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DEPARTMENT OF ENERGY, MINES AND RESOURCES

MEMOIR 362

# GEOLOGY AND MINERAL DEPOSITS OF TULSEQUAH MAP-AREA, BRITISH COLUMBIA

J.G. Souther



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# GEOLOGY AND MINERAL DEPOSITS TULSEQUAH MAP-AREA, BRITISH COLUMBIA (104K)

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FIGURE 1. View looking southwest from the Tahltan Highland across Tatsamenie Lake to the inner ranges of the Coast Mountains.

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By
J. G. Souther

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# PREFACE

Taku River was used as a route to the Yukon during the Klondike gold rush of 1898 and this led to extensive prospecting, but it was not until 1937 that any of the silver-gold showings discovered in the intervening years were brought into production. Declining metal prices resulted in the closure of the last producing mine in 1957, but in recent years extensive geophysical and geochemical surveys have been made by several major exploration companies and new prospects have been discovered.

The layered rocks of Tulsequah map-area comprise intensely folded and regionally metamorphosed Triassic, Permian and older strata, separated by a major unconformity from younger sedimentary and volcanic rocks. The western part of the area is underlain by granitic rocks of the Coast Crystalline Belt which were emplaced between early Mesozoic and Tertiary time. These varying lithologies are fully discussed in this report, the structural and tectonic history of the area is outlined, and the mineral deposits are described in some detail.

Y. O. FORTIER,
*Director, Geological Survey of Canada*

OTTAWA, December 19, 1967

MEMOIR 362 - - Geologie und Erzlagerstätten des Kartenblatts Tulsequah (Britisch-Kolumbien)

Von Jack Gordon Souther

Es wird ein Gebiet verformter und metamorphisierter triassischer, permischer und älterer Schichten, weniger gefalteter mesozoischer Ablagerungs- und Eruptivgesteine und frühmesozoischer bis tertiärer Granitgesteine beschrieben. Silber- und Golderzlagerstätten kommen vor.

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МЕМУАР 362 - - Геология и месторождения полезных ископаемых картографированного района Тулсекуа, Британская Колумбия.

Джек Г. Созер.

Описывается район деформированных и метаморфических триасовых, пермских и иных толщ, в меньшей степени складчатых мезозойских осадочных и изверженных пород и гранитных пород от раннемезозойского до третичного века. Встречается минерализация серебра и золота.

# CONTENTS

# Illustrations

# GEOLOGY AND MINERAL DEPOSITS OF TULSEQUAH MAP-AREA, BRITISH COLUMBIA


## *Abstract*

The area comprises a deeply incised plateau, a narrow highland zone, and a mountainous area that is part of the Coast Mountains. The latter contains deeply incised valleys giving a local relief of 5,000 to 7,000 feet.

Indications of Pleistocene glaciation are found on Stikine Plateau and indicate that the ice moved southwestward through Taku Valley to the sea. A gradual retreat of present-day glaciers began in the mid-nineteenth century.

The layered rocks comprise intensely folded and regionally metamorphosed Triassic, Permian and older strata, separated by a pre-Upper Triassic unconformity from less folded Mesozoic sedimentary and volcanic rocks that have not been regionally metamorphosed. The western part of the area mapped is underlain by leucogranite to pyroxene diorite of the Coast Crystalline Belt. These granitic rocks were emplaced between early Mesozoic and Tertiary time. All consolidated rocks in the map-area are overlain unconformably by flat-lying late Tertiary and Pleistocene basalt.

Three main episodes of tectonic activity culminating in mid-Triassic, Upper Jurassic and early Tertiary time affected the area.

There is a close correlation between type of mineralization and geological environment, and these associations are described. Brief summary descriptions of the known mineral deposits are given.

Seven detailed stratigraphic sections and lists of fossils collected at various localities are presented in two appendices.



## *Résumé*

La région comprend un plateau profondément entaillé, une étroite zone de hautes-terres et une zone montagneuse faisant partie de la chaîne Côtière. Cette dernière, coupée de vallées profondes, a un relief allant de 5,000 à 7,000 pieds.

On trouve des traces de la glaciation du Pléistocène sur le plateau Stikine, indiquant que les glaces sont descendues vers le sud-ouest jusqu'à la mer, par la vallée Taku. Un recul graduel des glaciers actuels a commencé vers le milieu du 19$^{e}$ siècle.

Les couches rocheuses contiennent des strates fortement plissées et localement métamorphisées datant du Trias, du Permien et de périodes plus anciennes et qui sont séparées par une discordance antérieure au Trias supérieur, des roches sédimentaires et volcaniques du Mésozoïque, moins plissées, ne présentant pas de métamorphisme régional. Sous la partie ouest de la région cartographiée reposent des roches de la zone cristalline côtière allant du leucogranite à la diorite à pyroxène. Ces roches granitiques ont été mises en place entre le début du Mésozoïque et le Tertiaire. Toutes les roches consolidées de la région cartographiée sont recouvertes en discordance par des couches horizontales de basalte datant de la fin du Tertiaire et du Pléistocène.

La région a été affectée par trois périodes principales d'activité tectonique, dont le maximum d'intensité se situe au milieu du Trias, au Jurassique récent et au début du Tertiaire.

Il existe un rapport étroit entre le type de minéralisation et le milieu géologique environnant; l'auteur décrit ces associations et donne une description sommaire des gisements minéraux connus.

Deux appendices présentent sept coupes stratigraphiques détaillées et des listes des fossiles recueillis en divers endroits.

# INTRODUCTION

## Location and Access

Tulsequah map-area and the small part of the adjacent Juneau map-area that lies within Canada, comprises approximately 5,000 square miles of mountainous country bounded by latitudes 58° and 59°N; longitude 132° on the east, and the Alaska Boundary on the west. The town of Tulsequah, now abandoned, was formerly a customs station, airport and supply depot used by travellers following Taku Valley between the coast and the interior. With the development of the Polaris Taku Mine in 1937, and the nearby Tulsequah Chief and Big Bull Mines in 1951, the main settlement shifted from Tulsequah to the mining camp at Polaris Taku.

During the operation of the mines a regular river-boat service was maintained between Juneau, Alaska, and a landing on Taku River, near the mouth of the Tulsequah. A motor road connected the landing with the camp site and with the Big Bull and Tulsequah Chief Mines. An airstrip a short distance south of the Polaris Taku camp was used by planes which maintained a twice-weekly flight to Atlin.

All of these services were discontinued when mining operations were suspended in 1957, and the total population of about 300 moved out of the camp. The buildings and equipment remain in the charge of a caretaker who is presently the only permanent resident in the map-area.

The old Telegraph Trail between Atlin and Telegraph Creek crosses the northeastern corner of the map-area. Elsewhere, trails are nonexistent or in such poor repair as to be impassable. Small river boats have navigated the Taku and Inklin Rivers as far east as the mouth of the Sheslay, but the current is swift and there are many dangerous shoals and rapids. Many of the lakes are suitable for float-equipped aircraft, but in large sections of the Coast Mountains the helicopter provides the only practical means of access.

Travel on foot is relatively easy in the northeastern part of the area where the forest is open and the slopes above timberline are not steep. In the Coast Mountains, however, the lower valleys are choked with dense forest and almost impenetrable undergrowth. Many of the higher valleys are occupied by glaciers that provide easy travel for short distances but are frequently interrupted by crevasses and ice falls. The upper slopes are precipitous, sculptured by ice into steep-walled cirques, spires and saw-toothed ridges. Travel in this high country can only be accomplished by using mountaineering techniques.

## Previous Geological Work

Parts of Tulsequah area were previously examined by W. E. Cockfield and F. A. Kerr, both of the Geological Survey of Canada. Cockfield mapped the area east of Sheslay River during his explorations between Atlin and Telegraph Creek (Cockfield, 1926). In 1930, Kerr

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made a geological reconnaissance between Stikine and Taku Rivers (Kerr, 1931), and in 1932 he mapped the Taku River area (Kerr, 1948). In 1955, J. D. Aitken of the Geological Survey commenced mapping in the northeastern part of the area. The results of his work have been incorporated in this report and an earlier report on the eastern half of the area (Souther, 1960).

## Field Work

In 1958 the writer commenced the geological study of Tulsequah map-area. Field work occupied about two weeks in 1958 and the entire field-seasons of 1959 and 1960. In 1958 and 1959 transportation was provided by a float-equipped Supercub aircraft which was able to land on most of the small lakes in the eastern part of the map-area. A helicopter, employed for part of the 1960 field season, greatly facilitated mapping in the mountainous, western part of the map-area.

## Acknowledgments

The writer is indebted to the staff of Cominco Limited, especially to Mr. and Mrs. William Nelson of Tulsequah, for the use of Company facilities at the Polaris Taku camp. Special thanks are also due to Mr. and Mrs. R. S. Hyland of Telegraph Creek and to Mr. Wm. Dunn of Silver Stand Mines for their help in expediting the field work.

The following provided invaluable general information on the area as well as data on specific mineral deposits: R. S. R. Adamson, D. D. Barr, Wm. Dunn, J. J. DeLeen, T. J. R. Godfrey, G. Gutrath, J. R. Louden, R. R. MacCrae, G. W. Mannard, C. S. C. Ney, and Alex Smith.

The willing co-operation and skillful service provided by Supercub pilots, W. J. Harrison and Alfred Pelletier and helicopter pilot, David Alder, are gratefully acknowledged.

Able assistance in the field was given by R. K. Gerlib, D. C. Miller, and B. E. O'Shea in 1958; D. W. Hyndman, J. F. Ricker, and D. West in 1959; K. E. Baker, N. B. Church, D. W. Morris, H. H. R. Naylor, M. G. Pitcher, and R. J. van Ryswyk in 1960.

# PHYSIOGRAPHY AND GLACIATION

## Physiography

The northeastern corner of Tulsequah area lies in the Taku and Nahlin divisions of the Stikine Plateau (Holland, 1964). It is a deeply incised area of nearly flat summits mainly below 5,000 feet in elevation. The general plateau character is broken only by the Menatatuline Range, a mountainous belt with many points over 6,000 feet above sea level. This range is underlain by the Nahlin ultramafic body and it is one of the few major topographic features that reflect the bedrock geology. Most of the plateau area is underlain by northwesterly trending sedimentary and volcanic rocks which impart a distinct grain to the surface. The smaller streams and the grooves and hummocks reflect the northwesterly trend of the rocks, but there is no integration of the main drainage pattern. The valleys of the major rivers cut obliquely across the trend of the strata, and the interstream areas are comprised of randomly oriented groups of hills and ridges.

The plateau is bounded on the southwest by the Tahltan Highland (Fig. 1, *Frontispiece*), a transitional zone between the plateau and the Boundary Ranges of the Coast Mountains. Within the plateau only small remnants of the undissected upland surface remain; these slope upward toward the west and terminate abruptly against the precipitous eastern edge of the Coast Mountains.

In Tulsequah area, the northwest trend of the Boundary Ranges is interrupted by the broad valleys of Whiting and Taku Rivers which flow southwesterly into Stephens Passage. These rivers and their tributaries have dissected the Boundary Range into discrete groups of mountains, each with a small ice field or cluster of cirque glaciers. The peaks are steep and rugged, and sculptured by glacier ice into jagged spires and narrow saw-toothed ridges (Fig. 2). The deeply incised valleys in the central part of the Range give it a local relief of 5,000 to 7,000 feet.

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FIGURE 2. Devils Paw, 8,584 feet above sea level. View looking south from Nelles Peak.

## Landslides

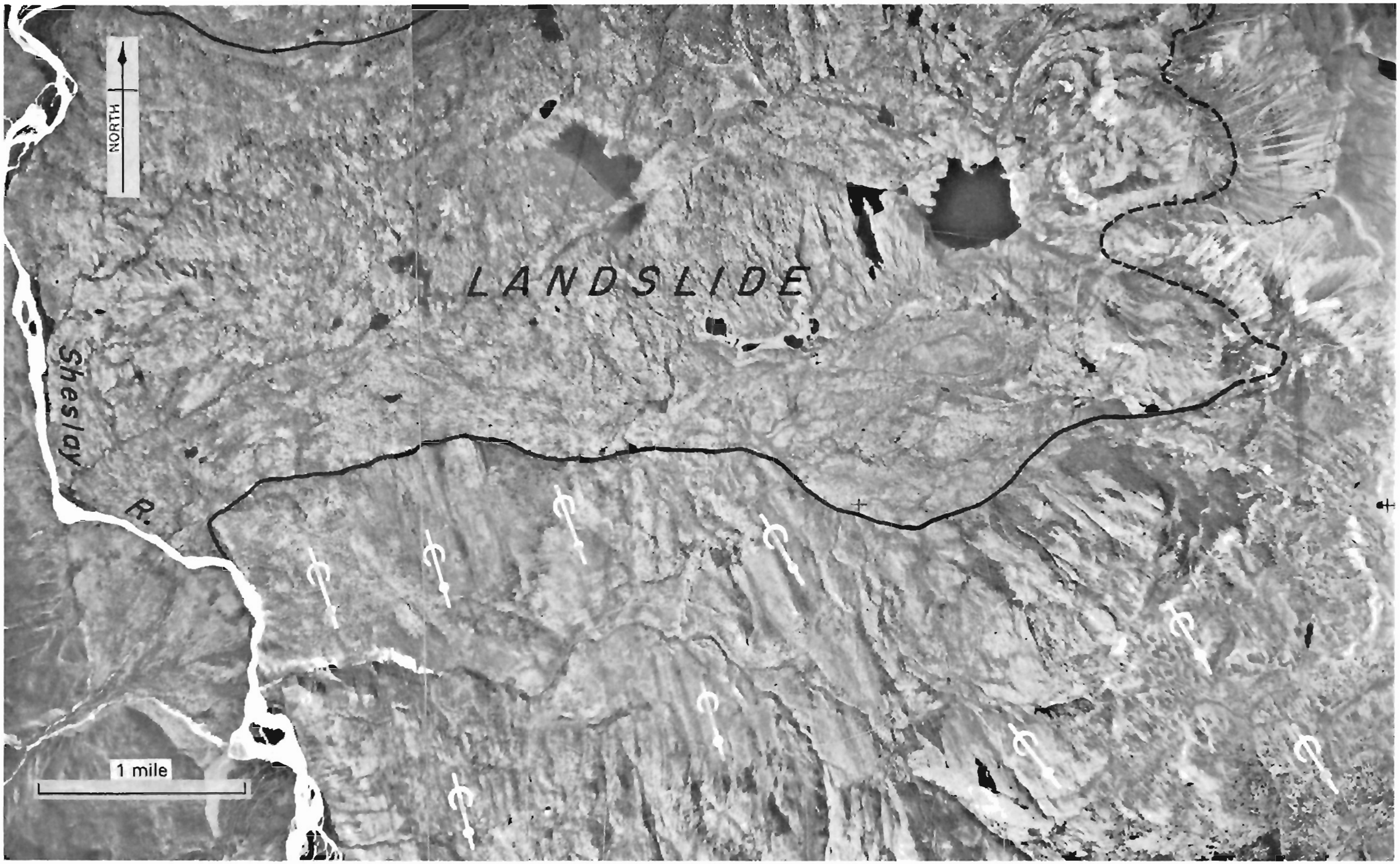
Earthflows, rock glaciers, and small landslides are found in nearly all the major valleys of Tulsequah map-area. Most are small and, on the map, are included with undifferentiated colluvium of map-unit 19. However, three landslides: the Sheslay slide, Yeth Creek slide, and Bearskin slide are large enough to warrant discussion (map-unit 19a).

The Sheslay slide (Fig. 3) is in Sheslay River Valley on the southeastern side of Heart Peaks Plateau. It is 5 miles long, has an average width of 2.5 miles, and a fall of 3,800 feet from the crown of the main scarp to the toe of the slide on Sheslay River. It consists almost entirely of Level Mountain Basalt (map-unit 18) mixed with lesser amounts of till and Heart Peaks volcanic ash. A series of large rotational slump blocks have moved downward and outward along a concave, basin-shaped surface of rupture on the edge of the basalt plateau. The main cirque-like scarp at the head of the slide is over 600 feet high, and crescent shaped cracks around the crown indicate that slumping is still going on. Below the main scarp are a series of large, step-like rotated slump blocks bounded by minor scarps from 50 to 100 feet high. The foot, or lower lip of the main surface of rupture, is estimated to be at least a mile from the top of the main scarp. Beyond the foot of the slide, broken debris from the slump blocks has moved for another 4 miles in the form of an earthflow. The surface is characteristically rough with well-developed transverse cracks and ridges on which the trees have been tilted or deformed into wierd, twisted shapes in their attempts to maintain a vertical position on the still shifting surface of the slide. At the two-mile-wide toe of the slide, the main channel of Sheslay River has been deflected and forces against the western side of the valley.

Several factors contributed to the development of a large slide in this position. The most important was a thick pile of basalt deposited on the rubble and ash-covered surface that slopes toward the west into Sheslay Valley. Secondly, the well-developed columnar joints in the basalt provided numerous vertical planes of weakness along which the initial slumping occurred. Finally, the close jointing of the flows and the virtually unconsolidated flow breccia between them caused the slump blocks to disintegrate into small fragments that continued to move by slow earth flowage.

The Bearskin landslide is on the south-facing slope above the outlet of Bearskin Lake and may, in fact, have formed the barrier behind which the lake is impounded. It appears to be the result of a single rock fall that originated near the top of the 6,000 foot ridge and swept down the steep slope into the valley and part way up the opposite slope. The floor of the valley, from the outlet of the lake to more than a mile downstream is strewn with huge boulders: many are more than twenty feet in diameter. The cause of the slide was not determined.

A large, complex landslide near the head of Yeth Creek involves peridotite, serpentinite and related diorite of the Nahlin ultramafic body. The main scarp forms a semicircular amphitheatre about a mile in diameter and more than 1,500 feet high. From the base of this scarp the slide rubble extends for 3½ miles, spreading to a maximum width of 1½ miles then narrowing to an almost pointed toe around which Yeth Creek has been diverted. In the centre of the slide is a hill of diorite about 400 feet high and nearly ½ mile across at the base, and several smaller hills of unbroken peridotite. On first inspection these hills appear to be bedrock, rooted in the original slope and surrounded by slide rubble. However, the orientation of layers in the peridotite varies from one hill to another and is inconsistent with trends observed in the Nahlin body. Moreover, joints in the diorite have been jostled and opened, in many places leaving deep cracks several feet across and resembling glacial crevasses. These features suggest that, despite their large size, the hills were transported virtually intact, probably by rock gliding during an early stage in the development of the slide. Subsequent smaller




EMR A11641-114, A11641-115

FIGURE 3. Vertical air photograph showing rock drumlins, and landslide in Sheslay River Valley.

slumps around the margins of the initial scarp, along with vast quantities of talus, have continued to feed the upper part of the slide. This relatively small volume of debris formed a slow-moving earth flow that has partly overridden and surrounded the large blocks transported by the initial slide.

## Self-dumping Glacier-dammed Lakes

Two self-dumping glacier-dammed lakes are known in Tulsequah map-area. One of them, Tulsequah Lake, has been observed for many years and its behaviour has been described by Marcus (1960). The other, a small unnamed lake 5 miles west of Tunjony Lake, has not been described previously.

Tulsequah Lake is about 3 miles long and ½ mile wide. It occupies a steep-walled valley dammed at one end by a short distributary arm of Tulsequah Glacier. The lake fills during the spring and early summer, reaching a depth of 200 to 350 feet by late summer or early fall, when the water suddenly drains out beneath the ice and discharges at the toe of Tulsequah Glacier (Fig. 4). About three days are required for the lake to empty, during which time from 8,000 to 13,000 million cubic-feet of water are poured into Tulsequah Valley. During this dumping period the broad flood plain of Tulsequah River is inundated by a catastrophic flood that fills the entire valley with rushing silt-laden water. Old water courses are plugged by gravel bars and new channels carved in the shifting surface of the flood plain which, during the few days of flood, may be altered almost beyond recognition. As the lake empties and the buoyant support of the water is lost, the edge of the ice dam collapses into a chaotic pile of broken ice, and finally the dry lake bed is left strewn with stranded icebergs, some over 100 feet high (Fig. 5).

The cycle of filling and dumping has occurred annually since 1942 and periodically for at least the past 60 years. According to a theory advanced by Thorarinsson (1939) the drainage frequency of self-dumping lakes is determined by their rate of filling. When the depth of water reaches nine-tenths the height of its ice barrier, the barrier is floated sufficiently to allow water to escape beneath it. Once flow is started the opening is rapidly enlarged by melting (Marcus, 1960).

The periodic outbursts of water from Tulsequah Lake assumed great economic significance during the operation of the Polaris Taku, Big Bull and Tulsequah Chief mines. At the height of the floods nearly all the flat land in Tulsequah Valley, including much of the townsite at Polaris Taku is covered with glacial water. Roads linking the townsite and mill on the west side of Tulsequah River with the Big Bull and Tulsequah Chief mines on the east side were largely destroyed by each flood, and bridges across the braided channels of the Tulsequah River were either washed away or buried in gravel, or were left as useless relics spanning abandoned channels on the rebuilt flood plain.

The second self-dumping lake is dammed by a small tongue of ice that occupies a west-flowing tributary in the headwaters of Sutlahine River. The glacier enters the valley nearly at right angles, then spreads laterally, sending a long tongue of ice down the valley, and a short distributary arm, against which the lake is impounded, up the valley. The lake is slightly more than ½ mile long and ½ mile wide, and has an estimated depth of about 80 feet. During the dumping period the water flows for 2 miles under the ice, and discharges through a cavernous archway that remains perpetually open at the toe of the glacier.

In 1959 the lake drained during the period August 17th to August 19th, and in 1960 it drained completely during the night of August 2nd. Although the lake is relatively small it discharges very rapidly and could pose a hazard to anyone working or camping in the upper part of Sutlahine Valley.

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FIGURE 4. Violent discharge of water from beneath the ice at the foot of Tulsequah Glacier during the 1960 dumping of Tulsequah Lake. Flood water is seen covering the entire flood plain of Tulsequah Valley, which is normally occupied by a few small braided channels.

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FIGURE 5. Icebergs stranded on the bed of Tulsequah Lake after water drained under Tulsequah Glacier (background) during the 1960 flood.

## Glaciation

In the northwestern corner of Tulsequah map-area, evidence of Pleistocene glaciation is preserved on the upland surfaces of the Stikine Plateau. Grooves, striae, and trains of erratic boulders are found over the entire plateau within the map-area, including the highest peaks of the Menatatuline Range. North of Inklin River, coarse glacial grooves trend west-southwesterly and peridotite erratics derived from the Menatatuline Range have been found as far west as Chakluk Mountain. Farther south near Tatsamenie Lake the direction of ice movement was north-northwesterly (Fig. 3), swinging around to west near King Salmon Lake. Boulders from a distinctive quartz monzonite body at the north end of Tatsamenie Lake occur as erratics on the ridges to the northwest. All this evidence indicates that the ice converged on Taku Valley from the northeast and southeast, and flowed southwesterly through Taku Valley to the sea.

This southwestward flow of ice through Taku Valley contradicts Kerr's conclusion that ice from the central Coast Range flowed northeasterly up Taku Valley (Kerr, 1948). The northeasterly direction of flow is based mainly on the presence of crystalline erratics in the mountains along upper Taku Valley. There can be little doubt, as Kerr points out, that these boulders originated in the Coast Crystalline Belt. However, the writer believes that they came from the high ranges northwest or southeast of Taku Valley. The ice that entered Tulsequah map-area from the north is the extension of at least two converging ice streams described by Aitken (1959) in Atlin area. One of them arose in the Coast Mountains west of Atlin Lake and flowed first eastward off the flank of the Coast Mountains, and then southward into the Taku trench. The second ice stream entered Tulsequah map-area from the northeast. It is an extension of the southern branch of Aitken's "main ice stream" which must have arisen far to the east, probably within the Cassiar Mountains. The ice that moved northwesterly into Taku Valley probably had its origin in the Coast Mountains south of Taku River. It is believed to have been fed by many tributaries that flowed off the eastern edge of the Coast Mountains and converged into a great northerly flowing ice stream. Either of the ice streams that arose in the Coast Mountains could have carried crystalline erratics into the upper part of Taku Valley.

In the Coast Mountains only the gross features of the Pleistocene glaciation are preserved. The typical U-shaped valleys with their over-steepened walls, truncated spurs, and hanging tributary valleys owe much of their present form to the Pleistocene glaciation. The uplands, however, have been sculptured by recent Alpine glaciers and all traces of earlier glaciation have been removed. The valleys, too, have been greatly modified by ice that remained in the Coast Mountains long after the Cordilleran ice-sheet had retreated. There is evidence here, as in other parts of the northern Cordillera, that recession of the Coast Mountains ice was followed by a long interval of warm climate, during which alpine glaciers receded beyond their present position and may have disappeared entirely. Fragments of large logs are found under the receding glaciers at the head of Sutlahine and Samotua Rivers. Both of these glaciers are now entirely above timber line and the presence of the logs suggests that their valleys were once occupied by mature forests. The warm period, during which the forest thrived, must have been followed, in relatively recent time, by a cooler climate accompanied by rejuvenation and advance of alpine glaciers in the Coast Mountains. In southeastern Alaska this local glaciation, called the "Little Ice Age" by Matthes (1942) reached a maximum at about the middle of the nineteenth century.

Since then the gradual retreat of glaciers in the Coast Mountains has been interrupted by periodic lesser advances, each represented by a small inner moraine. Many of the alpine and valley glaciers of northern British Columbia have built two prominent terminal moraines, the outer built during maximum advance and the inner built during a later advance that brought the ice almost to its maximum position. In the narrow valleys of the Boundary Ranges most of the outer moraines have been eroded or buried by outwash. The few that remain are covered with vegetation and their distance from the ice is extremely variable, depending on the size and elevation of the glacier. The inner moraines have little or no vegetation and are continuous with the present trim lines that surround all the glaciers in the area (Fig. 6). Recession of this ice from the inner moraine has been extremely rapid and appears to

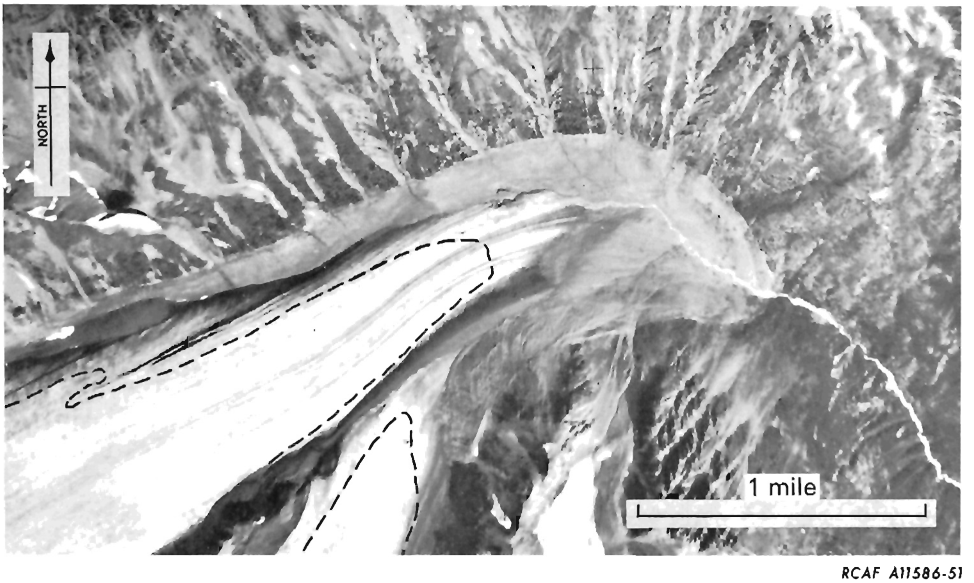


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FIGURE 6. Vertical air photograph of a typical small valley glacier, near the southeast corner of the map-area, illustrating rapid recession of the ice. The position of maximum advance is clearly shown by the ground moraine which is still free of vegetation. The photograph was taken in 1948 and the dashed line shows the approximate position of the ice in 1960.

be continuing at a steady rate. A comparison of the 1928 maps (Kerr, 1948) and printed maps based on the 1948 air photographs shows considerable wastage of the glaciers. The most extreme example is Sittakanay Glacier which in this 20 year period receded over 2 miles. The tributary glacier that joined Sittakanay on the southwest in 1928 was separated and had receded 1½ miles from Sittakanay Valley by 1948. These are extreme examples but all the glaciers in the area show a marked decrease in size during this period. By comparing the extent of valley glaciers in 1960 with that shown on the 1948 air photographs it is apparent that recession is continuing at a rapid rate. Many of the valley glaciers have retreated ¼ to ½ mile since the air photographs were taken. In the same period ablation on the high ice fields has revealed many large nunataks that were covered in 1948 and hence do not appear on the map.

# GENERAL GEOLOGY

The layered rocks of Tulsequah map-area fall into two broad divisions separated by a major unconformity below the Upper Triassic. The lower division includes strata of known Permian and Middle Triassic age as well as great thicknesses of older strata whose age is unknown. All of these rocks are intensely folded and regionally metamorphosed. They vary from phyllite and greenstone in the east to amphibolite gneiss in the west. The principal areas of these older rocks are the Atlin Horst (Wheeler, 1959) and the Stikine Arch (Fig. 7). The

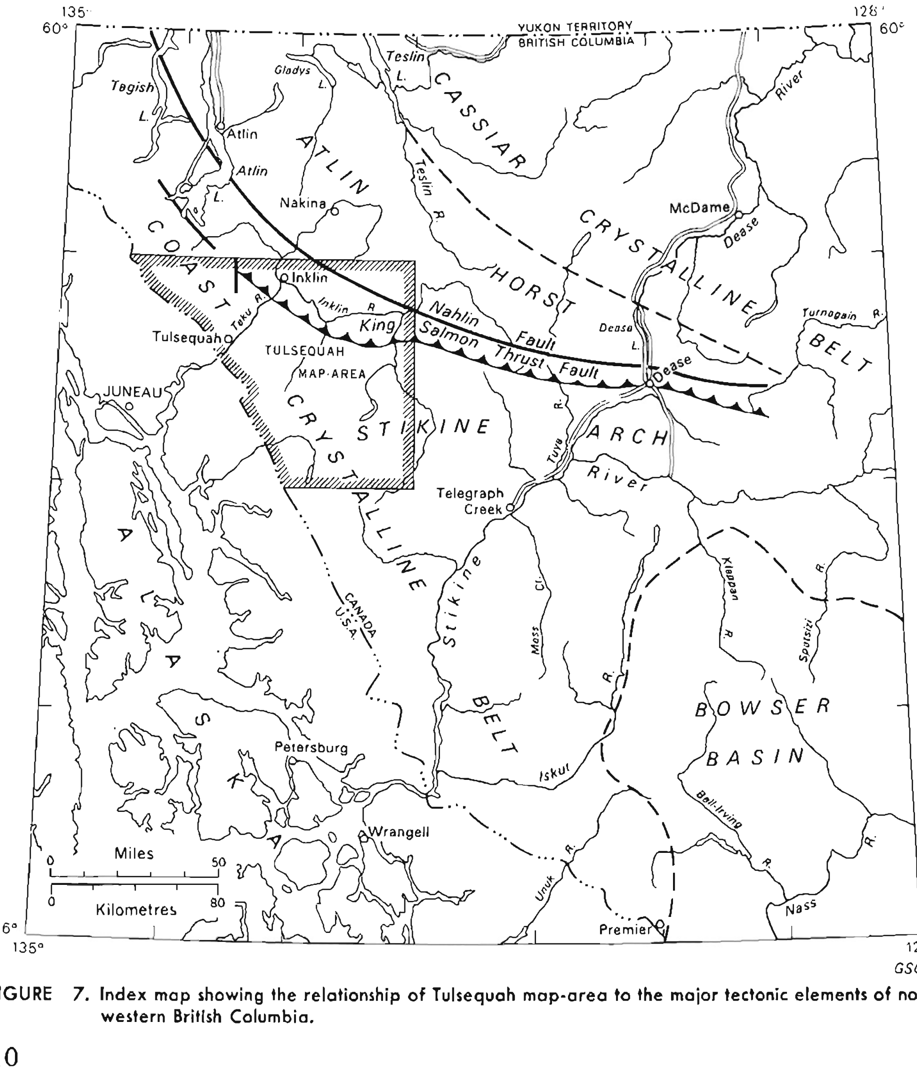


**FIGURE 7. Index map showing the relationship of Tulsequah map-area to the major tectonic elements of northwestern British Columbia.**

name Stikine Arch is proposed for the great salient of older layered rocks and intrusions that projects northeasterly from the Coast Crystalline Belt to Stikine River and beyond. The Atlin Horst is a large wedge-shaped block of older rocks bounded by faults associated in many places with ultrabasic intrusions.

Tulsequah map-area includes the southern edge of the Atlin Horst, which crosses the northeastern corner of the map-area, and the northern edge of the Stikine Arch where it curves sharply eastward away from the Cordilleran trend. Between these two positive elements of older rocks are Mesozoic sedimentary and volcanic rocks that comprise the second, younger, division of map-units. These rocks have not been regionally metamorphosed nor are they as intensely folded as are the older group of rocks. The sedimentary rocks of this division show marked facies changes from off-shore types in the northeast to near-shore types toward the southwest where they overlap the older, more highly folded rocks of the Stikine Arch.

Most of the western part of the map-area is underlain by granitic rocks of the Coast Crystalline Belt. These vary in composition from pyroxene diorite to leucogranite and exhibit a long complex history of emplacement, extending from early Mesozoic to Tertiary time. The youngest intrusions are genetically related to early Tertiary volcanic rocks of the Sloko Group.

All of the foregoing rocks are overlain unconformably by flat-lying late Tertiary and Pleistocene basalt.

## Table of Formations

### Sedimentary and Volcanic Rocks

| Era | Period or Epoch | Formation | Lithology |
|---|---|---|---|
| Cenozoic | Pleistocene and Recent | Map-unit 19 | Alluvium, felsenmere, glacial outwash, till and alpine moraine; (19a) landslide |
| | Late Tertiary and Quaternary | Map-unit 18 Level Mountain Group (1,500±) | Basalt, olivine basalt and related pyroclastic rocks; in part younger than some of 11 |
| | | Conformable contact | |
| | | Map-unit 17 Heart Peaks Formation | Trachyte and rhyolite flows, pyroclastic rocks and related intrusions |
| | | Unconformity | |
| Mesozoic and Cenozoic | Early Tertiary and Late Cretaceous | Map-unit 14 Sloko Group (4,000′±) | Light-coloured rhyolite, dacite, and trachyte flows, pyroclastic rocks and derived sediments |

## Table of Formations (*cont.*)

### Sedimentary and Volcanic Rocks

| Era | Period or Epoch | | Formation | Lithology |
|---|---|---|---|---|
| Unconformity | | | | |
| | Lower and Middle Jurassic | Laberge Group | Map-unit 11 Takwahoni Formation (11,000′) | Granite-boulder conglomerate, chert-pebble conglomerate, greywacke, quartzose sandstone, siltstone, and shale |
| | | | Facies Boundary | |
| | | | Map-unit 10 Inklin Formation (10,000′) | Interbedded greywacke, graded siltstone and silty sandstone; pebbly mudstone, limestone pebble conglomerate and minor limestone |
| | Disconformity (local conformity ? local unconformity) | | | |
| | Upper Triassic | | Map-unit 9 Sinwa Formation (2,000′±) | Limestone; minor sandstone, argillite and chert |
| | | | Disconformity? | |
| | | | Map-unit 7 Stuhini Group Undivided (12,000′) | Andesite and basalt flows, pillow lava, volcanic breccia and agglomerate, lapilli tuff, volcanic sandstone, greywacke and siltstone |
| | | | Facies Boundary (local disconformity, local unconformity) | |
| | | | Map-unit 8 King Salmon Formation (4,000′) | Thick-bedded, dark-coloured greywacke, conglomerate, mudstone, siltstone and shale; minor andesitic lava, volcanic breccia, tuff, limestone and limy shale |
| Unconformity | | | | |
| Mesozoic and Paleozoic | Triassic and Older | | Map-unit 4 (8,600′+) | Fine-grained clastic sediments and intercalated volcanic rocks, mainly altered to phyllite and greenstone; chert, jasper greywacke and minor limestone |
| | Conformable contact | | | |
| | Permian | | Map-unit 3 (2,500′) | Limestone, dolomitic limestone; minor chert, argillite and sandy limestone |

## Table of Formations (*cont.*)

### Metamorphic Rocks

| Era | Period or Epoch | Formation | Lithology |
|---|---|---|---|
| Mesozoic and Paleozoic | | Map-unit A | Diorite gneiss, amphibolite, Migmatite |
| | | Relation to A unknown: unconformably below Stuhini Group (7) | |
| | | Map-unit 5 | Quartz-albite-amphibole gneiss; quartz-biotite schist; garnetiferous schist; augen gneiss and tremolite marble |
| | | In part gradational with map-units 3 and 4 | |

### Plutonic Rocks

#### *Coast Plutonic Rocks*

| | | | |
|---|---|---|---|
| Mesozoic and Cenozoic | Cretaceous and Early Tertiary | Map-unit 16 Younger Quartz Monzonite | Medium- to coarse-grained, pink, biotite-hornblende quartz monzonite |
| | Intrusive contact | | |
| | Pre-Upper Cretaceous | Map-unit 13 Central Plutonic Complex | Granodiorite, quartz; minor diorite leucogranite, migmatite and agmatite |
| | Relation to 13 unknown, intruded by 16 | | |
| | Lower or Middle Triassic | Map-unit 6 | Fine- to medium-grained, strongly foliated diorite, quartz diorite and minor granodiorite |

#### *Minor Intrusions*

| | | | |
|---|---|---|---|
| Mesozoic and Cenozoic | Cretaceous and Early Tertiary | Map-unit 15 | Felsite and quartz-feldspar porphyry |
| | Relation to 6 unknown | | |
| | Post-Middle Jurassic | Map-unit 12 | Hornblende-biotite granodiorite; biotite-hornblende quartz diorite; hornblende diorite; augite diorite |

## Table of Formations (*conc.*)

*Ultrabasic and Basic Rocks*

| Era | Period or Epoch | Formation | Lithology |
|---|---|---|---|
| Paleozoic | Permian | Map-unit 2 | Fine- to medium-grained gabbro and pyroxene diorite |
| | | Intrusive contact | |
| | | Map-unit 1 | Peridotite, serpentinite, gabbro and pyroxene diorite |

## Metamorphic Rocks

### Map-unit 5

Map-unit 5, comprising regionally metamorphosed sedimentary and volcanic rocks, is confined to the western part of the map-area. It is equivalent in part to rocks of the Yukon Group in Atlin area to the north (Aitken, 1959) and in part to less highly metamorphosed strata of map-unit 4. Contacts with the latter unit are gradational, reflecting the gradual increase in metamorphic grade from east to west. On the map the eastern contact of map-unit 5 represents the approximate position at which secondary hornblende and micas appear as major rock components. This corresponds to the appearance of metamorphic layering and the disappearance of most primary bedding features.

The predominant rocks in the eastern part of this zone are finely laminated quartz-feldspar-mica gneiss and micaceous quartzite, interlayered with lesser amounts of fine-grained hornblende-biotite-chlorite-schist, quartz-sericite schist, and a few lenses of sheared, bluish grey limestone. Many of the quartzites exhibit a marked crenulation superimposed on an earlier foliation.

Farther west the gneisses are coarser, typically with ¼- to ½-inch layers rich in hornblende or biotite alternating with light layers of granular quartz and feldspar. Augen-shaped porphyroblasts of feldspar are common and a large amount of quartz occurs as veins, lenses, and irregular patches throughout the gneiss. Here and there, very coarse grained, black, lustrous amphibolite and garnet-bearing quartz-biotite schist form layers from a few inches to more than 30 feet thick. Several lenses of coarsely crystalline limestone, locally with tremolite, occur north of upper Tulsequah glacier.

South of the Polaris Taku Mine and in the mountains south of Mount Ogden there is an apparent gradation from gneisses and schists of map-unit 5 into phyllitic sediments of map-unit 4. Elsewhere the metamorphic rocks are isolated by intrusions or faults and their original age cannot be established; however, their exceptionally high silica content and the presence of limestone suggests a correlation with the Permo-Carboniferous chert-limestone succession.

Only fault contacts were observed between map-unit 5 and Mesozoic sedimentary and volcanic rocks, but metamorphic fragments are found in Upper Triassic, Stuhini, conglomerate near Sittakanay Glacier. The presence of these fragments plus the much more intense folding of map-unit 5 as compared with Upper Triassic strata in the same area suggest that the two are separated by an unconformity. Moreover, the rocks of map-unit 5 must have been metamorphosed and intensely deformed before the Upper Triassic rocks were deposited.

### Map-unit A

The rocks of this map-unit are characterized by an abundance of hornblende and accessory magnetite. Amphibolite, hornblendite, diorite-gneiss, and migmatite are the principal rock types. Unlike the regionally metamorphosed rocks of map-unit 5, this map-unit occurs as isolated patches of intensely dioritized sedimentary and volcanic rocks, usually associated with intrusive diorite.

The body on Sutlahine River is mainly a diorite-migmatite, comprising an intimate mixture of contorted hornblende-plagioclase-gneiss and crudely foliated hornblende diorite. The texture is extremely variable, changing within a few feet from fine-grained diorite to coarse amphibolite with hornblende crystals up to 3 inches long, and irregular patches and random stringers of epidote.

The occurrences near Tatsamenie Lake include a higher proportion of massive coarse-grained hornblendite and amphibolite. These rocks contain from 5 to 20 per cent accessory magnetite—sufficient to cause appreciable deflections of the compass in that area. Magnetite in the form of black sand has been concentrated by streams draining the area and deposited in deltas and bars along the northwest shore of Tatsamenie Lake.

## Layered Rocks

### Permian

*(Map-unit 3)*

Rocks of known Permian age are exposed in the Atlin Horst (Fig. 7) and in a series of northerly trending anticlines south and east of Tatsamenie Lake. Lithologically similar but unfossiliferous rocks near Mount Ogden and at the head of Sheslay River are also included.

The Permian is represented principally by a succession of limestone beds, interbedded locally with chert, shale, and sandstone members. The limestone is usually fine grained and medium grey in colour, except near granite contacts where it has been re-crystallized to a white medium-grained marble. Most exposures are completely massive and, where beds can be distinguished, they are thick with poorly defined bedding planes. Many are of clastic or bioclastic origin with abundant crinoid and shell debris.

The best exposures are in the northwest corner of Tulsequah map-area where fine-grained, thick-bedded limestone outcrops in a broad west-northwest trending belt parallel with the southern edge of the Atlin Horst. This belt is an extension of the "major limestone unit" mapped as part of the Cache Creek Group in Atlin map-area to the north (Aitken, 1959). It occupies the core of a greatly attenuated antiform that plunges gently towards the southeast and is overturned slightly toward the southwest. The base of the limestone is not exposed, but a partial section measured on the ridge south of Victoria Lake gives a minimum thickness of 2,500 feet (Appendix I, Section 1). Well-preserved specimens of the late Permian fusilinid *Yabeina* are abundant in the upper 200 to 300 feet of the section. This suggests that the top of the Permian section coincides approximately with the top of the limestone, and that the overlying chert and slate of map-unit 4a are of post-Permian age.

The Permian is also well exposed in the cores of several northerly trending anticlines east and south of Tatsamenie Lake (Fig. 8). Each of these exposures is believed to represent the same Permian beds repeated by folding. The limestone is more intensely deformed and more coarsely crystalline than that to the north, but poorly preserved fusilinids and corals are widespread. These confirm the Permian age of the rock, although the fauna is distorted and too highly silicified to permit precise identification of species. No fossils were found in the limestone exposure near the head of Sittakanay River or in the exposure on Sheslay River near the southeastern corner of the map-area. These have been assigned to the Permian on the basis of their great thickness and lithological similarity to known Permian.

The Permian limestone in all parts of Tulsequah map-area is overlain conformably by thin-bedded chert, siliceous argillite, slate, and phyllite of map-unit 4.

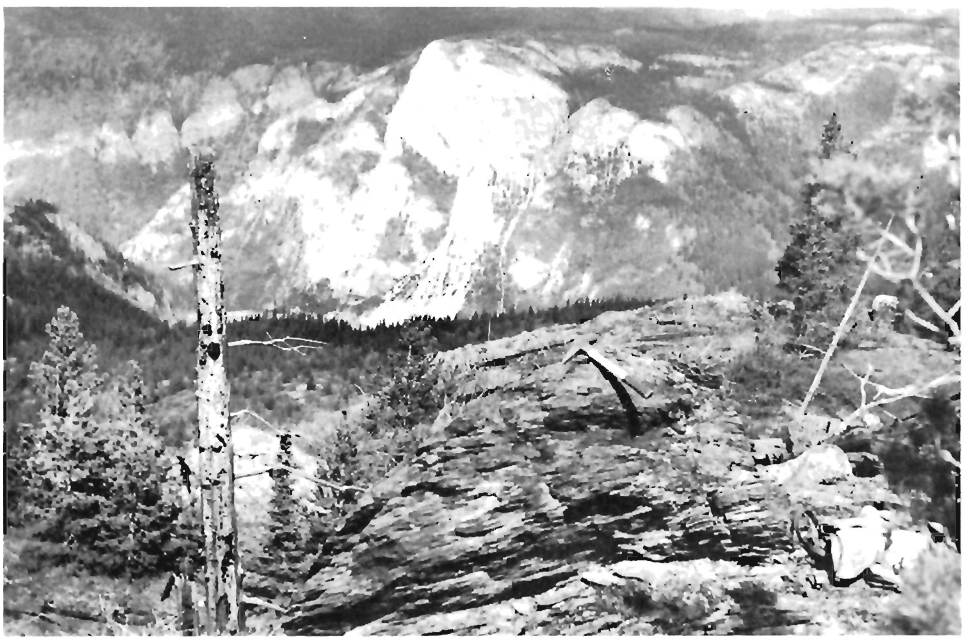

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FIGURE 8. View looking northwest across Samotua River Valley. White cliff in background is massive Permian limestone (map-unit 3) in the core of the anticline. Overlying rocks in the right and left background and the slaty outcrop in the foreground are slaty phyllites of map-unit 4.

## Triassic and Older

### (*Map-unit 4*)

Triassic and older rocks (map-unit 4) underlie large areas within the Atlin Horst and the Stikine Arch and smaller areas within the Coast Crystalline Belt (Fig. 7). The map-unit consists mainly of fine-grained, dark clastic sedimentary rocks and intercalated volcanic rocks. They have been intensely folded and sheared with the consequent development of slaty cleavage and foliation. Sufficient fine-grained, secondary mica has formed in most of the sedimentary rocks to give them a platy, phyllitic texture and lustrous sheen. The volcanic rocks have been largely converted to greenstone and chlorite-amphibolite schist. Despite this widespread alteration many primary bedding and textural features are preserved.

One of the least deformed sections (Appendix I, Section 2) occurs in the northeastern part of the map-area, within the southern part of the Atlin Horst. There the pre-Upper Triassic rocks can be divided into three lithologic units: a lower chert unit, an intermediate limestone unit, and an upper greenstone unit. The chert unit lies with apparent conformity on Permian limestone. It comprises at least 4,000 feet of thin-bedded, grey to black chert and argillaceous quartzites. A few beds of graded siltstone and intraformational conglomerate are interbedded with the chert near the base of the unit and interbeds of massive greenstone become increasingly abundant near the top. Above the chert are thin but persistent limestone beds with partings of chert and lustrous grey phyllite. This unit attains a maximum thickness of 100 feet but varies greatly—due partly to intense deformation which has affected it to a much greater degree than the relatively competent rocks above and below. In some places the limestone is sheared out entirely while at others it occurs only as isolated, lenticular boudins. The limestone unit is overlain by at least 4,500 feet of greenstone derived from lavas and sediments composed of volcanic materials. Primary features are scarce in the greenstones, most of which are massive fine-grained rocks, commonly minutely fractured and veined with epidote stringers. Pillow structures are visible in several outcrops near the base of the unit and elongated amygdules are fairly common. On some weathered surfaces the faint outlines of angular and rounded volcanic fragments can be distinguished from their matrix although fresh surfaces appear structureless. Relatively thin chert layers and small isolated pods of limestone are widespread within the greenstone unit.

In the western and southern parts of the map-area, within the Stikine Arch, it has not been possible to subdivide the pre-Upper Triassic rocks into lithological units such as those mapped north of the Nahlin Fault. This is due partly to the greater structural complexity of these areas, but also to facies changes, particularly to the increasing proportion of thick sedimentary members intercalated with the greenstone in the upper part of the succession. The similarity of these sedimentary rocks to those in the lower part of the section makes it difficult to determine the stratigraphic position of partial sections isolated by faults and intrusions. This is further complicated by increasing metamorphism in the western part of the area where some of the rocks assigned to this map-unit may actually be older than the Permian limestone.

A relatively undeformed section is exposed south of Tatsamenie Lake where fossiliferous Permian limestone is overlain by approximately 2,000 feet of light green, buff-weathering siliceous phyllite interlayered with calcareous and dolomitic phyllite, chert and a few thin beds of dolomite. This sequence is overlain by several thousand feet of medium to dark green quartzite and chloritic phyllite, some of which is derived from volcanic rocks.

The exposures farther south, near the headwaters of Samotua River are believed to be still higher in the sequence. There the sections exposed a thick, monotonous succession of dark greenish grey rusty weathering sedimentary rocks with only minor volcanic components. Most are phyllitic or sub-phyllitic siltstone and fine-grained greywacke which form flaggy outcrops with thin distinct bedding. Fine lamellar banding, commonly showing grading or crossbedding is visible in many beds and a few contain pebbles and cobbles of volcanic rock.

The absence of fossils and persistent horizon markers makes correlation of the pre-Upper Triassic rocks impossible except in very broad terms. The stratigraphic limits of the unit are defined by the underlying, massive Permian limestone and the overlying unconformity with the Upper Triassic rocks. North of the Nahlin Fault, the rocks of this map-unit trend northwesterly into Atlin area where they have been mapped together with the underlying

Permian limestone as part of the Cache Creek group (Aitken, 1959). In Chutine and Telegraph Creek map-areas to the south (Souther, 1959), similar fine-grained siliceous sediments conformably overlying the Permian limestone contain the Middle Triassic pelecypod, *Daonella*. As noted under Permian (map-unit 3) of this section, the underlying limestone in both Atlin and Tulsequah areas contains the fusilinid, *Yabeina*, which is of uppermost Permian age. On the basis of this it appears that the rocks considered here may include very late Permian strata but that they are mainly of Lower or Middle Triassic age.

## Upper Triassic

The Upper Triassic rocks of Taku River area were subdivided by Kerr (1948) into the King Salmon Group of clastic sedimentary rocks, the Stuhini Group composed mainly of volcanic rocks, and the Honakta Formation of mainly limestone. The King Salmon and Stuhini Groups together form a thick, extremely variable succession of eugeosynclinal sedimentary and volcanic rocks. The sedimentary units are mainly dark, poorly sorted rocks composed of detritus eroded from an adjacent volcanic terrain, commonly mixed with ash and coarse pyroclastic debris erupted directly into the basin of deposition. They exhibit rapid lateral changes in thickness and lithology, the purely sedimentary beds interdigitating with thick local piles of volcanic flows and pyroclastic rocks. Local unconformities are common and attest to the extremely active tectonic conditions under which these rocks were laid down. Under such conditions even thick stratigraphic units may be rapidly deposited and have very limited lateral extent. Lithological correlations are possible only in a general way, and usually for only short distances.

Along Taku River, Kerr was able to distinguish King Salmon from Stuhini strata only in the central part of his area. In the western part no such distinction was possible and there all the Upper Triassic strata were mapped as Stuhini. The writer's work suggests that the clastic sedimentary rocks of Kerr's King Salmon Group are restricted to a northwesterly trending belt along the eastern side of the Coast Mountains and that they wedge out toward the west. Within the Coast Mountains, rocks of King Salmon age are mainly volcanic and cannot be distinguished from overlying rocks that Kerr has assigned to the Stuhini Group. Thus the thick, predominantly volcanic succession of Upper Triassic rocks in the western part of the

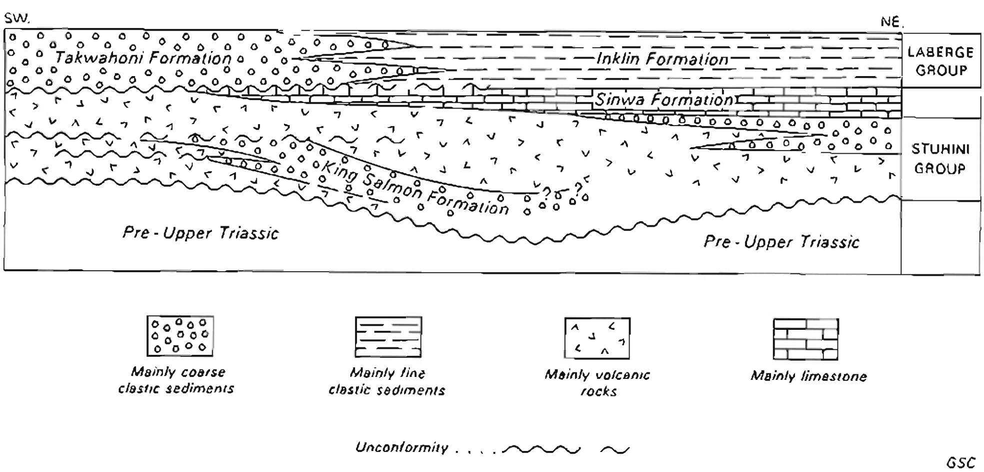


FIGURE 9. Diagrammatic cross-section illustrating the stratigraphic relationship of the Stuhini and Laberge Groups and the King Salmon Formation.

map-area includes strata equivalent in age to both Kerr's King Salmon and Stuhini Groups farther east (Fig. 9). Similar difficulty is experienced in attempting to distinguish between King Salmon and Stuhini strata in the extreme eastern part of the map-area. There, the increased content of clastic sediments and corresponding decrease in the amount of flow rocks within the upper part of the Stuhini make it similar in appearance to the underlying King Salmon sequence. It is not practical, therefore, to consider the King Salmon and Stuhini as distinct rock groups of equal status.

In this report the definition of the Stuhini Group is extended to include all the Upper Triassic volcanic and sedimentary rocks that lie above the mid-Triassic unconformity and below the Sinwa limestone. Within this group the King Salmon Formation comprises a locally mappable assemblage of clastic sedimentary rocks that form an elongate wedge along the eastern flank of the Coast Mountains.

The name Honakta Formation has been dropped and all of the Upper Triassic (Norian) limestone included as part of the Sinwa Formation.

### *Stuhini Group (Map-units 7 and 8)*

The Stuhini Group occupies a broad, gently curving belt that extends from the east-central part of the map-area to nearly the northwestern corner, conforming approximately to the northwestern margin of the Stikine Arch. Three smaller areas of volcanic rock along the southern margin of the Atlin Horst are also mapped as Stuhini on the basis of their lithological similarity to Stuhini volcanic rocks in the central part of the map-area. The belt is cut off a few miles west of Taku River by a system of north-trending faults that bring the Stuhini strata into contact with pre-Upper Triassic rocks of map-unit 2 and metamorphic rocks of map-unit 5. East of Tulsequah the belt of Stuhini rocks can be traced across the southern half of Dease Lake area where it becomes broader and turns in a southerly direction around the eastern margin of the Stikine Arch (Souther and Armstrong, 1966).

Within the belt underlain by rocks of the Stuhini Group, two assemblages of volcanic and derived sedimentary rocks can be recognized, each apparently related to a separate broad locus of volcanism. The first of these is in the southwestern part of the belt, near Sittakany Mountain, and is characterized by a predominance of andesitic rocks. The second assemblage is in the south-central part of the belt, near Trapper Lake, where the Stuhini volcanic rocks are typically basaltic. The boundary between the two cannot be precisely defined. In a general way it corresponds to Sutlahine Valley, but there is considerable overlap of both flows and clastic rocks from the two regions, and many rock types are common to both. In addition to the compositional difference between the southwestern and south-central volcanic assemblages, each assemblage exhibits a facies change from predominant flows and pyroclastic rocks on the southwest to a mixture of volcanic and derived sedimentary rocks toward the northeast.

The southwestern assemblage is well exposed along Taku Valley where the Stuhini Group was first described by Kerr (1948). The base of the group was observed only in the most westerly exposures, along Sittakany Valley, where a basal conglomerate rests unconformably on contorted phyllite and quartzite of map-unit 4. Pebbles and boulders in the conglomerate are mainly volcanic but occasional clasts of gneiss, quartzite, chert, and, at one locality, a few well-rounded pebbles of granodiorite, indicate that metamorphic rocks like those of map-unit 5 and also an early phase of the Coast plutonic rocks, were exposed to erosion during Stuhini time.

The basal conglomerate is overlain by a succession, at least 12,000 feet thick, of andesitic flows and pyroclastic rocks interlayered with coarse breccia, volcanic conglomerate, and lesser amounts of greywacke and siltstone. The andesites, both in flows and breccia-fragments, are predominantly dark green in the lower part of the section whereas those in the middle and upper part of the group are lighter green or purple. Most are fine-grained to aphanitic rocks with numerous white feldspar phenocrysts, usually less than 1 millimetre across but locally as large as 1 centimetre. Dark minerals are relatively scarce and almost wholly replaced by chlorite. Breccias and volcanic sandstones derived from the erosion of adjacent volcanic land masses are difficult to distinguish from pyroclastic rocks deposited directly from volcanic vents. Flow breccias in which both fragments and matrix are of the same composition are common in the western part of the area, particularly in the lower half of the section, but scoriaceous or amygdaloidal rocks that might indicate a nearby source are notably absent. True tuffs are, likewise, difficult to identify. Many of the fine-grained clastic rocks in the lower part of the group are extremely massive, with uniform grain size and poorly defined layering. They undoubtedly contain some airborne ash but the interbedded coarser fractions usually have rounded pebbles and cobbles indicating the presence of water-transported materials. Well-bedded sedimentary rocks are confined to the lower and upper part of the Stuhini succession. The former are restricted to the central and northern part of the outcrop belt where they are assigned to the King Salmon Formation. Sedimentary rocks in the upper part of the Stuhini Group are best developed along the northern margin of the main belt underlain by Stuhini rocks. There, conglomerates and breccias composed of green and purple andesite fragments are interbedded with banded volcanic sandstone, graded siltstone, and occasional lenses of impure limestone.

The assemblage of Stuhini rocks in the central and eastern part of the map-area differs from that farther northwest, not only in the average composition of the lavas but also in the environment of deposition. Whereas the rocks of the northwestern assemblages appear to be mainly subaerial flows, pyroclastic rocks, and their sedimentary derivatives, those of the southeastern assemblage are entirely of submarine origin. Pillow lavas, breccias and agglomerates of dark grey to black basalt or basaltic andesite are the principal rock types. The pillow lavas are best developed in south-central exposures, where the volume of flows greatly exceeds that of interlayered clastic and pyroclastic rocks. One section at Trapper Lake exposes over 4,000 feet of pillow lavas without any interlayered clastic rocks. Where fragmental rocks are associated with the pillow lavas they, like the lavas, reflect a submarine origin. One type consists of block breccia with many wedge-shaped and rectangular chunks of broken pillows and a few complete pillows suspended in a mass of unsorted volcanic debris. These rocks are believed to be the result of slides on the oversteepened slopes of submarine volcanoes. Another common fragmental rock, particularly near the top of the section, comprises well-sorted, commonly graded, breccias and micro-breccias in which angular fragments of amygdaloidal lava are enclosed in a calcareous cement. Similar rocks in the Upper Triassic of Vancouver Island were described by Hoadley (1953), where they are believed to be the result of pyroclastic material falling into accumulations of limy mud on the sea floor.

The pillow lavas interdigitate with andesitic breccias and flows northwest of Trapper Lake. Though much thinner, they have been recognized as far northwest as Sittakanay Mountain where they occupy a few hundred feet near the base of the section. Northeast of Trapper Lake the proportion of clastic and pyroclastic rocks increases at the expense of the flows, although well-formed pillows occur as far north as the junction of Tatsatua Creek and Sheslay River. The interbedded clastic rocks of this eastern facies, unlike those to the northwest, have an abundance of amygdaloidal fragments. Breccia and breccia-conglomerate with dark green, grey and black clasts in a dark grey to brown matrix form several thousand feet of strata along the eastern margin of the belt underlain by Stuhini rocks. They are interbedded with brown to dark grey finer grained tuffs, volcanic sandstones, and graded siltstones that are similar to the well-layered rocks of the King Salmon Formation.

The three small areas of Stuhini Group that lie along the southern margin of the Atlin Horst consist almost entirely of pillow lavas similar to those in the Trapper Lake section. Contacts with the overlying Inklin Formation are poorly exposed. Also, during folding of the Inklin rocks the great difference in competency between the massive lavas and the relatively thin-bedded Inklin strata resulted in considerable shearing and brecciation of the contact.

*King Salmon Formation (Map-unit 8)*

The King Salmon Formation comprises a locally mappable succession of well-bedded clastic sediments within the Upper Triassic Stuhini Group. It is confined to the central and northwestern parts of the belt underlain by Stuhini rocks (Fig. 9). The base of the King Salmon Formation was not observed at any place in the map-area, but good partial sections are exposed along Taku River in the cores of several northwesterly trending anticlines. These folds plunge to the northwest and southeast and the King Salmon beds disappear under younger strata a few miles from Taku Valley. The most northerly of the anticlines can be traced southeasterly to Sutlahine River where a reversal in plunge again brings King Salmon beds to the surface in the core of the fold. A third area of the King Salmon Formation occurs in a fault slice on the mountain northwest of King Salmon Lake.

The northern section on Taku River and the section southeast of Sutlahine River (Appendix I, Section 3) each expose about 4,000 feet of beds and the sequence of rocks is similar in both places. The lower part consists of andesitic lavas interlayered with tuff, volcanic sandstone, coarse breccia-conglomerate and agglomerate. The lavas are dark green to black, usually porphyritic and, in the Taku River section, a few have pillow structures. The breccias and conglomerates consist almost wholly of volcanic materials similar in colour and texture to the interbedded lavas. Thin-bedded, dark green to grey tuffs and poorly sorted volcanic sandstones and grits occur throughout the section but become more abundant in the upper half. Also in the upper part of the section, the volcanic sediments are interlayered with shale, argillite, and argillaceous quartzite. Some of the shale contains calcareous nodules and thin lenses of dark grey limestone. In the upper 300 to 400 feet of the section most of the sandstones and fine breccias have a calcareous cement that weathers out to give the rocks a rough pitted surface.

Limy shales in the upper part of both sections have yielded a scant but diagnostic marine fauna (Appendix II) including *Halobia* and *Tropites* which, according to E.T. Tozer of the Geological Survey of Canada, designate a Karnian (early Upper Triassic) age.

The section northeast of King Salmon Lake differs from those just described in that it has a greater proportion of fine-grained sedimentary rocks and no volcanic flows. About 3,000 feet of beds are exposed, the lower 2,000 feet consisting almost entirely of thick-bedded greenish grey greywacke, volcanic sandstone, and grit. Toward the top of this interval the beds become thinner and include dark and light green, brown-weathering siltstones and sandy siltstones with conspicuous graded bedding and banding. Thin-bedded sandy siltstones, argillaceous quartzite and shale predominate in the upper 1,000 feet and black, calcareous shale with well-preserved *Halobia* and *Tropites* forms the uppermost member of the section.

As the King Salmon Formation is traced southwesterly along Taku Valley, the thin-bedded sedimentary units appear to wedge out by interfingering with coarser clastic rocks and flows. On Jeanne Mountain the upper part of the King Salmon Formation is mainly coarse breccia and conglomerate interbedded with relatively thin volcanic sandstone and siltstone members. Still farther southwest, near Sittakanay Glacier, a few thin, widely separated siltstone bands occur within the Stuhini volcanic sequence. One near the middle of the section, contains poorly preserved fragments of ribbed bivalves that resemble *Halobia*. This suggests that the King Salmon Formation represents a northeastern, sedimentary facies, equivalent in age to the predominantly volcanic lower part of the Stuhini Group farther southwest within the Coast Mountains.

### *Sinwa Formation (Map-unit 9)*

The Sinwa Formation, and its equivalents, provides one of the most useful horizon markers in northwestern British Columbia. It consists almost entirely of grey, usually petroliferous, white-weathering limestone and, although it varies in thickness from only a few feet to more than 2,000 feet, it is extremely widespread.

The name Sinwa Formation was introduced by Kerr (1948) who applied it to the thick limestone band that crosses Taku Valley at Sinwa Mountain. At this point the limestone is structurally above the Lower Jurassic Takwahoni Formation which is, in turn, above a thinner but otherwise similar limestone that Kerr named the Honakta Formation. Upper Triassic fossils were recovered by Kerr from the Honakta but his fossil collections from the Sinwa proved to be of no value in determining its age. In the absence of paleontological evidence Kerr was forced to conclude that the two limestones were in normal stratigraphic position above and below the Takwahoni Formation. The Sinwa was thus considered to be Jurassic.

The writer's work has revealed a sparse, but well-preserved Upper Triassic fauna at many points within the Sinwa Formation (Appendix II). Most of these collections were examined by E. T. Tozer of the Geological Survey who reported that the presence of *Monotis subcircularis* Gabb and *Halorites* cf. *H. americanus* prove a Norian (late Upper Triassic) age. Coralline structures from the Sinwa Formation were examined by E. W. Bamber of the Geological Survey of Canada, who reported that "most of them contain schleractinian corals, which means that they are Middle Triassic or younger". From this it is evident that the Sinwa Formation and the Honakta Formation are of the same age. Moreover, the present work indicates that the position of the Sinwa, above the Lower Jurassic, Takwahoni Group, is due to a low angle thrust fault that is localized along the base of the limestone. The name Honakta Formation has thus been dropped and both limestones included as part of the Upper Triassic Sinwa Formation.

In Tulsequah area, the Sinwa limestone has served as a relatively weak plane, along which extensive thrust faulting, accompanied by intense local folding has occurred. The principal fault corresponds closely to the main belt of limestone, and is referred to here as the King Salmon thrust fault. The direction of movement has been from northeast to southwest, and a small klippe of Sinwa Formation resting on Lower Jurassic beds east of Trapper Lake indicates a minimum displacement of 10 miles. In the allochthonous block, which represents the northeastern facies, the Sinwa Formation attains a maximum thickness of 2,500 feet. In the autochthonous block to the southwest its maximum thickness is 600 feet, and its most westerly exposure, on Mount Dirom, is less than 100 feet thick. This progressive thinning toward the southwest appears to be due to onlap of the limestone beds over a relatively low landmass in the western part of the area. The thin, southwestern facies of the limestone rests unconformably on rocks of the Stuhini Group and King Salmon Formation, however, the base of the thick northeastern facies is obscured by faulting and its relation to the older rocks is unknown.

The Sinwa Formation can be correlated along trend with Norian limestones both east and north of Tulsequah map-area. To the east, in Dease Lake area (Gabrielse and Souther, 1962), fossiliferous Upper Triassic limestone near the south end of Dease Lake is faulted against Triassic volcanic rocks believed to be equivalent to the Stuhini Group. This same relationship is found still farther to the east in Cry Lake area (Gabrielse, 1962). Thin limestone members of Norian age are found throughout the Stikine area to the south (GSC Map 9-1957).

When the band of Sinwa limestone that crosses Tulsequah area is projected toward the northwest, beneath the younger Sloko Group of volcanics, it is found to be on trend with a thin limestone band in the southwestern corner of Atlin area that Aitken (1959) mapped (Aitken's map-unit 5) as Pennsylvanian and/or Permian. This age is based on poorly preserved fossils, mainly corals and bryozoa (GSC Cat. No. 22321) that were thought by P. Harker of the Geological Survey of Canada to be of Permian or Pennsylvanian age. In his report Aitken noted the extreme lithological differences between the rocks containing these fossils and Permian rocks elsewhere in Atlin area and said: "The palaeontological evidence does not admit the possibility that these rocks are younger than the Cache Creek; therefore, if the two groups are not equivalent, then map-units 4 and 5 must be the older". Study of the Sinwa Formation in Tulsequah area lead to an examination of Aitken's fossil collections by P. Harker and E. T. Tozer who reported (pers. comm., 1960) that the corals are probably Upper Triassic forms. This indicates that Aitken's map-unit 5 of the Atlin map-area is equivalent to the Sinwa Formation and of Upper Triassic rather than Carboniferous age.

## Lower and Middle Jurassic

### *Laberge Group (Map-units 10 and 11)*

The Lower and Middle Jurassic rocks of Tulsequah area form an apparently conformable sequence of clastic sedimentary rocks. They occupy a broad synclinorium bounded on the northeast by faults adjacent to the Atlin Horst and, on the southwest, by an unconformity that corresponds approximately to the gently curving Lower Jurassic strandline on the northeastern side of the Stikine Arch. The trough in which these sediments accumulated was formerly much wider than the present belt of outcrop, having been greatly shortened by northwesterly trending folds and faults. Much of this shortening has taken place along the King Salmon Thrust which brings rocks deposited in the central part of the trough southward over rocks deposited along its southwestern margin. Thus the Lower Jurassic rocks south of the King Salmon thrust fault represent a nearshore facies that is distinct from rocks of the offshore facies north of the fault.

The abundantly fossiliferous nearshore facies was named the Takwahoni Group by Kerr (1948) who considered it to be stratigraphically below the Sinwa limestone. The rocks north of the King Salmon fault and above the Sinwa limestone are generally unfossiliferous but, due to their position above the Sinwa Formation, Kerr considered them to be younger than the Takwahoni. He subdivided them into two conformable groups; a lower Yonakina Group of Jurassic (?) age and an upper Inklin Group of Lower Cretaceous (?) age. No basis for this subdivision was found during the present work. Kerr's Inklin and Yonakina Groups appear to be equivalent strata repeated by complex folding, and both are physically continuous with the Lower Jurassic, Laberge Group of Atlin and Whitehorse areas.

It is apparent that the Inklin, Yonakina, and the Takwahoni strata are together equivalent to the Laberge Group as defined by Wheeler in Whitehorse area (Wheeler, 1961). As it is desirable to subdivide the Jurassic rocks of Tulsequah area it is proposed that the Takwahoni and Inklin be made formations within the Laberge Group. The Takwahoni Formation includes the coarse clastic rocks of the nearshore facies and the Inklin Formation includes the finer grained sedimentary rocks of the off-shore facies. Rocks formerly assigned to the Yonakina Group are included in the Inklin Formation, and the name Yonakina has been dropped.

*Inklin Formation (Map-unit 10)*

Rocks of the Inklin Formation rest with structural conformity on the Upper Triassic, Sinwa limestone. The contact is irregular, and the upper part of the Sinwa Formation is fractured, often vuggy, and deeply stained with hematite. In many places the upper part oJ the limestone consists entirely of rounded limestone pebbles and cobbles in a matrix of recrystallized secondary calcite and hematite. Similar limestone-pebble conglomerate with a sandy or shaly matrix is interbedded with shale and greywacke in the lower part of the Inklin section. At two localities, a few pebbles of granitic and volcanic rock were found with the limestone in these conglomerates. Thus the Sinwa and Inklin rocks appear to be separated by a disconformity that reflects a brief, probably local, period of uplift and erosion prior to deposition of the Inklin strata.

The lower 1,000 to 1,200 feet of the Inklin Formation (Appendix I, Section 5) consists mainly of thin-bedded siltstone and shale, interbedded with lesser amounts of subgreywacke and limestone-pebble conglomerate. Many of the siltstones and shales in this lower unit are calcareous and, unlike those higher in the section, commonly contain fragments of coalified wood and other plant debris. The upper part of the section, over 9,000 feet thick, comprises a monotonous succession of thick-bedded greywacke and subgreywacke interbedded with thick sequences of graded siltstone, shale, and occasional reeflike lenses of autoclastic limestone. Except for the coarse-grained greywackes, which form thick structureless beds, the rocks are characterized by distinct light and dark grey banding (Fig. 10). Convoluted bedding, slump structures, graded bedding, and intraformational conglomerate are present throughout; whereas shallow-water features, such as ripple-marks, are absent. All of these features, as well as the general lack of fossils in the Inklin Formation compared to their abundance in the contemporaneous Takwahoni Formation, suggest a deep water origin. The silt, mud and sand that formed the Inklin strata were probably transported by turbidity currents that swept unconsolidated deltaic and shelf deposits into the deep, central part of the basin.

Only one diagnostic fossil, a well-preserved ammonite (Appendix II) identified by H. Frebold of the Geological Survey as *Arnioceras*, has been found in the Inklin Formation of Tulsequah map-area. It was collected from talus that must have originated between 400 and 1,500 feet above the base of the formation. According to Frebold it indicates the Sinemurian stage of the Lower Jurassic.

*Takwahoni Formation (Map-unit 11)*

The Takwahoni Formation comprises a thick assemblage of interbedded conglomerates, greywackes, siltstones, and shales. The rocks are characterized by rapid facies changes, local unconformities, channelling, and other features associated with deposition in a rapidly subsiding basin near a source-area of high relief. Although much of the clastic debris has been derived from a volcanic terrain, primary volcanic rocks are either absent or restricted to the lower few hundred feet of the section.


FIGURE 10. Specimen of Inklin siltstone illustrating typical graded and convoluted bedding.

The most complete sections (Appendix I, Sections 6 and 7) were measured south of King Salmon Lake where over 11,000 feet of Takwahoni beds are exposed on the northeastern limb of a relatively open syncline. The upper 6,500 feet of this section correspond to 7,500 feet of beds on the southwestern limb of the same fold which is cut off by a granitic intrusion. Comparison of these two sections, which can be precisely correlated, illustrates the characteristic change in facies from coarse clastic rocks in the southwest to finer grained rocks in the northeast. The composite thickness of the three principal rock types in equivalent beds on opposite limbs of the syncline is as follows:

| | Southwestern limb | Northeastern limb |
|---|---|---|
| Conglomerate | 2,200 feet | 600 feet |
| Greyacke | 2,600 feet | 3,100 feet |
| Siltstone and shale | 1,700 feet | 3,800 feet |

Partial sections measured by Kerr (1948) along Taku River exhibit a similar change from predominantly coarse clastic sediments in the southwestern exposures to finer grained sedimentary rocks in the northeastern exposures.

The relationship between the Takwahoni and the underlying Triassic rocks varies, although in most exposures, a disconformity or unconformity is indicated. In all of the southwestern exposures except those on Mount Dirom, the Sinwa Formation is missing between the Stuhini Group and the Takwahoni Formation. Although this may be partly due to non-deposition, the presence of occasional limestone clasts in the Takwahoni conglomerate suggests that part of the Sinwa was eroded away prior to deposition of the Takwahoni. Southwest of King Salmon Lake the basal member of the Takwahoni is a volcanic breccia interbedded with volcanic sandstone, some of which may be tuffaceous. Farther northwest, on Mount Lester Jones, Stuhini volcanic rocks are overlain with apparent conformity by well-bedded Lower Jurassic siltstones up to 200 feet thick which have, in turn, been channelled through and displaced by thick wedges of boulder conglomerate.

Conglomerate is confined to the lower half of the section. South of King Salmon Lake individual conglomerate beds (Fig. 11) reach a thickness of more than 900 feet, and beds of more than 100 feet are common along the full length of the southwestern margin of Takwahoni exposures. The cobbles and boulders are well rounded, the majority being 2 inches to 1 foot in diameter although individual boulders up to 3 feet across are not uncommon. Like Lower Jurassic conglomerates at many points within the western Cordillera, those of Tulsequah area contain the first major influx of granitic debris. Boulders and cobbles of granodiorite and quartz diorite similar to all but the most recent phases of the Coast Intrusions form 20 to 50 per cent of the clasts. Volcanic rocks, similar to the underlying Triassic, form most of the remaining clasts and a small percentage are derived from limestone, greywacke, shale, and metamorphic rocks.

The Takwahoni sandstones, like the conglomerates, reflect the presence of granitic rocks in the source area. Unlike the greywackes and volcanic sandstones of the underlying Triassic strata, they contain a relatively high proportion of quartz and potash feldspar (Fig. 12). The majority are greywackes, although subgreywacke, arkose, and volcanic sandstone are locally important. The subgreywacke and volcanic sandstone are mostly medium- to coarse-grained, dark grey to black rocks that form massive beds from 1 foot to 30 feet thick. Weathered surfaces are usually brown and much lighter coloured than fresh surfaces. Banding within the sandstones is either absent or restricted to broad, poorly defined bands of different grain size. A characteristic feature of the Takwahoni sandstones is the presence of spherical nodules

FIGURE 11
Takwahoni conglomerate. Note large granitic boulder to left of hammer.

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in which the normal chloritic or argillaceous cement is replaced by calcareous cement. Solution of the calcite leaves hemispherical pits from 4 inches to 1 foot across on the weathered surface of many beds.

The pelitic rocks of the Takwahoni Formation are mainly silty and sandy shales, dark grey to brownish grey in colour, with thin platy or flaggy bedding. They form monotonous, uniform units from a few feet to more than 1,000 feet thick between massive beds of greywacke and conglomerate. Thin beds and lenticular nodules of black, rusty weathering ironstone are interbedded with many of the silty shales and a few beds of calcareous shale and argillaceous limestone occur near the top of the section. East of Trapper Lake the Bajocian (Middle Jurassic) shales contain occasional beds of a dense, resinous coal from 1 inch to 4 inches thick.

Rocks of the Takwahoni Formation contain an abundance of well-preserved fossils (Appendix II), and many collections, mainly ammonites, were made during the course of mapping. These collections were studied by H. Frebold of the Geological Survey of Canada who prepared a paper (Frebold, 1964) describing the fauna and its correlation with Jurassic faunas from other areas. He reported the presence of the Pliensbachian and Toarcian stages of the Lower Jurassic, and the Middle Bajocian stage of the Middle Jurassic. The Hettangian

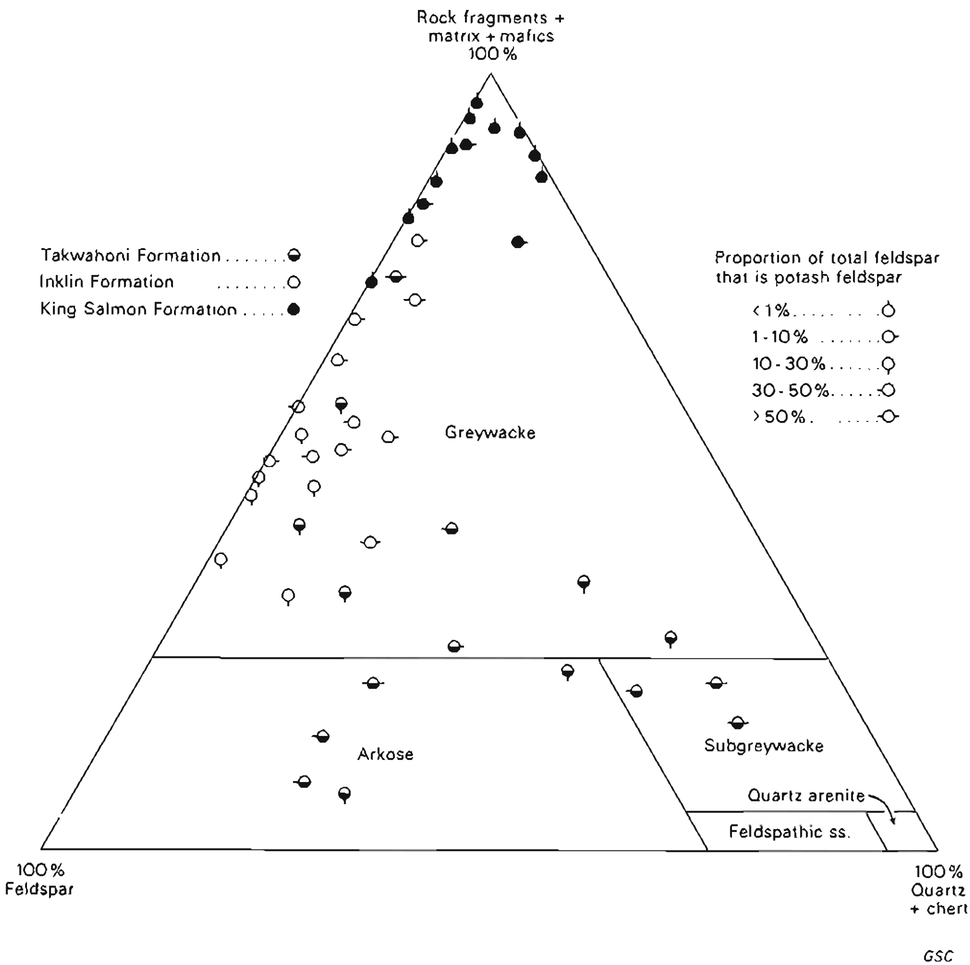


FIGURE 12. Plot of the compositions (volume per cent) of Mesozoic arenites from Tulsequah map-area.

and Sinemurian stages of the Lower Jurassic were not found, and there is no faunal evidence of Lower Bajocian rocks. Although no major unconformity was recognized within the Takwahoni Formation it is possible that a break in deposition occurred between Lower and Middle Jurassic time.

## Upper Cretaceous and Early Tertiary

### *Sloko Group (Map-unit 14)*

The Sloko Group is confined to a broad northwesterly trending belt along the eastern flank of the Coast Mountains (Fig. 13) where it is preserved in downfaulted blocks and erosional remnants on many of the higher uplands. The largest and most northerly area of Sloko rocks in the map-area is continuous with the type locality at Sloko Lake where the

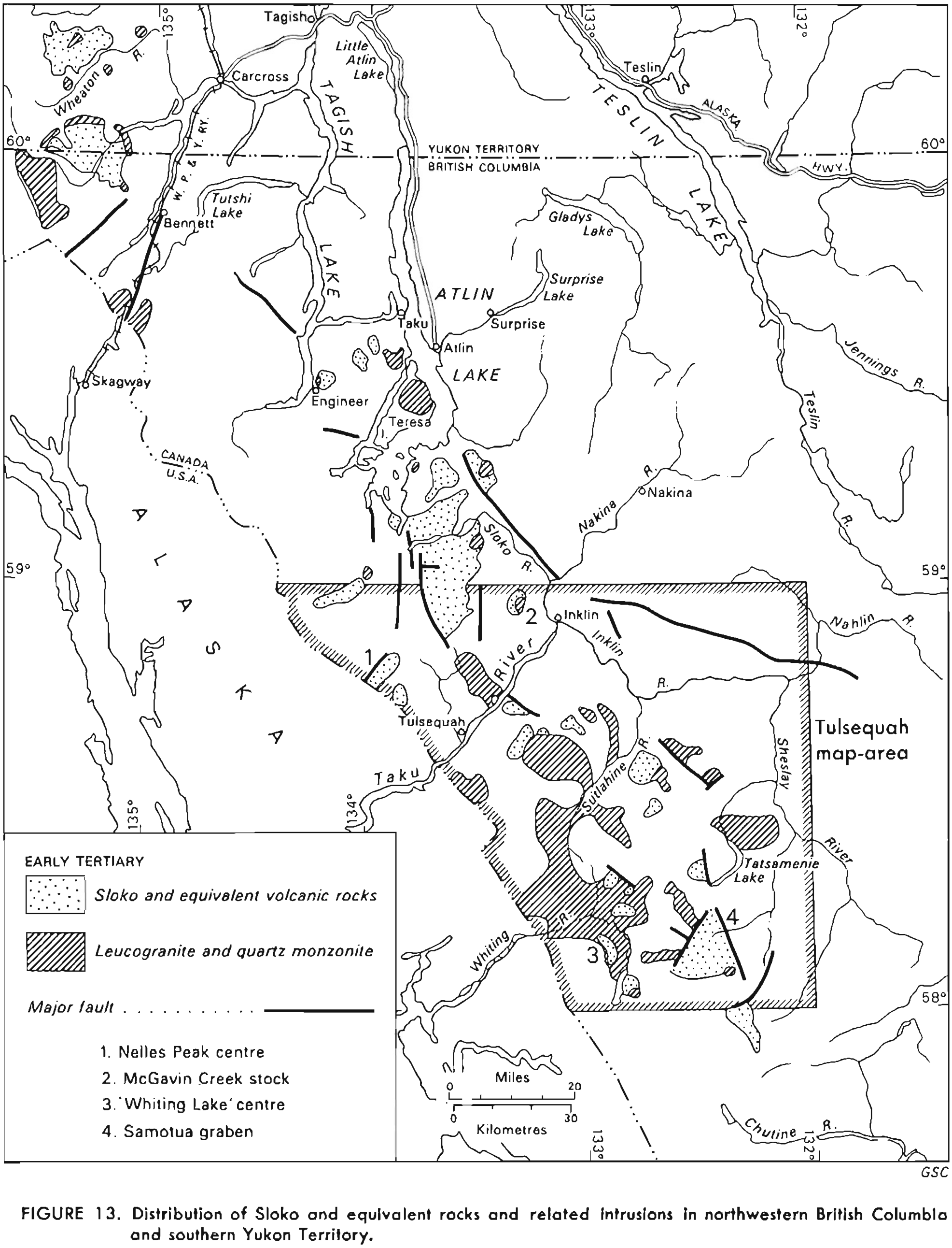


FIGURE 13. Distribution of Sloko and equivalent rocks and related intrusions in northwestern British Columbia and southern Yukon Territory.

group was first described by Aitken (1959). The present map also includes in the Sloko Group some of the rocks that were formerly mapped as Yonakina Group in Taku River area (Kerr, 1948).

The Sloko Group comprises a bright coloured assemblage of intermediate to acid volcanics and derived sediments that rest with profound angular unconformity on Jurassic and older rocks. The great majority are pyroclastic, varying from coarse explosion breccias and agglomerates to fine-grained, delicately banded vitric tuffs and ignimbrites. Dark purple, green, grey and reddish brown andesites and trachytes alternate with lesser amounts of dacite and rhyolite, usually in lighter shades of green and creamy white. The weathered surface of most of the flows is deep rusty red or black whereas the pyroclastic and sedimentary rocks weather to light, chalky shades of green, purple and brown.

Andesite and occasional basalt flows are present in most sections but they are always subordinate to pyroclastic rocks. Moreover, many of the rocks that appear to be massive vitrophyric flows in the field are seen under the microscope to be welded tuffs. Small lithic and crystal fragments are enclosed by flattened, commonly greatly attenuated, shards of partly devitrified glass (Fig. 14) which forms the bulk of these rocks. Many have fine fluidal banding, resembling the flow structure of acid lavas. In addition to clasts of essential and accessory volcanic material that form the bulk of pyroclastic fragments, many of the tuffs and breccias contain large amounts of accidental clasts. One of the most striking examples is on the north side of Nelles Peak (Fig. 13, No. 1). There gneisses and granitic rocks at the base of the flat-lying volcanic pile are completely shattered to a breccia of randomly oriented angular blocks in a sparse matrix of comminuted rock debris and devitrified glass. At the head of Samotua River, breccia consisting of andesite and quartz monzonite fragments in a volcanic matrix forms thick wedges adjacent to the bounding fault on the northeast side of the volcanic pile (Fig. 13, No. 4). Rocks exposed to the northeast of the fault are entirely sedimentary thus the granitic clasts must have originated in the subvolcanic basement.

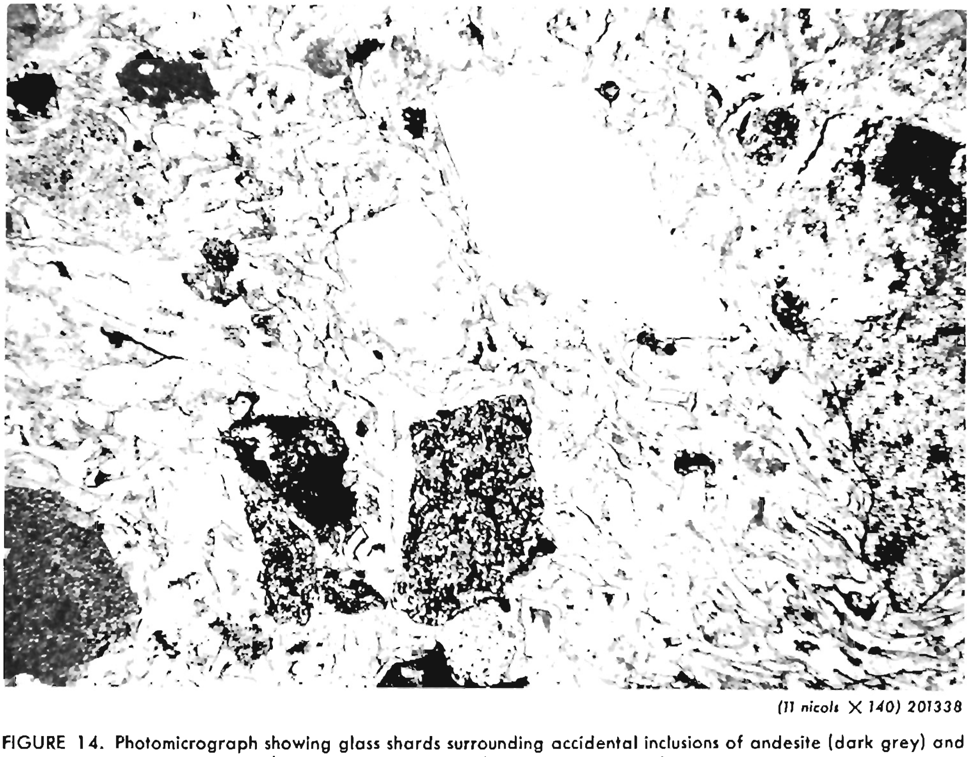

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FIGURE 14. Photomicrograph showing glass shards surrounding accidental inclusions of andesite (dark grey) and quartz monzonite (clear angular fragments) in Sloko welded ash-flow.

Similar clasts of quartz monzonite and crystal fragments derived from them are included in vitric and welded tuffs east of Whiting Lake (Fig. 13, No. 3).

Sedimentary rocks within the Sloko Group consist almost entirely of angular to subangular debris derived from adjacent volcanic accumulations. Many consist partly or wholly of shards, ash, and lapilli, erupted directly into small bodies of water, where they have settled to form graded sequences. Some vitric tuffs and many of the tuffaceous sedimentary rocks contain coalified plant debris, thin coal seams, and, in a few places, carbonized logs up to 10 inches in diameter.

The thickness of the Sloko Group and the relative proportion of flows, pyroclastic rocks and sedimentary rocks varies considerably from place to place. Over 4,000 feet of strata are exposed near Mount Haney in the northern part of the map-area, yet only six miles farther northeast the entire section laps out against an old erosion surface. Further evidence that the Sloko rocks were deposited on a surface of high local relief is found at many places. At Whiting Lake nearly flat-lying tuffs and breccias, resting unconformably on sedimentary and granitic rocks at an elevation of 4,000 feet, are continuous with welded tuffs and coarse ignimbrites in the valley 3,500 feet below. The lower rocks must have been deposited by a glowing avalanche that swept down a slope not too different from the present steep valley wall.

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FIGURE 15. Flat-lying Sloko breccia and welded ash-flows (hill in right background) resting on steeply dipping Takwahoni strata south of King Salmon Lake.

Most of the Sloko strata are either flat lying (Fig. 15) or gently tilted, but in a few places dips of up to 40 degrees were noted. Folds, where present, have random orientation and appear to have developed in response to block faulting rather than regional compression.

Normal faults, on both large and small scale, are the principal structures in the Sloko Group and they frequently form the bounding structure between Sloko and older rocks. In many places these faults are either occupied or paralleled by swarms of andesite, trachyte, and, less commonly, glass dykes believed to be feeders for the Sloko volcanic accumulations. This suggests that the faulting and volcanism were at least partly contemporaneous, and that subsidence of graben-like blocks of volcanic rocks has occurred in response to near-surface intrusions. The small circular stock on McGavin Creek, for example, is nearly surrounded by an accumulation of pyroclastic breccia (Fig. 13, No. 2). This, in turn, has been dropped down at least 300 feet relative to the enclosing Jurassic strata, suggesting a cauldron subsidence. A similar origin would explain the close spatial association and conflicting age relationships between the Sloko volcanic rocks and the felsite and quartz monzonite of map-units 15 and 16. As noted previously accidental inclusions of quartz monzonite are found in the pyroclastic deposits. At many places, particularly north and west of Whiting Lake, pyroclastic deposits grade imperceptibly downward into homogeneous aphanitic felsite, which, in turn, grades downward into fine-grained, and finally medium-grained quartz monzonite. North of Whiting Lake the complete transition occurs within a vertical distance of less than 5,000 feet. At other places a fine-grained phase of the quartz monzonite appears to cut Sloko pyroclastic rocks. All of these features imply a genetic relationship between the extrusive Sloko and intrusive quartz monzonite. Moreover, the Cretaceous or early Tertiary age of the Sloko Group as inferred from abundant but poorly preserved plant remains is in agreement with the potassium-argon age of 69 m.y. obtained on biotite from the quartz monzonite (Leech, *et al.*, 1963, GSC age determination No. 62-75). It is probable that the Sloko Group is derived from periodic explosive eruptions accompanying intrusion of extensive bodies of quartz monzonite. The intrusion appears to have been accompanied by extensive faulting, block foundering and stopping, which in a few instances brought the intrusive magma into contact with the lower part of the Sloko volcanic accumulation.

## Late Tertiary and (?) Pleistocene

### *Heart Peaks Formation (Map-unit 17)*

The brightly coloured group of pyramid-shaped summits on the western flank of Heart Peaks forms a prominent landmark, visible for many miles. The area is underlain by rhyolitic and trachytic lavas, tuffs, and breccias that weather to bright hues of red, yellow, and orange. All of the rocks have a closely spaced random fracture system, with the result that most slopes are covered with a thick mantle of felsenmeer and talus. Several active rock glaciers have also developed on the slopes and pushed their way well down into the fringing forest.

The fresh lavas have a light grey to purplish grey aphanitic matrix surrounding clear, light grey, tabular phenocrysts of feldspar, occasional books of biotite, and small rounded blebs of quartz. Quartz stringers and quartz-lined vugs are locally abundant. In a few outcrops crude columnar jointing can be recognized but the columns are small and randomly oriented. Under the microscope the flow rocks are seen to have a trachytic texture in which the groundmass, consisting mainly of glass and ores, surrounds a felted mass of plagioclase microlites. Phenocrysts, which comprise up to 20 per cent of the rock, are complexly zoned andesine ($An_{35-50}$).

The pyroclastic rocks are porous and highly oxidized, comprising fine, scoriaceous ejecta, broken feldspar crystals, and angular blocks of porphyritic lava. Several beds contain accidental fragments from the underlying Takwahoni shale and one bed of which crystal-lithic tuff contains a few carbonized plant stems. In thin section the tuffs are seen to contain a high proportion of glass and several beds near the base of the pile are composed entirely of vitreous, welded shards.

The Heart Peaks Formation appears to be overlain by flat-lying basalt; the base of the sequence was not observed in the vicinity of Heart Peaks. It is possible therefore that the earliest basalt flows may predate the rhyolite-trachyte. This appears to be the case 20 miles farther south, where a similar group of acid tuffs has been studied in detail by Panteleyev (1964). There the tuffs are divisible into two units separated by a 250-foot section of columnar basalt. This basalt is similar to the main basalt above the upper tuff unit and was believed by Panteleyev to represent a series of early flows rather than sills. If this is so, then eruption of the acid tuffs must have been more or less contemporaneous with eruption of the earliest Level Mountain basalt.

A potassium-argon age of 15 m.y., or late Miocene, has been obtained on biotite collected by Mr. C. S. Ney from Panteleyev's upper tuff unit.

### *Level Mountain Group* (*Map-unit 18*)

The two areas of flat-lying basalt along the eastern boundary of the map-area are small outliers on the western edge of a vast lava field that extends almost 40 miles to the east and underlies over 1,500 square miles. The western limit of the basalt is marked by a steep escarpment that exposes many tiers of reddish brown-weathering columnar flows separated by thin layers of brick-red scoriaceous flow breccia. In Tulsequah area at least 25 flows with an aggregate thickness of over 1,500 feet are exposed. The base of the pile rests on an old erosion surface, exposed in section at several places along the base of the escarpment. Mesozoic sediments below the oldest flow are fractured, deeply weathered and capped by a thin regolith of rounded pebbles in a grey, earthy matrix. A thick layer of ash and cinders separates the regolith from the base of the first flow, forming an effective thermal insulator and preventing any apparent baking or alteration of the underlying soil layer. At several places the basalt has filled old stream channels and near the southern end of the Heart Peaks escarpment the early flows must have entered a large body of water. There the normal columnar jointing gives way to well-developed pillow structure in the lower few hundred feet of the pile.

Most of the flows are dark grey to black, fine-grained, equigranular basalt. Open vesicles are developed in the upper part of many flows and some contain amygdules of aragonite or chalcedony. Several of the thicker flows are porphyritic, containing 10 to 15 per cent clear, honey-yellow labradorite laths up to $\frac{1}{4}$ inch across. Microscopically all the non-vesicular flows are porphyritic or micro-porphyritic olivine basalt, comprising about 50 per cent labradorite ($An_{50-60}$), 30 per cent augite, and 10 per cent olivine. The remaining 10 per cent is made up of basaltic glass, ores, and a trace of apatite.

As outlined in the previous section, the earliest basalt flows may be as old as late Miocene. The youngest flows exposed in the map-area are older than the last stage of Pleistocene glaciation, but a six-foot layer of unconsolidated material resembling till was observed below the uppermost flows east of Heart Peaks. If this material is in fact till, then eruption of the basalt must have continued into the Pleistocene Period.

## Plutonic Rocks

The crystalline rocks of Tulsequah map-area can be divided into three main classes: the Coast plutonic rocks, minor intrusions, and ultramafic intrusions. The Coast plutonic rocks are confined to the southern and western parts of the area. They comprise the central plutonic complex and the large batholithic masses of relatively uniform composition and texture that underlie much of the eastern flank of the Coast Crystalline Belt. The minor intrusions, stocks, plugs, and tabular bodies, have a wider distribution and are more varied in texture and composition. Ultramafic rocks and associated diorite and gabbro are localized along major faults in the northeastern part of the map-area.

The age of the crystalline rocks cannot be determined as precisely as the age of sedimentary and volcanic strata, nor can lithological correlations be made with the same confidence. Thus, in defining map-units, the composition, texture, and other physical properties of the rock are of more importance than the age. Nevertheless, an attempt has been made to relate age boundaries to compositional boundaries by extrapolating from the relatively few points where age relationships are known. It is assumed, in the absence of contrary evidence, that granitic rocks of similar composition, texture, and structure are of similar age. While this is probably valid in most instances, there are undoubtedly exceptions that will become apparent with more detailed mapping and the determination of more absolute ages.

## Coast Plutonic Rocks

### (*Map-units 6, 13 and 16*)

In Tulsequah map-area the Coast plutonic rocks may be divided into three main groups: an older group of foliated quartz diorite, believed to be of Lower or Middle Triassic age; an undivided group, comprising the Central Plutonic Complex, of pre-Upper Cretaceous age; and a younger group of quartz monzonites of Cretaceous and early Tertiary age.

### *Lower or Middle Triassic*

#### *Foliated Quartz Diorite (Map-unit 6)*

This group of rocks underlies approximately 300 square miles in the southeastern part of the map-area. The rocks are fine to medium grained and range in composition from diorite to quartz monzonite, the majority being quartz diorite and granodiorite (Fig. 16). Their colour index is about 25 per cent, with hornblende, virtually altered to chlorite, the most abundant mafic constituent. The feldspars are opaque, chalky white or tinted pink from the inclusion of alteration products. The most characteristic feature of the rocks is their strong mineral alignment, both foliation and lineation, a feature that is poorly developed in younger members of the Coast plutonic rocks. The internal structure is complex and bears no obvious relationship to contacts with older or younger rocks.

In thin section the rock exhibits a high degree of alteration. Plagioclase in subhedral grains is highly charged with sericite, epidote, and iron oxides, and ragged poikiloblastic grains of hornblende are partly or wholly altered to chlorite (pennine). The plagioclase is mostly andesine, simply twinned, and in most sections unzoned or with slight normal zoning in the outer rims of the crystals. Quartz and potash feldspar are interstitial to the plagioclase and hornblende. Accessory minerals include apatite, epidote, magnetite, and rarely sphene.

Clearly intrusive, discordant contacts with older rocks were noted in only a few places. On the east side of Tatsamenie Lake, for example, an apophysis of foliated quartz diorite cuts across the trend of pre-Upper Triassic sediments. The quartz diorite is enriched in

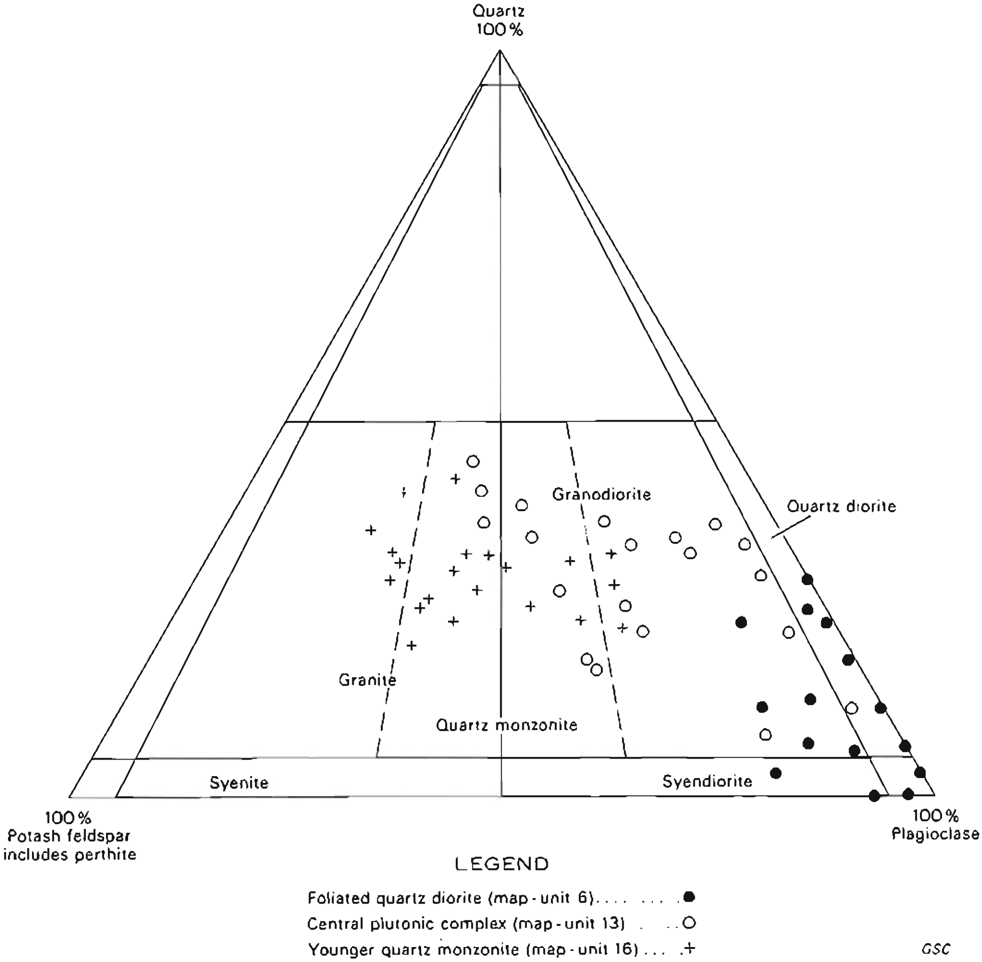


FIGURE 16. Proportions (volume per cent) of quartz, potash, feldspar and plagioclase in Coast plutonic rocks of Tulsequah map-area.

hornblende near the contact and the adjacent sediments are altered to a hard, spotted-hornfels veined by magnetite-amphibole stringers. More commonly the contacts are concordant, commonly with complex interdigitation of crystalline and non-crystalline rock. Many of the contacts with older rocks are faulted as evidenced from increased shearing, brecciation and greater hydrothermal alteration of rocks in the contact zone.

The actual age of the foliated crystalline rocks can only be inferred from stratigraphic data. They are similar in texture and mineralogy to granitic boulders in the Lower Jurassic Takwahoni Formation and there is no evidence that they intrude Upper Triassic strata. Potassium-argon determinations on two boulders from the Takwahoni give ages of 206 and 227 m.y., indicating an early Triassic age (Leech, *et al.*, 1963, GSC Age Determination Nos. 62-76, 62-77). Thus the evidence suggests that this foliated phase of the Coast plutonic rocks was emplaced in early Triassic time, possibly during the period of uplift and folding that preceded the deposition of Upper Triassic sediments and volcanic rocks.

## *Pre-Upper Cretaceous*

### *Central Plutonic Complex (Map-unit 13)*

This map-unit comprises a plutonic complex containing rocks of more varied composition and texture than those of unit 6. It includes both intrusive and ultra-metamorphic phases probably of several different ages. Migmatite, contorted gneiss and complex agmatite are minor but widespread variants, and even the more uniform granodiorite and quartz diorite phases commonly contain swarms of dark rounded or elliptical xenoliths or streaks of schlieren. Within the map-area the complex is confined to relatively small areas along the International Boundary, however, similar rocks underlie vast areas farther west in the central ranges of the Coast Mountains.

The most common and most uniform rock type is medium-grained, grey, moderately foliated granodiorite (Fig. 16) with a colour index of 15 to 25, and about 10 per cent clear granular quartz. Biotite and hornblende are present in most specimens and either may be the predominant dark mineral. Both the plagioclase and potash feldspar are light grey and can only be distinguished in thin section. Under the microscope the plagioclase is seen to form subhedral grains with strong normal zoning ($An_{50-20}$). The potash feldspar occurs both interstitially and as subhedral grains. It is rarely perthitic and shows little or no tendency to embay or replace the plagioclase. The mafic constituents and potash feldspar are usually free of alteration products.

In addition to granodiorite the complex also contains large areas of quartz diorite, and a complete spectrum of minor phases that range in composition from leucogranite to diorite with up to 60 per cent hornblende. Contacts between phases within the complex may be either gradational or abrupt. In general the lighter phases are relatively young, forming tabular dyke-like bodies and irregular stringers within darker phases or forming a matrix enclosing xenoliths and schlieren of darker rock. A single outcrop may exhibit as many as six distinct phases, the darkest being relatively old and each successively lighter phase either cutting through or surrounding darker phases. Mafic-rich phases are most abundant in contact zones where they may be completely gradational with dioritized sediments or volcanics on the one hand and with uniform granodiorite or quartz diorite on the other.

## *Cretaceous and Early Tertiary*

### *Younger Quartz Monzonite (Map-unit 16)*

This major division of the Coast plutonic rocks is characterized by fresh, non-foliated younger rocks that underlie some of the most rugged parts of the Coast Mountains. Their bold topographic expression reflects a simple, widely spaced joint system and uniform texture. Peaks and ridges are steep-walled with rounded summits, the result of exfoliation and surface decay that forms a crumbly rind of partly or wholly disaggregated mineral grains.

Most of the rocks of this group are coarse- to medium-grained quartz monzonites (Fig. 16) with a colour index of less than 10. Hornblende is the chief mafic constituent but biotite is usually present and locally it is the predominant dark mineral. Two feldspars are distinguishable in hand specimen—plagioclase forming light grey, white or occasionally greenish subhedral crystals surrounded by anhedral grains of flesh coloured potash feldspar. Clear, colourless or smoky quartz occurs as interstitial grains and subhedral crystals lining miarolitic cavities. In thin section the rocks are seen to be relatively free of alteration products. The plagioclase is strongly zoned ($An_{15}$ to $An_{65}$) with frequent reversals, resorbed grain boundaries, and many small rounded inclusions of earlier formed plagioclase crystals. Quartz and coarsely perthitic potash feldspar are interstitial to and partly replace the plagioclase. Hornblende and biotite form small, unaltered euhedral crystals with random orientation. Accessory minerals are apatite, magnetite and allanite.

The younger quartz monzonite bodies have sharp, discordant contacts with both the older crystalline rocks of the Coast Plutonic Complex and layered rocks up to and, in a few places, including the Sloko Group of volcanics. The close spatial relationship and mineralogical similarity suggest a genetic relationship between the Sloko Group of volcanics and the younger quartz monzonite. This view is supported by a potassium-argon age of 69 m.y. (Upper Cretaceous) obtained on biotite from a typical quartz monzonite batholith southeast of Niagara Mountain (Leech, *et al.*, 1963, GSC Age Determination No. 62-75).

## Minor Intrusions

### (*Map-units 12 and 15*)

Stocks, sills and dykes, many too small to be shown on the map, are found throughout Tulsequah map-area. They exhibit a great variety of textures and compositions, but, two principal groups can be recognized. The first comprises medium-grained, equigranular rocks of dioritic to granodioritic composition and the second group comprises fine-grained to aphanitic rocks, usually porphyritic, and invariably with a high content of quartz and potash feldspar. The age of the first group (map-unit 12) is unknown, save that some of the stocks cut Laberge sediments and are therefore post-Middle Jurassic. The second group (map-unit 15) of mainly felsitic rocks bears a close spatial relationship to the Sloko volcanic rocks and to the younger quartz monzonite phase of the Coast Plutonic Rocks; it is on this basis that they are considered to be of Upper Cretaceous or early Tertiary age.

### *Post-Middle Jurassic*

#### *Hornblende-biotite granodiorite (Map-unit 12a)*

Small stocks of hornblende-biotite granodiorite are found on Red Cap Creek, at the head of Sittakanay Glacier and on the ridge five miles northwest of Trapper Lake. The Red Cap stock, which has been described by Kerr (1948), and the Sittakanay stock are intrusive into Stuhini volcanic rocks. Their contacts are irregular and the margins of the stock as well as the surrounding volcanic rocks are highly altered and pyritized over a width of several tens of feet. The stock northwest of Trapper Lake cuts Triassic and older sediments of map-unit 4 and is itself intruded by quartz feldspar porphyry of map-unit 15. Unlike the other stocks in this group it is bounded by sharp, regular contacts and the intruded rocks show little or no signs of alteration.

The granodiorite is a light grey, medium-grained rock with closely spaced joints along which the rock is commonly altered and rusty. In thin section it is seen to consist of approximately 50 per cent strongly zoned andesine, 20 per cent quartz, 15 per cent potash feldspar, 10 per cent biotite, and 5 per cent hornblende.

#### *Biotite-hornblende quartz diorite (Map-unit 12b)*

The largest stock of quartz diorite occurs on the northern edge of the map-area about four miles east of Nakina River. It is the southern extension of the McMaster stock described by Aitken (1959) in Atlin map-area. In Tulsequah area it cuts Triassic and older sedimentary rocks of map-unit 4, and basic and ultrabasic rocks of the Nahlin ultramafic body. Contacts with the sediments are nearly concordant and a strong foliation has developed parallel with the contact within both the stock and intruded rocks. Contacts between the quartz diorite and ultrabasic rocks are poorly exposed and marked by a strong zone of shearing.

The quartz diorite of both the McMaster stock on the north side of Sittakanay Mountain is a medium-grained, light grey, white-weathering rock with glomeroporphyritic clusters of small hornblende and biotite crystals. Thin sections show that it is made up of about 45 per cent plagioclase, 20 per cent quartz, 7 per cent potash feldspar, 20 per cent hornblende and 8 per cent biotite. The plagioclase crystals exhibit strong normal and oscillatory zoning, ranging from labradorite in the cores to oligoclase at the rims. Quartz and potash feldspar are commonly intergrown to give graphic or myrmekitic textures.

*Hornblende diorite (Map-unit 12c)*

Small stocks of hornblende diorite intrude sedimentary and volcanic rocks of the Laberge and Stuhini Groups in the northeastern part of the map-area and sedimentary rocks of map-unit 4 in the western and southern parts of the map-area. The two roughly circular stocks that cut the Inklin Formation near the northeastern corner of the map-area have been studied in the most detail and appear to be typical of the group. They have sharp discordant contacts and the adjacent shales and greywackes are sheared and bleached to a light grey, rusty weathering hornfels for a distance of 10 or 15 feet from the contact.

The central part of both stocks is a medium-grained, even-textured rock with 20 to 25 per cent dark minerals. Near the margins the percentage of mafic minerals increases to 30 or 35 per cent and the texture becomes porphyritic with euhedral laths of plagioclase up to ½ inch long surrounded by a dark, fine-grained matrix. Feldspar laths in the porphyritic phase are strongly oriented parallel with the margins of the stock.

Under the microscope the diorite is seen to consist of subhedral grains of plagioclase, dark green hornblende, occasional books of biotite and a small amount of interstitial quartz. The feldspar composition varies from calcic andesine to calcic labradorite and many grains exhibit complex oscillatory zoning. Accessory minerals are epidote, sphene and magnetite.

*Augite diorite (Map-unit 12d)*

Diorite containing 5 to 20 per cent augite forms a large number of small rocks, sills, and dykes that intrude all rocks older than and including the Lower Jurassic, Takwahoni Formation. Their contacts are sharp, usually marked by a decrease in grain size within the diorite and a narrow zone of spotted hornfels in the adjacent sedimentary or volcanic rocks. The diorite is fine to medium grained, and dark grey in colour, with a mafic content in excess of 40 per cent.

Thin sections show it to consist of about equal amounts of plagioclase and ferromagnesian minerals, rarely with a trace of interstitial quartz and potash feldspar. The plagioclase exhibits strong normal zoning from calcic labradorite in the cores of grains to oligoclase at the rims. Ferromagnesian minerals include hornblende, augite, and minor biotite. Hornblende is usually more abundant than pyroxene, however, in some specimens the reverse is true. Apatite and magnetite are always present as accessory minerals and a few crystals of zircon were noted in one section.

## *Cretaceous (?) and Early Tertiary Intrusions*

### *Felsite and quartz-feldspar porphyry (Map-unit 15)*

Bodies of intrusive felsite are found in close association with remnants of Sloko volcanic rock throughout the southern and western parts of the area. They range in size from small cupolas only a few tens of feet across to stocks with areas of several square miles. Many of the bodies are tabular, occurring either as independent dykes or sills or in great swarms a mile or more across and many miles long. Most of the felsite intrusions, including the largest individual intrusions, are concentrated in a west-northwesterly trending belt that extends from Trapper Lake through King Salmon Lake to Yonakina Mountain. Similar bodies southwest of this belt are found cutting all phases of the Coast plutonic rocks, and a single stock northwest of Yonakina Mountain appears to occupy the central part of a collapse structure within the Inklin Formation.

The outcrops of felsite are usually deeply weathered and rusty, with a closely spaced system of joints and random fractures generally associated with concentric liesegang banding. In many outcrops the deeply weathered rusty zone is covered with a thin rind of chalky white rock from which the iron oxides have been leached. The fresh rock is usually light grey but subtle hues of green, mauve, and pink are also common. They vary in texture from aphanitic, porcelain-like rocks locally with orbicular or pisolitic textures, to fine-grained phases in which the component minerals can be distinguished with the naked eye. The majority are porphyritic with 1 to 3 mm phenocrysts of feldspar and rounded blebs of quartz. Biotite and blue-green hornblende occur both as fine flecks in the groundmass and, less commonly, as small euhedral phenocrysts. Mafic minerals rarely form more than 2 or 3 per cent of the rock and some phases contain no dark minerals at all.

Under the microscope the phenocrysts are seen to be mostly sodic plagioclase with complex oscillatory zoning and, less commonly, rounded and embayed grains of quartz and K-feldspar. The groundmass is a fine intergrowth of quartz, albite, and potash feldspar with a fairly uniform sprinkling of mafic and opaque minerals. Most of the latter appear to be pyrite.

The felsite bodies usually display sharp, straight contacts, however, the relationship is often obscured by intense hydrothermal alteration, particularly pyritization and dolomitization of both the felsite and the intruded rock. They cut all other rocks in the area except the late Tertiary volcanic rocks (17, 18), however, they exhibit ambiguous relations with respect to the Sloko volcanic rocks and the younger quartz monzonite phase of the Coast plutonic rocks. On the east side of Whiting Lake, for example, rusty weathering felsite with a high content of disseminated pyrite cuts the lower part of the Sloko Group, yet tuff-breccias within the same volcanic pile contain accidental inclusions obviously derived from the felsite. A similar contradiction is found north of Whiting Lake where a large felsite mass grades upward into tuffs and breccias of the Sloko Group and downward into medium-grained quartz monzonite, yet felsite dykes believed to be related to the main felsite body cut both the volcanic rocks and the quartz monzonite. These relationships are probably the result of contemporaneous intrusion and related volcanism. The felsites are believed to be hypabyssal, shallow intrusions related on the one hand to the Sloko volcanics and on the other to the intrusive younger quartz monzonite. On this basis the felsite is considered to be mainly of late Cretaceous and early Tertiary age.

## Basic and Ultrabasic Rocks

### *Permian* (?)

*The Nahlin ultramafic body* (*Map-unit 1*)

The Nahlin ultramafic body, with an area of over 100 square miles, is the largest of a belt of ultramafic bodies that parallel the southwestern side of the Atlin Horst. In plan it forms two long, narrow prongs that converge in an acute angle at Nahlin Mountain. The longer axis of the body, like that of the belt as a whole, trends west-northwesterly, obliquely across the main Cordilleran trend. In Tulsequah map-area it underlies the axis of the Menatatuline Range, forming barren, rounded summits over 6,000 feet high. The rocks weather to a uniform reddish brown and even at low elevations are almost devoid of vegetation.

The most common rock is a hard, tough, dark green to black peridotite consisting of fine-grained, partly serpentinized olivine, 10 to 20 per cent orthopyroxene, minor augite, and traces of chrome spinel. The pyroxene forms discrete crystals and crystal clusters from ⅛ to ½ inch across, that stand out on weathered surfaces to give the outcrops a rough, warty appearance. Zones relatively enriched in olivine or pyroxene are fairly common but do not form more than a small percentage of the total rock volume. The principal variation within the body is in the degree of serpentinization. It is most intense along contacts and sheared or brecciated zones where the normally unfoliated peridotite assumes a platy fabric accentuated by light and dark green serpentine streaks, lenses of magnetite, and a myriad of slickensided fractures. Serpentinization of unsheared peridotite containing pseudomorphs of olivine and pyroxene (bastite) has occurred in zones adjacent to sheared serpentinite and in lensoid horses surrounded by highly sheared serpentinite. Locally the highly serpentinized rock contains a filigree of fine crysotile veinlets usually less than a millimetre across. All observed thicker crysotile veins contain a brittle slip-fibre of no commercial value.

In thin section the peridotite is seen to consist of an inequigranular mosaic of olivine crystals up to 2 mm in diameter, with larger subhedral grains of orthopyroxene up to 5 mm in diameter. Wavy extinction and protoclastic textures are common. The pyroxene is mainly enstatite, usually with fine exsolution lamellae of diopsidic augite. Independent crystals of clinopyroxene are common and appear to be confined to pyroxene-rich phases of the peridotite. Serpentinization of unsheared peridotite can be observed in all stages from the initial formation of platy antigorite along grain boundaries and cracks in the olivine to complete replacement of both olivine and pyroxene. Where serpentinization is complete the original grain boundaries and cracks are preserved as veinlets of reticulated antigorite blades peppered with magnetite granules, whereas the central parts of grains are converted to clear, amorphous serpentine. Where shearing has accompanied serpentinization the entire rock is converted to a mass of feathery antigorite crystals with lensoid streaks of magnetite granules.

Although there is some variation in the relative proportions of olivine and pyroxene within the body, no gravity layering could be detected nor is there any systematic change in composition across the body as a whole. The most conspicuous internal structures are joints, shear zones and pyroxene-rich 'replacement layers'. The joints are widely spaced, tight, and show little or no evidence of movement or alteration. Serpentinized shear zones from a few feet to many tens of feet across tend to parallel the margins of the body. Contrast in the weathering characteristics of serpentinized and unserpentinized peridotite give some outcrops a gross banding that may be mistaken for compositional layering when viewed from a distance.

Pyroxene-rich layers, containing 70 to 90 per cent orthopyroxene are found throughout the central, unsheared part of the peridotite body. They are ½ to 6 inches thick and irregularly spaced, in some places occurring in swarms only a few inches apart, and at other places are separated by tens or hundreds of feet of structureless peridotite. Greater resistance of the pyroxene to weathering causes the planes to stand out as light reddish brown ribs on the surface. Most of the layers strike parallel with the margins of the peridotite body and dip steeply in either direction, however, it is not uncommon to find two or more layers running together or crossing at a low angle. Each layer has a prominent rectangular system of transverse joints or fractures that does not extend beyond the layer itself (Fig. 17). The joints are at right angles both to each other and to the plane of the layer, and each is equally well developed with a regular spacing of $\frac{1}{8}$ to $\frac{1}{2}$ inch. The joints are open, usually widest near the centre of the layer, and pinch out near the margins. In section they resemble desiccation cracks in layers of clay.

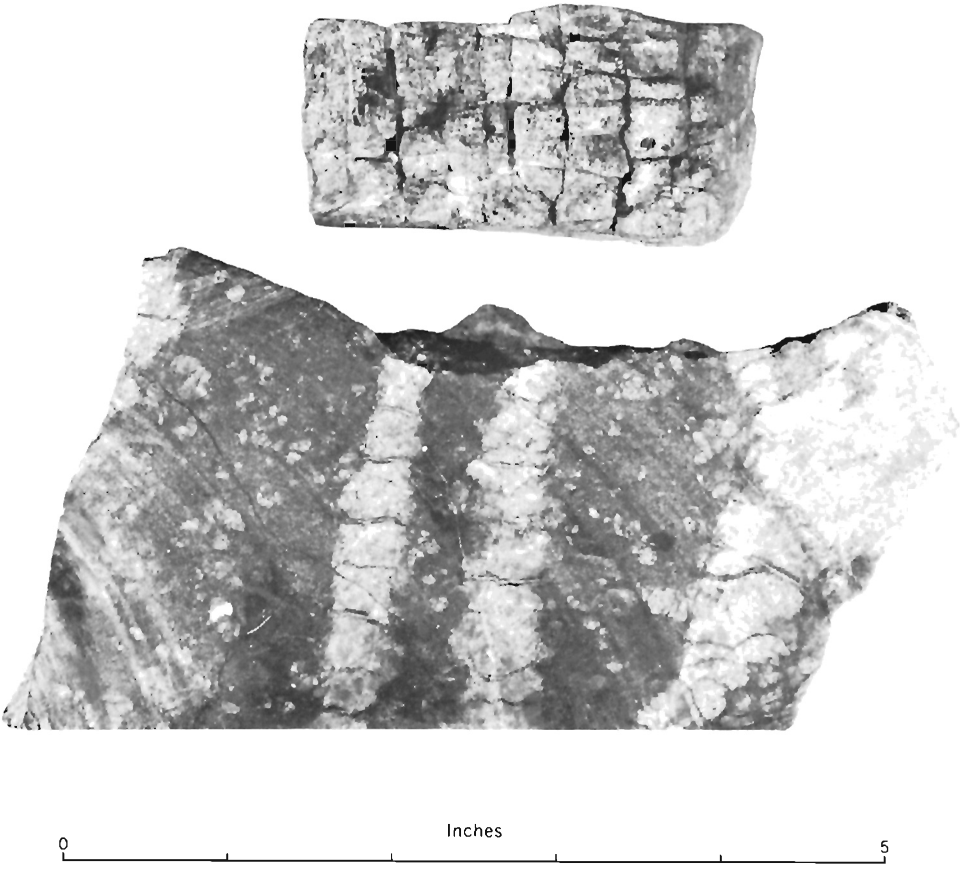


FIGURE 17. Pyroxene-rich layers in Nahlin peridotite. Plan view (top) and section (bottom) illustrate prominent rectangular joint system that is developed in layers but not in the adjacent peridotite.

The pyroxene layers are believed to have formed by replacement of olivine by orthopyroxene rather than by any mechanism of crystal settling. The flat, planar structure of the layers, their narrow uniform width and tendency to run together or cross, all suggest that the replacement was initiated along incipient fracture or shear planes. These planes may have formed either during a late stage of crystallization or in response to a subsequent cold intrusion which brought the body of the present crustal level. The rectangular joints within the pyroxene layers formed in response to shrinkage caused by a volume change during replacement of olivine by orthopyroxene.

Exposed contacts between the Nahlin ultrabasic body and layered rocks of map-units 4 and 10 are invariably marked by fault zones adjacent to which the peridotite has been sheared and serpentinized. The Nahlin fault, which bounds the southwestern margin of the body has been studied in the greatest detail and is typical of the other contacts. It comprises a subparallel network of anastomosing shear planes and fractures with steep northerly or vertical dips. Although the plane of the fault zone is roughly parallel with structures in the adjacent Laberge Group sediments, there is no similar correspondence in section. Laberge Group beds dip both toward and away from the fault zone which truncates several thousand feet of strata.

The width and complexity of the Nahlin fault zone varies. Some parts, such as that between Teditua Creek and the head of Yeth Creek, are relatively narrow with only 20 to 50 feet of sheared serpentinite separating Laberge sediments from unsheared peridotite. Farther north, above Yeth Creek, the zone of faulting is several thousand feet wide and includes a chaotic mixture of slickensided serpentinite, horses of Laberge sediments, basic rocks, and fault bounded lenses of relatively unsheared peridotite. Many of the major fault zones have been carbonatized, producing bright orange-weathering outcrops from a few feet to over 20 feet wide. Ankerite is the principal carbonate but veins of pure white, microgranular magnesite and coarsely crystalline dolomite were also observed. The carbonatized zones are riddled with a network of thin chalcedony or opal stringers, and in addition many contain traces of bright green nickeliferous chlorite.

Except for shearing and brecciation within a few feet of the fault zone the adjacent sediments, both in the Laberge Group and in map-unit 4, have been relatively little affected by emplacement of the Nahlin body. Instead most of the shearing and hydrothermal alteration has occurred within the ultrabasic rocks. Metamorphism of the adjacent sediments is nowhere above the average regional grade which, in the case of the Laberge Group, means no metamorphism at all.

Speculation as to the ultimate origin of the Nahlin ultramafic rocks is beyond the scope of this study. More detailed work may reveal a cryptic layering or other evidence of magmatic origin. There can be little doubt, however, that the body reached its present high crustal level as a solid or near solid intrusion, gliding upward along steep bounding faults.

*Other ultramafic rocks*

Three small bodies of ultramafic rock are associated with northerly trending faults in the south-central part of the map-area. The two larger bodies outcrop on the felsenmeer-covered ridge southeast of Tatsamenie Lake and in creek bottoms between the lake and the ridge. Both are surrounded by foliated hornblende diorite and one is on trend with the band of dolomitic limestone that forms a fault-bounded screen within the diorite. The small elliptical body on the ridge southwest of Tatsamenie Lake occupies a fault slice between Stuhini pillow lava and Sloko volcanics. Projected downward, this fault would also intersect the dolomitic limestone band exposed at the lake.

All three bodies are composed of black to greenish black microcrystalline serpentinite. Slickensided surfaces and small streamlined horses coated with shiny dark green serpentine are characteristic of most outcrops. A few veinlets of brittle fibrous serpentine were noted near the southern end of the largest body. The rock lacks the pseudomorphs of large crystals and crystal clusters typical of the Nahlin ultramafic rocks, and in none of them was primary olivine or pyroxene observed. In thin section the rock is seen to comprise a felted mass of antigorite and talc with minor amounts of carbonate and magnetite.

The proximity of these rocks to beds of dolomitic limestone and to fault zones, the absence of primary minerals, and the intense hydrothermal alteration of nearby rocks all suggest that these ultramafic bodies are of metamorphic origin.

*Gabbro and diorite (Map-unit 2)*

Tabular bodies of gabbro and basic diorite are associated with ultramafic rocks of the Nahlin body, particularly along its southwestern edge. They are broadly concordant with the margins of the ultramafic body, forming subparallel swarms of dykes and, less commonly, elongate stocks. The basic rocks are clearly intrusive into the peridotite. Their contacts are marked by a decrease in grain size within the gabbro, and the adjacent peridotite is altered to dark green or black serpentinite for a distance of from 6 inches to 2 feet. Many of the gabbro bodies are bounded by zones of intense shearing, and in many places sills or dykes of gabbro are broken up into rectangular boudins completely surrounded by serpentinized peridotite. The relatively brittle gabbro must have broken up during plastic deformation of the peridotite, probably during cold intrusion of the body as a whole.

The gabbro and diorite are normally fine- to medium-grained with a colour index of 50 per cent or more. Under the microscope they are seen to have a diabasic texture. Euhedral and subhedral crystals of unzoned labradorite are virtually surrounded by anhedral grains of diopsidic augite and smaller amounts of pale brown hornblende.

# STRUCTURAL GEOLOGY

The structures of Tulsequah map-area can be related to three main episodes of tectonic activity which culminated in mid-Triassic, Upper Jurassic and early Tertiary time. Each episode left a major unconformity and a group of related structures that were characteristic of that particular episode of deformation. The mid-Triassic episode, called here the Tahltanian Orogeny, was a time of uplift, folding, regional metamorphism, and granitic intrusion, the results of which are recognized in many parts of northern and central British Columbia. It is approximately equivalent to the Cassiar Orogeny as defined by White (1959), but the most abundant and detailed stratigraphic and structural evidence for a mid-Triassic orogeny are to be found in the Stikine region, home of the Tahltan indians. For this reason the name Tahltanian Orogeny is proposed for the great epoch of tectonic activity that closed the period of Carboniferous and mid-Triassic deposition and preceded the Upper Triassic period of volcanism and clastic sedimentation. Folds formed during the Tahltanian Orogeny were partly masked by younger, Upper Jurassic, folds, although the relatively greater intensity of the older folds makes it possible to distinguish between the two groups of structures in many parts of Tulsequah map-area. Structures related to the early Tertiary deformation cannot be distinguished from older structures except where Sloko rocks are affected.

## Mid-Triassic and Older Structures

### Nahlin Fault

The Nahlin fault, which forms the southern boundary of the Atlin Horst (Fig. 7) has been traced almost continuously for a distance of more than 250 miles. It extends from southern Yukon Territory southeasterly across northern British Columbia to the Cassiar Mountains where it appears to swing south into the Pinchi fault zone. The section of the fault that crosses the northeastern corner of Tulsequah map-area is bounded by basic, ultrabasic, and pre-Upper Triassic sedimentary rocks on the north, and on the south by volcanic and sedimentary rocks of the Stuhini and Laberge Groups which have a combined thickness of approximately 20,000 feet. As both the Stuhini and Laberge strata adjacent to the fault are deep-water, offshore facies, it is reasonable to assume that they were originally also deposited north of the fault and subsequently removed by erosion. Thus a minimum vertical displacement of 20,000 feet must have taken place on the Nahlin fault since Middle Jurassic (Laberge) time.

As described under Basic and Ultrabasic Rocks the width and complexity of the Nahlin fault zone varies greatly. Along some segments the movement appears to have been confined to a single fault plane comprising 30 to 50 feet of highly sheared and hydrothermally altered serpentinite. At other places the zone of faulting is several thousand feet wide and contains a network of many subparallel faults bounding small, wedge-shaped horses of both serpentinite and Laberge sediments. However, nearly all of the component faults and shear planes within the Nahlin fault zone are vertical or dip steeply northeast. Slickensides, which are frequently well developed on fault planes cutting the serpentinite, indicate nearly vertical upward movement of the northeast side. No evidence of transcurrent movement was found.

The Nahlin fault had a profound influence on both the mid-Triassic and Upper Jurassic folding as described in the following sections. Its relation to the older folds implies that it was in existence before the mid-Triassic folding terminated, and it is thus considered to be one of the oldest structures in the region. Its trace on the surface probably reflects a deep-seated crustal rift, a view consistent with its close association with ultramafic rocks.

### Folds

The trend of folds in the pre-Upper Triassic rocks is markedly different on opposite sides of the Nahlin fault. North of the fault the fold axes trend west-northwesterly, almost parallel with the fault itself, whereas south of the fault the trend of the older folds is nearly north-south. This difference in fold orientation implies that the Nahlin fault separates two discrete crustal blocks each of which was subject to a different stress pattern during the mid-Triassic, Tahltanian Orogeny.

The fundamental structure north of the Nahlin fault is an east-southeasterly plunging anticlinorium. Permian limestone of map-unit 3 is exposed in the core and is flanked by successively younger members of map-unit 4. The intensity of secondary folding within the anticlinorium is closely related to the competence of the rock involved. The massive limestone of map-unit 3 is deformed into close parallel folds with amplitudes of $\frac{1}{4}$ to $\frac{1}{2}$ mile, whereas the thin-bedded cherts and argillites of map-unit 4a are compressed into tight, near-isoclinal folds with amplitudes of a few hundred or a few tens of feet. The lack of horizon markers in the greenstone of map-unit 4b makes it impossible to trace individual folds, but the greenstone unit contains a relatively large number of small faults and shear zones which suggest that it responded to deformation by fracturing rather than folding.

The pre-Upper Triassic rocks in the south-central part of the map-area are more highly deformed than those north of the Nahlin fault. The folds trend north-south and have steep, nearly parallel limbs. Fracture cleavage, usually parallel with the bedding, is well developed in medium and thick bedded members whereas thin bedded members are characterized by bedding plane schistosity. The most intense deformation is seen in the limestone of map-unit 3 which is exposed in the cores of several anticlines south and east of Tatsamenie Lake. The beds are contorted into complex isoclinal and fan folds with greatly attenuated limbs and thickened crests. In some places diapiric folds were observed in which the limestone core is completely separated from its limbs.

The intensity of folding, as well as the grade of regional metamorphism of the pre-Upper Triassic rocks increases toward the west. Map-unit 5 and the most westerly exposures of map-unit 4 are characterized by close, north-northwesterly trending isoclinal folds and pronounced axial plane foliation. In many outcrops, particularly in the northwestern corner of the map-area, the axial plane foliation has itself been tightly folded and crenulated, indicating more than one stage of deformation.

## Upper Jurassic Structures

### King Salmon Thrust Fault

The trace of the King Salmon thrust fault runs in a west-northwesterly direction, almost parallel with the Nahlin fault farther north. It dips to the northeast and, for most of its exposed length in Tulsequah map-area, the plane of the thrust conforms to the base of the

Upper Triassic, Sinwa Formation which has been thrust southward over Lower Jurassic rocks of the Takwahoni Formation. A small outlier of limestone resting on Lower Jurassic rocks east of Trapper Lake is believed to be a klippe of Sinwa limestone which, if it is related to the King Salmon thrust, would indicate a minimum displacement of 10 miles.

At King Salmon Lake, a second, nearly parallel thrust diverges from the main thrust fault, bringing King Salmon strata over rocks of the Takwahoni Formation. This latter fault appears to cut across several thousand of King Salmon and Takwahoni beds, suggesting that these rocks were folded prior to the thrusting.

The actual fault contact between Takwahoni and Sinwa rocks is exposed at several places along the King Salmon thrust. West of Taku River, Kerr (1948) noted that minor folds in the underlying Takwahoni rocks appear to be truncated by the Sinwa Formation, a relationship that has since been confirmed on Sinwa and Headman Mountains and on the ridges both east and west of Sutlahine River. In rocks both above and below the thrust the intensity of minor folding and shearing increases markedly as the fault is approached. This is especially apparent in the overlying Sinwa limestone which, at many places near the fault, is contorted into near isoclinal folds with amplitudes of 1 or 2 feet overturned toward the south. Elsewhere within the fault zone the Sinwa Formation is brecciated and stained with hematite across a width of 10 to 50 feet. Open cavities and vugs are common between the angular breccia blocks which, in most outcrops, are partly cemented by coarse secondary calcite.

In the eastern part of the map-area, the King Salmon fault dips northward at 5 to 10 degrees. It steepens to an average of about 45 degrees in the central part of the area and dips as high as 60 degrees were noted west of Taku River. The variation in the dip of the fault and its relatively steep attitude in the western part of the map-area suggest that the thrust has been deformed by later folding.

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FIGURE 18. Small decollement fold in interbedded siltstone and greywacke of the Inklin Formation.

## Folds

Folds related to the Upper Jurassic episode of deformation are separated into two structural provinces by the King Salmon thrust. North of the thrust, evenly bedded rocks of the Inklin Formation are deformed into west-northwesterly trending open folds with amplitudes of ¼ to ½ mile. Southwest limbs are usually steeper than northeast limbs and the rocks are characterized by a well-developed north-dipping cleavage. Some folds, particularly near the thrust, are recumbent, with steeply north-dipping axial planes. Small decollement structures in which highly deformed members rest on relatively undeformed members of the Inklin Formation are well exposed in tributary valleys extending south from Inklin River (Fig. 18). North of Inklin River, folds in the Inklin rocks are cut off abruptly by the nearly vertical Inklin fault.

South of the King Salmon thrust, Takwahoni and Stuhini rocks are deformed into broad symmetrical folds of much greater amplitude than those in Inklin rocks farther north. The folds, many of which are doubly plunging, trend northwesterly in the western part of the map-area, their trend is nearly east-west. Axial plane cleavage, so well developed in rocks

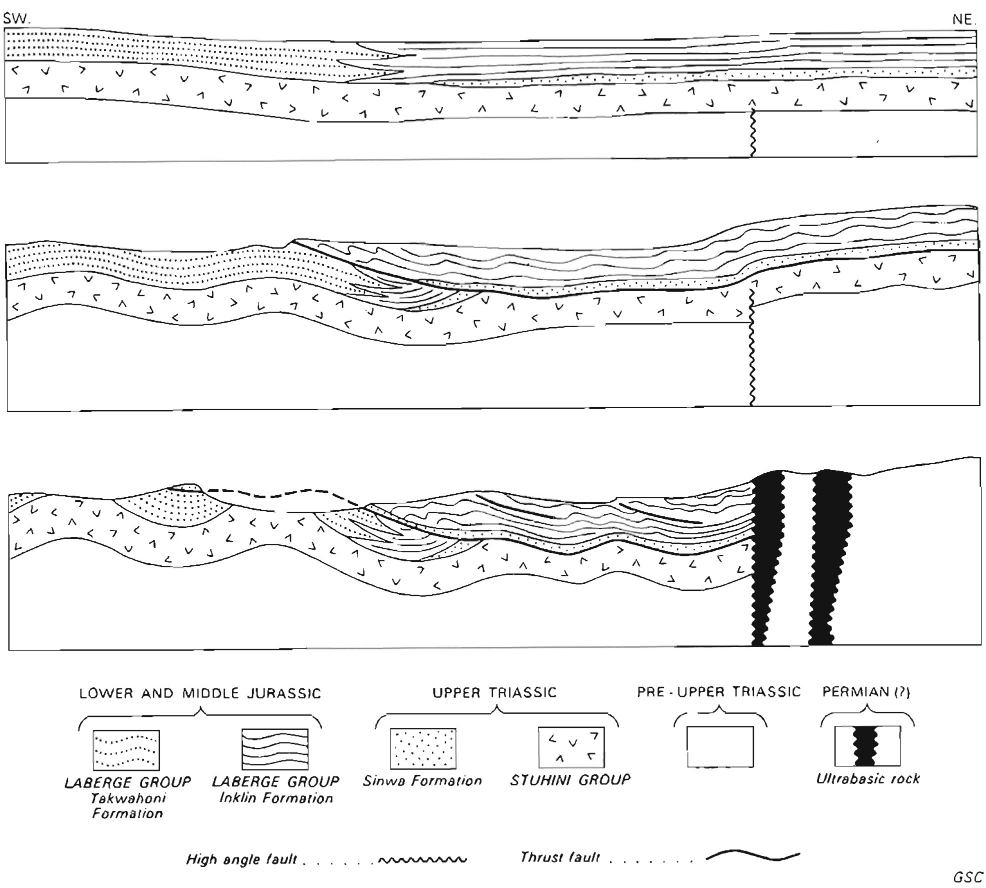


FIGURE 19. Schematic cross-section illustrating three stages in the evolution of Upper Jurassic structures and their relationship to the uplifted Atlin Horst.

north of the King Salmon thrust, is absent in lithologically similar rocks south of the fault, but there is much evidence of minor faulting and shearing, particularly in the western exposures of Stuhini Group.

The development of the Upper Jurassic folds and thrust faults is believed to be closely related to uplift of the Atlin Horst by renewed movement on the ancient Nahlin fault (Fig. 19). The asymmetrical folds and decollement in the Inklin Formation probably developed in response to gravity sliding, southward, off the southern margin of the uplifted Atlin Horst. At a later stage, as uplift of the horst continued, the early formed gravity structures in the rocks above the King Salmon thrust must have been accompanied or followed by northeast-southwest compression of strata between the horst and the Stikine Arch. This is reflected by the broad, open folds south of the King Salmon thrust and by warping of the thrust plane itself.

## Early Tertiary Structures

Many of the remnants of Sloko Group in Tulsequah map-area are preserved in graben-like blocks bounded by high angle normal faults. Similar, but smaller scale block faulting is common within the areas underlain by Sloko strata and, although the age of normal faults cutting pre-Sloko rocks cannot be established, it is probable that many of them are also of early Tertiary age. Folds in the Sloko rocks, like the faults, have random orientation and appear to be related to sagging of the strata in response to faulting or block foundering rather than to compressive folding.

# TECTONIC HISTORY

The location of Tulsequah map-area with respect to the major tectonic elements of the northwestern Cordillera is shown in Figure 7. It includes the southern edge of the Atlin Horst and the northern edge of the Stikine Arch, and spans the intervening trough of Mesozoic layered rocks. The trough is the southern extension of the Whitehorse Trough described by Wheeler (1961) in southern Yukon Territory. In Tulsequah area it is deflected eastward by the great salient of the Stikine Arch to form a gently curving embayment, named here the Taku embayment.

The sequence of Mesozoic tectonic events in Tulsequah area is recorded in the stratigraphic succession within the Taku embayment, which reflects conditions not only within the trough itself but also in the adjacent source areas. The tectonic history presented here is an interpretation based on the stratigraphy, the distribution of sedimentary and volcanic facies, and their relationship to major structural features.

The thick, widespread carbonate sections that characterize the late Permian strata suggest stable, shelf conditions during that time. Although there is no evidence of Permian facies changes or strandlines within the map-area, the predominance of bioclastic textures in the limestone indicates that low coast lines or reefs were exposed to wave action. The gradual change from carbonate deposition to chert and fine-grained clastic rocks of map-unit 4a reflects the beginning of uplift in the west and the encroachment of river-borne silts and mud into the carbonate basin. The sudden and widespread appearance of chert above the Permian limestone may be due to the release of silica into the sea by submarine volcanic emanations expelled during an early phase of the volcanism that later produced thick piles of flows and volcaniclastic rocks now preserved as the greenstones of map-unit 4b.

Tectonic activity continued into the mid-Triassic and culminated with a period of uplift, folding, metamorphism and intrusion some time between Middle (*Daonella*) and upper Triassic (*Tropites*) time. This period, called here the Tahltanian Orogeny, left a marked hiatus between the Upper Triassic and older strata, which is recognized throughout most of western and central British Columbia. In Tulsequah area the Tahltanian Orogeny was characterized by intense folding of the pre-Upper Triassic strata, particularly in and adjacent to the Coast Crystalline Belt. The trend of these folds appears to have been influenced by the Nahlin fault, which is considered to be one of the oldest structures of the region. Folding was accompanied by regional dynamothermal metamorphism which increased in intensity from the eastern to the western part of the map-area. Potassium-argon ages of 227 and 206 m.y., obtained on granodiorite boulders from Lower Jurassic conglomerate, indicate that the Tahltanian Orogeny was also a time of granitic intrusion.

The Tahltanian Orogeny was followed in Upper Triassic (Karnian) time by extensive volcanism in the western part of the map-area and rapid subsidence of the Taku embayment farther east. During this time the thick piles of volcanic and volcaniclastic rocks comprising the Stuhini Group were deposited. In the west, the presence of polymictic conglomerate, with crystalline clasts, in the lower part of the Stuhini Group indicate that parts of the Coast Crystalline Belt emerged when Upper Triassic volcanism began in early Karnian time. This emergent area, augmented by subaerial flows and volcanic islands erupted during early Stuhini time, provided a western source for the thick wedges of sediment that accumulated in the Taku embayment and which are now preserved as the bedded clastic rocks of the King Salmon Formation. During later Karnian time the locus of volcanism shifted northeast and a great volume of submarine flows was poured into the deepening Taku embayment to form the thick pillow lava sequence in the upper part of the Stuhini Group.

By the end of the Karnian stage of the Upper Triassic, volcanic activity had begun to subside and the formerly high source areas in the west had become too low to contribute coarse detritus to the central and eastern part of the map-area. Fine-grained siltstone and shale bearing *Halobia* indicate that the latest Karnian was a time of relative quiescence during which many of the volcanic islands were reduced to lowlands from which the silts and muds of the Upper Karnian deposits were derived.

The trend toward more stable conditions continued into the Norian stage of the Upper Triassic. Shales and silts were superseded by the deposition of carbonate beds represented in Tulsequah area by the Sinwa Formation. During this time a marine trough occupied the northeastern part of the map-area and received the greatest thickness of carbonate deposits. Toward the southwest, as the margin of the Taku embayment is approached, the limestone thins and shales out, indicating a low emergent area in the region of the Stikine Arch.

Beginning in early Jurassic time the western and southwestern parts of the area were again the locus of profound tectonic activity. Rapid uplift of the Coast Mountains Belt and the Stikine Arch produced a source area of high relief along the western and southwestern margin of the Taku embayment. Volcanic activity was notably absent, thus nearly all the clastic debris shed into the Taku embayment was derived from older rocks.

The western source area was deeply dissected, exposing granitic rocks that were emplaced in the early Triassic, as well as metamorphic rocks and Upper Triassic volcanic and sedimentary strata. Coarse debris from all of these older rocks was carried eastward and deposited in great piedmont fans, deltas, and channel deposits along the eastern flank of the uplifted area, where they are preserved as the greywackes and polymictic conglomerates of the Takwahoni Formation. Farther northeast, beyond the outermost deltas, the bottom of the Taku embayment sloped steeply down to the offshore trough. Thick deltaic wedges, rapidly accumulated along the foreshore, periodically slumped away and swept down the steep submarine slope as turbidity currents that settled out in the deep, central part of the trough. There the great thicknesses of silts, sands, and muds that comprise the Inklin Formation were deposited.

The width of the trough must, formerly, have been much greater than the present width of the outcrop belt, extending northeastward beyond the area now underlain by older rocks of the Atlin Horst. Toward the end of the Lower Jurassic period the Taku embayment had begun to fill with sediments, and broad deltas converged to form a low-lying plane that extended far to the northeast of the Lower Jurassic strandline. By Middle Jurassic time, shallow, brackish water conditions existed as far east as Trapper Lake where thin coal seams are found associated with Bajocian ammonites.

In Tulsequah map-area a great gap in the sedimentary record separates the Middle Jurassic shales from the Upper Cretaceous Sloko Group. Despite this, a great deal can be deduced about this interval from structural relationships and from the sedimentary record in adjacent areas to the south and east. During this time the Mesozoic rocks of Tulsequah area were folded, uplifted, and deeply eroded. Again the greatest uplift occurred in the Coast Mountains Belt and Stikine Arch but this time it was accompanied by uplift of the Atlin Horst. Between these two great positive elements the Mesozoic strata were deformed into relatively open folds with west-northwesterly trends, clearly reflecting the eastward projecting salient of the Stikine Arch. Uplift of the Atlin Horst was accomplished by renewed movement on the ancient, nearly vertical, Nahlin Fault.

With uplift of the Atlin Horst, southerly directed gravity folding and thrusting were initiated in the overlying Mesozoic sediments. The King Salmon thrust fault, which is the most extensive single fault to develop in response to this uplift, is localized along the base of the Sinwa limestone, below the Lower and Middle Jurassic, Inklin Formation. Movement of at least ten miles occurred on this one fault, and many lesser thrusts and decollement indicate a massive southerly directed tectonic transport of rocks above and along the southern flank of the uplifted Atlin Horst.

Material removed by erosion from this vast uplifted area was carried south of the map-area and deposited, during Upper Jurassic time, in the Bowser Basin (Fig. 7). The northern strandline of the Bowser Basin has been removed by later erosion but the most northerly exposures of Bowser sediments include extensive channel conglomerates that thicken northward and consist almost entirely of chert pebbles that could only have come from Permo-Triassic rocks north of the Nahlin fault.

The Upper Jurassic folding and uplift marked the end of marine sedimentation in Tulsequah map-area. Since that time the area has remained emergent and by late Cretaceous time it had become a deeply dissected area of moderate to high relief. Beginning in the Late Cretaceous or early Tertiary, a large number of volcanic centres began to erupt in the western and central part of the map-area, giving rise to the Sloko volcanic deposits. The eruptions were of the explosive type, throwing out quantities of ash and coarse pyroclastic debris, and lesser amounts of andesitic and dacitic lava. Much of the loose volcanic material was quickly eroded and transported to intermontane basins where great thicknesses of volcanic sediments accumulated, together with primary pyroclastic deposits. The presence of large carbonized logs and coaly layers in the tuffaceous beds indicate that whole forests were periodically destroyed by the rapid accumulation of volcanic debris.

The volcanic activity was accompanied by extensive normal faulting and block foundering as well as shallow but widespread plutonic activity. Emplacement of the younger quartz monzonite batholiths of map-unit 16, intrusion of the felsite stocks and dykes of map-unit 15, and eruption of the Sloko volcanics are all related to the same widespread episode of late Cretaceous and early Tertiary igneous activity.

It is not known when the Sloko volcanism ceased, but a potassium-argon age of 15 m.y. on biotite-bearing tuff below the Heart Peaks basalt indicates that sporadic eruption of acidic lavas continued until at least late Miocene. By the time the Level Mountain basalt was erupted in late Tertiary the eastern and central part of the map-area had been reduced to a gently rolling plateau drained by narrow, steep-walled valleys. Onto this surface the basalt was poured, filling the youthful valleys and spreading in thin sheets over many square miles of the plateau surface. The quiet outpouring of basalt continued periodically into the Pleistocene, by which time the main topographic features of the area had been established.

# ECONOMIC GEOLOGY

## History of Mining and Prospecting

The early history of mining and prospecting in Taku River area was reviewed by Kerr (1948), who mentioned a record of gold discovery along Taku River as early as 1875. During the Klondike Rush of 1897 and 1898 the Taku was used as a route of entry to the interior and this lead to extensive prospecting of the country accessible from Taku Valley. In 1923 the Tulsequah Chief property was discovered on the east side of Tulsequah River, and active development of the property in 1929 attracted prospectors who staked claims. Those which were later to become the Big Bull and Polaris Taku mines were both discovered in 1929, as were the Ericksen-Ashby and several other smaller properties situated in the lower part of Taku Valley.

Early attempts at development were abandoned and it was not until 1937 that the Whitewater property was brought into production as the Polaris Taku mine. It continued to operate until 1951, during which time a total of 719,336 tons of ore was milled, yielding gold valued at more than $8,000,000. Following closure of the Polaris Taku mine in 1951 the mill and camp were leased to the Consolidated Mining and Smelting Company of Canada Limited (now Cominco Ltd.) which started production from the Big Bull (Manville) and Tulsequah Chief mines that same summer. Ore from both mines was trucked to the Polaris Taku mill and concentrates shipped by barge down Taku River to tidewater. From 1951 until production ceased in 1957 due to low metal prices, combined production from the Big Bull and Tulsequah Chief mines amounted to 1,029,089 tons of ore milled, yielding 94,254 ounces of gold, 3,400,773 ounces of silver, 13,603 tons of copper, 13,463 tons of lead, 62,346 tons of zinc, and 227 tons of cadmium.

In recent years Tulsequah area has received considerable attention from several major exploration companies who have employed helicopters to take prospectors to remote parts of the map-area and to carry out geophysical and geochemical surveys of selected areas. Many new properties have been staked since the field mapping was completed. The more promising prospects have been explored by stripping, trenching or diamond drilling and several, such as the Bing, Thorn, and Ericksen-Ashby are scheduled for further development.

## Geological Associations of Mineral Deposits

In addition to staked properties, many mineral occurrences were noted in the course of field mapping. With few exceptions there is a close correlation between the type of mineralization and the geological environment.

Small amounts of nickel, asbestos, and magnesite are associated with ultrabasic rocks in the Menatatuline Range and on the ridge southeast of Tatsamenie Lake. All the asbestos occurrences seen in the course of field mapping are small and consist of short, brittle fibre, however, commercial quality fibre is reported by prospectors from the head of Yeth Creek.

Traces of nickel (millerite) and veins of magnesite are found in shear zones along the margins of the Nahlin ultramafic body. The nickel-bearing zones are sheared, carbonated serpentinite, veined with a stockwork of chalcedony and opal stringers.

Occurrences of copper were most frequently found associated with the Upper Triassic volcanic rocks, with the younger quartz monzonite phase of the Coast plutonic rocks, and with felsite porphyry bodies believed to be a phase of the quartz monzonite. Within the Stuhini volcanic rocks copper is found as thin films of malachite on joint surfaces or small amounts of disseminated chalcopyrite in shear zones, particularly where the volcanics are altered near intrusive bodies. Similar occurrences are rare in pre-Upper Triassic volcanics, but small lenticular quartz veins carrying pockets of massive chalcopyrite were noted at a few places within the pre-Upper Triassic sediments. Copper occurrences related to the quartz monzonite and to the felsite porphyry bodies, such as the FAE and Bing properties, usually contain significant amounts of molybdenite as well as chalcopyrite. Mineralization was confined to zones of fracturing either within the intrusion or the adjacent wall-rock which is usually silicified and feldspathized. The chalcopyrite and molybdenite are found both as veins and disseminations throughout the sheared and altered rock.

Molybdenum occurs without copper at many places in the younger quartz monzonite and its related leucocratic phases. The Nan and Elaine properties are the largest deposits of this type so far located within the area, however, smaller occurrences are found within and adjacent to the swarm of felsite dykes that runs northeasterly from Sittakany Valley, and in aplitic phases of the younger quartz monzonite northwest of Whiting Lake.

Base metal deposits with significant amounts of gold and silver occur as replacement bodies in sheared Stuhini volcanic rocks (Tulsequah Chief and Big Bull), in sheared Permian limestone (Ericksen-Ashby), and in quartz-feldspar porphyry bodies cutting Stuhini volcanic rocks. Each of these deposits is in or near Stuhini volcanic rocks cut by young felsite intrusions. This same geological association applies to most of the small lead-zinc occurrences noted in the course of field mapping. The country rock is highly silicified, carbonatized, and albitized, and charged with finely disseminated pyrite. The altered rock commonly contains quartz-carbonite, barite, or stibnite stringers. The principal ore minerals, which may occur as veins or local disseminations, are chalcopyrite, sphalerite, argentiferous galena, and tetrahedrite.

The arsenical gold ores of the Polaris Taku mine also occur in highly fractured and carbonatized Stuhini volcanic rocks. The gold-bearing arsenopyrite is disseminated in the altered rock and in quartz-carbonate stringers. No other deposits of this type were noted within the area.

Antimony occurrences cannot be related to any particular host rock. The Council, Surveyor, and Baker properties are in Stuhini volcanic rocks whereas the stibnite veins west of Tatsamenie Lake are in pre-Upper Triassic sediments and those on the east side of Tatsamenie Lake in foliated meta-diorite. In each case, however, the surrounding rock is intensely altered to a mass of quartz and carbonate with finely disseminated pyrite.

The large zone of hydrothermally altered rock on the west side of Tatsamenie Lake contains occasional veins of stibnite and barite, one known occurrence of chalcocite, and many quartz-carbonate veins either with or without pyrite. It is the largest of several such zones in a belt extending northwesterly to include the Thorn and B.W.M. properties and southeasterly to include the Bing and FAE groups. The altered rocks are bleached to a light buff or greenish colour with a deep rind of rusty weathering. The original rock textures have been largely destroyed and replaced with a fine mosaic of quartz-albite and carbonate with occasional rhombs of ferrodolomite. Microscopic veinlets of quartz and carbonate are common and the entire rock is charged with finely disseminated pyrite and iron oxides. This type of alteration is similar to that surrounding most of the lead-zinc-copper deposits and all of the stibnite occurrences known in the area. In a few places the alteration can be related to felsite intrusions; in others, where no intrusive body is exposed, it is reasonable to expect that one is present at moderate depth below the surface. If these altered zones are in fact contact aureoles then the presence of stibnite, barite, and chalcocite would suggest a low temperature environment, relatively near the outer limit of alteration. Deposits of lead, zinc, and copper such as the Thorn, or deposits of copper-molybdenum such as the Bing and FAE might logically be expected at greater depth, adjacent to or within the intrusive body.

Although more data are needed to prove a genetic relationship between many of the mineral deposits, between the zones of quartz-albite-pyrite alteration and the young felsite intrusions there is unquestionably a close spatial relationship. If the relationship is genetic then the felsite bodies are polymetallic, inasmuch as Mo, Cu, Pb, Zn, Sb, Ag, and Au have all been found either within them, or within adjacent zones of alteration. Moreover, there appears to be a zonal distribution of metals with respect to the top of the intrusions. Molybdenite is found in the coarse-grained quartz monzonite phases and deep-seated dykes and sills that exhibit little or no wall-rock alteration. Copper appears with molybdenum in small stocks and cupolas such as the Bing and FAE, and copper, lead, and zinc are found in the altered wall-rock adjacent to felsite cupolas, dykes, and sills as at the Tulsequah Chief, Thorn and Ericksen-Ashby. Veins of stibnite and barite are most abundant in the outer part of the altered zones, some distance above the actual intrusion.

## List of Mineral Properties

The locations of mineral properties listed here are shown on the accompanying Map, 1262A. The brief summary descriptions are based on field observations, published reports, and information supplied by company geologists. For more detailed descriptions of many of the properties the reader is referred to the reference listed below.

### 1. Polaris Taku Mine (Formerly Whitewater)

References: Minister of Mines, B.C. Ann. Repts.: 1929, p. 142; 1930, p. 122; 1931, p. 61; 1932, p. 64; 1933, p. 172; 1935, pp. B27, G47; 1936, p. B21; 1937, pp. A7, B3, 40, 42; 1938, pp. A33, 39, B24; 1939, pp. 35, 42, 64; 1940, pp. 23, 51; 1941, pp. 24, 53; 1942, pp. 26, 53; 1946, pp. 35, 61; 1947, p. 62; 1948, p. 61; 1949, p. 72; 1950, p. 73; 1951, pp. 40, 74; Smith, Alexander, 1948, p. 112; Kerr, F. A., 1948, p. 65.

The Polaris Taku mine was in operation from 1937 until 1951 with the exception of the war years, 1942 to 1946, when production was suspended. It is a gold property, the gold occurring in fine needles of arsenopyrite disseminated in a fault-bounded wedge of Stuhini volcanic rocks. The deposits are shear zones containing numerous replacement veins adjacent to which the wall-rock is carbonatized and locally albitized.

### 2. Tulsequah Chief

References: Minister of Mines, B.C. Ann. Repts.: 1924, p. 89; 1926, p. 106; 1928, p. 103; 1929, p. 136; 1930, p. 122; 1936, p. 321; 1946, p. 61; 1947, pp. 68-70; 1948, p. 63; 1949, p. 73; 1950, p. 74; 1951, p. 40; 1952, pp. 39-75; 1953, pp. 42,81; 1954, p. A80; 1955, pp. 11, 12, 13; 1956, pp. 12, 13; 1957, p. 5; Smith, Alexander, 1948, p. 112; Kerr, F.A., 1948, p. 58.

The Tulsequah Chief mine was operated by the Consolidated Mining and Smelting Company of Canada Limited from 1951 until 1957. The ore deposits occupy shear zones in altered Stuhini volcanic rocks. The alteration is associated with large felsite dykes and northeasterly trending faults. Ore minerals consist of massive, fine-grained, pyrite and chalcopyrite in lenses, and sphalerite, pyrite, and galena in a dense quartz-carbonite-barite gangue. Metals produced were copper, lead, zinc, gold, silver, and cadmium.

### 3. Big Bull (Manville)

References: Minister of Mines, B.C. Ann. Repts.: 1929, pp. 125, 118, 139; 1930, p. 121; 1931, p. 62; 1936, p. B21; 1946, p. 61; 1947, p. 68-69; 1948, p. 62; 1949, p. 73; 1950, p. 74; 1951, pp. 40, 74; 1952, pp. 39, 75; 1953, pp. 42, 81; 1954, pp. 47, 80; 1955, pp. A46, 11; 1956, pp. A47, 12; 1957, pp. A43,5; Smith, Alexander, 1948, p. 121; Kerr, F.A. 1948, p. 61.

The Big Bull mine was operated during the same period as the Tulsequah Chief, and ore from both mines was concentrated at the same mill. Mineralization at the Big Bull is similar to that of the Tulsequah Chief, comprising mixed sulphide replacement of sheared and highly altered Stuhini volcanic rocks. As at the Tulsequah Chief the alteration is related to dykes and northerly trending faults.

### 4. Ericksen-Ashby

References: Minister of Mines, B.C. Ann. Repts.: 1951, p. A74; 1952, p. A76; Kerr, F.A., 1948, p. 71; 1964, Prospectus of Ericksen-Ashby Mines Ltd.

This property was first staked in 1929 and development work, including hand-trenching and drilling, was carried out intermittently until 1963. In September 1963, Ericksen-Ashby Mines Ltd. was incorporated as a private company, and in 1964 it began an extensive diamond-drilling program on the property. Mineralization consisted of massive sulphide replacement of limestone lying immediately below the Stuhini volcanic rocks, which are cut by a large tabular body of fine-grained quartz monzonite. The minerals present are pyrite, sphalerite, galena, and freibergite.

### 5. Red Cap

References: Minister of Mines, B.C. Ann. Repts.: 1930, p. 122; 1931, p. 63.

Mineralization on this property is related to the contacts of a small granodiorite stock. The adjacent Stuhini and King Salmon volcanic rocks have been silicified, carbonatized, and heavily pyritized for a distance as much as 3,000 feet from the contact. Within this altered zone are quartz-carbonite-pyrite veins with lesser amounts of sphalerite, galena, chalcopyrite, and arsenopyrite.

### 6. B. W. M.

References: Minister of Mines, B.C. Ann. Repts.: 1950, p. A75.

This property is on a large rusty zone adjacent to a small quartz diorite stock that cuts upper Triassic volcanic and sedimentary rocks. Both the stock and the altered wall-rock are cut by tabular and irregular masses of pink quartz feldspar porphyry. Fracture zones within the porphyry and for several feet into the surrounding rock are filled with drusy quartz veins and vugs containing calcite, limonite, and chalcopyrite.

### 7. Thorn

References: Minister of Mines, B.C. Ann. Repts.: 1963, p. 6.

The Thorn group of claims, owned by Julian Mining Co. Ltd. of Vancouver, is in the bottom of a deep narrow valley occupied by a northwesterly flowing tributary of Sutlahine River. The ridge to the northeast is capped by several thousand feet of Sloko volcanics, whereas the ridge to the southwest consists of Stuhini pillow lavas. Intermittent outcrops in the creek bottom include andesite believed to be altered Stuhini lava and a green quartz-feldspar porphyry that may be part of a system of feeders for the overlying Sloko volcanics. The porphyry and nearby andesite are charged with disseminated pyrite and lesser amounts of chalcopyrite and, in addition, a stockwork of quartz veins with chalcopyrite, tetrahedrite, stibnite and enargite. The company reports significant values in copper, gold, silver, lead and zinc.

### 8. Bing

The Bing group is near the margin of a large body of foliated diorite adjacent to which the pre-Upper Triassic volcanic and sedimentary rocks have been intensely dioritized. In the vicinity of the property the dioritized rocks are cut by young feldspar porphyry dykes, sills, and irregular masses, which have caused further feldspathization and silicification of the intruded rock. Mineralization, comprising disseminated chalcopyrite and molybdenite, is related to fracturing within this altered zone. Chalcopyrite also occurs with pyrite in masses and knots of epidote.

### 9. FAE

References: Minister of Mines, B.C. Ann. Repts.: 1963, p. 7.

Low grade disseminations of chalcopyrite and molybdenite occur in silicified fracture zones along the southern margin of a small locally porphyritic, quartz monzonite stock which cuts pre-Upper Triassic sediments and volcanics. A magnetite-rich skarn on the north side of the same body also contains small amounts of copper.

### 10. Nan

Float, bearing molybdenite, was discovered on the glacier at the head of the south fork of Sittakany River in 1961. Although part of this comes from aplitic dykes that cross the valley at many places, the greater part appears to have been supplied from a tabular body of hydrothermally altered felsite, exposed in the cirque on the southern side of Mount Ogden. The body has an exposed length of over 5,000 feet and a maximum width of about 500 feet. Molybdenite is sporadically distributed throughout the body as small clots and fracture coatings.

### 11. Elaine

The Elaine claims are on the contact of a well-defined apophysis of quartz monzonite that cuts foliated diorite south of Trapper Lake. Small amounts of molybdenite are found as local disseminations within the quartz monzonite, but the main showing consists of three east-west-trending quartz veins (up to 18 inches wide) within the diorite a short distance from the quartz monzonite contact. Coarse-grained molybdenite forms rosettes up to six inches across along the selvages of the veins.

### 12. Surveyor, and 13. Council

References: Minister of Mines, B.C. Ann. Repts.: 1930, p. 121; Kerr, F.A., 1948, p. 69.

Both of these properties are in sheared and altered Stuhini volcanic rocks. The deposits consist of veinlets of massive and disseminated stibnite and pyrite in a quartz-carbonate gangue.

### 14. Baker Group

This property was not visited but is reported to cover a large altered zone in volcanic rock containing veins and disseminations of stibnite.

## REFERENCES


Aitken, J. D.

1959: Atlin map-area, British Columbia; *Geol. Surv. Can.*, Mem. 307.

Cockfield, W. E.

1926: Explorations between Atlin and Telegraph Creek; *Geol. Surv. Can.*, Sum. Rept. 1925, pt. A.

Frebold, Hans

1964: Lower Jurassic and Bajocian Ammonoid Faunas of northwestern British Columbia and southern Yukon; *Geol. Surv. Can.*, Bull. 116.

Gabrielse, H.

1962: Cry Lake map-area, British Columbia; *Geol. Surv. Can.*, Prel. Map. 26-1962.

Gabrielse, H., and Souther, J. G.

1962: Dease Lake map-area; *Geol. Surv. Can.*, Prel. Map. 21-1962.

Geological Survey of Canada

1957: Stikine River Area, Cassiar District, British Columbia; Prel. Map 9-1957.

Hoadley, J. W.

1953: Geology and mineral deposits of the Zeballos-Nimpkish Area, Vancouver Island, British Columbia; *Geol. Surv. Can.*, Mem. 272.

Holland, S. S.

1964: Landforms of British Columbia, A physiographic outline; *B.C. Dept. Mines and Petrol. Resources*, Bull. 48.

Kerr, F. A.

1931: Explorations between Stikine and Taku Rivers, B.C.; *Geol. Surv. Can.*, Sum. Rept. 1930, pt. A.

1948: Taku River map-area, British Columbia; *Geol. Surv. Can.*, Mem. 248.

Leech, G. B., Lowdon, J. A., Stockwell, C. H., and Wanless, R. K.

1963: Age determinations and geological studies (including isotopic ages—Report 4); *Geol. Surv. Can.*, Paper 63-17.

Marcus, M. G.

1960: Periodic drainage of glacier-dammed Tulsequah Lake, British Columbia; *Geograph. Rev.*, vol. L, No. 1, pp. 89-106, Jan. 1960.

Matthes, F. E.

1942: Glaciers; *in* Physics of the earth, vol. 9, Hydrology; New York, McGraw-Hill Co., pp. 149-219.

Penteleyev, André

1964: A late Tertiary sequence in the Sheslay River vicinity, Stikine area; Univ. British Columbia, B.A. thesis.

Smith, Alexander

1948: Tulsequah Area, *in* Structural geology of Canadian ore deposits; *Can. Inst. Mining Met.*, Jubilee Volume, 1948.

Souther, J. G.
1959: Chutine map-area; *Geol. Surv. Can.*, Prel. Map 7-1959.
1960: Tulsequah map-area; *Geol. Surv. Can.*, Prel. Map 6-1960.

Souther, J. G., and Armstrong, J. E.
1966: North central belt of the cordillera of British Columbia; *in* Tectonic history and mineral deposits of the western cordillera; *Can. Inst. Mining Met.*, Special Vol. No. 8, pp. 171–189.

Thorarinsson, S.
1939: Vatnajokull: Scientific results of the Swedish-Icelandic Investigations (1936-37-38), Chapter IX: The ice dammed lakes of Iceland with particular reference to their values as indicators of glacier oscillations; *Geografiska Ann.*, vol. 21, 1939, pp. 216-242.

Wheeler, J. O.
1959: Mesozoic tectonics of central southern Yukon; *Geol. Assoc. Can.*, vol. 11.
1961: Whitehorse map-area, Yukon Territory; *Geol. Surv. Can.*, Mem. 312.

White, Wm. H.
1959: Cordilleran tectonics in British Columbia; *Bull. Am. Assoc. Petrol. Geol.*, vol. 43, No. 1, Jan. 1959.

*Appendix I*

# STRATIGRAPHIC SECTIONS

*Section 1*

PERMIAN (Map-unit 3)

Section measured on ridge 2 miles south of the western end of Victoria Lake.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Triassic and Older (Map-unit 4) (*See* section 2) | | |
| | Conformable contact | | |
| 17 | Limestone, skeletal, light to medium grey, medium grained; 2- to 4-foot beds; white weathering; abundant crinoid, shell and bryozoan debris, occasional large solitary corals. | 140 | 2,540 |
| 16 | Limestone, medium grey, fine grained, massive; weathers light grey to white; abundant crinoid and shell debris and occasional fusulinid tests. | 215 | 2,400 |
| 15 | Limestone, medium grey, fine grained; 1- to 6-foot beds; weathers white to brownish grey; some beds contain abundant large, Yabeina-like fusulinids. | 35 | 2,185 |
| 14 | Limestone, medium grey, fine grained, massive to thick bedded; weathered surface light grey with random network of very thin siliceous ribs. | 370 | 2,185 |
| 13 | Limestone, coquina, brownish grey, fine grained; closely packed foraminiferal test including large Yabeina-like fusulinids; regular 1- to 2-foot beds; weathers medium grey. | 15 | 2,150 |
| 12 | Limestone, light grey, fine grained; massive, in part bioclastic with crinoid, shell, and bryozoan fragments, and lumps in a micrite matrix; weathers white. | 355 | 1,765 |
| 11 | Limestone, dolomitic, brownish grey, fine grained; uniform 2- to 3-foot beds; weathers light grey. | 210 | 1,410 |
| 10 | Limestone, bioclastic, medium grey, fetid; composed of medium to coarse skeletal grains (largely crinoid; bryozoan and molluscan debris); occasional small fusulinid tests; weathers white. | 320 | 1,200 |
| 9 | Limestone breccia, medium grey with scattered nodules of dark grey chert; breccia blocks up to 1 foot in diameter are entirely bioclastic limestone cemented by foraminiferal limestone; weathers white. | 60 | 880 |
| 8 | Limestone, medium grey, fine grained, fetid; massive. | 220 | 820 |
| 7 | Limestone, light grey with yellow staining on fracture surfaces, fine grained, autoclastic. | 20 | 600 |
| 6 | Limestone, dolomitic, medium grey with irregular brownish grey dolomitized patches; massive. | 210 | 580 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 5 | Limestone, medium grey, fine grained; thick bedded to massive; weathers light grey; occasional small crinoid fragments. | 70 | 370 |
| 4 | Limestone, dolomitic, medium grey with irregular brownish grey dolomitic patches; fine grained; 2- to 4-foot beds; scattered, highly irregular silicified patches that weather to a rough, hackley surface; occasional crinoid and bryozoan fragments. | 130 | 300 |
| 3 | Limestone, greyish brown, cherty, very fine grained; 1- to 8-inch beds with irregular bedding surfaces; weathers medium grey, flaggy; occasional small crinoid stems and poorly preserved fusulinids. | 80 | 170 |
| 2 | Limestone, medium grey, crystalline, fine grained; 2- to 3-foot beds; scattered, irregular chert nodules; weathers white with brown staining on joint surfaces; occasional small, poorly preserved, silicified fusulinids. | 40 | 90 |
| 1 | Limestone, light grey, crystalline, fine grained; massive, highly fractured with rectangular boxwork of veins and stringers of coarsely crystalline white, secondary calcite; fracturing due to severe deformation along axis of anticline. | 50 | 50 |

*Section 2*

TRIASSIC AND OLDER (Map-unit 4)

Section measured on ridge 3 miles south of the eastern end of Victoria Lake.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Top of section | | |
| 17 | Mainly greenstone, interlayered with minor volcanic greywacke, chert, and occasional small pods and lenses of limestone; unit is predominantly massive, locally pillow and fragmental structures are visible in the greenstone and indistinct bedding in the greywacke; weathering dark greenish grey to black. | 2,900 | 8,168 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 16 | Chert and argillaceous quartzite, dark grey to black, thin bedded; weathers dark grey to black. | 280 | 5,268 |
| 15 | Greywacke and siltstone, phyllitic, greenish grey; 1- to 2-foot beds with indistinct light and dark grey banding; weathers greenish grey. | 50 | 4,988 |
| 14 | Greenstone, dark greenish grey to black; massive; fragmental texture visible on weathered surfaces. | 45 | 4,938 |
| 13 | Greywacke, volcanic, greyish green, fine to medium grained; thick bedded to massive; sheared; brown weathering. | 160 | 4,893 |
| 12 | Greenstone, dark greenish grey to black with veins and stringers of light green epidote and white carbonate; massive. | 200 | 4,733 |
| 11 | Phyllite, light grey, lustrous; thin bedded, friable. | 110 | 4,533 |
| 10 | Limestone, crystalline, light grey, fine grained, massive. | 8 | 4,423 |
| 9 | Argillite, phyllitic, dark grey; thin bedded, sheared weathers greenish grey. | 240 | 4,415 |
| 8 | Limestone, crystalline, light grey with dark bluish grey streaks, fine grained, massive. | 75 | 4,175 |
| 7 | Mainly chert, interbedded with minor siliceous argillite and quartzite: black, medium grey, and brown; 1- to 3-inch beds (ribbon chert); weathers black to reddish brown. | 1,600 | 4,100 |
| 6 | Quartzite, argillaceous, dark grey to greenish grey; 2- to 8-inch beds with indistinct laminar banding; well-developed shear cleavage parallel to bedding, in part phyllitic; weathers greenish grey, flaggy. | 670 | 2,500 |
| 5 | Argillite, cherty, black; thin bedded, sheared; fracture surfaces coated with graphite. | 160 | 1,830 |
| 4 | Quartzite, argillaceous, dark grey to greenish grey, fine grained; 4- to 6-inch beds, sheared; weathers dark grey. | 450 | 1,670 |
| 3 | Argillite, dark grey to black; thin bedded, pronounced cleavage parallel to bedding; weathers greenish grey. | 130 | 1,220 |
| 2 | Chert, argillaceous, black; 1- to 2-inch beds, strongly sheared. | 410 | 1,090 |
| 1 | Argillite, phyllitic, dark grey to black; thin bedded to fissile; weathers greenish grey. | 680 | 680 |
| | Conformable contact | | |
| | Permian (Map-unit 3) | | |
| | (*See* section 1) | | |

*Section 3*

## KING SALMON FORMATION (Map-unit 8)

Section measured on high ridge east of Sutlahine River, 8 miles south of the junction of Sutlahine and Inklin Rivers.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Top of section, younger beds not exposed | | |
| 12 | Tuff and breccia, dark grey to black; regular alternation of coarse-grained and fine-grained, ½- to 2-foot beds; clasts comprise ash, lapilli and angular blocks up to 6 inches in diameter of basaltic-andesite, calcareous matrix; weathered surface black, rough and pitted. | 190 | 3,750 |
| 11 | Shale, dark grey, silty, fissile, with a few 2- to 6-inch interbeds of calcareous siltstone; sparse fragments of *Halobia*? | 80 | 3,560 |
| 10 | Volcanic sandstone, gritstone, and tuffaceous siltstone, interbedded; sandstone and gritstone greenish to purplish grey, siltstone greyish green; thin beds of the three rock types alternate throughout the unit; clasts in the gritstone are mainly subangular fragments of volcanic rock, but a few chips of grey chert are present in some beds; siltstone contains ammonite and pelecypod fragments. | 130 | 3,480 |
| 9 | Volcanic breccia, gritstone and sandstone, interbedded; unit comprises a regular alternation of coarse-grained and fine-grained clastic ½- to 2-foot beds, all clasts are greenish grey or purplish grey andesite; coarse clasts subrounded; fine-grained beds have indistinct banding due to size sorting. | 110 | 3,350 |
| 8 | Volcanic breccia, ½ inch to 10 inches, angular to subangular clasts of greenish and purplish grey, porphyritic andesite in a sparse matrix of the same composition; massive unit with no apparent bedding. | 100 | 3,240 |
| 7 | Shale and siltstone, unit mainly black, thin-bedded shale with a few irregular beds and lenses of light to medium grey siltstone, shale contains sparse, poorly preserved fragments of *Halobia* and *Juravites*, GSC Loc. 43693. | 190 | 3,140 |
| 6 | Volcanic sandstone, siltstone, shale and tuff, interbedded; sandstone dark to medium grey, medium grained, some beds with indistinct layering due to size sorting, ½- to 4-foot beds with siltstone or shale partings, flaggy, dark grey weathering; siltstone (greyish green) and shale (dark grey) comprise thin-bedded members from 1- to | | |

| Unit | | Thickness (feet) Unit | *Total from base* |
|---|---|---|---|
| | 30-foot thick interbedded with the sandstone; tuff, dark grey to black, fine to very coarse grained, forms members up to 30 feet thick with regular layering indistinct on fresh surfaces but appears as prominent black and white bands from $\frac{1}{8}$ to ½ inch on weathered surfaces, some beds of coarse lapilli tuff have a calcareous matrix. | 770 | 2,950 |
| 5 | Volcanic sandstone and breccia-conglomerate, interbedded, about 50% of each; sandstone, dark greenish grey to dark purplish grey, medium to very coarse grained gritstone, grains subangular to subrounded, mainly andesite fragments but including small amounts of chert, 1- to 6-foot beds; flaggy, weathering very dark greenish grey; breccia-conglomerate, clasts entirely dark greenish or purplish grey porphyritic andesite, most clasts subangular to subrounded but some well rounded, poorly sorted, beds thick, massive; weathering dark greenish grey. | 580 | 2,180 |
| 4 | Lava flows and volcanic breccia interlayered; both flows and breccia fragments consist of dark green to black, less commonly dark purple, porphyritic andesite with abundant small white feldspar phenocrysts and locally small amygdules of carbonate, bedding irregular and poorly defined, weathering dark grey to black. | 290 | 1,600 |
| 3 | Volcanic breccia and conglomerate interbedded with lesser amounts of greywacke and fine-grained tuff; breccia and conglomerate; clasts entirely dark greenish grey fine-grained andesite, angular to subrounded, $\frac{1}{2}$ inch to 6 inches in diameter, poorly sorted, crudely stratified, beds very thick with poorly defined bedding planes, large sections appear massive and structureless, weathering dark greenish grey; greywacke, medium grey, medium to coarse grained, irregular or lenticular 1- to 2-foot beds; tuff, dark grey, fine grained, fresh surfaces appear structureless but weathered surfaces display thin, white lamellar banding. | 780 | 1,310 |
| 2 | Volcanic conglomerate and greywacke interbedded; conglomerate clasts are subangular to subrounded and comprise 90% fine-grained andesite, 8% phyllitic, argillaceous quartzite, and 2% fine- to medium-grained hornblende diorite; greywacke, and matrix of conglo- | | |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | merate comprise poorly sorted angular to subrounded grains of volcanic rock and chert; weathering, dark greenish grey. | 110 | 530 |
| 1 | Volcanic sandstone interbedded with lesser amounts of lava; sandstone, dark greenish grey, very coarse grained, thick massive beds with thin partings of greenish grey tuffaceous siltstone; poorly sorted, comprising angular to subrounded grains of very fine grained to aphanitic volcanic rock, minor chert and argillite; lava, dark greenish grey, porphyritic andesite, massive; both sandstone and lava weather dark greenish grey. | 420 | 420 |
| | Base of formation not exposed | | |

*Section 4*

## SINWA FORMATION (Map-unit 9)

Section was measured across a prominent limestone ridge 12.5 miles southeast of the intersection between Sutlahine River and the southeasterly trending belt of Sinwa Formation. It is overlain disconformably by the Inklin Formation (section 5) whereas the base is cut off by the King Salmon thrust fault.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Inklin Formation | | |
| | Structurally conformable contact (disconformity) | | |
| 5 | Limestone, light yellow with dark yellow and rust coloured streaks and patches, medium to fine grained; very porous and soft; thin bedded, flaggy; upper part of unit is fractured and stained with hematite and appears to be deeply leached. | 35 | 2,415 |
| 4 | Limestone, medium grey, fine grained, massive; white weathering, freshly broken surfaces have strong petroliferous odour; fossils sparse, include sponges, pelecypod fragments and poorly preserved solitary corals and bryozoa, GSC Loc. 40433. | 1,626 | 2,380 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 3 | Limestone, silty, brownish grey; thin, flaggy bedding; light grey weathering; contains a few pelecypod fragments. | 12 | 754 |
| 2 | Limestone, medium grey, fine-grained, massive; unit includes a few thin lenticular chert beds and irregular nodules; freshly broken surfaces have strong petroliferous odour; small spherical, silicified sponges are abundant, GSC Loc. 40439. | 382 | 742 |
| 1 | Limestone breccia; fragments are highly angular and range in size from small grit-sized particles to individual blocks up to 3 feet across; 85% of fragments are fine grained; medium grey limestone; 15% light grey chert, interstices are filled with coarsely crystalline secondary calcite and locally with hematite; many open spaces including small caves lined with opaque, white calcite crystals; weathering white, locally with red hematite strains. | 360 | 360 |
| | Fault contact | | |
| | Takwahoni Formation | | |

*Section 5*

## INKLIN FORMATION

Section measured along low ridge 13 miles east of Sutlahine River and 9 miles south of Inklin River. It is a direct continuation of section 4. The lowermost beds rest with structural conformity on the irregular, deeply leached upper surface of the Sinwa Formation. The top of the Inklin Formation is not exposed.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Top of section, younger beds not present | | |
| 27 | Subgreywacke, medium grey, medium to coarse grained; 2- to 4-foot beds with flat, regular bedding planes and no partings; weathering reddish brown, flaggy. | 150 | 7,739 |
| 26 | Subgreywacke and siltstone, interbedded; subgreywacke, light grey, medium grained, $\frac{1}{2}$- to 2-foot beds; weathering reddish brown, flaggy; siltstone medium grey with dark grey laminations and streaks, thin bedded, weathering dark grey. | 180 | 7,589 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 25 | Mostly covered, intermittent outcrops of medium-grained greywacke and thin-bedded siltstone. | 490 | 7,409 |
| 24 | Siltstone and greywacke, interbedded; siltstone, dark grey with light grey laminations and streaks, thin bedded; greywacke, medium grey, fine to medium grained; 1- to 2-foot beds, weathering light brown. | 160 | 6,919 |
| 23 | Greywacke, medium grey, coarse grained; 2- to 6-foot beds; beds grade downward into coarse gritstone containing few pebbles of limestone and bluish green chert. | 150 | 6,759 |
| 22 | Covered, intermittent outcrops of fine-grained greywacke. | 420 | 6,609 |
| 21 | Greywacke, medium grey, fine to medium grained; 1- to 4-foot beds, some beds contain intraformational shale fragments; weathering light brown. | 280 | 6,189 |
| 20 | Siltstone and silty shale, finely laminated graded sequences alternate with intervals of slumped and convoluted bedding. Intraformational fragments of shale present in many of the siltstone beds; light to medium grey weathering, flaggy. | 275 | 5,909 |
| 19 | Greywacke and subgreywacke, medium to light grey, fine to medium grained; 2- to 10-foot beds, no apparent internal structures of variations in texture, some beds separated by partings of siltstone; weathering light to medium grey. | 450 | 5,634 |
| 18 | Conglomerate, pebbles of light grey fine-grained limestone (90%) and cherty siltstone (10%) in a fine-grained matrix of limy siltstone. | 10 | 5,184 |
| 17 | Siltstone and shale, light and dark grey banded, thin bedded; graded and convoluted bedding common; many of the silty beds contain intraformational shale fragments. | 230 | 5,174 |
| 16 | Subgreywacke, light to medium grey; most beds medium grained but some very coarse; ½- to 4-foot beds; thin beds exhibit grading, thick beds have no apparent textural variation; weathered surface light brownish grey, flaggy; some beds pitted from solution of carbonate grains. | 500 | 4,944 |
| 15 | Conglomerate, ¼- to 1-inch pebbles of light grey limestone in a sparse, brown siliceous matrix; weathered surface rough and pitted due to preferential solution of the limestone clasts. | 15 | 4,444 |

| Unit | | Thickness (feet) Unit | *Total from base* |
|---|---|---|---|
| 14 | Mostly covered, intermittent outcrops of graded medium grey siltstone and silty shale; 1- to 6-inch beds; slump structures and intraformational conglomerate common; weathering light grey; flaggy; some beds contain small chips of carbonized wood. | 390 | 4,429 |
| 13 | Conglomerate, pebbles of limestone (80%), chert (10%), and siltstone (10%) in a fine-grained matrix of limy siltstone, clasts well rounded. | 10 | 4,039 |
| 12 | Mostly covered, intermittent outcrops of siltstone and silty shale. | 800 | 4,029 |
| 11 | Siltstone and subgreywacke, interbedded, about 50% of each; siltstone, light greenish grey with medium to dark grey streaks and bands; graded and convoluted bedding common; subgreywacke, medium grey, fine to medium grained with scattered grains of dark grey chert and light grey carbonate to 3 mm intraformational shale fragments abundant; 1- to 6-foot beds, massive; weathering light brown; both siltstones and sandstones in this unit contain a few widely scattered fragments of carbonized wood. | 1,126 | 3,149 |
| 10 | Gritstone, very pale grey, coarse grained with scattered light grey carbonate and chert pebbles; massive; weathering greyish orange. | 12 | 2,023 |
| 9 | Shale and siltstone; monotonous succession of graded beds from 1 inch to 3 feet thick; siltstone, sandy, light greenish grey at base of beds grading upward into dark grey shale at top convoluted bedding and intraformational conglomerate common. | 1,308 | 2,011 |
| 8 | Siltstone and subgreywacke, interbedded; siltstone (80% of unit), light and dark grey banded, 1- to 10-inch beds, graded and convoluted bedding common; subgreywacke (20% of unit) medium grey, fine grained with occasional grains of chert and carbonate to 3 mm intraformational shale chips common near tops and bottoms of beds; 1- to 3-foot beds, weathering light grey. | 205 | 703 |
| 7 | Conglomerate; limestone and chert clasts as in unit 3. | 8 | 498 |
| 6 | Shale, dark grey, silty; thin bedded, laminated; pronounced slaty cleavage. | 245 | 490 |
| 5 | Subgreywacke, medium grey, very coarse grained, with scattered subrounded grains of grey chert, carbonate, and clear quartz to 4 mm; thick bedded, massive; weathers light brown, surface pitted from solution of carbonate grains. | 40 | 245 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 4 | Shale, black with medium grey laminations, silty. | 120 | 205 |
| 3 | Conglomerate, pebbles and cobbles of limestone and chert in matrix of limy siltstone; clasts well rounded. | 12 | 85 |
| 2 | Shale, black, silty; thin bedded, friable. | 55 | 73 |
| 1 | Conglomerate, polymictic; clasts 40% limestone, 20% andesite, 20% greywacke, 10% chert, 10% granitic; limestone clasts are subrounded and range in size from 1 inch to 18 inches in diameter; they are dark grey, fine grained and have the petroliferous odour characteristic of Sinwa limestone, some of the clasts contain fragments of corals, bryozoa, and sponges similar to those in the Sinwa Formation, GSC Loc. 40460; andesite, greywacke and granitic clasts are well rounded and range in size from 1 inch to 10 inches in diameter; chert clasts, light grey, 1 inch to 4 inches in diameter, angular. | 18 | 18 |
| | Sinwa Formation (section 4, unit 5)<br>Disconformity | | |

*Section 6*

## TAKWAHONI FORMATION

Section was measured along the ridge 6 miles southwest of King Salmon Lake. It is exposed on the northeast limb of a broad northwesterly trending syncline. The uppermost beds are overlain unconformably by volcanic rocks of the Sloko Group whereas the lower contact with Stuhini Group is obscured by an intrusive body of quartz feldspar porphyry.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Sloko Group<br>Unconformity | | |
| 29 | Greywacke and gritstone, medium to light grey, coarse grained with many thin pebble layers; 6- to 10-foot beds, weathering brown. | 262 | 11,394 |
| 28 | Subgreywacke and shale, interbedded in about equal amounts, both in 1- to 6-foot beds; subgreywacke, greyish green, medium to coarse grained with abundant | | |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | subrounded white feldspar and black chert grains, weathering light brown; shale, medium grey, silty, laminated. | 1,137 | 11,132 |
| 27 | Shale, siltstone and greywacke, interbedded; shale, dark grey, fissile; siltstone, medium to light grey, laminated, slump structures and graded bedding common; greywacke, medium grey, fine grained, 1- to 4-foot beds, flaggy, weathering brown; unit includes a few 1- to 4-inch beds of rusty weathering, argillaceous limestone. | 704 | 9,995 |
| 26 | Covered. | 153 | 9,291 |
| 25 | Shale and greywacke, interbedded in the ratio 80% shale, 20% greywacke; shale, medium grey, silty with sandy streaks of lighter grey, commonly crossbedded, a few thin calcareous beds; greywacke, medium grey, medium grained with many thin lenses of grit and pebbles, thick bedded, weathering brown. | 1,804 | 9,138 |
| 24 | Greywacke and shale, interbedded in the ratio 70% greywacke, 30% shale; greywacke, medium grey, medium grained with thin grit layers containing chert, feldspar, and rock fragments to 5 mm; 1- to 10-foot beds, flaggy, crossbedded, weathering brown; shale, dark grey, silty, laminated. | 619 | 7,334 |
| 23 | Covered. | 282 | 6,715 |
| 22 | Shale and greywacke, interbedded in the ratio 60% shale, 40% greywacke; shale, dark grey, silty, 1- to 8-foot beds; greywacke, light grey, fine grained, ½- to 2-foot beds, weathering brown, spherical calcareous nodules. | 209 | 6,433 |
| 21 | Subgreywacke, light grey, very coarse grained, subangular grains of quartz and feldspar are present in the upper part of the unit, pebble layers composed mostly of granitic clasts are present near base; 1- to 6-foot beds, weathering brown. | 207 | 6,224 |
| 20 | Shale, black, silty; few thin beds of black, light yellow weathering argillaceous limestone; *Dactylioceras* sp. indet. and *Peronoceras* sp. indet., GSC Loc. 40475 at base of unit; *Harpoceras* sp. indet. and abundant small ammonite fragments GSC Loc. 40428 near top of unit. | 832 | 6,017 |
| 19 | Greywacke, greyish green, coarse grained, 2- to 4-foot beds; weathering brown; some beds contain calcareous nodules. | 150 | 5,185 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 18 | Conglomerate, unit grades from coarse boulder conglomerate at base to pebble conglomerate at top, well rounded clasts of granitic, metamorphic and volcanic rocks; thick bedded; sandy matrix, weathers light brown. | 138 | 5,035 |
| 17 | Greywacke, medium grey, coarse grained; unit grades downward into coarse boulder conglomerate with well rounded boulders of granodiorite and andesite; weathering light brown. | 158 | 4,897 |
| 16 | Shale, black, friable; abundant poorly preserved fragments of ammonites and pelecypods. | 280 | 4,739 |
| 15 | Shale, medium grey, sandy, laminated and crossbedded; some thin calcareous beds weather brownish yellow. | 420 | 4,459 |
| 14 | Covered, intermittent exposures of black shale. | 245 | 4,039 |
| 13 | Greywacke, dark grey, medium grained, 4- to 10-foot beds; weathering light brown; lowest bed in unit grades downward into coarse boulder conglomerate. | 71 | 3,794 |
| 12 | Shale, black silty; some thin calcareous beds weather brownish yellow. | 81 | 3,723 |
| 11 | Conglomerate, well rounded boulders and cobbles of foliated hornblende quartz diorite in medium-grained greywacke matrix, thick bedded, rusty weathering matrix. | 95 | 3,642 |
| 10 | Shale, black; silty near top of unit, progressively more sandy toward base; abundant poorly preserved ammonite fragments including imprints of *Harpoceras* or *Grammoceras*, GSC Loc. 43639. | 138 | 3,547 |
| 9 | Shale, medium grey, sandy; thin bedded with distinct laminations and crossbedding in upper part of unit. | 208 | 3,409 |
| 8 | Conglomerate, well rounded granitic and volcanic boulders in a matrix of subgreywacke; grades upward into very coarse grained subgreywacke. | 150 | 3,201 |
| 7 | Subgreywacke and arkose, medium grey, coarse grained; subrounded to angular grains of clear quartz, white feldspar and black chert surrounded by a dark grey matrix; thick bedded; upper part of unit contains a few pebble and grit layers; weathering rusty brown; *Harpoceras* sp. indet., GSC Loc. 40427. | 597 | 3,051 |
| 6 | Greywacke, conglomerate and siltstone, interbedded; greywacke, dark grey, medium grained, thick bedded; conglomerate, small, well rounded pebbles of volcanic rock and chert in a greywacke matrix; siltstone, light | | |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | brownish grey, calcareous, thin bedded; the lowest siltstone bed of the unit is highly fossiliferous; *Trigonia* sp., *Gervillia* sp., GSC Loc. 40476; coquina with very large pelecypod fragments (*Weyla* sp.) GSC Loc. 43678; at base of unit; *Arieticeras algovianum* (Oppel) GSC Loc. 43668 near top of unit. | 684 | 2,454 |
| 5 | Siltstone, medium grey, laminated and crossbedded, weathering brownish grey. | 245 | 1,770 |
| 4 | Conglomerate and volcanic sandstone, interbedded; conglomerate, subrounded pebbles and boulders up to 12 inches in diameter are composed entirely of fine-grained porphyritic andesite; volcanic sandstone; maroon, graded, coarse to fine grained, thin bedded. | 990 | 1,525 |
| 3 | Volcanic sandstone, maroon, graded, coarse to fine grained, thin bedded; ammonite fragments gen. et sp. indet., GSC Loc. 40453 | 91 | 535 |
| 2 | Agglomerate and tuff, interbedded; agglomerate beds contain angular and irregular clasts of fine-grained porphyritic and amygdaloidal andesite up to 10 inches in diameter in a matrix composed entirely of volcanic grains; tuff, maroon, graded 2- to 6-inch beds, medium grained at base of beds, fine grained at top. | 194 | 444 |
| 1 | Greywacke, light greyish green, fine grained, thick bedded, spheroidal weathering. | 250 | 250 |
| | Map-unit 15, quartz feldspar porphyry | | |
| | Intrusive contact | | |

*Section 7*

## TAKWAHONI FORMATION

Section was measured along ridge 8 miles southwest of King Salmon Lake. It is exposed in the southwest limb of a broad northwesterly trending syncline. The uppermost beds are overlain unconformably by volcanic rocks of the Sloko Group. The base of the section is in intrusive contact with quartz monzonite of map-unit 16.

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| | Quartz monzonite | | |
| | Intrusive contact | | |
| 18 | Greywacke and gritstone, medium to light grey, coarse grained with many thin pebble layers; 6- to 10-foot beds, weathering brown; same beds as unit 29, section 6. | 187 | 7,210 |
| 17 | Subgreywacke and shale, interbedded succession of 2- to 10-foot beds; subgreywacke, medium grey with conspicuous grains of dark grey chert and white feldspar, medium grained, flaggy, weathering brown; shale, dark grey, silty, finely laminated and crossbedded. | 1,408 | 7,023 |
| 16 | Shale, black, strongly silty, small calcareous concretions; a few thin beds are weathering rusty. | 347 | 5,615 |
| 15 | Greywacke, medium grey, medium grained, high content of rock and feldspar grains, little quartz or chert; bedding very irregular, flaggy, a few beds have coalified plant debris. | 77 | 5,268 |
| 14 | Shale, medium grey, sandy; interbedded with a few 1- to 2-foot beds of flaggy, fine-grained greywacke. | 329 | 5,191 |
| 13 | Subgreywacke, light grey, coarse grained with many subangular grains of dark grey chert and clear quartz; some thin beds and spherical nodules have calcareous cement, 2- to 5-foot beds, crossbedding and channelling common, weathering reddish brown. | 386 | 4,862 |
| 12 | Covered, intermittent outcrops of sandy shale; unit includes a 10-foot dyke of quartz diorite. | 753 | 4,476 |
| 11 | Conglomerate, well-rounded pebbles and cobbles in a fine-grained subgreywacke matrix; beds (2 to 4 feet thick) grade upward into gritstone and coarse-grained sandstone in which only a few pebbles are suspended; clasts about 60% granitic rock, 40% volcanic and sedimentary rock. | 530 | 3,723 |
| 10 | Greywacke, light to medium grey, medium grained with sparse subangular grains of dark grey chert up to 4 mm; 2- to 4-foot beds with black shale partings 6 inches to 2 feet thick; weathering light brown. | 343 | 3,193 |

| Unit | | Thickness (feet) Unit | Total from base |
|---|---|---|---|
| 9 | Shale, medium grey, sandy, crossbedding and convoluted bedding common; unit cut by a 30-foot dyke of felsite. | 192 | 2,850 |
| 8 | Conglomerate, well rounded, poorly sorted pebbles and boulders in a medium-grained rusty weathering arkosic matrix; clasts about 80% crystalline (granodiorite to diorite), 15% andesite, 5% sedimentary (chert and quartzite). | 423 | 2,658 |
| 7 | Greywacke, medium grey, medium to coarse grained; 2- to 4-foot beds, thin partings of black silty shale; flaggy, weathering brown. | 139 | 2,334 |
| 6 | Shale, medium grey, silty, contains a few small ironstone nodules and thin rusty weathering beds of silty limestone; crossbedding and slump structures common; abundant ammonite fragments, indet. GSC Loc. 43674. | 342 | 2,195 |
| 5 | Conglomerate, well rounded, poorly sorted pebbles and boulders up to 2 feet in diameter, clasts of volcanic and crystalline rock are present in about equal amounts; beds very thick, massive with poorly defined bedding planes. | 764 | 1,853 |
| 4 | Conglomerate, well rounded, poorly sorted pebbles and boulders up to 2 feet in diameter; volcanic clasts predominate but granitic clasts are more abundant than in unit 3; beds very thick, massive. | 487 | 1,089 |
| 3 | Conglomerate, well rounded, poorly sorted pebbles and boulders in a medium-grained greywacke matrix; clasts mostly fine-grained andesite but include 2 to 3% granodiorite, gneiss and quartzite; beds very thick, massive with poorly defined bedding planes. | 351 | 602 |
| 2 | Greywacke and conglomerate, interbedded; greywacke, medium grey, medium grained with sparse angular grains of black chert and white feldspar to 4 mm; thin flaggy bedding; conglomerate, well-rounded boulders of crystalline and volcanic rock in a medium-grained greywacke matrix, boulders to 18 inches in diameter, 2- to 4-foot beds. | 71 | 251 |
| 1 | Conglomerate, cobbles and pebbles of granodiorite, gneiss, and andesite in a coarse-grained arkosic matrix, some beds contain nodules of authogenic carbonate. | 180 | 180 |
| | Intrusive contact | | |
| | Map-unit 16, quartz monzonite | | |

*Appendix II*

# FOSSIL LOCALITIES

## KING SALMON FORMATION

(Determinations by E. T. Tozer)

GSC loc. 43695. Elevation 4,000′. On east ridge of King Salmon Mountain; lat. 58°45′54″N, long. 133°13′12″W.

*Halobia* cf. *ornatissima* Smith
*Spirogmoceras* sp.
*Traskites* sp.
*Tropites* sp.
*Discotropites* cf. *sandlingensis* Hauer
*Trachysagenites* cf. *herbichi* Mojsisovics
Upper Karnian, Dilleri Zone

GSC loc. 43698. Elevation 5,100′. 4.2 miles west of Wade Lake.

*Halobia* sp. indet.
*Homerites semiglobosus* (Hauer) (impressions)
Upper Karnian, Welleri Zone

GSC loc. 43686. Elevation 4,300′. 1.2 miles south of the south end of Wade Lake; lat. 58°33′12″N, long. 132°29′24″W.

*Halobia* cf. *superba* Mojsisovics
*Tropites* sp. indet.
*Discotropites* sp. indet.
Upper Karnian

GSC loc. 43699. Elevation 4,900′. 4 miles west of the southwest end of Wade Lake; lat. 58°34′18″N, long. 132°36′00″W.

*Juravites* s.l. sp. indet.
Upper Triassic

GSC loc. 43693. Elevation 5,050′. On ridge 3 miles east of Sutlahine River and 8 miles south of Inklin River; lat. 58°36′42″N, long. 132°42′48″W.

*Halobia* sp.
*Juravites* s.l. sp. indet.
Upper Karnian or Norian

GSC loc. 43690. Elevation 3,900′. On mountain 4 miles north-northwest of the west end of King Salmon Lake; lat. 58°45′54″N, long. 132°58′12″W.

*Halobia* sp. indet.
Upper Triassic

GSC loc. 43688. Elevation 4,600′. On east ridge of Shustahini Mountain; lat. 58°49′30″N, long. 133°23′30″W.

*Halobia* sp. indet.
Upper Triassic

GSC loc. 40454. Elevation 4,400′. On mountain 3 miles north of King Salmon Lake; lat. 58°45′30″N, long. 132°54′12″W.

*Halobia* sp. indet.
Upper Triassic

GSC loc. 40426. Elevation 4,200′. On ridge 3.6 miles north of the west end of King Salmon Lake; lat. 58°45′36″N, long. 132°56′42″W.

*Halobia* sp.
*Discotropites* cf. *sandlingensis* Hauer
*Tropites* sp.
Upper Karnian, Upper Triassic

GSC loc. 40435. Elevation 5,600′. On ridge 5.3 miles north of the north end of Trapper Lake; lat. 58°33′42″N, long. 132°40′00″W.

*Halobia* sp.
*Aulacoceras* sp.
Upper Triassic, probably Karnian

## SINWA FORMATION

(Determinations by E. T. Tozer)

GSC loc. 43696. Elevation 2,500′. In small canyon 6.2 miles northwest of the east end of King Salmon Lake; lat. 58°47′24″N, long. 132°59′00″W.

*Monotis subcircularis* Gabb
Upper Norian

GSC loc. 43707. Elevation 2,400′. On west bank of Kowatua Creek, 8.5 miles from its junction with Inklin River; lat. 58°38′24″N, long. 132°17′24″W.

Terebratuloid brachiopod
Probably Upper Triassic

GSC loc. 40429. Elevation 4,400′. 4.6 miles north of the west end of King Salmon Lake; lat. 58°46′42″N, long. 132°56′48″W.

*Monotis subcircularis* Gabb
*Halorites* cf. *H. americanus* Hyatt & Smith
Upper Norian, Lower Suessi Zone

## INKLIN FORMATION

(Determinations by H. Frebold)

GSC loc. 40463. Elevation 4,830′. 1 mile north of One-way Lake; lat. 58°38′10″N, long 132°33′10″W.

*Arnioceras*? sp. indet.
Sinemurian

## TAKWAHONI FORMATION

(Determinations by H. Frebold)

GSC loc. 40422. Elevation 4,850′. West side of cirque, 3 miles south of King Salmon Lake; lat. 58°39′58″N, long. 132°54′30″W.

*Liparoceras* (*Becheiceras*) *bechei* (Sowerby)
Ammonite gen. et. sp. indet.
Pliensbachian

GSC loc. 40473. Elevation 4,800′. 2 miles southwest of One-way Lake; lat. 58°36′10″N, long. 132°35′48″W.

*Amaltheus stokesi* (Sowerby)
Pliensbachian

GSC loc. 43659. Elevation 5,100′. 2.3 miles south of King Salmon Lake; lat. 58°40′42″N, long. 132°55′45″W.

*Amaltheus stokesi* (Sowerby)
*Arieticeras algovianum* (Oppel)
Pliensbachian

GSC loc. 43668. Elevation 4,400′. 5.2 miles west, southwest of King Salmon Lake; lat. 58°41′45″N, long. 133°04′24″W.

*Arieticeras algovianum* (Oppel)
Pliensbachian

GSC loc. 40424. Elevation 4,810′. 2.5 miles south of west end of King Salmon Lake; lat. 58°41′09″N, long. 132°55′04″W.

*Prodactylioceras davoei* (Sowerby)
Pliensbachian

GSC loc. 43651. Elevation 4,300′. 5.5 miles southeast of Mount Lester Jones and 6.5 miles southwest of King Salmon Lake; lat. 58°40′45″N, long. 133°06′44″W.

*Dactylioceras* sp. indet.
Early Toarcian

GSC loc. 40475. Elevation 3,900′. 4.5 miles south-southwest of the west end of King Salmon Lake; lat. 58°40′06″N, long. 133°03′18″W.

*Peronoceras* sp. indet.
*Dactylioceras* sp. indet.
Early Toarcian

GSC loc. 40430. Elevation 2,950′. West end of One-way Lake; lat. 58°37′39″N, long. 132°33′42″W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
*Harpoceras* sp. (juvenile)
*Laevicornaptychus*
Early Toarcian

GSC loc. 40438. Elevation 4,770′. 2 miles south of King Salmon Lake; lat. 58°41′13″N, long. 132°53′42″W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
Early Toarcian

GSC loc. 40431. Elevation 3,450′. On small lake 2 miles southeast of Headman Mountain; lat. 58°48′12″N, long. 133°06′32″W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
Aptychi
Early Toarcian

GSC loc. 40447. Elevation 1,780′. South side of creek bottom (creek flowing out of One-way Lake); lat. 58°39′38″N, long. 132°40′50″W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
Early Toarcian

GSC loc. 40449. Elevation 1,765′. South side of creek flowing out of One-way Lake. Same position as GSC loc. 40447.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
*Harpoceras* sp. (juvenile)
*Laevicornaptychus*
Early Toarcian

GSC loc. 43650. Elevation 4,800′. On ridge west of Sutlahine River, 9 miles above its junction with Inklin River; lat. 58°37′35″N, long. 132°50′50″W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
Early Toarcian

GSC loc. 43669. Elevation 5,000'. 6 miles southeast of Mount Lester Jones; lat. 58°40'58"N, long. 133°05'40"W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
Early Toarcian

GSC loc. 43642. Elevation 3,600'. North side of Niagara Mountain; lat. 58°29'36"N, long. 132°27'54"W.

*Harpoceras* cf. *H. exaratum* (Young and Bird)
Early Toarcian

GSC loc. 43680. Elevation 4,000'. On north side of ridge 6 miles east of the north end of Trapper Lake; lat. 58°29'36"N, long. 132°27'54"W.

*Chondroceras allani* (McLearn)
*Chondroceras* sp.
Middle Bajocian

GSC loc. 43681. Elevation 4,000'. On north side of ridge 6 miles east of the north end of Trapper Lake. Talus block, 10 feet above GSC loc 43680.

*Chondroceras allani* (McLearn)
Middle Bajocian

GSC locs. 40434, 40452, 40462. Canyon formed by small tributary on south side of Kowatua Creek, 7 miles east of the north end of Trapper Lake.

*Chondroceras allani* (McLearn)
Middle Bajocian

GSC loc. 43675. Ridge east of Trapper Lake. Same position as GSC loc. 43680 and 43681.

*Stephanoceratidae* gen. et. sp. indet.
Middle Bajocian

GSC loc. 43673. Elevation 4,500'. On ridge 6 miles east of the north end of Trapper Lake; lat. 58°29'03"N, long. 132°28'24"W.

*Stephanoceratidae* gen. et. sp. indet.
Middle Bajocian

GSC loc. 43679. Ridge 6 miles east of the north end of Trapper Lake. 30 feet above GSC loc. 43673.

*Stephanoceratidae* gen. et. sp. indet.
Middle Bajocian

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