BEDROCK GEOLOGY OF CHEAM RIDGE AREA, CHILLIWACK REGION, BRITISH COLUMBIA

by

ALLAN ROBERT REID

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Department Geology

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CHAPTER I

INTRODUCTION

Location and Access

The area of study covers approximately 45 square miles between the Fraser River to the north and the Chilliwack River to the south. Elevation varies from 100 feet in the Fraser River valley to more than 7,800 feet, the summit of Welch Peak. The slopes below 5,000 feet are heavily timbered with few outcrops. The upper slopes are bare rock with steep cliffs on the north-east facing side of Cheam Ridge. Seven small cirques are located on the north-east side of the ridge.

Access from the north is by logging roads to an elevation of 4,000 feet and then by a poorly maintained foot-trail to the summit of Cheam Peak. From the south a trail parallels Foley Creek to Foley Lake then climbs steeply to a small lake below Welch and Foley Peaks. A well built trail goes to the summit of Mount Laughington, but it is extremely difficult to locate the beginning of this trail without inquiring at the Cultus Lake Ranger Station.

Purpose, Previous Work

This investigation of the Cheam Ridge area was undertaken at the suggestion of Dr. Peter Misch, who had noted that the previously published interpretations of this area (R.A. Daly 1912, and C.E. Cairnes, 1942)

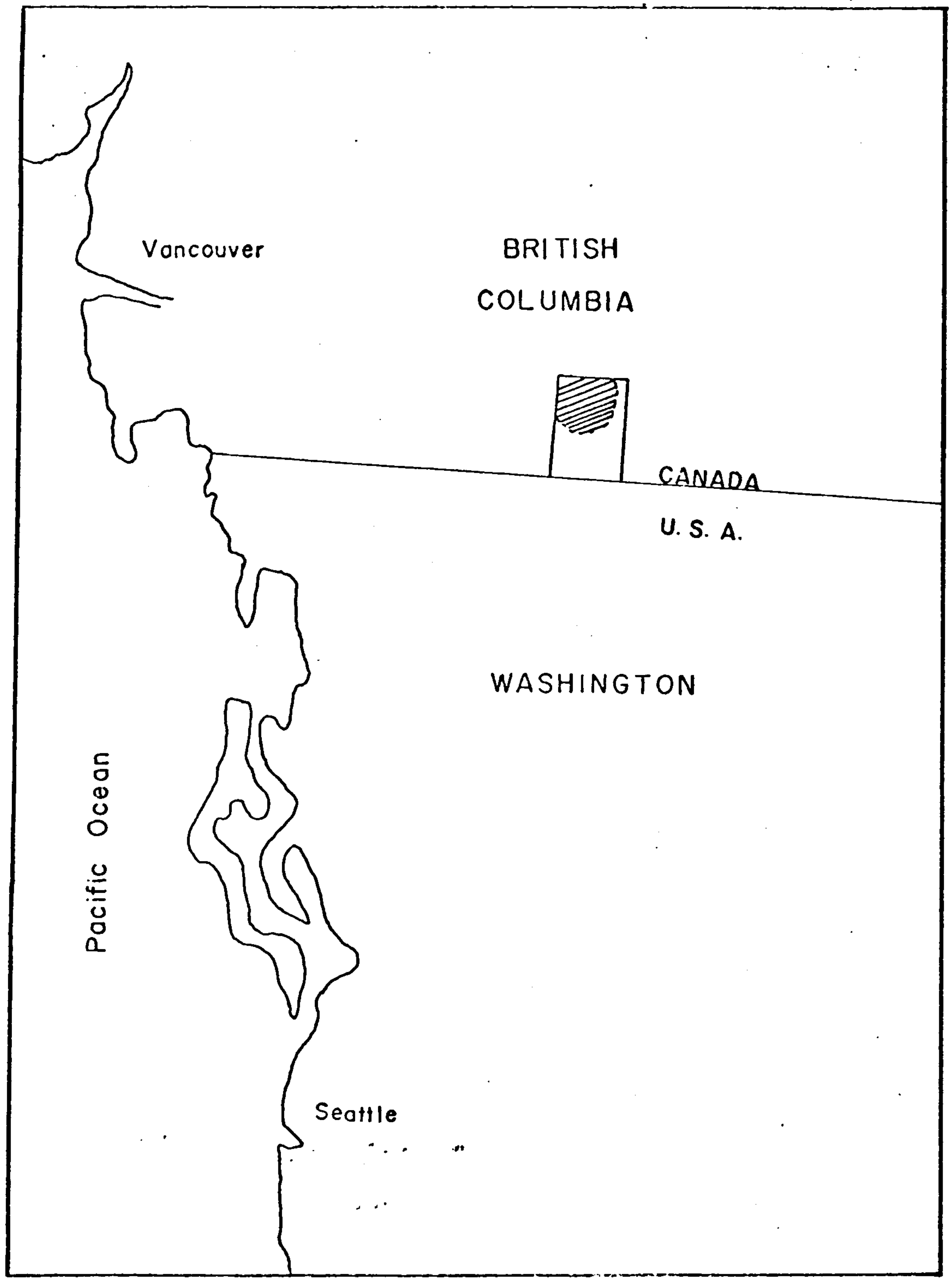


Fig I. Thesis area shown by cross-hatched lines.

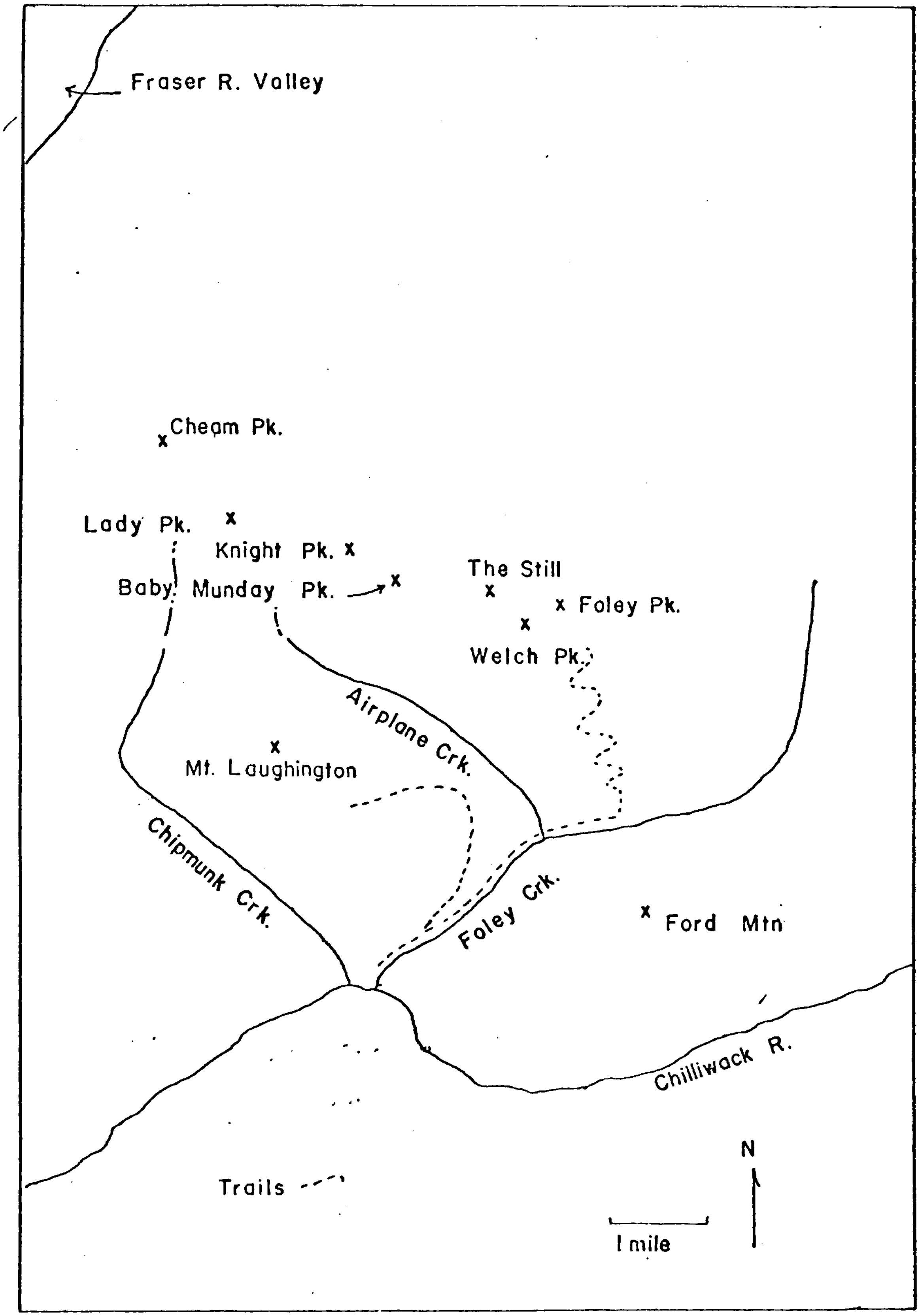


Fig 2. INDEX MAP OF CHEAM RIDGE AREA, B.C.

did not seem to correlate with the geology mapped by him south of, and, immediately west of the present area, across the 49th Parallel (Misch, 1960, and data incorporated in map accompanying 1960 Field Trip Guide Book published by Vancouver Geological Discussion Club; Misch, 1966). Recently, Monger (1966) re-mapped the lower Chilliwack River area, including part of the area described in this thesis, but neither he nor Daly (1912) and Cairnes (1942) reported metamorphic rocks corresponding to the pre-Devonian Yellow Aster Complex or to the later Shuksan Metamorphic Suite which has been mapped south of the Border and immediately north of the Border in association with the Shuksan Thrust and the underlying imbricate zone (Misch, 1960,1962,1963,1966). Therefore, the purpose of this study was to determine whether rocks of these metamorphic units and the associated structures continue into the Chilliwack River-Cheam Ridge area.

Methods of Study

A total of 6 weeks was spent in the field during the summer and fall of 1967. A 3 week fire closure of Provincial Forest lands made the collected data less than anticipated. Petrologic study of 93 thin sections was carried out at the University of Washington during the 1967-68 academic year.

CHAPTER II

ROCK UNITS

General Statement

The rock units discussed in this thesis are (1) heterogeneous plutonic rocks and associated ultramafic lenses, that have been assigned to the Yellow Aster Complex as recognized to the south (Misch, 1962,1963, 1966). These are in a thrust relationship with (2) geosynclinal, slightly metamorphosed sediments and volcanics of the Upper Paleozoic Chilliwack Group. To the east the Tertiary Chilliwack Batholith intrudes the Chilliwack Group.

Both the Chilliwack Group and the Chilliwack Batholith were named and mapped by R.A. Daly (1912). The Yellow Aster Complex was recognized by Misch (loc.cit.) as pre-Devonian basement.

The Basement Complex

Certain crystalline rocks exposed in the area have been assigned to the pre-Devonian basement complex (Yellow Aster Complex) recognized south of the Border (Misch, 1962, 1963,1966). They occur as thrust slices within the Chilliwack Group. The largest exposure of these rocks is at the saddle between Welch and Foley Peaks, and as nunataks in Foley Glacier to the south-east of the saddle. The rocks in question are strongly altered gabbros to diorites which are underlain by highly deformed ultramafics. The same unit, but without the underlying ultramafic rocks, is also found on Welch Peak and on the summit of Ford Mtn. to the south of Cheam Ridge.

The rocks here assigned to the basement are medium to coarse-grained and range from diorite to gabbro. Associated with these rock types are several fault-bounded lenses of ultramafic rocks, varying from dunites to talc-hornblende-augite-tremolite rocks. All of these rocks have been partially to completely reconstituted by chlorite grade synkinematic metamorphism. Biotite and muscovite are not common,but do occur. Some of the samples show superimposed contact metamorphic alteration characterized by the assemblage albite-epidote-green hornblende. The presence of hornblende indicates a somewhat higher temperature during contact alteration than had been attained during regional metamorphism.

Ultramafic Rocks

Three types of ultramafic rocks are associated with the basement complex. The most abundant type is represented by dunite lenses consisting of magnesian olivines. The other type include a hornblende schist with talc and epidote (probably derived from calcic introduction near the batholith and is therefore thought to represent a low-temperature hydrothermal stage associated with the batholith. In the basement rocks, besides developing the new minerals listed, the contact metamorphism has partially annealed the fractured epidote and some of the actinolitic hornblende; it has partially annealed the cataclastic albite, and close to the contact it has completely recrystallized the albite. The restriction of cordierite to a few feet within the contact zone would seem to indicate rapid loss of heat in the wall rocks. This is probably due to a shallow depth of intrusion of the batholith.

Chilliwack Group, General Statement.

The Chilliwack Group consists of cherts, arkoses, limestones, greywackes, slates, volcanic breccias, diabases, basalt flows and silicified tuffs. The ages determined from fossils in the Chilliwack area are Pennsylvanian to Permian (Daly, 1912; Monger, 1966). Incipient regional metamorphism is in prehnite-pumpellyite facies. Superimposed contact metamorphism is evident close to the Chilliwack Batholith. The less competent strata within the Chilliwack Group exhibits slaty cleavage. Shearing-off faults have occurred between some units. Minor folds are seen in outcrop and a possible major overfold has been postulated on Mt. Laughington. Hydrothermal mineralization has stained most of the rocks a red-brown. Total thickness of the Chilliwack Group in adjacent areas is in excess of 10,000 feet (Misch 1966).

Volcanic Rocks

The volcanic rocks within the Chilliwack Group consist of flows, diabases, volcanic breccias, and tuff breccias with compositions ranging from andesite to basalt. The texture of the basalt flows varies from porphyritic with a very fine grained groundmass to fine-grained equigranular. The majority of the phenocrysts are plagioclase but pyroxene does occur as a phenocryst also. The groundmass plagioclase has apparently been albitized with the consequent growth of volcanic hydrothermal pistacite. The plagioclase phenocrysts show minor alteration to hydrothermal pistacite and sericite, but generally they have a composition near An_{25}. The pyroxenes are very fresh, showing only minor alteration at the rim to penninite. In the basalts from near the batholith contact blue-green amphibole clusters have been developed by contact metamorphism. Penninite is very common in the groundmass of basalts close to the contact; it also occurs, but to a much lesser extent, in basalts that have not undergone contact metamorphism. The diabases are medium-grained, even granular and consist of pyroxene (augite), plagioclase, very minor quartz, and incipient penninite as an interstitial growth. The diabases appear to have been cooled more slowly than the adjacent basalts and may in fact have been intruded into the Chilliwack Group during geosynclinal deposition. The volcanic breccias contain fragments of varying size and composition. The fragments from a breccia on Lady Peak contain amygdaloidal basalt, porphyritic basalt, and fragments of altered, very fine-grained basalt or andesite, all set in a cryptocrystalline matrix. This particular rock is strongly altered, with the development of albite and hydrothermal pistacite and inter-fragmental penninite.

Limestone

Although many of the clastic rocks within the Chilliwack Group have a high calcite content in the matrix and as clasts, there are only a few locations where limestones exist as discrete units. On Mt. Laughington are several discontinuous limestone outcrops of Permian age (Monger 1966). On Cheam Ridge four large limestone lenses were mapped. Small poorly preserved Crinoid stems of probable Permian age were found on Lady Peak (Monger 1966) The author sampled limestone lenses on Knight Peak (Figures 17 and 18) and on Welch Peak but failed to find any fossils. This is probably due to the high degree of recrystallization of the limestone. All of the samples were checked by X-ray diffraction for the presence of aragonite. None was found, perhaps due to reconversion to calcite. In several samples biaxial calcite was noted with a variable $2V_x$ of between 0° and 20°. This may indicate inversion from aragonite (Boettcher and Wyllie 1967).

Arkoses

Very minor arkosic rocks occur in the area. The degree of rounding of the clasts of quartz and feldspar is moderate, and the sorting is poor. Alteration of the plagioclase may have occurred due to the fact that it is now all albitic. Calcite is commonly found as interclast patches. The calcite may be primary, or it may have been introduced during later metamorphism. Minor mimetic biotite parallels the layering in samples from near the batholith contact. The occurrence of arkose may reflect the sporadic influx of material weathered from a crystalline source area.

Greywackes

Greywackes within the Chilliwack Group contain a high proportion of volcanic fragments, chert clasts, and appreciable quartz clasts. In some samples from the north side of Cheam Peak limestone clasts occur in the greywackes. Plagioclase, where present, has been albitized. Detrital epidote is commonly present. Calcite occurs as an intergranular filling, and as late veins postdating quartz veins. The orientation of the veins is generally random, but some veins do parallel primary layering in the rocks. The clasts in the greywackes are generally sub-rounded and very poorly sorted. Biotite, mimetic after bedding, is found in samples from close to the batholith contact. Late hydrothermal formation of stilpnomelane, related to introduction of iron oxides, has occurred in a few samples. Incipient cordierite was noted in two samples from very close to the batholith.

Cherts

Ribbon cherts and argillaceous cherts occur as minor members of the Chilliwack Group in this area, averaging less than 50 feet thick. The ribbon cherts occur high in the section, overlying limestone lenses of probable Permian age. This would make the cherts probably Permian in age. The more argillaceous cherts and the siliceous argillites have developed slaty cleavage and occasionally contain ptygmatically folded quartz veins. Sericite is common in the argillaceous cherts and the siliceous argillites. Iron oxide veins and minor stilpnomelane occur in samples close to the batholith.

Conclusions

The overall picture presented by the Chilliwack Group is that of a eugeosynclinal environment with abundant volcanism. The high concentration of volcanic fragments in the greywackes probably indicates explosive sub-aqueous eruptions. The volcanic breccias and tuff breccias are most certainly derived from the immediate area. The angular fragments are generally quite large, indicating that transportation was minimal. Calcite deposition was almost continuous during clastic deposition, but at only a few localities was carbonate concentration great enough to form limestone bodies. Ribbon chert has been moderately to strongly deformed. These chert beds and more massive argillaceous chert bodies may be related to volcanism in the geosyncline. The abundance of volcanic material and the relatively minor amounts of chert may make this interpretation feasible. The arkoses indicate a crystalline source area. The supply of clastic material from this area may have been relatively constant, but the arkoses may only have developed when volcanism was temporarily quiet. During these quiet periods the dilution of crystalline-derived clastics by volcanic fragments would cease.

The metamorphism exhibited by the Chilliwack Group falls into two periods. The older is regional, synkinematic, incipient, and of prehnite-pumpellyite facies. The other is static contact metamorphism by the Chilliwack Batholith. Deformation associated with the prehnite-pumpellyite facies metamorphism consists of fracturing of the rocks accompanied by injection of quartz veins, quartz and chlorite veins and calcite veins. Folding of the rocks has continued after the veining. Prehnite is found only rarely in the Chilliwack Group and pumpellyite is only a little more common. In outcrop many of the finer grained rocks show a crinkling of the slaty cleavage. Broad gentle folding of the slaty cleavage could be seen in outcrop on Mt. Laughington.

Chilliwack Batholith and Other Igneous Intrusive Rocks

The Chilliwack Batholith intrudes the Chilliwack Group rocks to the east of the thesis area. Sills and lenses of dacitic and andesitic composition have intruded the sediments. Because the contact area of the batholith was not mapped in detail it is not known whether these sills are related to the Chilliwack Batholith or to Tertiary (Oligocene) volcanics (Misch, personal communication). Generally the lenses have followed directions of slaty cleavage but locally they follow cross-cutting fractures (Figure 22). Figure 15 shows a photomicrograph of a typical andesite sill from Ford Mtn. The groundmass of all of the mapped dikes and sills consists of a felty aggregate of feldspar and probably quartz with euhedral phenocrysts of plagioclase and quartz. These dikes appear to have had little contact effect upon the wall rock, due to rapid heat loss.

Secondary mineralization related to the batholith has affected many of the Chilliwack Group rocks, resulting in a deep red stain upon oxidation. This mineralization has produced chalcopyrite, pyrite, and iron oxides in seams and vuggy quartz concentrations. Iron oxide is found most commonly along slatey cleavage and as an alteration product of pyrite. A high grade replacement deposit of chalcopyrite occurs in a limestone unit southeast of Foley Peak (Cairnes, 1944). The metavolcanic rocks have not been receptive to this mineralization.

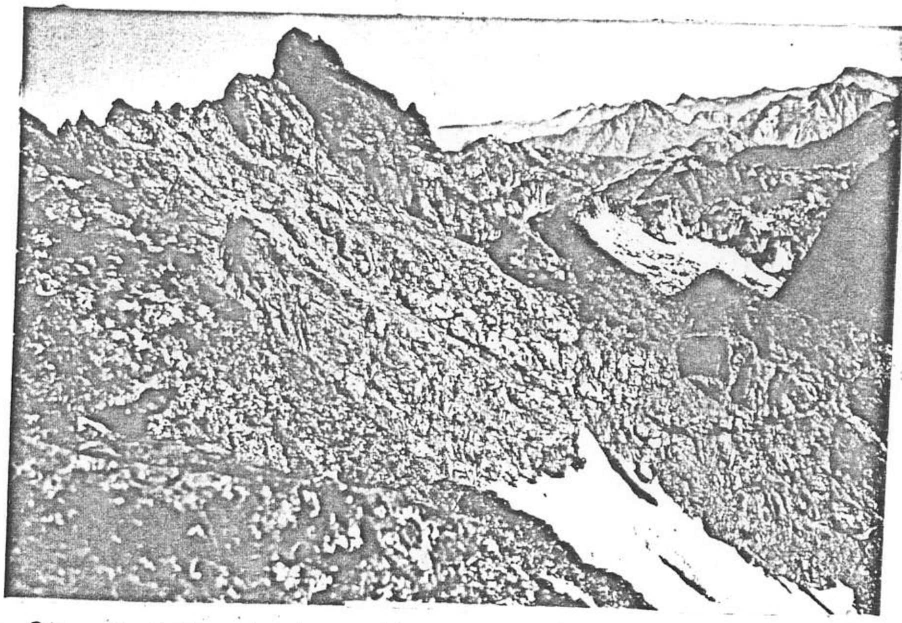


Figure 24. Saddle between Foley and Welch Peaks. Thrust contact between basement rocks and Chilliwack Group

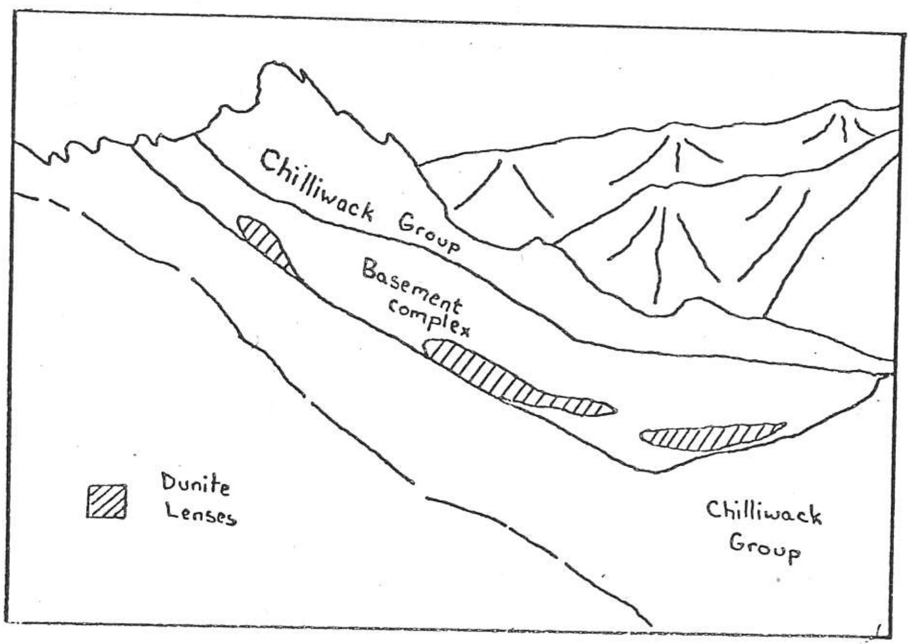


Figure 25. Sketch from picture above showing fault contact between Chilliwack Group and basement complex.

CHAPTER III

STRUCTURE

The thrust contact of the basement rocks with the Chilliwack Group is best exposed at the saddle between Foley Peak and Welch Peak. In figure 24 the tectonic relationship of the heterogeneous basement rocks and associated ultramafics to the underlying and overlying Chilliwack Group metasediments is clearly visible. Weathering differences and the relative susceptibility of the rocks to iron oxide mineralization accentuate the contacts.

The petrologic evidence for this thrust slice is based upon the number of metamorphic cycles that each unit exhibits. Both units show evidence for the incipient prehnite-pumpellyite facies metamorphism and the contact metamorphism of the Chilliwack Batholith. The basement rocks have been involved in an earlier metamorphic period that has not affected the Chilliwack Group. Therefore, the basement rocks must have been tectonically implaced into their present position after this earlier metamorphic cycle.

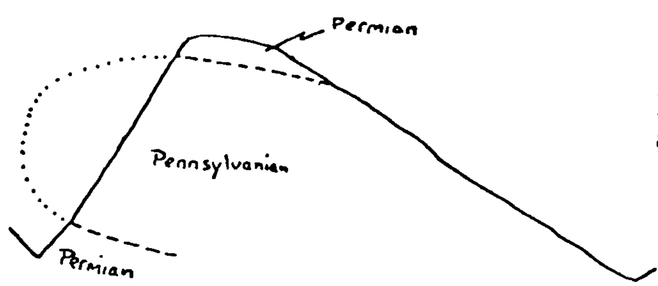
The present areal extent of the remnants of this imbricate thrust is difficult to determine as the Foley Glacier covers much of the area where thrusting has taken place. To the east of the known exposures of the imbricate thrust the Chilliwack Batholith has engulfed any possible relics of the thrust slices. To the south and north of Foley Peak erosion has cut deeply into the Chilliwack Group and the land surface is now below the projected level of the thrust plane. On Ford Mtn. outcrops are abundant on the steep western termination of the ridge. On the crest and along the sides of the ridge overburden covers outcrops, making the eastward tracing of the thrust difficult.

Shearing-off faults within the Chilliwack Group occur between competent strata, such as basalts, and incompetent strata, such as argillites or micro-greywackes. The direction and amount of movement on individual faults of this kind cannot be determined. The only indication that faulting has occurred is a gouge zone 2 inches to 1 foot thick at the contact between units.

The re-mapping, during this investigation, of the eastern part of Monger's (1966) thesis area has eliminated the need for assuming thrust faults at the summits of Cheam Peak and Mt. Laughington and on the east side of Airplane Creek. Cheam Peak and Mt. Laughington have been reinterpreted as concordant and probably conformable sections of Pennsylvanian to Permian rocks, and not as Permian faulted against Mesozoic rocks as Monger's (1966) map shows. The thrust slice that Monger had proposed east of Airplane Creek has been reinterpreted as a concordant basalt member within the Chilliwack Group.

Minor folds seen in outcrop and in thin section have been ascribed to mid-Cretaceous orogeny. Ptygmatic folding of calcite and quartz veins was noted on Mt. Laughington. Minor crinkling of slaty cleavage has developed near Baby Munday Peak. The trend of the crinkling is N30W and the strike of the slaty cleavage is N15W.

The ages of strata on Mt. Laughington, determined from fossil occurrences, show the relationship illustrated in figure 26



Diagrammatic representation of Mt. Laughington

Figure 26.

The overfold interpretation on preference to a fault relationship is based on a similar relationship on Mt. McGuire, to the south-west (Misch 1960,1966).

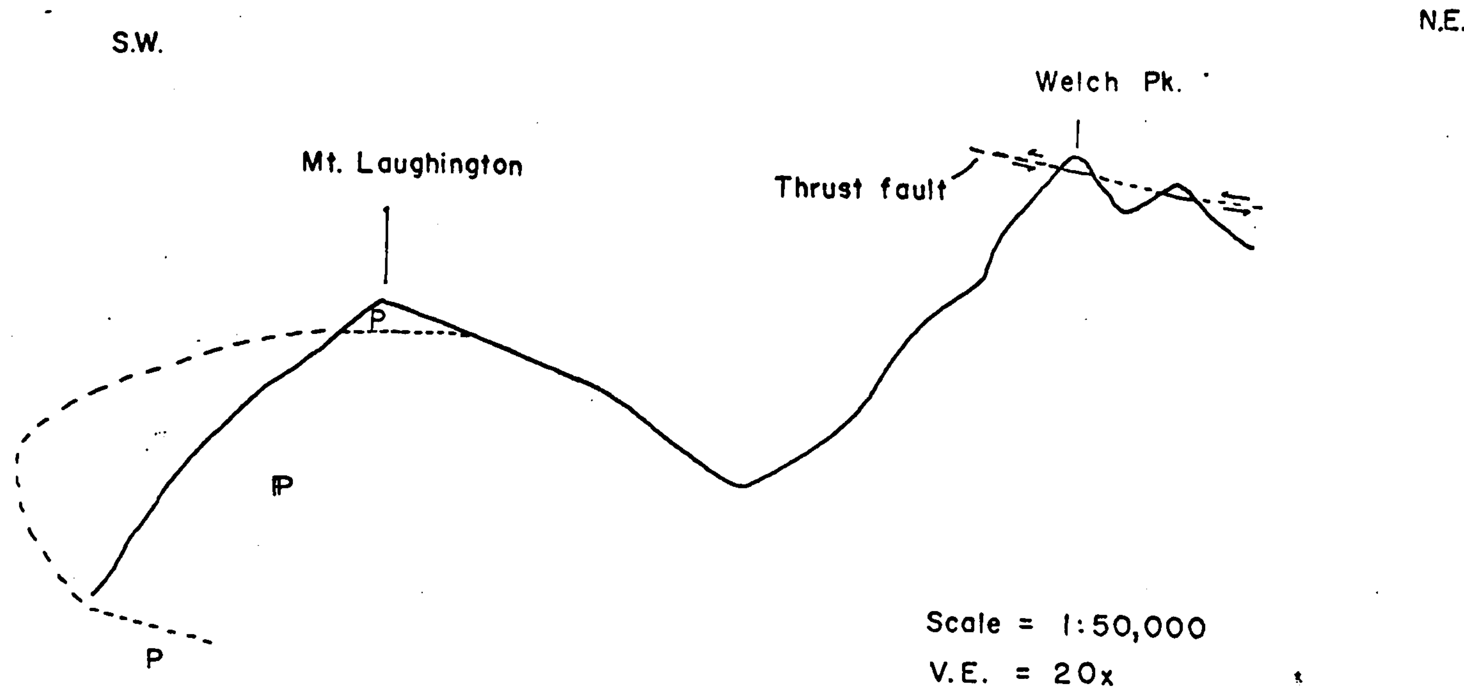
CHAPTER V

CONCLUSIONS

The occurrence of basement rocks in a tectonic slice within the Chilliwack Group is very similar to the pattern mapped south of the Border (Misch 1960,1962,1966). If this slice thrust correlates with the multiple slices occurring below the sole of the Shuksan thrust to the south, it is indicated that the Shuksan thrust continues north of the Border. The basement slice here described occurs farther east than the similar slices south of the Border. The absence of rocks of the Shuksan Metamorphic Suite, that is, of the plate above the imbricate zone, in this area, is possibly due to the turning of the root of the thrust more to the east, where it has been destroyed by the Chilliwack Batholith. As the basement slices occur below the sole of the Shuksan thrust sheet south of the Border, and as the slice here described occupies the summit of Cheam Ridge, it seems probable that the overlying Shuksan rocks have been removed by erosion in this area.

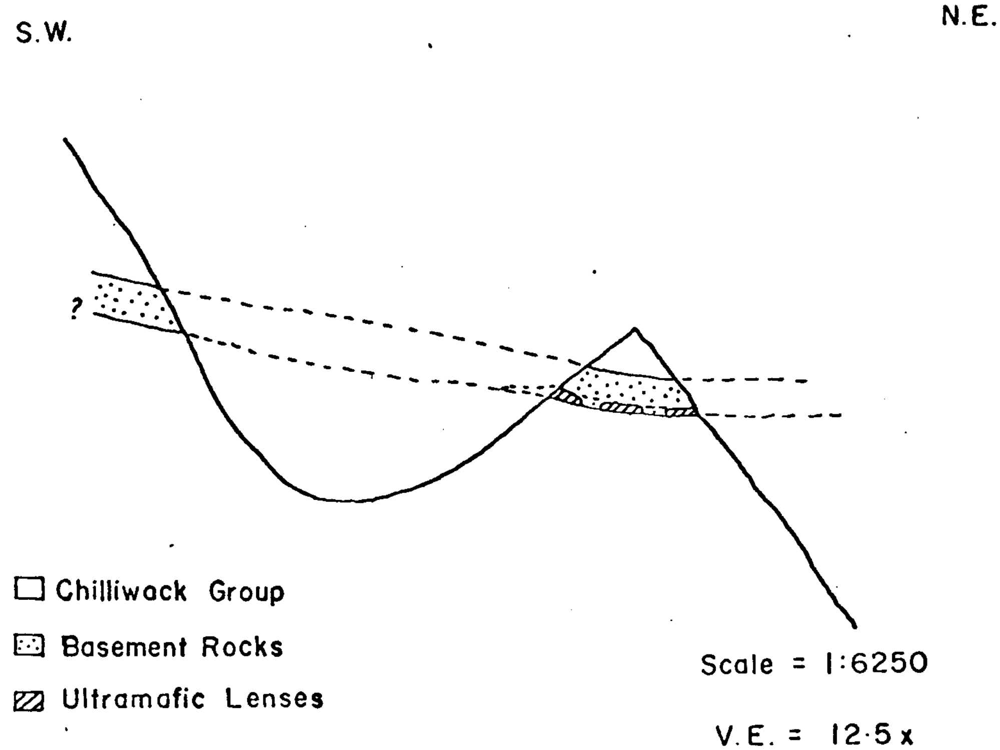
The Mesozoic Cultus Formation does not occur in the area studied, though it had been mapped by Monger (1966). His assignment of many of the rocks in the Cheam Ridge area to the Mesozoic was based upon their lithologic similarity to fossiliferous Cultus Formation in Pierce

Creek. The writer's discovery of Pennsylvanian crinoid stems (identification by Dr. P. Misch and Dr. V.S. Mallory of the University of Washington) has shown that, although the rocks on Mt. Laughington may be lithologically similar to Cultus Formation, they are upper Paleozoic in age.



Cross-section of thesis area.

Plate I



Cross section through Welch-Foley saddle

Plate II

GEOLOGY OF CHEAM RIDGE