone by basal Hauterivian rocks.

The abrupt lateral replacement of the siltstones and mudstones of the *Buchia crassicollis* zone by the fine- to coarse-grained, possibly tuffaceous Hauterivian greywacke in Section 6 suggests that pre-Hauterivian uplift may also have occurred on the southwestern flank of Tyaughton Trough. The character of the pre-Hauterivian movements remains obscure as no proof of an erosional disconformity, let alone transgressive overlap, has been observed in the only known exposure of the contact (*see* under preceding section and also Appendix, Section 6).

Whatever their nature, the pre-Hauterivian movements could hardly have been severe in the Taseko Lakes map-area as they obviously did not cause any interruption of sedimentation and only a slight shallowing of the axial part of Tyaughton Trough. Nor is there any evidence of major uplifts of the flanks of the trough as such uplifts would inevitably result in accumulation of appreciable volumes of coarse clastics (piedmont facies) within the marginal facies belts.

Early to mid-Hauterivian shaly rocks (*Homolsomites oregonensis* and *Speetoniceras-Simbirskites (Hollisites)* zones)

The early to mid-Hauterivian rocks do not seem to exhibit any regular facies belts comparable to those easily observable in the underlying units of the Relay Mountain Group (Figs. 4, 14). All sections (Sections 10, 11, 16, 20) show irregular alternation of dark grey, pure to sandy shales or siltstones with lesser amounts of dark to light grey or green grey, fine-grained, silty, commonly calcareous greywacke and minor, mostly light coloured, arenaceous coquina limestones. The ratio of the coarser rock types to shale and siltstone varies widely from one section to another as does the thickness of the early to mid-Hauterivian shaly rocks. The thickest and finest grained sections known do not occur either on the northeastern slopes of Cardtable Mountain or near the top of Relay Mountain where the axial part of Tyaughton Trough was formerly situated. They occur instead in the extreme western part of the Taseko Lakes map-area (Figs. 4, 14). The centrally situated early to mid-Hauterivian part of Section 16 includes a greater percentage of fine greywacke and impure coquina limestone than the equivalent parts of any other section studied. As now known, the incomplete westernmost sections, just south of Yohetta Lake (Section 20) consist, in contrast, mainly of pure to silty shale with only insignificant siltstone and fine-grained greywacke interbeds. Sections 10 and 11 on the northern and eastern slopes of Relay Mountain are transitional between Sections 16 and 20.

The visible (incomplete) thickness of the Homolsomites oregonensis and (?) Speetoniceras-Simbirskites (Hollisites) zones in the Yohetta Lake sections reaches 800 feet compared with the 180 to 184 1/2 feet of the same rocks exposed in Section 16. Sections 10 and 11 include respectively 396 and 420 feet of apparently equivalent rocks. The comparison of thicknesses of these sections is made difficult by their structural complexity, incompleteness, and scarcity of index fossils. The Homolsomites oregonensis fauna was, for example, only found in the extreme western sections (Section 20, etc.) where the Speetoniceras-Simbirskites (Hollisites) fauna is only doubtfully represented in one of the sections. Conversely, a readily determinable Speetoniceras-Simbirskites (Hollisites) fauna was only found in one section situated on the northeastern slope of Cardtable Mountain (Section 16) where a Homolsomites oregonensis fauna was not found. None of the other sections measured yielded definite elements of either of these diagnostic faunas. The diagnostic value of these two faunas only becomes evident when one uses information obtained in the Taseko Lakes map-area in conjunction with that obtained in Oregon by American workers (see pp. 9-10). The early to mid-Hauterivian shaly rocks were not observed in the same continuous sections with the apparently younger mid-Hauterivian shales. This and the sporadic occurrence of Inoceramus colonicus Anderson in both units makes it possible that they are contemporary lithological and faunal facies, in part at least. The assumption of a superposition of the mid-Hauterivian shale on the Speetoniceras-Simbirskites (Hollisites) zone is favoured only because of the apparent absence of these zonal ammonites in the former unit.

Correlation of early to mid-Hauterivian ammonite zones of the Taseko Lakes map-area with the corresponding standard zones of Europe is difficult because of the absence of common species and the scarcity of common genera. The writer cannot add anything to the intercontinental correlations proposed by Popenoe et al. (1960) and Imlay (1960).

The apparent absence of the northwesterly trending facies belts in the early and mid-Hauterivian rocks of Tyaughton Trough was probably connected with the much greater spread of this transgression as compared with that of the earlier Lower Cretaceous and late Upper Jurassic transgressions. Considering the presence of what is believed to be a shallow water, marginal facies during early to mid-Hauterivian time in the Spruce Lake part of the area it seems probable that the southwestern flank of the trough became submerged completely and a short-lived supplementary, presumably northwesterly trending depositional basin formed to the west of it in the Yohetta Lake area (Figs. 4, 14). This suggestion finds additional support in the well-documented report of early to mid-Hauterivian rocks still farther west in the Tatlayoko and Chilko Lake areas. This short-lived (?)depositional basin was then apparently permanently obliterated by the late Hauterivian uplift. It is possible, furthermore, that the emergence of this supplementary depositional basin in the Yohetta Lake area was accompanied

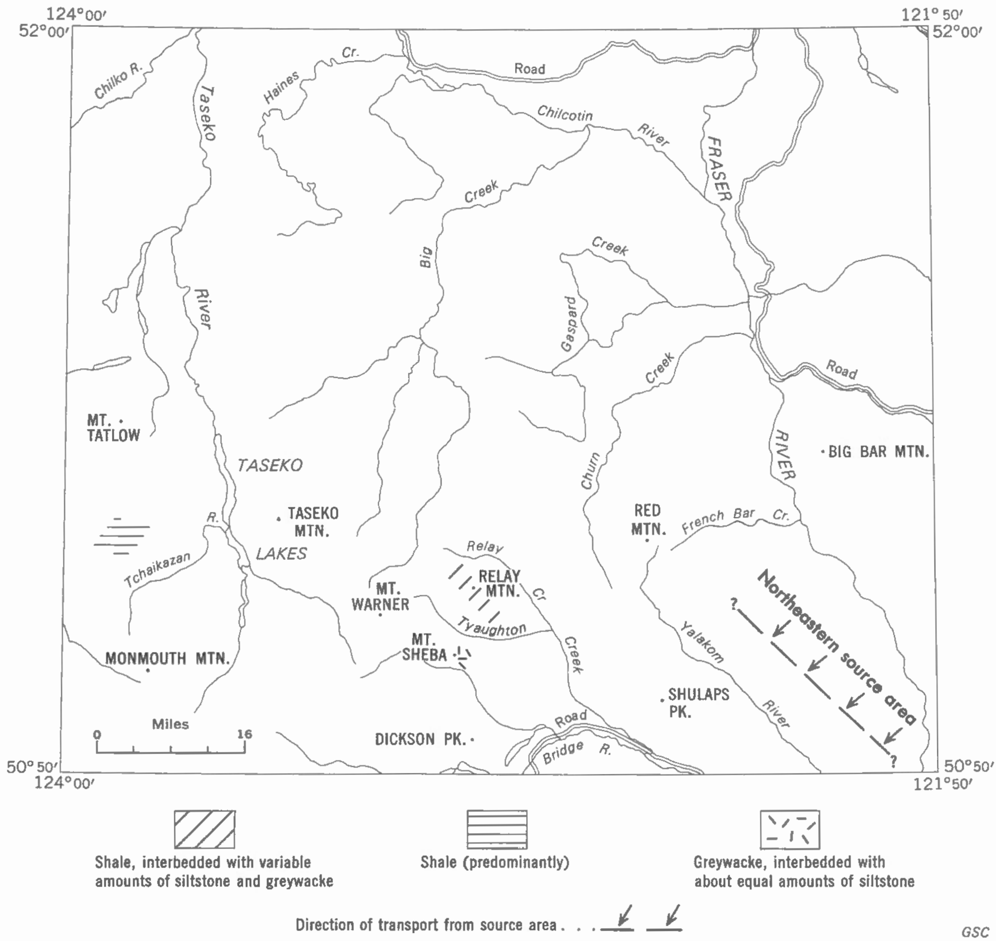

Figure 4. Facies of early to mid-Hauterivian rocks (Homolsomites oregonensis and Speetoniceras-Simbirskites (Hollisites) zones only) in the southern part of Taseko Lakes map-area.

by a considerable shallowing of the axial part of the Tyaughton Trough proper. If so, the trough as a negative unit did in fact migrate westward during that time. Much detailed field work is needed to confirm or to reject this working hypothesis.

Mid-Hauterivian shale

A thick shale unit devoid of any diagnostic fossils, except for sporadically occurring *Inoceramus colonicus* Anderson (=*I. ovatoides* Anderson) is widespread in the part of Taseko Lakes map-area situated between Lorna Lake, the northern shoulder of Elbow Mountain, and the eastern headwaters of Tyaughton Creek. Elsewhere it is only doubtfully present in one section (Section 11, unit 7) on the northeastern slope of the Relay Mountain massif.

Except when hardened and bleached by the intrusive heat or rust-coloured from the effects of faulting and shearing, the mid-Hauterivian shales are grey to dark grey or black in fresh outcrops; they are laminated in part, mostly pure, extremely uniform in appearance, and friable to medium hard. In the weathered state these shales can be chocolate brown, rust-coloured, grey-yellow or ash-grey with these colours locally alternating in thin layers or lamellae; they weather chippy, splintery or earthy and recessively which results in generally poor outcrops. For the most part, the mid-Hauterivian shales are either completely devoid of, or poor in any concretions or bands of clay ironstone, hard shale or impure limestone. However, at a few levels which do not seem to match in different sections, it is rich in, or replete with small and large, mostly irregularly shaped to lenticular concretions and persistent 6 to 12 inch thick bands of hard, dark to bluish grey or black, commonly whitish grey or yellow-weathering calcareous shale or cryptocrystalline limestone. The concretions tend to occur in persistent rows. These concretions and bands are generally replete with *Inoceramus colonicus* and apt to acquire the appearance of a veritable coquina limestone. *Aulacoteuthis*- and *Acroteuthis*-like belemnites and pelecypods occur rarely in association with the predominant *I. colonicus*, but none of these forms appears to be diagnostic.

The mid-Hauterivian shale unit reaches a maximum thickness of about 960 feet in Section 9 (unit 1) south of Elbow Mountain. It is at least 750 feet thick in Section 5 (units 4, 5). The base of the unit is, however, not exposed in either of these sections. If the topmost shale member exposed in Section 11 (unit 7) represents the basal part of the *Inoceramus colonicus* shales rather than the *Speetoniceras*-*Simbirskites* (*Hollisites*) shaly rocks their complete thickness is in excess of 1,000 feet.

The mid-Hauterivian shales underlie conformably and probably gradationally the unfossiliferous mid-Hauterivian siltstones. Accepting their post-Speetoniceras-Simbirskites (Hollisites) age, the mid-Hauterivian shales of the area can only correspond to some part (middle?) of the Hauterivian stage.

Arenaceous equivalents of the mid-Hauterivian shales probably occur in the early to mid-Hauterivian? greywacke-siltstone division of Spruce Lake. The facies distribution of that time is therefore believed to be similar to that of the Homolsomites oregonensis and Speetoniceras-Simbirskites (Hollisites) time, except that the mid-Hauterivian shales are not known to occur in the Yohetta Lake area or farther westward.

Early to mid-Hauterivian greywacke and siltstone of Spruce Lake area

The unfossiliferous equivalents of the Buchia crassicollis zone occurring near the northwestern end of Spruce Lake are apparently conformably overlain by a unit of bluish grey, mauve-tinged, fine- to medium-grained, tuffaceous(?) greywacke (Section 6, unit 5) which is at least 500 feet in thickness. This unfossiliferous unit is believed to be the shallow-water, marginal facies of the Homolsomites oregonensis zone because of its stratigraphic position. The bluish grey greywacke unit is overlain with apparent conformity by a poorly exposed and extremely strongly faulted but obviously thick sequence of dark grey to black, commonly arenaceous siltstone and fine- to medium-grained, hard, green-grey greywacke. These two principal rock varieties are about equally common in this sequence and form an alternation of more or less cyclical members 100 to 300 feet in thickness. Some bands and concretions of rust-weathering clay ironstone and minor interbeds of dull grey, orange-weathering, hard, impure limestone with rare and fragmentary specimens of Inoceramus cf. colonicus Anderson occur in the middle part of the sequence. Similar but even less satisfactorily preserved inocerami and some poorly preserved, non-diagnostic pectenid and nuculid pelecypods have been collected slightly higher in the siltstone interbeds. A few Acroteuthis- or Pachyteuthis-like belemnites have been collected at another section probably representing a still higher level within this arenaceous sequence. Poorly preserved plant remains and some carbonaceous specks have been seen in greywackes underlying the fossiliferous middle part of the sequence which appear to be several hundred feet higher in the succession than the basal greywacke member. This enigmatic greywacke-siltstone sequence occupies the higher slopes of the western shore of Spruce Lake and outcrops for at least 1/2 mile west therefrom along small streams entering Spruce Lake from the west. The top was nowhere observed but at least 1,500 feet of section are believed to be exposed.

The rare occurrence of Inoceramus cf. colonicus in the middle part of the greywacke siltstone sequence suggests correlation with the mid-Hauterivian shale of the more northwesterly parts of the area. The apparently conformable superposition of the higher parts of this sequence on the assumed equivalents of the Homolsomites oregonensis zone (i.e. the basal greywacke member; see Section 6, unit 5) suggests that it includes equivalents of the Speetoniceras-Simbirskites (Hollisites) zone as well. The upper part of the sequence overlying the beds containing Inoceramus cf. colonicus could possibly extend into late Hauterivian but is compared tentatively only with the unfossiliferous mid-Hauterivian siltstones directly overlying the Inoceramus colonicus shales.

The greywacke-siltstone sequence of the Spruce Lake area occurs in the part of the Taseko Lakes map-area occupied by the southwestern flank of Tyaughton Trough during mid-Kimmeridgian to mid-Valanginian time. The lithology of this sequence agrees well with its interpretation as the marginal early to mid-Hauterivian facies on the southwestern flank of Tyaughton Trough. However, the apparent absence of the shaly facies of early to mid-Hauterivian rocks to the northeast (Relay and Cardtable Mountains) and its apparent presence both to the north (Sections 3, 4, 5, 9) and far to the west (Section 20) of Spruce Lake (Fig. 4) seems to conflict with the interpretation of this sequence as a marginal facies. It could be a residual, shoal-like elevation within the expanded early to mid-Hauterivian Tyaughton Trough originally surrounded by the shale facies (Fig. 4, Fig. 14). Alternatively, it could be a remnant of the southwestern flank of the trough unaffected by the Hauterivian transgresion if one would assume that the direction of Tyaughton Trough in early to mid-Hauterivian time changed from northwest to almost west. The former hypothesis is favoured by the writer because of the apparent persistence of the northwesterly direction of Tyaughton Trough in late Hauterivian and Aptian-Albian times.

Mid-Hauterivian unfossiliferous siltstones

The mid-Hauterivian shale unit is conformably and probably gradationally overlain by a fairly thick siltstone unit which has not yielded any marine fossils. This unit was encountered in the same sections as the mid-Hauterivian shale and does not seem to be present in any other part of the area. It consists predominantly of dark grey to greenish grey, mostly soft siltstone weathering ash-grey to brown-grey. This rock is interbedded with variable but always lesser amounts of dark grey to black, soft shale and greenish to bluish grey, fine-grained, silty greywacke usually in thin layers and beds 1 inch to 3 feet but forming beds up to 50 to 60 feet in some sections; they are, as a rule, hard and more resistant to weathering than the intervening siltstone. The unit weathers recessively and its outcrops are characteristically poor. Irregularly shaped, 1 to 3-foot concretions and egg-shaped, 3 to 6 inch concretions of very hard bluish grey, orange- to rust-weathering clay ironstone or ferruginous siltstone are common locally (e.g. in Section 5); these concretions have only yielded plant remains, abundant but extremely poorly preserved and mostly comminuted. The lithological variability of the unfossiliferous mid-Hauterivian siltstones is best illustrated by comparison of units 6 and 7 of Section 4 with the equivalent units 6c to 6e of Section 5. Unit 2 of Section 9 is less suitable for comparison as this section was studied in much less detail. No regularity of any kind has been observed in the lateral lithological changes of the unfossiliferous mid-Hauterivian siltstones.

The unfossiliferous mid-Hauterivian siltstones are thickest in the southwesternmost section (Section 9, unit 2) where they are 450 feet thick. Eastward their thickness decreases to about 313 feet in Section 5 (units 6c-6e) and to about 310 feet in Section 4 (units 6, 7). This gradual thinning out of the unit parallels closely that observed in the overlying late Hauterivian variegated clastic rocks.

The unfossiliferous mid-Hauterivian siltstones are assigned to the later part of the mid-Hauterivian stage because of their occurrence immediately below the well dated late Hauterivian variegated clastic rocks with which they appear to be connected by a transition. The complete absence of any marine fossils combined with the local presence of comminuted plant remains is suggestive of the non-marine origin of these siltstones.

Late Hauterivian variegated clastic rocks

Like the underlying mid-Hauterivian shales and the unfossiliferous mid-Hauterivian siltstones, the late Hauterivian variegated clastic rocks have so far been found only in the area between Lorna Lake, Elbow Mountain, and the eastern headwaters of Tyaughton Creek. Unlike the mid-Hauterivian shales, they are unknown on Relay Mountain.

The late Hauterivian variegated clastic rocks are characterized by strong prevalence of:

(1) Dark green to dark grey, hard, fine to coarse grained, commonly gritty and pebbly greywacke, generally tuffaceous and locally containing minor interbeds of brown to lavender coloured volcanic rocks which seem to include both lava flows and pyroclastics. These volcanic rocks appear to be confined to the top part of the unit and their total thickness does not seem to exceed 15 to 20 feet (Section 4, unit 9). The greywacke often includes irregular inclusions and lenses of lighter coloured, more or less calcareous greywacke.

(2) Fine to coarse, often pebbly grit and fine to coarse pebble conglomerate. Conglomerate pebbles and grit particles appear to be all built of the locally derived sedimentary rocks (black shale, siltstone, and greywacke) indistinguishable from those occurring in the late Hauterivian variegated clastic unit itself and in the underlying Hauterivian rocks. Pebbles are, as a rule, well rounded and were not seen to exceed 8 inches in diameter; they are enclosed in gritty, arenaceous and silty matrix. The colour of these coarse clastics is characteristically brown- to green-grey or rust-coloured.

The ratio of rock varieties (1) and (2) varies greatly from one section to another. For example, in Section 9 (unit 3) grit and pebble conglomerate comprise 60 to 65 per cent of the total thickness of the unit. In Section 5 (units 6a, 6b), however, grit and conglomerate make up between 20 and 25 per cent of the total thickness and are largely confined to a single 22-foot thick bed at the top of the unit. These coarse clastics are less prominent in Section 4 (units 8-10) where they comprise less than 10 per cent of the total thickness of the unit. No medium to coarse pebble conglomerate was, furthermore, noted in the last section.

Variable, but always minor interbeds of hard to soft, mostly sandy siltstone are present in all sections. These interbeds are usually confined to the lower part of the unit which is transitional in its lithology to the upper part of the unfossiliferous mid-Hauterivian siltstones; they may, however, occasionally appear at its top (Section 4, unit 10). The thickness of the late Hauterivian variegated clastic rocks decreases more or less steadily in an easterly direction. In Section 9 the unit is about 600 feet thick but it is only about 218 feet thick in Section 4 and about 104 feet thick in Section 5. The facies change of the unit appears to be fairly regular and to parallel closely its change of thickness. The largest amounts of grit and pebble conglomerate occur in the westernmost section studied (Section 9, unit 3) where they predominate. These coarse clastic rocks are less common in Section 5 (unit 6a) which is situated east of Section 9. They are even less common in Section 4 (unit 9) which is situated only about 500 feet south-southeast of Section 5. The ratio of greywacke and siltstone increases as that of the coarse clastics decreases (Fig. 12). The rocks found in Section 9 probably represent the marginal facies of the late Hauterivian variegated clastic rocks whereas Sections 4 and 5 appear to represent a deeper water facies. Interpreting these facies relationships in terms of the persistent facies pattern observed in the pre-Hauterivian rock units of the Relay Mountain Group, Section 9 represents the outer part of the southwestern flank of Tyaughton Trough whereas Sections 4 and 5 represent the inner part of the same flank. The facies of the latter sections is reminiscent of that of the axial part of the trough which was largely represented by siltstone and shale in its Valanginian and earlier development. This interpretation cannot be confirmed as no sections of the late Hauterivian variegated clastic rocks are known to occur either east or northeast of those exposed in Sections 4 and 5 but the data available suggest that the general strike and position of the late Hauterivian Tyaughton Trough were similar to those of mid-Kimmeridgian to mid-Valanginian time.

The late Hauterivian variegated clastic rocks are sparsely fossiliferous throughout, the diagnostic fossils are for the most part confined to the uppermost beds of the unit. The fauna includes such latest Hauterivian index fossils as Craspedodiscus cf. discofalcatus (Lahusen), Simbirskites (Simbirskites) cf. broadi Anderson, and S. (S.) ex gr. progredicus (Lahusen). These diagnostic ammonites range almost to the top of the unit (Section 4, unit 10). This indicates that the lithological boundary with the overlying shales approximately coincides with the Hauterivian-Barremian boundary. Elements of this late Hauterivian fauna accompanied by Inoceramus colonicus have also been found locally near the base of the unit (Section 9, unit 3). The age significance of the Craspedodiscus cf. discofalcatus fauna has already been discussed in connection with the zonal subdivision of the Relay Mountain Group.

Late Hauterivian uplift

The late Hauterivian variegated clastic rocks are characterized by a marked increase of grit-pebble conglomerate and greywacke beds as compared with the rocks of the older Hauterivian units which consist largely or entirely of siltstone and shale. Minor interbeds of volcanic rocks were noted in some of the late Hauterivian sections. This change of lithology reflects a strong late Hauterivian uplift (at least in the limited part of the area where the late Hauterivian rocks are present). As already mentioned, this part of the area is believed to represent the southwestern flank of Tyaughton Trough. The uplift must have been greatest in the westernmost part of the area (actually in the southwesternmost part considering the inferred direction of Tyaughton Trough). This strongly suggests a southwestern source of the late Hauterivian coarse clastic rocks. In addition to the rather rapid northeasterly wedging out of the late Hauterivian coarse clastic rocks, this uplift is indicated by the abrupt decrease in thickness of the late Hauterivian variegated clastic rocks in the same direction.

Nothing is known about the facies relationships in the axial part of the late Hauterivian Tyaughton Trough and on its northeastern flank. However, it appears probable that they were essentially similar to those observed on its southwestern flank. Tyaughton Trough was considerably narrowed by the late Hauterivian uplift as compared with early to mid-Hauterivian time when the marine fine clastics were deposited in the Yohetta Lake part of the area and marine rocks of an unknown lithology extended westward at least into the Chilko Lake area. The piedmont lithology of the late Hauterivian variegated clastic rocks in Section 9 suggests the presence of their source area a few miles to the southwest as such coarse clastics could hardly travel more than 20 miles.

The acme of the late Hauterivian uplift was apparently reached in latest Hauterivian time when the coarse clastic wedge had penetrated farthest into the trough's interior. This is strongly suggested by the previous comparison of the lithology of the unit in Sections 9, 5 and 4 (see also Fig. 12). These relationships indicate the occurrence of a well defined late Hauterivian pulse of uplift which was followed by a prolonged time of relative tectonic quiescence during most or all of the Barremian. Judging by the volume of coarse clastics dumped into the southwestern part of Tyaughton Trough during this uplift, it was much stronger than any of the preceding late Upper Jurassic and early Lower Cretaceous uplifts. It must have been, on the same grounds, a considerably weaker uplift than the ensuing Aptian uplift to which it appears to be a preliminary. So far as known, the late Hauterivian uplift was not accompanied by an erosional interval or tilting of the underlying units of the Relay Mountain Group as the coarser clastics appear to grade downward into the finer ones (see Section 5, units 9a, 9b). This conclusion is supported by the presence of fairly abundant marine fossils in coarse greywacke, grit, and pebble conglomerate of the late Hauterivian variegated clastic rocks.

Barremian variegated clastic rocks

The topmost part of the Relay Mountain Group consists of fine to coarse clastic rocks which are just as variable in their composition as are the late Hauterivian variegated clastic rocks. However, the Barremian variegated rocks are invariably much finer grained than those of the latter unit, even in their westernmost exposures. They have been found only in the area between Lorna Lake, Elbow Mountain, the eastern headwaters of Tyaughton Creek and northwestern slopes of Mount Sheba. They are, therefore, essentially confined to the same part of the area as the mid- to late Hauterivian rocks.

The Barremian variegated clastic rocks are predominantly dark grey to black shale and lighter grey to brown-grey more or less sandy siltstone which weather ash grey to yellowish grey. These rocks are medium hard to soft, massive to thin bedded, commonly fissile and characteristically poor in concretions. Some interbeds of limy siltstone have been observed in Section 4 (units 14, 16).

In the more southwesterly sections (Sections 9, 17) shale and siltstone generally form beds 20 to 60 feet thick and units 100 to 500 feet thick. Within these units numerous layers, inclusions and lenses 1 to 6 inches thick and 1/2 to 1 foot thick interbeds of sandy to very sandy siltstone, fine grained, silty greywacke and coarser clastics occur. The thick shaly to silty beds and units are irregularly interbedded with 1 to 10-foot beds (and locally with thicker beds) of light coloured, more or less quartzose (subgreywacke?) sandstone, dark to brown-grey or green, fine to coarse grained greywacke, fine to coarse grit and fine pebble conglomerate. All of these coarser clastic beds are lenticular and interfinger intricately. Sharp, uneven contacts commonly delimit such lenticular interbeds; they are commonly accompanied by scour channels and load casts. Intensive crossbedding is common in some sandstone and greywacke beds.

The grit and pebble conglomerate interbeds have, with a single exception (Section 5, unit 11), only been found in Sections 9 and 17. They are fairly common in Section 9 (units 5, 6, 8) but have only been seen near the top of Section 17 (unit 7) in a thin transitional zone to the overlying Aptian conglomerate. However, the underlying beds of Section 17 (units 1, 3) include prominent interbeds of fine-grained sandstone replete with commonly flattened clay balls. The more northeasterly situated sections (Section 4, units 11-16; Section 5, unit 7) almost lack greywacke or coarser clastic interbeds. Their shale and siltstone units contain little or no sandy siltstone and fine-grained greywacke pods, and interbeds.

The contact of the Barremian variegated clastic rocks with the overlying thick pebble conglomerate of the Taylor Creek Group is transitional in Section 17 (units 7,8). This contact is a fault in Section 9 (units 11, 12). A maximum thickness of 1,370 feet of the Barremian variegated clastic rocks is exposed in faulted Section 9. In Section 17 about 419 feet of the upper part of the unit are exposed but the rocks of the unit are faulted and possibly repeated. Section 4 exposes only the lower 439 1/2 feet of the shaly facies of the unit. Possibly the total thickness of the variegated Barremian clastic rocks approaches 2,000 feet locally.

The facies changes of the Barremian variegated rocks parallel closely those described for the late Hauterivian variegated rocks and may be interpreted essentially in the same way. However, the relatively much finer grained character of the Barremian rocks suggest that they were deposited farther from the southwestern source area than the late Hauterivian rocks of the corresponding sections. Sections 9 and 17 are believed to represent not the outer but the inner part of the southwestern flank of the Barremian trough whereas Sections 4 and 5 are believed to represent either the innermost part of this flank or the outermost part of its axial zone. The pronounced late Hauterivian uplift was thus replaced by an appreciable subsidence and probable marine transgression in Barremian time. This subsidence must have considerably widened the depositional part of at least the southwestern flank of the trough compared with its development in late Hauterivian time. However, the tectonic land farther southwestward persisted and continued to supply considerable amounts of greywacke and coarser clastic rocks. The complex intertonguing of these clastic rocks with shale and siltstone suggests somewhat unstable conditions of the source area, possibly punctuated by minor uplifts. No information is available about the axial part and northeastern flank of Tyaughton Trough in Barremian time. However, it seems likely that the conditions on the northeastern flank paralleled closely those described for the southwestern flank.

Barremian(?) marine fossils have only been found in the more northeasterly situated Sections 4 and 5. This suggests that the unfossiliferous rocks of the more southwesterly situated sections were deposited under deltaic or lagoonal conditions, in part at least. The widening of the Barremian depositional trough was, therefore, not necessarily accompanied by a commensurate transgression of the sea.

No diagnostic Barremian fossils have been found in any of the fossiliferous sections studied. The dating of the variegated Barremian unit depends accordingly on its conformable and gradational superposition on the reliably dated latest Hauterivian rocks and on its being apparently conformably and gradationally overlain by the presumably Aptian basal conglomerate of the Taylor Creek Group. These stratigraphic relationships make it probable that the Barremian stage is more or less completely represented in the Taseko Lake map-area. The Barremian rocks of other areas of the Canadian western Cordillera are known to contain diagnostic fossils (Rice, 1947, p. 19; Duffell and McTaggart, 1952, p. 48; and Jeletzky, unpublished). All diagnostic fossils collected from the Barremian rocks of the Princeton and Ashcroft map-area on the mainland and of Quatsino Sound on Vancouver Island are closely related to those of California and Oregon.

JACKASS MOUNTAIN GROUP (HWT)

The name 'Jackass Mountain Conglomerate group' was given by Selwyn (1872, p. 60) to the sediments, predominantly conglomerate, shale, and greywacke, that are exposed on Jackass Mountain east of Fraser River about 11 miles southeast of Lytton. The name was changed to Jackass Mountain Group by Richardson (1876, p. 73) and this usage was continued by Dawson (1895, p. 64b). When the Ashcroft map-area was restudied by Duffell and McTaggart (1952, pp. 39-52), they subdivided the group into three units, divisions A, B, and C composed of marine and non-marine sedimentary rocks. A brief discussion on the correlation of the group (Duffell and McTaggart, 1952, pp. 50-52) emphasized the confusion that exists when trying to correlate with other Lower Cretaceous groups. Trettin (1961) accepted Duffell's and McTaggart's subdivisions of the group and described them in greater detail.

In Taseko Lakes map-area, divisions B and C have been recognized and show little lithological variation from the divisions as described in the type area (Duffell and McTaggart, 1952, pp. 40-43). Division A, on the other hand, is not represented in Taseko Lakes map-area. A non-marine section, predominantly of greywacke, underlies division B in a few places and may represent a non-marine facies of the marine upper part of division A described by Duffell and McTaggart (1952, pp. 39-40); it could also be a facies of the lower part of division B.

The divisions erected by Duffell and McTaggart (1952, p. 39) were not described as formations although B and C, at least, appear to be distinct, mappable, lithologic units. Division B was, in fact, found to be the equivalent of the earlier named French Bar Formation in Taseko Lakes map-area.

Stratigraphy

Sedimentary rocks underlying division B

This unit is mainly interbedded light greenish grey to grey greywacke, buff-coloured greywacke, pebble conglomerate, and soft, dark grey siltstone and shale. Greywacke predominates or is prominent in all sections. Carbonaceous plant fragments are abundant. These strata and division C are difficult to distinguish and can only be recognized with certainty when division B is present. The position of these beds immediately below division B requires that they be considered a facies of either division A or division B but in either case, they are part of Jackass Mountain Group.

Over 4,000 feet of interbedded greywacke, pebble conglomerate, and siltstone underlie division B on the northeast spur of Red Mountain. Approximately 800 to 1,000 feet of mainly greywacke occur along the south side of Hungry Valley. Elsewhere the unit is poorly exposed.

The only fossils known in these rocks are collections of plants obtained northwest of Red Mountain. They indicate an Aptian age according to W.A. Bell.

Division B or French Bar Formation

In 1920 Mackenzie (1921, pp. 76-77) introduced the name French Bar Formation to distinguish rocks he described as follows:

"This formation is well exposed on upper French Bar Creek, and underlies the country westward across the ridges in which Yalakom River heads as far as upper Churn Creek drainage basin. It may have a considerable extension in the area southeast of that just described.

"The French Bar Formation is made up of very coarse conglomerates with lenticular sandstone beds in subordinate amounts. The rocks are much less indurated than any of the sediments of those included in the Eldorado series, and the pebbles and boulders easily weather out of their sandy matrix. The formation is characterized by a high percentage of large, well rounded boulders of the plutonic rocks of the Coast Mountains. The conglomerate beds range from 10 to 100 feet thick, and the formation as a whole gives the impression of being of fluviatile origin.

"The thickness of the French Bar Formation as exposed near the creek of that name is approximately 2,000 feet."

"On lithologic and structural grounds, this formation is tentatively correlated with the Coldwater Group of Dawson, supposedly of Oligocene age".

Mackenzie's correlation with the Coldwater Group of Oligocene age is not valid. The French Bar Formation is of Aptian age and is equivalent to division B of the Jackass Mountain Group.

The French Bar Formation is characterized by coarse boulder conglomerate composed mainly of granitic boulders up to 2 feet in diameter, 1 to 1 1/2 feet is common, set in a soft, friable, arkosic matrix. Lesser amounts of andesitic and dacitic volcanic rocks, chert, argillite, and greywacke are present as cobbles, pebbles, and boulders, in places comprising 30 per cent of the rock. These non-granitic pebbles and cobbles usually display a greater rounding and smoothness than the granitic boulders, which although fairly well rounded are usually rougher and less spherical. This conglomerate occurs in beds 50 to 150 feet thick. The conglomerate is poorly stratified, but in places interbedded lenses up to 100 feet thick of pebble conglomerate are present. Greenish greywacke, shale, and siltstone are also interbedded here and there but these are rare occurrences. The formation varies in thickness but is as much as 3,000 feet thick, commonly 1,500 to 2,000 feet.

The French Bar Formation is well exposed along the creek from which it gets its name, north of Poison Mountain, north and west of Red Mountain, along the south side of Hungry Valley to Mount Tom, and in a few small exposures to the northwest. This northwest-trending outcrop pattern suggests an obvious source of the granitic debris, namely the granitic mountains and hills forming a parallel northwest-trending belt through Piltz Peak to the north. These granitic rocks are thought to be Jurassic and they are now covered in part by Tertiary volcanic rocks.

The age of the formation in Taseko Lakes map-area is Aptian as the main part of the formation conformably overlies strata carrying Aptian flora and is overlain conformably by division C that also carries Aptian flora.

Division C

The strata of this division are interbedded grey to greenish grey greywacke, buff-coloured greywacke, light grey arkose, grey to dark grey siltstone and shale, and buff-coloured to greenish grey pebble conglomerate. According to Duffell and McTaggart (1952, p. 42) greywacke forms 60-70 per cent of this division and conglomerate 4 per cent; siltstone, shale, and arkose make up the remaining 25 to 35 per cent.

The detrital material of these rocks is varied. Most of the rocks are micaceous and commonly feldspathic. Quartz is usually present but is not commonly a major constituent. Rock fragments, particularly of argillite, greywacke, and volcanic rocks, can be recognized as major constituents of the coarser greywacke and conglomerate.

The greywacke, arkose, and conglomerate are usually well-indurated and commonly form coarse scree slopes of irregular slabs of rock. The softer and less abundant shales and siltstones are commonly masked by the greywacke talus thus creating the impression of an even greater predominance of greywacke. The hills and mountains underlain by rocks of this division are usually rounded and do not have precipitous slopes. This division is well exposed in Camelsfoot Range and northwestward through Poison and Buck Mountains and in the mountains on the north and south sides of Dash Creek valley.

The thickness of division C is considerable, in the Camelsfoot Range it is over 8,000 feet and in the range north of Dash Creek a thickness of more than 10,500 feet has been estimated. In these two localities exposure is good and no evidence of repetition of the section is evident.

The age of this division is Aptian based on collections of fossil flora from the lower part of the division and identified by W.A. Bell. The unfossiliferous upper part of the division may extend into the Albian but is probably older than Middle Albian.

Age and Correlation

In Taseko Lakes map-area the Jackass Mountain Group appears to be mainly or entirely of Aptian to mid-Albian age. Furthermore it is non-marine and entirely sedimentary. This does not accord with the interpretation in the Ashcroft map-area (Duffell and McTaggart, 1952, pp. 39-52) where division A is considered to be marine Barremian, division B also Barremian, and division C non-marine Aptian and marine Cretaceous and Upper Jurassic.

The only fossils obtained from Jackass Mountain Group in Taseko Lakes map-area are plant remains and these indicate an Aptian age. On this basis the beds immediately below and above division B (or French Bar Formation) are dated as Aptian and it follows that division B (or French Bar Formation) must be the same age. The unfossiliferous strata of the upper two thirds of division C are older than the upper Albian or Cenomanian sediments of the Kingsvale Group.

Some uncertainty exists regarding time span of Aptian flora. Recently Stott (1963, p. 13) has shown that Aptian flora of the Gates Member of the Commotion Formation in Pine River region of the Rocky Mountain Foothills occur in beds that are equivalent to strata containing middle Albian marine fossils. His conclusion is that the Aptian "Lower Blairmore-Luscar-Gething flora extends upward into rocks of middle Albian age" (p. 14). In Taseko Lakes map-area, some of the flora identified as Aptian in age may be lower Albian but this cannot be proven. In this report the strata containing this flora will be considered Aptian fully realizing that some or all of these rock units may be middle or lower Albian in age. The unfossiliferous upper part of division C probably was deposited in lower or middle Albian time and is a non-marine correlative of the marine Taylor Creek Group.

The non-marine origin of divisions B and C of the Jackass Mountain Group is difficult to prove. Plant remains are the only fossils found in this group in Taseko Lakes map-area. In addition to the few collections containing identifiable leaves there are fragments of leaves, bits of carbon, carbonized branches and logs throughout the group and locally may be abundant. Shale beds are commonly carbonaceous but no coal or lignite was seen. No marine fossils were found and nothing suggestive of a marine depositional environment was noted.

The disparity in age of the group with that of the type area can, in the writer's opinion, be readily explained. In the type area, division B was dated as Barremian (Duffell and McTaggart, 1952, pp. 48-50) and in Taseko Lakes map-area it is Aptian. Assuming that division B is either Barremian or Aptian, it follows that the overlying division C must be younger than Barremian. Therefore the marine fossils of division C that were dated as Neocomian and Upper Jurassic (Duffell and McTaggart, 1952, pp. 48-50) give an erroneous dating of division C. The position of division C above division B is not in question and redeposition of older fossils in younger beds has never been suggested as an explanation. Furthermore several collections of plants from division C in the type area were dated as Aptian. The writer believes that these marine fossils from division C may have been introduced by faulting and that the rocks containing them are the only strata that are marine. Although there is a lithological similarity, these rocks are not in their proper stratigraphic sequence and should not be considered part of division C.

Intense faulting along major valleys, such as Tyaughton Creek and Yalakom River is characteristic of Mesozoic rocks of Taseko Lakes map-area. Fairly complete sections are exposed from which the stratigraphic succession has been interpreted but within the fault zones or near the main faults, many normal and thrust faults can be recognized and, of more importance, imbricate or schuppen structures have been recognized and proven by repetition or reversal of faunal sequences. In unfossiliferous sections lacking distinctive lithologic units the type of faulting is not obvious of if the exposure is poor the faulting may not be recognized at all. If one or two fossiliferous slices of rock are introduced with an apparently conformable attitude into a younger unfossiliferous section of similar lithology, the section as a whole may be dated erroneously from the older, introduced fossils. The contradictory evidence from the Ashcroft map-area may thus be explained, as there the Jackass Mountain Group occurs along the intensely faulted, forested, and drift-filled Fraser River valley.

The age of division B in the type area is said to be Barremian (Duffell and McTaggart, 1952, pp. 48-50) but in Taseko Lakes map-area the age of division B (or French Bar Formation) is Aptian based on fossil flora. In the type area both division B and division A contain Barremian fossils and Duffell and McTaggart (1952, pp. 43-44) indicate an erosional unconformity between these divisions, and possibly an angular discordance. It is unlikely that the same fossils would be expected to occur above and below an unconformity of this magnitude. Conglomerates do occur in division A but whether or not in the marine section is not indicated. In the writer's opinion there is reason to question the age indicated for division B in the type area. The age of the division in Taseko Lakes area is Aptian and as discussed in the section on Taylor Creek Group, it is correlative with the marine basal conglomerate beds of that group. An ammonite found there is dated as upper Barremian to lower Albian and an Aptian age is favoured.

In the type area division A includes a section of marine greywacke with Barremian fossils. In the discussion of the Relay Mountain Group evidence was presented suggesting that poorly fossiliferous Barremian rocks are present at or near the top of the group which is essentially a conformable succession. In Taseko Lakes map-area these Barremian rocks are structurally, stratigraphically, and palaeogeographically related more closely with the Relay Mountain Group and hence are not here considered part of Jackass

Mountain Group. The presence of conglomeratic beds in the Barremian may herald the beginning of an uplift that culminated in the Aptian French Bar Formation or division B.

Origin of Jackass Mountain Group

The Jackass Mountain Group was deposited on the northeastern and eastern flank of a northwest trending trough. As will be discussed more fully under the Taylor Creek Group, the northeastern flank of the trough was non-marine whereas the southwestern part of the trough was probably marine where the Taylor Creek Group accumulated at about the same time. The source of the material was apparently the granitic rocks and older intruded rocks that form a northwest trending belt through the central part of Taseko Lakes map-area and may have a southeastern extension as the Mount Lytton batholith. In the Taseko Lakes map-area the age of these granitic rocks is post-Triassic and pre-Upper Jurassic, possibly Bathonian. On Vancouver Island granitic intrusive rocks of this age have been recognized by Jeletzky (1954a, 1954b), and such intrusions may be widespread.

This belt of intrusive rocks in Taseko Lakes map-area was apparently uplifted slowly after emplacement and gradually restricted the marine trough of the Relay Mountain Group so that after Barremian time the marine area was either eliminated from this region or, more probably, was shifted southwestward. The uplift on the northeast side may have accelerated, but in any event a flood of non-marine greywacke, shale, and pebble conglomerate accumulated first, followed abruptly by coarse granitic debris, presumably near the base of a granitic range, and spread outward over alluvial fans (French Bar Formation). The rapid build up of the coarse conglomerate was abruptly terminated and was followed by rapid deposition, mainly of greywacke (division C). The thickness of the group suggests that the site of deposition was being downwarped as the sediment accumulated as the total thickness is much greater than the total thickness of the marine Taylor Creek Group which is the marine equivalent. Apparently, except for time of deposition of the French Bar Formation, the downwarping of the site of deposition kept pace with the rise of the source area thus producing a fairly uniform greywacke-shale sequence throughout division C.

TAYLOR CREEK GROUP (HWT)

Cairnes (1943, p. 6) applied the name Taylor Group to a group of rocks that "is characterized chiefly by an abundance of conglomeratic rock, but includes, as well, great thicknesses of finer grained, clastic materials and minor intercalations of volcanic rocks." Its typical occurrence is in the basin of Taylor Creek, southeast of Eldorado Mountain on the south edge of this map-area. This group was traced into the Taseko Lakes map-area where it is exposed on Eldorado Mountain and its east slope, on Quartz Mountain, on the mountains northwest of Relay Mountain and on Dash Hill. These exposures are typical of the group as described by Cairnes. Southwest of these exposures the conglomerates wedge out abruptly and the shales thicken and form a dominantly shale facies on the northern ridges of Sheba Mountain. Farther to the west on the ridge south of Yohetta Lake, volcanic flows and breccias are interbedded with the shale and locally predominate. Conglomerate, shale, and volcanic rocks all occur in the type area according to Cairnes but the proportion of one to another varies in the facies described from Taseko Lakes map-area. The black shale is present in all sections but is not everywhere predominant. Several fossil collections from the different facies indicate that all facies accumulated over the same span of time. Although these facies might be considered as separate formations, they do appear to be one group.

The name "Taylor" has been applied to other units, particularly the Taylor Marl of central and east Texas and as this is an earlier named unit, the name is therefore preoccupied. However, the Taylor Group appears several times in the literature of British Columbia and a complete change of name would cause further confusion. It is proposed that the name should be expanded to Taylor Creek Group and it is defined as synonymous with Cairnes' Taylor Group. In this report the rocks of the group are briefly described and an origin of the group is suggested. Cairnes presented arguments for a Jurassic age of this group but lacked diagnostic fossils. Fossils obtained by the writer indicate an Albian age for most or all of the group.

Stratigraphy

Cairnes believed the group was characterized by abundant conglomeratic rocks but, although conglomerate is common and locally predominant, it is not everywhere present in the group. Black or dark grey shale is the more common rock type and, although not predominant in all sections, it is nevertheless present. There are several facies in this group so that it changes from a conglomerate and shale section, to a dominantly shale section, a tuff, shale, and breccia section, or a volcanic flows, tuffs, breccias and shale section. The group is believed to have been deposited mainly in a northwest-trending trough (Fig. 5).

Shale and subgreywacke

Black and dark grey shale is characteristic of the group but it varies greatly from place to place. In general it is soft and crumbly, in places limy, and commonly concretionary. A typical occurrence is thinly bedded, varve-like sections in which beds 1/4 inch to 1/2 inch thick have rhythmically been deposited. In other places beds 6 inches to 10 inches thick are common but these are usually interbedded with grey greywacke. Where interbedded in conglomeratic sections they are commonly massive mudstones with no obvious fine bedding. Thin beds of grey to dark grey limestone occur rarely.

Subgreywacke is prominent in the lower part of the group and is usually grey to light grey in colour. It occurs in beds up to 1 foot thick commonly interbedded with more abundant shale. The subgreywacke is commonly quartzose and in places some beds of nearly pure quartz sandstone are present. Sorting has been very good. Lobate rill marks, crossbedding and poorly developed ripple-marks have been noted in a few places in subgreywacke.

Although shale is present in all sections it is best exposed on the northern ridges of Sheba Mountain where it is the predominant rock type. All fossils found in Taylor Creek Group occur in shale beds or lenses.

Conglomerate

The conglomerate that Cairnes regarded as typifying the group was formed on the eastern and northeastern side of the trough (Fig. 6). It occurs as beds up to 200 feet thick with interbedded black shale. Where the conglomerate beds are thickest and coarsest the shale beds are thinnest. The conglomerate beds thin and become finer to the southwest and west.

The conglomerate is composed of well-rounded, black, grey and white chert pebbles up to 4 inches in diameter, generally 1/2 inch to 1 inch. Chert pebbles make up about 90 per cent of the total pebbles and the other 10 per cent is hard fine-grained volcanic rocks and argillite. Granitic pebbles are not present nor are any easily weathered rock fragments. The pebbles are closely packed with little or no matrix around them and as a result in many sections the conglomerate is porous, the pebbles resting against each other and the interstices empty. Where present the matrix is invariably siliceous, simply a finer version of the pebbles. The conglomerate is commonly rust-weathering.

Sedimentary structures are rare in the conglomerate. Bedding is rarely seen, a few lenses of finer conglomerate or grit may be present but the usual characteristic is massive, well-sorted pebble conglomerate.

Exposure is not good enough to observe the lateral changes of the conglomerate in detail, however, it apparently thins rapidly basinward (i.e. southwestward) and is absent in the central part.

Volcanic rocks

In the western and southwestern part of the trough the shales are subordinate. There they are tuffaceous in part and are interlayered with dark green, green to mauve and purple andesitic and basaltic flows, breccias and tuffs (Fig. 6). The flows vary greatly in thickness, possibly up to 200 feet thick, but little is known of the detailed stratigraphy. Much faulting and intrusion of sills and dykes have complicated the section. Preliminary study suggests that the section is thick, possibly 3,000 to 4,000 feet, but repetition may have occurred. Conglomerate and greywacke have not been recorded in any section studied. Volcanic rocks comprise as much as 75 per cent of the section in the range north of Tchaikazan River.

Basal conglomerate

A unique conglomerate occurs at the base of the group and is exposed on the north side of Sheba Mountain (see Section 17). What is believed to be the same conglomerate is exposed on the south side of Relay Mountain and south of Elbow Mountain. In the central part of the trough it is represented as fine pebble conglomerate, breccia, and greywacke.

This conglomerate is composed of closely packed boulders, cobbles, and pebbles up to 1 foot in diameter, usually 4 inches, set in a subgreywacke matrix. It is poorly sorted and bedding is rare. A few lenses of greywacke or subgreywacke may be interbedded. The clasts are composed of a great variety of rock types, greywacke, argillite, volcanic rocks, limestone, chert, volcanic? porphyries, and uncommonly, granitic material. The sedimentary rock pebbles commonly contain fossils as old as Upper Jurassic (Oxfordian) and as young as Barremian and probably Aptian.

Although the exposure is poor the conglomerate is believed to thin basinward (i.e. northeastward) from a possible thickness of 800 to 900 feet to as little as 50 feet. The exposures south of Elbow Mountain and those on Sheba Mountain (Sections 9, 18) are thought to be on the southwest side of the trough.

Distribution and Thickness

The facies distribution of the Taylor Creek Group is illustrated in Figure 5 and the shape of the trough and the source areas are suggested.

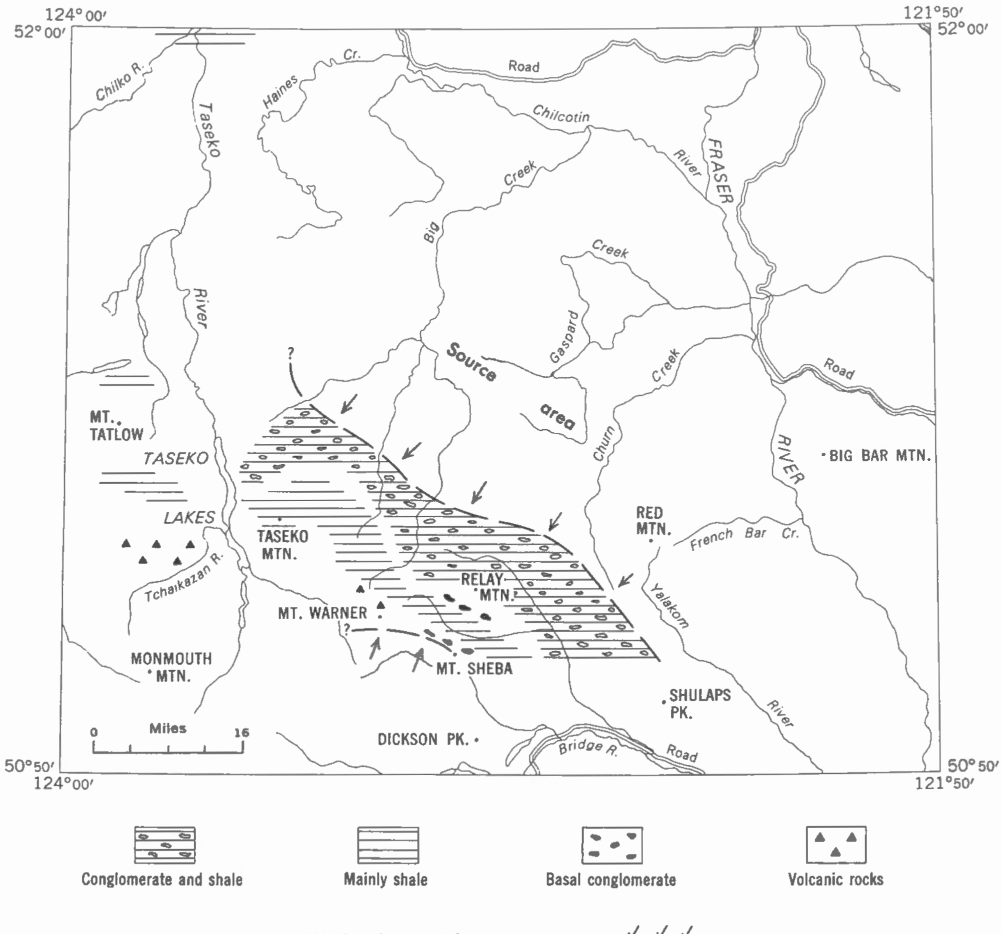

Figure 5. Distribution of facies within the Taylor Creek Group.

The various facies interfinger and the change from one to another is not clearly defined. However the changes do occur over relatively short distances. The total thickness of the unit probably does not exceed 4,000 feet but is difficult to estimate due to severe faulting and insufficient palaeontologic control.

Age and Correlation (JAJ)

Marine fossils are rare in Taylor Creek Group of Taseko Lakes map-area and its equivalents elsewhere in southern and central British Columbia.

The basal conglomerate of Taylor Creek Group in Taseko Lakes map-area has yielded a single index fossil, *Aconeceras* sp. indet., which probably occurs in place (*see* Section 17, unit 9). So far as known, this is the first record of *Aconeceras* anywhere on the Pacific slope of North America. In Europe, in the European Arctic, and in the southern hemisphere *Aconeceras* ranges from late Barremian into basal Albian but is largely restricted to the Aptian stage. The probable occurrence of *Aconeceras* sp. indet. in the basal conglomerate of the Taylor Creek Group tends to support an Aptian age inferred from the stratigraphic position and floral evidence.

The shale and subgreywacke of the group have yielded diagnostic marine fossils of late lower and middle Albian age (=early and late middle Albian in the sense of Spath, 1923-1942). Most of the fossils collected are referable to the late lower Albian zone of *Brewericeras hulenense* which is widespread on the Pacific slope of North America from California to Alaska. Only one locality (Section 19, unit 5) represents the middle Albian zone of *Cleoniceras (Grycia?) perezianum* of McLearn (in preparation). There is no fossil evidence favouring the presence of the upper Albian *Mortoniceras* and *Desmoceras (Pseudouhligella) dawsoni* zone of McLearn (in preparation), but there are unfossiliferous shales above the *Cleoniceras (Grycia?) perezianum* zone that may represent this upper Albian zone. The fossils of the group are for the most part specifically identical to those occurring in the lower and middle parts of the late Lower Cretaceous (Albian) sandstone member of the Haida Formation of Queen Charlotte Islands (*see* Table 4) and the Albian part of the Taylor Creek Group is believed equivalent to the Albian sandstone member of the Haida Formation. The same appears true of marine Albian strata (Dewdney Creek Group in part?) of Princeton map-area (*see* Table 2).

The early lower Albian rocks (*Leymeriella tardefurcata* zone of the international standard or *Brewericeras (Leconteites) lecontei* subsp. *whiteavesi* zone of the Pacific slope; Table 2) are unknown on the mainland of British Columbia and in most sections of the Haida Formation. It is not

TABLE 2

Distribution of Albian fossil zones in southern and western British Columbia

	Queen Charlotte Islands (McLearn)	Taseko Lakes (this report)	Whitesail Lake (this report)	Princeton (this report)
Upper Albian	Mortoniceras spp. and Desmoceras (Pseudouhligella) dawsoni	Unknown, probably present.	Unknown	Present
Middle Albian	Cleoniceras (Grycia?) perezianum	Present	Present	Probably present.
Lower Albian	Brewericeras hulenense and Douvilleiceras sp.	Present	Unknown, probably present.	Present
	Brewericeras (Leconteites) lecontei subsp. whiteavesi	Unknown	Unknown	Unknown

known whether these rocks are a non-marine facies on the mainland or whether a hiatus occurs between the Aptian rocks and the overlying late lower Albian strata. The latter alternative finds some support in the widespread occurrence of such a hiatus in North America and elsewhere.

The late lower Albian *Brewericeras hulenense* fauna is of greatest value in correlation of the marine Albian rocks within the Taseko Lakes map-area and is present in other areas of British Columbia. In the Princeton map-area, *Brewericeras hulenense* was collected by J. Usher (unpublished; GSC loc. 20196) in the uppermost member of Dewdney Creek Group on the left bank of Memaloose Creek about 3 miles above its confluence with Similkameen River. About 4 1/2 miles northwest of this locality in a road cut on Hope-Princeton highway (west of Allison Pass 1/4 mile east of east bridge over Cedar Creek), W.L. Fry collected *Douvilleiceras*? sp. indet. and *Hulenites*? sp. indet. of possible middle Albian affinities (GSC loc. 26851). West of Taseko Lakes map-area *Brewericeras hulenense* occurs (unpublished) at a locality about 1 mile northwest of Emerald Lake and 6 miles south of Tatla Lake (51°55' N. Lat., 124°30' W. Long.) indicating the extension of marine Albian facies at least this far west.

The middle Albian *Cleoniceras* (*Grycia*?) *perezianum* fauna is equally as widespread as the *Brewericeras hulenense* fauna but the rocks are not as fossiliferous. In addition to its occurrence in Taseko Lakes map-area, this middle Albian fauna is present in Whitesail Lake map-area and presumably in Princeton map-area. In Whitesail Lake map-area poorly preserved marine Albian fossils were collected by Duffell in an unnamed shale-sandstone unit and were originally referred by Jeletzky to the *Brewericeras hulenense* zone (Duffell, 1959, pp. 66-67). Subsequent research by McLearn (in preparation) necessitated their transfer into the younger middle Albian *Cleoniceras* (*Grycia*?) *perezianum* zone and the rock unit concerned is thus correlative with unit 5 of Section 19 of Taseko Lakes map-area. It should be mentioned that these sedimentary rocks of Whitesail Lake map-area are 2,000 to 3,000 feet thick and probably some unfossiliferous beds are correlative with rocks of Taseko Lakes map-area containing the *Brewericeras hulenense* fauna. In the Princeton map-area the presence of marine equivalents of *Cleoniceras* (*Grycia*?) *perezianum* zone is suggested by the occurrence of a poorly preserved *Hulenites*? sp. indet. in association with *Douvilleiceras*? sp. indet. in the uppermost member of Dewdney Creek Group at GSC loc. 26851 (*see* p. 68).

The only record of the upper Albian *Mortoniceras* spp. and *Desmoceras* (*Pseudouhligella*) *dawsoni* zone on the mainland of British Columbia is in the Princeton map-area near the other Albian localities. The fossil *Mortoniceras* s. lato sp. indet. was found in 1910 (GSC loc. 14927) on Mamloos Creek, a tributary of Roche River, Similkameen district, apparently referring to Memaloose Creek of more recent maps. This occurrence strengthens the belief that the unfossiliferous shales above middle Albian strata in Taseko Lakes map-area are of upper Albian age.

Origin of the Taylor Creek Group and its relation to the Jackass Mountain Group (HWT)

The writer believes that the Taylor Creek Group and the Jackass Mountain Group were formed penecontemporaneously and that they were formed in the same basin, the former in a marine part and the latter in a non-marine part. The unifying element of the two groups is the Taylor Creek basal conglomerate and the French Bar Formation of Jackass Mountain Group. These two units have been dated rather closely and present evidence indicates that they are Aptian(?) or early Albian at the latest. These two conglomeratic units differ greatly in composition but this can be explained by a difference in source areas, the French Bar Formation from the granitic mountains to the northeast and the Taylor Creek's basal conglomerate from the southwest. The relationship is illustrated in Figure 6. The interfingering of the two groups cannot be demonstrated because of the complex faulting but in the area where the two groups come together the intricate faulting suggests a close relationship.

There is a suggestion that the Taylor Creek Group in the upper part, overlaps the Jackass Mountain Group and separates it everywhere from the lowest sedimentary beds of the overlying Kingsvale Group. Such an expansion of the Albian marine area is also indicated by two wells drilled in central British Columbia, one just north of Taseko Lakes map-area near Redstone by Hudson Bay Oil and Gas Company and the other farther north near Nazko by Honolulu Oil Corporation. Palynology studies by the companies of cores and cuttings indicated a mainly non-marine late Lower Cretaceous section in both cases but a marine Albian section was also intersected. The obvious conclusion is that the marine transgression was widespread in middle to late Albian time. It was followed by the deposition of the non-marine Kingsvale Group.

The formation of the chert pebble conglomerate of the Taylor Creek Group with an abundance of chert pebbles seems unusual and needs an explanation. The writer considers this to be a beach deposit. As illustrated by the French Bar Formation, the detritus being supplied to the basin from the northeastern land area was varied but mainly granitic. There was also a subordinate amount of chert. During the period of deposition of division C of Jackass Mountain Group there were no coarse conglomerates developed, only an abundance of greywacke, shale, arkose, and thin pebbly conglomerate beds. Obviously the granite debris from the source area was being broken down during this cycle of erosion and deposition. Under these conditions only resistant pebbles, like chert, could withstand the abrasion

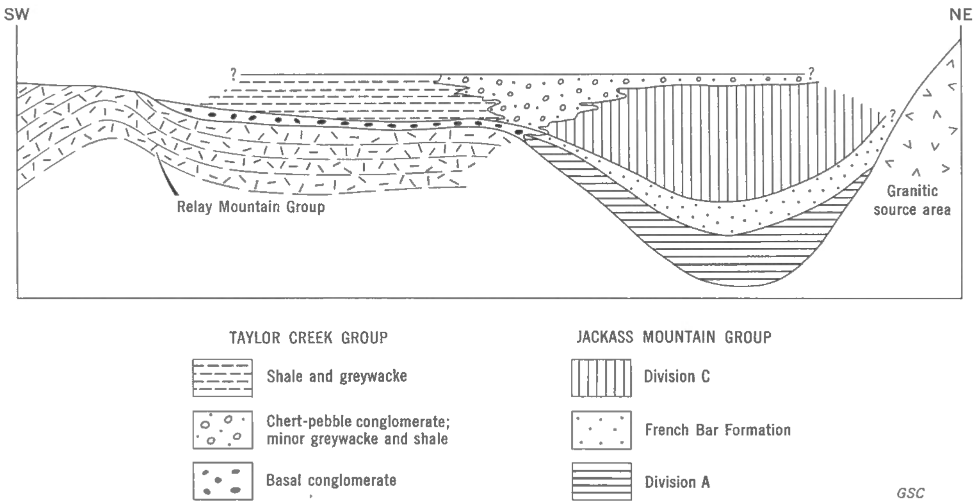

Figure 6. Diagrammatic section showing relationship of Taylor Group to Jackass Mountain Group.

and weathering that detritus would undergo during transportation into and across the non-marine Jackass Mountain basin to the edge of the marine Taylor Creek basin. Presumably the mode of transport was by streams that, on reaching the sea, would deposit their load. Wave action would further abrade and sort this material so eventually a deposit of mainly chert would be left and the weathered material would be winnowed out and carried farther into the basin to be deposited as shale. A process such as this that involves selective sorting and reworking is preferred to any suggestion of a unique source area that would supply only chert. Granitic debris was being supplied to this basin both before and after the formation of the chert pebble conglomerates and any explanation must account for its absence from the chert pebble conglomerate of Taylor Creek Group.

KINGSVALE GROUP (HWT)

In the Princeton map-area the Kingsvale Group was named by Rice (1947, pp. 25-27) for some interbedded breccias, tuffs, and green, mauve, purple, black and brown lavas with minor sedimentary rocks at the base. The group was loosely defined, was dated by flora as Albian, and was found to vary in lithology from place to place. The thickness was unknown but in places the breccias were many hundreds of feet thick. Cockfield continued this usage in the Nicola map-area (1961, pp. 19-21). In the Ashcroft map-area, Duffell and McTaggart (1952, pp. 55-58) considered the Kingsvale Group to be "a succession of basaltic and andesitic lavas and fine to coarse agglomerates, tuffs, and breccias that have at their base a zone of sedimentary rocks of varying thickness, which in places may be missing". The thickness of the volcanic part was not known but was considered to be in the order of 3,500 feet and that of the sediments 800 to 1,000 feet.

In Taseko Lakes map-area the group is lithologically similar and partly of the same age as in the type area but the thickness, over 15,000 feet, is apparently greater and it becomes necessary to subdivide it into mappable units. Therefore the Kingsvale Group as represented in Taseko Lakes map-area is divisible into four units, namely divisions A, B, C, and D and is of latest Albian(?) to Late Cretaceous age. These divisions are possibly definable as formations but as no type section has been measured and as our knowledge of the stratigraphic relations of the units is inadequate, they are not rigidly defined as formations. Division A corresponds in part with the sedimentary zone at the base of the group in Ashcroft map-area and consists of interbedded greywacke, conglomerate, and shale. Divisions B and D are equivalent to the volcanic upper part of the group as described in Ashcroft map-area and are predominantly volcanic breccias and tuffs. Division C is essentially conglomerate, greywacke, and shale with some interbedded breccia and tuff but the unit is of variable thickness and is not everywhere present.

Stratigraphy

Division A

This unit is the lowest in the group and conformably overlies the Taylor Creek Group. It comprises 5,400 feet of interbedded buff to greenish grey greywacke, coarse to fine pebble conglomerate, and soft dark grey shale and siltstone, green to grey tuffs and tuffaceous shale, minor volcanic breccias, and minor green to grey andesite flows. The sedimentary rocks are in general very micaceous; in places they are feldspathic, and poorly consolidated but well-bedded. The conglomerates contain many chert pebbles and fragments as well as abundant volcanic pebbles, granitic debris and other well indurated rock fragments. The beds vary in thickness up to 25 feet but are commonly thinner, about 10 to 15 feet. Wood fragments and carbon are abundant and plant remains, in many places with excellent preservation, are a common occurrence.

This division is well-exposed on the north slope of Tatlow Mountain, in the mountains west of Taseko Lakes, on the hills and mountains on both sides of Relay Creek, and at many other localities in the southwest quarter of the map-area. It is usually a recessive unit except where conglomerates are locally abundant and well consolidated. The thickness on Mount Tatlow is in excess of 5,400 feet.

Several facies of the unit can be recognized and are readily explained through a knowledge of the Kingsvale Group sedimentary basin. The source of the detrital material, as for the Jackass Mountain Group, was to the north and northeast. As a result the sections exposed on the northeast side of this basin, on Mount Tatlow and along Relay Creek, are up to 50 per cent conglomerate, in places as coarse as cobble conglomerate but commonly a pebble conglomerate. Greywacke is next in abundance and shale is the least important. Conglomerate increases upward in the section. No volcanic rocks are found along the northeast side of the basin. Southwestward the section thins abruptly and shale and greywacke become predominant with conglomerate becoming finer and occurring in thinner beds. Farther to the southwest, on the ridge north of Tchaikazan River, conglomerate is missing, the section has thinned further, and greenish tuff, tuffaceous shale, and a few thin andesite flows are interbedded in this predominantly shale section.

The unit is believed to be non-marine. Current bedding, cut and fill structures, coarseness of the detrital material, abundance of wood fragments, carbon and plant remains, and the absence of anything suggesting a marine basin is convincing evidence for a non-marine environment. A possibility exists that the lower part of the unit may interfinger with the marine Taylor Creek Group but all contacts seen show an abrupt change in lithology.

Plant fossils are abundant and were dated by W.A. Bell as Albian and as Cenomanian. A few collections indicated a general Albian-Aptian age but none were definitely Aptian and as the Kingsvale Group is younger than marine middle Albian strata, the Aptian possibility may be discounted. The underlying Taylor Creek Group includes fossiliferous middle Albian shale and unfossiliferous shale of possible upper Albian age. If this be the case, the overlying division A of Kingsvale Group must have been deposited in very late Albian and Cenomanian time.

Division B

This unit is best exposed on Tatlow Mountain and southward where it is a section over 6,000 feet thick of interbedded coarse volcanic breccias and tuffs. Breccias with angular fragments up to 2 feet diameter are present in beds up to 150 feet thick. They are poorly sorted, are not waterlain, and are typically andesitic and basaltic displaying maroon, purple, bright green, mauve, grey, dark-grey, and brown colours. The breccias are slightly weathered and fragments are easily distinguishable, set in a fine tuffaceous matrix. The tuffs are fine, usually thin layers 6 inches to 2 feet thick and although in distinct beds with distinct contacts with the breccias they are not believed to be waterlain. They are of the same composition as the breccias but darker or duller colours predominate. Near the base of the division tuffs are more abundant and grade into the underlying sediments of division A over distances of less than 50 feet.

Southwest from Mount Tatlow volcanic lavas that appear identical in composition and appearance to the fragments of the breccias are interbedded with the fragmental rocks but comprise less than 20 per cent of the section. Many dykes and sills are present in the section and may be mistaken for flows but many can be proven to be intrusive.

The thickness of division B on Tatlow Mountain is more than 6,000 feet and this may be a maximum thickness in the area. All other sections are faulted or thinned by erosion; the best exposures are west of Taseko Lakes. No fossils have been found in the division.

Division C

This division varies greatly in thickness from 0 to 1,000 feet. It also varies greatly in composition but is mainly conglomerate, greywacke and shale, and interbedded tuffs, breccias, and tuffaceous sediments. No two sections are identical in lithology and can only be recognized by three criteria: (a) age, (b) mainly volcanic sediments, and (c) position between the two volcanic units, divisions B and D.

Near the base of Battlement Ridge on the south side a thick pebble conglomerate overlying volcanic breccia is exposed. The conglomerate varies in colour from purple to brown, green and grey and is almost entirely volcanic pebbles and cobbles up to 8 inches diameter and in places boulders up to 2 feet. Thickness of the conglomeratic section is over 885 feet with some volcanic fragmental rocks interbedded. Overlying this section are several hundred feet of volcanic breccias and then more sediments, mainly shale and greywacke. This is overlain by division D. On Tatlow Mountain only about 200 feet of coarse volcanic conglomerate is exposed. On Sheba Mountain thin beds of siltstone and greywacke, 100 feet or more thick occur between the volcanic divisions.

A few plant remains and silicified wood have been obtained from these sediments and according to W.A. Bell and F.M. Hueber they suggest an early Late Cretaceous age.

Division D

This unit is indistinguishable from division B and where division C is missing, the two divisions cannot be separated because in all respects the two divisions are lithologically similar. The thickness of beds exposed on Mount Tatlow is over 4,000 feet. The unit is also exposed on the ridge northwest of Battlement Ridge and west of the peak on Mount Sheba. No fossils have been found in this division.

Age and Correlation of Kingsvale Group

Plant fossils indicate Albian, Cenomanian, and later(?) Upper Cretaceous ages for divisions A and C. Upper age limit of division D is not established within the group. However, another sedimentary unit, probably younger than division D has been dated as Maestrichtian or Campanian. The Kingsvale Group probably ranges in age from Albian to mid-Upper Cretaceous.

It should be emphasized here that these rocks are only dated by fossil flora. As the Taylor Creek Group includes strata that are probably upper Albian, the lower beds of division A of Kingsvale Group must be very late Albian if they are Albian at all. When correlative marine faunas are eventually found in association with the Albian flora, the age of the flora may be open to revision and may possibly be shown to be Cenomanian. However, they have been assigned an Albian age and tentatively this Albian age has been accepted as the age of the lower beds of division A.

Lithologically the group is similar to Kingsvale Group in the type Princeton map-area, Nicola map-area, and in the Ashcroft map-area although the four divisions or the range of age was not evident there. In the Ashcroft map-area two units were noted, some 800 feet of Albian sediments overlain by a thick volcanic section. The sediments would be equivalent to division A in this area and the volcanic section to division B or B and D combined.

In Whitesail Lake map-area (Duffell, 1959, pp. 64-67) marine middle Albian mudstones and siltstones are overlain by "several hundred feet of arkosic sandstone" containing fragmentary plant remains. This sandstone is overlain in turn by some 2,000 feet of red, green, and brown breccia and tuff and grey, brown, and black andesitic and basaltic flows. The stratigraphic position above the marine Albian rocks and the lithologic character of the sandstone and the volcanic rocks suggest they may be equivalent to divisions A and B respectively. The Redstone and Nazko wells previously mentioned indicate the presence of Albian and Upper Cretaceous non-marine sediments in the central part of the province but no volcanic rocks of this age were encountered. The section is apparently much thinner there.

Origin of the Kingsvale Group

The Tyaughton Trough that was first in evidence as a well-defined tectonic element in late Oxfordian time persisted throughout the remainder of Jurassic time and throughout lower Cretaceous time. The width of it apparently varied during its existence and it was, at different times the depositional site of both marine and non-marine sediments. The axis of this trough is difficult to define at all times but in this map-area it roughly follows a line from Relay Mountain to Mt. Tatlow. For the western part this is partly an assumption in that the only well exposed group in the area around Taseko Lakes, the non-marine Kingsvale Group, is thickest along such a line.

The Kingsvale Group, so far as known, had an area of deposition similar to the older Taylor Creek and Jackass Mountain Groups. The source area for the sedimentary material of division A was the same northwest trending granitic range through the centre of the map-area that was the source area of Jackass Mountain Group. Coarse conglomerates, greywacke and shale were deposited in the area to the southwest of this source area and the best exposures of these rocks in Taseko Lakes map-area are in the southwest quarter, west of Big Creek. The conglomerates and greywacke were deposited mainly along the northeast margin of the basin and southwestward the sediments thinned and became finer grained. In the southwestern part along Tchaikazan River the sediments are mainly fine greywackes and shales, in places probably tuffaceous. No evidence was noted of a southwestern land area that could be a source of sediment.

The coarseness of the Kingsvale sediments compared with those of the Taylor Creek Group and division C of Jackass Mountain Group suggest an abrupt uplift in the northeast source area at the close of Albian time, hence the coarse conglomerates on the northeast flank of the trough. This uplift would account for the exclusion of the sea westward from central British Columbia and beyond the limits of this map-area at the close of Albian time.

This period of sedimentation was abruptly terminated by the onset of volcanism that probably was most active southwest of the inferred axis of the trough, as the thickest volcanic accumulations of the group occur there. During the volcanic period, sedimentation occurred in small, separate basins, probably controlled by local conditions and having a local source.

OTHER UPPER JURASSIC AND LOWER CRETACEOUS GROUPS OF SOUTHWESTERN BRITISH COLUMBIA (JAJ, HWT)

The introduction of a multitude of group or formation names for Jurassic and Cretaceous rocks of western Cordillera has added a complexity of nomenclature to a natural geological complexity. Few of these names are usable beyond the restricted areas in which they were recognized and few of the units are properly defined. Tables 3 and 4 illustrate the problems of nomenclature that exist and offer a tentative correlation with the groups in Taseko Lakes map-area. The following brief comments on each of these groups or formations may assist in clarifying their status.

As mentioned on pages 6 and 48, the difficulties of establishing valid groups and formations are augmented by the common development of schuppen or imbricate structure. This feature was first recognized by Crickmay (1930b, pp. 482-491) in the Harrison Lake area where he records (1962, p. 10) "the Pennsylvanian, Lower Cretaceous, and Paleocene are imbricated with one another to such a degree as to appear interbedded". From the writers' experience in Taseko Lakes map-area, Crickmay's observations appear correct in principle and from the complex and contradictory stratigraphic evidence in adjacent areas they believe that such structural features are common but have gone unrecognized.

TABLE 3

Correlation of Upper Jurassic and Cretaceous groups and formations of southwest British Columbia with units in Taseko Lakes map-area

TASEKO LAKES	ASHCROFT	PRINCETON	HOPE	HARRISON LAKE
Kingsvale Group: - Div. D - Div. C - Div. B - Div. A	Kingsvale Group (volc.) Kingsvale Group (sed.)	Kingsvale Group Pasayten Group	Volcanic rocks Skagit Formation	
	Spences Bridge Group	Spences Bridge Group		
Taylor Creek Group	Brew Group (in part)	Marine Albian (Dewdney Creek Group in part?)		
Jackass Mt. Group: - Div. C - French Bar Formation (Div. B)	Jackass Mt. Group: - Div. C - Div. B	Dewdney Creek Group: - Div. D - Div. C	Dewdney Creek Group Jackass Mt. Group	
Relay Mountain Group	- Div. A Brew Group (in part) Lillooet Group Jackass Mt. Group - Div. C (in part)	- Div. B - Div. A (in part) - Div. A (in part)	Ladner Group Conglomerate, sandstone, and shale	Brokenback Hill Formation Peninsula Formation Extensive hiatus Agassiz Prairie Formation
			Tamihy Group Agassiz Group	Kent Formation

Skagit Formation (HWT)

This formation occupies a small area in the Hope map-area (Cairnes, 1944) on the International Boundary. It is mainly volcanic rocks and has been correlated on a lithologic basis with the Kingsvale Group. No fossils have been found.

Pasayten Group (HWT)

In the Princeton area Rice (1947, pp. 19-24) subdivided this group into five divisions of sedimentary and volcanic rocks. The group is entirely non-marine and has an Albian flora. It is considered to have a total thickness in the order of 20,000 feet. An obvious correlative in Taseko Lakes map-area is division A of the Kingsvale Group. However, they differ considerably in lithology and the Pasayten Group is much thicker. From Rice's comments on the age of the group (op. cit. p. 23) it is apparent that fossils were only obtained from two divisions (B and C) and the other divisions may be older or much younger. Therefore, the Pasayten Group may only be tentatively correlated with other groups or formations until more palaeontologic control is obtained.

Spences Bridge Group (HWT)

This group is known in the Nicola (Cockfield, 1961), Ashcroft (Duffell and McTaggart, 1952) and Princeton (Rice, 1947) map-areas where it is essentially a group of volcanic rocks of probable Aptian age. The rocks were described by Rice (op. cit. p. 24) as lavas varying in composition from cherty rhyolite to soft dark brown basalt. Most of them are dacites, but many are comparatively free from quartz and are andesites. Flow banding and well developed spherulites are common features. The colours are "brown, yellow-brown, reddish brown, mauve, purple, green, and grey". The group is unconformably below the Kingsvale Group for which it may be easily mistaken. The age is established by probable Aptian flora. The group does not occur in Taseko Lakes map-area and is believed by the writers to be a local group occurring near and southeast of its type locality around Spences Bridge. The unfossiliferous northwest extension of Spences Bridge Group from the type area (Duffell and McTaggart, 1952, map 1010A) may in reality be Kingsvale Group. Evidence in Taseko Lakes map-area suggests that Kingsvale Group rocks mapped there are a direct extension of Spences Bridge Group as mapped in the northwest quarter of Ashcroft map-area.

Brew Group (HWT)

In the Ashcroft map-area Duffell and McTaggart (1952, pp. 34-36) describe the lower part of the group as consisting of argillite, fine-grained quartzite, and a few beds of pebble conglomerate. A collection of fossils was identified as "Aucella ex. gr. crassicollis Keyserling, of early Lower Cretaceous age" (op. cit. p. 35). This part of the group is probably a correlative of part of the Relay Mountain Group.

The upper part of the group is described thus: "Boulder conglomerate, locally at least 600 feet thick, overlies the succession described above. The boulders are well rounded, up to 8 inches in diameter, and generally closely packed". The composition of the boulders varies greatly and apparently consists of volcanic rocks, argillite, quartzite, coarse-grained gneiss, and granitic textured rocks, probably diorites. "Banded argillite and impure quartzite, totalling at least 3,000 feet in thickness, overlie the conglomerate. Locally these rocks show varve-like bedding" (op. cit. p. 35). This description of the upper part of the group fits the Taylor Creek Group precisely and stratigraphically it could be unconformably(?) above the lower part of the group which is a possible correlative of Relay Mountain Group.

Lillooet Group (HWT)

As described by McTaggart (Duffell and McTaggart, 1952, pp. 36-39) this group is composed mainly of argillite and minor greywacke in the lower part with volcanic conglomerate and tuffaceous sandstone in the upper part. The fossils present are early Lower Cretaceous Buchia (=Aucella) and the lithology as well as the age point to a correlation with the Cretaceous part of the Relay Mountain Group. As in the Relay Mountain Group, conglomerate is common in the upper part.

Dewdney Creek Group (HWT)

It is apparent from published and unpublished information that the Dewdney Creek Group is probably more diverse than envisaged by Rice (1947, pp. 15-19) who subdivided the group into four divisions, A to D, and with the available palaeontological evidence described the group as essentially Lower Cretaceous and possibly, in part, Jurassic. One recognizable unit is division C, a massive coarse granitic boulder conglomerate, that, in the writer's opinion, is the correlative of Jackass Mountain division B or French Bar Formation. The overlying division D resembles division C of Jackass Mountain Group. Barremian fossils from division B suggest a correlation with the mid-Lower Cretaceous part of Relay Mountain Group whereas the presence of Buchia-bearing beds in division A suggest correlation with the Jurassic part of the group. As mentioned earlier (p. 56) three known occurrences of Albian fossils have been recorded from rocks mapped in the Princeton area as Dewdney Creek Group. One of these is recorded from the uppermost member of the group and the assumption is that they are all from the upper unit of division D. This unit would therefore in part be correlative with Taylor Creek Group.

Ladner Group (HWT)

Slate, greywacke, schist, grit, and conglomerate make up the bulk of the Ladner Group in the Hope map-area (Cairnes, 1944). It is said to contain Upper Jurassic or Lower Cretaceous fossils. Its description in the Coquihalla area (Cairnes, 1924) could apply in part with little modification to the Albian Taylor Creek Group, the Relay Mountain Group, or Middle and Lower Jurassic shales of Taseko Lakes map-area. However the fossils and its position below the Dewdney Creek Group suggest a correlation of the Ladner Group with Relay Mountain Group.

Upper Jurassic and Lower Cretaceous rocks of Harrison Lake area (JAJ, HWT)

The names Brokenback Hill, Peninsula, and Agassiz Prairie Formations were introduced by Crickmay (1927, 1930b, 1962) for Upper Jurassic and Lower Cretaceous strata of Harrison Lake area. These rocks lithologically resemble the Relay Mountain Group, except that they contain considerable units of pyroclastic rocks which were not found in the Relay Mountain Group and contain proportionally more pebble conglomerate, grit, and greywacke. This lithology suggests that these rocks of the Harrison Lake area represent the marginal facies of the southwestern flank of Tyaughton Trough situated close to its southwestern source area and farther updip than the corresponding rocks of its southwestern flank in Taseko Lakes map-area.

The fossils of the first two named formations indicate their correlation with the lower Berriasian to Hauterivian part of the Relay Mountain Group (Jeletzky, 1965a, Fig. 4). The Agassiz Prairie Formation is older than the Buchia concentrica beds and correlative at least with the upper part of mid-Callovian(?) to lower Oxfordian shales of the group as it contains Cardioceras (Anacardioceras) perrini (Crickmay, 1930b, p. 487). A prolonged hiatus separates, therefore, the early Oxfordian Agassiz Prairie Formation from the earliest Berriasian basal beds of the Peninsula Formation. This hiatus and the accompanying slight discordance (Crickmay, 1930b, pp. 484, 487) reflects the intensification of Upper Jurassic tectonic pulses observed on the southwestern flank of Tyaughton Trough in the Taseko Lakes area toward the margin of the trough. The updip intensification of these pulses may have resulted in a prolonged period of continuous erosion and non-deposition which lasted from the upper Oxfordian to the upper Tithonian time inclusive in the Harrison Lake area. However, it is equally possible that the upper Oxfordian to upper Tithonian marine rocks have been originally deposited in the Harrison Lake area, in part at least, but were eroded away in all sections studied by Crickmay (1927, 1930b, 1962) during the intensive but shortlived latest Jurassic tectonic pulse. The presence of a shorter, late Upper Jurassic hiatus on the west coast of Vancouver Island seems to favour the latter hypothesis but further study is needed to solve this problem.

Tamihy Group, Agassiz Group, and Kent Formation of Harrison Lake-Hope areas were not dated palaeontologically but are believed to be early Upper Jurassic. All three units are entirely sedimentary and mainly conglomeratic with lesser amounts of greywacke and shale. Apparently they are pre-Buchia-bearing (i.e. pre-upper Oxfordian) beds and so could only be correlative with the mid-Callovian(?) to lower Oxfordian shale of the Relay Mountain Group. However, the conglomeratic nature of these units does not suggest their correlation with the Relay Mountain Group and their assumed age is unfavourable to correlate them with other groups of the Taseko Lakes map-area.

Upper Jurassic and Lower Cretaceous rocks of west coast of Vancouver Island (JAJ)

A thick sequence of sedimentary, mid-Callovian to mid-Valanginian rocks occurs on the west coast of Vancouver Island between Kyuquot Sound and Esperanza Inlet (Jeletzky, 1950, 1954a, 1965a; Table 4 and Figs. 7, 8 of this report). The lower, mid-Callovian to (?)early Kimmeridgian unit has been named informally division A (Jeletzky, 1950, p. 19). On the basis of index fossils it may be correlated with the mid-Callovian? to Oxfordian shale and the upper Oxfordian to lower Kimmeridgian variegated rocks of Taseko Lakes map-area. Division A is largely represented by the commonly tuffaceous mudstones and siltstones. Considerable greywacke and minor pebble conglomerate interbeds occur in its mid-Callovian part. Another important rock unit composed of fine-grained greywacke occurs in the early to basal late Oxfordian part of the division. This shallowing of the sea on the west coast of Vancouver Island apparently corresponds to the tectonic pulse which has taken place at the lower upper Oxfordian boundary in Taseko Lakes map-area. The top of division A is not exposed.

Younger Upper Jurassic rocks named division B by Jeletzky (1950, p. 32) were found only in the Grassy Island section and consist of bluish grey

TABLE 4

Correlation of Upper Jurassic and Cretaceous groups and formations of Vancouver Island and Queen Charlotte Islands with rock units of Taseko Lakes map-area

Taseko Lakes	West coast of Vancouver Island	Quatsino Sound	Queen Charlotte Islands
Kingsvale Group: Division D, Division C, Division B, Division A			Skidegate Formation
			Honna Formation
			Unconformity
			Haida Formation
Taylor Creek Group		Shales and sandstones (Haida equivalents)	
Jackass Mountain Group (in part): Division C - French Bar Formation (Division B) Unnamed rocks		Aptian pebble conglomerates and sandstones	Hiatus and(?) unconformity
		Late Valanginian to late Barremian marine rocks	Longarm Formation
Relay Mountain Group	One Tree Formation	Unconformity	Unconformity
	Erosional disconformity		
	Unnamed Upper Jurassic rocks: Division B, Division A		
			Upper Yakoun Formation

to grey shale with minor interbeds of silty, fine-grained sandstone and sandy siltstone. This unit corresponds to the upper part of the mid-Kimmeridgian to Portlandian s. str. beds of Taseko Lakes map-area (Table 4, Fig. 2). The exposed part of division B includes the uppermost part of the Buchia mosquensis s. lato zone, the Buchia n. sp. aff. piochii zone, and the lower part of the Buchia cf. blanfordiana zone of the Taseko Lakes map-area. The base of division B is covered and its top truncated by an erosional disconformity.

The hiatus above division B embraces the uppermost Portlandian s. str. and upper Tithonian rocks (Jeletzky, 1950, pp. 34, 35, 38; 1965a, pp. 17, 18, Fig. 4; this report pp. 7, 8). This results in the basal Berriasian marine rocks of One Tree Formation overlapping the lower part of Buchia cf. blanfordiana zone. These late Upper Jurassic tectonic movements were much weaker in the Taseko Lakes map-area where they produced only a very brief hiatus on the southwestern flank of Tyaughton Trough (Section 3) and failed to interrupt the marine sedimentation in its central part (Sections 13-15, Table 2, Fig. 2). However, a much more prolonged hiatus (upper Oxfordian to upper Tithonian inclusive) occurring in Harrison Lake area reflects the greater intensity of the late Upper Jurassic movements there.

The early Lower Cretaceous rocks of One Tree Formation (Jeletzky, 1950, p. 38; 1965a, Fig. 4; this report, Fig. 8) consist of greywacke with lesser interbeds of siltstone and shale, and minor interbeds and inclusions of pebble conglomerate, grit, and coquina limestone. This formation includes rocks ranging from early Berriasian to mid-Valanginian age. It corresponds essentially in age and facies with late Berriasian(?) to (?)mid-Valanginian arenaceous rocks of the northeastern flank and to the upper part of the latest Portlandian s. str. to (?)early Valanginian arenaceous rocks of the southwestern flank of the Tyaughton Trough in Taseko Lakes map-area. Younger Cretaceous marine rocks have not been found exposed on the west coast of Vancouver Island.

Lower Cretaceous rocks of Quatsino Sound (JAJ)

Cretaceous rocks are widespread in Quatsino Sound (Table 4, Fig. 8) where they transgressively overlap various Lower Jurassic volcanic and sedimentary strata and the Mid-Jurassic Coast intrusions (Jeletzky, 1954a, b). So far as known, the earliest Cretaceous rocks represent the late Valanginian Buchia crassicollis zone and the equivalents of the older parts of the Relay Mountain Group are completely absent, probably because of non-deposition (Jeletzky, 1965a, Fig. 4). The late Valanginian rocks are represented by lithologically variable, commonly calcareous greywackes with minor interbeds of conglomerates. In the westernmost part of the area (Forward Inlet) they are overlain (conformably?) by a thick sequence of siltstones and sandstones of Hauterivian age representing the Homolsomites oregonensis, Speetoniceras-Simbirskites (Hollisites)(?) and Simbirskites (Simbirskites) broadi zones. These rocks are either absent or incompletely developed farther eastward (a hiatus?). Relatively thin coquina limestones rich in Inoceramus colonicus but containing also Shasticrioceras sp. indet. juven. overlie disconformably, and possibly unconformably, the older lower Cretaceous rocks and are believed to correspond to the lower Barremian Shasticrioceras pontiente zone of California, Oregon, and Washington (Popenoe et al., 1960, p. 1508). The overlying siltstone-sandstone unit has yielded: Phylloceras (Phyllopachyceras) cf. infundibulum d'Orbigny, Lytoceras (s. lato) cf. phestus Matheron, Eulytoceras ex aff. inequalicostatum (d'Orbigny), Heteroceras (Heteroceras) cf. heliceroides (Karsten) or tardieui Kilian, Acroteuthis? n. sp., Inoceramus ex aff. quatsinoensis Whiteaves, other indeterminate pelecypods and indeterminate gastropods. This fauna is of late Barremian age, in part at least. The total thickness of the late Valanginian-late Barremian rocks of Quatsino Sound is estimated at about 800 to 1,000 feet (Jeletzky, 1954b, p. 1269).

The complete development in Quatsino Sound of equivalent of the late Valanginian to late Barremian part of the Relay Mountain Group contrasts strongly with the apparent complete absence of equivalents of its mid-Callovian(?) to mid-Valanginian part there (Table 4). This absence is believed to be due to non-deposition, rather than subsequent removal. It reflects the extremely marginal position of the Quatsino Sound Cretaceous rocks on the eastern flank of the marine trough (Fig. 8) well updip from the Callovian to mid-Valanginian marine rocks outcropping on the west coast of Vancouver Island. This marginal belt was apparently flooded by the late Valanginian sea. Previously it represented an eastern source area for the Callovian to mid-Valanginian marine rocks deposited farther west along the west coast of Vancouver Island (Jeletzky, 1965b; this report Fig. 8).

Thick pebble conglomerates apparently erosionally disconformably overlie the equivalents of the late Valanginian to late Barremian part of the Relay Mountain Group (Table 4). In the more easterly part of Quatsino Sound area they are at least 2,000 feet thick. Westward (in Forward Inlet) they begin to intertongue with thick beds of medium- to coarse-grained, gritty and pebbly quartzose sandstones which clearly indicates their derivation from an eastern source area. No diagnostic fossils have been found in these pebble conglomerates and sandstones but their lithology and occurrence between the late Barremian marine rocks and presumed Albian rocks indicate an Aptian age and equivalence to the French Bar Formation of the Jackass Mountain Group and the basal pebble conglomerate of the Taylor Creek Group. This pebble conglomerate-sandstone unit registers the same Aptian uplift as that affecting the conglomeratic units of the Jackass Mountain Group of Taseko Lakes map-area (Table 4).

In some sections the Aptian conglomerate-sandstone unit is apparently conformably overlain by a few hundred feet (? 1,000 feet or more) of presumably marine, grey, commonly hard and laminated shales and sandstones. These rocks did not yield any diagnostic fossils but their lithological similarity with shales and sandstones of the Haida Formation was recognized by Dawson (1887, p. 88B). Because of their stratigraphic position and lithological character these "Upper Shales" are correlated tentatively with the Albian part of the Taylor Creek Group of Taseko Lakes map-area. Younger Cretaceous rocks have not been found exposed in Quatsino Sound area.

Upper Yakoun, Longarm, Haida, Honna, and Skidegate Formations of Queen Charlotte Islands (JAJ)

The pre-late Valanginian part of the Relay Mountain Group appears to be completely absent on Queen Charlotte Islands, except for the upper part of the Yakoun Formation which includes beds that are probably equivalent to the lower part of the mid-Callovian? to lower Oxfordian shale (Table 4). This hiatus is believed to correspond to a prolonged period of non-deposition when all of the Queen Charlotte Islands stood above sea level and were undergoing intensive erosion. As already mentioned the same was apparently true of the Quatsino Sound area.

Sutherland Brown (in press, a, b, and personal communication) has recently discovered a rock unit on Queen Charlotte Islands which appears to be correlative with the late Valanginian to late Barremian rocks of Quatsino Sound (Table 4). This unit, at least 4,000 feet thick, has been named the Longarm Formation; it consists of heavy boulder to pebble conglomerate in the lower part and of medium- to coarse-grained greywackes with minor(?) interbeds of siltstone, limestone and volcanic rocks in the upper part. The Longarm Formation overlies Upper Triassic sedimentary rocks with a profound angular unconformity. In addition to Buchia crassicollis s. str., which is presumed to be the oldest fauna of the formation, the Longarm Formation has yielded Simbirskites (s. lato), "Dichotomites" (i.e. Homolsomites) or Craspedodiscus, Heteroceras (Heteroceras) apparently identical with that found in Quatsino Sound, and Inoceramus colonicus. Therefore, it apparently ranges in time from late Valanginian to late Barremian and is correlative with the upper part of the Relay Mountain Group of Taseko Lakes map-area. The Longarm Formation is lithologically similar to the late Hauterivian to Barremian variegated rocks of that area and is a shallow water, marginal deposit.

No rocks equivalent to the Aptian conglomeratic units of Quatsino Sound and other parts of the Western Canadian Cordillera are known to occur anywhere on Queen Charlotte Islands (Sutherland Brown, in press, a) and the Albian rocks of the Haida Formation seem to overlie directly the Longarm

Formation. The writer is inclined to think that this area was elevated above sea level and was undergoing erosion throughout Aptian time. This agrees well with the extremely shallow water character of the Longarm Formation, which was presumably deposited quite close to the southeastern source area (Sutherland Brown, in press, a, and Fig. 8 of this report). The strong Aptian movements, which affected all of Western Canada (see section on palaeogeography), would naturally uplift such marginal areas well above sea level.

Some 3,000 feet of marine sandstone and shale of the Haida Formation were deposited on Queen Charlotte Islands during the lower Albian to (?)Turonian time. These rocks obviously correspond to the upper part of the Taylor Creek Group and to division C of the Jackass Mountain Group; they may also include rocks corresponding to the lower part of the overlying Kingsvale Group and its equivalents on the mainland of British Columbia (Table 4).

According to Sutherland Brown, in press, a) a slight unconformity separates the Haida Formation from the overlying conglomerate and sandstone of the Honna and Skidegate Formations. These thick (up to 4,000 feet) rocks have only been dated as Late Cretaceous; they may be equivalent to the Kingsvale Group, in part at least (Table 4).

In conclusion, it may be mentioned that the Nanaimo Group of eastern Vancouver Island may possibly include rocks equivalent to the Kingsvale Group. This late Santonian and Campanian unit is, however, tentatively assumed to be younger than the Kingsvale and equivalent non-marine rocks of the mainland of British Columbia.

PALAEOGEOGRAPHY AND GEOLOGICAL HISTORY OF TYAUGHTON TROUGH AND ADJACENT STRUCTURAL ELEMENTS OF BRITISH COLUMBIA (JAJ, HWT)

Areal extent of Tyaughton Trough

As shown in Figures 7, 8, and 9, southeast and south of Taseko Lakes map-area beds containing Buchia mosquensis (but apparently not Buchia concentrica!), Buchia n. sp. aff. piochii and various Hauterivian, Barremian, and Albian marine fossils occur in the Princeton ("Dewdney Creek Group") and Ashcroft ("Jackass Mountain Group") map-areas (Rice, 1947, pp. 18-19; Duffell and McTaggart, 1952, p. 49 and previously mentioned unpublished data). These beds appear to be in the southeastern extension of Tyaughton Trough as defined in the introductory section (p. 3). The Agassiz Prairie, Peninsula and Brokenback Hill Formations of

Harrison Lake area (Crickmay, 1930a, 1930b, 1962; Jeletzky, 1965a, 1965b) definitely form part of Tyaughton Trough and the same appears to be true of a thick succession of upper Oxfordian to upper Valanginian siltstones and sandstones recently discovered by Dr. P. Mish in the Nooksack area of northwestern Washington (Jeletzky, 1965a, p. 66). The thick upper Valanginian pebble conglomerates of Speden Island in northwestern Washington (Jeletzky, 1965a, p. 64, Fig. 4; this report Fig. 8) are, finally, interpreted as a northern marginal facies of a sublatitudinal seaway connecting Tyaughton Trough with the Vancouver Island-Queen Charlotte Islands Trough defined in the next section.

Northwest of Taseko Lakes map-area, there are Buchia-bearing Valanginian and early to mid-Hauterivian marine rocks in Chilko Lake area (unpublished fossil collections) and these outcrops appear to represent the northwestern extension of Tyaughton Trough. It is impossible to trace the trough farther to the northwest (or north) at present and some of the palaeogeographic discussion in the following sections is in part conjectural.

Vancouver Island-Queen Charlotte Islands Trough

The upper Oxfordian to late Lower Cretaceous marine and nonmarine rocks of western Vancouver Island, Quatsino Sound, and Queen Charlotte Islands (see pp. 69-74) were deposited not in the Tyaughton Trough but on the northeastern flank of another northwest trending subsiding trough (Figs. 7, 8, 9). This trough was separated from the Tyaughton Trough by an extensive, northwest trending, cordillera-like tectonic highland built of the strongly dislocated and often metamorphosed older strata invaded by the presumably Mid-Jurassic Coast intrusions (Jeletzky, 1965b, p. 72; Sutherland Brown, in press, a, b, and personal communication). This tectonic land served as a source area for the predominantly neritic to littoral, fine to coarse grained clastic rocks outcropping in the above-mentioned areas (see pp. 69-74). The axial part and the southwestern flank of this trough are believed to be concealed beneath the Pacific Ocean. As shown in the following sections, the geographic extent of the trough and its northeastern source area varied considerably throughout their geologic history. However, their relative positions remained approximately the same until mid-Upper Cretaceous (Coniacian or Santonian) time when considerable segments of the northeastern source area became submerged (Jeletzky, 1965b, p. 72). As already mentioned, this trough was connected with the Tyaughton Trough by a seaway occurring just south of the International Boundary (Figs. 8, 9). The northwest continuation of this trough is not well known beyond Queen Charlotte Islands. However, the western outlet of the seaway, which presumably connected it with the Tyaughton Trough somewhere to northwest of the Taseko Lakes map-area, could have been situated just northeast of Graham Island.

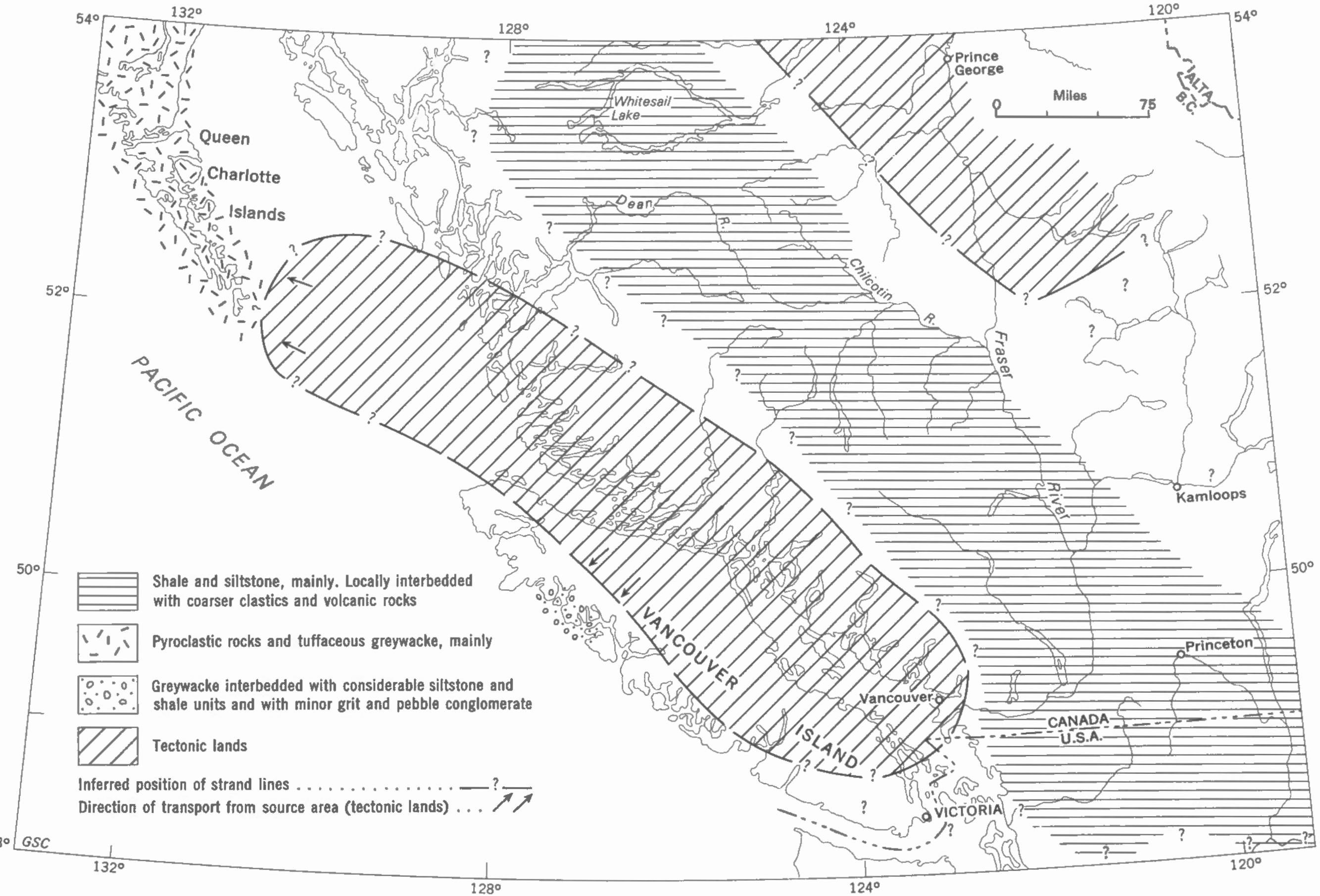

Figure 7. Mid-Callovian (?) to lower Oxfordian palaeogeography of the southern part of Canadian western Cordillera.

The name Vancouver Island-Queen Charlotte Islands Trough is proposed for this depositional trough situated off the coast of British Columbia.

Mid-Callovian(?) to Barremian (Relay Mountain) Time

Marginal marine facies (i.e. arenaceous or coarser clastic rocks) of mid-Callovian to lower Oxfordian time are almost unknown in western British Columbia. The shaly sediments of the mid-Callovian(?) to lower Oxfordian shale division probably extended far beyond their known outcrops in Taseko Lakes map-area (Fig. 7). The equivalents of this division are known to occur in the Harrison Lake area, on the west coast of Vancouver Island, on Queen Charlotte Islands, in Hazelton-Skeena region, and possibly in Princeton-Hope and Ashcroft map-areas (see pp. 69-74). Except for the west coast of Vancouver Island (Jeletzky, 1950) and Queen Charlotte Islands (pp. 73-74), where the largely volcanic mid-Callovian to lower Oxfordian rocks contain considerable amounts of mostly fine-grained greywackes and sandstones and some interbeds of grit and pebble conglomerate, these rocks are apparently represented predominantly by shales and siltstones. This suggests that the previously mentioned (pp. 4, 75) tectonic highland that separated the Tyaughton Trough from the Vancouver Island-Queen Charlotte Islands Trough (Figs. 7, 8, 9) had a low relief and was possibly largely submerged in mid-Callovian to lower Oxfordian time. The marine connection between these two troughs was probably unrestricted at that time.

Throughout the time of deposition of mid-Callovian(?) to lower Oxfordian shale division there apparently was a connection between the Tyaughton Trough and the shelf sea (Fernie Sea) but whether it was unrestricted or not is open to question. Frebold (1957, pp. 37-44, Fig. 5) concluded that there was no "real coherent landmass" (i.e. "Jurozephyria") separating the Jurassic marine region of the western Canadian Cordillera from that of the present day Rocky Mountains and Great Plains. This may be essentially correct in central and northern British Columbia during Early Jurassic and early Middle Jurassic time and during Early Jurassic to lower Oxfordian time in southern British Columbia but it does not preclude the existence of a developing tectonic land through central British Columbia during Triassic-Jurassic time (Tipper, 1959, pp. 42-48; Gabrielse and Reesor, 1964; Basso, Best, and Meyers, 1965). Direct connections between these eastern and western marine areas undoubtedly existed but a tectonic landmass was evolving along the central axis of the province coincident with present outcrop areas of the Cache Creek Group and the Topley and Guichon batholiths (Little, 1961, Map 932A; this report, Fig. 7). Lack of any marginal facies northeast and east of Tyaughton Trough can only be explained as removal by erosion after mid-Callovian to lower Oxfordian time. The uniform character of the mid-Callovian(?) to lower Oxfordian

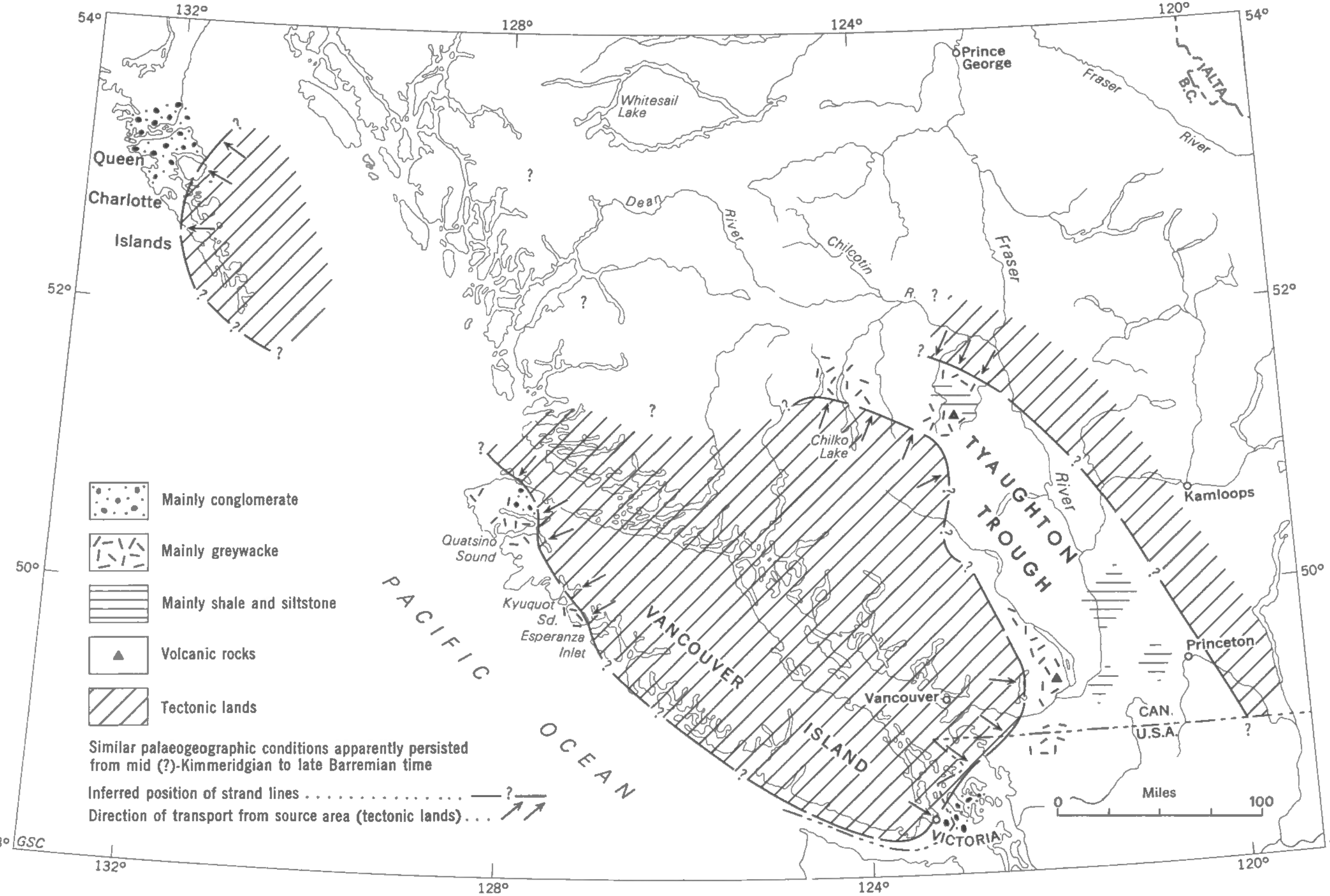

Figure 8. Mid- to late Valanginian palaeogeography of the southern part of the Canadian western Cordillera.

shale over wide areas suggests that any such eastern tectonic land was largely submerged, at least in southern British Columbia, and the marine connection was essentially unrestricted during mid-Callovian(?) to lower Oxfordian time (Fig. 7).

Palaeogeographical conditions apparently changed abruptly at the onset of late Oxfordian time. In Taseko Lakes map-area the basal part of the upper Oxfordian to lower Kimmeridgian variegated rocks includes considerable greywacke and some interbeds and lenses of pebbly grit and pebble conglomerate. This unit apparently overlies disconformably the mid-Callovian(?) to lower Oxfordian shale division. This important facies change appears to be attributable to the tectonic movements northeast and southwest of the Taseko Lakes map-area. These movements apparently uplifted and enlarged the previously low lying tectonic lands of these areas (compare Fig. 7) and transformed them into cordillera-like highlands which became the source areas for the coarse and poorly sorted detritus of the upper Oxfordian to lower Kimmeridgian variegated rocks of the Taseko Lakes map-area. Granitic pebbles make their first appearance in the upper Oxfordian to lower Kimmeridgian variegated rocks of Taseko Lakes map-area indicating that erosion has reached the Bathonian(?) granitic bodies underlying the tectonic highlands, flanking the upper Oxfordian to lower Kimmeridgian Tyaughton Trough. The apparent absence of well defined facies belts in the upper Oxfordian to lower Kimmeridgian variegated rocks of the Taseko Lakes map-area (p. 17 and Fig. 14) suggests that the trough was considerably wider at that time than at any subsequent period of its history and comparable to the mid-Callovian(?) to lower Oxfordian trough in its width (Fig. 7). The upper Oxfordian to lower Kimmeridgian marginal facies belts were presumably situated entirely outside of the present outcrop areas of these rocks, at least in Taseko Lakes map-area.

Disconformable relationships between the lower and upper Oxfordian rocks probably are not restricted to the axial part of Tyaughton Trough of the Taseko Lakes map-area. As already mentioned, the apparent absence of Buchia concentrica beds in Harrison Lake area (p. 68) could reflect non-deposition rather than subsequent erosion of the upper Oxfordian to lower Kimmeridgian (as well as some mid(?)-Kimmeridgian to upper Tithonian) rocks in the marginal zone of the southwestern flank of Tyaughton Trough (Figs. 7, 8). The equivalents of the Jurassic part of Relay Mountain Group are also unknown in Chilko Lake area. This area was presumably situated as high up on the southwestern flank of Tyaughton Trough as the Harrison Lake area (p. 69 and Figs. 7, 8). This suggests that the upper Oxfordian to lower Kimmeridgian rocks (and also possibly mid(?)-Kimmeridgian to upper-Tithonian rocks) were regressive all along the southwestern margin of the Tyaughton Trough because of the late Oxfordian uplift.

Upper Oxfordian uplifts northeast of Taseko Lakes map-area and the apparent absence of Buchia concentrica beds in the eastern parts of Hope-Princeton and Ashcroft map-areas suggest the uplift and enlargement of the mid-Callovian(?) to lower Oxfordian tectonic land (Fig. 7) on the northeastern flank of Tyaughton Trough. The shape and areal extent of the upper Oxfordian to lower Kimmeridgian land barrier (a chain of islands or a cordillera?) between Tyaughton Trough and the contemporary shelf sea of the Western Interior region is not yet known. However, it apparently was larger than the mid-Callovian(?) to lower Oxfordian tectonic land and occupied the place of the Lower Cretaceous Nelson uplift of Rudkin (1965, p. 156, Fig. 11). For reasons outlined under the discussion of the mid(?)-Kimmeridgian to upper Tithonian palaeogeography, this land barrier must have been breached by a seaway at least in one place in central British Columbia (in Vanderhoof area). This seaway permitted a free exchange of upper Oxfordian to lower Kimmeridgian marine fauna between the Tyaughton Trough and the uppermost Fernie-lower Nikanassin shelf sea of the Western Interior region.

The exact nature and regional extent of the tectonic movements that occurred between the lower and upper Oxfordian are difficult to assess but the above data give some clue to their regional nature and intensity. This unnamed tectonic phase apparently occurred after a prolonged, regional interval of relative tectonic quiescence and was responsible for the emergence of a well defined Tyaughton Trough. However, it was only the first of a series of tectonic pulses that occurred at intervals during the upper Oxfordian to Barremian period of geological history which culminated in a major Aptian movement. The upper Oxfordian tectonic movements mark, therefore, an important turning point in the geological history of the western Canadian Cordillera.

Mid(?)-Kimmeridgian to early Portlandian time (Buchia mosquensis zone) witnessed the development of marginal facies of Tyaughton Trough within the Taseko Lakes map-area (Mire Creek and Graveyard Creek areas; Fig. 14). This reflects a considerable narrowing of the axial part of Tyaughton Trough in comparison with the late Oxfordian-early Kimmeridgian time, presumably caused by further uplifts on its flanks. Upper Oxfordian to upper Tithonian marine rocks are probably absent and may never have been deposited along the southwestern margin of the trough (p. 79). At the same time thick siltstone-greywacke sequences of Buchia mosquensis zone occur in the central parts of Hope-Princeton and Nooksack map-areas, that presumably represent the southeastern extension of the axial part of Tyaughton Trough. This suggests that the considerable narrowing of Tyaughton Trough in Taseko Lakes map-area occurred throughout its length (compare Figs. 7, 8).

The facies pattern and width of facies belts established in the mid(?)-Kimmeridgian to early Portlandian s. str. (Buchia mosquensis) time in the

Taseko Lakes segment of Tyaughton Trough were apparently maintained through most of its Upper Oxfordian to Barremian geological history (Fig. 8). However, because of the scarcity or absence of exposures of several of the relevant fossil zones on the northeastern flank of the trough, this pattern can only be demonstrated for latest Portlandian s. str. to mid-Valanginian time when the coarser clastics are known to occur both northeastward and southwestward of the axial part of the trough occupied almost exclusively by the latest Portlandian s. str. to late Valanginian shales and siltstones (Fig. 14). Short-lived and minor uplifts, which may have affected some parts of the southwestern flank of the trough in the early Valanginian (Buchia tolmatschowi zone proper) apparently did not effect any change of the depositional pattern.

More widespread and stronger latest Valanginian tectonic movements may have caused a disruption of the pattern in early to mid-Hauterivian time (Fig. 4). This disruption may, however, be more apparent than real as early to mid-Hauterivian rocks of Taseko Lakes map-area are irregularly distributed, commonly almost unfossiliferous and consequently not fully understood (Fig. 14).

Late Hauterivian and Barremian time is characterized by a marked increase in the ratio of grit-pebble conglomerate beds to the finer clastics throughout the southwestern flank of Tyaughton Trough in Taseko Lakes map-area, and an apparent restoration of the mid to late Valanginian facies pattern (compare Fig. 8). However, Tyaughton Trough was apparently considerably narrowed by the late Hauterivian-Barremian tectonic movements as compared to either the early to mid-Hauterivian or mid- to late Valanginian time when it obviously extended westward at least into Chilko Lake area (Fig. 4).

Little information is available on the mid(?)-Kimmeridgian to Barremian palaeogeography and structural history of Tyaughton Trough outside of Taseko Lakes map-area. The relevant geological record along its southwestern margin begins with the transgressive Buchia-bearing Lower Berriasian clastics of the Harrison Lake area. On Speden Island and in Chilko Lake area the geological record begins respectively with late and mid-Valanginian Buchia-bearing rocks. If older early Lower Cretaceous and mid- to late Upper Jurassic marine rocks were not deposited in these areas, as seems likely, the data would suggest a gradually expanding early Berriasian to late Valanginian transgression along much of the southwestern margin of Tyaughton Trough. This interpretation is supported by the occurrence of a well documented late Valanginian transgression along the eastern margin of the Vancouver Island-Queen Charlotte Islands Trough (e.g. in Quatsino Sound and Skidegate Inlet; pp. 72-74).

The presence of early to mid-Hauterivian marine shales and siltstones above the arenaceous to psephitic Berriasian and Valanginian marine rocks in the Harrison Lake and Chilko Lake areas is a good indication that the Berriasian-Valanginian transgression continued during Hauterivian time all along the southwestern margin of Tyaughton Trough. No reliable data are available about the Berriasian to Hauterivian tectonic movements anywhere outside of Taseko Lakes map-area.

The Valanginian and Hauterivian marine rocks of Chilko Lake area may occur near or at the eastern outlet of a seaway which connected the northwestern part of Tyaughton Trough with the Bowser Basin and with the northern end of Vancouver Island-Queen Charlotte Islands Trough across the present Coast Ranges (Fig. 8). Unfortunately, the western limit of these marine rocks is unknown. If this seaway existed as seems likely on palaeontological grounds, it probably extended through to the northern part of Queen Charlotte Islands where the marginal early to mid-Lower Cretaceous marine sediments have been derived from a southeastern source according to Sutherland Brown (in press, a, b). It seems possible that this seaway appeared sometime in the Valanginian because of the gradual spreading of the Berriasian to Valanginian transgression on both sides of the western Upper Jurassic tectonic land postulated by Jeletzky (1965b). In Valanginian-Barremian time this land probably extended southward to about the International Boundary (Fig. 8). North of Vancouver Island it probably did not extend beyond the southern part of Queen Charlotte Islands (Moresby Island) as the late Valanginian to late Barremian Longarm Formation comprises fine to coarse clastics derived from a southeastern source and grades or interfingers southeastward into clean sandstones and shoreline conglomerates (Sutherland Brown, in press, a). In this case, the Valanginian transgression transformed this tectonic land into a more or less elliptical island confined between the International Boundary and fifty-second to fifty-third parallel (Fig. 8). The existence of an uninterrupted, long, Lower Cretaceous Coast Range uplift extending from the State of Washington to southeastern Alaska (Rudkin, 1965, Fig. 11) appears to be improbable.

On the northeastern flank of Tyaughton Trough the upper Oxfordian to lower Kimmeridgian tectonic land must have continued to separate the Taseko Lakes segment of the trough from the Western Interior shelf sea throughout mid(?)-Portlandian s. str. to upper Tithonian time judging by the persistence of facies patterns established in Buchia mosquensis time right to the end of the Upper Jurassic (see Fig. 2). Nothing is known about the facies relationships elsewhere along the northeastern flank of Tyaughton Trough. However, the gradual northward retreat of the Western Interior shelf sea during the Oxfordian-Portlandian s. str. time clearly indicates that this land barrier extended southeastward beyond the International Boundary by early Portlandian (early Kootenay-early Nikanassin) time. Consequently no marine connection between the Tyaughton Trough and the Western Interior Portlandian-upper Tithonian sea apparently existed southeast of Taseko Lakes map-area. North of Taseko Lakes map-area, however, the marine connection between these two basins must have remained open to the end of the Jurassic because of the virtual identity of their upper Oxfordian to upper Tithonian Buchia faunas. The overall Portlandian s. str. to upper Tithonian (and presumably upper Oxfordian to upper Kimmeridgian) palaeogeographical relationships were apparently similar to those inferred by Rudkin (1965, p. 158, Fig. 11) for the Lower Mannville (i.e. Neocomian) time. There seems to be little doubt that Frebold (1957, p. 44, Fig. 5) is justified in postulating a complete separation of both the geosynclinal sea of western British Columbia and the shelf sea of the Canadian Western Interior region from the Arctic sea throughout the Upper Jurassic time.

There does not seem to be any reason to assume that the marine seaway connecting the geosynclinal and shelf seas of British Columbia became closed at the end of the Jurassic and opened again in the early Berriasian. Its marine regime more likely persisted into the earliest Cretaceous time just as it did in the Taseko Lakes map-area.

The marine connection between the geosynclinal seas of western British Columbia and the shelf sea of the Western Interior region apparently persisted essentially unchanged through the Berriasian and Valanginian. Berriasian and Valanginian marine faunas of the marine Bullhead Group are closely allied to contemporary marine faunas of the western Cordillera of Canada and the United States and much less similar to those of northwestern Mackenzie District, northern Yukon, and Canadian Arctic Archipelago. As recognized by Rudkin (1965, p. 158, Fig. 11), the seaway connecting these basins was situated between his Nelson and Cassiar-Omineca uplifts. However, Rudkin's (1965, p. 158) conclusion that the early Lower Cretaceous seas of western British Columbia presumably originated from transgressions of the Arctic early Lower Cretaceous seas across Whitehorse area and from those of the contemporary Western Interior seas through the above mentioned seaway between the Nelson and Cassiar-Omineca uplifts is untenable. His conclusion that these Western Interior seas were connected with the Arctic seas is likewise untenable as Jeletzky's (1961, 1964b, etc.) field work in northern Yukon and northwestern Mackenzie District has demonstrated that the early Lower Cretaceous Arctic seas did not penetrate south of the Richardson Mountains and Dawson area. Likewise there is no evidence favouring the extension of the Bullhead seas northward into the Liard River basin. There is, on the contrary, ample faunal and lithological evidence of lasting and easy marine connections between the early Lower Cretaceous Tyaughton Trough on the one hand and the Vancouver Island-Queen Charlotte Islands and Washington-Oregon Troughs (southern extension of Tyaughton Trough proper) on the other (see Fig. 8 and in previous pages of this section). Therefore, it must have been the Bullhead sea that resulted from the early Lower Cretaceous transgression(s) originating in western British Columbia and not vice versa. Furthermore, all invertebrate species and genera common to the Canadian Arctic basin and the Bullhead sea also occur in the corresponding early Lower Cretaceous faunas of western British Columbia. This indicates their migration into the Bullhead sea through the seaways of the latter region. Whether they reached western British Columbia across southeastern Alaska or through an ancestral Bering Straits is not known.

The early Lower Cretaceous seas had mainly left northeastern British Columbia and adjacent areas by the end of the Valanginian. However, a few little known marine interbeds occur in the post-Monach non-marine sediments now lumped together with Gething Formation. This suggests the absence of any elevated land barriers between the Western Interior and Western Cordilleran depositional basins throughout Hauterivian-Barremian time and the occurrence of minor ingressions of the geosynclinal mid-Lower Cretaceous seas of western British Columbia into the Western Interior region until the Aptian tectonic movements effected a complete and lasting change of the structural pattern.

Aptian and Albian (Jackass Mountain-Taylor Creek) Time

The beginning of deposition of the Jackass Mountain-Taylor Creek Groups reflects a radical change of environment over large parts of Tyaughton Trough. The marine regime was ended along the northeastern flank by an influx of coarse conglomerate of the French Bar Formation of the Jackass Mountain Group (Fig. 9). This conglomerate apparently accumulated as a piedmont deposit at the base of a range of granitic mountains that were abruptly uplifted in the northeastern source area of the trough and suffered rapid dissection and degradation. However, the sea persisted southwest of this belt where another penecontemporaneous conglomerate, the basal conglomerate of the Taylor Creek Group, was deposited, probably under marine conditions. This conglomerate was derived mainly from a southwesterly source, and was much thinner; it was, nevertheless, a product of the uplifts within the southwestern source area of the trough occurring at that time. That these southwestern uplifts have displaced the marine part of the Tyaughton Trough northeastward and narrowed it (compare Figs. 8, 9) is suggested by the abundance of pebbles and boulders of various, obviously locally derived Upper Jurassic and early to (?)mid-Lower Cretaceous marine rocks in the basal conglomerate of the Taylor Creek Group of the Mount Sheba section (Section 17). These pebbles and boulders indicate that much of the southwestern flank of Tyaughton Trough previously covered by Upper Jurassic and Lower Cretaceous seas was elevated above sea level and undergoing rapid erosion in Aptian time.

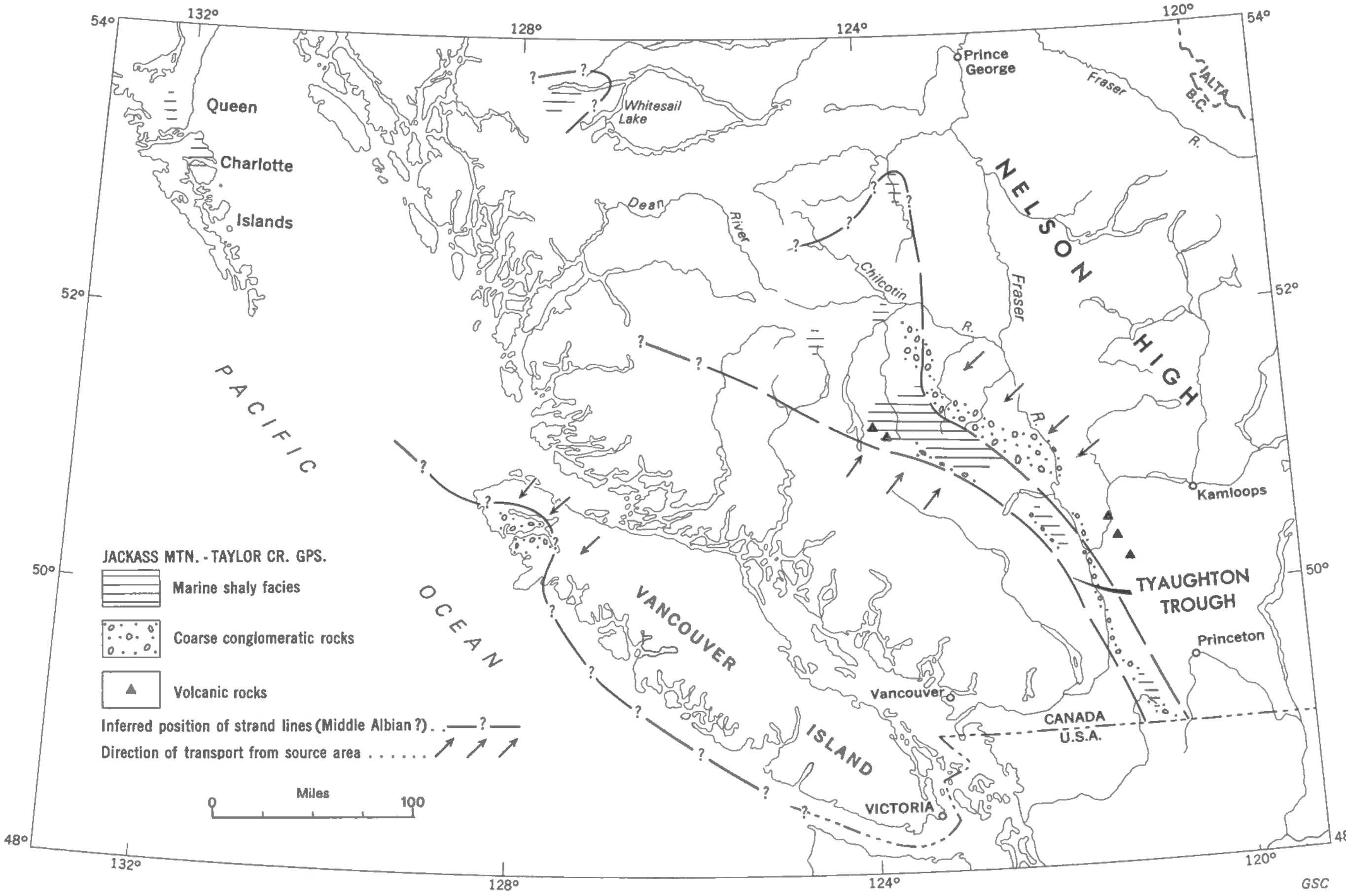

Figure 9. Distribution of volcanic and sedimentary rocks of Aptian to Albian time.

The marine part of Tyaughton Trough no longer coincided with its depositional axis which was situated closer to the northeastern margin of the trough (Fig. 6) within the belt of non-marine sedimentation of the Jackass Mountain Group. The conglomerates were succeeded by thick deposits of greywacke, siltstone, and thin pebble conglomerates in the non-marine part of the trough and by shales and subgreywacke in the marine area, which reflects a pause or a slowing down of the process of uplift in the source areas. This pause was followed by widespread inundation of the central and southern parts of the mainland of western British Columbia by the late lower Albian (Brewericeras hulenense) seas which overlapped the non-marine Jackass Mountain Group at the same time volcanic rocks were accumulating in the southwestern part of Tyaughton Trough. In the Ashcroft and Princeton map-areas correlatives of these marine rocks occur, indicating the southeastern extension of Tyaughton Trough (Fig. 9). To the north and northwest, marine Albian rocks occur in Chilko Lake area, Queen Charlotte Islands, Quatsino Sound, Whitesail Lake map-area, and Nazko region marking a northwesterly extension of Tyaughton Trough and other poorly outlined marine basins. It is certain that the Albian marine transgressions were confined to the western British Columbia region and the Western Interior region respectively. This is attested by the dissimilarity of the Albian faunas of western British Columbia (including Whitesail Lake map-area and Tyaughton Trough) with those of the Western Interior region, including northeastern British Columbia. The western interior Albian seas were connected only with the Canadian Arctic seas and the seas of the Gulf of Mexico and this new palaeogeographic pattern persisted through most of the Upper Cretaceous.

Latest Albian to Middle Late Cretaceous (Kingsvale) Time

The deposition of late Albian sediments apparently marked the end of marine transgression in central British Columbia, presumably as a result of a renewed uplift. However, in Taseko Lakes map-area the Tyaughton Trough that had persisted since upper Oxfordian time was still in evidence and was the site of the greatest accumulation of coarse sediments of latest Albian or Cenomanian age. A thick section of Pasayten rocks of Princeton map-area (Rice, 1947) indicates the persistence of this trough to the southeast. At the start of late Cretaceous time this sedimentary cycle was ended by a thick accumulation of volcanic breccias, tuffs and volcanic flows that were poured out into the sedimentary trough and adjacent areas. Other areas of sedimentary and volcanic rocks thought to have been formed at this period occur at many places in central and southwestern British Columbia (Fig. 10) but whether these were deposited in isolated intermontane basins or whether they are remnants of a more extensive blanket cover of the region is not known. The lack of palaeontological control does not permit correlation of these strata with any

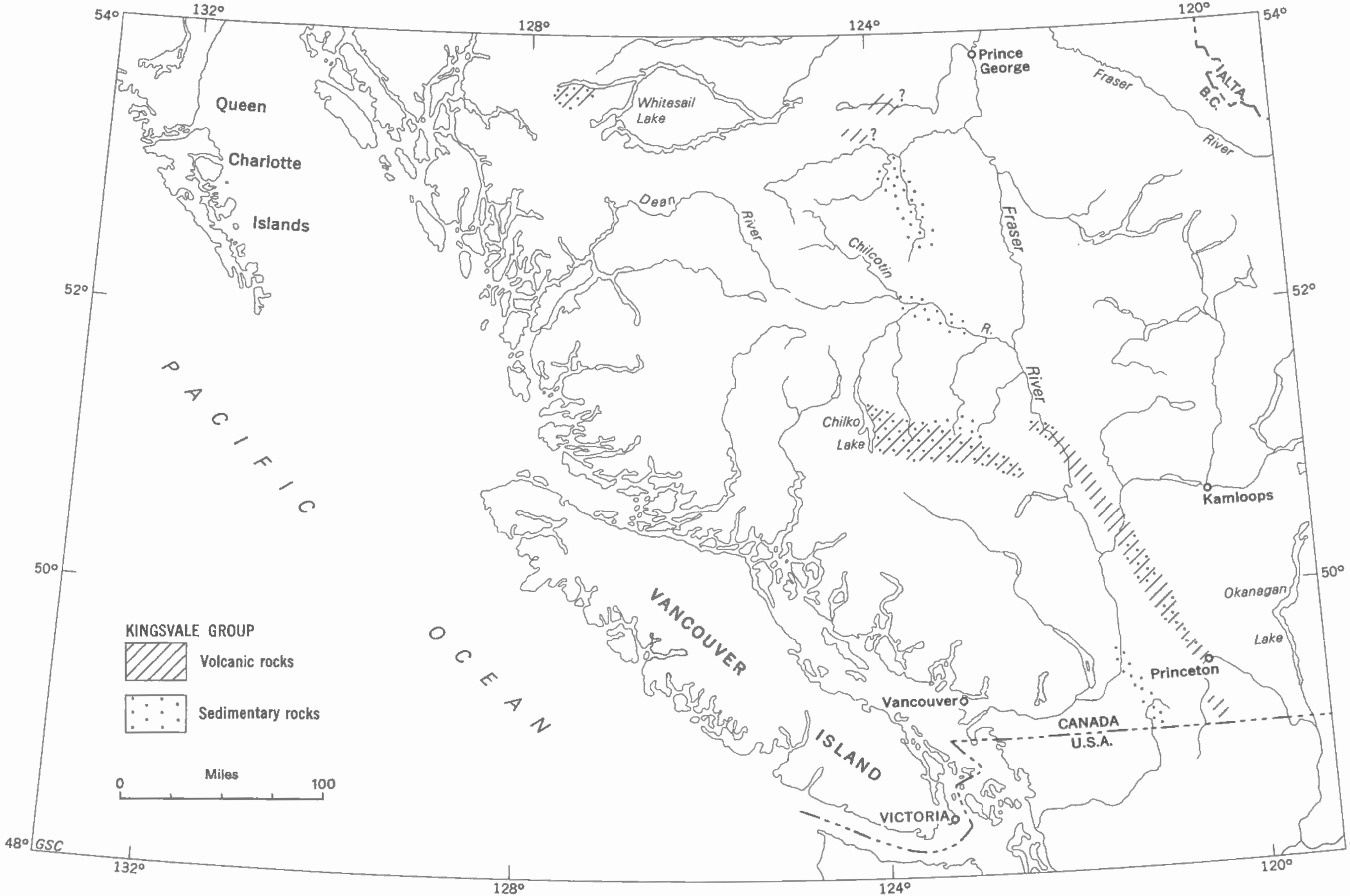

Figure 10. Distribution of volcanic and sedimentary rocks of late Albian to middle late Cretaceous time.

certainty but the writers believe that unfossiliferous volcanic and sedimentary rocks of this age are widespread in British Columbia and have been, in many cases, erroneously correlated with Jurassic or Tertiary rocks.

APTIAN MOVEMENTS; THEIR NATURE AND IMPLICATIONS (JAJ, HWT)

As pointed out in the palaeogeographical chapter, the Aptian uplift represented an important turning point in the geological history of the region. However, the nature and interregional implications of the Aptian tectonic movements were even more important. The conglomeratic equivalents of the French Bar Formation can be traced through Ashcroft and Princeton map-areas to the International Boundary. North and northwest of the area the situation is more obscure, however, these conglomeratic equivalents may be present locally in the Hazelton region. The widespread occurrence of these coarse clastic piedmont deposits on the northeast side of Tyaughton Trough indicates the presence of an extensive tectonic highland farther northeastward (Fig. 9). The formation of this presumably narrow but rather extensive welt (combined Nelson and Cassiar-Omineca uplifts of Rudkin, 1965) interrupted completely and permanently the long-lasting seaway connecting the seas of the Western Interior region with those of the western Canadian Cordillera. This is confirmed by the occurrence of another apparently contemporary (Aptian?) conglomeratic unit on the eastern slope of the Rocky Mountains. This unit, the Cadomin Formation, extends from its type locality near Athabasca River to Bullmoose Mountain just south of Pine River (Stott, 1963, p. 5); it appears to be the counterpart of the French Bar Formation on the east side of the welt. Farther north this uplift is reflected in a 5-10° angular discordance observed by Jeletzky (1961, pp. 539-544) within the Aptian marine sequence in the southern Richardson Mountains. In this area the discordant contact was followed by deposition of conglomeratic rocks. The regional absence of Hauterivian to Aptian rocks throughout northern Alaska combined with the presence of an unconformity between late Valanginian and Albian rocks throughout that region (Miller et al., 1959, p. 104) further stresses the widespread nature of Aptian movements. These incomplete data are sufficient to outline the interregional extent and significance of the Aptian uplift in the eastern Canadian Cordillera, northern Yukon and Alaska (Jeletzky, 1961, p. 543).

Southwest of the Taseko Lakes map-area the same uplift is manifested by the presumably marine basal conglomerate of the Taylor Creek Group, which must have been derived from a southwestern source that appears to be another tectonic land (Jeletzky, 1965b; Rudkin, 1965; Sutherland Brown, in press, a; this report and Figs. 8, 9) which, at least in Aptian time, was presumably lower than that situated to the northeast of the Tyaughton Trough, judging by the much smaller thickness and time range of the basal conglomerate. It was presumably reduced to low relief by early Albian time (zone of Brewericeras hulenense) judging by the facies changes.

The southwestern tectonic land concerned extended across the Coast Mountains of southern and central British Columbia as the thick Aptian pebble conglomerates obviously derived from an eastern source reappear in Quatsino Sound, northern Vancouver Island. This tectonic land probably did not extend southward much beyond the International Boundary in the Aptian time. Its northward extent is unknown. However, unlike the Valanginian to Barremian western tectonic land, it possibly extended through to southeastern Alaska and had the extent and shape suggested by Rudkin (1965, Fig. 11) for his Coast Range uplift. The above data attest to the interregional character and apparent intensity of the Aptian tectonic movements in the Canadian Coast Mountains pointed out by Jeletzky (1961, p. 543).

The exact nature of Aptian tectonic movements is not yet clear. The apparent absence of regional metamorphism and Lower Cretaceous intrusions in the pre-Aptian Cretaceous rocks of the western Canadian Cordillera is against their orogenic nature and furthermore no angular discordances have been observed at the base of thick Aptian conglomerates anywhere in this region. The above described accumulation of thick conglomeratic aprons on the flanks of all known tectonic lands affected by the Aptian movements is quite compatible with the "en block" uplift. However, these conglomerates would be equally compatible with the orogenic nature of these same structures and the absence of angular discordances may be more apparent than real. These should be best developed near the margins of depositional trough where Aptian rocks are either absent or represented by non-marine clastics. For these reasons the orogenic nature of the Aptian movements is tentatively favoured in this report.

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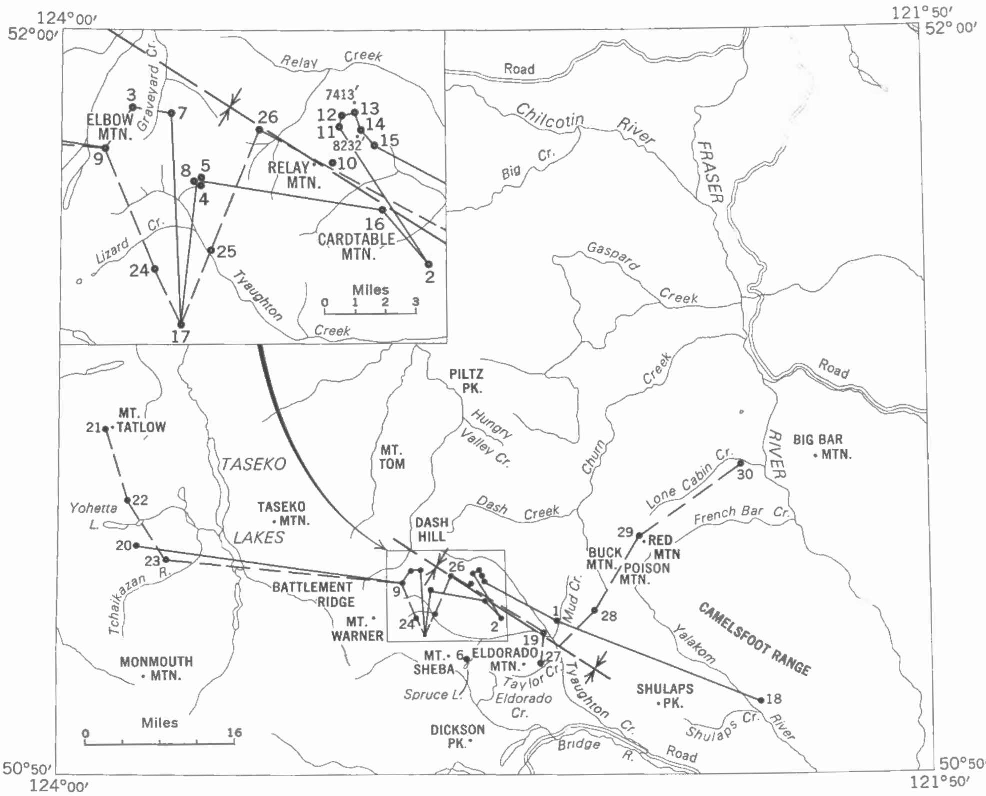

Section locality . . . . 6•

Sections illustrated in columnar profiles, Figure 12 . . . . ——•16——

Sections illustrated in columnar profiles, Figure 13 . . . . — —•26- —

Approximate position and direction of the axis of Tyaughton Trough during the time of deposition of the Relay Mountain Group. . . . . . .

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Figure 11. Location of sections in Taseko Lakes map-area

APPENDIX

Section 1

(Field Nos. JA-1 and JA-2 combined)

Location: Northwest bank of Mire (=Mud) Creek about 1 mile upstream (southeast) of Manitou Mine (abandoned). The section is at about 51°5'N Lat. and 122°46'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Mid(?)-Kimmeridgian to Portlandian s. str. rocks		
	Lower Portlandian s. str.		
	Basal part of *Buchia* n. sp. aff. *piochii* zone and uppermost part of *Buchia mosquensis* s. lato zone		
12	Interbedded dark grey to greenish grey, silty greywacke and dark grey to blackish grey, sandy mudstone; soft to hard, commonly weathers rust-coloured. Ratio of mudstone increases rapidly upward so that only a few 1- to 3-foot thick interbeds of greywacke occur in mudstone above 26 feet from base of unit. Outcrops become poor as slope becomes gentle above 22 foot level. Fossils were collected at 55 feet, 45-46 feet, 12 feet, 4 feet, and 2 feet above base of unit. Except in basal 4 feet, fauna consists of predominant *Buchia* n. sp. aff. *piochii* Gabb, fairly common, mostly small, advanced forms of *Buchia mosquensis* (Buch) and almost equally common *Buchia* aff. *mosquensis* of Anderson (1945). The small advanced forms of *Buchia mosquensis* (Buch) s. lato predominate in basal 4 feet; some poorly preserved generically indeterminate perisphinctid ammonites occur rarely throughout. The boundary between *Buchia mosquensis* s. lato and *Buchia* n. sp. aff. *piochii* zones is placed 8 feet above base of unit. Top not reached at upper end of outcrops at level of trail that leads upstream from Manitou Mine		

Unit	Description	Thickness (feet) Unit	Total From Base
	along upper slope. Appears to correspond to units 18 and 19 of Section 13; thickness exposed.	55	267
	Upper part of <u>Buchia mosquensis</u> zone		
	<u>Coarse greywacke member</u>		
11	Greywacke, light to greenish grey, fine- to medium-grained; irregular pods, lenses and interbeds up to 3 feet thick and 20 feet long of greywacke as in underlying unit; about 24 and 26 feet below top of unit occur 1- to 3-inch thick layers (lenticular) rich in <u>Cylindroteuthis</u>-like belemnites; about 3 feet below top several thin layers are rich in <u>Astarte</u> (s. lato) sp. indet. and other non-diagnostic pelecypods. Contact with overlying bed concealed.	56	212
10	Greywacke, light grey with greenish tinge or light green-grey, coarse to very coarse; mostly massive but with interbeds and pods of thinly bedded greywacke; attitude at top; strike 10°, dip 5°W; upper contact is very sharp (erosional?).	17	156
9	Pebble conglomerate; pebbles 2 to 3 inches in diameter predominate; consist of sedimentary rocks, quartz, and ?strongly kaolinized intrusive rocks; pebbles are poorly rounded and enclosed in an abundant fine- to medium-grained, greywacke matrix; lower and upper contacts fairly distinct but not erosionally sharp.	4	139
8	Greywacke, green-grey to dirty green, coarse to very coarse and gritty, mostly massive; includes interbeds of light grey, soft, medium-grained greywacke; base covered and believed cut off by a fault; strike 120°, dip 30°-35°NE; thickness exposed.	22	135

Unit	Description	Thickness (feet) Unit	Total From Base
7	Greywacke, green-grey to dirty grey, coarse to very coarse and gritty, massive; rare belemnite fragments occur locally; attitude as in underlying units; top covered and believed cut off by a fault; thickness exposed.	14	113
6	Greywacke, green-grey, mostly coarse, locally gritty and pebbly, massive; rare belemnite fragments occur locally; lower boundary gradational, upper one appears to be erosionally disconformable, uneven, sharp and accompanied by accumulation of mudstone pebbles.	12	99
5	Greywacke, greenish grey, fine to coarse, local aggregations of grit and fine pebbles or scattered pebbles and grit particles; many lenses and interbeds of sandy mudstone as in unit 2; ratio of coarse greywacke increases upward and the rock grades into unit 6. Poorly preserved pelecypods collected 6 feet below top include shells resembling <u>Aucellina</u>? n. sp. aff. <u>schmidti</u> Sokolov.	9	87
4	Siltstone, light greenish grey, locally sandy, distinctly and thinly bedded, rich in plant fragments accumulated along bedding planes; grades into overlying and underlying beds.	3	78
3	Greywacke, greenish grey, medium- to coarse-grained; contains aggregations of mudstone as in underlying unit, some as pebbles and boulders derived from erosion of unit 2.	2	75
2	Mudstone, dark grey, weathers brown to maroon, spheroidally; rare, loaf-like, buff- to yellow-weathering, dolomitic(?) concretions 2 to 6 feet long and 2 to 4 feet thick occur locally forming at one horizon an irregular row; advanced forms of <u>Buchia</u> <u>mosquensis</u> (Buch) found about 9 1/2 to 10 feet below top.	16	73

Unit	Description	Thickness (feet) Unit	Total From Base
1	Greywacke, dark greenish grey, fine-grained, silty; contains irregular interbeds and aggregations of medium- to coarse-grained, lighter coloured greywacke and of sandy mudstone; massive throughout; basal 10 to 20 feet along base of cliff are sheared and jointed; strike 125° dip 75°-80°SW; irregular lenses of rocks replete with advanced forms of Buchia mosquensis (Buch) and its elongated variants such as occur in lower part of division B on Grassy Island (Jeletzky, 1950, p. 33) are scattered throughout unit; they are predominantly confined to coarser rock varieties; only rare scattered Buchia shells occur between these lenses; base concealed at level about 20 feet above creek bed. Completely covered interval between base of the unit and creek bed may be site of a major fault; thickness exposed.	57	57

Section 2

(Field No. JA-5)

Location: Measured across a saddle in the ridge extending southeastward of Cardtable Mountain at a point about 3 1/5 miles SE of its top on the southeast limb of a syncline; the section is at about 51°5'N Lat. and 122° 56'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Upper Oxfordian to (?)Lower Kimmeridgian variegated rocks		
	Buchia concentrica zone		
9	Shale, dark grey to brownish grey where fresh, weathers dull grey or yellow, commonly silty, soft, weathers flaky or earthy; some interbeds of similarly coloured sandy and limy siltstone; seems to grade into underlying rocks; top not reached in syncline's axis; Buchia concentrica (Sowerby) s. lato fauna collected from a 3- to 6-inch thick interbed of buff-coloured, sandy siltstone 5 feet below visible top; thickness exposed.	20	327
8	Greywacke, dull grey when fresh, weathers whitish to light brownish grey, hard and weathering resistant, appears massive.	1	307
7	Shale as in unit 9 but more silty and with some siltstone interbeds.	15	306
6	Greywacke, dark to greenish grey, coarse and gritty; interbeds of similarly coloured medium- to fine-grained greywacke; some interbeds and aggregations of pebbly grit in middle part; some poorly preserved belemnites; strike 235° dip 65°NW; grades into overlying and underlying rocks.	3	291
5	Shale as in units 9 and 7 but with some interbeds of dark grey, hard, sandy siltstone and fine-grained greywacke up to 2 feet thick; Buchia		

Unit	Description	Thickness (feet) Unit	Total From Base
	concentrica s. lato fauna including elongate and narrow as well as broad B. fischeriana-like forms occur at several levels in middle part of unit; fossil wood.	54	288
4	Siltstone, brownish grey, sandy, medium hard; several 3- to 6-inch thick interbeds of greenish grey fine-grained greywacke; resistant to weathering and stands out in relief; well-preserved Buchia concentrica s. lato (same forms as in unit 5) were collected in basal 2 feet.	15	234
3	Shale as in units 9, 7, and 5; some interbeds of harder siltstone and fine-grained, silty greywacke; Buchia concentrica s. lato fauna collected about 20 feet below top; poorly preserved perisphinctid ammonites identified as Perisphinctes s. lato by H. Frebold occur rarely in equivalents of this unit on northwest limb of syncline outside of section.	56	219
2	Greywacke, dark grey to dark green-grey, fine- to medium-grained, laminated to thinly bedded; commonly gritty and pebbly, poorly preserved Cylindroteuthis- and Pachyteuthis-like belemnites common locally in upper 2 to 2 1/2 feet; strike 10°, dip 65°-70°NW; abundant and well-preserved B. concentrica s. lato fauna including same forms as in unit 5 was collected from topmost 2 to 2 1/2 feet; farther down no fossils seen.	13	163
	Mid-Callovian(?) to Lower Oxfordian Shale		
	Cardioceras zone?		
1	Shale as in units 9, 7, 5, and 3; some siltstone interbeds; outcrops are scarce throughout and only deeply weathered rock was seen; no fossils seen; base covered; thickness exposed.	(est.) 150	150

Unit	Description	Thickness (feet) Unit	Total From Base
	Southeastern slope of knoll just southeast of section's base is probably underlain by shale of unit 1 for another 100 feet or so. Then everything is covered for several hundred yards.		

Section 3

(Field No. JA-6)

Location: Measured along the crest of the southern half of the northern spur of Elbow Mountain, starting about 200 yards north of the main body of the mountain; the section is at about 51°9'N Lat. and 123°8'W Long. (Air Photo B.C. 371:90).

Unit	Description	Thickness (feet) Unit	Total From Base
	Lower Cretaceous		
	Hauterivian?		
	Upper part of mid-Hauterivian shale or younger(?)		
	Inoceramus colonicus beds(?)		
35	Shale, grey to dark grey, partly laminated, uniform, medium hard; unfossiliferous; attitude (approx.); strike 200°, dip 65°-70°E; contact with unit 34 is a major fault (thrust) which brings overturned Berriasian and mid-Valanginian rocks atop of these presumably overturned younger rocks; upper part not examined; thickness exposed (est.).	600	1,691
	Upper Berriasian		
	Latest Portlandian s. str. to (?)early Valanginian arenaceous rocks		
	Buchia uncitoides zone		
34	Siltstone as in units 29 and 31; contains rare *Buchia uncitoides* and so is presumably a schuppen of unit 31; closely jointed and partly sheared; width of zone across prevalent strike.	20	

Unit	Description	Thickness (feet) Unit	Total From Base
	<u>Mid- and (?)late Valanginian variegated rocks</u>		
	<u>Mid-Valanginian</u>		
	Basal part of <u>Buchia pacifica</u> zone		
33	Tectonic breccia of fine- to coarse-grained greywacke and coquina; all rock varieties orange-coloured and exhibit strong sulphide mineralization in upper part; judging by least affected parts of unit, general attitude is about strike 300° dip 80°-85°NE (overturned). Basal 10 to 15 feet contain what appears to be poorly preserved mixed fauna of <u>B. tolmatschowi</u> and <u>B. pacifica</u>. Stratigraphically higher beds of unit are rich in <u>Buchia pacifica</u> but <u>B.</u> cf. <u>tolmatschowi</u> occurs as well. Unit is believed to represent schuppen of basal part of <u>Buchia pacifica</u> zone; both contacts appear to be faults (thrusts?); width across general strike.	37	
	<u>Latest Portlandian s. str. to (?)early Valanginian arenaceous rocks</u>		
	<u>Upper Berriasian</u>		
	<u>Buchia uncitoides</u> zone		
32	Greywacke, medium blue to dull blue or green-grey where fresh, weathers brown to rust-coloured and speckled, fine grained, hard, massive to irregularly and conchoidally bedded; attitude: strike 305° dip 80°NE (overturned); is progressively more jointed and then both jointed and sheared toward visible top; strongly sheared top part is commonly orange-coloured; top cut off by shear zone (a fault?); mostly rich in advanced forms of <u>B. uncitoides</u> (Pavlow) et var; thickness exposed.	40	1,091
31	Siltstone as in unit 29; mostly strongly and closely jointed and somewhat sheared near visible base; attitude: strike 310° dip		

Unit	Description	Thickness (feet) Unit	Total From Base
	70°-75°NE (overturned); rare typical Buchia uncitoides s. lato occur locally; contact with overlying unit gradational.	8	1,051
30	Shear zone consisting of scattered to mylonitized bright orange-coloured and altered siltstone and greywacke (as in adjacent beds); sulphide mineralization occurs locally; Buchia cf. uncitoides s. lato occur locally in rock fragments within this zone.	14	1,043
	Lower Berriasian		
	Buchia okensis zone		
29	Siltstone as in unit 25; some interbeds of very fine, silty greywacke in lower 4 feet; attitude: strike 310° dip 55°-60°SW (normal); B. okensis s. lato collected 3 1/2 to 4 1/2 feet above base; only rare and poorly preserved B. cf. uncitoides s. lato and B. cf. okensis s. lato were found in higher part of unit. Top cut off by shear zone; thickness exposed.	27	1,029
28	Greywacke, dark green-grey when fresh, weathers rust-coloured; fine- to medium-grained, hard, massive but weathers splintery; outcrops scarce and mostly only weathered rubble seen. Attitude: strike 305° dip 65°?SW (normal?). Buchia okensis f. typ. and its variants were collected from fresh rubble at 1 to 2 foot level (above base). Late forms of B. okensis s. lato and B. uncitoides s. lato were collected in place at 6 to 7 foot level. The same late forms of B. okensis s. lato and fragments of berriasellid ammonites (Berriasella? sp. indet.) were collected at 13 to 16 foot level (above base). A 1 1/2 to 2 feet wide zone of poorly exposed, bright yellow, soft, powdery, arenaceous and apparently pebbly rock (greywacke?) with some aggregations of fine pebble conglomerate separates this		

Unit	Description	Thickness (feet) Unit	Total From Base
	unit from underlying rocks; this zone is probably a brecciated (mylonitized?) fault plane.	18	1,002
	Upper Jurassic		
	Upper Tithonian		
	Buchia piochii zone?		
27	Greywacke, bluish grey when fresh, weathers dull to greenish grey, with rusty specks; very hard, flinty; dense and massive, non-porous (quartzite-like); weathers blocky; upper contact appears to be sharp but it is very poorly exposed; no fossils seen; thickness exposed.	15	984
26	Pebble conglomerate, brown-grey, fine- to medium-grained; pebbles ranging from 2 1/2 to 3 inches in diameter predominate but their average size tends to decrease upward in bed; pebbles of granitic composition strongly predominate, most are reasonably well rounded; conglomerate is tightly packed with predominantly fine sandy and silty matrix, it contains aggregations and interbeds of fine greywacke, and sandy siltstone as in underlying units; lower contact is abrupt but boundary is not sharp, basal pebbles being embedded in siltstone of unit 25 and some small, scattered pebbles occurring even deeper, up to 2 inches beneath contact; upper contact appears to be gradational, scattered pebbles being present in basal 6 inches of unit 27; *Buchia piochii* f. typ. and *B.* cf. *terebratuloides* (Lahusen) occur scattered throughout.	2 3/4	969
25	Siltstone, blue-grey when fresh, weathers dull grey with rust-coloured tinge and rusty specks, sandy, siliceous, dense and hard, massive when fresh, weathers blocky to splintery; *Buchia piochii* collected 3 to 4 1/2 feet above base.	20	966

Unit	Description	Thickness (feet) Unit	Total From Base
24	Greywacke, light mottled grey, weathers rust-coloured, coarse-grained and gritty; pebbly in part; contains irregular aggregations of medium grey, hard and dense greywacke up to 1 1/2 feet thick and 6 feet long; lower contact sharp and uneven; a 3 to 6 inch thick layer of medium to coarse pebble conglomerate separates units 24 and 23; upper contact sharp and abrupt but apparently even; attitude: strike 290° dip 30°NW (overturned); Buchia piochii f. typ. and B. cf. terebratuloides (Lahusen) occur scattered or in small nests throughout.	7	946
23	Siltstone, blue-grey when fresh, rusty-weathering, massive, hard, siliceous to cherty; interbeds of similar silty shale; strongly jointed and sheared; zone of tectonic breccia occurring between 30 and 55 foot levels above base probably represents a fault. Above this breccia jointing and shearing decreases progressively; lower 71 feet did not yield any fossils, higher in section are found several interbeds rich in Buchia piochii s. lato. This species dominates Buchia fauna to top of unit but Buchia ex gr. mosquensis (Buch) and B. cf. terebratuloides (Lahusen) are associated with it at several levels.	162	939
22	Interbedded blue-grey when fresh, rusty-weathering, fine to very fine grained, silty greywacke and similar very sandy siltstone; unfossiliferous.	10	777
21	Coquina limestone consisting predominantly of large Pachyteuthis-like belemnites and large Arctica-like pelecypods; Buchia cf. piochii s. lato and B. cf. fischeriana s. lato occur rarely; very sandy and pebbly, grades locally into coquina conglomerate or tightly packed fine to medium pebble conglomerate; both contacts appear to be gradational.	2	767

Unit	Description	Thickness (feet) Unit	Total From Base
20	Greywacke, light grey to greenish grey, fine grained, massive; locally calcareous; becomes very fine grained and commonly grades into sandy siltstone in upper 6 to 7 feet; concretions, 1 to 3 feet in diameter of reddish rusty weathering impure limestone are irregularly scattered through unit or form rows within it; mostly unfossiliferous but locally carries pods and layers of *Astarte*-like pelecypods and (or) *Aucellina*? n. sp. aff. *schmidti* Sokolov; thickness approximately.	25	765
19	Greywacke (subgreywacke), brownish grey to green-grey, fine to very fine grained; medium hard, calcareous, contains scattered chert and shale pebbles up to 4 inches in diameter; belemnites and large *Astarte*? sp. indet. occur rarely on west side of shoulder; on east side of shoulder rock becomes much more limy and grades commonly into impure coquina limestone with aggregations and interbeds of calcareous greywacke; number of scattered pebbles and belemnite guards increases in same direction and thickness of bed increases from 1 1/4 to 4 feet; attitude: strike 325° dip 75°-80°NE (overturned); upper contact apparently gradational, although number of shells decreases rapidly and rock becomes almost unfossiliferous within 5 to 6 inches of top of unit.	1 1/4-4	738-741
18	Siltstone, as in unit 16; becomes more sandy and may grade in very fine grained greywacke as in unit 17 in upper 2 feet; upper boundary abrupt; it undulates slightly all along contact and so appears to be erosional; no basal conglomerate or grit layer occurs at boundary.	15	737

Unit	Description	Thickness (feet) Unit	Total From Base
	Mid-Kimmeridgian to Portlandian s. str. rocks		
	Portlandian s. str.		
	Buchia cf. blanfordiana zone		
17	Greywacke, light greenish grey, very fine-grained, silty; grades into very sandy siltstone, hard; almost unfossiliferous except for few scattered shells of Buchia cf. blanfordiana (Stoliczka).	7	722
16	Siltstone, blue-grey, flinty, hard and dense, mostly massive; numerous 1- to 2-foot thick interbeds of fine to very fine grained greywacke as in unit 15 in basal 35 feet; higher in section, siltstone is uniform in colour and appearance; rare rounded, very hard, calcareous siltstone concretions 1 to 3 feet in diameter and 1- to 2-foot thick interbeds of similar siltstone occur locally; attitude: strike 315° dip 75°-80°NE (overturned); base of unit is cut off by strong fault striking toward 265°. Faunal content of basal beds of unit (see below) indicates that Buchia mosquensis (Buch) and Buchia n. sp. aff. piochii zones are faulted out between units 15 and 16; upper contact is gradational. Buchia cf. blanfordiana (Stoliczka) f. typ. and its variants, such as were figured by Jeletzky (1965a, plates II-III), dominate the Buchia fauna of unit, except in basal 20 to 21 feet where they are replaced by small, relatively slender early variants of the species. The latter are associated with fairly common more or less typical forms of B. mosquensis (Buch) s. lato, B. cf. piochii (Gabb) f. typ. and var. mniovnikensis (Pavlow) and other little understood Buchia forms apparently transitional between B. mosquensis s. lato and B. cf. blanfordiana s. lato. These same forms of Buchia ex gr. piochii s. lato and B. ex gr. mosquensis s. lato occur		

Unit	Description	Thickness (feet) Unit	Total From Base
	sporadically in younger parts of unit to its top and seem to be more common in its upper 120 to 130 feet. However, buchias become so rare in this interval that it could not have been properly sampled; other than Buchia, very rare and poorly preserved oppelioid (Streblites? sp. indet.), perisphinctid, and phylloceratid ammonites, and equally rare pectinid and Pleuromya-like pelecypods occur locally in unit.	220	715
	Upper Oxfordian to Lower Kimmeridgian variegated rocks		
	Buchia concentrica (=?bronni) zone		
15	Greywacke, grey to greenish grey where fresh, weathers brown to rust-coloured, medium hard, strongly jointed and sheared; upper contact is a fault (see above); lower contact may also be complicated by faulting; well-preserved and typical B. concentrica (Sowerby) s. lato (late forms?) were collected 7 to 8 feet above visible base of unit; thickness exposed.	11	495
14	Siltstone, blue-grey, flinty, hard, massive, strongly jointed and attitude very variable; well-preserved and typical forms of Buchia concentrica (Sowerby) s. lato (late forms?) were collected in topmost 1 foot.	65	484
13	Almost completely covered but patches of blue-grey siltstone as in overlying unit suggest that this interval is underlain by this rock throughout. Width across general strike.	3 1/2	419
12	Greywacke, light green to light yellow-green, fine to medium grained, hard, massive; top covered; lower contact appears gradational; thickness exposed.	3 1/2	415 1/2

Unit	Description	Thickness (feet) Unit	Total From Base
11	Pebble conglomerate, coarse to medium, pebbles 2 to 5 inches in diameter predominate; pebbles mainly scattered in greywacke matrix; most pebbles greywacke and siltstone similar to underlying unit, and appear locally derived; numerous interbeds of pebbly greywacke.	5 1/2	412
10	Greywacke, light green to light yellow-green, fine to medium grained, hard, massive; contains 1- to 3-foot thick interbeds of siltstone as in underlying bed at irregular intervals.	93	406 1/2
9	Siltstone, blue-grey, flinty, hard, massive; sandy and lighter coloured in interval 30 to 105 feet above base; well-preserved and rich fauna of B. concentrica (Sowerby) s. lato (late forms?) collected from a 2 to 4 inch thick layer 22 feet above base; rare scattered specimens of B. concentrica s. lato occur higher to about 30 foot level.	142	313 1/2
8	Greywacke, green-grey, weathers rust-brown, fine-grained, medium hard, strongly sheared and jointed in basal 1 to 2 feet; higher up indistinctly bedded to massive; abundant well-preserved B. concentrica (Sowerby) s. lato occur 3 to 4 feet above base.	5	171 1/2
7	Siltstone as in units 5 and 3; no fossils seen.	30	166 1/2
6	Pebble conglomerate, fine, hard; granitic? and chert pebbles 1 to 1 1/2 inches in diameter predominate; tightly packed in bluish grey, calcareous siltstone matrix and are mostly well-rounded; Cylindroteuthis-like belemnites and indeterminate pelecypods occur in agglomerations and lenses locally; attitude: strike 260° dip 85°N (overturned).	1/2	136 1/2

Unit	Description	Thickness (feet) Unit	Total From Base
	Mid-Callovian(?) to Lower Oxfordian Shale		
	Lower Oxfordian?		
	Cardioceras zone?		
5	Siltstone, as in unit 3 but weathers dark brown to maroon; scarce *Astarte*-like pelecypods occur irregularly scattered throughout; 10 feet above base a 3 inch thick layer replete with these shells.	60	136
4	Interbedding of coarse grit with fine- to medium-grained greywacke; scattered pebbles 1/8 to 2 inches in diameter occur locally; grades downward into unit 3; attitude: strike 295° dip 80°N (overturned).	4	76
3	Siltstone, blue-grey, flinty, hard, massive.	22	72
2	Covered across general strike.	35	50
	Lower Oxfordian		
	Cardioceras zone		
1	Siltstone, bluish grey where fresh, rusty-weathering, hard and splintery; interbeds of greenish grey, sandy siltstone; outcrops poor; top concealed; base in intrusive contact with a sill-like body of bluish grey, feebly porphyritic, dense intrusive rock; up to 35 feet of this intrusive is exposed to assigned base (covered interval) of section; numerous Lower Oxfordian? cardioceratids and a few pelecypods occur on float in basal 6 feet of unit; same forms were also collected in place 1 to 2 feet above intrusive contact; thickness exposed.	15	15

Section 4

(Field No. JA-8)

Location: Western slope of the knoll-like, southern spur of a sharp, east-west trending ridge situated 2 2/5 miles southeast of the top of Elbow Mountain and overlooking the headwaters of the easternmost branch of Lizard Creek; the section is at about 51°8'N Lat. and 123°5'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Lower Cretaceous		
	Barremian variegated clastic rocks		
	(unzoned)		
16	Siltstone, medium to dull grey where fresh, weathers light to dark green-grey with rusty spots, soft, weathers rubbly, more or less sandy throughout; top cut off by a major fault with attitude: strike 335° dip 55°E which thrusts equivalents of unit 7 of Section 8 atop this section; lower contact abrupt but even; Acroteuthis? ex gr. impressa (Gabb), Aulacoteuthis-like belemnites, and poorly preserved Inoceramus ex aff. quatsinoensis Whiteaves scattered throughout; thickness exposed.	34	1,433
15	Greywacke as in interbeds of unit 14; contact with unit 14 appears gradational; strongly sheared and jointed in places; cut by some minor faults; attitude as in overlying beds.	20	1,399
14	Shale as in unit 13 but interbedded with several 2- to 5-foot thick beds of brown to brown-grey, fine-grained greywacke at intervals from 20 to 30 feet; attitude: strike 335° dip 55°-60°E; Inoceramus ex aff. quatsinoensis Whiteaves and Acroteuthis-like belemnites occur in basal 10 feet.	146	1,379

Unit	Description	Thickness (feet) Unit	Total From Base
13	Shale, dark brown to brown-grey when fresh, soft, silty, weathers first conchoidally and dirty yellow, then finely splintery and brown-grey; outcrops mostly discontinous; largely covered by debris (depression of slope).	130	1,233
12	Shale, as in unit 11 but apparently without harder siltstone and greywacke interbeds; mostly covered by debris and outcrop poor; only weathered rock seen.	70	1,103
11	Shale, dark grey to brownish grey when fresh, weathers light brown to grey-brown, soft and earthy; contains numerous 1/2- to 3-foot thick interbeds of hard to medium hard, green to blue-grey, ferruginous sandy siltstone and similarly coloured, fine-grained greywacke occurring at spaces of 2 to 6 feet; attitude as in unit 14; about 25 feet above base a generically indeterminable crioceratid ammonite of Hauterivian to Aptian affinities, and *Inoceramus* ex aff. *quatsinoensis* Whiteaves.	40	1,033
	Late Hauterivian variegated clastic rocks		
	Craspedodiscus cf. *discofalcatus* zone		
10	Greywacke and siltstone much as in unit 7 but softer and accordingly producing more gentle slopes; siltstone interbeds increase upward at expense of greywacke; shale interbeds appear near top; grades into overlying and underlying beds; attitude: strike 350° dip 40°E; *Simbirskites* (*Simbirskites*) ex gr. *progredicus* (Lahusen), an indeterminate lytoceratid ammonite, and some non-diagnostic pelecypods occur in basal 4 feet of unit.	23	993
9	Greywacke, green-grey, fine to coarse grained, tuffaceous; minor interbeds of fine pebble conglomerate, tuff, and basaltic lava flows(?) at irregular intervals; attitude as in		

Unit	Description	Thickness (feet) Unit	Total From Base
	overlying unit; indeterminate phylloceratid and lytoceratid ammonites, Acroteuthis ex gr. impressa (Gabb) and various non-diagnostic pelecypods were collected 96 to 99 feet below top; this unit is hard and resistant-weathering so forms steep, bluffy slopes; base covered by debris for 60 to 70 feet across general strike; thickness exposed.	175	970
	Moved southward along slope for some 250 feet and resumed section on south side of prominent 220°-230° trending fault which has estimated downthrow of 70 to 80 feet on its north side. On southern side of this fault basal bed of unit 9 appears to overlie directly and gradationally unit 8.		
8	Greywacke, much as in unit 7 but lighter brown to buff-weathering and fine to medium grained.	20	795
	Mid-Hauterivian unfossiliferous siltstone (unzoned)		
7	Greywacke, dark green-grey to brownish grey, weathers grey-brown to chocolate-brown, hard, massive to indistinctly bedded, fine-grained; less interbeds of hard to soft siltstone and shale than in units 6 and 5; attitude: strike 345° dip 30°E.	130	775
6	Shale, as in unit 5 but with numerous 3- to 10-foot thick interbeds of similarly coloured, harder siltstone and green-grey, hard, massive, fine to very fine grained greywacke occurring at intervals from 15 to 30 feet; clay ironstone concretions and bands rare or absent; attitude: strike 350° dip 35°E?; unfossiliferous except for a large but indeterminate lytoceratid? ammonite and a few poor		

Unit	Description	Thickness (feet) Unit	Total From Base
	pelecypods collected about 100 feet above base; thickness (est.).	180	645
	<u>Middle Hauterivian</u>		
	<u>Mid-Hauterivian Shale</u>		
	Inoceramus colonicus beds		
5	Shale, medium to dark brown-grey, weathers chocolate-brown and ash-grey or rust-coloured and chippy to splintery; outcrops poor and mostly weathered rock seen; numerous 6 inch to 2 foot thick concretions and bands of rusty-red-weathering, hard clay ironstone; no fossils seen; base and top covered; thickness exposed (est.).	300	465
	<u>Latest Portlandian s. str. to (?)early Valanginian arenaceous rocks</u>		
	<u>Valanginian?</u>		
4	Greywacke, light grey-green, fine to very fine grained, medium hard, massive, strongly sheared and jointed, top apparently cut off by a major fault which has probably removed several hundred feet of overlying shale unit as well (compare Section 5); base covered by debris for 10 to 12 feet across general strike; thickness exposed.	15	165
3	Siltstone, bluish grey where fresh, weathers brown and rubbly, sandy, soft; thickness exposed.	80	150
2	Greywacke, dull grey, weathers green-grey, fine to medium grained, medium hard to friable, massive to indistinctly bedded; occur strongly jointed and sheared; base covered for a few feet across strike and may be cut off by a major fault; thickness exposed (est.).	45	70

Unit	Description	Thickness (feet) Unit	Total From Base
	Upper Berriasian		
	Buchia uncitoides zone		
1	Greywacke, blackish grey when fresh, weathers bright red-brown, fine grained, friable; replete with late to typical forms of Buchia uncitoides (Pavlow); Pecten (Camptonectes) cf. praecinctus Spath and Cylindroteuthis cf. baculus Crickmay occur more rarely; base covered and discontinuous outcrops only were observed for 20 to 25 feet farther down slope; yet farther down slope the greywacke of unit 1 seems to be cut off by a fault; thickness exposed.	25+	25

Section 5

(Field No. JA-8a)

Location: Measured about 500 feet north-northwest of the corresponding parts of Section 4 (downward sequence); the section is at about 51°8'N Lat. and 123°5'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Lower Cretaceous		
	Barremian variegated clastic rocks		
	Lower Barremian(?)		
	(unzoned)		
7	Siltstone, superficially similar to shale of unit 11 of Section 4 to which it corresponds, but apparently includes somewhat harder siltstone and some fine- to very fine-grained greywacke; contact with continuation of unit 12 of Section 4 conformable but fairly abrupt; attitude at top: strike 325°-330° dip 60°-65°NE; about 3 to 4 feet above assigned base occurs a 6 to 10 inch thick interbed of fine to medium pebble conglomerate consisting exclusively of locally(?) derived shale, siltstone and greywacke pebbles 1/2 to 4 inches in diameter embedded in silty to fine greywacke matrix; this bed is locally rich in *Acroteuthis* sp. indet., some of which were transformed into pebbles; contact of this pebble conglomerate with underlying basal siltstone is sharp but apparently even.	45	1,332
	Late Hauterivian variegated clastic rocks		
	Craspedodiscus cf. *discofalcatus* zone		
6	Much coarser-grained equivalents of units 9 and 10 of Section 4 (compare there) may be subdivided as follows (downward sequence):		

Unit	Description	Thickness (feet) Unit	Total From Base
6a	Pebble conglomerate, pebbles range from 1/4 to 8 inches in diameter; all are fairly well- to well-rounded; apparently locally derived as only pebbles of same shale, siltstone and greywacke varieties as occur in underlying beds of units 9 and 10 have been seen; abundant matrix varies from fine pebbly to shaly; many interbeds, pods and lenses of fine to coarse greywacke and fine to coarse grit whose grains consist of same rock types as conglomerate pebbles; pebbles, grit and sand particles are poorly sorted according to size; some pods of lighter coloured, brown-grey to yellow-weathering, fine to coarse grained, commonly pebbly calcareous greywacke and sandy siltstone occur locally; 10 to 13 feet below top some *Acroteuthis*-like belemnites and *Simbirskites (Simbirskites)* sp. indet. f. juven. were collected in such pods; attitude at base: strike 325° dip 55°E; appears to grade into underlying rocks.	22	1,287
6b	Greywacke, dark greenish grey when fresh, weathers brownish grey with dark brown to rust-coloured specks, fine-grained rock predominates except in upper 8 to 10 feet; many interbeds of similarly coloured, sandy to very sandy siltstone appear in basal 20 to 25 feet; however, 3 to 6 inch thick interbeds of fine to medium pebble conglomerate (as in 6a), grit and coarser greywacke may occur locally at any level; all coarser rock varieties appear to form lenticular beds or pods in fine-grained greywacke or siltstone; resistant-weathering and hard, massive-looking, bedding indistinct or absent; bands and pods of light grey to yellowish grey and differentially-weathering, partly fossiliferous greywacke and siltstone common in lower 50 feet; *Craspedodiscus* cf. *discofalcatus* (Lahusen), *Simbirskites (Simbirskites)*? indet. juven., an indeterminate lytoceratid ammonite, *Acroteuthis* sp.		

Unit	Description	Thickness (feet) Unit	Total From Base
	indet., Inoceramus sp. indet., and other indeterminate pelecypods were collected 45 to 46 feet and 50 to 51 feet below top; contact with underlying beds poorly exposed but probably gradational.	92	1,265
	Mid-Hauterivian unfossiliferous siltstone (unzoned)		
6c	Shale, dark grey to black in fresh and weathered state, medium hard, massive, contains some interbeds of lithologically similar siltstone and some rounded concretions, 2 to 3 feet in diameter, or rusty-weathering, hard clay ironstone.	60	1,173
6d	Interbedded dark to greenish grey siltstone and shale as in unit 6c; minor interbeds of fine- to very fine-grained, silty greywacke; in middle part of unit, these rocks mostly alternate in 1 to 4 inch thick layers or thin laminae; reliable attitude: strike 335° dip 53°NE; grades into overlying and underlying rocks.	53	1,113
6e	Siltstone, dark grey where fresh, weathers light brownish grey and finely chippy to earthy, moderately hard to fairly soft, bedding poor to absent; outcrops mostly poor; irregularly shaped, concretions 1 to 3 feet in diameter and small (3 to 6 inches in diameter) egg-shaped concretions of hard to very hard, bluish grey clay ironstone, weathering orange or rust-coloured, occur in rows or scattered at irregular intervals; some of these are composed of siltstone or sandy siltstone rather than shale and are rich in poorly preserved, fragmentary plant remains; no other fossils seen.	200	1,060

Unit	Description	Thickness (feet) Unit	Total From Base
	<u>Mid-Hauterivian shale</u>		
	<u>Inoceramus</u> <u>colonicus</u> beds		
5	Shale, dark to very dark grey when fresh, weathers dull or grey-yellow and earthy, soft; outcrops poor to very poor throughout and mostly only weathered rock seen; attitude assumed about same as in unit 6e; very few or no clay ironstone or siltstone concretions seen in upper 485 feet of unit, but a row of strongly jointed concretions of hard, bluish grey, whitish grey- or yellow-weathering shale (calcareous?) concretions occur at 485 foot level below top; below the 495 foot level shale becomes replete with same concretions which are even more strongly jointed and sheared (commonly shattered); general attitude changes to: strike 20°-30°, dip 40°-60°SE; at level 545 feet below top, a row of these concretions is replete with <u>Inoceramus</u> <u>colonicus</u> Anderson 1938; all beds at that level and farther down section are shattered and dragged toward north being bent into a loop.	565	860
	Underlain by about 120 foot wide (along slope i.e. across dominant strike) zone of same concretionary shale as in unit 5; rock is first extremely strongly sheared and contorted and then mylonitized; it is bright orange- to rust-coloured in lower 60 to 70 feet; no estimate of thickness possible; base cut off by a major, probably north-south-trending thrust which brings mid-Hauterivian <u>I.</u> <u>colonicus</u> beds atop basal Barremian beds and upper Hauterivian <u>Craspedodiscus</u> cf. <u>discofalcatus</u> beds.		

Unit	Description	Thickness (feet) Unit	Total From Base
	Barremian variegated clastic rocks		
	Lower Barremian(?)		
	(unzoned)		
4	Shale, very hard and flinty (baked), blue-grey to blue (discoloured), very strongly sheared and jointed; mylonitized and orange-weathering in upper part; this is altered equivalent of unit 12 of section 4 (see there); general attitude: strike 345° dip 60°-70°E; top cut off by above-mentioned thrust fault; thickness exposed (est.).	120	295
3	Interbedded fine greywacke and siltstone, same colour as in unit 4 and equally strongly hardened; same attitude; this unit is altered equivalent of unit 7 of Section 5 and of unit 11 of Section 4.	50	175
	Late Hauterivian variegated clastic rocks		
	Craspedodiscus cf. *discofalcatus* zone		
2	Interbedded fine to coarse pebble conglomerate exactly like that of unit 6a of Section 5 so far as lithology of pebbles and matrix is concerned; coloured bluish grey to light grey (discoloration) and weathers dull grey or rust-colour in upper 15 to 20 feet; some 20 feet below top reverts to normal colour of unit 6a of Section 5.	25	125
1	Greywacke, as in unit 6b of Section 5 and obviously equivalent to it; attitude: strike 345°-350° dip 60°-65°NE; only poorly preserved pelecypods and belemnites seen; thickness exposed (est.).	100	100
	Farther downslope begin poor outcrops of siltstone and shale obviously equivalent to units 6c and 6d of this section; they were not measured or studied in detail.		

Section 6

(Field No. JA-9)

Location: Steep southeast and east slopes of a high hill overlooking the lower end of Spruce Lake from the west and crowned by topographical marker B.C. 670; the section is at about 51°1'N Lat. and 122°58'W Long. (downward sequence).

Unit	Description	Thickness (feet) Unit	Total From Base
	Early to mid-Hauterivian greywacke and siltstone		
	Early Hauterivian(?)		
	Homolsomites oregonensis zone(?)		
5	Greywacke, bluish grey with mauve tinge when fresh, weathers light green-grey and mottled, very dense and hard, quartzite-like, massive-looking or split into irregular blocks and fragments; no reliable bedding observed, fine to medium grained; very poorly sorted and rounded; commonly tuffaceous(?); in basal 3 to 4 inches the rock consists mainly of angular, medium-sized to coarse fragments and may be strongly tuffaceous or a tuff; some particles of coarse grit and very fine breccia occur in this basal layer, which nevertheless can hardly be interpreted as a basal conglomerate; Inoceramus? prisms and other minute shell fragments occur in some places in basal 1 foot, higher up no fossils were noted; contact with underlying rocks distinct and somewhat uneven but apparently not erosionally disconformable; no traces of fault; attitude of contact: strike 20°, dip 85°SW; top not reached on hill-top; thickness exposed (est.).	250	387

Unit	Description	Thickness (feet) Unit	Total From Base
	<u>Mid- to late Valanginian variegated rocks</u>		
	<u>Upper Valanginian</u>(?)		
	<u>Buchia</u> <u>crassicollis</u> zone(?)		
4	Siltstone, dark grey with strong olive tinge where fresh, locally blackish grey, weathers dark brown-grey to grey-brown with orange to rust-coloured specks; medium hard to friable, poorly bedded to massive where fresh, weathers chippy, then earthy; no reliable attitude; only poor <u>Inoceramus</u>(?) sp. indet., <u>Buchia</u>(?) sp. indet., and fragments and moulds of small belemnite guards seen; siltstone is more and more sandy and markedly darker in basal 5 feet until it is almost black with brown tinge and strongly sandy and so grades into underlying unit.	25	137
3	Mudstone, black to dark brown-grey when fresh, weathers dark grey with dark brown and whitish brown spots; sandy to very sandy; contains many lenses of silty, fine-grained, greenish grey greywacke and commonly grades into this laterally; only poorly preserved, rare fragments and moulds of <u>Cylindroteuthis</u>-like belemnites seen.	20	112
	<u>Middle Valanginian</u>		
	<u>Buchia</u> <u>pacifica</u> zone (upper part)		
2	Greywacke, dark greenish grey when fresh, weathers dark brown to dark rust-coloured, fine-grained, commonly very silty and with numerous sandy siltstone interbeds; contains several 3 inch to 1 foot thick interbeds of sandy coquinoid limestone replete with <u>Buchia</u>, elsewhere fossils are scarce or absent; few poorly preserved <u>Cylindroteuthis</u>-like		

Unit	Description	Thickness (feet) Unit	Total From Base
	belemnites in upper 6 to 7 feet; Buchia fauna of lower part of unit characterized by relative scarcity of Buchia pacifica s. lato, and prevalence of Buchia keyserlingi s. lato, B. inflata (Toula), and var. crassa (Pavlow) and var. majuscula (Lahusen) figured by Jeletzky (1965a, plates XVII, XVIII); some B. aff. crassicollis s. str. also occur in this fauna; few Homolsomites cf. giganteus (Imlay) (see Jeletzky, 1965a, plate XVIII) about 20 feet below top of unit.	32	92
1	Coquina, light grey to medium grey, weathers brown to rust-coloured; sandy to very sandy and locally pebbly; locally grades into calcareous greywacke or sandy siltstone as in unit 2; replete with typical Buchia pacifica and variants (see Jeletzky, 1965a, plates XVI, XIX); few Buchia ex gr. keyserlingi-inflata-crassicollis; few Acroteuthis n. sp. A (see Jeletzky, 1965a, plate XVIII) and Cylindroteuthis-like belemnites associated with buchias locally; few Homolsomites cf. giganteus near top of unit; base covered at bottom of steep slope some 250 feet above lakeshore; attitude: strike 200° dip 70°SE? (overturned?); thickness exposed.	60	60

Section 7

(Field No. JA-11)

Location: Northwest shoulder of a nameless mountain situated about 1 1/2 miles east of Elbow Mountain (across Graveyard Creek); the section is at about 51°9'N Lat. and 123°5'W Long. (downward sequence).

Unit	Description	Thickness (feet) Unit	Total From Base
	Jurassic		
	Mid-Kimmeridgian to Portlandian s. str. rocks		
	Lower Portlandian		
	Upper part of Buchia mosquensis zone		
3	Siltstone, dark grey when fresh, weathers dull grey to rust-coloured, medium hard; interbedded with an almost equal amount of similarly coloured shale; some lenses and 1 foot thick bands of impure limestone as in unit 2 of Section 6; top cut off by strong north-south trending fault cutting through shallow saddle near summit of southern end of shoulder; only a few poor imprints of Buchia sp. indet. seen locally (none collected); thickness exposed.	105	305
2	Greywacke, much as in unit 1 but predominantly fine grained; interbedded with sandy dark grey siltstone; becomes softer in upper 60 feet and grades into overlying siltstone; attitude: strike 195° dip 80°NE; small, often relatively thick forms of Buchia mosquensis (Buch) occur at several levels; they are locally associated with Meleagrinella ex aff. echinata (Smith).	180	200
1	Greywacke, green-grey to dark grey; weathers brown-grey with rust-coloured specks, predominantly coarse to medium grained, but the coarse-grained greywacke is mainly		

Unit	Description	Thickness (feet) Unit	Total From Base
	restricted to lower 10 feet; higher, it becomes finer-grained and grades into unit 2; bedding mostly indistinct to absent but some interbeds of slabby rock occur; some thin layers of belemnite "battle fields" occur locally with Cylindroteuthis ex gr. obeliscoides-tornatilis. Small, late forms of Buchia mosquensis (Buch) and var. rugosa (Fischer) were collected 16 to 17 feet above base; attitude: strike 185° dip 60°-65°E; base covered and probably cut off by a fault; thickness exposed.	20	20

Section 8 (combined)

(Field No. JA-12)

Location: Units 7 to 11 inclusive were measured on the western slope and crest of the southern spur of a sharp, east-west trending ridge (Toong's Ridge) situated 2 2/5 miles southeast of Elbow Mountain and overlooking the headwaters of the unnamed creek which falls into Tyaughton Creek from the northeast at a point about 1 mile above the mouth of Lizard Creek; situated about 200 feet north of the top part of Section 4; the section is at about 51°8'N Lat. and 123°5'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Latest Portlandian s. str. to early Valanginian arenaceous rocks		
	Lower Valanginian(?)		
11	Lava flows, light to dull green, porphyritic, basic(?); interbeds of similarly coloured volcanic tuff and tuffaceous greywacke; top concealed on east slope of ridge; contact with underlying rocks distinct but apparently even; thickness exposed.	80+	475
10	Pebble conglomerate, fine to coarse; rich in sandy or silty matrix; most pebbles range from 1/4 inch to 6 inches in diameter; size and number of pebbles gradually increases in basal 5 to 6 inches of unit until pebbles 3 to 6 inches in diameter begin to predominate; higher, pebble size decreases until pebbles 1/4 to 1 inch in diameter become predominant in topmost 3 to 4 inches of unit; outcrops poor.	4+	395
	Upper Berriasian		
	Buchia uncitoides zone		
9	Siltstone, dull grey to green, sandy to very sandy, interbedded with similarly coloured fine-grained greywacke, grades imperceptibly		

Unit	Description	Thickness (feet) Unit	Total From Base
	into overlying pebble conglomerate by becoming more pebbly in uppermost 1 1/2 feet and then becoming fine pebble conglomerate; grades into underlying unit; unfossiliferous except for one lens replete with B. uncitoides f. typ. 11 to 12 feet below top.	21	391
8	Interbedded greywacke as in underlying bed and sandy, grey siltstone; some fine to medium pebble conglomerate; abounds in typical and late forms of B. uncitoides (Pavlow), Cylindroteuthis- and Acroteuthis-like belemnites, and large pectenids throughout; grades into underlying and overlying beds; attitude: strike 340° dip 55°-60°E.	20	370
	Top part of Buchia okensis zone.		
7	Greywacke, bluish grey where fresh, weathers dark brown to rust-coloured, fine grained, medium hard; replete with typical and late forms of Buchia okensis (Pavlow) throughout; base covered (cut off by thrust fault?); thickness exposed.	12	350
	The following, older beds of Section 8 (Field No. JA-12) have been measured at the northern end of the ridge about 1/4 mile northward of its Valanginian and Berriasian part (units 7 to 11 inclusive) (downward sequence).		
	Mid-Kimmeridgian to Portlandian s. str. rocks		
	Upper Portlandian s. str.		
	Buchia cf. blanfordiana zone		
6	Greywacke, light brown, weathers rust- to brown-coloured, medium hard, fine grained; top covered for about 45 to 50 feet across general strike; equivalents of unit 2 of Section 8		

Unit	Description	Thickness (feet) Unit	Total From Base
	outcropping south of covered interval are separated from unit 6 by a major fault; thickness exposed.	20	338
5	Interbedded shale and siltstone, brown-grey to blackish grey, weathers rust- to brown-coloured, soft, sandy, no fossils seen; attitude as in underlying beds; appears to grade into underlying and overlying rocks.	70	318
4	Greywacke, much as in unit 6; *Buchia* cf. *blanfordiana* (Stoliczka) occurs fairly abundantly in 6 inch interbed 5 feet below top.	25	248
3	Siltstone, much as in unit 5.	70	223
2	Pebble conglomerate, fine to medium; pebbles range from 1/4 inch to 4 inches in diameter near base and their size diminishes toward top of unit; attitude as in underlying bed (overturned); base covered for a few feet: this covered interval is assumed to harbour a major thrust which brings rocks of *Buchia concentrica* zone in contact with those of *Buchia* cf. *blanfordiana* zone; thickness exposed.	3	153
	Upper Oxfordian to Lower Kimmeridgian variegated rocks		
	Buchia concentrica zone		
1	Interbedded dark grey to blackish grey, fine-grained, medium hard greywacke with similar sandy siltstone; attitude: strike 295° dip 55°S (overturned); strongly jointed, sheared and locally contorted; base covered; a major fault is assumed to run through this covered interval as lower Callovian rocks outcrop on its northeastern side; *Buchia concentrica* (Sowerby) was collected in place some 15 feet above base of unit; thickness exposed (est.).	150	150

Section 9

(Field No. JA-13)

Location: Measured along the western slope of a nameless flat-topped mountain next south of the Elbow Mountain massif. The top of the section is at the base of its northwestern shoulder overlooking Elbow Mountain; the section is at about 51°8'N Lat. and 123°8'W Long. (downward sequence).

Unit	Description	Thickness (feet) Unit	Total From Base
	Taylor Creek Group		
	Albian		
	(unzoned)		
18	Interbedded hard, light brown to dark grey, laminated, sometimes crossbedded siltstones and shales with brown-grey to brown, fine to coarse grained, often crossbedded and/or thin-bedded to laminated sandstones; these principal rock types alternate cyclically in 10 to 45 feet thick beds; some minor grit interbeds occur; top covered and presumed to be cut off by major normal(?) fault as topmost 100 to 120 feet of unit visible are orange-coloured, sheared and contorted; farther down section, attitude is about: strike 305° dip 55°N; thickness exposed (est.).	550	6,710
17	Grit, buff- to yellow-coloured, rich in feldspathic grains (arkosic), poorly sorted and rounded; interbedded with lesser amount of fine to medium, poorly sorted and rounded pebble conglomerate and about equal amounts of sandstone and shale-siltstone as in unit 18; ratio of coarse (grit-conglomerate) to fine (sandstone-shale-siltstone) clastics increases downward in unit until former become predominant and form 20- to 60-foot thick members separated by 10- to 20-foot thick beds of fine clastics; attitude as in unit 18; thickness exposed (est.).	450	6,160

Unit	Description	Thickness (feet) Unit	Total From Base
16	Siltstone, dark grey, interbedded with lesser amount of sandstone and shale; all rock varieties have same appearance as those of unit 18; outcrops poor; thickness exposed (est.).	160	5,710
15	Diorite, light grey, porphyritic, coarse grained, mostly feldspar grains; forms 10- to 12-foot thick sill.	—	—
14	Rocks much as in unit 17 but somewhat thinner bedded (10 to 12 feet) and include at least 60 per cent of sandstone-siltstone interbeds; conglomerate often contains 2 to 10 inch pebbles of shale like that of unit 13; unit forms northern rim of flat-topped plateau.	110	5,550
	Late Lower Albian?		
	Brewericeras hulenense and Douvilleiceras zone?		
13	Shale, dark grey, weathers ash-grey and earthy, soft; outcrops poor and intermittent, mostly only weathered rock seen; poorly preserved plant fragments occur locally; if attitude remains nearly the same throughout and unit is not repeated by faulting, its thickness would be at least.	2,000	5,440
	Ammonites resembling Brewericeras hulenense (Anderson, 1938) more closely than any other form known to writer, but not identifiable with certainty even to genus, have been found by Tipper in top beds of this unit in another section situated about 1 mile farther east (GSC loc. 62334).		

Unit	Description	Thickness (feet) Unit	Total From Base
	Basal pebble conglomerate of Taylor Creek Group		
	Aptian?		
	(unzoned)		
12	Pebble conglomerate, spotted brown-green, fine to coarse with some cobbles up to 12 inches in diameter; abundant matrix of very fine pebbles (1/8 inch) and fine- to coarse-grained grit; sorting and rounding of pebbles and grit particles extremely poor; all larger pebbles and cobbles consist of dark grey, apparently locally derived shale; attitude: strike 260° dip 80°N; both contacts covered; judging by change in attitude, units 12 and 13 may be separated either by fault or (?) by angular unconformity; thickness exposed.	60	3,440
	Relay Mountain Group		
	Barremian variegated clastic rocks		
	(unzoned)		
11	Shale, dark grey, fissile, medium hard, thin-bedded to laminated; contains laminae and 1/2 inch thick layers of rust-coloured, sandy siltstone and fine-grained, silty sandstone; thickness exposed.	100	3,380
10	Diorite, as in unit 15; forms about 20-foot thick sill.	-	-
9	Shale, as in unit 11; cut by 1- to 3-foot thick basic dykes in places; general attitude: strike 285° dip 70°N to ±90°; beds are contorted and probably faulted locally; thickness exposed (est.).	500	3,280
8	Grit, medium grey, fine to coarse, pebbly, contains interbeds and lenses of		

Unit	Description	Thickness (feet) Unit	Total From Base
	coarse-grained sandstone and fine pebble conglomerate; both contacts covered for a few feet at least; thickness exposed (est.).	170	2,780
7	Mostly covered; irregular patches of brownish grey to medium brown, massive to thin bedded, sandy siltstone; probably underlain by this siltstone throughout.	170	2,610
6	Siltstone as in unit 7; considerable interbeds of blackish grey, fissile shale, fine- to coarse-grained, grey-green greywacke and fine to coarse (sometimes pebbly) grit; coarser clastics are often thin-bedded and/or crossbedded and exhibit scour channels and fluting at contacts with shale and siltstone; contacts between clastic types often sharp and distinct; shale and siltstone beds carry some 6 to 8 inch cannon-ball concretions of hard, dark grey siltstone; attitude: strike 265° dip 65°-70°N.	200	2,440
5	Interbedded fine- to coarse-grained greywacke with fine to coarse grit and fine pebble conglomerate; some interbeds of shale and siltstone as in unit 6.	80	2,240
4	Siltstone much as in unit 6; outcrops poor and intermittent; thickness (est.).	150	2,160
	Late Hauterivian variegated clastic rocks		
	Craspedodiscus cf. *discofalcatus* zone		
3	More or less cyclical alternation of: (1) fine to coarse, often pebbly grit; (2) fine to coarse pebble conglomerate; (3) coarse to very fine greywacke; (4) sandy to pure, dark to brown-grey siltstone. Grit and conglomerate comprise about 60 to 65 per cent of unit and only a few siltstone members were seen; all coarse clastics abound in grains and pebbles of dark grey to black shale and siltstone apparently locally		

Unit	Description	Thickness (feet) Unit	Total From Base
	derived from underlying Cretaceous rocks; attitude: strike 255° dip 55°N; thickness (est.).	600	2,010
	The dating of this unit depends on the following fossils found by Tipper in unit's continuation in another section about one mile farther east: 1. Simbirskites (Simbirskites?) sp. indet. f. juven., Inoceramus? sp. indet., Astarte? sp. indet. and Pecten (s. lato) sp. indet. found on locally derived fresh float in topmost part of unit (GSC foss. loc. 62446); and 2. Simbirskites (s. lato) f. juven., indeterminate ammonoid, genus and species indet., Acroteuthis ex aff. conoides Swinnerton and numerous and well-preserved Inoceramus colonicus Anderson 1938 found in place in basal part of unit (GSC foss. loc. 62450).		
	Mid-Hauterivian unfossiliferous siltstone (unzoned)		
2	Siltstone, dark grey to bluish grey when fresh, weathers ash-grey to brown; mostly soft and weathers earthy but includes numerous interbeds of hard, siliceous, sandy siltstone which is resistant-weathering and forms hogbacks and cliffs; some interbeds of fine to coarse, bluish grey, hard greywacke; grades into underlying beds; thickness (est.).	450	1,410
	Mid-Hauterivian shale Inoceramus colonicus beds		
1	Shale, black to dark grey, weathers ash-grey and earthy, fissile, soft and crumbly; numerous interbeds of siltstone as in unit 2 in uppermost 75 feet; 6 to 10 inch thick interbeds of dark grey, hard impure limestone		

Unit	Description	Thickness (feet) Unit	Total From Base
	appear common from level 50 feet below top of unit, downward; in interval 50 to 125 feet below top these limestone interbeds have yielded: Inoceramus colonicus Anderson (very common), Inoceramus ex aff. ovatus Stanton (rare), Aulacoteuthis-like belemnites (rare); no fossils found in interval 125 to 400 feet below top; fossils rare in interval 400 to 460 feet below top except for a few Inoceramus colonicus Anderson, Acroteuthis? ex gr. impressa Anderson and Nucula (s. lato); at 460 foot level a few coarsely ribbed Inoceramus ex aff. ovatus Stanton, Acroteuthis? ex aff. impressa Anderson, and Pinna aff. calamitoides Shumard; no fossils in basal 500 feet; general attitude: strike 260° dip 55°N; base concealed and probably cut off by major east-west trending fault in saddle between traversed mountain and one next to south (immediately east of Lorna Lake); thickness exposed (est.).	960	960

Section 10

(Field No. JA-14)

Location: Measured on the east slope of Relay Mountain about 1/2 mile east of its top. Top of the section is on the south bank of a small creek flowing eastward and joining one of the left tributaries of Paradise Creek; the section is at about 51°8'N Lat. and 122°58'W Long.

		Thickness (feet)	
Unit	Description	Unit	Total From Base
	Lower Cretaceous		
	Lower Hauterivian		
	Homolsomites oregonensis zone(?)		
6	Shale, dark grey when fresh, weathers ash- to yellowish grey and splintery, soft, almost pure to pure; rare lenses and pods of impure limestone as in unit 4 but unfossiliferous; these are especially common in basal 3 to 4 feet of unit which are silty. 70 feet above base a 6 to 11 inch thick bed of hard, very sandy and silty, ferruginous, orange- to chocolate-coloured siltstone; other similar siltstone beds occur at 83 and 100 foot levels above base and in sheared rocks near top; row of 1 foot thick and 3 to 5 feet long loaf-like concretions of rust-coloured, whitish grey-weathering, limy, fine-grained greywacke occurs 115 feet above base; attitude: strike 300° dip ±90° except between 195 foot level and exposed top where it changes to: strike 310° dip 75°SW (overturned) and rocks become strongly sheared and partly contorted; few poor specimens of Acroteuthis? ex gr. impressa (Gabb) collected 195 feet above base; top concealed and apparently cut off by strong east-west trending fault following valley of creek; thickness exposed (est.).	395	446

Unit	Description	Thickness (feet) Unit	Total From Base
5	Greywacke, grey, fine-grained, unfossiliferous.	1/3	51
4	Limestone, grey when fresh, weathers rust to brown and with honeycombed surface, impure, medium hard; 1 to 6 inch thick pods, lenses and persistent interbeds of shale as in underlying bed and those of fine- to medium-grained, friable greywacke occur in limestone; rich in _Cylindroteuthis_-like belemnites, _Acroteuthis_ ex gr. _impressa_ (Gabb) and _Inoceramus_ aff. _ovatus_ Stanton throughout; no representatives of _Buchia_ found; appears to grade into overlying shales; contact with unit 3 seems to be distinct but even.	1	50 2/3
3	Shale, dark grey, fissile, silty and sandy, friable; moderately rich in _Acroteuthis_? ex gr. _impressa_ (Gabb); _Inoceramus_ shells appear absent; upper and lower contacts appear distinct but even.	1/3	49 2/3
	Mid- to late Valanginian sandstone and siltstone		
	Upper Valanginian		
	Buchia crassicollis zone		
2	Greywacke, grey, fine grained but pebbly, limy, friable, moderately rich in _Buchia crassicollis_ s. str.; representatives of _Buchia_ cf. _pacifica_ s. lato are less common; contact with unit 1 appears even but distinct.	1/3	49 1/3
1	Siltstone, dark grey when fresh, weathers brownish grey to ash-grey and flaky, soft, more or less sandy; scattered angular agglomerations of whitish to light grey weathering, hard, very limy siltstone grading into impure coquina in lower 18 to 20 feet; persistent 1-foot thick bed of this rock replete with _Buchia crassicollis_ (Kerserling) s. str.		

Unit	Description	Thickness (feet) Unit	Total From Base
	and carrying relatively rare shells of <u>Homolsomites quatsinoensis</u> (Whiteaves) occurs 13 1/2 to 14 1/2 feet above exposed base of unit; same fauna occurs in scattered limestone agglomerations below this bed; 15 1/2 to 16 1/2 feet above exposed base an apparently persistent row of limestone concretions is rich in same fauna; higher up only poorly preserved, rare, scattered <u>Buchia</u> shells noted; base cut off by strong, north-northeast trending fault; thickness exposed.	49	49

Section 11

(Field Nos. JA-16 and -19 (combined))

Location: Measured on the steep southern slope of an east-west-trending creek at a point about 1 5/8 miles NNE of the top of Relay Mountain and about 5/8 mile WNW of the top of summit 8222; the sections are at about 51°9'N Lat. and 122°58'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Lower Cretaceous		
	Early to Mid-Hauterivian shaly rocks		
	Mid-Hauterivian?		
	Speetoniceras-Simbirskites (Hollisites) zone?		
7	Shale, dark grey, weathers ash-grey and earthy, soft; interbedded with 2- to 10-foot thick beds of similarly coloured siltstone and sandstone as in underlying unit; irregularly scattered lenses and concretions of hard, rust-weathering clay ironstone and hard, black limy shale occur throughout unit; Inoceramus cf. colonicus Anderson and Acroteuthis-like belemnites were collected some 20 feet below exposed top; top not reached in axis of tight, squeezed syncline atop plateau at point 150 yards west of Section 12; thickness exposed (est.).	100	440
6	Greywacke, dirty grey when fresh, weathers buff, very fine-grained, silty, poorly but locally thinly bedded and with laminae of organic matter on bedding planes; thickness exposed (est.).	60	340
	Moved about 200 yards eastward (upstream) along the upper rim of the slope to the point where the base of		

Unit	Description	Thickness (feet) Unit	Total From Base
	unit 4 occurs only 25 feet below the edge; the following downward sequence is exposed in the creek's slope there:		
	Lower Hauterivian?		
	Homolsomites oregonensis zone?		
5	Shale, dark grey when fresh, weathers ash- to yellow-grey, and splintery, soft, almost pure to pure; rare 1/2- to 3-foot thick bands, lenses and agglomerations of grey, impure limestone, rust-weathering, hard, ferruginous siltstone (clay ironstone), and light greenish grey, fine-grained, hard sandstone and similar sandy siltstone occur at irregular intervals, except in basal 98 feet; attitude: strike 300° dip 75°S in upper part; poor imprint of ammonite possibly referable to Homolsomites packardi Anderson was found in place about 80 feet below top; Acroteuthis? ex gr. impressa Anderson, an indeterminate phylloceratid ammonite, poorly preserved Inoceramus sp. indet. and Lima sp. indet. were collected about 160 feet below top; Inoceramus cf. ovatus Stanton collected about 30 feet above base; otherwise unfossiliferous.	259	280
4	Limestone, grey when fresh, weathers rust- to brown-coloured and with honeycombed surface, impure, medium hard; 1 to 6 inch thick lenses and persistent interbeds of shale as in underlying beds and those of fine- to medium-grained, friable greywacke occur in limestone; attitude: strike 310° dip ±90°; rich in Cylindroteuthis-like belemnites, Acroteuthis? ex gr. impressa (Gabb) and Inoceramus aff. ovatus Stanton throughout; no representatives of Buchia found; appears to grade into overlying shales, contact with unit 3 is distinct but even; thickness exposed (approx.).	1	21

Unit	Description	Thickness (feet) Unit	Total From Base
	Mid- to late Valanginian sandstone and siltstone		
	Upper Valanginian?		
	Buchia crassicollis zone?		
3	Greywacke, grey, fine grained, but pebbly and gritty; more or less limy, friable; in places lenses occur moderately rich to rich in *Acroteuthis*? ex gr. *impressa* (Gabb); also contains *Inoceramus* cf. *quatsinoensis* Whiteaves; no *Buchia* seen; thickness exposed (approx.).	1	20
	Upper Valanginian		
	Buchia crassicollis zone		
2	Siltstone, greenish grey; weathers dirty white to light whitish grey; sandy to very sandy and limy, moderately hard; locally grades laterally into fine-grained, silty and limy sandstone or sandy to very sandy coquina; both contacts are distinct; replete with well-preserved *Buchia crassicollis* (Keyserling) f. typ. and var. *solida* (Lahusen); no other *Buchia* forms noted; *B. crassicollis* s. str. disappears abruptly at upper contact.	4	19
1	Siltstone, dark grey when fresh, weathers brownish grey to ash-grey and flaky, soft, more or less sandy; apparently devoid of harder, limy, fossiliferous interbeds such as occur in equivalent unit 1 of Section 10; base covered by snow for at least 60 feet farther downslope; thickness exposed.	15	15

Section 12

(Field No. JA-17)

Location: The top part of the section (units 3-7) was measured on the steep southern slope of an east-west-trending creek at a point about 1 5/8 miles NNE of the top of Relay Mountain and about 5/8 mile WNW of the top of summit 8222. The lower part of the section (units 1, 2) was measured about 1/4 mile farther west on a western slope of a steep north-south trending ridge overlooking the headwaters of the same creek; the section is at about 51°9'N Lat. and 122°57'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Mid- to late Valanginian sandstone and siltstone		
	Upper Valanginian?		
	Buchia crassicollis zone?		
7	Greywacke, dull grey, weathers dull grey with rust-coloured spots, fine-grained, calcareous, locally grades into very sandy coquina; numerous lenses and interbeds of lithologically similar siltstone; medium hard, massive to indistinctly bedded; attitude: strike 310° dip 55°S; corresponds to unit 3 of Section 11 and is overlain by equivalents of its younger beds (not studied in this section); fauna consists of abundant Acroteuthis? cf. impressa (Gabb), rare Inoceramus? sp. indet. and very rare Buchia? sp. indet.	2	515
	Upper Valanginian		
	Buchia crassicollis zone		
6	Pebble conglomerate, fine to coarse, rich in calcareous to sandy matrix; elongated to well-rounded pebbles 1 to 4 inches in diameter predominate; no intrusive pebbles noted; locally transformed into pebbly coquinoid siltstone or sandstone; upper and lower contacts		

Unit	Description	Thickness (feet) Unit	Total From Base
	appear gradational; rich in *Buchia crassicollis* s. str. and in less common poorly preserved *Buchia* aff. *pacifica* s. lato throughout.	1	513
5	Greywacke, dull grey when fresh, weathers light greenish grey; fine to very fine grained, silty and calcareous; often grades laterally into very sandy siltstone; grades downward into unit 4 and rapidly becomes sparsely fossiliferous; replete with *Buchia crassicollis* s. str.	1	512
	Basal Upper and Mid-Valanginian		
	Buchia crassicollis zone and upper part of *Buchia pacifica* zone		
4	Siltstone, dark grey when fresh, weathers dark brownish grey and flaky to earthy, sandy to very sandy in upper 2 to 3 feet, less sandy to almost pure farther down, soft to friable, some lenses of hard, nodular, medium grey, calcareous siltstone or impure limestone rich in buchias, otherwise buchias scarce except for a few irregularly distributed lenticular layers; *Buchia crassicollis* s. str. fauna restricted to upper 15 to 16 feet; a mixed *Buchia pacifica*-*B. crassicollis* s. str. fauna occurs in interval 16 to 20 feet below top; farther down only typical *B. pacifica* and *Buchia* ex gr. *keyserlingi*-*inflata* were seen.	40	511
	Middle Valanginian		
	Middle part of *Buchia pacifica* zone		
3	Siltstone much as in overlying unit but replete with buchias nearly throughout and containing some crushed *Homolsomites* cf. *giganteus* Imlay locally. *Buchia pacifica* fauna as in lower part of unit 4.	160	471

Unit	Description	Thickness (feet) Unit	Total From Base
	White-weathering coquinoid member		
	Mid-Valanginian to Berriasian		
	Basal part of Buchia pacifica zone, Buchia tolmatschowi and Buchia uncitoides zones		
2	Alternation of 1 to 5 feet thick lenticular beds of siltstone as in overlying unit with similarly thick beds of harder, weathering-resistant, white- to whitish grey-weathering, limy coquinoid siltstone or impure coquinoid limestone; attitude near top: strike 300° dip 70°-75°S (normal); Buchia shells are crowded in white-weathering, harder beds but occur scattered or form small clusters in intervening grey siltstone. Buchia pacifica s. lato predominates in upper 33 feet; no well-preserved shells were found in interval 33 to 41 1/2 feet below top and farther down Buchia tolmatschowi s. lato becomes dominant form; boundary between Buchia pacifica and Buchia tolmatschowi zones is placed arbitrarily 38 feet below top; Buchia tolmatschowi remains dominant downward to level 135 feet below top; below 141 foot level it is largely replaced by small to medium-sized, regularly and heavily ribbed, advanced forms of B. uncitoides s. lato; exceedingly poor preservation of all buchias in interval 135 to 141 feet below top precludes any closer placement of this boundary; B. uncitoides remains dominant to base of unit; contact with unit 1 more or less distinct although white-weathering beds replete with Buchia diminish gradually between 126 foot level and base.	151	311

Unit	Description	Thickness (feet) Unit	Total From Base
	Berriasian		
	Basal part of Buchia uncitoides and upper part of Buchia okensis zone		
1	Shale, dark grey, pure, weathers brown-grey and rubbly, soft, poor in fossils and apparently noncalcareous; rows of 1/2 to 2 foot thick concretions and bands of very similar but harder to very hard and often calcareous shale and coquina occur at irregular intervals; Buchia uncitoides s. lato and Spiticeras? sp. indet. juven. fauna appear restricted to upper 55 to 60 feet; at level 55 to 65 feet below top occurs a mixed fauna of Buchia uncitoides s. lato and late forms of Buchia okensis s. lato corresponding to that of so-called overlap beds between Buchia uncitoides and Buchia okensis zones (Jeletzky, 1965a, pp. 23-24); at 65 to 75 foot level below top, a similar mixed Buchia fauna is associated with numerous berriasellid ammonites Berriasella (Pseudargentinoceras) n. sp. aff. gallica Mazenot and Berriasella (s. lato) sp. indet. found both in float and in place; at level 121 to 122 feet below top occurs typical B. okensis s. lato fauna apparently representing some part of its zone proper (Jeletzky, 1965a, pp. 20-27). Other beds within interval 124 to 135 feet below top contain, however, mixed faunas of Buchia okensis s. lato and B. uncitoides s. lato. Base is cut off by major 260°-trending fault which results in repetition of unit 1 in adjacent (northern) part of slope; thickness exposed (est.).	160	160

Section 13

(Field No. JA-18)

Location: Measured on the bluffy northern slope and across the flat top of an east-west trending, prominent spur situated about halfway between summits 8222 and 7413; the top of the section is about 2 miles, and the base about 2 3/8 miles, north-northeast of the top of Relay Mountain; the section is at about 51°9'N Lat. and 122°57'W Long. (downward sequence).

Unit	Description	Thickness (feet) Unit	Total From Base
	Upper Jurassic		
	Mid(?)-Kimmeridgian to Portlandian s. str. rocks		
	Upper Portlandian s. str.		
	Buchia cf. *blanfordiana* zone		
28	Siltstone, dull to bluish grey when fresh, weathers reddish brown or rust-coloured, sandy to very sandy, grades locally into similarly coloured very fine-grained, silty greywacke, medium hard to hard; attitude: strike 280° dip 60°-65°S (normal); rock is strongly jointed and sheared above level 22 feet above base; buchias occur more or less rarely as single specimens or in small agglomerations throughout; large to small, typical forms of *Buchia* cf. *blanfordiana* (Stoliczka) predominate but *Buchia piochii* (Gabb) and var. *mniovnikensis* (Pavlow) are by no means rare at some levels; also *Buchia* cf. and aff. *piochii* (Gabb), *B.* aff. *lahuseni* (Pavlow) and var. *tenuicollis* (Pavlow) occur locally; top covered by debris on higher southern slope of spur and is presumably cut off by major 260°-270° trending (thrust?) fault; thickness exposed.	129	2,136
27	Greywacke, dull grey to green or dark grey when fresh, weathers brownish grey with		

Unit	Description	Thickness (feet) Unit	Total From Base
	orange specks and spots or rust-coloured, friable to hard, fine to medium grained, distinctly to indistinctly bedded; contains rare to moderately common but scattered *Buchia* shells at all levels and includes several 1- to 3-foot thick beds and many irregularly scattered lenses and agglomerations replete with *Buchia*; otherwise only few pectenid and *Pleuromya*-like pelecypods occur locally; large, *Turbo*-like gastropods are common in bed 55 to 57 feet above base; in lower 35 feet occurs mixed *Buchia* fauna consisting of somewhat more common small to medium-sized early variants of *Buchia* cf. *blanfordiana* (Stoliczka), somewhat more rare *Buchia piochii* (Gabb) and *B. piochii* var. *mniovnikensis* (Pavlow), and *B.* cf. and aff. *lahuseni* (Pavlow) and var. *tenuicollis* (Pavlow); large and typical variants of *B.* cf. *blanfordiana* are rare to very rare; the above mentioned early variants of *B. piochii* s. lato and *B.* cf. *blanfordiana* are connected by numerous transitional forms throughout this interval; in interval between 35 and 70 feet above base small and medium-sized, early variants of *B.* cf. *blanfordiana* become the dominant form of *Buchia* fauna but its large and typical representatives are still rare to fairly rare; above mentioned variants of *B. piochii* s. lato and transitional forms between it and *B.* cf. *blanfordiana* remain more or less common throughout this interval; *Buchia* fauna of upper 32 feet of unit is, finally, dominated by large and typical representatives of *B.* cf. *blanfordiana* such as were figured by Jeletzky (1965a, plates II, III) but above-mentioned variants of *B. piochii* s. lato and transitional forms between it and *B.* cf. *blanfordiana* are fairly common in these beds; grades into unit 28.	102	2,007
26	Greywacke, light grey with yellow tinge when fresh, weathers yellowish grey, very fine		

Unit	Description	Thickness (feet) Unit	Total From Base
	grained, silty; some pods of dark grey, greenish-tinged shale and siltstone as in units 24 and 25 occur locally; intensely sheared and bright orange-coloured in zone 15 to 25 feet above base which trends toward 215° across ridge (forms saddle) and probably is fault; however, fauna and lithology remain same on both sides of this shear zone; single specimens and small (15 to 20 specimens) clusters of Buchia are scattered irregularly throughout the thickness; contact with unit 27 distinct and uneven but no basal conglomerate noted; Buchia fauna is mixture of small to very small but thick and twisted B. aff. blanfordiana (Stoliczka) with insufficiently understood B. ex gr. piochii and B. aff. mosquensis (Buch) s. lato.	50	1,905
	Upper to middle (but not uppermost) Portlandian s. str.		
	Buchia n. sp. aff. piochii zone		
25	Siltstone, dull grey, olive-tinged when fresh, weathers olive-green to green-grey or dirty yellow and rubbly, partly sandy, medium hard; several 3 inch to 1 foot thick, lenticular interbeds of sandstone as in unit 24; some of these are rich in buchias; abundant loaf-like 2 to 10 feet long and 1 to 2 feet thick or rounded locally richly fossiliferous (only Buchia) concretions of rust-weathering, ferruginous, fine-grained hard sandstone appear 15 feet above base, they mostly occur in rows and their number increases markedly upwards until they form up to 25 per cent of the thickness between 12 and 43 feet above base; above 43 foot level lenses and interbeds of this sandstone form 10 to 12 per cent of thickness; the siltstone itself is almost unfossiliferous except in concretions or pods; attitude: strike 280°, dip 60°-65°S (normal); Buchia fauna consists of insufficiently		

Unit	Description	Thickness (feet) Unit	Total From Base
	understood forms which are here designated as Buchia n. sp. aff. piochii (Gabb) s. lato and numerous forms transitional between them and the late narrow forms of B. mosquensis (Buch) s. lato; some B. cf. terebratuloides (Lahusen) s. str. and small forms of B. cf. blanfordiana (Stoliczka) occur locally.	74	1,855
24	Shale, medium grey to grey and olive-tinged when fresh, weathers dirty yellowish grey, pure except in basal 1 to 2 feet where it becomes silty, and near top; weathers fine rubbly or conchoidally (locally); several 3 to 9 inch thick interbeds of light greenish grey, sandy siltstone or silty, very fine-grained sandstone occur in upper 10 feet; 2 1/2 foot thick bed of darker grey, concretionary-weathering siltstone forms top; mostly unfossiliferous but contains some 6 inch to 1 foot thick pods and interbeds rich in same Buchia forms as those occurring in unit 25.	25	1,781
23	Greywacke, dark greenish grey when fresh, weathers reddish brown, fine to coarse grained (in lenticular alternation along and across the strike), friable to medium hard, medium- to thin- but indistinctly bedded; attitude: strike 295°, dip 60°-65° (normal); forms crest of ridge across which section was measured; more or less fossiliferous throughout and contains several 1 to 3 foot thick, often lenticular interbeds replete with Buchia shells; other fossils rare to absent; upper 20 feet of unit contain exactly same Buchia forms as those occurring in units 24 and 25; no fossils collected in interval 36 to 22 feet above base; fauna collected 21 to 22 feet above base contains in addition to above-mentioned, predominant forms, almost equally numerous thick and triangular-shaped Buchia aff. mosquensis of Anderson (1945, pl. 12, fig. 3); this form differs		

Unit	Description	Thickness (feet) Unit	Total From Base
	from B. cf. blanfordiana in its much shorter, straighter beak and in the shape of left valve; some late elongated forms of B. mosquensis s. lato were noted here for first time; basal 3 feet of unit also contains somewhat peculiar Buchia fauna; this fauna is rich in Buchia aff. mosquensis Anderson 1945, large representatives of B. piochii (Gabb) var. mniovnikensis Pavlow and in forms transitional between latter and large broad forms of B. mosquensis (Buch) and var. rugosa (Fischer); these three forms are more common in this bed than the previously mentioned Buchia forms dominating the fauna of units 24 and 25.	67	1,757
22	Greywacke, much as in unit 21 but predominantly medium-grained and with numerous interbeds of coarse-grained greywacke occurring locally; generally poor in fossils except for several 1 to 3 inch thick layers replete with Buchia; this fauna consists essentially of same forms as those occurring 21 to 22 feet above base of unit 23; however, ratios of early forms of B. piochii s. lato, B. aff. mosquensis Anderson and transitional forms between the two fluctuate considerably from one layer to another; late, narrow and elongated forms of B. mosquensis (Buch) s. lato appear to be more common in this unit than in overlying one.	69	1,690
21	Greywacke, dull grey, weathers brown-grey, fine grained, hard, mostly massive to indistinctly bedded, mostly rich in, but not replete with, essentially the same forms of Buchia as those occurring in unit 22.	49	1,621
20	Greywacke, much as in unit 18, but weathers pronouncedly conchoidally or spheroidally; mostly replete with essentially the same Buchia forms as those occurring in unit 22.	23	1,572

Unit	Description	Thickness (feet) Unit	Total From Base
19	Siltstone, dark grey, weathers chocolate-brown and rubbly, medium hard; rows of round 1 to 3 feet in diameter concretions of similar but harder siltstone and of intensely rust-weathering, hard, ferruginous siltstone (clay ironstone) occur at 3 to 10 foot intervals; becomes more and more sandy in topmost 5 feet and grades into unit 20; relatively rare (mostly in concretions) Buchia fauna apparently mostly consists of same forms as those occurring in overlying units; however, broad but thin, advanced forms of Buchia mosquensis (Buch), such as occur in lower part of Division B of Grassy Island (Jeletzky, 1965a, pp. 17-18, 65) appear to be fairly common here for the first time (especially near base).	73	1,549
	Lower Portlandian s. str.?		
	Upper part of Buchia mosquensis zone?		
18	Greywacke, dark green-grey, weathers chocolate-brown to rust-coloured, fine-grained, friable; grades upward into siltstone of unit 19; mostly forms top part of a shear cliff and lower contact was only seen from distance; rare mixed Buchia fauna collected 5 feet above base consists of apparently about equally numerous, small and thick advanced forms of B. mosquensis s. lato resembling B. subpallasi (Krumbeck, 1936), and early forms of B. piochii (Gabb) s. lato; lower 3 feet of bed are replete with apparently the same Buchia forms but were inaccessible; attitude as before.	15	1,476
17	Greywacke (subgreywacke?) whitish grey to dull grey or intensely rust-coloured; these colours alternating in 6 inch to 5 foot thick bands, fine grained, often ferruginous, friable to medium hard; often thin- and crossbedded; some poor plant remains noted about 23 feet		

Unit	Description	Thickness (feet) Unit	Total From Base
	above base, otherwise, no fossils seen; top cut off by a 10° trending and about vertical normal fault with downdrop on its west limb of at least 200 feet; faulted-out upper about 70 feet thick part of unit was only observed from distance in an about 200 feet high shear bluff which occurs west of fault; measured lower part is 115 feet thick; thickness exposed (est.).	185	1,461
16	Greywacke, dull green to dull reddish brown, upper 50 to 60 feet is mostly dull reddish brown, thinly banded and (?)tuffaceous, mostly coarse grained but with considerable interbeds of medium-grained greywacke as in unit 15 at several levels; some thin interbeds of coarse-grained, pebbly greywacke and fine but pebbly grit; hard to friable, mostly massive-looking but actually thinly banded; attitude as in underlying beds; often rich in very poor plant fragments; otherwise only a few poorly preserved belemnites seen (none collected).	128	1,276
15	Greywacke, ash-grey to light greenish grey, mostly medium-grained but with interbeds of coarse, gritty greywacke, friable to fairly hard, massive to indistinctly bedded; fossils rare or absent except for poor plant fragments; some poorly preserved _Buchia_ cf. _piochii_ (Gabb) s. lato and _B_. cf. _mosquensis_ (Buch) s. lato, and a few _Meleagrinella_ aff. _echinata_ (Smith), were collected a few feet above base.	35	1,148
	Lower Portlandian and (?)uppermost Kimmeridgian		
	Middle part of _Buchia mosquensis_ zone		
14	Greywacke, much as in unit 12 but fine to very fine grained and with concretions and interbeds of light coloured siltstone and fine-grained greywacke as in unit 11; except for		

Unit	Description	Thickness (feet) Unit	Total From Base
	carbonized imprints of fossil wood, no fossils were seen in interval between 20 and 110 feet above base; few poor _Buchia_ cf. _mosquensis_ (Buch) s. lato were seen (none collected) in float in the interval 115 to 125 feet above base and a mixed fauna of more common _Buchia mosquensis_ (Buch) f. typ. such as occurs in early Portlandian s. str. _Dorsoplanites panderi_ zone in central Russia (Gerassimov, 1955, pl. XII, figs. 6-8) associated with the thicker and narrower forms of _B. mosquensis_ (Buch) s. lato and _Buchia piochii_ (Gabb) var. _russiensis_ (Pavlow) and var. _mniovnikensis_ (Pavlow) was collected 20 feet above base.	130	1,113
13	Greywacke, dull green-grey when fresh, weathers dark brown or light grey and speckled, medium hard, mostly fine to medium grained but with a few interbeds of medium- to coarse-grained greywacke near top, indistinctly to thinly bedded; attitude: strike 290°, dip 65°-70°S (normal); replete with _Buchia_ in basal 2 feet, higher up fossils are rare; _Buchia_ fauna is dominated by _B. mosquensis_ (Buch) f. typ. such as occur in lower Portlandian _Dorsoplanites panderi_ zone of central Russia (Gerassimov, 1955, pl. XII, figs. 6-8) throughout; no advanced forms of _B. mosquensis_ s. lato, early forms of _B. piochii_ s. lato or _B._ aff. _mosquensis_ Anderson, 1945 were seen in this unit except rarely near its top.	40	983
12	Greywacke, dark grey to dark green when fresh, weathers dark greenish brown to chocolate-coloured and fine rubbly to earthy, very fine-grained, silty, friable, rare concretions and interbeds as in unit 11; becomes less and less silty and fine grained instead of very fine grained in top 10 feet; few thin interbeds of similar but medium-grained greywacke in same interval; very poor in fossils but		

Unit	Description	Thickness (feet) Unit	Total From Base
	apparently contains B. mosquensis (Buch) f. typ. throughout; about 13 feet above base the same forms of B. mosquensis f. typ. as in unit 13 were collected from 1-foot thick zone; some more slender variants superficially resembling B. cf. blanfordiana (Stoliczka) and B. cf. volongensis (Sokolov) but probably transitional to B. tschernyschowi (Sokolov) also occur here.	36	943
	Upper and Middle (?)Kimmeridgian		
	Lower part of Buchia mosquensis zone		
11	Siltstone, much as in unit 9 but somewhat darker grey weathering, and locally grading into very silty and very fine-grained greywacke; 6 inches to 2 feet thick interbeds and rows of concretions of light to dark grey, weathering dirty white, medium hard, worm-burrowed, very sandy siltstone or very fine, silty greywacke occur at intervals of 8 to 30 feet; grades into very fine-grained, dark green-grey, friable greywacke in uppermost 1 foot; in upper 110 feet Buchia fauna is dominated by such early (upper Kimmeridgian) forms of B. mosquensis species group as Buchia tschernyschowi (Sokolov), Buchia volongensis (Sokolov), Buchia mosquensis var. polita (Keyserling) and related forms often resembling superficially B. cf. blanfordiana and early forms of B. piochii s. lato; Buchia mosquensis f. typ. and its var. paradoxa (Sokolov) are common to fairly common in upper 42 feet of unit becoming progressively scarcer downward within this interval; between 132 and 92 feet below top they appear to be rare or absent and replaced by various transitional forms between B. mosquensis and B. concentrica species groups, among which Buchia lindstroemi (Sokolov) is particularly prominent; in interval between		

Unit	Description	Thickness (feet) Unit	Total From Base
	57 1/2 and 48 feet above base of unit the above mentioned upper Kimmeridgian fauna is replaced by that dominated by B. lindstroemi (Sokolov) and other closely allied narrow and elongated forms tentatively referred to Buchia mosquensis species group; at level 32 to 33 feet above base B. lindstroemi (Sokolov) is not too common and the fauna is dominated by B. mosquensis (Buch) var. paradoxa (Sokolov); B. volongensis (Sokolov) and similar but as yet little understood forms of upper Kimmeridgian affinities.	170	907
10	Greywacke, as in unit 8 but relatively poor in fauna; lower contact sharp and distinct while upper contact is gradational; scarce and somewhat poorly preserved Buchia ex gr. mosquensis (Buch) fauna collected in lower 4 to 5 feet of bed appears to be same as that occurring in unit 11.	14	737
	Upper Oxfordian to lower Kimmeridgian variegated rocks?		
	Lower Kimmeridgian(?)		
	Upper part of Buchia concentrica zone(?)		
9	Siltstone, dark greenish grey to dark grey or brown, sandy to very sandy, soft; weathers earthy; more sandy in basal 10 feet than higher up; some interbeds of greywacke as in unit 7; no fossils seen.	100	723
	Upper Oxfordian to lower Kimmeridgian variegated rocks		
	Buchia concentrica zone		
8	Greywacke, dark green to dark green-grey, weathers intensely rust-coloured and earthy, very fine-grained and silty, very friable, replete with Buchia concentrica (Sowerby) and its late B. mosquensis var.		

Unit	Description	Thickness (feet) Unit	Total From Base
	paradoxa-like variants; some transitional forms toward B. volongensis (Sokolov) were also observed; grades upward into unit 9.	9	623
7	Greywacke, dull grey to light grey or green-grey when fresh, weathers light grey or rust-coloured; fine-grained, friable; replete with B. concentrica (Sowerby); this fauna includes typical forms of the species in association with its large, flat variants and thick, strongly incurved B. mosquensis (Buch) var. paradoxa (Sokolov)-like forms.	6	614
6	Siltstone, greenish grey to yellow-green, weathers dull brown, sandy to very sandy; locally grades into superficially similar, fine-grained and silty greywacke and contains agglomerations and interbeds of the same in places; outcrops poor.	78	608
5	Greywacke, like that occurring as interbeds in unit 4; locally contains some interbeds and pods of siltstone as in unit 4 and of fine pebble conglomerate; greywacke is often strongly crossbedded and ripple marked; no fossils seen; outcrops poor.	30	530
4	Siltstone, dark grey when fresh, weathers dull grey to dull brown and chunky; contains numerous 3 inch to 1 foot thick interbeds of harder, light grey-weathering shale and of whitish to light brownish grey, very fine-grained, silty greywacke; these interbeds occur at 2 to 30 feet wide intervals; attitude: strike 315°, dip 50°-55°W (normal) in upper 225 feet, farther downsection it changes to strike 305°, dip 80°SW (normal) probably due to faulting; almost unfossiliferous except at level 270 to 272 feet above base where elongated and typical forms of B. concentrica (Sowerby) are fairly common; thickness exposed (est.).	324	500

Unit	Description	Thickness (feet) Unit	Total From Base
3	Interbedded dark grey, fine-grained, hard greywacke and softer, light to whitish grey, fine-grained, calcareous greywacke; attitude: strike 305°, dip 80°SW (normal); mostly replete with Buchia concentrica (Sowerby) s. lato including the same forms as those occurring in unit 7.	17	176
	Mid-Callovian(?) to lower Oxfordian shale?		
	Lower Oxfordian?		
	Cardioceras zone?		
2	Shale, dark grey to black when fresh, weathers light brownish grey and earthy, soft, no fossils seen; outcrops poor throughout.	72	159
1	Shale, brown-grey when fresh, weathers dark brown to rust-coloured, soft; 2-foot thick bed of harder, dark grey (weathering light brown) splintery shale forms top of unit; no fossils seen; base covered on lower part of south slope of a pronounced, completely covered, east-west trending valley apparently representing the site of a major fault; thickness exposed.	87	87

Section 14

(Field No. JA-20)

Location: Measured along the crest of the northeastern spur of summit 8,222; the top is situated about 350 yards northeast of its top and about 400 feet southwest of the first pronounced saddle northeast of the summit. The section is at about 51°9'N Lat. and 122°57'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Latest Portlandian s. str. to late Berriasian shale		
	Upper Jurassic		
	Latest Upper Tithonian		
	Lower part of Buchia terebratuloides s. lato zone		
13	Almost completely covered but with minor patches of dark grey, soft, completely decomposed (earthy) shale and probably underlain by this shale throughout; no fossils seen; farther southwest along crest everything is covered and overgrown by grass for some 500 feet across general strike to base of the pillar-like top part of summit 8,222 built of plateau basalt; thickness exposed across general strike.	24	667
12	Shale, dark to dull grey when fresh, weathers brownish grey, mostly fairly to strongly glauconitic and silty; some glauconitic siltstone interbeds and agglomerations; slabby, medium hard; stands out like low ridge in places; contacts covered; locally fairly rich in Buchia and Lima (Limea) ex aff. blackei Cox; Buchia fauna is dominated by Buchia terebratuloides f. typ., var subinflata (Pavlow), and var. occidentalis (Anderson), and transitional forms between these three variants; early forms of B. okensis (Pavlow) s. lato and forms transitional between them and B. terebratuloides-B. fischeriana species		

Unit	Description	Thickness (feet) Unit	Total From Base
	group are common, but B. fischeriana (s. lato) itself and late forms of B. lahuseni (Pavlow) s. lato are rare; this fauna is the same as that occurring 20 to 40 feet above base of unit 1 of Section 15; rare fragments of Cylindroteuthis-like belemnites.	1	643
11	Mostly covered, but with larger ratio of completely decomposed soft shale as in unit 13, no fossils seen.	45	642
	Upper Tithonian (but not uppermost)		
	Buchia fischeriana zone(?)		
10	Shale, medium grey when fresh, weathers light to bluish grey, silty and often more or less glauconitic, some interbeds and pods of strongly glauconitic siltstone as in unit 12, locally calcareous and possibly grades into impure limestone in places; slabby, medium hard; abundant Buchia fauna dominated by various, often large forms of B. terebratuloides (Lahusen) f. typ. and var. subuncitoides (Bodylevsky), B. lahuseni (Pavlow), and specimens transitional between these forms; B. fischeriana (d'Orbigny) f. typ. and var. trigonoides (Lahusen) are fairly common; B. terebratuloides var. subinflata and var. occidentalis and early forms of B. okensis are very rare and even forms transitional between them and Buchia ex gr. lahuseni-fischeriana are relatively rare; this fauna is believed to be somewhat older than that occurring in the basal 12 1/2 feet of unit 1 of Section 15; both contacts conformable and gradational.	1 1/2	597
9	Shale, much as in units 13 and 11, but with some interbeds and concretions of harder glauconitic shale and siltstone than that of units 12 and 10; unfossiliferous except at level 12 to 15 feet below top where few poorly		

Unit	Description	Thickness (feet) Unit	Total From Base
	preserved Buchia and belemnites apparently represent the same fauna as that occurring in the overlying unit 10.	49	595 1/2
	Buchia fischeriana zone		
8	Shale, much as in unit 12, but hard and weathering-resistant; stands out in relief as low hogback; attitude: strike 290°-300°, dip 80°-85°N (overturned); closely jointed and partly sheared, some slickensides; contains lenses of similar but more or less calcareous shale moderately rich in Buchia; only scattered Buchia shells occur elsewhere; this fauna is dominated by small- to medium-sized representatives of Buchia lahuseni (Pavlow) and B. lahuseni var. tenuicollis (Pavlow); the latter variant was not seen at all in overlying beds; conversely the dominant forms of unit 10, such as large forms of B. lahuseni and B. terebratuloides var. subuncitoides (Bodylevsky) or transitional forms between B. lahuseni and B. terebratuloides s. lato are rare in unit 8; Buchia fischeriana (d'Orbigny) and B. fischeriana var. trigonoides (Lahusen) are also rare in this faunal phase of Buchia fischeriana zone.	1 1/2	546 1/2
7	Shale, as in unit 9; outcrops poor throughout and only weathered rock seen; attitude: strike 300°-310°, dip 65°NE (in upper part); unfossiliferous to almost unfossiliferous except at level 31 to 32 feet below top where irregularly shaped 1 foot thick and about 2 feet long concretion of hard shale as in unit 8 is fairly rich in small- to medium-sized Buchia lahuseni (Pavlow) f. typ. and transitional forms to B. terebratuloides (Lahusen); B. lahuseni (Pavlow) var. tenuicollis (Pavlow); small to medium-sized B. terebratuloides (Lahusen) s. lato, and B. fischeriana (d'Orbigny) s. lato are rare in		

Unit	Description	Thickness (feet) Unit	Total From Base
	this fauna and no other buchias were seen in it; this Buchia fauna was also found 67 to 68 1/2 feet below top as scattered pods in an interbed of harder, weathering-resistant (forms low hogback), dark grey, brownish grey-weathering, sometimes glauconitic and limy shale; 88 1/2 to 99 1/2 feet below top a rich Buchia fauna dominated by medium to large forms of B. terebratuloides (Lahusen) f. typ. and large to small forms of B. lahuseni (Pavlow) and B. lahuseni var. tenuicollis (Pavlow) was found in a row of 1 to 2 feet long, loaf-like concretions of hard, dull grey, light brownish grey to yellow-grey-weathering (dolomitic?) shale; other than these two species, this fauna includes less common B. fischeriana (d'Orbigny) f. typ. et var. trigonoides (Lahusen) and numerous transitional forms between all above mentioned forms; rare phylloceratid ammonites and Cylindroteuthis-like belemnites also occur in this fauna; representatives of the same Buchia species were found 109 1/2 to 110 1/2 feet below top in a row of 5 feet long and 1 to 2 feet thick agglomerations of harder rust-grey-weathering ferruginous shale; 168 1/2 feet below top occurs a fauna of small to medium-sized buchias apparently identical with that occurring at 31 to 32 and 67 to 68 1/2 foot levels; some Pleuromya cf. vancouverensis (Whiteaves), indeterminate belemnites and fragments of fossil wood also occur at this level; this fauna was collected from scattered loaf-like concretions, 2 to 5 feet long and 1 to 2 feet thick, of grey silty shale or sandy siltstone which weathers light brownish grey; irregular agglomerations of what appears to be water-lain fine- to coarse-grained volcanic tuff occur in some of these concretions; in basal 3 to 4 feet of unit occurs a persistent row of 2 to 5 feet long and 3 to 4 feet thick loaf-like concretions consisting of similar interfingering siltstone and shale as at 168 1/2 foot level		

Unit	Description	Thickness (feet) Unit	Total From Base
	and containing similar agglomerations of waterlain tuff(?) and fragments of fossil wood; Buchia fauna collected there is similar to that occurring at 31 to 32 and 67 to 68 1/2 foot levels, except that small to medium-sized B. fischeriana (d'Orbigny) f. typ. are fairly common in it; several specimens of Phylloceras s. lato cf. subplicatium (Burkhardt) and Pleuromya sp. indet. were also found in this bed.	176	545
	Upper Tithonian and (?)uppermost Portlandian s. str.		
	Lower part of Buchia fischeriana zone and Buchia piochii f. typ. zone		
6	Siltstone, blackish grey to brownish grey when fresh; weathers brownish to rust-grey and very finely rubbly to earthy, soft; pods and interbeds of flinty, laminated dark grey shale and soft sandy siltstone; some buchias were collected 23 1/2 to 24 1/2 feet below top from around 3 feet in diameter concretion of the same tuffaceous(?) siltstone-shale as occurs in lower 18 feet of overlying shale unit; this fauna consists predominantly of small to medium-sized B. fischeriana (d'Orbigny) f. typ. and similarly sized B. lahuseni (Pavlow) f. typ. connected by transitional forms; some late forms of B. piochii (Gabb) f. typ. and transitional forms between it and B. lahuseni (Pavlow) were also found; only very few small shells referable to B. lahuseni (Pavlow) var. tenuicollis (Pavlow) and B. cf. terebratuloides (Lahusen) s. lato occur in this fauna; some fragments of fossil wood; no fossils except small Patella-like shells were found in next 55 feet below top; 79 1/2 to 82 1/2 feet below top occurs a 2 to 2 1/2 foot thick persistent concretionary band of hard, dull grey, light brown-weathering blocky siltstone standing out as low hogback; fairly rich Buchia fauna occurring		

Unit	Description	Thickness (feet) Unit	Thickness (feet) Total From Base
	in this bed is dominated by about equally numerous late forms of B. piochii (Gabb) f. typ. and B. lahuseni (Pavlow) f. typ. et var. tenuicollis (Pavlow); fair number of transitional forms between these forms occur in this fauna which otherwise includes only very rare small forms of B. fischeriana (d'Orbigny) and B. cf. terebratuloides (Lahusen); rare Lima (Limea) aff. blackei Cox is associated with this Buchia fauna which is placed in the topmost part of Buchia piochii zone; 11 1/2 to 12 1/2 feet lower in the unit occurs a persistent row of rounded 2 to 3 feet long and 1 to 1 1/2 feet thick concretions of dull grey, buff-weathering, hard, often more or less sandy siltstone containing a rather similar Buchia fauna and fairly numerous "Rhynchonella" ex aff. schucherti Stanton; 27 1/2 feet farther down occurs another row of similar concretions replete with "Rhynchonella" ex aff. schucherti Stanton and often forming an impure coquina limestone; fairly numerous Buchia closely similar to those of overlying beds of the unit; the fauna includes however, many medium- to large-sized specimens and a somewhat greater ratio of B. lahuseni (Pavlow) f. typ. and var. tenuicollis (Pavlow) and B. fischeriana (d'Orbigny) s. lato than these latter; three feet farther down occurs a 1/2 inch thick layer of light yellow weathering siltstone (bentonite?); 20 feet to 21 feet below this bentonitic(?) layer occurs a row of 1 to 2 feet in diameter rounded concretions of speckled, dull grey, yellowish-weathering, very sandy siltstone or fine- to medium-grained, tuffaceous? sandstone fairly rich in buchias and containing also a few Cylindroteuthis-like belemnites; Buchia fauna is about the same as in immediately overlying concretionary row; 12 to 13 feet farther down occurs a row of 5 feet long and 1 foot thick loaf-like to lens-like concretions of brownish grey, dirty yellow weathering sandy siltstone		

Unit	Description	Thickness (feet) Unit	Total From Base
	locally grading into fine-grained silty sandstone; Buchia fauna of this bed consists predominantly of small to large representatives of late to typical forms of B. piochii (Gabb); B. lahuseni (Pavlow) f. typ. and var. tenuicollis Pavlow and forms transitional between these two species are rare; no other Buchia species were noted; a small fault with 6 to 7 foot displacement cuts through this bed; 28 to 29 feet farther down (174 to 175 feet below top) occurs a row of 2 to 4 feet long, and 1 to 1 1/2 feet thick bluish grey weathering, white to whitish grey, hard, more or less sandy siltstone with agglomerations and lenticular interbeds of fine-grained silty sandstone which locally show worm trails; rare "Rhynchonella" ex aff. schucherti Stanton and fairly rare Buchia occur scattered in these concretions; Buchia fauna is about the same as in overlying concretionary interbed; in basal 42 to 43 feet, siltstone is interbedded with, and locally replaced by slightly silty, hard, medium grey, light grey weathering shale; concretions occurring 207 to 208 feet below top have yielded only a few fragments of B. piochii (Gabb) f. typ. and small Patella-like shells; attitude at this level is: strike 310°, dip 80°-85°E (overturned).	217	369
5	Greywacke, black to blackish grey when fresh, weathers dark brown to intensely rust-coloured and medium to coarsely rubbly; some concretionary weathering in middle part; extremely rich in dark minerals, fine to very fine grained, silty to very silty in places and mostly very poorly sorted, friable to medium hard; irregularly shaped 1 to 2 feet long concretions of orange- to bright yellow-weathering limonite occur near middle of unit; one or two rows of rounded, extremely hard concretions of fine- to medium-grained, blackish green to greenish black greywacke extremely rich in dark minerals occur 6 to 8 feet above base; grades into shale		

Unit	Description	Thickness (feet) Unit	Total From Base
	of unit 6 through a 3 to 4(?) foot thick zone of more or less sandy siltstone; outcrops mostly poor and covered by rubble; fossils generally absent or rare, but 6 to 8 inch thick layer replete with buchias occurs some 5 feet below top; a couple of similar layers and some scattered pods replete with buchias occur 3 to 6 feet above base; this Buchia fauna is dominated by small to medium-sized forms of B. piochii (Gabb) f. typ. but similar sized B. cf. and aff. lahuseni (Pavlow) et var. tenuicollis (Pavlow) are fairly common also; rare to very rare small representatives of B. cf. blanfordiana (Stoliczka) and large, flat variants of this species approaching B. piochii (Gabb) occur locally.	27	152
	Mid-Kimmeridgian(?) to Portlandian s. str. rocks		
	Upper Portlandian(?)		
	Buchia cf. blanfordiana zone		
4	Greywacke, bluish to dull grey when fresh, weathers maroon to dull brown and finely rubbly to chippy, medium hard to friable, fine grained, silty to very silty; locally grades into sandy siltstone; contains less dark minerals than overlying unit; moderately to richly fossiliferous throughout and contains several coquina interbeds of Buchia cf. blanfordiana (Stoliczka) fauna which is relatively poor in typical forms of the species but rich in its slender and elongate variants and in flat variants often resembling large forms of B. piochii (Gabb) f. typ.; rare B. cf. mosquensis (Buch) and B. ex gr. piochii also occur in this fauna.	8	125
3	Greywacke, greenish grey when fresh, weathers dull brownish green and rubbly or concretionary, fine to medium grained, soft to moderately hard, grains poorly rounded and sorted, rich in dark minerals;		

Unit	Description	Thickness (feet) Unit	Total From Base
	upper and lower contacts appear distinct but conformable; almost unfossiliferous except in basal 2 to 2 1/2 feet where occurs the same fauna of B. cf. blanfordiana (Stoliczka) etc. as in overlying bed and rare indeterminate phylloceratid ammonites; only few poor imprints of Buchia cf. blanfordiana were seen higher up; dip about vertical.	10	117
2	Shale, medium grey and olive-tinged when fresh, weathers light brown to buff and rubbly, pure to silty; mostly indistinctly bedded; contains tubes (worm burrows?) 1/2 to 1 inch in diameter, wood fragments and irregular 2 to 5 inch long pods of greywacke as in unit 3 in topmost 4 to 6 inches; unfossiliferous; attitude: strike 310°, dip 80°-85°S (normal).	2	107
1	Siltstone, olive-grey to dull grey when fresh, weathers light olive-grey to brown-grey and fine rubbly or, locally, concretionary; more or less sandy for the most part and may include agglomerations and 1- to 1 1/2-foot thick interbeds of very sandy siltstone and silty, green-grey or dull green, fine-grained, medium hard greywacke; medium hard, mostly indistinctly bedded or massive, but includes interbeds of distinctly and thin- to medium-bedded siltstone in interval 25 to 50 feet below top; a 6 inch thick bed of distinctive whitish grey coloured arkosic, fine-grained sandstone occurs 50 feet below top; lower 55 feet contains several rows of 10 to 15 feet long and 1 to 2 feet thick lenses and 1 to 2 feet long and 1/2 to 2 feet thick, rounded to loaf-like concretions of ferruginous, dull grey (when fresh) dark rust-coloured weathering siltstone; also some irregular lenses and 1/2 to 1 foot thick interbeds of distinctive, whitish grey fine-grained arkosic sandstone occur in this interval; only a few poorly		

Unit	Description	Thickness (feet) Unit	Total From Base
	preserved *Buchia* cf. *blanfordiana* occur in upper 50 feet; lower 55 feet are equally sparsely fossiliferous except in some of the concretionary interbeds which yielded a *Buchia* cf. *blanfordiana* fauna which differs from that occurring in overlying units in the rather common occurrence of typical representatives of the species; this unit corresponds to the topmost unit of Section 18 (*see* there); it is underlain by complete sequence of beds exposed in that section.	105	105

Section 15

(Field No. JA-22)

Location: Measured across the steep upper southeastern slope of summit 8,222 at a point about 3/4 mile toward 110° from its top at an altitude of about 6,700 feet; the top of the section is situated about 300 yards southeast of a pronounced conical auxiliary hill occurring on this slope; the base is situated about 100 yards southeast of the same hill; the section is at about 51°9'N Lat. and 122°57'W Long.

Unit	Description	Thickness (feet) Unit	Thickness (feet) Total From Base
	Uppermost Portlandian s. str. to late Berriasian shale		
	Lower Cretaceous		
	Upper Berriasian		
	Buchia uncitoides zone (basal part)		
3	Shale, dark grey when fresh, weathers light grey to ash-grey; splintery, soft; rare 1- to 2-foot thick interbeds of *B. uncitoides* s. lato coquina similar to those of overlying beds; shale itself is poor in buchias; this unit appears to be equivalent to upper 55 to 60 feet of unit 1 of Section 12 and is overlain by complete but strongly sheared and partly contorted succession of beds of white-weathering member (unit 2 of Section 12) which was not measured in Section 15; attitude: strike 345°, dip 80°S (normal); grades into overlying beds.	55	376
	Lower Berriasian		
	Top part of *Buchia okensis* zone (including its overlap beds with *Buchia uncitoides* zone)		
2	Shale, dark grey to dark brown-grey when fresh, weathers medium to ash-grey, brownish-tinged and flaky to earthy; no coquina interbeds or clay ironstone concretions noted, except 10 feet below top where the following		

Unit	Description	Thickness (feet) Unit	Total From Base
	fauna of the overlap beds was found in clay ironstone concretions; large lytoceratid ammonite, large, advanced variants of _Buchia okensis_ var. _canadiana_ (Crickmay), large forms of _B. uncitoides_ var. _spasskensoides_ (Crickmay) and buchias transitional between these two forms; outcrops are poor throughout.	35	321
	Basal Cretaceous and Uppermost Jurassic		
	Basal Berriasian and Uppermost Tithonian		
	Principal part of _Buchia okensis_ zone and _Buchia terebratuloides_ s. lato zone		
1	Shale, as in unit 2 but rich in variously shaped large and small concretions and 1 to 2 feet thick bands of clay ironstone and impure limestone; weathers light brownish grey; upper 140 feet of unit contains fauna of typical small to giant _Buchia okensis_ (Pavlow) s. lato with greater or smaller admixture of _B. uncitoides_ s. lato and forms transitional between these two species; 52 to 62 feet below top the same berriaselid [_Berriasella (Pseudargentinoceras)_ n. sp. aff. _gallica_ Mazenot, _Berriasella (Mazenoticeras)_ aff. _broussei_ Mazenot, _Berriasella_ (s. lato) sp. indet.?] ammonites as those found in unit 1, Section 12, were found in float and in place associated with mixed _B. okensis-B. uncitoides_ fauna; lower part of unit beginning with 193 1/2 foot level below top carries uppermost Tithonian (uppermost Jurassic) _Buchia terebratuloides_ var. _subinflata_ and var. _occidentalis_ fauna of Anderson (1945); this fauna also contains some early forms of _Buchia okensis_ in upper 75 to 80 feet of this interval; basal 12 1/2 feet of unit are characterized by decrease in _B. terebratuloides_ var. _occidentalis_ (Anderson)		

Unit	Description	Thickness (feet) Unit	Total From Base
	and var. subinflata (Pavlow) and the appearance of numerous representatives of small to large forms of B. terebratuloides (Lahusen) f. typ. and var. subuncitoides (Bodylevsky), and less common B. fischeriana (d'Orbigny) and B. aff. lahuseni (Pavlow) which are rare or absent in its higher beds; base concealed in bed of small ravine and probably cut off by an east-west striking fault; thickness exposed.	286	286

Section 16

(Field No. JA-23)

Location: Measured along the northwestern slope of a prominent spur of Cardtable Mountain trending toward 255°. The base of the section is situated about 1 1/2 miles NE of the top, below the plateau basalts and thick porphyritic intrusion occupying the upper part of the shoulder; its top (section is overturned) is about 1 1/2 miles southwest of a large transverse dyke cutting through the lower part of the spur.

Unit	Description	Thickness (feet) Unit	Total From Base
	Lower Cretaceous		
	Early to Mid-Hauterivian shaly rocks		
	Middle Hauterivian or ?younger		
	(unzoned)		
31	Siltstone, blackish grey when fresh, weathers dull grey and chippy, soft, more or less pure; a row of irregularly shaped, 2 to 3 feet long and 10 to 12 inches thick concretions of hard, light brownish grey-weathering siltstone occurs about 6 feet above base; no fossils except for fragments of indeterminate *Inoceramus* and a couple of poor belemnite fragments; top cut off by major strike-slip(?) fault that brings this bed in contact with *Buchia crassicollis* shales; attitude: strike 345°, dip 50°S (overturned); thickness exposed.	13	2,027
	Middle Hauterivian		
	Speetoniceras-Simbirskites (*Hollisites*) zone		
30	Greywacke, as in unit 27, but interbedded with siltstone much as in unit 28 in lower 15 feet; however, this siltstone differs from that of unit 28 in its greater hardness and more weathering-resistant character; it contains numerous pods, lenses and concretions up to		

Unit	Description	Thickness (feet) Unit	Total From Base
	several feet long and 2 feet thick of greywacke and of calcareous greywacke or very sandy coquina limestone as in unit 27; rich fauna of _Speetoniceras_ cf. _agnessense_ Imlay, _Simbirskites (Hollisites) lucasi_ Imlay et var. _inflatus_ Imlay, _Simbirskites (Hollisites?)_ cf. _dichotomus_ Imlay, _Simbirskites (Simbirskites?)_ sp. indet., _Inoceramus colonicus_ Anderson, _Acroteuthis?_ ex gr. _impressa_ (Gabb) and other fossils occur commonly both in concretions and scattered in intervening greywacke in lower 25 feet of unit; higher up occur only indeterminate _Inoceramus_ sp. and belemnite fragments; grades upward through a 1 1/2- to 2-foot thick bed of much more friable, finer grained greywacke into unit 31.	36	2,014
29	Siltstone, dark greenish grey when fresh, weathers mottled whitish- and light green-grey, medium hard, sandy to very sandy and limy to very limy (locally grades into strongly arenaceous limestone), locally strongly glauconitic; numerous interbeds and pods of siltstone as in unit 28 replete with large but poorly preserved _Inoceramus_ sp. indet. and belemnite fragments; attitude: strike 325°, dip 65°SW (overturned); stands out as hogback along slope; bed is strongly lenticular and seems to pinch out completely some 50 feet higher up slope.	3-7	1,978
28	Siltstone, dark grey when fresh, weathers dull grey and fine rubbly to chippy, more or less sandy, fairly soft and forms depression along slope; only few poor belemnite fragments noted; strongly sheared and shot through by numerous calcite stringers, especially so at contact with unit 27.	17	1,973
27	Greywacke, dark grey both in fresh and weathered state, weathers splintery to rubbly, numerous rust-coloured specks and spots, very fine and silty, medium hard to		

Unit	Description	Thickness (feet) Unit	Total From Base
	hard; contains rows of concretions and bands of calcareous greywacke or very sandy limestone weathering whitish grey to light brown; lower 47 feet contain only more or less rare, poorly preserved belemnites; higher (between 48 and 72 feet) contain same rich ammonite, inocerami and belemnite fauna as that occurring in unit 30 almost throughout, attitude: strike 300°, dip 50°SW (overturned).	72	1,956
	Lower Hauterivian?		
	Homolsomites oregonensis zone?		
26	Greywacke, dark brownish grey when fresh, weathers light grey with rust-coloured specks and rubbly, medium hard, very fine-grained and silty, contains two rows of sandstone concretions as in unit 24 at levels 3 1/2 to 4 1/2 and 17 1/2 to 18 1/2 feet above base; Pleuromya aff. vancouversensis Whiteaves and a few other indeterminate pelecypods and gastropods were collected from upper row.	25	1,884
25	Siltstone, black when fresh, weathers dark brown to rust-coloured, medium hard, sandy to very sandy and grades locally into fine-grained silty greywacke; row of loaf-like, 3 feet long and 1 foot thick concretions of dark grey, sandy to very sandy, hard, limy(?) siltstone weathering light brown occurs at top of bed; they carry few belemnites; grades into underlying unit.	4	1,859
24	Greywacke, dark grey when fresh, weathers whitish grey to light grey and rubbly, very fine and silty; medium hard; contains several rows of rounded to loaf-like concretions of similar but harder greywacke weathering dirty white; these concretions often have darker brown-grey coloured inner cores; they are especially numerous in upper 5 feet		

Unit	Description	Thickness (feet) Unit	Total From Base
	of unit; only fossil wood, indeterminate immature ammonites (desmoceratid?), pelecypods and gastropods were found in these concretions; attitude: strike 300°, dip 75°SW (overturned).	10	1,855
	This and all overlying (stratigraphically underlying) beds of section are strongly jointed and sheared; they are, furthermore, locally strongly contorted and cut by dykes of the same intrusive rock as occurs farther downsection; attitude of all beds changes several times as they form broad bends along the slope between the crest of the shoulder and the level 250 feet downslope where the section was measured; the dykes and contortion prevent the measurement of the section near the crest; farther downslope the continuity of the section is not lost and it is measurable some 100 to 200 feet above the trace of a strong north-northeast-trending strike slip fault.		
	<u>Mid- to late Valanginian Shale</u>		
	<u>Upper Valanginian and (?)basal Hauterivian</u>		
	<u>Buchia crassicollis</u> zone and (?)younger		
23	Siltstone, dark grey when fresh, weathers brownish grey and flaky to earthy, soft; at southwestern margin of outcrop becomes whitish grey, hardened (baked) and exhibits a perfect intrusive contact with the dyke rock as in unit 22, trending: strike 300°, dip 80°-85°SW; between level of 60 and 120 feet above base it is orange- to rust-coloured and cut by several 3 to 6 feet thick dykes of fine-grained, amygdaloidal intrusive rock; few <u>Buchia crassicollis</u> (Keyserling) etc., were found in the basal 2 feet of unit and same fossils occur again at		

Unit	Description	Thickness (feet) Unit	Total From Base
	irregular intervals in thin layers or strings of individual specimens to level of 60 feet above base; no fossils of any kind were seen higher up in unit; attitude as in underlying beds.	140	1,845
	Upper Valanginian		
	Buchia crassicollis zone		
22	Shale, dark brown to blackish grey when fresh, weathers light brownish grey and flaky to earthy, very soft, mostly pure; some interbeds of similar, more or less sandy siltstone; contains rare 2 to 5 feet long and 1 to 2 feet thick, loaf-like concretions of dull grey, light brownish grey to brown-grey weathering hard shale and siltstone and cannonball concretions (3 to 8 inches in diameter) of very hard dark to blackish grey shale; numerous (irregularly scattered) rough-surface, septaria-like irregularly shaped concretions of hard dark grey calcareous shale occur locally; these concretions are often brecciated by thin lamellae of calcite which may be tectonically introduced; shales are strongly sheared and contorted in interval between 120 and 190 feet above base; about 183 feet above base occurs a 5- to 6-foot thick vertical northeast- to southwest-trending dyke of dull grey, brown-weathering amygdaloidal intrusive rock; this dyke is cut by fault and its sections displaced horizontally for about 25 feet; no definite attitudes were observed in lower 170 feet of unit because of poor outcrop; higher up (between 180 and 285 feet) it is: strike 325°-330°, dip 70°-75°SW (overturned); no fossils were found in lower 180 feet of unit; in siltstone interval 180 to 185 feet above base a few concretions have yielded: *Polyptichites* (*Euryptichites*)? sp. indet., *Homolsomites quatsinoensis* (Whiteaves),		

Unit	Description	Thickness (feet) Unit	Total From Base
	Olcostephanus sp. indet.?, *Bochianites* sp. indet., *Buchia crassicollis* (Keyserling) et var. *solida* (Lahusen), *Pleuromya* sp. indet., *Astarte*? sp. indet., crinoid stems, etc.; the unit seems to grade into siltstone of unit 23 on crest of ridge but outcrops there are poor in its uppermost 50 feet or so; base covered; thickness exposed.	285	1,705
	The partly overgrown west slope some 100 to 150 feet downslope from above described exposures of the upper 120 feet of unit 22 and directly in its strike, exposed the following sequence of badly faulted and strongly contorted rocks, which must represent its more sandy and richly fossiliferous facies, judging by their fossils and position in the section (downward sequence):		
22a	Interval of very poor exposures about 40 feet wide along the shoulder (across predominant strike); probably underlain by the same shales as those of unit 22 and equally strongly invaded by the same dyke rocks; may be entirely underlain by this dyke rock in places.		
22b	Siltstone, dark to blackish grey, sandy to very sandy, soft to medium hard, weathers rubbly; contains several 2 to 5 feet thick lenticular to concretionary bands and some isolated concretions of similar but harder siltstone or fine-grained, silty greywacke replete with *Buchia crassicollis* (Keyserling) et var. *solida* (Lahusen); other scarcer fossils include *Olcostephanus pecki* Imlay, *O.* cf. *popenoei* Imlay, *Homolsomites quatsinoensis* (Whiteaves), *Homolsomites* cf. *giganteus* Imlay, a phylloceratid, and various pelecypods and gastropods; siltstone between concretionary bands is only poorly fossiliferous; rocks are		

Unit	Description	Thickness (feet) Unit	Total From Base
	almost as badly smashed and contorted as in underlying unit but seem to have predominant attitude: strike 280°, dip ±90° (almost across shoulder); top concealed; thickness exposed(?) (est.).	45	
22c	Shale and siltstone, much as in units 22 and 23, strongly invaded by intrusive dykes similar to those occurring in units 22 and 23; all rocks are smashed and contorted so that they form tectonic breccia; rare B. crassicollis (Keyserling) s. str. occur in place (mainly in crushed concretions); this unit may be repetition of part of unit 22; outcrop is 50 to 60 feet wide along shoulder but no estimate of thickness or attitude is possible.		
22d	Almost completely overgrown interval and nearly covered by debris of intrusive (dyke) rock, such as occurs in units 22 and 23; this interval occupies a marked transverse ravine accompanied by a marked saddle on crest of shoulder which is occupied by upper 100 feet of shales of unit 22; downsection it is flanked by fossiliferous interval (180 to 185 feet above base) of same unit; about 50 feet wide along shoulder.		
	No rocks similar to those of unit 22b were observed in upper part of unit 22 where they apparently belong, according to their fauna and stratigraphic position between base of unit 23 and 180 to 185 foot level of unit 22; this unit most likely represents a sandy facies (underwater bank?) of these shaly beds. This sandy facies could possibly have been moved out of its proper position by a strong strike-slip fault known to cut into wooded part of slope either at its level or somewhat farther downslope.		

Unit	Description	Thickness (feet) Unit	Total From Base
21	Almost completely covered interval in saddle of ridge and deep but gently sloping overgrown ravine crossing slope occurs between units 20 and 22; small patches of completely decomposed soft grey-brown shale with same concretions as in unit 20 were observed within them; probably underlain by this shale throughout; about 90 feet wide across predominate strike (est.).	90	1,420
	<u>Middle Valanginian</u>		
	<u>Buchia</u> <u>pacifica</u> zone		
20	Shale, blackish grey when fresh, weathers light brownish grey and earthy, very soft; 1 to 2 1/2 feet long, loaf-like or rounded concretions of blackish or bluish grey, light brown- to brown-grey-weathering, hard to very hard shale or siltstone occur in rows at intervals from 5 to 10 feet; rock is unfossiliferous except in lower 25 feet where two rows of concretions have yielded <u>Buchia</u> <u>pacifica</u> f. typ. and its variants such as occur in middle and lower parts of <u>Buchia</u> <u>pacifica</u> zone; outcrops very poor in lower 30 to 40 feet; attitude: strike 310°, dip 55°-60°SW (overturned); top concealed; thickness exposed.	95	1,330
	<u>White-weathering coquinoid member</u>		
	<u>Lower Valanginian and uppermost Berriasian</u>		
	<u>Buchia</u> <u>tolmatschowi</u> and <u>Buchia</u> <u>uncitoides</u> zones (combined)		
19	Shale, brownish grey when fresh, weathers whitish grey to dirty white and flaky, thinly laminated, soft, locally calcareous; contains numerous 6 inches to 4 feet thick interbeds of coquina replete with <u>Buchia</u>; light grey when fresh and weathers white; lower 55 feet (approx.) carry <u>B</u>. <u>uncitoides</u> (Pavlow) and		

Unit	Description	Thickness (feet) Unit	Total From Base
	its variants; upper 45 feet (approx.) contain Buchia tolmatschowi s. lato fauna; thickness exposed (est.).	100	1,235
	Latest Portlandian to late Berriasian Shale		
	Berriasian		
	Lower part of Buchia uncitoides zone and Buchia okensis zone		
18	Shale, as in unit 17 and with same, often intensely rust-weathering concretionary bands and concretions; extremely closely jointed, sheared and strongly contorted in basal 70 feet; strongly slickensided and shot through with calcite veinlets and stringers just above exposed base (covered interval); general attitude in upper part of unit is: strike 310°, dip 65°SW; small to large representatives of B. okensis s. lato and less common Buchia uncitoides s. lato were collected from shattered concretions 70 to 72 feet above base and again 124 feet above base; numerous small and medium-sized B. uncitoides (Pavlow) such as are diagnostic of Buchia uncitoides zone proper were collected 160 feet above base; judging by shattered and slickensided appearance of shale and concretions 145 to 160 feet above base, fault cuts through unit just below 160 foot level; boundary between Buchia okensis and Buchia uncitoides zones is drawn tentatively at base of this fault zone (145 foot level); apparently grades into overlying rocks; base concealed; thickness exposed (est.).	218	1,135

Unit	Description	Thickness (feet) Unit	Total From Base
	Upper Jurassic		
	Upper Tithonian Stage		
	Buchia fischeriana zone (lower part?)		
17	Shale, dark grey when fresh, weathers bluish grey with rust-coloured specks and flaky, more or less silty; interbeds and rows of irregularly shaped, large (up to 4 feet in diameter) concretions of hard, bluish grey, weathering brownish grey to brown, sandy and limy shale and siltstone; attitude more or less as in underlying rocks; jointed and contorted for the most part; 5 to 6 foot thick sill-like body of medium grey-brown-weathering, porphyritic intrusive rock broken by several north-south-trending faults with maximum displacement of 20 feet occurs 190 to 195 feet above base; mixed fauna of small to medium-sized B. fischeriana (d'Orbigny) and B. piochii (Gabb) f. typ. was collected at 120 and 160 to 163 foot levels above base; top covered and presumed cut off by major fault; some 400 feet of rocks (Buchia terebratuloides s. lato zone and parts of Buchia fischeriana and Buchia okensis zones) are faulted out here; thickness exposed.	220	917
	Mid(?)-Kimmeridgian to Portlandian s. str. siltstone and shale		
	Portlandian s. str. and late Kimmeridgian		
	Buchia piochii s. str., Buchia cf. blanfordiana, Buchia n. sp. aff. piochii and (?)Buchia mosquensis zones		
16	Siltstone, greenish grey to dark greenish grey when fresh, and rust-coloured in upper part, more or less sandy, soft; weathers flaky to		

Unit	Description	Thickness (feet) Unit	Total From Base
	splintery; contains some up to 6 inches thick interbeds and pods of fine-grained silty greywacke in upper half (above 93 foot level) and rare rows of loaf-like, 1 to 2 feet long and 4 to 10 inch thick light brown- to brown-grey-weathering, bluish grey, hard concretions of limy siltstone or shale locally grading(?) into impure limestone; closely jointed and often more or less sheared; lower 72 feet did not yield any fossils; fairly rich fauna of small to medium-sized representatives of B. cf. blanfordiana (Stoliczka) associated with almost equally numerous early forms of B. piochii (Gabb) and forms transitional between the two species were collected 72 feet above base from a row of limy siltstone concretions; 83 feet above base another row of such concretions has yielded more typical Buchia cf. blanfordiana fauna including large typical forms of the species associated with its even more numerous slender representatives; this fauna also includes fairly numerous B. piochii (Gabb) f. typ. and other insufficiently understood variants of B. piochii s. lato; Buchia fauna consisting exclusively of small to medium-sized forms of B. piochii (Gabb) f. typ. and allied forms was collected 97 feet above base; this fauna is placed at base of Buchia piochii zone proper; another Buchia fauna collected 122 feet above base consists predominantly of B. piochii (Gabb) f. typ. associated with Buchia forms transitional to B. lahuseni var. tenuicollis (Pavlow), and other insufficiently understood B. ex gr. piochii (Gabb); upper and lower contacts seem gradational but are poorly exposed.	150	697
	Unless unit 16 is cut by an unnoticed major fault bringing rocks of Buchia cf. blanfordiana zone against those of Buchia concentrica zone, zones of Buchia n. sp. aff. piochii and Buchia		

Unit	Description	Thickness (feet) Unit	Total From Base
	mosquensis s. lato are contained in the unfossiliferous lower 72 feet of unit. This interpretation is favoured by writer, as he was unable to discover any indications of strong faulting either within lower part of unit 16 or between it and unit 15 containing Buchia concentrica fauna. The abnormally small thickness of the zones concerned could perhaps be explained by their tectonic thinning in this overturned section.		
	Upper Oxfordian to lower Kimmeridgian variegated rocks		
	Buchia concentrica zone		
15	Greywacke, brown-green, fine grained but coarser and less silty than that of unit 14, weathers rubbly, medium hard; attitude: strike 330°, dip 55°SW (overturned); closely jointed and often sheared; large broad (late?) variants of B. concentrica (Sowerby) and less common B. concentrica var. erringtoni (Gabb) were collected in topmost 1 1/2 feet of unit.	10	547
14	Greywacke, light to greenish grey when fresh; weathers light brown to rust-coloured, is intensely rust-coloured in places, very fine-grained, silty, closely jointed and often sheared; no fossils seen; base merges into underlying shear zone (unit 13); thickness exposed.	40	537
13	Zone of intensely sheared and brightly orange-coloured (hydrothermally altered?) rocks (interbedded greywacke and shale?); sequence could not be determined; occurrence of Buchia concentrica fauna closely above and below this zone indicates that any probable faulting within it must be limited to repetition (or less likely, faulting out) of parts of that zone; width along crest of ridge (across predominant strike) is about 350 feet.		

Unit	Description	Thickness (feet) Unit	Total From Base
	Upper Oxfordian to lower Kimmeridgian variegated rocks		
	Buchia concentrica zone		
12	Shale, as in unit 2; top merges into above-described shear zone trending toward 10°; thickness exposed.	25	497
11	Greywacke, much as in units 6 and 8; contains several 1 to 5 feet long and 1 to 2 feet thick lenses and pods of fine to coarse grit; same forms of Buchia concentrica fauna as in unit 15 and some Cylindroteuthis-like belemnites occur locally forming agglomerations in lens-like interbeds of fine-grained, silty greywacke.	7	472
10	Shale, as in unit 2 and with same concretions, attitude: strike 360°, dip 60°-65°S (over-turned); some fossil wood and B. concentrica (Sowerby) s. lato occur locally in concretions (none collected).	183	465
9	Irregularly interbedded shale and siltstone, much as in units 5 and 7 but with minor interbeds of greywacke as in units 6 and 8; some lenses and pods of pebbly and gritty greywacke and fine to medium pebble conglomerate; Buchia concentrica (Sowerby) s. lato and Cylindroteuthis-like belemnites occur locally (none collected).	75	282
8	Greywacke, as in unit 6; altered (baked), brecciated (sheared and jointed) and intensely rust-coloured in part (minor faulting?); 2-foot thick bed of coarse-grained, gritty and pebbly greywacke rich in Cylindroteuthis-like belemnites and Buchia concentrica (Sowerby) s. lato forms base of unit.	30	207
7	Siltstone, brown to rust-coloured, weathers flaky to earthy, soft but hardened (baked)		

Unit	Description	Thickness (feet) Unit	Total From Base
	and brecciated in places; only weathered or altered rock seen.	26	177
6	Greywacke, green-grey when fresh, weathers rust-coloured with green-orange specks, fine grained, thin- but indistinctly bedded; attitude: strike 335°, dip 30°SW; separated from unit 5 by a 3 foot wide zone of calcite-permeated, intensely orange-weathering greywacke (fault zone?).	21	151
5	Shale, much as in unit 2, but more intensely brown and rust-weathering, soft, fine rubbly- to splintery-weathering.	48	130
4	Greywacke, grey-green when fresh, weathers rust-brown-coloured, fine to coarse grained and locally pebbly, very poorly sorted and contains lenses and pods of fine to medium pebble conglomerate; pebbles 1 to 2 inches in diameter predominate, no granitic pebbles noted; *Buchia concentrica* (Sowerby) s. lato and poorly preserved *Cylindroteuthis*-like belemnites occur locally; bed is lenticular and varies within short distances.	1 1/2-3	82
	Mid-Callovian(?) to lower Oxfordian shale		
3	Shale, dull grey when fresh, weathers dull brown, splintery, soft; contains rows of loaf-like concretions 4 to 5 feet long and 2 to 3 feet thick, of similar but harder shale; attitude (persistent): strike 330°, dip 40°-45°SW (overturned); contains interbeds of concretionary weathering intensely rust-coloured shale; in places cut by up to a few feet thick sills and stringers of green porphyritic intrusive rock.	80	80
2	Shale, brown grey to dull brown or black; only weathered rock seen; contains peculiar rectangular-shaped concretions of black		

		Thickness (feet)	
Unit	Description	Unit	Total From Base
	limestone; outcrops poor and patchy, most of surface being debris-covered; attitude uncertain; width along shoulder in order of 1,100 feet (est.).		
1	Intrusive rock (sill?), whitish grey, buff-weathering; porphyritic and rich in rust-coloured crystals of feldspar; width along shoulder (est.) 600 feet; base and top covered by debris for 100 to 150 feet (along shoulder).		

Section 17

(Field No. JA-26)

Location: Measured within high pass (altitude $\pm$8,000 feet) about 1 3/4 miles northwest of the top of Sheba Mountain and along the crest of a north-south-trending ridge beginning on the west side of the pass beneath a summit (a klippen?) built of Upper Cretaceous volcanic rocks. The top of the section is situated about 1 mile north of this klippen and its base is on the SW side of the pass about 300 feet beneath the divide.

Unit	Description	Thickness (feet) Unit	Total From Base
	Taylor Creek Group		
	Lower Cretaceous		
	Albian Stage		
17	Sandstone, as in units 12 and 11, fine-grained, somewhat more rust-weathering than usual; contact with overlying faulted and contorted black ferruginous shales with clay ironstone appears to be gradational; the latter shales were not studied; they extend northward for about 1 mile along ridge to point where it ends in a plug-like intrusive body; thickness exposed (est.).	100	3,016
16	Interbedded shale as in unit 13 and grey, brown- or rust-weathering siltstone and fine-grained sandstone as in unit 17; ratio of sandstone interbeds increases upward in section; cut by some contorted dyke- and sill-like bodies up to a few feet thick; rocks are strongly faulted and contorted so that no estimate of thickness is possible; width across general strike of unit 15 about 50 feet.		
	Brewericeras hulenense zone?		
15	Shale, black when fresh, weathers intensely rust-coloured, soft, pure, laminated; rich		

Unit	Description	Thickness (feet) Unit	Total From Base
	in clay ironstone concretions and bands; general attitude: strike 20°-40°, dip 70°NE (normal); at level 290 to 300 feet above base, shale is replete with variously shaped, clay ironstone concretions mostly not exceeding 1 foot in diameter and with rounded 1/2 to 1 foot in diameter concretions of medium- to coarse-grained, gritty, brown-grey greywacke; several small specimens of Brewericeras cf. hulenense (Anderson,1938) and indeterminate pelecypods were collected from clay ironstone concretions at 300 foot level; poor Sonneratia-like ammonites, Hamites? sp. indet., Inoceramus ex gr. anglicus Woods? and other indeterminate pelecypods were collected from another row of similar clay ironstone concretions; base and top appear cut off by faults; thickness exposed (est.).	325	2,916
	Albian and (?)older		
	(unzoned)		
14	Siltstone, grey when fresh, weathers brown, medium hard; minor interbeds of shale as in unit 13 and sandstone as in units 12 and 11; some pods and lenses of sandstone exhibit scour channels and carry flattened shale pebbles; rocks badly faulted and contorted throughout so that no estimate of thickness was possible; extends for about 350 yards along the crest of the ridge.		
13	Shale, essentially as in unit 11 but ferruginous and intensely orange, rust, or brown weathering; rich to very rich in 1 to 3 inch thick bands and variously shaped, 3 inches to 1 foot in diameter concretions of rust-weathering, hard clay ironstone; several 6 to 10 inch thick beds of fine-grained, hard, ferruginous, rust-weathering sandstone occur in this unit; cut by intrusive dykes		

Unit	Description	Thickness (feet) Unit	Total From Base
	(as in underlying beds) occurring at irregular intervals; all rocks are more or less strongly faulted and contorted; they are so badly dislocated in upper part of unit that measuring was discontinued 675 feet above its base; these contorted rocks continue, however, for next 500 feet along ridge (oblique to general strike) so that total thickness of unit is probably in order of 1,000 feet.	1,000(?)	2,591
12	Sandstone, much as that occurring in topmost 15 feet of unit 11; often slabby to laminated; locally weathers rust- to light brown-coloured; scour channels and ripple marks occurring in this unit suggest that section is overturned; in places sandstone appears to be arkosic rather than subgreywacke; contains numerous interbeds of siltstone as in top 15 feet of unit 11 near base and top; attitude: strike 20°, dip 60°NE to almost 90° (near top); this unit appears to be sandstone lens rather than a persistent member as it seems to disappear in both directions along strike by interfingering with shales and its tongues pinch out farther along strike; maximum thickness.	25	1,591
11	Shale, black when fresh, weathers blackish grey and chippy to earthy, soft, extremely monotonous; cut in places by same dykes as those cutting through units 9 and 10; these dykes exhibit typical intrusive contact with shale; in proximity of conglomerate unit 9 margins of dykes are fringed by hardened and discoloured (baked) fine pebble conglomerate which apparently was dragged up from lower level where invading molten mass was passing through unit 9 before reaching unit 11; these conglomeratic fringes were observed only in dykes cutting lower 50 feet of unit 11; attitude: strike 350°, dip 80°-85°E to vertical; 1 to 3 inch layers and		

Unit	Description	Thickness (feet) Unit	Total From Base
	3 to 4 feet long and 1/2 to 1 foot thick irregular pods of orange-weathering, hard siltstone occur locally in lower 140 feet of unit; above 140 foot level it is extremely strongly cut by dykes, weathers brown-orange and appears to be sheared; above level of 235 feet shale becomes replaced by brownish grey siltstone interbedded with 1/2 to 4 inch thick layers, agglomerations and lenses (up to 3 feet thick) of grey, light brown-weathering fine-grained, well-sorted and rounded hard sandstone as in unit 1 of section; this sandstone exhibits scour channels and flattened shale pebbles, its interbeds increase gradually upward in unit 11 until it grades into unit 12.	250	1,566
	Upper Cretaceous(?)		
10	Volcanics (lava flows?); lavender to purple coloured; severely cut by several feet thick intrusive dykes, and contorted; soft, outcrops poor, contact with underlying conglomerate abrupt; this unit is believed to be downfaulted sliver of Upper Cretaceous volcanics interrupting normal succession of Albian rocks; no estimate of thickness possible; width across predominant strike about 55 to 60 feet.		
	Aptian(?)		
9	Pebble conglomerate, fine to coarse and containing a number of cobbles and boulders 10 inches to 4 feet in diameter; those ranging from 1 to 5 inches in diameter appear to predominate, friable to soft throughout; pebbles are predominantly various sedimentary types (sandstone, shale and chert being predominant); they were presumably derived from Upper Jurassic and early to mid-Lower Cretaceous units exposed in same general area judging by		

Unit	Description	Thickness (feet) Unit	Total From Base
	lithology and presence of small to large boulders of Buchia- and ammonite-bearing sandstone and shale; Buchia species found in conglomerate include B. concentrica (Sowerby) s. lato, B. mosquensis (Buch) s. lato, B. cf. blanfordiana (Stoliczka) and possibly Buchia uncitoides (Pavlow) s. lato; ammonites represented by late Upper Jurassic perisphinctids, a single simbirskitid resembling Simbirskites (Hertleinites) rectoris (Anderson, 1938) and single representative of Aconeceras sp. indet.; conglomerate is thus probably of general Aptian age; base covered; thickness exposed (est.).	500	1,316
	Moved across a strong north-south-trending fault zone (for several hundred feet) to east side of the pass where conglomerates presumably representing the lower part of unit 9 are exposed; the downward sequence of rocks there is:		
8	Pebble conglomerate, fine, mottled grey to grey-brown-coloured; mostly soft to friable; extremely rich in coarse sandy to gritty matrix with scattered smaller pebbles; sorting and rounding of pebbles is generally poor; pebbles 1/4 to 1 inch in diameter predominate; variety of sedimentary pebbles occurs, including various shales, sandstones and aquamarine green chert similar to that occurring in Triassic rocks southeast of Spruce Lake; intrusive pebbles are rare but at least one granitic pebble was seen; no fossiliferous pebbles found; attitude: strike 300°, dip 45°SW (overturned); pebbles exceeding 2 inches in diameter appear above 80 foot level, some of them reach 4 to 5 inches in diameter; outcrops poor; top covered by extensive snowfield, thickness exposed.	135	816

Unit	Description	Thickness (feet) Unit	Total From Base
	Relay Mountain Group		
	Barremian variegated clastic rocks		
	(unzoned)		
7	Siltstone, greenish grey when fresh, weathers brown-grey, soft to moderately hard, locally sandy; interbedded with grey sandstone as in unit 1; grades upward into unit 8 through a transitional zone several feet thick where a hard variety of this siltstone is thinly interbedded with fine pebble conglomerate and coarse grit; outcrops poor; attitude as in unit 8.	30	681
6	Interbedded shale and siltstone, blackish grey when fresh, weathers dark to dull grey and earthy, very soft, only weathered rock present on surface; apparently without any sandstone interbeds or lenses.	130	651
5	Siltstone, much as that of unit 4 but with 6 inches to 2 feet thick interbeds of dull grey, slabby, fine-grained, well-sorted and rounded dark brown-weathering sandstone occurring at intervals from 5 to 15 feet; at 110 to 120 foot level above base occur several 1 to 3 foot thick lenticular beds of massive ferruginous sandstone similar to that occurring in unit 1 on south side of pass and likewise containing some flattened shale pebbles; attitude as in underlying rocks.	170	521
4	Siltstone, dark grey, weathers dull grey and earthy, soft; exposures poor throughout and mostly only weathered rock seen.	35	351
3	Sandstone (subgreywacke), medium grey when fresh, weathers light greenish grey, medium hard, well-sorted and rounded, poor in dark minerals; interbeds and pods of ferruginous sandstone with flattened shale pebbles as in		

Unit	Description	Thickness (feet) Unit	Total From Base
	unit 1; strongly sheared and somewhat contorted close to covered fault contact with unit 2 but reverts to regular attitude: strike 320°, dip 80°NE (normal) higher in unit; base covered; thickness exposed.	4	316
	<u>Upper Cretaceous (undivided)</u>		
2	Lava flows, dull grey to speckled mauve, strongly amygdaloidal with interbeds of volcanic tuff and breccia; both contacts presumed to be faults and this unit appears to represent another downfaulted sliver of Upper Cretaceous volcanic rocks interrupting sedimentary Albian-Aptian sequence; this unit occupies crest of pass; thickness (assumed).	62	312
	<u>Relay Mountain Group</u>		
	<u>Barremian</u>		
	(unzoned)		
1	Sandstone (subgreywacke), brown-grey to light grey, slabby (beds 1 to 3 feet thick); contains pods, lenses, and interbeds of ferruginous, fine-grained sandstones weathering dark brown to rust-coloured; these sandstones commonly contain layers replete with fine (1/2 to 2 inches in diameter) pebbles of dark grey hard shale; these pebbles are often flattened; scour channels of type attributed to turbidity currents occur locally in these same sandstone interbeds; 10 to 30 feet wide intervals between above-described sandstone beds are almost completely covered by their rubble; small patches of dark grey, earthy- to flaky-weathering sandy siltstone and (?)shale occur here and there within these intervals; it seems possible that they are underlain by these soft rock varieties, in part at least; attitude: strike 340°, dip		

Unit	Description	Thickness (feet) Unit	Total From Base
	60°NE (normal); base covered for some 40 to 50 feet across strike; thickness exposed (est.).	250	250
	Unit 1 is underlain by Upper Cretaceous (undivided) lava flows, dull grey to speckled mauve, strongly amygdaloidal with interbeds of volcanic tuff and breccia; these rocks are assumed to be a downfaulted block of Upper Cretaceous volcanics brought in contact with Aptian? sediments by a strong west-east fault, the trace of which runs about 300 feet beneath crest of pass (on its south side). Extends for considerable distance farther downslope; thickness was not measured.		

Section 18

(Field No. JA-28)

Location: Measured on left (northeast) slope of Yalakom River, on the west side of Grouse Creek about one mile above its mouth, nearly opposite the mouth of Shulaps Creek; the section is at about 50°57'N Lat. and 122°15'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Lower Cretaceous		
	Late Berriasian(?) to (?)mid-Valanginian arenaceous rocks		
	Valanginian and ?upper Berriasian		
	Buchia uncitoides to Buchia pacifica zones?		
5	Siltstone, greenish grey to dull grey, weathers speckled light to brown-grey. Above outcrop's end at approximately 4,500 feet elevation the sparsely wooded slope is completely covered for at least 250 feet; uppermost 95 feet of unit is composed dominantly of speckled, hard, laminated, flinty and often sandy siltstone. In underlying 23 feet softer to medium hard siltstone begins to interbed with flinty laminated siltstone occurring in 6 to 12 inch bands. Underlying 32 feet of siltstone is mostly pure and includes 6 to 10 inch bands and scattered concretions, 6 to 12 inches in diameter, or clay ironstone. Siltstone is sandy to very sandy in some beds, especially in lower 20 feet. There are a few lamellae and a 1 to 3 inch layer of fine to very fine silty greywacke at base. Attitude: strike 140°, dip 35°NE (normal) throughout, top is covered.	170	328
4	Thin interbedded siltstone and fine greywacke; siltstone forms about 2/3 of unit; unit 5 grades into unit 4 by gradual increase in thickness and number of greywacke layers in		

Unit	Description	Thickness (feet) Unit	Total From Base
	lower 25 feet; two or three pods of fine, very limy pebble conglomerate are also present; 1 to 1 1/2 foot thick bands and lenses of such conglomerate occur at irregular intervals in lower 28 feet.	53	158
3	Conglomerate, pebble, fine to medium; grey, fine and very fine, gritty (1/8 to 1/2 inch in diameter) conglomerate predominates in upper 3 feet where medium (2 to 4 inches in diameter) conglomerate is restricted to irregular pods and lenses. Lower 1 1/2 to 2 feet are mostly built of medium pebble conglomerate; rounding and sorting (according to size) of pebbles is fair to poor; volcanic pebbles predominate; larger pebbles are often grey limestone (Triassic?); other sedimentary types such as sandstone and shale are rare; no intrusive pebbles noted; both contacts appear distinct but not uneven.	5	105
2	Thinly interbedded greywacke and siltstone, similar to unit below, greywacke and siltstone beds normally 2 to 4 inches thick; alternation very regular.	45	100
1	Interbedded fine-grained, hard, weathering-resistant, light to greenish grey greywacke in beds 2 to 3 feet thick with soft, dark to greenish grey conchoidally weathering siltstone of similar thickness; base covered; attitude: strike 140°, dip 35°NE (normal); thickness exposed.	55	55

Cretaceous sediments outcrop sporadically for another 100 feet downslope. Another hundred feet below completely shattered volcanics of greenstone type begin to outcrop, but disappear about 700 feet above river-bed below. Volcanics reappear on conical hill below saddle separating hill from

Unit	Description	Thickness (feet) Unit	Total From Base
	main slope. Volcanics then outcrop down to level 300 feet above river-bed. No outcrop below.		
	Section 28 is presumably the Cretaceous section from which Buchia crassicollis s. lato (i.e. B. pacifica n. sp.) was collected by Leech and identified by Jeletzky (Leech, 1953, p. 21).		

Section 19

(Field No. JA-29)

Location: Measured on the left slope of Tyaughton Creek valley at a point about 9/10 mile above its confluence with Relay Creek. The section was started at the base of a gentle wooded upper slope some 1,000 feet above creek level and ended on the level of a new mining road just above water level (at the bridge across Tyaughton Creek).

Unit	Description	Thickness (feet) Unit	Total From Base
	Taylor Creek Group		
	Albian		
	(unzoned)		
6	Interbedded siltstone as in unit 5 with several rows of large but irregular lenses of fine to coarse pebble conglomerate, fine- to coarse-grained greywacke and arkose(?); most persistent conglomeratic zone occurs 120 to 150 feet stratigraphically below exposed top of unit; it consists of about 4 bands of medium pebble conglomerate each 5 to 10 feet thick; these lenticular bands are separated by similarly thick bands of sandy siltstone with pods of fine- to coarse-grained greywacke and grit; this unit is 35 to 40 feet thick; the stratigraphically highest beds exposed (atop steep slope) again carry numerous irregularly shaped 4 to 5 feet thick and 20 to 25 feet long pods and lenses of medium to coarse pebble conglomerate; pebbles 1 to 3 inches in diameter predominate but larger pebbles are common locally; similar agglomerations and lenses of fine- to coarse-grained greywacke and (?)arkose also occur in these topmost beds; attitude: strike 310°, dip 75°-80°NE; top concealed beneath gentle, wooded slope adjoining from northeast and northwest traversed steep		

Unit	Description	Thickness (feet) Unit	Total From Base
	slope; outcrops poor and beds may be faulted locally; base concealed; thickness exposed (est.).	150	1,330
5	Siltstone, blackish grey, weathers dark grey and fine rubbly to flaky, more or less sandy, soft to moderately hard; several rows of 4 to 6 feet long and 2 to 3 feet thick concretions of hard, dark grey, calcareous (dolomitic?) shale weathering light brown occur in topmost 50 feet of unit; single well-preserved Desmoceras (Pseudouhligella) cf. alamoense (Anderson, 1958) and indeterminate pectenids were found in these concretions; attitude: strike 310°, dip 80°-85°NE; outcrops mostly poor and both contacts are covered; thickness exposed (est.).	300	1,180
4	Almost completely covered; some small patches of blackish grey, fine-grained, silty greywacke and similarly coloured, very sandy siltstone occur locally 170 to 200 feet above base (across slope) and again at its top where they have attitude: strike 315°, dip 50°-55°NE; only couple of indeterminate pelecypods seen (none collected); whole interval is assumed underlain by these rocks; thickness assumed.	450	880
3	Interbedded shale and siltstone, ash grey when fresh, weathers dull brown and flaky to rubbly, soft; several 1- to 4-foot thick interbeds and lenses of fine- to coarse-grained greywacke, coarse grit and fine pebble conglomerate as in unit 2 occur in lower 100 feet of unit; top concealed; thickness exposed (est.).	300	430
2	Pebble conglomerate, fine poorly rounded and sorted, grey to greenish grey, often grades into coarse poorly sorted pebbly grit; thickness exposed (est.).	10	130

Unit	Description	Thickness (feet) Unit	Total From Base
1	Shale, bluish grey, brownish grey-weathering, soft to medium hard; 1 to 3 feet long and 6 inches to 1 foot thick concretions of hard bluish grey, yellow-weathering, dolomitic(?) shale occur irregularly scattered throughout thickness; attitude: strike 290°, dip 70°-75°N; poor fragment of phylloceratid ammonite and pteriid pelecypod were found in float some 25 feet stratigraphically below top; base covered; seems to grade into unit 2 through 4 to 6 feet thick interval containing interbeds of fine- to coarse-grained greywacke; thickness exposed (est.).	120	120

Section 20

(Field No. JA-27)

Location: Measured along the east side of a north-northeast-trending ridge (elevation 7,500 feet) about 3 miles slightly east of south of the eastern end of Yohetta Lake (downward sequence); 51°12'N Lat. and 123°51'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Upper Cretaceous		
	(unzoned)		
6	Volcanic rocks, green-grey to lavender; bedding poor or absent, hard; extend for a considerable distance northward from contact with unit 5 but were not measured or traversed; thickness exposed (est.).	300	1,600
	Early to mid-Hauterivian shaly rocks		
	Middle (?)Hauterivian		
	Speetoniceras-*Simbirskites* (*Hollisites*) zone?		
5	Shale, dark grey, weathers brown-grey to brown, mostly soft, extremely monotonous; some small (2 to 6 inches in diameter) rounded to elliptical (potato-like) concretions of rust-weathering, hard, clay ironstone and dark-grey calcareous, hard siltstone occur scattered or in rows; contact with overlying volcanic rocks is covered but presumed to be a fault; shales strike northwesterly and dip at moderate angles toward northeast; 150 to 200 feet stratigraphically below covered contact with volcanics the following fauna was collected in concretions: *Simbirskites* (s. lato)? sp. indet. juven., a juvenile phylloceratid ammonite, indeterminate belemnitid (phragmocone), *Lima* (*Limea*) ex gr. *blackei* Cox, *Nucula* (s. lato) sp. indet., *Inoceramus*? sp. indet., a rhynchonellid		

Unit	Description	Thickness (feet) Unit	Total From Base
	brachiopod, an indeterminate crustacean; grades into underlying rocks; thickness exposed (est.).	200	1,300
4	Shale, as in unit 5 but almost barren of concretions; no identifiable fossils seen; thickness (est.).	250	1,100
	Lower Hauterivian		
	Homolsomites oregonensis zone		
3	Shale, much as in overlying units but with several 1/2 to 1 1/2 feet thick, often lenticular interbeds of grey, orange-weathering, silty and sandy limestone (coquina) replete with fossils; the following fossils have been collected from prominent 1 1/2 foot thick limestone interbed at top of unit: Homolsomites ex aff. oregonensis (Anderson, 1938) f. juven., a lytoceratid ammonite, Inoceramus n. sp.; grades into overlying and underlying rocks; thickness exposed (est.).	100	850
2	Shale, as in overlying units but almost devoid of concretions; about 200 feet stratigraphically above exposed base Homolsomites cf. oregonensis (Anderson, 1938) and a phylloceratid ammonite were collected from a row of rounded, white-weathering 6 inch thick concretions of hard, calcareous, black shale; well-preserved and typical Homolsomites oregonensis (Anderson, 1938) was collected from another row of such concretions about 215 feet above exposed base; attitude as in unit 5; base covered; thickness exposed (est.).	350	750
	Valanginian(?)		
1	Mostly covered but with irregular patches of grey, white-weathering, fine-grained,		

Unit	Description	Thickness (feet) Unit	Total From Base
	friable sandstone; presumably underlain by this rock throughout; base covered; thickness exposed(?).	400	400
	Just south of exposed base of unit 1 begin precipitous cliffs of Jurassic(?) volcanic rocks which were not traversed.		

ADDENDUM TO SECTION 20

(May 1968)

Since this was written this section has been studied in a much greater detail and found to be overturned. The stratigraphically upper part of unit 5 has yielded the presumably latest Valanginian Valanginites n.sp. ex aff. V. nucleus (Roemer) while its stratigraphically lower part has yielded the early lower Hauterivian Homolsomites oregonensis (Anderson).

The stratigraphically basal beds of unit 2 underlying its Homolsomites oregonensis-bearing beds have, finally, yielded well preserved and typical late lower Hauterivian Homolsomites packardi (Anderson).

The volcanic rocks forming the precipitous cliffs just south of Section 20 have been found to be of mid?-Hauterivian age [presumably Speetoniceras-Simbirskites (Hollisites) zone].

The stratigraphical and palaeogeographical interpretation of Section 20 attempted elsewhere in this report (see pp. 32-33, Fig. 4) should be emended accordingly.

Section 21

Location: A north-south section across Mount Tatlow. Top of the section is to the south and the base is about three miles north of the peak of Mount Tatlow; 51°23'N Lat. and 123°50'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Kingsvale Group		
	Division D		
	Upper Cretaceous		
4	Interbedded coarse and fine volcanic breccias and minor poorly stratified tuff of andesitic and basaltic composition; beds up to 150 feet thick were observed; maroon, purple, bright green, grey and dark grey; poor sorting in the breccias with fragments up to 2 feet in diameter; attitude is about: strike 265°, dip 45°S; thickness (est.).	4,000+	15,600
	Kingsvale Group		
	Division C		
3	Coarse volcanic conglomerate, waterlain; well-rounded pebbles and boulders of locally derived volcanic material embedded in a sandy tuffaceous matrix; to the southeast on Battlement Ridge this unit thickens to several hundred feet of coarse conglomerate, chert-pebble conglomerate, sandstone and shale; at several localities Upper Cretaceous plants have been found in this unit; it is presumably absent in some sections; thickness (est.).	200+	11,600
	Kingsvale Group		
	Division B		
2	A monotonous succession of coarse breccias, fine breccias, and minor tuffs		

Unit	Description	Thickness (feet) Unit	Total From Base
	indistinguishable from unit 4; includes grey andesitic, dioritic, and basaltic sills up to 100 feet thick; in lower part fine breccia and tuff predominate, may in part be waterlain; predominantly dark green and dark grey or grey; attitude: strike 265°, dip 65°S; thickness (est.).	6,000+	11,400
	<u>Kingsvale Group</u>		
	Division A		
	<u>Albian and (?)Upper Cretaceous</u>		
1	Interbedded greywacke, siltstone, pebble conglomerate, and shale; the conglomerate is composed of rounded pebbles of chert, argillite, and volcanic rocks embedded in a greywacke matrix; greywacke is greenish grey to greenish brown, well-sorted and massive with pieces of carbon and plant material throughout; siltstone and shale are light grey to dark grey, rarely black, "salt and pepper" appearance is common; rocks are interbedded, beds up to 25 feet thick commonly with sharp contacts; the uppermost beds are tuffaceous and are in conformable contact with overlying fragmental volcanic rocks; Albian flora occurs about 400 feet below the top, base not exposed; attitude: strike 75°, dip 80°S; thickness (est.).	5,400+	5,400

Section 22

Location: A north-south section across the range north of Yohetta Lake at its east end. Top is to the north; 51°18'N Lat. and 123° 45'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Kingsvale Group		
	Division B		
	Upper Cretaceous		
3	Interbedded coarse volcanic breccias, minor tuffs; mainly dark green, green, grey, purple, maroon, and reddish brown; andesitic and basaltic rocks; not waterlain, no interbedded sediments; attitude: strike 90°, dip 55°N; thickness (est.).	6,000+	12,100
	Kingsvale Group		
	Division A		
	Albian		
2	Coarse conglomerate, pebble conglomerate, greywacke, shale; grey micaceous greywacke, dark grey shale, buff to green conglomerate; in places greywacke has large sandy concretions up to 18 inches in diameter; some wood fragments occur near top of unit; fault contact with underlying unit; thickness (est.).	4,100+	6,100
	Taylor Creek Group(?)		
	Albian(?)		
1	Black to dark grey banded, hard, fine-grained argillite or shale interbedded with fine-grained greenish tuff in beds 1 inch to 6 inches thick; near top of section some interbeds of greenish greywacke and fine grey to		

Unit	Description	Thickness (feet) Unit	Total From Base
	dark grey limestone; shales are commonly limy and a few limy concretions present; wood fragments absent; base is faulted; attitude: strike 120°, dip 70°NE; thickness (est.).	2,000+	2,000

Section 23

Location: A composite section across the range south of Yohetta Lake. No unfaulted section exists. Sections studied occur in eastern half of the range; 51°12'N Lat. and 123°42' W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Kingsvale Group		
	Division B		
	Upper Cretaceous		
3	Interbedded volcanic breccias, tuffs, and minor flows, not waterlain except locally; greenish, greyish, purplish andesite and basalt; unaltered except near faults; dykes and sills of similar composition abundant; thickness (est.).	1,000+	2,700
	Kingsvale Group		
	Division A		
	Albian		
2	Interbedded black, brown, rusty red, green, purple tuffaceous shale, tuff, minor andesitic flows, greywacke; abundant wood fragments; Albian flora occurs within 200 feet of top; thickness exposed (est.).	1,200	1,700
	Taylor Creek Group		
	Late lower Albian		
	Brewericeras hulenense zone		
1	Interlain andesitic and basaltic flows, related tuffs and breccias, and shales and bedded tuffs; volcanic rocks are dark grey, dark green, mauve, brown; shales are black or dark grey, massive to well-banded, limy in		

Unit	Description	Thickness (feet) Unit	Total From Base
	places; volcanic rocks predominate four to one; late lower Albian fauna found in this unit includes Brewericeras hulenense (Anderson 1938), cf. Hamites glaber Whiteaves, Goniomya sp. indet., Paralellodon? sp. indet., and indeterminate pelecypods (GSC loc. 62399); thickness (est.).	500+	500

Section 24

Location: Ridge southeast of Lizard Creek, top to the north; 51°5'N Lat. and 123°7'W Long.

Unit	Description	Thickness (feet) Unit	Thickness (feet) Total From Base
	Taylor Creek Group		
	(unzoned)		
4	Black to dark grey siltstone and shale with minor interbedded subgreywacke; shale has soot-like texture, soft, crumbly, in places finely bedded in bands 1/2 to 1 inch thick; siltstone is commonly laminated, hard and compact; greywacke is grey-green, dull grey, micaceous and forms beds 6 to 10 inches thick with well-formed rill marks in places; cut by many felsitic dykes; thickness (est.).	3,500+	6,550
3	Subgreywacke, well-sorted in beds 4 to 10 inches thick, hard, dull grey, greenish grey, brown, pale greyish mauve; in places siliceous and a few thin impure quartz sandstone beds present; thickness (est.).	900+	3,050
2	Pebble conglomerate and grit; conglomerate has smooth rounded pebbles of chert, argillite, volcanic rocks and the grits are finer rock types of similar composition; thickness (est.)	150	2,150
1	Subgreywacke, hard, compact, similar to unit 3; base faulted; thickness (est.).	2,000+	2,000

Section 25

Location: North side of Tyaughton Creek, two miles southeast of the junction with Lizard Creek; 51°7'N Lat. and 123°4'W Long.

		Thickness (feet)	
Unit	Description	Unit	Total From Base
	Taylor Creek Group		
	Albian		
	(unzoned)		
2	Fine chert pebble conglomerate interbedded with greenish grey greywacke in beds 5 to 25 feet thick; well-cemented; thickness (est.).	250+	500
	Brewericeras hulenense zone		
1	Fine-grained, black, finely banded shales and siltstones in beds 1/2 inch to 2 inches thick; contains abundant calcareous concretions some containing fossils *Brewericeras hulenense* (Anderson, 1938), *Douvilleiceras?* sp. indet. (juven.), a crab, genus and sp. indet., pelecypods genus and species indet. (GSC locs. 56858 and 62396); base faulted; thickness (est.).	250+	250

Section 26

Location: Ridge northwest of Relay Mountain, southeast slope; 51°9'N Lat. and 123°1'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Kingsvale Group		
	Division B		
	Cenomanian		
12	Soft, dark grey micaceous shale with abundant wood fragments and carbon fragments interbedded with grey to grey-green greywacke; beds 6 inches to 2 feet thick commonly; minor conglomerate; eight miles north near Dash Hill fossil flora indicated late Albian(?) and Cenomanian age; thickness (est.).	750	4,800
11	Coarse poorly sorted greywacke conglomerate with well-rounded boulders and pebbles up to 3 to 4 inches diameter of chert, argillite, volcanic rocks, greywacke, embedded in greenish greywacke matrix; thickness (est.).	200	4,050
	Albian		
10	Soft, dark grey, greenish grey shale interbedded with greenish to buff greywacke; rocks are micaceous, crumbly "salt and pepper" texture, much organic material, contains Albian flora; thickness (est.).	825	3,850
9	Dark grey to light grey micaceous shale and siltstone, soft and crumbly, abundant carbonaceous material; "salt and pepper" texture, well-banded in bands 1 inch to 3 inches thick; thickness (est.).	800	3,025

Unit	Description	Thickness (feet) Unit	Total From Base
8	Greywacke pebble conglomerate with lenses of greywacke; similar to unit 12; thickness (est.).	200	2,225
7	Soft, grey, carbonaceous shale and siltstone similar to unit 9; thickness (est.).	900	2,025
	Taylor Creek Group		
	Albian		
	(unzoned)		
6	Medium to coarse chert pebble conglomerate; few pebbles other than chert; rusty-brown colour, hard, brittle, porous because of little matrix, pebbles well-rounded, well-sorted; thickness (est.).	200	1,125
5	Crumbly black to dark grey shale or siltstone; well-bedded in beds 1/2 inch thick; in places rocks are limy; a few fragmentary pelecypods (unidentifiable); attitude: strike 40°, dip 60°W; thickness.	125	925
4	Chert pebble conglomerate identical to unit 6	50	800
	Brewericeras hulenense zone		
3	Black shale and siltstone; soft crumbly; blocky fracture, limy in part, a few thin limestone bands; shale bands 1/2 to 2 inches wide; concretionary in places with concretions rarely fossiliferous; *Brewericeras hulenense* (Anderson, 1938), *Douvilleiceras*? sp. indet., *Hamites* sp. indet. (GSC locs. 56858 and 62396); thickness (est.).	400	750
2	Chert pebble conglomerate similar to units 4 and 6; thickness (est.).	150	350
1	Soft, black banded shale similar to unit 3; base not exposed; thickness (est.).	200+	200

Section 27

Location: Ridge east of Eldorado Mountain and the basin of Taylor Creek; a composite section; 51°2'N Lat. and 122°46'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Kingsvale Group		
	Division A		
	Albian(?)		
2	Interbedded greywacke, conglomerate, siltstone, and greywacke; conglomerate is unsorted with abundant greywacke matrix; boulders of volcanic rocks, chert, sedimentary rocks, granitic rocks up to 4 inches in diameter; siltstone is soft, grey, much carbonaceous material, "salt and pepper" texture; greywacke is greenish grey, green, brown, buff, well-sorted, with wood fragments, a few fragmentary leaves, and scattered pebbles; unit is mainly conglomerate; thickness (est.).	2,500+	4,000
	Taylor Creek Group		
	Middle or upper Albian(?)		
1	Massive beds of chert pebble conglomerate, in places porous because of lack of matrix, hard, brittle, almost entirely chert pebbles up to 3 to 5 inches in diameter, usually smaller; interbedded with soft, soot-black shales; rare marine fossils include *Inoceramus* sp. indet. (probably *I*. ex gr. *anglicus* Woods), *Inoceramus subsulcatus* Wiltshire, 1869, *Inoceramus sulcatus* Parkinson, 1819 (GSC locs. 62441 and 62422); base not exposed; thickness (est.).	1,500+	1,500

Section 28

Location: Quartz Mountain area, a composite section. Sections exposed south of Quartz Mountain and northwestward. No unfaulted section occurs in this area; 51°6'N Lat. and 122°40'W Long.

		Thickness (feet)	
Unit	Description	Unit	Total From Base
	Kingsvale Group		
	Division B(?)		
	Upper Cretaceous(?)		
3	Interbedded volcanic flows and breccias, green, purple, mauve, brown; andesitic and basaltic mainly; fresh, amygdaloidal and vesicular in places; resembles Upper Cretaceous volcanic rocks but here is in fault contact with other units; thickness (est.).	700+	2,600
	Division A		
	Albian(?)		
2	Interbedded conglomerate, greywacke, siltstone and shale; fine-grained rock types increase downsection; conglomerate is mainly pebbles and boulders up to 6 inches in diameter of greywacke, chert, volcanic rocks, argillite, granitic rocks; shale and siltstone are grey to dark grey, soft, crumbly, poorly stratified, "salt and pepper" texture; greywacke is dull grey, greyish green, and buff, micaceous, some beds are arkosic; abundant wood fragments and fragmentary plant remains; thickness (est.).	1,500+	1,900

Unit	Description	Thickness (feet) Unit	Total From Base
	Taylor Creek Group		
	Late lower Albian		
	Brewericeras hulenense zone		
1	Coarse chert pebble conglomerate interbedded with greywacke and soft, black, crumbly shales; conglomerate has boulders to 6 inches in diameter, mainly chert, rusty brown and well-cemented; shale near top of section has a few fossils Brewericeras cf. hulenense (Anderson, 1938), Puzosia cf. dilleri Anderson, 1958, Inoceramus? sp. indet. (GSC loc. 62335); thickness (est.).	400+	400

Section 29

Location: Northwest spur of Red Mountain, to Poison Mountain, and upper Yalakom River; 51°13'N Lat. and 122°33'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Jackass Mountain Group		
	Division C		
	Aptian		
3	Interbedded greywacke, shale, and thin beds and lenses of pebble conglomerate; greywacke is coarse, conglomeratic in places, micaceous, in places arkosic, grey-green to buff, massive beds; greywacke pebble conglomerate with well-rounded pebbles of chert, quartz, greywacke, volcanic rocks and rarely granitic; shale is soft, grey, banded, a minor part of this section; wood fragments common; beds vary in thickness from 6 to 10 inches up to 25 feet; unit well-exposed along upper Yalakom River; west of Poison Mountain this unit contains Aptian flora; thickness (est.).	8,000+	15,000
	French Bar Formation or Division B		
2	Coarse boulder conglomerate; boulders up to 2 feet across of granodiorite and andesite, pebbles of chert, argillite embedded in a coarse feldspathic matrix; boulders and pebbles are rounded, well-cemented in places; poorly bedded, in places lenses of greywacke and pebble conglomerate; well exposed on lower slopes on north and south sides of Red Mountain; thickness (est.).	3,000+	7,000
1	Interbedded shale, greywacke, and pebble conglomerate similar to unit 3 but more shaly; much carbon and woody material; Aptian flora occurs infrequently; unit best exposed northwest of Red Mountain; thickness (est.).	4,000	4,000

Section 30

Location: Lone Cabin Creek, 4 miles upstream from junction with Fraser River; 51°19'N Lat. and 122°20'W Long.

Unit	Description	Thickness (feet) Unit	Total From Base
	Kingsvale Group		
	Division B(?)		
	Upper Cretaceous(?)		
2	Interlayered purple, green-grey, red-brown volcanic flows and breccias; porphyritic andesite, basalt and minor dacite; not intensely deformed; weathers bright red-brown to reddish purple; extends southeastward along Fraser River; thickness.	1,100+	1,350
	Kingsvale Group(?)		
	Division A(?)		
	Albian(?)		
1	Buff to grey-green greywacke, minor grey shale; well-sorted, coarse greywacke in beds 8 to 10 inches thick; shale occurs as a few interbeds up to 6 or 8 inches thick, dull grey; carbonaceous material is common; base not exposed; thickness (est.).	250+	250