GEOLOGY OF THE SOUTHEASTERN PART OF THE SULTAN QUADRANGLE KING COUNTY, WASHINGTON

by

HORACE LIOYD BETHEL

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A thesis submitted in partial fulfillment for the degree of

DOCTOR OF PHILOSOPHY

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The writer is indebted to Professor G. E. Goodspeed, Executive Officer, Department of Geology, University of Washington, for his help in planning the subject matter of this thesis and for his valuable criticisms and suggestions, particularly with regard to the mineral deposits.

This opportunity is taken to express particular appreciation to Dr. Peter Misch, University of Washington, under whose direction most of the report was written, for generously giving his time for the reading and editing of the manuscript and for his many helpful suggestions and constructive criticisms during the course of the investigation.

Dr. Howard Coombs and Dr. H. E. Wheeler, University of Washington, have furnished helpful suggestions, and the writer has drawn freely from the previous work of J. H. Mackin on the glaciation of the area. The writer is grateful to the other members of the faculty of the Geological Department at the University of Washington for their interest and assistance.

It is impossible to acknowledge all the assistance rendered by many persons connected with the United States Forest Service and with the mining and logging companies in the area during the course of the field work. Special thanks

occupany, Edwin Sauers and Jack Madden of the Consolidated Molybdenum Company, Robert Crippen of the Bear Basin Mining Company, and to Robert Prufer and M. F. Gilbreath of the Goat Mountain and Quartz Creek properties, respectively, for their hospitality and guidance during visits to the mining properties.

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GEOLOGY OF THE SOUTHEASTERN PART OF THE SULTAN QUADRANGLE KING COUNTY, WASHINGTON

INTRODUCTION

Location

about forty miles east of Seattle, within the Cascade Mountains (of Plate 1). It includes about 135 square miles in
the vicinity of the North and Middle Forks of the Snoqualmie
River. The town closest to the area is the small municipality of North Bend, which is located on the main cross-state
highway from Seattle to Yakima by way of Snoqualmie Pass.
From North Bend gravel roads extend up both the North and
Hiddle Forks of the Snoqualmie River for about twenty miles
and allow limited access to the area. Most of the region outside of these main river valleys is accessible only by trail.

Purpose of the Inventigation

For many years intermittent prospecting has been carried on in the vicinity of the North and Middle Forks of the Snoqualmie River. The southeastern part of the Sultan

PLATE 1

MT. BAKER Lake Stillagua GLACIER PEAK (5) Stevens MT. STUART North TACOMA ELLENSBURG

VICINITY MAP

- 1 Area included in this thesis
- 2 U.S.G.S. Snoqualmie Folio (9)
- 3 Smith, W.S., Skykomish Basin (11)
- 4) Weaver, C.E., Index District (15)
- (5) Spurr, J. E., Monte Cristo District (12)

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quadrangle includes some of these deposits which have been actively prospected in recent years. No written description of the general geology or mineral deposits of this area was available, and the only geological information consisted of the State of Washington preliminary geological map of 1936 (1). This map was based on the information available at the time it was prepared and showed the Snoqualmie granodiorite as occupying much of the area.

No visitor to this region could help but be impressed by the variety of granitic rock types present. The purpose of this investigation has been two-fold: first, to map the general geology of the area, with particular emphasis on fixing the boundaries as closely as possible of the various types of granitic rocks; and, second, to map and describe the mineral deposits and correlate them with the areal geology. As the study progressed it became apparent that the area offered some interesting relationships between the sedimentary and volcanic rocks and between some of the granitic rock types, and these relationships have been discussed in some detail from both a descriptive and genetic standpoint.

Field Work

to visit some of the mineral deposits prior to commencing work on this thesis in 1949. During the summers of 1949 and 1950 a total of five months were devoted to field work in this area.

During the past two years approximately 250 thin sections of rock and ore specimens collected in the field have been made by the writer in the University of Washington Laboratory.

GROSTATIS AND MINELPHANKS

Arrangin by M. Arrangin

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GROGRAPHY AND PHYSIOGRAPHY

Tenography and Drainage

The southeastern part of the Sultan quadrangle lies in the western part of the Cascade Range. The entire area is mountainous, with the only flat areas being the flood plains along the North and Middle Forks of the Snoqualmie River. The highest peaks are in the eastern part of the area. These include Mt. Roosevelt at 5885 feet and Preacher Mountain at 5930 feet in the southeast. Mt. Garfield at 5500 feet in the east central part of the area, and Goat Mountain at 5600 feet and Bear Mountain at 5700 feet in the northeast (of Plate 2). The lowest parts of the area are the valleys of the North and Middle Forks of the Snoqualmie River, which are from 1000 to 1500 feet elevation through most of the area. Since these rivers have fairly low gradients in their lower courses, the relief becomes greater as the mountains become higher in the eastern part of the area where several summits are over 4000 feet above the valleys of the major rivers.

The valleys of these major rivers have been severely glaciated and are broad and U-shaped. They are never over a mile wide and are widest at junctions with important tribu-

PLATE 2

SOUTHEASTERN PART OF THE SULTAN QUADRANGLE King County, Washington

Scale ½ O Contour Interval: 500 feet 47.40 47°30'

The mountainous areas above 4000 feet elevation are shown in brown while the valleys below 2000 feet elevation are shown in green.

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taries such as the Taylor and Pratt Rivers along the Middle Fork and Sunday Creek along the North Fork of the Snoqualmie River.

Cirques heading in steep walls are common at altitudes above 4000 feet. At some places these cirques meet to form mife-edged ridges while in other places remants of the pre-glacial upland are present. Features resulting from glaciation are discussed more completely in a later paragraph.

Where the ridges are at lower elevations, such as in the northwestern corner of the map area timber reaches to the summits and the precipitous alopes common in the higher glaciated regions are absent.

The southern two-thirds of the map area is drained by the Middle Fork of the Snoqualmie River and its tributaries. An important tributary is the Pratt River, a rapidly flowing stream fed by numerous side streams heading in high cirque lakes. It drains an important part of the southern third of the map area. Granite Creek is a sizeable stream which enters the Middle Fork of the Snoqualmie River in the southwestern part of the map area. A considerable portion of the east-central part of the region drains into the Snoqualmie Middle Fork through the Taylor River and through an important tributary of the latter, Quartz Creek.

The northern third of the map area is separated from the southern two-thirds by a divide running in a northeasterly direction. It includes such peaks as Green Mountain at 4890 Early on the favile and look Rivers along the Early of the anoqualinis Early and Emetry Crook slong the North North North of the anoqualinis

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foot, Bessemer Mountain at 5022 feet, and Dog Mountain at 5406 feet. Drainage of this northern third of the map area is by means of a number of tributaries to the North Fork of the Snoqualmie River. Important tributaries from west to east are Big Creek, Sunday Creek, and the Lennox River.

River show an uneven grade with stretches of relatively little fall alternating with stretches of swift water and fairly rapid fall. One of the more noticeable stretches of low gradient is along the North Fork of the Snoqualmie River near the mouth of Sunday Creek. Here numerous meanders and deserted meanders, and one ox-bow lake are present (of Plate 3).

Parther downstream, outside of the map area, the river cascades through a rather narrow canyon with no meanders. Some meanders and cut-offs are present along the Snoqualmie Middle Fork also, but the stretches of low gradient are short and the meanders poorly developed, while numerous rapids exist between these stretches of quieter water.

The control of drainage pattern by jointing and

faulting is evident at numerous places. Thus the mineralized

fault zones at the Lamox, Devil's Canyon, Jack Pot, Beaver
dale, and Goat Hountain mining properties all have all or part

of their length traversed by small streams. In the central

portion of the map area the minor tributaries of the Middle

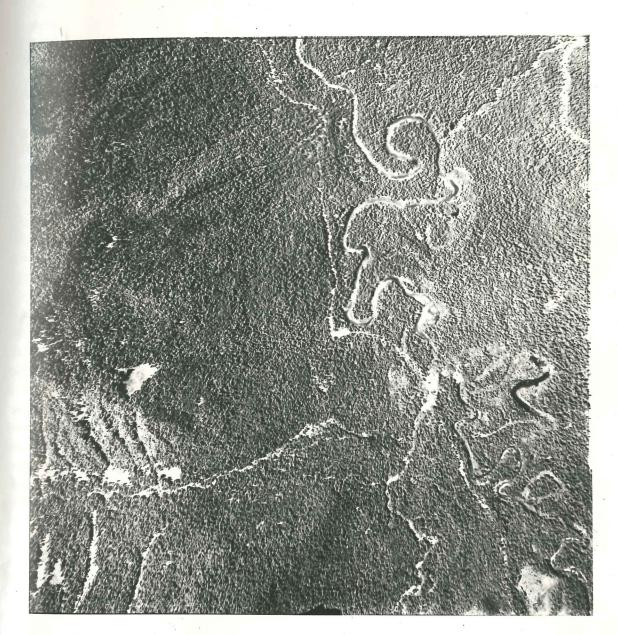
Fork of the Snoqualmie River form a parallel drainage pattern

in a northwest-southeast direction. Likewise, the small tri-

fact, Sessence Mannicia at 9022 fact, and Dee Sourgain at 9400 fact. Desimage of this number this number of the Sessence of the Sessence of the Sessence to the North Pork of the Sangualria River. Important tribularies from most to sent and the Sangualria Sunday Creek, and the Lernon Sirver.

River show an answen grade with stratches of relatively little fall altermeting with stratches of swift water and fairly repld fall. One of the work notineed a stratches of low granting that, one of the work of the sangualnie sires of the stratches favor man the mouth of family Greek. Here measured recorders and described measured, and one ox-bow lake are present (of Flate 3). Forther despetate a sather nexten carpon with no macedance and case was carpon with no macedance. Some rescaldance and wateries nexten along the shortestance of low greatest and another stratches of low greatest and another seather and carpon with no macedance as death remainders and catestake are present along the decay and the the remainders and stratches of low greatest are short and the conditions and stratches of low greatest another and the the

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This aerial photo of the North Fork of the Snoaualmie river shows the wide valley near the mouth of Sunday creek, with numerous deserted meenders. This is a temporary graded condition since above end below the section shown in this photo the gradient of the river is much steeper.

butaries of the Taylor River near Et. Garfield are in this same direction and the fault which controlled the course of one of these tributaries was exposed where it crossed the divide south of Norton Lake (cf Plate 4). The fact that the Fratt River and also the valley of the Middle Fork of the Snoqualmie River upstream from its confluence with the Taylor River also are in this same general direction suggests that they too may owe their present courses in part to a similar fault control.

Glaciation

Most of the higher valleys have cirques at their heads. In many cases these cirques are occupied by beautiful mountain lakes, such as Lake Caroline, Lake Philippa, Cougar Lake, Upper Wildeat Lake, and others. Most of the valleys show the typical stepped profile of glaciated valleys and in some valleys two basins at different elevations each contain a lake, for example, Lake Matrine and Little Matrine, Lower and Upper Wildeat Lakes, and Derrick and Caroline Lakes.

In some cases glacial erosion by the advancement of cirques is far advanced, and basins several miles long with steep sides extend from the major river valleys into the intervening upland. Examples of these large basins are those along Bear Creek, Cougar Creek, and the basins at the head of lake Hancock and Lake Calligan. In such cases the ridges at the head of these basins are narrow, often knife edged ridges. In other

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Host of the idence or your have circuse at their heads in namy exact these singulars of their heads and takes, such as lake Caroline, Inica Philippe, Couper lake, Upper Wildret Lake, and others. Heat of the valleys show the typical stagged profile of glastated valleys and in some valleys two backur at different elevations and in some valleys and in some values or conseque, Inica Matrice and Intelle Matrices and Intelle Matrices and Upper for conseque, industrial matrices and Caroling lakes.

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Many small streams have their courses controlled by jointing or faulting. This photograph shows a fault surface on the divide south of Norton Lake along the course of a minor tributary of the Taylor River.

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cases the cirques advancing into a ridge cause one side of
the ridge to drop off abruptly for many hundreds of feet to
the floor of the cirque while the other side of the ridge will
slope off rather gently to a stream valley with no cirques
developed. Such assymetrical ridges are present between the
basins occupied by Norton and Nowich Lakes and the valley of
Quartz Creek, and also between the basin occupied by Rainy
Lake and the valley of the Pratt River.

Some similar assymetrical ridges occur which have stream valleys on the steep side rather than cirques. Examples are the steep cliff forming the south side of the Lonnox River valley just above its confluence with the Snoqualmie North Fork, the cliff on the southwest side of Quartz Creek, the cliff on the southwest side of Illinois Creek, and numerous others. The cause of these steep slopes seems to have been a nivation or freeze and them process at the edge of snow accumulations in these valleys. The steepest slopes are on the shaded sides of the ridges where the snow persisted longer.

North and Middle Forks of the Snoqualmie River, the Taylor River, and Pratt River, the relative proportion of steepening of valley sides and widening of valley floors by sayping and nivation and by corrasion of moving ice is unknown. However, the fact that neither hanging valleys nor morainal deposits are conspicuous, and that often the valleys will show steepening and faceting of spurs on only one side leads the writer

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in shaping the valleys of the major rivers. Taylor (13), from his observations of glacial erosion now active in Antarctica, saw no reason why a relatively stagnant glacier, filling a normal river valley, could not ultimately give rise to faceted walls and a typical catenary profile by sapping at its margin and erosion of ice marginal streams. Some grinding away of rock by ice seems necessary to produce the rock flour now present as glacial clays along the valley of the Middle Fork of the Snoqualmie River.

Mivation is still active in the higher altitudes which explains the fact that some glacial features have been so little modified in post glacial time. An example which might be cited is that of the dissection of Mt. Garfield. That peak when viewed from the air shows knife like ridges and many steep slopes bare of vegetation. Where snow drifts can accumulate they form small basins by nivation. The melting of snow in these small basins forms a supply of water for the freeze and them process to cut out large guilles. These gullies extend from the snow patches to the nearest river or stream and their size is out of proportion to the amount of water that normally flows in them. In these gullies most of the material moves down by gravity.

the erosional activity was illustrated by the severe winter of 1948-49. At that time extremely heavy snowfall in the

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winter months was accompanied by numerous slides. The slides stripped the soil and timber in their path causing freezing and thawing processes to increase their activity on the bare rocks thus exposed. One of these slides piled up once twenty to thirty feet deep along the Taylor River at 1300 feet elevation which persisted into the middle of the summer. During this same surmer compacted snow remained in Devil's Canyon off Cougar Creek at elevations above 3200 feet until early fall, and the top of this snow was liberally sprinkled with rock which had fallen from the sides of the canyon. During that year of 1949 many of the peaks near 5000 feet elevation had small snow fields which had not melted away by the time the next winter's snows began. Thus it appears that a long succession of winters not much more severe than those of 1948-49 could result in important accumulations of snow at high elevations and the movement of that snow to lower elevations by slides, accompanied by greatly accelerated erosion.

lake in the valley now occupied by the Middle Fork of the Snoqualmie River is seen in the presence of remnants of glacial clay within this area. These clays are well exposed near the lower end of the Quartz Greek logging road, and along the southwest side of the Middle Fork opposite Mt. Garfield, where under-cutting of the river has caused the top soil and trees to move on the soft wet clays with a resulting land-slide topography. Additional exposures occur at scattered points

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clay within this ower. These diegs are sell exceed that white wast side of the Middle Fork opposite Mt. Carfield, where second buts Lion and add frautino and north add to notific tobay oblin-boni autifures a staw avais des abs on over et alaked benediase to tueco sourceoms facetible, referenced

along the southeast bank of the Middle Fork of the Snoqualmie River below the Taylor River (of Plate 5), and northwest of the river on the lee side of the small island of rock extending into the glacial and alluvial deposits near the point where the St. Regis logging road crosses the Middle Fork of the Snoqualmie River.

As has been ably reasoned by J. Hoover Mackin in his study of the glaciation of the region around North Bend (6), this lake was impounded by the darming of the mouth of the valley now occupied by the Middle Fork of the Snoqualmie River by continental ice reaching to about the vicinity of Granite Greek. At this point the farthest advance of the continental ice is marked by a large moraine. This moraine is partly removed by the cutting of the Middle Fork of the Snoqualmie River, but a portion of the moraine still remains. To an observer looking down the valley from any elevated spot such as Nordrum Lookout it is strikingly apparent as a broad flat topped bench extending into the valley of the Middle Fork from the northwest slope of the river opposite Granite Creek. The material composing this moraine is exposed on the Granite Creek logging road and is seen to be mainly rocks of local derivation, rather than rocks carried down the valley of the Middle Fork of the Snoqualmie River by valley glaciers. J. H. Mackin attributed this morainal material to erosion from the surrounding mountains at the margin of the continental ice. The top of the moraine is at approximately 1400 feet elevation.

PLATE 5

The brigh alcome of the Olympia between the same and to be been assured to the same the same

Photograph showing glacial clays overlain by coarse river gravel along the Middle Fork of the Snoqualmie River.

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the hat object necessary is necessary that the day are atidy of the plantanton of the region around forth hand (6). Greek, he this point the tarthest advance of the continental tee to marked by a large meralme. This meralme is garaly neme of antisect filte entrane of the college a find , revision these the continues slage of the river opposite frantis Orent, "The saverage of no beacons at animous airis animous of the Granibe destination, rather than pooks especial down the valley of the Middle Park of the Speciale Miver by valley gladiers. I. Il Madda abtedlered this messing asterial to complete them The top of the moments is at approximately 1900 for old wallon. This corresponds with the elevation of some terraces along the Middle Fork of the Snoqualmie River east of Mt. Garfield and also along the Pratt River, and may indicate that this was the level of the lake for a considerable period of time.

The series were as a Clinate

The climate in this vicinity of the Cascades is essentially the product of three factors: the high elevation of the Cascade Range, the presence of the ocean to the westward, and the prevailing south to west winds bringing moist maritime air from the sea against the mountains.

To the west and southwest of the area covered by this thesis are the Puget Sound Basin and the Olympic Nountains. The moist maritime air moving from the Pacific Ocean during winter storms before reaching this area must either move from the west across the Olympic Nountains or move from the southwest up Puget Sound through the broad Chehalis Valley which forms a gap in the Olympic Range. Westerly winds impinging on the high slopes of the Olympic Mountains cause extremely heavy rainfall on the western slopes of these mountains and in so doing the air loses part of its moisture. As a result, the precipitation in the map area is less than for areas of similar elevation on the western slopes of the Olympic Mountains. The fact that the precipitation is still very considerable is due to the fact that the westerly winds pick up more moisture on crossing Puget Sound, and also winds from the south can bring

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moist maritime air from the ocean through the gap in the mountains occupied by the Chehalis River, and northward up Puget Sound with little loss of moisture. These south to southwest winds impinging on the western slopes of the Cascade Range cause heavy precipitation.

The important effect of topography on precipitation is seen in a comparison of climatelogical data for the ten year period from 1935 to 1944, for the three stations at Seattle, Snoqualmie Falls, and Snoqualmie Pass. Seattle is near sea level, whereas the town of Snoqualmie Falls is along the Snoqualmie River west of the area included in this thesis, at an elevation of 430 feet. Snoqualmie Pass is southeast of this thesis area, at an elevation of 3010 feet, and precipitation there is typical of portions of the thesis area at a similar altitude. The yearly averages of precipitation, in inches, were 31.9, 51.4, and 92.2 for Seattle, Snoqualmie Falls, and Snoqualmie Pass, respectively. At high elevations much of the precipitation in the winter months is in the form of snow, and at Snoqualmie Pass during the ten year period under consideration the average annual snowfall was 363.9 inches. This snow normally reaches depths of ten to twelve feet in the highest basins, and locally much greater depths where it accumulates by snow slides at the foot of steep slopes.

During the summer precipitation is less than during the winter and there are many summy days. The air is usually moist, but an occasional east wind, bringing warm dry air from

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partied from 1935 to 1944, for the three excitors at the series an elevation of 450 feet. Endparis Russ to amitwell of at .colfettale of the yearly averages of presignation, in Anches, were 31.9. St. b. and 92.2 for Scattle, Securityle balang thou not old animab appl alatangent to has there to A.Edf any Makapaga Lancina angkaya add makapadingsa makap Inches. This same notwelly reaches digitive of ten to traine

Plate 6

COMPARISON OF ANNUAL PRECIPITATION IN INCHES AT SEATTLE, SHOQUALKIE FALLS, AND SHOQUALKIE PASS FOR THE TEN YEAR PERIOD 1935 TO 1944 (2)

| Year | Seattle Elev. 14 | Snoqualmie Falls Elev. 430* | Snoqualmie Pass Elev. 3010 |
|----------------------------------|---------------------|--------------------------------|-------------------------------|
| 1935 | 31.55 | W7+25 | 87.36 |
| 1936 | 35.42 | 54.96 | 105.90 |
| 1937 | 43.86 | 67.65 | 125.04 |
| 1938 | 23.92 | 45.12 | 83*97 |
| 1939 | 33.12 | 54.55 | 93.84 |
| 1940 | 36.75 | 50.66 | 85.18 |
| 1941 | 34-56 | 54+30 | 82.72 |
| 19/15 | 30.80 | 54.94 | 95.69 |
| 1943 | 26.86 | 46.32 | 84.13 |
| 1944 | 22.91 | 38.55 | 78.56 |
| Average for 10-year period | 31.9 | 51.4 | 92.2 |

east of the Cascades, will cause a drop in the humidity so that all logging operations in the area must be stopped because of the fire danger.

Plate 6

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cast of the Canadadan, will cause a drop in the inmidity and that old longing operations in the area must be atogosed because of the fire dangers.

Vegetation

Being in a moist climate, the area included in this thesis has abundant vegetation. The type of vegetation varies considerably with the altitude. Along the valley floors and on the more gentle slopes up to 3000 feet elevation there are thick forests containing excellent Douglas fir and hemlock timber. Logging operations have removed much of this timber from the valleys of the Middle Fork of the Snoqualmie River and its tributaries the Pratt and Taylor Rivers, and in the past few years logging operations have begun along both sides of the North Fork of the Snoqualmie River.

Above 3000 feet elevation the timber thins out and hemlock, cedar and white fir predominate. Many of the talus slopes and glaciated surfaces with a thin soil cover have a covering of vine maple, or nettles where the ground is moist. Some of the higher open slopes are covered with huckleberry bushes and grasses.

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Bistribution of Rock Types

The geologic map (of Plate 70) shows a large, rather complex formation consisting of graywackes, argillites. tuffs, and tuffaceous sediments outcropping in the western part of the area. This formation has been designated the Calligan formation after the exposures in the vicinity of Lake Calligan. An age of Cretaceous to Paleocene is suggested for the bulk of the Calligan formation on the basis of a similarity to formations in neighboring areas which contain fessil leaves, and also of the occurrence of worm tubes which resemble those found in other formations of that general age in western Washington. Within its map boundaries it could very well include some older rocks. However, there is no evidence of rocks of a different environmental facies that could be construed as a base to the Calligan formation. Thick accumulations of foldspathic graywackes and argillites occur in the vicinity of the Snoquelmie Middle Fork. Dark gray, fine grained graywackes are abundant near Sunday Take and in the northwestern corner

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The seederic may (of First 70) shows & Lagran, rather complex fermation completing of erromatice, wellians, part of the area, this formation inches inches the care Lake Californ, An are of Cretacocks to Palebooks the Dugstund and he spirarrol implified oil to sind self the bornes open and admirate companional restaura and the sum when the costs will not the trop of collaboration forthvill a to place to permitte on al predy provide oldsagablet to englishions something of delapathic best stated the state of the green and distributed or a consequence of the state of

of the map area. To the north in the vicinity of Big Creek graywacke and shale beds are interbedded with andesitic to rhyolitic tuffs and tuffaceous sediments. Some of the massive fine grained tuffs within the sediments may be the direct product of volcanic explosions, but much of the tuff has been sorted by water and more or less mixed with other material.

With an increase in the amount of pyroclastic material the graywackes grade into tuffaceous sediments and finally into tuffs. In the vicinity of Mt. Phelps these tuffs are largely without stratification and accompanied by massive andesites. For purposes of mapping, the area of predominantly tuffs and andesites is shown separately from the area of essentially clastic sediments. However, in parts of the area where clastic and tuffaceous rocks are thinly interbedded no boundary can be mapped in the field and the dotted line shown on the map is largely diagramatic.

In the vicinity of Mt. Garfield along the Snoqualmie Middle Fork is another area of volcanic rocks, consisting principally of volcanic breccies. This group of rocks has been designated the Mt. Garfield Volcanics.

Younger dikes of andesitic to rhyolitic composition can be observed cutting the Calligan formation and also the andesitic and granitic rocks.

The granitic rocks include: the Preacher granite, a

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Sedimentary Rocks - Callican Formation

General Features

of graywackes, argillites, andesitic to rhyolitic tuffs and tuffaceous sediments. The formation outcrops along the western part of the map area from south of the Snoqualmie Middle Fork to the northern limits of the map. It also occurs locally as islands surrounded by later granodicrite, along the Lannox River and near Paradise Lake.

In the vicinity of the Middle Fork of the Snoqualmie River are outcrops of massive feldspathic graywackes and argillites. These graywackes consist predominantly of feld. # Propago . # 20 vietnicy od

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spar and quarts with a matrix which is chloritic in the less metamorphosed portions and is largely changed to biotite in the vicinity of the granitic masses. As the graywackes become metamorphosed some of the feldspar is replaced by quarts and the rocks become more quartzitic, but the original character of the rocks is apparent as the outcrops are followed to less metamorphosed areas.

No satisfactory estimate of the thickness of the graywackes and argillites in this vicinity can be made as the structure in the massive rocks is uncertain and much disharmonic folding and considerable faulting has occurred. in part presumably during emplacement of the neighboring granitic rocks. The base of the formation is nowhere exposed as all the contacts observed were either intrusive or fault contacts. The beds outcrop from 1000 feet elevation along the Snoqualmie Middle Fork to altitudes of 5000 feet on the divide separating the drainage basins of the North and Middle Forks of the Snoqualmie River, and the thickness is probably at least 5000 feet and possibly locally much more.

The coarse clastic rocks in the southern part of the area are quite feldspathic and rock fragments are few except where the rocks contain fragments of the associated argillites. In some other parts of the Cascades rocks

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similar to these have been called arkoses but due to the fact that these rocks in general have a chloritic matrix when not metamorphosed they are also referred to as gray-wackes.

As the formation is followed to the north the amount of volcanic material increases. Occasional beds of white fine grained rhyolitic tuffs representing ash falls are present, some of which are recrystallized to cherty appearing rocks. In the vicinity of Take Calligan the coarse felds—pathic graywackes contain andesite fragments and proceeding to the north and northeast of Take Calligan the volcanic material becomes increasingly important, and the amount of chloritic matrix increases in proportion to the feldspar and quartz fragments. In the vicinity of Big Creek and on the Weyerhauser logging roads north of the Snoqualmie North Fork there are relatively thin bedded shales, graywackes, rhyolitic tuffs and tuffaceous sediments.

Hear the mouth of Sunday Creek and on Mt. Phelps the tuffaceous material is largely without stratification and accompanied by massive andesites. Clastic sediments in this area are inconspicuous, and these rocks are described separately as the Mt. Phelps Volcanio Rocks.

For purposes of petrographic study the Calligan for-

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mation will be divided into (1) the graywacks, (2) the intraformational breccias, (3) the tuffaceous sediments, and (4) the argillites and shales. The metamorphism of these rocks adjacent to granitic areas will be discussed separately.

Graywackes

The graywackes are the most abundant rocks in the formation. They vary from fine grained, dark gray rocks of nearly uniform texture to coarser grained, light to medium gray rocks in which the larger clastic quartz and feldspar grains can be recognized by the naked eye. They weather to lighter gray or brownish gray colors. The coarser grained graywackes commonly include fragments of argillite. Where these fragments are abundant the rocks are treated separately as intraformational breedias.

The graywackes are usually massive and break with a more or less conchoidal fracture. In the northwestern part of the area they are exposed along the Wayerhauser logging roads in beds five to ten feet thick interbedded with fine grained, dark colored and sometimes thin bedded shales, and with light colored massive tuffaceous sediments (of Plate 7).

Where these sediments suffer from much folding and faulting the massive graywacks beds act as competent members and the fine grained shales are folded disharmonically and

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Photomicrograph of a fine grained, dark gray graywacks from Big Creek showing angular quarts and feldspar
grains and a considerable amount of chloritic matrix. Some
fragments of andesite and shale are visible. (Plain light;
x 12)

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and accumulate at other places so that in the more disturbed areas the exact bedded nature of the formation is
poorly defined.

under the microscope the most conspicuous constituents are the clear, very angular grains of quartz. They
make up twenty to forty per cent of the rock. Occasionally
the grains show undulating extinction. In some cases this
is due to later deformation of the beds but in a few cases
in less disturbed portions of the formation a few grains
of quartz will show these strain effects while the bulk of
the quartz grains are unstrained. These few strained
quartz grains are interpreted as being derived from rocks
which had undergone deformation prior to their erosion and
redeposition. Some of the quartz grains are spotted with
small vacuole inclusions.

Iess conspicuous but more numerous than the quartz grains are the angular grains of feldspar. The predominant variety is oligoclase, but some orthoclase grains and an occasional grain of microcline are present. Under the microscope the feldspar grains are seen to be mostly cloudy with alteration products. Some, however, are quite clear and show good twinning. The alteration in most cases is an alteration to sericite, often with the release of finely divided quartz. In the more altered graywackes the feld-

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spars commonly lose their original outlines with the small plates of the chlorite in the matrix penetrating the margins of the foldspars.

Rock fragments make up a variable percentage of the graywacks. They include fragments of andesites and tuffs (of Piato 8), including some recrystallized tuffs, plus fragments of argillite or shale formed from subaqueous erosion of the associated fine grained rocks.

All of the above constituents are contained in a fine grained matrix which usually makes up less than twenty-five per cent of the rock. This matrix is predominantly chloritic, with greenish flakes, needles and irregular patches of chlorite occurring between the other grains. The matrix also includes finely divided quartz and foldspar particles and some opaque particles which are probably partly clay. Also present are some small grains of pyrite and magnetite, epidote, and zircon. Sometimes elongated larger quartz and foldspar grains lie with their long axes in the direction of the bedding. As the graywackes become more disturbed and metamorphosed the chlorite changes to biotite and some incipient growth of biotite is usually present.

Intraformational breceias

The intraformational breceias are coarse grained graywackes which contain appreciable amounts of fragments

PLATE 8

the lastywoods matrix. This fact makes it returned their



Photomicrograph of a coarse grained, light gray, fedspathic graywacks from the north shore of lake Calligan showing angular grains of quartz and feldspar and a small amount of chloritic matrix. A fragment of andesite is visible in the center of the photo. (Plain light; x 12)

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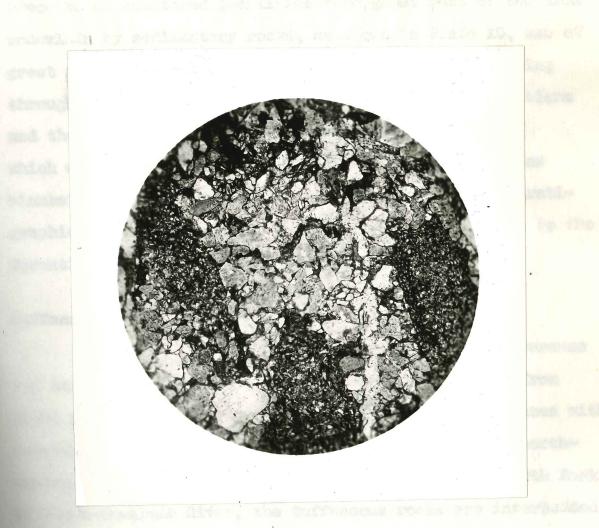
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of the associated fine grained argillites. These fragments are of the same composition, but of smaller grain size, as the graywache matrix. This fact makes it extremely likely that these intraformational breccias were formed by the breaking up by subaqueous erosion of partially indurated beds of the associated argillites and finer grained graywackes, and their incorporation in the coarser grained graywackes. These fragments are always angular and range in size from one millimeter to one centimeter and occasionally larger. The proportion of these fragments varies from an occasional fragment up to nearly fifty per cent of the rock. They are often oriented with their long axes in the direction of the bedding. A photomicrograph of a thin section from a typical breedia occurring north of lake Calligan is shown in Plate 9.

Since the thermal metamorphism of portions of the Calligan formation changes the megascopic appearance of the graywackes, and since there are variations in the quantity of tuffaceous material from place to place, there was some question during the early stages of mapping as to whether all the sedimentary rocks should be included in one unit. As mapping proceeded it was found that the most distinctive rocks, which could be recognized both in the metamorphosed and unmetamorphosed state, were the intra-

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Typical intraformational breeds from ridge northeast of lake Calligan. The fragments of fine grained argillite are of the same composition as the enclosing graywacks.

(Plain light; x 12)

of pirches just to be the a title stratification of

formational breceiss. The finding of outcrops of these brecciae at scattered localities throughout most of the area underlain by sedimentary rocks, as shown in Plate 10, was of great assistance in showing that the graywackes occurring throughout the area were deposited under similar conditions and therefore could be considered as one unit, part of which was metamorphosed. These breceiss do not occur as blanket deposits and therefore can not be used as a stratigraphic marker, but only as a sort of lithologic guide to the formation as a whole.

Tuffaceous sediments

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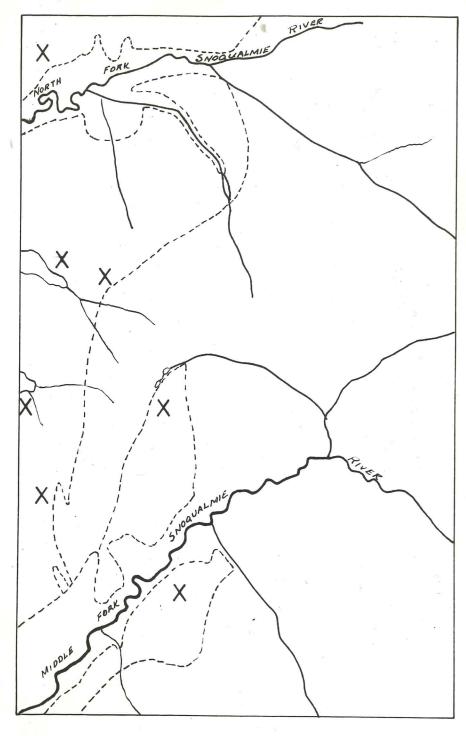
The tuffaceous rocks vary considerably in appearance and texture from place to place. Their color varies from light yellowish gray to dark greenish gray, in some cases with considerable variation in a single specimen. In the northwestern part of the map area, on both sides of the North Fork of the Snoqualmie River, the tuffaceous rocks are interbedded with graywackes and shales (of Plate 11). A thin section of a specimen from one of the tuffaceous beds seen in the photograph shows a few larger grains of quartz and orthoclase and fragments of micropegmatite in a fine grained tuffaceous base which makes up the bulk of the rock (of Plate 12). This fine grained base appears as an indistinctly polarizing aggregate of quartz, foldspar, and chlorite, with a mosaic texture, and the rock has apparently suffered some recrystallization. The fact that the

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distancedly and chierite, with a mean texture, and the rook the

Plate 10



Intraformational Graywacke preceiss are one of the distinctive rocks of the Calligan formation. "X" marks the locations of observed outcrops of these rocks, within the outcrop area of the Calligan formation and the associated volcanic rocks.

PLATE 11



Photograph of light colored massive water-laid rhyolitic tuffs with an included pod of shale, along Weyerhaeuser logging road up Big Creek. During deformation the massive tuffaceous layers act as competent members and the shales are squeezed out at some spots and accumulate at others. EL LINLS

PLATE 12

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the grained state. A thin scarter of this rook source

Photomicrograph of water-laid rhyolitic tuff from interbedded tuffs and graywackes along Big Creek (of Plate 11). Fragments of quartz are contained in a fine grained tuffaceous groundmass. (Plain light; x 12)

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adjacent argillite is relatively unaltered illustrates the relative ease with which the fine-grained tuffaceous rocks are recrystallized. The light color and abundant quartz would class this as an acid tuff, probably rhyolitie.

Arcillites and shales

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The argillites are dark gray to nearly black rocks.

In the northwestern part of the area they are relatively unaltered and often thin bedded, and are best called shales.

These shales are usually sheared and quite fissile. Closer to the granitic bodies these finer grained rocks become very hard and break with a conchoidal fracture and are best called indurated argillites.

Along the western boundary of the map area, and still better exposed outside the boundary along Weyerhauser logging roads west of lake Hancock are considerable thicknesses of the black frieble shales. A specimen of these shales from the vicinity of Big Creek contains some coarser grained fragments in the fine grained shale. A thin section of this rock shows the coarser fragments to be pieces of graywacke in which all of the grains show evidence of much strain. The breccious appearing rock can be interpreted as resulting from deformation. The thin layers of graywacke originally interbedded with thick layers of shale were broken up during deformation and scattered through the shale.

Some of the argillites show a tendency toward graded bedding. This often is rather hard to see in a hand specimen

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logging road along the Shoqualmic Middle Fork. Although the
clastic texture is still plainly visible here, the rock has
a spotted character due to the development of incipient porphyroblasts of a mineral which is probably feldeper, and thus
has suffered some metamorphism.

Metamorphism of the Calligan Formation

As stated previously, there is some recrystallization in the fine grained tuffaceous rocks and development of chlorite in the matrix of the graywackes throughout the area, but it is only where thermal metamorphism has been active near the granitic masses that the rocks are strongly metamorphosed.

Metamorphism of the graywackes

The larger quarts grains are the last to lose their clastic appearance and thus the coarse grained graywackes are the least changed in appearance of any of the rocks of the Calligan formation. Considerable thicknesses of these metamorphosed graywackes are exposed along and above the CCC road on the north slope of the Snoqualmie Eiddle Fork. In these rocks the larger quartz grains often still retain their angular shape although there has been some overgrowths and coalescence of neighboring grains. Hany of the quartz grains have cremulated borders.

The matrix of the graywackes has been recrystallized

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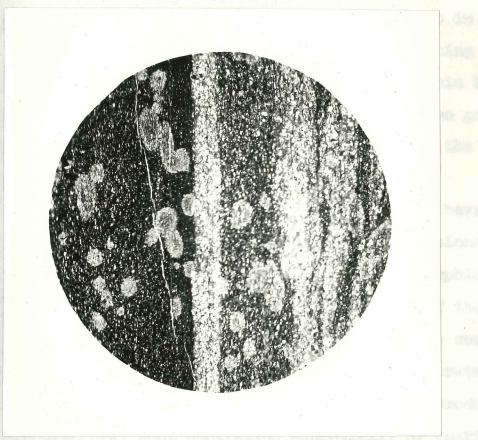
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Photomicrograph of argillite from the road along the Middle Fork of the Snoqualmie River, showing graded bedding. The spots are incipient porphyroblasts, probably feldspar. (Plain light; x 12)

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with development of aggregates of biotite. The smaller quartz and feldspar grains have recrystallized and coalesced so as to produce a mosaic texture. The large feldspar grains have lost most of their clastic appearance and are often hard to tell from newly formed grains of oligoclase which develop in the rock. However, the latter usually do not show twinning and contain numerous inclusions. There are in places thin layers around this crystalloblastic feldspar in which coarse grained biotite has concentrated as if during the growth of the feldspar the biotite had been pushed out.

Quartz veinlets are numerous and they often have selvages of biotite on both sides indicating some solutional
transfer of materials within the rock during metamorphism.

Locally intense deformation has caused fracturing of the larger
grains and stringing out of the biotite and in these rocks the
original clastic texture is almost completely obliterated.

light purplish gray rock consisting essentially of quartz, feldspar and biotite, with a granulose texture, which is best called a biotite granulite. The coarse grained feldspathic graywackes in some localities are even more transformed, as will be described in connection with the Quartz Creek Complex and the Preacher Granite.

Metamorphism of the tuffaceous sediments

In these rocks metamorphism has caused more strongly marked changes than in the graywackes. In the metamorphosed

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areas of the Calligan formation there are associated with the granulites and hornfelses some dark green, usually somewhat banded rocks, composed essentially of hornblende. These amphibolites are the metamorphic equivalents of the basic tuffaceous rocks. There are other rocks containing both biotite and hornblende along with granular quarts and feldspar, which were derived from rocks which were intermediate between graywackes and tuffs. These latter rocks tend to green or greenish gray colors, often mottled, as contrasted with the purplish tints of the metamorphosed graywackes.

Netamorphism of the very fine grained siliceous tuffaceous rocks produces dense hard rocks, white to pale green
in color, which break with a conchoidal fracture. These rocks
resemble cherts and their true nature was revealed by the
finding of fragments of graywackes within them which still
retained their clastic texture. Epidote in the form of irregular grains and veinlets is common in the metamorphosed tuffaceous sediments as well as in the metamorphosed tuffs and andesites.

Metamorphism of the argillites

The most noticeable change in the argillites during metamorphism is a marked induration. They are no longer figsile but break with a concholdal fracture. Also there is a development of fine grained biotite which replaces the chlorite of the argillite causing these metamorphosed rocks to have a dark purplish gray color in contrast to the dark greenish gray

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or nearly black color of the unmetamorphosed argillites. In the more advanced stages of metamorphism these dense metamorphosed argillites are best called hornfelses.

In the hornfels the small clastic quartz and feldspar grains have recrystallized and also grown by coalescence, and thus lost their original outlines. Commonly there develop fairly large amoeba-like porphyroblasts of oligoclase containing numerous inclusions. Some quartz generally forms small disconnected veinlets which stand up as small ridges on the weathered surface of the hornfels. There appears to be some release of iron in the form of magnetite during the transformation of chlorite to biotite as this mineral is abundant. A thin section of a hornfels from the slope north of the Snoqualmie Middle Fork shows a diamond shaped tetrahedron of magnetite within a grain of biotite.

In the immediate contact zone some narrow bands within the metamorphosed argillites show a development of well formed red garnets. These were noted near the portal of the tunnel on the Langer mining claims, on the ridge between Paradise lake and the head of Illinois Creek, and south of Sunday Lake (of Plate 14).

Stratigraphy

The outerop pattern on the geologic map suggests that the Mt. Garfield Volcanics occupy a synclinal area and are Younger than the foldspathic graywackes in the southern part

entationed, that described for relativity of these wilder fall decrees

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Photonicrograph of biotite gramulite from near contact of Snoqualmie granodicrite south of Sunday Lake. A large porphyroblast of garnet is visible along with feldspar and much biotite. (Plain light; x 12)

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waskes with the Mt. Phelps volcanic rocks in the northwestern part of the area and fragments of andesites are present in the feldspathic graywackes in the vicinity of Calligan Take. However, these andesite fragments are scarce south of Take Calligan and andesite dikes cutting the Calligan formation are only conspicuous in the localities where volcanic rocks now outcrop. Those dips that can be obtained in the Calligan formation in the northern part of the area suggest that there may be an increase in volcanic admixtures in the Calligan formation upward in the section as well as laterally toward the north.

General statement

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Bo fossils except some worm tubes were found despite a diligent search of all likely outcrops. In similar formstions elsewhere in the Cascades the chief fossils have been leaves contained in shaly members. In this area nearly all the shales have suffered extreme deformation due to disharmonic folding, and fossil leaves would thereby be destroyed.

Some early workers have assigned some formations in the Cascades to the Paleozoic on the basis of metamorphism and this probably accounts for the inclusion of the area covered by the Calligan formation in the Carboniferous or older age group on the latest State of Washington Geological Map (1). Since it was found that most of the metamorphism .(stufquite Landings 30) acus out to

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observed other than the induration and development of chlorite in the graywackes was related to the emplacement of the Tertiary granitic bodies, metamorphism alone was not considered an indication of great antiquity.

unconformity to be valid must be of regional extent, accompanied by a change of facies, and the actual contact must be
observed. No such unconformity was recognized. The entire
sedimentary assemblage outcropping in the western portion of
the map is considered part of the same environmental facies
and therefore is mapped as one unit.

Worm tubes

of an outcrop of indurated sandy argillite of the Calligan formation on the ridge separating the two branches of the creek which enters lake Calligan from the southeast. The tubes are straight or very slightly curved and appear to be formed of cemented sand grains slightly coarser than the surrounding argillite. They average about an inch long and one-sixteenth inch in diameter, and usually have a single longitudinal groove due to a cracking of the tube (cf Plate 15). They stand up as ridges on the weathered surface.

As noted by W. R. Danner (4), who found similar worm tubes north of the map area in the vicinity of Sultan, Washington, and also in the Sol Due formation on the Olympic Peninsula, these worm tubes are identical with those from Kodiak Island,

PLATE 15

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Photograph of worm tubes on weathered surface of sandy argillite.

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Alaska, described and illustrated by E. C. Ulrich (14) of the Barriman Alaska Expedition. Ulrich describes the worm tubes from Eodiak as being not over 2.3 millimeters in diameter and to be usually cracked lengthwise due to compression, giving the same longitudinal groove that is present in the Lake Calligan occurrence. These Eodiak tubes were named Torebellina palachel after a member of the expedition. J. C. Roed and R. R. Coats (9) describe the occurrence in graywackes from Erusof Island, Alaska, of Terebellina palachel with Aucella crassicollis, a Lower Cretaceous pelecypod. Whether these tubes are of stratigraphic value, however, still remains to be proven.

Comparison of Calligan formation to sedimentary rocks in neighboring areas

Some geologists who are familiar with the clastic sediments of northwestern Washington have recognized the rocks of the Calligan formation as being similar in lithology to some of the Cretaceous and early Tertiary formations. For example, Dr. P. Misch noticed a resemblance of some of the feldspathic graywackes to parts of the Swauk formation outcropping to the east and to some rocks occurring in the Guye formation. Both Dr. N. Coombs and Dr. H. Wheeler of the University of Washington noticed a resemblance of the graywackes and especially the intreformational breccias to similar rocks in the Sol Duc formation outcropping in the Olympic Peninsula. The Sol Duc formation is itself of uncertain age,

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but is known to be older than the Metchesin baselt of Bocene age, and is considered by various geologists as either earliest Tertiary or Cretaceous. In view of this resemblance it was considered of some significance that Terebelline palachei was found in both formations.

The earliest publication on the stratigraphy of this vicinity of the Cascades was the pioneering work of G. O. Smith and F. C. Calkins in the Snoqualmie folio, published in 1906 (8). The northwest corner of the area covered by this folio joins the southeast corner of this thesis map area in the vicinity of Lower Wildost Lake. Smith and Calkins describe rocks ranging from schists to relatively little altered volcanic rocks and sediments, and make the difference in metamorphism the basis for a subdivision between the older or pre-Tertiary and the younger, or Tertiary, formations. The pre-Tertiary rocks, all outcropping east of Snoqualmie Pass, consist of some mica and hormblende schists, called the Easton schist, some black slates designated the Peshastin formation, and some metamorphosed volcanic rocks named the Hawkins greenstone. Since no paleontological evidence was available, Smith and Calkins assigned these rocks to the Carboniferous or older on the basis of metamorphism.

Barly Tertiary clastic sediments are shown outcropping over a considerable area in the eastern half of the Snoqualmie folio. These include two arkosic formations, the Swauk and Maches, which were considered by Smith and Calkins as contem-

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poraneous but to have originated in separate basins, since
the Maches formation contains a large amount of intercalated
basaltic tuffs and some rhyolite, called the Machess rhyolite.
The Maches is but one of several formations in the Cascades
where clastic formations considered near the same age as the
Calligan formation contain intercalated volcanic material.

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In the vicinity of Snoqualmie Pass Smith and Calkins mapped three rock units as Miocene. These include: (1) The Guye formation, consisting of grits, arkoses, shales, small amounts of chert and limestone, and some interbedded basalt and rhyolite. The Guye formation covers an area of about thirty square miles starting a short distance southeast of Lower Wildcat Lake. (2) The Keechelus andesites, covering an extensive area on the Snoqualmie folio map and consisting chiefly of pyroxene andesite and dacite, with some rhyolite and basalt. (3) The Snoqualmie granodiorite, which is later than both of the above formations and includes some biotite granite and quarts diorite as well as the more abundant granodiorite.

From the Guye formation Smith and Calkins obtained some fossil leaves, two species of which were identified by Dr. F. H. Knowlton as probably Miocene in age and a third as resembling a species from the Fort Union (Paleocene) formation of Montana. It was Smith and Calkins' opinion that if it were not for the Miocene age assigned these fossil leaves they would have made the Guye formation early Tertiary because of

emphisio tuffe and spac sipoliton, called the Radous sipolito. pil no suo mann off rent hereblance amplicatel editale cast. and to vicinity of shopping cast said as addition - donde in mose as asover colimatic type off .edilous bu dept Mildor Lale. (2) The Meechelus andsulted tools in chility of gyromous andsoite and dasite, with more more than rotal at Makes larknothouses sinfsupent and (E) .tissed but -one to a transfer the transfer that they be for each of the life transfer but the land the line before the farm, who real measure M. v. Editedouter and models which the line stor of the seas delication territories on distant to the territories

while there has been no publication to this effect, geologists such as Dr. P. Misch and Dr. H. Coombs, who are familiar with this portion of the Cascades, have considered the Miccene dating of the Guye formation to be in error and an early Tortiary age to be more probable.

Of the formations described in the Snoquelmie folio the Easton schist nowhere outcrops far enough west to be expected within the may area. Although the most recently published geological map of the State of Washington shows the sedimentary formations within the area covered by this thesis in the same color and symbol as the Peshastin formation of the Snoqualmie folio the results of this thesis show that the rocks are closer in lithology to the Tertiary formations of the Snoqualmie folio than to the Paleozoic Peshastin formation which outcrops east of the Cascade summit. Of the Tertiary formations described by Smith and Calkins, the arkosic portions of the Guye formation resemble some of the feldspathic graywackes of the Calligan formation, especially in the southern part, and both formations locally contain associated volcanic rocks. It is believed these two formations may be nearly contemporaneous and of early Tertiary or perhaps Cretaceous age rather than Miocene as the Guye is shown in the folio.

In 1913 W. S. Smith (11) mapped the rocks in the Skykomish quadrangle, which lies northeast of the map area and due north of the area included in the Snoqualmie folio men-

pale there has been no publication to this effect, goingtotic act as fir. F. Eligat and Dr. H. Cocybe, who are destitor data this yestian of the Capendon, have equilated the Choese ending of the Caye formation to be in ergor and an entry satisfy are to be now probable.

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tioned above. He describes certain rocks under the name of the Easton schist, and shows them outcropping in the northeastern portion of the Skykomish basin near the summit of the Cascade Range. As the next younger formation, he describes a metamorphic series, the Peshastin formation, occurring north of the northeastern corner of the area covered by this thesis, as consisting of quartzites, schists, and crystalline linestones with associated greenstones. Smith dated this formation as Ordovician on the evidence of fossils obtained from a cherty part of a limestone lens outcropping two miles west of Grotto. W. R. Danner (5), in an investigation of numerous limestone lenses outeropping in a belt which includes these mentioned by Smith, found some Permian fusilinids on Palmer Mountain near Grotto, which illustrates the diversity of ages of rocks in the Cascade goosyncline. The small area of metamorphic rocks in the vicinity of Paradise Lake in the northeastern corner of this thesis map area is an extension of the Peshastin formation as mapped by Smith. However, the rocks in question which are hornfelses, amphibolites, and metavolcanies, could very well be the result of metamorphism of interbedded argillites, graywackes and tuffaceous rocks similar to those outcropping farther west and mapped as the Calligan formation (of above). The only rocks in this group of metamorphies which are different from the metamorphosed portions of the Calligan formation to the west are some dense black argillites outcropping above Paradise Lake. They resemble the small out-

to term above. He deserthes contain rooms under the sens of at constating of quartation, achieve, and criminalists it is a series decrease elicated of forestle established from a Brown W. B. Damer (5), in an investigation of watering Mountain near Grotto, which illustrates the diversity of sees -ofor to the fine and controlled and the controlled acidemocrates to sucre with this steer wine aff . leveds to

crop of black argillite on the southwest slope of Et. Garfield.

Also near the southwest corner of Paradise Lake is an outcrop
of breccia identical with some of the coarse volcanic breccia
near the base of the Et. Garfield volcanics along the Taylor
River and Quartz Creek. Smith included the Et. Garfield volcanics in his Keechelus formation which he assigned to the
Eiocene. Therefore, if any of the fossiliferous rocks observed
by Smith and Danmer near Grotto extend into this area they
must form only a part of a greater assemblage which is chiefly
composed of much younger rocks.

In the Skykomish Basin northeast of the map area Smith mapped a large outerop of arkosic sandstones, shales and conglomerates, the shaly members of which contained fossil leaves which could be correlated with the flora of the Fort Union formation (Paleocene) of Montana. He called this formation Swauk because of its similarity to the Swauk formation mapped by Smith and Calkins in the Snoqualmie Quadrangle. His deserption of a typical sandstone is as follows:

It is fine grained, gray, mottled with brown specks. As primary minerals there are quartz, plagioclase and orthoclase; as secondary minerals or alteration products, chlorite, kaolin, epidote, sericite and quartz. The grains vary in size up to one-half millimeter and are bound together with quartz, clayey material, and chlorite.

It is apparent from the above description that the rock has a chloritic and argillaceous matrix and is not greatly different from some rocks of the Calligan formation, namely the feld-

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spathic graywackes which are relatively free of volcario admixtures and not metamorphosed.

Smith shows on his map several disconnected areas of volcanic rooks, all of which he designates as Keechelus formation of Miocene age. At some localities dikes of andesite were observed cutting the Swank formation. Included in his keechelus andesites are the volcanic rooks of Mt. Garfield, but unfortunately these volcanic rocks do not contact the clastic rocks.

Because of the similar lithology of the Swauk formstion of the Skykomish basin and of those Calligan graywackes free of volcanic material, it becomes of interest to investigate the relation of volcanic rocks to the sedimentary formstions of the Swauk type elsewhere on the west side of the Cascades. North of the Skylomish basin mapped by Smith, is an area of rocks mapped by Weaver (15) in the vicinity of Index. His oldest rocks are a series of schists, slates, crystalline limestones and cherts which he has called the Gunn Peak formation and thought to be of Carboniferous age. Among the Tertiary rocks Weaver describes a "West Index Andesite Series" consisting of a complex mass of intercalated layers of fine grained andesite breccias, conglomerates and badly altered lavas. Their age is uncertain but Weaver has noted a close resemblance to a series of andesites which he had found to be quite extensive farther to the west, south of Monroe, and which underlie the marine Oligocene of the Puget Sound Basin

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and overlie the Bocene brackish water beds. Weaver therefore thought the West Index andesite series might be of late Bocene age. He also found a formation of limited extent consisting of five to seven hundred feet of coarse angular arkosic conglomerate, with interbedded tuffs, lavas and andesite breceiss, which he called the Howard arkose. He mentioned the possibility that it was of the same age as the West Index andesite series but thought it probably was younger, possibly Biocene.

Farther to the north J. E. Spurr (12), in a report on the ore deposits of Monte Cristo, Washington, shows a similar section to that within this thesis area. He summarises it as follows:

| Earlier Tonalite Rhyolite Basaltic | | Mesosoic Rocene |
|---|----------|------------------------|
| | rocks | 48 |
| | -Vrozene | andesites, tuffs, etc. |

Spurr found his arkoses to contain fragments of andesite. He explains this as follows:

On the west side of Wooden Creek the attitude of the arkose series makes appearently overlie the volcanic series consisting of andesite, baselts etc. which lies to be northeast; but since the baselts into them the apparent relation indicated by the attitude is probably mislesting and is permans to be applained by a fault along Wooden Creek. The fragments of andesitie to come if the arloses therefore probably belong to older volcanics, associated with the

encode she to be a trained and and the state of the action of the booms of the boom

On the west ado of Western Creek the attact of the states of the anguarantar overthe that the apparentar overthe that the vestion of the series to the northeast; but which the beast is without the house of the beast to the wind in the series of the serie

In a later paragraph Spurr reports the finding of a single fessil on the mountain slopes northeast of Clacier Creek. His description is as follows:

The rock (containing the fossil) is a fine dark green arkose slate or tuff with layers of conglomerate containing pebbles of andesite and fine impure sandstone. It is probable that this horizon lies well up in the andesite series, although on account of the confusion introduced by the plicated structure of the region it is probable that its position is lower. The single fossil was found by Mr. W. I. Stanton to be Corbicula pugetensis, which was originally described from the Fuget Group at Carbonado, Washington . . . The Puget group was at first supposed to be Cretaceous, but later study by Dr. Knowlton of the fossil flore places it probably in the upper Eocene or lower Miocene. From all the data which we have therefore we may class the andesite series as lower Miocene.

However, later work by Weaver (16) on the Tertiary formations of Western Washington shows Corbicula pugetensis to be Eccene. Since Spurr has also considered his arkose to be Eccene, and since he describes the andesite boulders as being in an arkosic matrix, and also mentions the occurrence of andesite fragments in his arkoses it would seem that his early andesites could be nearly contemporaneous with the arkoses. Thus a similar relation seems to exist here as was found in the vicinity of Mt. Phelps, between the Mt. Phelps volcanic rocks and the Calligan formation.

Conclusions regarding age of the formation

A comparison of the rocks of the Calligan formation with rocks of the neighboring areas may be summarized as

In a later pare, raph Spurr reports the finding of a finding of a laster double somewhat alopes rortheest of Glablor freely. His description is as follows:

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convert later near by Verrat (16) on the Yestsery Indestions of testern Versitages photos Coratesia propersist to be locate, and that find the description and the description of the arisons to be locate, and the object to be description of the animals of the second of animals frequents of the extreme to would need that his early contemporaries with the arisons. This a claim a claim of the versitation coors to exist here as well the second in the violation of the later of the second the second of the second second of the second second of the second se

notingering of the conductive arone may be assembled as

follows:

- (1) No rocks have been found which could be definitely correlated with the Paleozoic formations of the neighboring areas, although it is probable some older rocks are included in the area mapped as the Calligan formation, especially in the northeestern part, and not recognized.
- (2) It is not unusual in the Cascades to find volcanic material interbedded with elastic rocks of the arkose-gray-wacke type.
- and graywacke, the portions of the Calligan formation which are relatively free from volcanic material are of similar lithology as the Swauk formation described by W. S. Smith, the arkosic portions of the Guye formation described by Smith and Calkins, and the arkosic formation of Monte Cristo described by Spurr.
- (4) On the basis of the worm tubes and the similarity of the lithology to the Swauk type sedimentary rocks, the portion of the Calligan formation from Lake Calligan to the Snoqualmie Eiddle Fork, where the rocks are relatively free of volcanic admixtures and very feldspathic, is dated with considerable confidence as Crotaceous to Falcocene.
- (5) Since some of the massive feldspathic graywaches in the vicinity of Lake Calligan contain andesite fragments the volcanic activity must have begun during the same period, Cretaceous to Falcocene. However, structural evidence indi-

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cates that volcanic activity in both the northwestern part of the area and in the vicinity of Mt. Garfield continued past the period of deposition of the feldspathic graywackes.

Volcanie Rocks

Distribution

Volcanic activity was widespread in the area and apparently lasted for a considerable length of time. There are two large areas of volcanic rocks plus some dikes of more recent age. The bulk of the volcanic rocks are concentrated in two localities, around Mt. Garfield in the south and around Mt. Phelps in the north, and are described separately as the Mt. Garfield Volcanics and the Mt. Phelps Volcanics. Neither of these accumulations of volcanic rocks are entirely within the map area, and, in fact, those in the vicinity of Mt. Phelps are only a part of an extensive area of volcanic rocks north of the map boundary. Both of these volcanic accumulations represent old volcanic centers and the rocks in them are largely of subacrial deposition and poorly stratified. The Mt. Phelps Volcanics are andesitic to rhyolitic in composition and grade into water laid tuffs which are interbedded with the graywackes and argillites of the Calligan formation. In this same area later andesite and dacite dikes cross-out the interbedded tuffs and sediments.

The volcanic rocks in the vicinity of Mt. Garfield are mainly andesite breccias, but there are some massive andesites.

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storik . and to dignol aldemoble oc times, Thore berry localities, eromed We. Gerried in the senth and around redital . Solesofor aglacit . We alt bus appropries . Haither area, and, in fact, those in the vicinity of Mt. Phelps by of subsection deposition and popular standard Labrestin by and surfilling of the Calligna formation. In this in endealte broceder, but there are sens massive endealter.

The volcanic rocks extend beyond the map area on the east. On the west they stop near the Taylor River at the boundary of the Preacher granite but a few scattered outcrops of coarse andesite breccia outcrop north of the CCC road to the west of this granite mass. Similar breccias were observed in the northesastern part of the map area near Paradise Lake. These coarse breccias are usually associated with some banded greenstones or amphibolites formed by metamorphism of fine grained volcanic rocks. Along the CCC road and about four miles west of the mouth of the Taylor River are several outcrops of andesite porphyry within the Calligan formation which appear to be large dikes intermediate in grain size between diorite and andesite. They have been metamorphosed along with the Calligan argillites and feldspathic graywackes.

While the structural relations (of regional structure) suggest that the Mt. Garfield Volcanics are younger than the feldspathic graywackes of the Calligan formation, there seems no reason to separate the two units by any great period of time; therefore the writer believes the volcanic activity in the vicinity of Mt. Garfield began at least as far back as early Tertiary time. It is possible some of the Mt. Garfield Volcanics are the equivalent of some of the rocks mapped as Keechelus in the Snoqualmie quadrangle (8).

Some later andesite and dacite dikes out the Preacher granite between the Snoqualmie Middle Fork and Rainy Lake and also along Quartz Creek.

and roots and are seen car and heroyed busines on the east. On the west they atop near the Taylor Sives at the boundary of the -chie owned to economic bereadana wat a sud salarun weekenoffe came. Minilar broweder were obcorred talints .come offe series of the rap area near Fernatian laims. These or the . estimated the estimate assessed only mining al estimated have been metamorphosed slong with the dailigen postalities of their the Mr. Gerffeld Volosition are printing their thei distribution and the first the second to believe the two will'd by any great period of on shoot and me Josef he maged bigitted . It to winder to Torribary time. It is possible come of the "to dirribate as abused after out to much to Justing out our call the in the Scoqualitie quadrangle (8). some Trates and end to estimate of the Processor

Mt. Garfield Volcanics

In the vicinity of Mt. Garfield the andesitic rocks are exposed over a vertical distance of more than 4000 feet from the Taylor River to the top of Mt. Garfield. The most pundant of the andesitic rocks is an aphanitic dark greenish gray, massive rock, which usually appears somewhat lighter gay on a weathered surface. It consists of a variable mount of fragments of andesitic lava and earlier tuff in a strix of finely divided andesitic tuff. In these tuffs the ragmental character of the rock is usually best seen on a mathered surface. Next in abundance are the massive andeites, some perphyritic. The outline of their outcrops is sually irregular and locally they seem to transect andesitic uffs. Some are fairly coarse grained with a holocrystalline roundmass and probably represent dike like masses, whereas thers are porphyritic with an aphanitic to nearly amorphous roundmass and were probably flows.

Although many of the rocks have a fragmental texture here is an almost complete absence of visible bedding. Probbly this could be due in part to subsequent alteration during placement of the neighboring granitic rocks, but large areas may from the granitic rocks are only weakly altered and it cortain some bedding would have been preserved if it had bur been present. The limited distribution of the rocks hapled with the predominance of pyroclastics, the great thick
be exposed, and the absence of any stratigraphic sequence

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suggests that the rocks represent material which has accumu-

The same andesitic tuffs outcrop in a small area north of the Taylor River above 1800 feet elevation on the ridge between the Taylor River and Quartz Creek. Above the Quartz Creek logging road a small outcrop of fine grained quartz biotite granulite and dark gray fine grained quartz diorites of the Quartz Creek Complex are overlain by a massive fine grained dark gray recrystallized tuff. This tuff forms a cliff several hundred feet high visible from the road.

Just south of the Taylor River near the eastern boundary of the map between 1600 and 2700 feet elevation there is an outcrop of volcanic breccia containing some blocks over two feet in diameter set in a matrix of andesitic tuff. Some of the blocks are andesite, while others are fragments of banded pyroclastics and tuffaceous sediments. In a creek a few hundred yards to the west of the breccia outcrops there is a coarse grained tuffaceous appearing rock which includes some one-fourth to one-half inch fragments of granite containing quarts and orthoclase intergrowths. These granite fragments and numerous embayed and brecciated quartz and feldspar crystals are contained in a dense, almost amorphous groundness, which has been highly sheared and slightly recrystallized. The fragments of granitic rock are too small to positively identify but they more closely resemble the Preacher granite than any of the other granitic rocks now exposed in the map area.

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In these fragmental rocks there is no evidence of any sorting of the coarser or finer materials and no stratification is visible. No coarse breccia was observed at a higher elevation than 2700 feet. While a lack of any stratification precludes a subdivision of the volcanic rocks it appears that the coarse volcanic breccia and the tuffs with granitic fragments belong near the base of the series.

Mt. Phelps Volcanics

Another area of volcanic rocks quite similar to those occurring on Mt. Garfield occurs on both sides of the North Fork of the Shequalmie River below its confluence with the Lennox River. This area presents the same assemblage of volcanies as at Mt. Garfield, namely, massive andesites, coarse andesitic tuffs or breccias, fine grained tuffs, and tuffaceous sediments. There are more fine grained tuffs and less coarse tuffs here than at Mt. Garfield. The tuffs and tuffaceous sediments are intercalated with the shaly sediments and graywackes of the Calligan formation and some are rhyolitic in composition.

The area of volcanics is separated into several parts
by the rather extensive alluvial deposits along the North
Fork of the Snoqualmie River and along Sunday Creek. On the
south the andesitic rocks are exposed along the ridge between
Sunday Creek and the Snoqualmie North Fork. The region is
heavily timbered and exposures are limited at low elevations

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is encountered at an elevation of 1700 feet, about 200 feet above the river level. These andesite outcrops continue at intervals in cliffs twenty to fifty feet high as the ridge is followed to a peak at an elevation of 3200 feet. These andesites are dark greenish gray, fairly coarse grained, and generally porphyritic with visible feldspar phenocrysts. They weather to light tan, green or brown colors. Some of them are large dike-like masses.

predominantly tuffs. Most of these tuffs are light greenish gray, with a porcelain like texture. They contain a few irregular fragments of coerser grained volcanic rocks. Going east into Section 18, south of the Lennox mine, an increasing amount of argillite is intercalated with the tuffs. This argillite sometimes shows fairly good bedding, striking between north and N30°E and dipping nearly 90°. The intercalated tuffs and argillites finally end at a contact with quartz diorite.

Iennox River and the Snoqualmie North Fork the tuffs mentioned above can be followed to the edge of the alluvium. At one place just south of the St. Paul and Tacoma logging road a large mass of rather coarse grained dark green porphyritic andesite can be seen cross-cutting fine grained percellaneous tuff. At this point there also occurs some coarse breccia

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of granite and some of graywacks, contained in a matrix of percellaneous tuff. The graywacks fragments appear quite fresh and the clastic texture is well preserved (of Plate 16) while the tuffaceous matrix is hard and breaks with a conchoidal fracture like chart and has numerous patches and veinlets of epidote.

The same volcanic rocks outcrop on the north side of the river where they form the bulk of Mt. Phelps. The tuffs are more abundant than the massive andesitos. To the east, below Mt. Phelps, these tuffs contact the Snoqualmie granodicrite which is often of quarts disritic composition along this contact. Considerable alteration of the volcanic rocks accompanied the emplacement of the granodicrite and resulted in the formation of abundant yellowish green epidote in veinlets and patches and also considerable silicification and induration.

lamination but it is of such local extent and of such diverse strike and dip that it is of doubtful stratigraphic value.

Some of the massive andesitic tuffs exhibit a coarse sheeted structure. This is illustrated by the photograph (of Plate 17) taken in a canyon on the south side of Mt. Phelps. No attempt has been made to subdivide these volcanic rocks into strati-graphic units.

Mt. Phelps is at the east end of a long ridge which

PLATE 16

Photomicrograph of brecela near confluence of the lemmox River and the North Fork of the Snoquelmie River showing fragments of graywacke (left) and a fragment of granitic rock (right) in a groundmass of porcellaneous tuff. (Plain light; x 12)

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Photograph showing sheeting in massive tuffs on south side of Mt. Phelps.

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generates the drainage area of the North Fork of the Snoqualmie River from that of the South Fork of the Tolt River. Going west from Mt. Phelps this ridge is composed of the same volcanic rocks as occur on Mt. Phelps. They comprise fragmental rocks and massive andesites. The tuffs are mostly light to medium gray or greenish gray. The massive andesites are usually dark gray or dark greenish gray, and though they are not conspicuously porphyritic their foldspars are usually visible as lighter colored crystals against a dull background. As the ridge is followed westward to near the section line between Sections 2 and 3, Township 25N, Range 9E, the tuffs contain numerous fragments of granite. These tuffs, except for the presence of the granitic fragments, are similar to the tuffs to the east.

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while the bulk of the rocks described so far appear to have been above the water when they accumulated, the tuffaceous rocks from this point to the western edge of the map area are mainly in the form of tuffaceous sediments interbedded with shales and graywackes and have been described in conjunction with the clastic rocks of the Calligan formation.

on the south side of the North Fork of the Snequalmie River west of Sunday Creek. Exposures are very limited but outcrops and float indicate that the same andesitic tuffs which outcrop northeast of Sunday Creek also outcrop southwest of the creek. Rowever, the massive andesites are lacking here and tuffs are

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The Little part of the Mt. Pashes voluments grown comments and the first annual size of the comments of the annual size of the comment of size of the comment of size of the comment of th

predated with some sediments and show some stratification.

it would appear that here, as in the northwestern part
the map area we are dealing with water laid tuffs and the
tamic center was north of the river in the vicinity of lit.
tamic center was north of the raterial appears to have accumulated
the water.

These tuffs, together with those previously described, ear to form a rough circle around a small area of biotite nite. This granite, which is described more fully in pection with the granitic rocks, is exposed on the north of the ridge between Sunday Creek and the creek flowing of Take Philipps.

Southward toward lake Philippa the proportion of pyrostic material decreases and the rocks are best classified
h the sedimentary rocks. These tuffaceous sediments, with
tuffs, can be traced westward to the vicinity of Big
ek. Here they are well exposed in a road cut on the Weyerser logging road and are described in connection with the
iments. But along this road, just at the western edge of
map area, is an irregular area of volcanic breccia less
h a mile across. The tuffaceous sediments here are relaely flat lying with small open folds and minor faulting.
breccia appears to break through these sediments with
hly inclined boundaries and with no evidence of stratifition. It is not greatly altered and consists of fragments

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fragments of the frieble shales which are included as small lenses between the massive tuffaceous sediments at this point. These fragments are inclosed in a very fine grained partly amorphous tuffaceous matrix. At one place the breccia is cut by a two-foot dark brown andesite dike (cf Plate 18).

Petrography of the Andesites

The massive andesites in the area around Mt. Garfield and the area around Mt. Phelps are essentially the same, although those in the vicinity of Mt. Phelps are in places more highly altered. The andesites are usually, although not always, porphyritic, and the feldspar crystals are easily detected by eye. When fairly fresh the andesites appear crystalline and break with an uneven fracture. They are dark gray or dark greenish gray in color, and weather to lighter gray or brown. The specific gravity averages 2.85.

The foldspar of the andesites is some variety of andesine. These foldspars form tabular crystals which are usually elongated into laths in the case of the smaller crystals. The small laths usually show no twinning or only carlsbad twinning. The larger crystals are usually twinned after both the carlsbad and albite laws. The feldspars usually are slightly zoned, the outer rim being slightly more sodic. The boundary between the zones is not abrupt or well marked as in the case of the zoned crystals of the granitic

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Photograph showing andesite dike cutting volcanic breceia along logging road up Big Creek,

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retrography of the knimites

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rocks, nor does the albite constant vary more than a few per

meter across, and as small grains or needles in the groundmass. Some of these needles in the groundmass are extremely small, of green color, and are often enclosed in feldspar crystals. The larger homblende crystals vary in color from brownish green to bluish green. Both varieties are pleochroic. The brownish green variety has Z = dark green, Y = green, and X = pale brown. The bluish green variety has Z = greenish blue, Y = green, and X = greenish yellow, and the extinction angle Z:c is eighteen degrees. Some of the bluish green variety is definitely of secondary origin as it is seen to occur along fractures.

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Quartz and orthoclase are absent. There are variable amounts of iron ores present. Hagnetite is most common, and forms either shapeless grains or small diamond shaped octahedrons. Pyrite is sometimes quite abundant, especially in the more altered specimens.

The andesites vary considerably in grain size. Although the majority are holocrystalline, some have an exceedingly finely divided groundmass, which was probably originally
partly glass. Fragments of these finer grained andesites are
common in the Mt. Garfield tuffs and one such andesite outcrops in the bed of a creek which flows down the north side
of Mt. Garfield and empties into the Taylor River two miles

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product the blutch group varioty has S = group blue, crown, the blutch group, wallow, and the emiliar blue, crown, and I = grountsh yellow, and the emiliarion angle is of the emiliar graem wallety in in of theest degrees. Code of the blutch graem wallety is nitedly of decorder of codes william and the second of codess wallety.

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The endoution vary compidently in grain also the compident of the compositive and indicated and compiled the compiled the compiled production, which was probably confined to the compiled and compiled the compiled and compiled

above its mouth. This andesite is porphyritic (of Plate 19), with phenocrysts of andesine feldspar (Am₄₂Ab₅₈) and green hornblende, set in a very dense, partly amorphous base.

An example of one of the coarser grained andesites is that mentioned earlier as occurring in an irregular mass eross-cutting tuffs south of the St. Paul and Tacoma logging road along the North Fork of the Snoqualmie River between the Lennox River and Sunday Creek. Although this rock is megascopically like the other andesites it shows in thin section a more coarse grained texture almost identical in size with the average fine grained quartz diorites. It is porphyritic with phenocrysts of andesine feldspar up to two millimeters in size while the groundmass consists of grains of feldspar and hornblende averaging one-half millimeter in size. There are mmerous grains of pyrite scattered through the groundmass. Much of the hornblende is fibrous and some of the hornblende grains pass into veinlets of hornblende, indicating that much of the fibrous hornblende is secondary. Some epidote is also present. Plate 20 shows a photomicrograph of an andesite porphyry from the west side of Mt. Garfield.

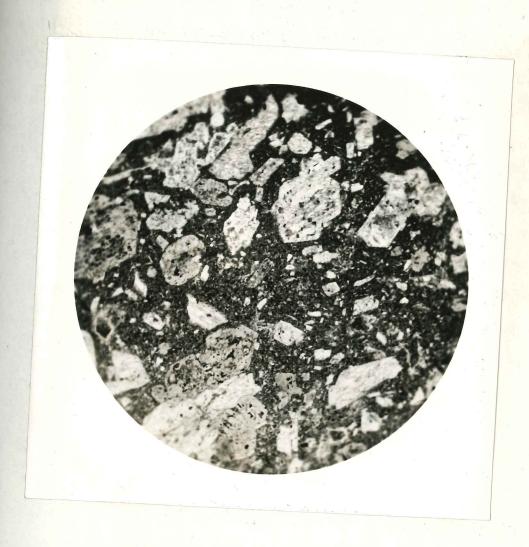
Petrography of the Andesitic Tuffs

The andesitic tuffs vary in color from dark to medium gray. With an increase in number and size of fragments they grade into andesite brecciss. On the other hand, as they deve its mouth. This andouble is newphysista (of Flate 19), its physical property of and green its physical and green business. Anythysis had green business and business and business and business and business and business.

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Petrography of the Andaeltic Puffe

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Photomicrograph of fine grained andesite from north slope of Mt. Garfield. Phenocrysts of andesine feldspar and hornblonde are inclosed in a partly amorphous groundmass. (Plain light; x 12)

Characteristical of the Statements Continues of the



Photomicrograph of porphyritic andesite from west side of Mt. Garfield. The phenocrysts are andesine feldspar and hormblende and the groundmass is holocrystalline and shows a development of much secondary hornblende and some recrystallisation of the foldspar. (x-Nicols; x 12)

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become water laid instead of subaerial they grade into the tuffaceous sediments (of Plate 21).

The tuffs and breccies are all very dense with no cavities. In the coarser grained tuffs or breccies the fragments are usually of a lighter color than the matrix.

This is especially true of rocks containing fragments of the capital rocks.

The matrix of the tuffs varies somewhat in grain size, granitic rock. but is usually very finely divided. Many of the andesitic tuffs on Mt. Garfield had an originally glassy base. This glassy matrix has been devitrified. In the less altered tuffs the matrix is exceedingly finely divided and indistinctly polarizing. In the case of the more altered tuffs the matrix shows a partial or total recrystallization. It then consists of a mosaic of small interlocking grains of feldspar with very irregular borders through which penetrate innumerable small needles of greenish hornblende. The feldspar appears to have a low birefringence as it gives only a gray interference color. Occasionally an imperfect albite twin can be seen and the extinction is usually almost parallel, which means the feldspar in the recrystallized tuffs is an oligoclase which is considerably more sodic than the feldspar of the andesites.

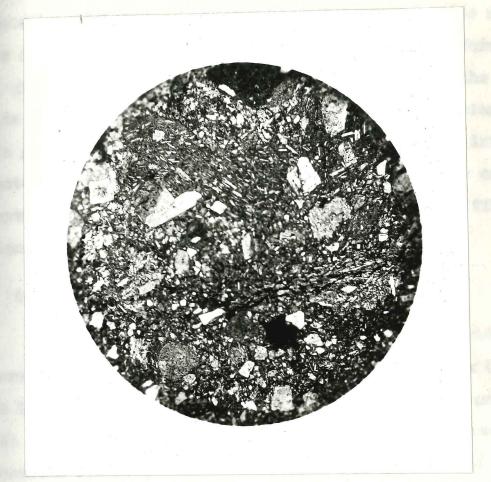
In certain of the fine grained tuffs such as those described from the cliff above the Quartz Creek logging road the entire rock has been thus recrystallized to form a fine the entire rock has been thus recrystallized to form a fine grained feldspar-hornblende-biotite hornfels. In this rock

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PIATE 21 the same constitution are the expension of the constitution of the



Photomicrograph of water-laid tuff from ridge between Philippa Creek and Sunday Creek. Numerous andesite fragments are mixed with some clastic quartz and feldspar. (Plain light; while the bar to want to be an amount of the la the x 12)

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there has also been an addition of some quartz which occurs in small scattered grains of irregular outline. A few of the feldspar grains have coalesced and grown to form larger porphyroblasts which have an amoeba-like shape and inclose many grains of hornblende. The biotite is deep brown and forms small grains about the size of the hornblende. Both the biotite and hornblende locally coalesce into porphyroblasts with a pronounced sieve texture (of Plate 22) or into irregular patches or bands surrounding areas composed mainly of feldspar. This is apparently a case of metamorphic differentiation.

Andesite Dikes Cutting the Calligan Formation

A number of dark brown dikes one to six feet wide were observed cutting the Calligan formation near Big Creek (cf Plate 18). They are often vesicular with holes up to one-fourth inch in diameter. Under the microscope they show an intersertal texture, with small lath shaped crystals of andesine feldspar and a mesostasis of green chloritic material that was probably originally glass.

Andesite Dike in Bear Besin

On the southeast side of Bear Creek across from the Bear Basin Mining Company camp is an andesite dike in the Stanodiorite, striking nearly parallel to the silver bearing veins in the basin. The dike is a dense black hard rock. A

PLATE 22

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Andanate Biles Cutting the Calling Formetice

A seminar of dark brown dilms one to six foot wide were

led to the Californ formation near Rig Creek (of

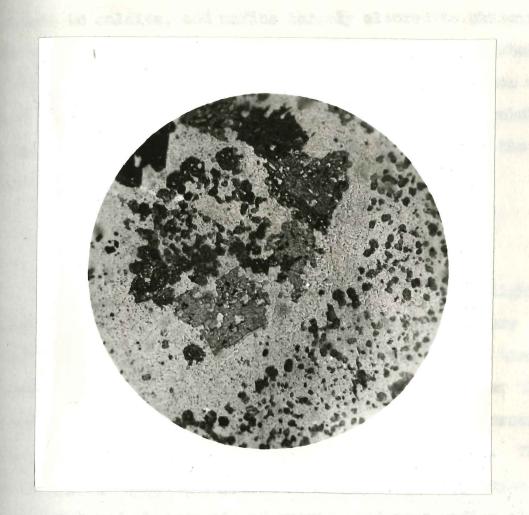
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Photomicrograph of recrystallized fine grained tuff from slope north of Quartz Creek logging road. There is a coarsening of grain size with coalescence of small hornblends and biotite grains into larger polkiloblastic grains and development of porphyroblasts of quartz and feldspar. (Plain light; x 50)

porphyritic. The phenocrysts consist of plagioclase largely altered to calcite, and mafics largely altered to chlorite. The groundmass shows a pilotaxitic texture and is composed of a mass of small plagioclase laths locally in flow lines with some interstitial iron ores and greenish material, probably chlorite. The dike weathers to a brown color due to the abundance of iron.

Dacite Porphyries in Granodicrite Near Granite Creek

On the ridge east of Granite Creek are some light greenish gray fine grained porphyritic rocks, which are probably dikes, although their scattered outcrops in timber prevent their true shape from being determined. Under the microscope they are seen to be dacite porphyries of essentially the same composition as the surrounding granodicrite. They contain large subhedral phenocrysts of andesine feldspar, some fractured phenocrysts of quartz, and some mafics altered to chlorite. The groundmass is a fine grained granular aggregate of quartz, plagicclase, orthoclase and chlorite.

Dikes in Preacher Granite West of Rainy Lake

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CONTROL OF THE STATE OF THE STA

On the ridge between the Snoqualmie Middle Fork and the valley occupied by the creek flowing from Rainy Lake are some dikes of varying composition outting the Preacher granite. These vary from dacite to andesite in composition. One dacite

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stands up as a ridge and exhibits good columnar structure (of Plate 23). It has phenocrysts of quartz, orthoclase, plagicelase, biotite and hornblende in a fine grained microcrystalline groundmass (of Plate 24). Some parts of the dike contain numerous fragments of granitic rock and one specimen consisted of about seventy-five per cent fragments (of Plate 25).

Several small dikes of fine grained pyroxene endesite and a small dike of andesite porphyry also cut the granite in this vicinity. The andesite dikes have chilled borders. These dikes represent later volcanic activity than that represented by the Mt. Garfield Volcanics.

Jake Wildest Metanorphies

General Features

This group of rocks outcrops in the southeastern part of the map area. It includes two small areas of banded metamorphic rocks which when combined cover less than one square mile, plus some massive greenstones of which only a small amount are within the map area. One of the areas of banded rocks is south of Mt. Roosevelt and north of Lake Maleetan, and the other is in the immediate vicinity of Lower Wildeat Lake. These rocks are relatively thin bedded pyroclastics and clastics metamorphosed to mylonitic schists and amphibolites (cf Plate 26).

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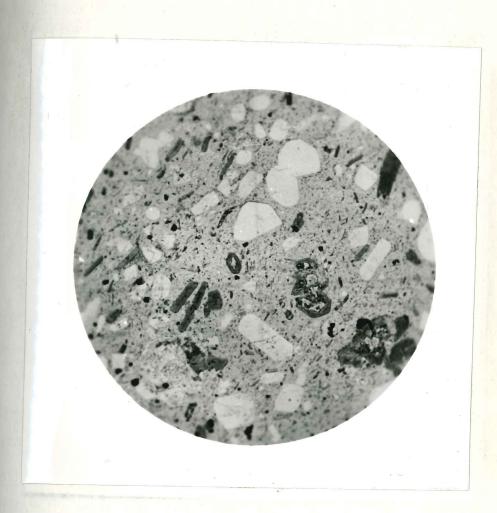
PLATE 23



Photograph of a dacite dike cutting Preacher granite north of Rainy Lake. The twenty-five foot dike shows good columnar structure.

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Photomicrograph of decite from dike north of Rainy
Lake (of Plate 23), showing phenocrysts of biotite, hormblende
and oligoclase and also corroded fragments of quarts and
feldspar from the surrounding granite. (Plain light; x 12)

FLAZE 25

PLATE 25

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Photomicrograph of a rock from near the border of a decite dike in which fragments of granite constitute seventy-five per cent of the rock. (x-Nicols; x 12)

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PLATE 26

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Photograph of banded mylonitic schist of Lake Wildcat Wetamorphics from outcrop southeast of Mt. Rocsevelt.

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The two small areas mentioned above are separated by granitic rocks of the Preacher stock, which in this border region include some microgranites. On the southeast the rocks give way to the more massive greenstones mentioned above.

Between Lower Wildcat Lake and Gem Lake the greenstones can be observed in contact with microgranites and granite perphyries of the Preacher stock. The contacts are very irregular, and at one point what appears to be bedding in the greenstone is highly inclined and distorted. Due to the extreme deformation of these rocks and their irregular contact with fine grained granitic rocks it is difficult to determine the exact stratigraphic relation between the banded rocks and the massive greenstones but it seems likely that they belong together and that their relation is similar to that between the Calligan formation and the Mt. Phelps and Mt. Garfield Volcanies.

On the north and northwest these rocks and the Preacher granite are interrupted by the elongated body of granodicrite which cuts across the Preacher stock in the vicinity of Mt.

Roosevelt and Upper Wildcat Lake. This contact can be observed on the ridge south of Mt. Roosevelt and also near the outlet of Lower Wildcat Lake.

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Some inclusions of banded hornfels and amphibolite similar to these rocks are found within the area of Preacher granite south of Mt. Garfield, and also on the slope between the Pratt River and Rainy Lake. Some banded greenstones (hf Plate 27) resembling the darker portions of these rocks form

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Photomicrograph of greenstone outcropping south of Lake Blethen showing numerous veinlets of hornblende. (Plain light; x 12) to senten those mooks to a populate formations

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the cours of Mt. Carffeld, and also on the clope between

small outcrops on the ridge south of Lake Blethen where they are interpreted as metamorphosed tuffaceous sediments of the calligan formation originating at the Mt. Garfield volcanic center. Some blocks ten to twenty feet in diameter of banded erconstones also outcrop just above the CCC road on the east side of the long tongue of granodiorite which extends down from Bessemer Mountain toward the Middle Fork of the Snoqualmie River. The outcrops south of Lake Blethen and above this CCC road are shown on the map in the same color as the Lake Wildcat metamorphics. Some similar bands of amphibolite occur in the vicinity of Paradise Lake in the northeastern part of the map area within the highly metamorphosed rocks in that small area of Calligan formation surrounded by granodiorite. Thus it would appear on the basis of lithology that these rocks could be highly metamorphosed tuffaceous and clastic rocks of the Calligan formation. However, Smith and Mendenhall (7), writing of the contact relations between the Snoqualmie granodiorite and the Guye sedimentary rocks in the vicinity of Snoqualmie Pass, describe an occurrence where carbonaceous slate has become a gneissoid rock, the black layers alternating with irregular bands of quartz and feldspar. Therefore, since these rocks could have originated by metamorphism of either the Guye or Calligan formations, or even be older, it seems better to assign these rocks to a separate formation.

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Petrology of the Take Wildest Mylonitie Schists, Amphibolites, Etcetera

Vary from several feet to fractions of an inch in width.

Common colors are dark green, purple, black and light gray.

The dark green bands are amphibolites, consisting primarily of a green amphibole, but usually with some biotite. The amphibole occurs in elongated, small grains. It is pleochroic, with Z = pale green, Y = very pale green, and X = pale yellow.

The maximum extinction angle Z to c observed was sixteen degrees. Due to its fibrous habit, pale color, and moderate extinction angle the amphibole is best called actinolitic horn-blende.

when examined in thin section show the rock to have suffered intense shearing during which quartz separated out into bands or lenses and biotite concentrated in biotite rich bands. The rock was then recrystallized statically so that the quartz in the bands and lenses forms a mosaic texture while the remainder of the rock consists of very fine grained biotite and quartz.

Magnetite is distributed throughout the rock and there is some hematite staining. Some of the lenticular shaped areas of quartz have some concentrations of biotite around their borders as further evidence of metamorphic differentiation.

The black bands are composed essentially of biotite, but there is usually some quarts and hornblende. This biotite

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ALL of these roots are bended, The Ladividual beads . They may may be it out to the sections of the states. - three partitions, but the all a will come biggins, respectively. -wolling militing will here among other wasn't all coming biles a 2 days so motor and profes the filter and hard a pale and on a second berg things award of foot our works nothing a high at Southwest, some shood offit due hodgestages nivery dollar palate bullesock complete ed? .combered to allegate at becauting open edite? for the combet of accept will seek on officelying benefitely over each asy the recordered and estate equation at the countries about the characters. arrang has obtable bookers enth that to established they and to sport bounds valuational but to send and there of the . collection of the participation of the tellers.

is fine grained, partly in well formed small plates and the remainder in more irregular grains. Abundant magnetite is scattered through the biotite. In some bands the biotite and hornblende are intimately intergrown but generally they occur in separate bands. The high concentration of biotite in dark bands appears to be the result of metamorphic differentiation, rether than of biotitization of hornblendic bands of which there is no indication.

The light gray bands consist of quartz, some untwinned feldspar, and disseminated fine grained biotite, the latter giving the bands the gray color. The biotite in these gray bands is of greenish brown color rather than reddish brown as in the case of the purple colored bands. One specimen of gray and black banded mylonitic schist from the outcrop shown in the photograph in Plate 28 shows much evidence of metamorphic differentiation with quartz bands alternating with bands of greenish brown biotite, often in very fine sharp banding.

Locally small veinlets of quartz extend cut from the quartzose bands cutting across the biotite bands indicating solutional movement of quartz within the rock.

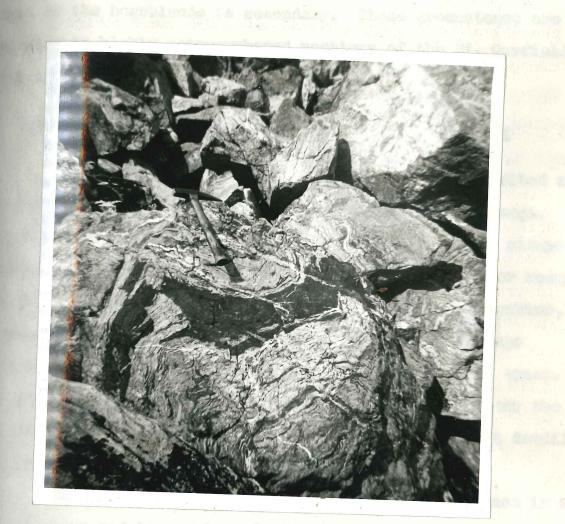
These metamorphic rocks have evidently formed from interbedded clastic and tuffaceous rocks. The amphibolites formed from tuffaceous rocks and the mylonitic schists formed from beds of quartzose argillites or graywackes, although the fine details of the banding are largely the result of metamorphic differentiation rather than original fine bedding.

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The light gray bands consist of quarts, adea delicar in the latter of the latter, and disseminated line grained biestes, the latter, the beauty and the gray color. The blotte in these gray as the first the property of a common of gray the first their their sense of the rupple colored beauty. One apparent of the control of the rupple colored beauty the control of the standard spinal size and aviante the control of the contr

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PLATE 28 TO THE PLATE 28 TO THE PLATE SHOW THE PROPERTY OF THE



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Photograph of mylonitie schist outcropping south of Upper Wildcat Lake.

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The massive greenstones are dense, dark green massive rocks composed essentially of andesine feldspar and hornblende. West of the hornblende is secondary. These greenstones are similar to highly metamorphosed portions of the Mt. Garfield Volcanies.

Subdivisions of "Snoguelede Batholith" in Hap Area

The "Snoqualmie Batholith" has long been described as one of the large granitic masses within the Cascade Range.

Previous geologists who have worked on it have almost always mentioned that granodicrite predominates but that other rocks also commonly occur, including such diverse types as gabbro, pyromene dicrite, quarts dicrite and granite. Nost maps published do not show any boundaries of these various types. On preparing this thesis an attempt has been made to map the boundaries of the various granitic types in as great a detail as possible.

In this thesis the term "granitic rocks" is used in a broad sense and is meant to include all the granular plutonic rocks varying from quartz diorite to granite. Within the map area granodiorite has the greatest distribution among the granitic rocks, covering about forty-two square miles. It is a directionless granodiorite, consisting of andesine feldspar, orthoclase feldspar, hormblende, biotite and quartz. Extensive outcrops of similar granodiorite occur north and east of this map area. Because of local usage the name Snoqualmie grano-

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diorite has been retained in describing this rock but in this
report the term is restricted to those coarse grained facies
in which the amount of plagioclase feldspar exceeds the amount
of orthoclase feldspar, and not as a general term covering all
the rocks in the "Snoqualmie Batholith." No detailed petrographic study of this granodiorite for the purpose of determining its genesis has been included in this thesis, but enough
thin sections have been made to establish it as a mappable
unit.

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The next largest mass of granitic rock within the map area is a body of leucocratic granite covering about eighteen square miles in the southern part of the area, which has been called the Preacher granite. It consists primarily of orthoclase, oligoclase, quartz and biotite. In contrast to the granodicrite which normally contains twenty to twenty-five per cent hornblende plus biotite, the Preacher granite normally contains less than ten per cent mafics, and these are biotite and secondary chlorite.

Closely associated with the Preacher granite is a more heterogeneous and less easily described area of rocks occurring in the general area of Quartz Creek, which is here designated as the Quartz Creek Complex. Because of its great hetero-ceneity and the limited exposures in the area this complex has not been mapped in detail but has been divided into areas in which certain rock types predominate. Within the Quartz Creek Complex are an area of heterogeneous granitic rocks of migmatitic

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character north of Quartz Creek; an area of greenish gray tonalite in the vicinity of Mowich Lake; and an area of fine grained quartz diorite centering between Quartz Creek and the snoqualmie River Middle Fork. The grouping of these areas together for mapping purposes is not meant to imply that all the rocks within the complex have a common genetic origin.

A very small body of blotite granite, the Sunday granite, outcrops along the North Fork of the Snoqualmie River between Philippa Greek and Sunday Greek. It consists primarily of microperthite, oligoclase, quartz and blotite. It is not conspicuous because of its limited exposures in a very heavily wooded area.

Quarts Creek Complex

General Statement

Complex has been divided into an area of heterogeneous granitic rocks between Quarts Creek and Marten Lake, an area of tonalite near Nowich Lake, and an area of fine grained quarts diorite near Quarts Creek. The boundaries dividing these separate areas on the accompanying map are largely diagramatic. These rocks are similar in that they have an overall heterogeneous appearance. Although part of the rock of tonalitic composition around Mowich Lake is of fairly uniform composition it is gradational on the south into some of the darker colored rocks of the Area of Heterogeneous Granitic

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Rocks. This latter area is made up of rocks varying in composition from quartz dioritic to granitic, with the rocks becoming more acidic toward the south and east.

The fine grained quartz diorites in the vicinity of Quartz Creek are of darker color and more basic in composition than the rocks of quartz dioritic composition included in the area to the north. The granite associated with the fine grained quartz diorite is the same as the Preacher granite and inclusions of quartz diorite are contained in the Preacher granite. There is also a zone of quartz diorite between the Preacher granite and the Mt. Garfield Volcanics on Mt. Garfield. The relations between the component parts of the Complex and between the Complex and the surrounding rocks will be discussed

conflorarate companies a hear wile to the east in a Area of Heterogeneous Granitic Rocks

General Features This putterns the spetch are grantite to This area offers limited exposures and therefore the field relations are somewhat in doubt. However, where exposures are available such as along some creek beds and on the crests of some ridges the rocks exhibit many variations in texture and composition. Light gray to light brown colored rocks of granitic to granedicritic composition predominate but come darker gray fine grained rocks of quartz dioritic composition also occur. Some of these latter rocks are indistin-Suishable from the finer grained tonalites near Mowich Lako

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and thus the northern boundary of this area is gradational. The amount of the lighter colored rock increases toward the eastern part of this area and between Quartz Creek and Warten Take, on the ridge north of the Taylor River, there are large outcrops of fine to medium grained leucocratic granitic rocks with numerous large quartz grains visible. Megascopically the rocks here somewhat resemble the Preacher granite.

A coarse conglomeratic appearing rock outcrops over an irregular shaped area about one-fourth mile in diameter along the Quartz Creek logging road above the first switchback. On the south and east this conglomeratic rock contacts quartz diorite. North and west of the conglomerate the overburden is deep and outcrops are few but the float is principally composed of relatively leucocratic granitic rocks. This granitic conglowerate reappears a half mile to the east in a small outcrop on the north side of the Taylor River Valley. North and east of this outcrop the rocks are granitic to quartz dioritic in composition. They are exposed in the small stream canyons leading north from the Taylor River as alternate light and dark colored bands and patches with irregular gradational boundaries. The rocks above and to the west of this small patch of granitic conglomerate are either fine grained quartz diorites or belong to the small area of Mt. Garfield Volcanies north of the Taylor River. The Area of Heterogeneous Granitic Rocks as shown on the map is arbitrarily fixed at this Point to include the granitic conglomerate and the hetero-

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geneous rocks along the Taylor River and exclude the fine grained quartz diorites and the volcanic rocks.

Some of the coarser grained gray rocks in the Area of Heterogeneous Granitic Rocks are similar to the large mass of granodiorite in the northeastern part of the map area. It is noticeable that east of Marten Lake and north of Cougar Lake the rocks are granodiorite throughout and of fairly uniform texture so the latter area is shown on the map as part of the Snoqualmie granodiorite.

The nature of the boundary on the west will be discussed below.

Petrography

The fine grained light gray to light brown rocks near the center of the area have a crystalloblastic texture. They consist of plagioclase and orthoclase in varying proportions together with quartz, hornblende and biotite. The plagioclase varies from eligoclase in the lighter colored rocks to andesine in the darker varieties, and it usually is twinned and also soned with a more albitic rim. The hornblende is in aggregates or in fibrous masses and appears to have grown by coalescence of numerous small grains by collective crystallization or local metamorphic differentiation. The ratio of hornblende to biotite varies widely, but in general the amount of biotite exceeds the amount of hornblende. In some cases the biotite appears to be forming by biotitisation of hornblende but in lost cases it appears as irregular shaped grains along the

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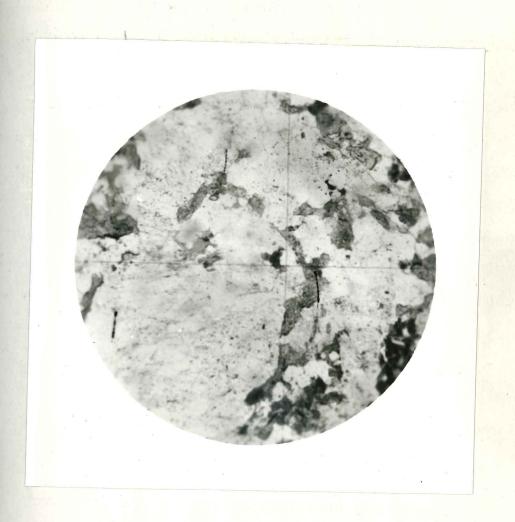
boundaries between quartz and feldspar (cf Plate 29). The plagiculase often forms grains somewhat larger than the remainder of the rock. The groundmass then usually consists of quartz, feldspar and mafics in a granulitie crystalloblastic texture (cf Plate 30).

The crystalloblastic texture of these rocks indicates that they have formed by metamorphism. Throughout most of the area the original character of the rock before recrystallizetion is largely obscured. However, in the western part of the Quartz Creek Complex, for example along the ridges south of Blethen Lake, there are some large outcrops of fine grained light to medium grained rocks which, on the basis of their appearance in the field, might be named microgranite or microdiorite. In thin section these rocks reveal relies of a clastic texture (of Plate 31). The quarts grains have grown by coalescence of numerous smaller grains or locally have recrystallised into a mosaic texture. New porphyroblasts of feldspar have developed which are clearer than the original clastic feldspar. The biotite has been excluded from the areas occupied by these porphyroblasts and forms ragged grains around their borders. Comparing the microscopic features of these rocks with those of the altered massive feldspathic graywackes of the Calligan formation to the west reveals that these rocks are metamorphosed feldspathic graywackes. Recrystallization has caused these rocks to have a fresh appearance on a fracture, which combined with the growth of the larger biotite grains and

PLATE 29

section (of Fince 30). boulday only to squastus cans large or street cold serve a lo seller Leeves meet spent spettes might al mercy over entern strang all, the quarte grains bever grown to atabideredgeog well .ocutest aleach a ctal beatfine was manys out most beharings smed and estimated and . required to a real sends to neughet picopaproin edd malusgrot .arched a

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Photomicrograph of partially granitized graywacke from north of Quartz Creek in Area of Heterogeneous Granitic Rocks, showing the irregular shaped hornblende and biotite grains.

(Plain light; x 40)

Photomicrograph of same partially granitized graywacke as Plate 29, showing porphyroblasts of plagioclase folispar in a granulitic groundmass. (x-Nichols; x 40)

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Photomicrograph of fine grained recrystallized foldspathic graywacks from ridge south of Biethen Lake (x-Nichols; x 40)

minutes and and polytophians of playlocked foldings in the state of th

a lack of any visible structure in the hand specimen gives them a misleading igneous appearance. Granitization of somewhat similar rocks belonging to the Swauk formation near Wenatchee has been described by H. A. Coombs (3).

Granitic Rocks are thus seen to be gradational into the Calligan formation to the west. In many cases the change is mostly one of recrystallization with little evidence of material being added. Since the feldspar in the feldspathic graywackes is largely plagioclase feldspar the rocks in the Area of Heterogeneous Granitic Rocks which have suffered only recrystallization are largely of quartz dioritic to granodioritic composition. The chloritic matrix of these graywackes recrystallizes to form both biotite and hornblende but biotite predominates.

In an intermediate stage of recrystallization the large quartz and plagiculase porphyroblasts become numerous and only small areas of groundmass with a granulitic texture remain (cf Plate 30). In a more advanced stage the entire rock is recrystallized to a coarse grained crystalloblastic texture (cf Plate 32). In these latter rocks there is usually considerable metasomatism with a replacement of some of the earlier plagiculase by orthoclase so that the rock has acquired the composition of a granite. This potash metasomatism is evident in the rocks north of the Taylor River between Marten Lake and Quartz Creek where some of the outcrops resemble

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PLATE 32

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Fhotomicrograph showing a medium grained granite formed by granitisation of a feldspathic graywacke; from ridge between Quarts Creek and Marten Lake. (x-Nicols; x 15)

the red space were also as the restrict ground as a ter-

parts of the Preacher granite. The north slope of the Taylor

River is quite steep and descending this slope the amount of

reucocratic rock decreases and the amount of dark gray mela-

nocratic rock increases, until, as mentioned above, near the

Taylor River the rocks consist of about equal amounts of dark

and light colored material. An examination of thin sections

composition with andesine feldspar and hornblende as the chief

of these rocks shows the darker rocks to be of dioritic

constituents while in the lighter colored patches the predominant minerals are oligoclase and quartz. Quartz forms irregular patches and poikiloblastic grains in the quartz diorite and makes up over fifty per cent of the lighter colored rock. Nuch of this quartz appears to have been introduced and in this locality it is hard to determine how much material has

between warts Crask and Warten helm. (see Hacker a 15)

Mention should be made of the occurrence of a finer grained, gray rock, with numerous megascopically visible quartz grains scattered through a rather fine grained gray groundmass, which outcrops at the top of the 5340 feet high peak west of Marten Lake. In thin section this rock is seen to have a cataclastic texture in which a rock of originally granitic composition and crystalloblastic texture has been extremely brecciated, with only porphyroclasts and elongated islands of the original rock remaining in a fine grained groundmass (cf Plate 33). The quartz grains of the original rock resisted

been added and how much originated by recrystallization of

pre-existing rocks.

The second secon

Photomicrograph of a mylonite from the peak west of Marten Lake showing porphyroclasts of an original granitic rock in a fine grained cataclastic groundmass. A small amount of blotite has developed in the groundmass. (x-Nicols; x 12)

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the shearing better than the other grains and predominate among the porphyroclasts, but even these show fracturing and undulating extinction.

Granitic conglomerate

This rock contains rounded pebbles up to six inches in size. Both pebbles and matrix have been recrystallized so that locally they can not be told apart and the conglomeratic appearance is more noticeable in the outcrop than in thin section. The pebbles and matrix are mostly leucocratic and fine to medium grained. However some of the pebbles contain more mafics and therefore are darker in color (of Plate 34). There are some patches of coarse grained leucocratic granitic rock. In thin sections of the conglomerate the texture of both fragments and matrix is seen to be crystalloblastic. The rock has been severely brecciated and fractures have occurred along the curved borders of many of the pebbles and fragments (of Plate 35). Along these fractures some chlorite and biotite often have developed. The matrix of the conglomerate is usually richer in quartz than the fragments. Much of this quartz in the matrix appears to have been hydrothermally introduced as is shown by the presence of small amounts of ore minerals with the quartz.

It is hard to explain the numerous well rounded pebbles and the diversity of fragments observed in this rock in any other way than by assuming a clastic origin. From the recrystallization of the other rocks in this vicinity it is apparent

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PLATE 34



Photograph of out surface of granitic conglomerate Outcropping along Quartz Creek logging road showing rounded Outlines of fragments. Two-thirds natural size.

PIATE 35

Photomicrograph of the border of one of the rounded granitic pebbles in granitic conglomerate from Quartz Creek logging road showing the curved fracture around the border of one pebble. (x-Nicols; x 12)

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that most of the original microscopic features of a small mass of conglomerate such as this would be altered by the recrystallisation, although the overall conglomeratic appearance could still be preserved.

Tonalite Wear Mowich Lake

General features

In the vicinity of Mowich Lake, near the headwaters of Sunday Creek, and south of this lake along the divide between Quartz Creek and the Sunday Creek drainage areas is an area of tonalite. In the vicinity of Mowich Lake it is a gray medium grained rock with semetimes a faint tinge of greem. Both feldspar and quartz grains are visible in the hand specimon. The mafics, consisting of hornblende and biotite, appear quite black, and have a tendency to occur in groups one-eighth to one-fourth inch in diameter. It is not as leucocratic as the large masses of granedicrite to the north of it and does not have as fresh an appearance or as uniform a texture.

The abrupt change from tonalite to granodicrite along the ridge between the Quartz Creek and Sunday Creek drainage areas directly south of Sunday Lake can be readily observed. This contact can also be noted north of Mowich Lake by a change in the type of talus west of the creek draining the lake. As the tonalite is followed to the south from Mowich Lake it decreases in grain size. This decrease can be noted when climbing up the Quartz Creek trail from Mowich Lake, at

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southern limit of the area of tonalite is arbitrary since the finer grained tonalite is indistinguishable from some of the darker colored rocks in the Area of Heterogeneous Granitic Rocks. The tonalite differs from the fine grained quarts dicrites to the south in being somewhat lighter colored and it does not have the fresh appearance of these quarts dicrites. The abundance of biotite in the tonalites and its scarcity in the fine grained quarts dicrites is another distinguishing feature. Some outcrops of fine grained gray rock similar to the tonalite occur in the Area of Fine Grained Quarts Dicrite also; so the division of the Quarts Creek Complex into the three areas given on the map is merely diagramatic and the distribution of rock types has numerous irregularities which are not shown.

Petrography

Although the grain size of some of the coarser grained tonalite near Mowich Lake approaches that of the normal grano-diorite to the northeast the rock is seen in thin section to be closer to a tonalite than to a granodiorite as only about five per cent of orthoclase is present. The plagioclase feldspar is andesine (averaging AngAb65) and comprises over fifty per cent of the rock. It occurs in subhedral crystals, one to two millimeters in size, and is usually zoned and free from alteration. Some of the plagioclase has a light greenish tinge in the hand specimen. The quartz comprises about twenty

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per cent of the rock and is mostly intergranular. A few verger grains of quartz are polkiloblastic and inclose earlier plagicolase (of Plate 36). The hornblende and biotite are mostly anhedral and occur partly in small groups or segregations, one-eighth to one-fourth inch in diameter, producing a somewhat "glomeroporphyritie" texture. The amount of biotite usually exceeds the amount of hornblends. Some of the biotite follows the boundaries between grains of quartz and feldspar and even seems to penetrate along some cleavage cracks in the plagioclase (of Plate 37). The overall texture is crystalloblastic. There is insufficient petrographic evidence in the specimens studied to reach any definite conclusions regarding the genesis of the tonalite. The poikiloblastic grains of quarts, the overall crystalloblastic texture, and the irregular nature of the biotite and hornblende suggest that it is a basic rock which has suffered considerable recrystallization and metasomatism but the nature of the original rock is unknown.

The Area of Fine Grained Quartz Diorites

Ceneral Features

These rocks are dark gray or dark greenish gray and of fine to medium grain size. They have andesine feldspar, horn-blende, and quarts as the principal constituents. From outcrop to outcrop they show numerous variations in grain size and in the percentage of feldspar, quarts, and mafics. Some of the finer grained quarts diorites can not be told megascopically

PLATE 36

twoon Quarts Creek and Sowiet Late. A large politicalistic all of quarts incloses an enhanced placing and crystal and to other smaller grains. (2010016; 21) Flate 37 shows

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Photomicrograph of same thin section as shown in Plate 36. (Plain light; x 15) The hornblende and biotite form irregular grains penetrating along the boundaries between quartz and feldspar.

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Some of the quartz diorites are uniformly fine grained with a fresh appearance on a newly fractured surface. This type is especially numerous around the northern border of the reacher granite and as inclusions within it, some of which measure as much as one hundred feet across. Locally these fine grained quartz diorites contain very irregular shaped patches of more leucocratic rock and then they have the appearance of migmatites. These migmatites are well exposed in the vicinity of Nordrum Lookout near the mouth of the Taylor Miver.

forming patches in some of the fine grained quartz diorites, locally also occur in fairly large masses. These leucocratic quartz diorites are usually adjacent to Preacher granite and also occur as inclusions in the granite. They have large gains of andesine feldspar in a groundmass which is darker in tolor and sometimes resembles the quartz diorites described in the previous paragraph, but often is even finer grained.

Other outcrops of quartz diorite have a streaky apDearance due to the growth of biotite and hornblende along
Fractures. Some of these rocks contain forty to fifty per
Ont hornblende and are so dark in color as to be told with
difficulty from the Mt. Garfield andesites without a microNope. They are especially numerous adjacent to these vol-

dis it, depolic and site distributions are uniformly fine qualment of freely expenses are uniformly fine qualment of freely expenses and an arrival and the series of the configuration are under the series of which are are as a freely freeze of the series of which are are as an arrival free as a freeze of which are are as a freeze of the configuration and then they have the arrow of analysis of those will are also are are also are as a series of an arrow of adjustical are also are also are as a series of adjustical areas are well arrowed in a distribution of the freeze are well arrowed in

The core is nowed the fine drained quarts diorities, as well as contain the fine drained quarts diorited, also contain the fairly large messes. These levelousite and contains are smully adjacents to Preacher drain to and contains as included and the graphs. They have large and contains an included in the graphs. They have large the contains the draining and constitute the draining and constitute the draining and constitute the draining and constitute of the graphs of the constitute of the constitute of the constitute and forth to the constitute of the constitute and the constitute and constitute and the constitute and const

diorites will be discussed in detail below, together with their petrographic details. Good exposures of quartz diorites are present along the St. Regis logging road on the north side of Quartz Creek. These rocks vary considerably in texture and have some areas of granite ten to twenty-five feet wide in them. They are cut by numerous faults striking N650% to N900% and the outcrops of granite are bounded by faults. One large outcrop exposed in a rock slide reveals rounded inclusions of dark colored fine grained quartz diorite in a coarser grained more leucocratic quartz diorite and is similar in appearance to some outcrops in the migmatitic border of the Snoqualmie granodiorite along the Lemmox River (cf Plate 52).

Quartz diorites outerop in irregular fashion along the northwest edge of the Preacher granite. At most places the transition from granite to quartz diorite is fairly abrupt, often with visible cataclastic textures. There is no tendency for a belted appearance of the outerops here, but rather the traces of the contacts between sediments and diorites and between diorites and granite are very irregular. Along the CCC road just within the edge of the Calligan formation as shown on the map are two large outerops about fifty feet wide of porphyritic rock with visible phenocrysts of feldspar in a dark colored aphanitic groundmass. A study of thin sections of the rocks shows them to be andesite porphyry, somewhat finer grained along the borders. The groundmass contains much horn-

nestroit estates to service to Scot estates object outes and direct one of hear guingal alger on and years from Some president of the second property of the country of the second of th ar after feet orly-variety of not diliner to make out A See (127 ocal Ta) howld morned oil ocals bother value of the state About the grantite are wast throughour. Along the good to -rog to obly soon while deep according egent our our day out to modicae gift to viere A assemblement officeador has -mod done satisfano, epartyulora est. 'suresana add anolo inte

mende and no quartz. These rocks can not be traced in the heavy timber beyond the road out but the contacts of the andesite porphyry with the highly disturbed Calligan graywackes and argillites appears to be in an approximate eastwest direction across the strike of any bedding that can be recognized in the vicinity so it is possible that they are Mike-like masses. These andesite perphyries megascopically resemble some of the finer grained quartz diorites. Contact relations in this vicinity are further complicated by faulting in an east-west direction. Immediately north of the coc road the quartz diorites contact hornfelses and granulites of the Calligan formation while farther to the north they are in contact with dark greenish metamorphosed tuffaceous rocks rich in hornblende. The quartz diorites display here the same wide variety of textures as in the vicinity of Quartz Creek. One large outcrop resembles the finer grained tonalites south of Mowich Lake and it is possible that these quartz diorites are of more than one age and genesis.

Petrography will fire to say a controlled to per control

Fine grained quartz diorites associated with Preacher

Franite. The fine grained fresh appearing quartz diorites

are everywhere closely associated with the Preacher granite

and it is hard to discuss the two rock types entirely separately.

Outcrops of the dark gray, even grained quartz diorite are

numerous on the slope north and northwest of Nordrum Lockout,

between the Middle Fork of the Snoqualmie River and Quartz

creek. The outcrops in the timber are about equally divided
between quartz dicrite and granite, including locally some
fine grained microgranite. One outcrop of granite contains
several round areas up to six feet in diameter of fine grained
quartz dicrite with very sharp boundaries, while a few hundred
yards away the quartz dicritic inclusions are elongated in an
east-west direction. One large outcrop forming a low cliff
consists of ninety per cent fine grained quartz dicrite with
ten per cent of irregular shaped patches of coarse grained
more leucocratic rock.

The fine grained quartz dicrite in the cutarons name

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The fine grained quarts diorite in the outcrops mentioned above consist of lath shaped grains of andesine feldspar and irregular shaped grains of green hornblends. The
most distinctive feature of the feldspars is the absence of
alteration products which accounts for the fresh appearance
of these rocks. Some intersticial quarts is present and the
amount varies from ten to twenty-five per cent. The hornblends
has a crystalloblastic texture with irregular outlines and
varies in amount from twenty to forty-five per cent of the
rock. Biotite may be entirely absent or present in amounts
less than five per cent and it appears to have formed by
biotitization of the hornblends.

Where light colored patches occur in the fine grained quartz diorite they are composed mainly of large subhedral grains of andesine feldspar and irregular grains of quartz. Whereas the andesine feldspar in the fine grained quartz

enterior of hims to governo and technique contains -one method of all all all all and postern and the cult had integra at aftern tatellement econ . micon the penningrof the transfer of the contract of the forth will be not be done the evilon transfer to the plant out? descent at the

Where light colored patches certy in the file making there is the character to the characte

cratic patches approaches oligoclase. The borders of the large feldspars are straight and the grains are mostly free of inclusions. Locally the larger quarts grains contain inclusions of lath shaped feldspars. The bornblende in the light colored patches forms irregular aggregates and has been largely replaced by biotite. There is no potash feldspars.

Hear the borders of the Mt. Garfield andesites there are numerous rocks which are intermediate between andesite and quartz diorite. In some of these rocks the original phenocrysts of plagioclase are still visible although partly altered, and small crystalloblastic plagioclase and quartz grains are developing in the groundmass of the andesite.

These rocks usually do not show much recrystallization and take on the fresh appearance of the fine grained quartz diorites unless there has been an appreciable metasomatic addition of quartz. The beginnings of some crystalloblastic growth of feldspar can be seen in the groundmass of the coarse grained andesite porphyry illustrated in Plate 20.

diorites thus might have resulted from recrystallization of basic rocks. The fact that the hornblende in the leucocratic patches is being biotitized and the presence of some inclusions of feldspar in the larger quartz grains suggests that these patches are due to the action of solutions containing potash and silica.

enginetons. Locally the larger querts exclus contain

and have developing in the group hands of the andepito.

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Variations in textures in the vicinity of Quartz The presence within the quartz diorite along the Quarts Creek logging road of some outcrops of granite bounded by faults has been mentioned above. For about ten feet adjacent to the fault the quartz diorite consists of numerous large grains of sodic andesine and quarts in a fine grained groundness. Many of the large feldspar grains show evidence of having been fractured and rehealed with feldspar of a different orientation indicating that fracturing and recrystalliration have occurred simultaneously. Some of the larger grains are composite and appear to be porphyroclasts of Preacher granite. The groundness appears somewhat cataclastic but the fragments have been recrystallized and there has been a development of some porphyroblasts of hornblende and some veinlets of hornblende so that the rock has a marked crystalloblastic texture. There are scattered grains and irregular shaped patches of quartz in the groundmass. Beyond this ten foot zone the quartz diorite is fine grained with lath shaped andesine grains, subhedral green hornblende, and a small amount of intersticial quarts.

Emall angular blocks of granite a few inches across contained in fine grained streaky appearing quartz diorite. Large thin sections of these blocks show them to be typical coarse grained granite highly fractured. The fine grained rock enclosing the block consists of anhedral to subhedral crystals

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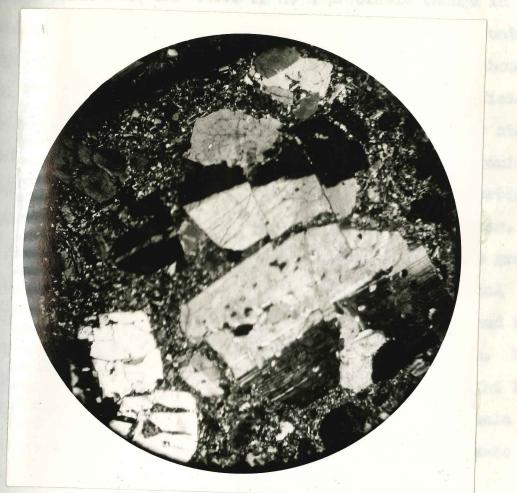
Parther to the north along the read there are seen a familiar blocks of available a few inches demons operating angular blocks, inred this single this show them to be typical coring to be typical to be typical coring to be typical to be typical coring to be typical typica

of andesine feldspar, quartz, and hornblende, about one millimeter in size, contained in a finer grained groundmass averaging about 0.2 millimeters in grain size. The groundmass looks cataclastic and the larger grains appear to be developing both as recrystallized porphyroclasts and as porphyroblasts (of Plate 38). The large grains in this quartz diorite are much clearer than the grains of the granite and have cremulated borders and some contain inclusions of the groundmass. Some hornblende is growing along fractures. These occurrences of granite surrounded by quartz diorite appear to be blocks of granite which have been involved in faulting, and the bree-clated granite and quartz diorite them recrystallized with some solutional interchange of material.

Et. Garfield. The southeastern part of Mt. Garfield consists of Preacher granite, and the northwestern part is composed of the Mt. Garfield Volcamics. Fine grained quarts diorite outcrops between the granite and the andesitic rocks and can be examined on both the southeast and southwest slopes of the mountain.

To reach the southeastern outcrops of quartz diorite one can follow the old logging grade up the Middle Fork of the Snoqualmie River to about four miles above the Taylor River, and then climb up to the north along the timbered slope between Garfield Mountain and Dingford Crock, sometimes called Green Ridge. As stated above, the quartz diorite here is in

PIATE 38



The fibe partern planted and (Angology), lovey por

Photomicrograph of fine grained quartz diorite from near faulted block of Preacher granite north of Quartz Creek road. Parts of the fine grained groundmass show the development of small lath shaped feldapar grains. (x-Nicols; x 15)

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contact with the Preacher granite. In this vicinity the latter comprises both fine grained granophyric and coarse grained varieties, and there is no appreciable change in the Preacher granite as one approaches the volcanic rocks until within less than 1000 feet of the contact. Here, at about 5000 feet elevation on the south-east side of Mt. Garfield, just above a small pond, there is an outcrop and talus slope showing a leucocratic rock slightly darker than the granite, which contains numerous inclusions of fine grained dioritic material varying from dark gray, fine grained inclusions, to skialiths visible only as darker shadows in the coarse grained rock. Going north the percentage of the darker material increases until the rock is almost entirely dioritic and fine grained, and then this rock contacts andesite breccias. This contact can be followed to the west in a fairly straight line with the rock on the north changing from andesite breccia to a rather friable porphyritic andesite, with no noticeable change in the character of the diorite on the south.

The fine grained diorite near the volcanic contact consists of fifty per cent plagioclase (AngoAbgo), forty per cent brownish green hornblende, and ten per cent quartz, all in an equigranular fabric averaging about 0.3 millimeters in size. The plagioclase forms randomly oriented elongate grains and some show fairly sharp boundaries against hornblende. The amphibole is mostly brownish green hornblende in irregular grains, but some more fibrous amphibole is present which is

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probably secondary. The quartz is in small irregular grains between the feldspar and hornblends. The grain size of the inclusions is considerably coarser than the groundmass of the surrounding leucocratic rock, although the abundant large porphyroblasts in the latter give it a much coarser grained appearance.

The more leucocratic portion of the quartz diorite mass nearer the granitic rock is composed of about fifty per cent large grains, ranging in size from one to two millimeters, of quartz and plagicolase (AnggAb72), and fifty per cent of a finely gramular groundmass averaging 0.1 millimeter in grain size. Some of the large grains are composite. A few grains show undulating extinction. A number of the large feldspar grains show one or two straight borders but mostly the crystal outlines are irregular and the borders of the crystals crenulated. The groundmass of this leucocratic quartz diorite consists of a fine grained granular aggregate of quartz, feldspar, and mafics. It looks cataclastic and incompletely recrystallised. Most of the quartz has undulating extinction. There are a few larger quartz grains which appear to have grown by coalescing of numerous smaller grains. There is a considerable quantity of epidote, and fibrous bluish green amphibole, and also some chlorite and some irregular aggregates of biotite are scattered through the rock. Well formed green hornblende is limited to the dioritic inclusions. Some large feldspar grains contain numerous inclusions of the groundmass minerals

niary of redemilies 0.0 minerays especiation religions to unious of the lains grains are not posted to guest to total for course out to recent A . . nother that again the of Pround though blancopount alds to another off act to -united to the second of the s proof . dollogithes paidelenum and prices and to see the of many quarter thinks which appears to have group again well a offered time of the profiler profile. There as desiderable abreliance therein bearer indeed alone and reported beared required open about the dominate dead they be being or

and under plain light these grains can not be told from the groundmass. The overall texture and composition of this leucocratic quartz dioxite suggest that it resulted from the brecciation and recrystallization of a more basic rock with the metasomatic addition of some silica and potash.

On the southwest side of Mt. Garfield the quartz diorite again forms a border to the granite. Here, on the slope above the Taylor River forest camp, the quartz diorite makes contact with some dark colored fine grained argillites which pass westward within a few hundred yards into tuffaceous rooks. The argillites have been recrystallized into a fine grained mosaic of quartz and feldspar but some carbonaceous material is still present and the argillites are quite friable. The immediate contact between the quartz diorite and the argillites appears to be a fault at which the rocks have subsequently been indurated. The contact strikes M61°E and follows the course of a small stream flowing down over bare rocks on the south slope of Mt. Garfield before disappearing under loose rock at 1500 feet elevation. Within two feet of the contact the quartz diorite is dark gray and very fine grained, and under the microscope it appears porphyritic with larger grains of plagioclase, hornblende and augite in a finegrained groundmass. The groundmass appears somewhat cataclastic, and some of the plagioclase crystals have been correded and fractured and then undergone further growth, leading to the formation of much fresher appearing feldeper.

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some of the quarts diorite containing augite near the contact
has an igneous appearing texture but the later growth following the fracturing appears to be crystalloblastic. The
weakly metahorphosed character of the argillite a few feet
from the contact indicates the absence of excessive heat during
or after the faulting up of the quarts diorite.

Going south from this contact toward the granite the quartz diorite becomes quite coarse grained and somewhat leucocratic. Several hundred yards from the contact it contains some round areas thirty feet in diemeter of granite, and finally a little farther south the leucocratic quartz diorite is rather abruptly succeeded by granite along a fault line striking M620E. This fault which is parallel to the border fault further illustrates the faulting which accompanied the upward movement of the granitic body.

The contact between quartz diorite and argillite on the southwest side of Mt. Garfield is clearly a fault contact and the cross-cutting nature of the andesite-quartz diorite contact on the southeast side of the mountain suggests that this too is a fault contact. From the petrographic details described above it might be postulated that the leucocratic quartz dioritic border of the Preacher granite at this locality represents basic rocks which have been partially granitized. This material appears to have moved up principally by faulting, but whether its emplacement has been entirely mechanical is uncertain. The cataclastic textures present in parts of the

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side of the mountain its groundmass is finer grained than the inclusions of more basic diorite suggests that there was considerable movement within the leucocratic quartz diorite itself as wall as at the border faults.

while rocks transitional between quartz diorite and volcanic rocks are present to the north in the vicinity of Quartz Creek, such rocks are missing here due to the fact that the Preacher granite and migmatitic quartz diorite here are faulted up against relatively slightly altered volcanic rocks.

Encacher Grandes Sans Sans Sans

General Features

Preacher Bountain which is one of the most striking topographical features within the mass, and covers an area of about eighteen square miles in the southeastern part of the map area. It shows a close association of leucocratic granite and quarts diorite and some mixed rocks intermediate between the two main types.

Preacher granite are not of as uniform a composition or texture as the Snoqualmie granodiorite (restricted, of above) but these rocks form a very distinctive and easily recognizable unit in that they are all rich in quartz and have a light color ranging

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minerals are quartz, potash feldspar, usually in the form of microperthite, oligoclase, and usually a few flakes of biotite. The textures vary somewhat from outcrop to outcrop and for descriptive purposes the granitic rocks can be divided into several varieties which grade into each other. These are: first, fine grained micrograpites and granite porphyries; second, coarse grained granite in which all the constituents are megascopically visible; and, third, a granophyric variety of granite in which micropegmatite makes up an important part of the rock. In addition to these groups there are some sugary aplites and narrow pegmatitic veins.

The distribution of the varieties of Preacher granite is not known in complete detail. Fine grained microgranites and granite porphyries occur near the borders of the Preacher granite. They do not form anything like a complete ring around the granite mass but rather form irregular shaped bodies which appear to be earlier than the coarser grained varieties. These finer grained rocks are numerous north of the Snoqualmie Middle Fork and they are similar to some rocks which have been described from the Quartz Creek Complex. Locally these microgranites are crossed by some coarse grained pegmatite veins. Between Lower Wildeat Lake and Gem Lake at the southern border of the Preacher granite are large outcrops of granite porphyrios and microgranites which contact the highly disturbed greenstones of the Lake Wildeat Metamorphics. Here also the coarse grained

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of these microgranites and some of these finer grained rocks
have veinlets and patches of coarser grained and more leucocratic granite. If outcrops were more numerous a more complete
gradation might be observed.

The southwest boundary of the granite appears to follow the course of the lower Pratt River, as granodiorite outcrops southwest of the river and the Preacher granite northeast of the river. In the vicinity of Lake Caroline the granite is interrupted by a mile wide area of granodiorite, but the granite outcrops again south of this granodiorite in the vicinity of the Wildest Lakes.

Within the main body of the granite are found a few inclusions of greenstone and mylonitic schist and also some inclusions of quartz diorite which become more numerous as the Quartz Creek Complex is approached.

The faulting on Mt. Garfield between the Preacher granite with its quartz dioritic border and the Mt. Garfield andesites noted earlier appears to be a line of major movement, extending from Mt. Garfield southwesterly along the south side of the Middle Fork of the Snoqualmie River. South of this fault in the up thrown block the Preacher granite is relatively free of quartz diorite inclusions while north of this line the Preacher granite has an irregular distribution intimately associated with quartz diorite.

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Petrography

Coarse grained granite

The coarse grained Preacher granite which is the most abundant variety is a leucocratic rock in which quartz, feldever and usually a few flakes of biotite are visible to the maked eye. The large rounded quartz grains resist weathering and often stand out sharply on weathered surfaces. Thin sections reveal an average composition of about forty per cent quartz, thirty per cent potash feldspar, mostly in the form of microperthite, twenty-five per cent oligoclase, and five per cent mafics. The quartz occurs in large irregular shaped grains, often cracked and partly penetrated by orthoclase, and also sometimes in rather coarse inter-growths with orthoclase. The plagicclase is generally zoned, with oligoclase in the center and with a more albitic rim. It occasionally forms subhedral grains surrounded by orthoclase and quartz but usually the oligoclase is ragged and seems to have been partly replaced by orthoclase (of Plate 39). The orthoclase is usually turbid. The most prevalent mafic is biotite in fairly large ragged plates. It is highly pleochroic, pale brown to very dark brown, almost opaque with the vibrations of the lower nicol parallel to the cleavage. The biotite is partly altered to chlorite and some magnetite is often present. Locally the Preacher granite contains some small veins of magnetite. The Patio of orthoclase to plagioclase shown above would classify

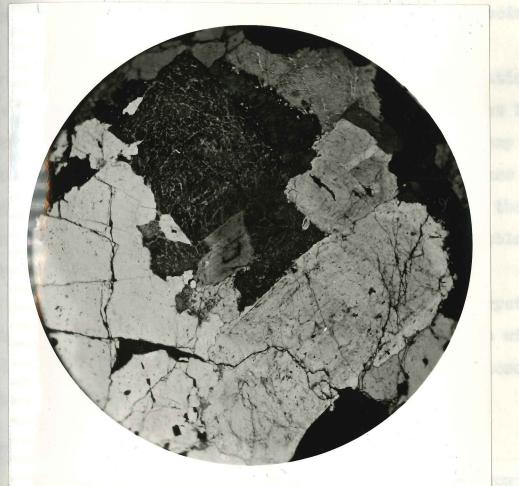
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Photomicrograph showing a specimen of typical coarse grained Preacher granite. A relic of plagioclase is contained in a grain of microperthite. (x-Nicols; x 15)

The stable dark and the State of the state o

this rock as a quartz monzonite, but since this ratio frequently varies within a small distance it will be more convenient to use the word granite to comprise all the rocks in this group; with the realization that an individual specimen may be actually a granite, quartz monzonite, or even a granodicrite depending on the orthoclase-plagiculase ratio in that specimen. This will help in subsequent discussions by differentiating these rocks from the rocks within the map area which are mapped as granodicrite in which the plagiculase feldspar definitely predominates. In thin sections of the granites, relatively less coarse grained areas of granoblastic quartz or quartz-feldspar mosaics are commonly seen.

The texture of the coarse grained granite is crystalloblastic. The origin of this crystalloblastic texture will
be discussed later following the descriptions of the microgranites and granite porphyries.

Granite porphyry and microgranite

(31 m paleo Men) . neldrangerola in also

These rocks present a variety of textures and compositions. Some granite purphyry outcropping north of Nordrum
Lookout near some fine grained quartz diorite is a nearly white
rock with some large grains of quartz and feldspar in a fine
grained groundmass. In this section the rock shows large
grains of oligoclase and quartz in a fine grained groundmass
composed of quartz, orthoclase, and oligoclase in nearly equigranular anhedral grains forming a fine grained mosaic. The

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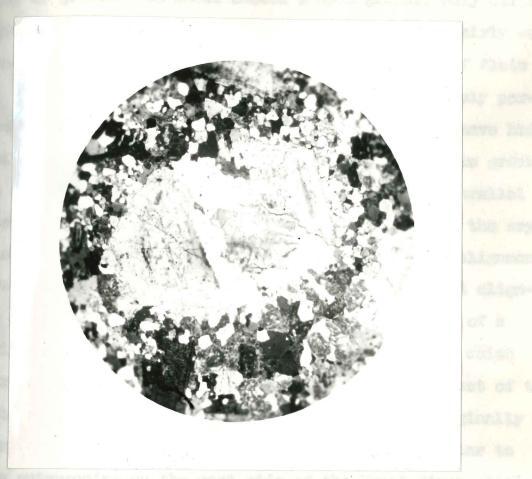
large plagiculase and quartz grains have cremulated borders and appear to be developing as porphyroblasts in the fine grained granular groundmass (of Plate 40). The texture of the granular groundmass is similar to the texture of the granulites to the west formed by metamorphism of feldspathic graywaches of the Calligan formation. This alteration of the granulites to a more granitic appearing rock has been described earlier as occurring in the Area of Heterogeneous Granitic Rocks. However, in that instance the change was mainly one of recrystallization while in this rock in the vicinity of Nordrum Lockout there has been a great deal of potash metasematism with the clastic derived oligoclase being partially replaced by orthoclase.

at the south end of the Preacher granite near lower Wildeat
Lake have a variety of textures. These include: first,
granite and granodicrite perphyries with large grains of
quarts, oligoclase and orthoclase in a fine grained groundmass; second, microgranites consisting of quarts, oligoclase,
orthoclase, hornblende and biotite in a fine grained equigranular texture; and third, fine grained granophyres which have
large crystals of oligoclase surrounded by micropegnatitic
intergrowths of quarts and orthoclase. A large outcrop of
leucocratic granite perphyry southwest of Lower Wildeat Lake
is similar in megascopic appearance to the rock near Nordrum
lookout described above. It has a fine grained groundmass of

plageon to be developing as perphyroblants in the fine compand of camular groundings (of Plate 10). The texture of compand of the crowdless of the groundings is absided to the crowdless of the groundings is absided to the crowdless of the condition of the groundings of the condition of the groundings of the groundings of the groundings in the Arca of Neterogeneous Grantile Region. However, in the Arca of Neterogeneous Grantile Region. However, in the textured the change was making one of nonzystal and the been a great deal of potent setseconstien with the last has been a great deal of potent matter of Newbran Locions and the been a great deal of potent matter of Newbran Locions and the been a great deal of potent matter of Newbran Locions and the been a great deal of potent matterly replaced by ortho-

The fine grained granite appending room openring the court of the Proscher granite near lower wilders the court of the Proscher granite near lower wilders, they have a variety of testere. These include: first, of testering of testere prophyrica with large grains of the country of decides and arthoclass in a fine grained ground, the second, microgramites densitite in a fine grained equipment testere, hermblends and bictite in a fine grained equipment testere; and third, fine grained granophyres which have arrested by microgramitite and episcolass. A large outeres of testere and third parabolass. A large outeres of testere in mercuescel appearance to the room near Sordern of antitar in mercuescels appearance to the room near Sordern of and described above. It has a fine grained groundwass of

PLATE 40



clarity approximate in the outer, or but in this paction the

Photomicrograph of "granite porphyry" from the vicinity of Nordrum Lookout showing the development of porphyroblasts of oligoclase in a fine grained granoblastic groundness.
(x-Nicols; x 12)

The same of salitation interest to a salitation of the large to the salitation of th

quarts, orthoclase, oligoclase and biotite in which porphyroblasts of oligoclase, quarts and orthoclase are seen in all stages of growth from small amoeba shaped grains, only elightly larger than the grains of the groundmass, to large fairly well formed grains showing some straight crystal faces (of Plate 41).

Other granite porphyries are less conspicuously porphyroblastic since all the grains of the groundmass have had considerable crystalloblastic growth. Frequently this groundmass contains elongated feldspar grains in a crude parallel structure suggesting flow (of Plate 42). In view of the crystalloblastic texture of the rock the origin of this alignment of foldspar grains is of interest. The same parallel alignment of feldspar grains is visible in a thin section of a specimen from an outcrop of quarts biotite granulite which occurs as an inclusion within the Preacher granite east of the Pratt River (of Plate 43). This rook, which was originally a feldspathic graywacks of the Calligan formation similar to those outcropping on the west side of the Pratt River still has a clastic appearance in the outcrop but in thin section the rock shows evidence of considerable recrystallization. The small recrystallized feldspar grains are developing a lathshaped subhedral outline. Since the rock still retains a clastic appearance both megascopically and to a less extent microscopically it suggests that the movement leading to the formation of alligned lath-shaped feldspars need not be large her involve a liquid magma, but can be of the nature of plastic

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Photomicrograph of "granite porphyry" from near Lower Wildcat Lake showing development of twinned feldspar porphyroblasts in a fine grained granoblastic groundmass. (x-Nicols; x 12)

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Photomicrograph of "granite porphyry" from outcrop

south of Lower Wildcat Lake, showing the development of lath

shaped crystalloblastic feldspar in groundmass. (x-Nicols;

x 15)

touch many more repulging address; to destround morally and desired to describe the desired seal desired to the seal desired t



the same of the distance of the same of th Photomicrograph of granulite inclusion in Preacher granite east of the Fratt River, showing development of alligned 23 feldspar laths. (x=Nicols; x 40)

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One specimen from near the contact between the fine grained granitic rocks of the Preacher granite mass and maggive greenstones of the Lake Wildcat Metamorphics has some large porphyroblasts of quartz and oligoclase in a fine grained groundmass similar to that of the granulite near the Pratt River described above. Some of the quarts in the groundness is in optical continuity with one of the large quartz porphyroblasts (of Plate 44). In the same rock biotite is developing around the boundaries of quartz and feldspar grains and in cracks in the quartz.

As the amount of the larger perphyroblests of quarts and feldspar increases and the amount of groundmass decreases the granite porphyries approach the coarse grained Preacher granite in appearance. With increased potash metasomatism the original oligoclase perphyroblasts become replaced by orthoclase and the rock becomes more granitic in composition.

Granophyric granite

In the granophyric granites large quartz grains and usually some oligoclase grains are contained in a dull white to light gray groundmass. Under the microscope the groundmass is seen to be composed of a micropegmatitic intergrowth of quarts and orthoclase.

The amount of micropegmetite in the granophyres varies. A specimen from the south side of Mt. Garfield consists of seventy per cent of a micropegmatitic intergrowth of quartz and

PLATE 14: BOSINES BENEGO PLATE 14: BOSINES BENEGO PLATE 1

Photomicrograph of "granite porphyry" from near the southern border of the Preacher granite south of Lower Wildcat Lake. Some of the quartz in the groundmass is in optical continuity with the large quartz grain. Some late biotite is growing along fractures in the quartz. (x-Nicols; x 15)

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orthoclase, ten per cent of rounded, somewhat embayed quartz grains, ten per cent of large irregular grains of microperthite, five per cent of irregular grains of oligoclase apparently being invaded and replaced by orthoclase and quartz, and five per cent of mafics. Other specimens have less micropegnatite.

While the quartz and orthoclase form a typical intergrowth in that the adjacent quartz patches have simultaneous extinction, only occasionally do the boundaries have the sharp angular appearance common to some graphic intergrowths.

Rather, the quartz varies widely from elongated blebs, parallel within one small area but not within the whole specimen, to rounded irregular grains surrounded by orthoclase (of Plates 45 and 46). The ratio of quartz to orthoclase within the micropegmatite is near 50-50. This is considerably different from the theoretical twenty-six per cent quartz and seventy-four per cent orthoclase which is the sutcetic mixture of these two constituents. The character of these intergrowths suggests growth in the solid state and penetration by replacement.

The relation of the larger grains in the granophyres
to the micropegnatitic groundmass varies. A fine grained
microgranite outcropping a quarter mile northwest of Nordrum
Lockout is light gray in color, fine grained, and is similar
in megascopic appearance to some of the granulites of the
Calligan formation. In thin section the rock is seen to consist of forty-five per cent quartz, twenty-five per cent ortho-

Photomicrograph of granophyric Preacher granite from Garfield Mountain showing a variety of patterns of micropegnatite. (x-Nicols; x 15)

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Penders A section of the largest grains in the collected states of the description of the description of the collected states of the description o



Photomicrograph of granophyric Preacher granite showing irregular shaped aggregate of small biotite grains, some growing along crystal boundaries. (Plain light; x 15)

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clase, twenty per cent oligoclase, and ten per cent irregular shaped grains of hornblende, biotite, and magnetite. Some of the quartz occurs as poikiloblastic grains inclosing small angular orthoclase and oligoclase grains, most of which do not have the same optical orientation. The simultaneous extinction of the quartz over a considerable area in the section gives the groundmass a somewhat micropegmatitic appearance. It is possible that this rock represents a more advanced stage of granitization of the granulites in which the growth of quartz and the replacement of oligoclase by orthoclase has destroyed the original clastic textures.

In some cases the boundaries between large oligoclase grains and surrounding micropegmatite will be straight lines following the crystallographic directions of the plagioclase. This would indicate replacement of earlier oligoclase by micropegmatitic material. In order to get this kind of arrangement during replacement there would need to be a solutional redistribution of material in the solid rock somewhat comparable to the manner in which small grains of hornblende and quartz coalesce into larger porphyroblasts. However, since most of the granophyric granites contain no relics of a clastic texture it is not possible to say to what extent they have formed by replacement of clastic derived granulite.

Inclusions of quartz diorite in Preacher granite

growing along organic boundaries. (Fight Mights x 15)

Within the northern part of the Preacher granite mass are exposed numerous inclusions of quartz diorite. These vary

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in size from large areas fifty to one hundred feet across to small blocks a few feet in size. The textures of the quarts diorites in these inclusions present all the variations seen in the quartz diorites around the margins of the Preacher granite. The inclusions are only conspicuous in the northern part of the Preacher mass.

One small inclusion which may be described as typical is exposed above the trail along the south side of the Snoqualmic Middle Fork opposite Mt. Garfield, about one-fourth mile below Tin Cup Joe Creek. It is an irregular shaped block of quartz dioritic material about three feet wide and six feet long. This block is surrounded by a zone of fine grained dark colored dense-appearing rock which passes outward into granite. Inside the dioritic block are some rounded patches of granite one-half to two inches across.

The quartz diorite in the block has a crystalloblastic texture which resembles the ten foot zone next to the granite outcrop along the Quartz Creek road and is also similar to parts of the quartz dioritic border to the Preacher granite on Garfield Hountain. It consists of andesine feldspar, horn-blende, quartz, and biotite grains in a finely granular, some-what clastic appearing groundmass. A few grains of oligoclase, quartz and bluish green hornblende larger than the rest seem to be growing by coalescence of some of the smaller grains. The granitic patches in the quartz diorite are composed of large quartz and oligoclase grains with some micropegmatite

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In the granulated zone there is considerable magnetite, some of it associated with biotite in such a fashion that it suggests a derivation from the original mafies in the quarts diorite. Toward the outside of this granulated zone the fine material begins to recrystallize into a mosaic of quartz and feldspar with scattered magnetite grains. Some large porphyroblasts of quartz and feldspar are contained in the granulated zone.

It appears on the basis of the observations noted above that this inclusion of quartz diorite in the Preacher granite is a relic of basic rock which has not been granitized although the original basic rock has been recrystallized and there has been some metasmatism.

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Origin and Mode of Emplacement of the Preacher Granite

Various features have been described above which should be considered if an interpretation of the origin and the mode of emplacement of the Preacher granite is attempted. These critical features may be summarized as follows: (1) The granite mass shows numerous variations in texture. (2) There is abundant evidence of the replacement of earlier placeicclase by later quartz and orthoclase. (3) The mafics occur in ragged plates or in irregular shaped aggregates of small grains and have a tendency to grow along crystal boundaries. (4) Some of the granite porphyries and microgranites near the borders of the mass have relict clastic textures resembling those in the altered feldspathic graywackes, and the contact between these microgranites and the feldspathic graywackes in the northwestern part of the granite mass is gradational. (5) In some of the granite porphyries the large feldspar and quarts porphyroblasts become numerous and the amount of groundmass is small; thus it appears that transitions exist from foldspathic graywacke to coarse grained Preacher granite. (6) In its northern parts the Preacher granite contains quarts diorite inclusions which are interpreted as basic rocks, probably part of the Mt. Garfield andesites, which have been recrystallised and locally been incompletely granitized but in general have resisted granitization more than the feldspathic graywackes. (7) The northern border of the Preacher granite shows evidence

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of much breceiation and faulting and on Mt. Garfield the granite together with some partially granitized quartz biotite has been faulted up against only slightly metamorphosed andesites. (8) The faulting mentioned above apparently occurred at a time when temperatures were still fairly high and the recrystallizing and granitizing solutions were still active because the breceiated zones have been recrystallized, and in some cases granitization is more advanced in the brecciated zones than elsewhere. (9) Some mobility in the Preacher granite is suggested by the presence of a parallel structure in elongated feldspar laths in some of the microgranites but the development of similar parallel structure in granulites which still retain some clastic appearance indicates this mobility was apparently in the form of plastic flowage under stress rather than movement of a liquid magma. (10) Some of the granophyres in which euhedral plagioclase grains are symmetrically surrounded by micropegnatite are of uncertain origin but in many of these rocks replacement features are evident. (11) The same processes which lead to the formation of the Preacher granite took place in the Quartz Creek Complex but the granitization there is more local in extent and not as far advanced.

On the basis of the criteria listed above much of the Preacher granite can be considered as having originated by Granitization of feldspathic graywackes of the Calligan formation, with the associated quartz diorites having formed by

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recrystallization of portions of the Mt. Carfield volcanies.

In some cases these may have been dikes in the Calligan graywackes. The Preacher granite and its associated quartz diorites has then moved upward by a combination of faulting which
is evident at its northern border, and of some plastic flowage,
which is visible at least at some places.

The emplacement of the Preacher granite and its relation to the Quarts Creek Complex will be discussed further in connection with the regional structure.

Sunday Grantte

General Features

A rather small area of granite occurs on the ridge between Philippa Creek and Sunday Creek from the edge of the alluvium along the Snoqualmic River North Fork and Sunday Creek to an elevation of 3200 feet. The outcrop is less than a square mile in area south of the river but microgranites outcrop north of the river and these have been shown on the map as part of the Sunday granite.

On the south at 3200 feet elevation the granite contacts tuffs and tuffaceous graywackes as noted by a change in
the type of float. One block of water laid tuff a few hundred
yards from the contact contains abundant angular andesite
fragments (of Plate 21) which are not highly altered. A clue
to this might lie in the occurrence of some trenches along
the crestline between this tuff and the contact, which are

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which accompanied the emplacement of the granite. As in the case of the Preacher granite, the temperature of this granite during emplacement might have been fairly low. On the basis of very limited emposures showing any visible strike and dip the tuffaceous rocks south of this granite and those to the north seem to dip away from the granite suggesting that there may have been some pushing up of the overlying rocks.

Several small granitic bodies ten to several hundred feet wide were observed on three sides of the Sunday granite. Because of the fact that exposures in the heavy timber in this vicinity are limited to a few road cuts and pieces of float. the true extent or shape of these bodies was not determined. but they seem to be concentrated around the Sunday granite. In these small bodies the most widely distributed rock type is a leucocratic granite porphyry. This rock is exposed as a thirty foot dike cutting shales and graywackes on the Weyerhauser logging road up Big Creek. Bodies of similar rocks are exposed along the lower Weyerhauser logging road along the north side of the North Fork of the Snoqualmie River opposite the mouth of Sunday Creek. Here they occur with other rocks of microgranitic and microgranodicritic character, and appear to cut argillites and tuffaceous sediments of the Calligan formation. There are no clear-cut intrusive contacts here and some of the contacts appear to be fault contacts.

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Petrography of the Sunday Granite

The Sunday granite is a medium grained leucocratic rock composed of quartz, feldspar and biotite grains in a white, rather sugary base. Under the microscope the granite is seen to consist of a few larger quartz, orthoclase and oligoclase grains in a slightly finer equigranular fabric of quartz and orthoclase, part of which forms coarse intergrowths. The orthoclase occurs mainly as microperthite. The texture is crystalloblastic and there are some areas of finer grained granoblastic mosaic of quartz and feldspar (cf Plate 47).

Farther south up the ridge between 2500 and 3200 feet elevation the granite contains some areas of microgranite.

This microgranite has essentially the same minerals as the granite, i.e. quartz, orthoclase, oligoclase and biotite, but the rock is slightly richer in oligoclase and biotite and some of the quartz and orthoclase intergrowths have a spherulitic form. A thin section of the microgranite shows some thin bands in which the feldspar and quartz and biotite are fine grained and show some parallel structure suggesting flow (of Plate 48). These finer grained areas are similar in texture to the granulite forming an inclusion in the Preacher granite (of Plate 43). However the bulk of the slide shows a coarser grain size and a granoblastic texture with large quartz grains replacing plagicclase and polkhloblastically inclosing earlier grains of feldspar. Some late radial intergrowths are replacing

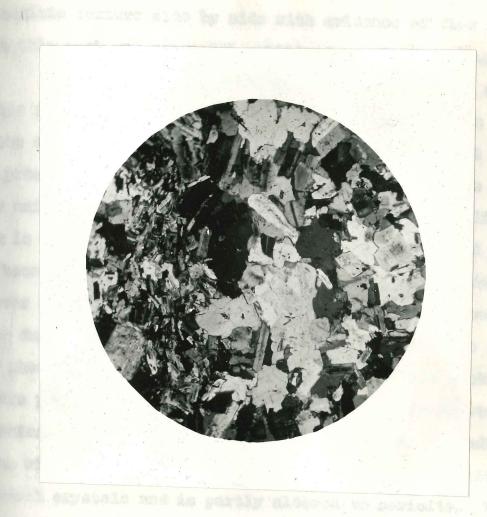
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Photomicrograph of specimen of Sunday granite from outcrop between Philippa Creek and Sunday Creek showing micro-perthite (cloudy) and quartz and plagioclase (clear), and a plate of biotite altering to chlorite. (x-Micols; x 12)



Photomicrograph of a finer grained border phase of the Sunday granite. The narrow band on the left shows local parallel structure suggesting flow, while the bulk of the rock has a granulitic texture as seen on the right. (x-Nicols; x 12)

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the gramulitic mosaic. These intergrowths are mostly quarts and feldspar but there is also some pale hornblende approaching a "feathery hornblende" type. The presence of a motamorphic granulitic texture side by side with evidence of flow suggests that this rock may represent mobilized granitized material.

The granite perphyry on the Big Creek road is a leucoeratic rock varying from nearly white to light gray in color in the central portion, with often a slight green tint due to the presence of scattered shreds of secondary chlorite as the only mafic mineral present. In the main body of the dike the rock is usually not noticeably porphyritic in the hand specimen because of the overall light color. Near the borders however the groundmass is usually a slightly darker green in color due to more abundant chlorite and then the white feldspar phenocrysts stand out more distinctly and the rock appears plainly porphyritic. The phenocrysts are quartz, orthoclase and oligoclase. The quartz occurs as corroded grains with inlets of the groundmass. The orthoclase forms subhedral crystals and is partly altered to sericite. The plagicclase is also altered to sericite and calcite. The latter mineral also occurs in some irregular shaped patches in the groundmass. While the phenocrysts are from one to three millimeters in diameter the grains of the groundmass are of the order of 0.1 millimeter in size (of Plate 49). Mafic minerals are limited to a few ragged patches of secondary chlorite.

PIATE 19

Photomicrograph of a specimen of granite porphyry from a dike cutting graywackes and tuffs along the logging road up Big Croek. Large crystals of orthoclase, plagicclase and quartz are contained in a fine grained groundmass. (x-Nicols; x 12)

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Alongside one of the outerops of granite porphyry on the Weyerhauser logging road on the north side of the river opposite Sunday Creek is an outerop of very fine grained microgranite. This rock contains elongated orthoclase laths about 0.2 millimeters wide and one millimeter long, elongated hormblende and biotite grains, both partly altered to chlorite, together with intergrammlar quarts. It is of interest primarily because of an imperfect parallel structure of the orthoclase and mafics suggesting flow structure.

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Another outcrop a short distance west of the above microgranite shows more granite perphyry with a finer grained variety between it and some fine grained tuff. The finer grained variety has the appearance of a perphyritic coarse grained rhyolite.

Thus it is apparent from microscopic examination that while these minor granitic bodies vary greatly in appearance due to differences in texture and amount of alteration, they are all of similar mineral composition. The structure in this area is not well enough exposed to determine the relation between the granite porphyries, some of which have an igneous appearance, and the coarser grained granite and microgranites which have a crystalloblastic texture. The possibility exists that the porphyries may be dikes composed of mobilized naterial derived from a partially mobilized central granite body.

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General Features

The "Snoqualmic granodiorite," as defined above, covers about forty-two square miles within the map area. The main mass of the granodiorite is in the northeastern part of the region and extends over a large area beyond the map boundaries.

A long tongue, one to two miles wide, of this granodiorite extends from the main mass in the northeast in a
westerly direction through Goat Mountain and along the divide
between Lake Calligan and Lake Blethen basins, and then swings
southward through Bessemer Mountain to the vicinity of the
Eiddle Fork of the Snoqualmie River, where, on the CCC road,
it is less than a mile in width.

Another area of similar granodiorite outcrops on the slope southwest of the Pratt River. Still another belt about one mile in width of this granodiorite cuts across the Preacher granite in the southeastern part of the map area, forming the bulk of 5885 feet high Mt. Roosevelt.

These separate areas of granedicrite are all considered as one unit because they are all of similar composition and texture, and they are correlated with the Snequalmic grano-dicrite southeast of the map area. Specimens picked at random from such widely separated outcrops as along Granite Creek, and along the Taylor River, from the vicinity of Cougar Creek, and

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from the head of Bear Basin all consist of the same type of directionless granodicrite.

Petrology

The granodicrite is a light gray medium to coarse grained rook. It is non-porphyritic. The important mineral constituents are, in the order of decreasing abundance, plagicelase, orthoclase, quartz, hornblende, and biotite.

A specimen taken from along Cougar Creek at an elevation of 3540 feet, in the northeastern part of the map area, is typical of the granodicrite. It consists of forty per cent plagicelase feldspar, twenty per cent potash feldspar, twenty per cent quarts, and twenty per cent hornblende plus biotite.

In all the granodiorites part of the biotite is chloritized and some magnetite is usually present. The texture is coarse grained. The plagioclase is andesine, which varies slightly but is usually near An_{bO}Ab₆₀. It is subhedral and part of the crystals are soned. The potash feldapar is predominantly orthoclase. A few grains of micropline were seen in the specimen from Cougar Creek. Some microperthite is usually present. The orthoclase grains are anhedral and very often enclose grains of the other minerals (of Flate 50). The quarts is usually intergranular and appears to have formed fairly late. Bornblende commonly, but not always is subhedral (of Plate 51), and sometimes is twinned. It often forms poild—loblastic grains or loose aggregates suggesting that it formed

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PLATE 50



Photomicrograph of a specimen of Snoqualmie grano-diorite from an outcrop along the CCC road showing large anhedral grain of orthoclase enclosing subhedral grains of plagioclase and also smaller grains of quartz and biotite.

(x-Nicols; x 15)

PLATE 51 To the second of the property of the second of th

Photomicrograph of specimen of Snoqualmie granodiorite from Devil's Canyon showing large subhedral grains of hornblende and ragged biotite grains growing along crystal boundaries. (Plain light; x 15)

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by collective crystallization. The biotite is usually in more irregular shaped plates and often partly altered to chlorite. As a rule the amount of hornblende slightly exceeds the amount of biotite. The texture is somewhat crystalloblastic, which seems to be due mainly to replacement of some earlier plagicalse by later quartz and orthoclase and due to the growth of some late biotite along crystal boundaries. This potash metasomatism is restricted to the confines of the granodioritic mass and must therefore be genetically related to this rock mass.

Some dark colored, more basic inclusions less than a foot in diameter occur, but are not very abundant. Within the granodiorite are some areas of more leucocratic granitic rock. Some lighter portions are well exposed in Bear Basin and are described in connection with the Bear Basin mine. These more leucocratic areas also have been observed on the east side of Goat Mountain, and on the slope between Mt. Roosevelt and Lake Caroline in the southeastern part of the map area. In both the Mt. Roosevelt and Goat Mountain areas some small veinlets and pockets of tourmaline occur and between Mt. Roosevelt and Lake Caroline pockets containing long prisms of epidote are also numerous.

Contacts and Border Zones of the Snoqualmie Granodiorite

The contacts of the granodiorite with the graywackes and argillites of the Calligan formation are usually quite

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The contacts of the grandicrite with the grayus

sharp. The contacts of the granodiorite with the tuffs and andesites are less sharply marked and more irregular, due to the fact that the metamorphosed volcanic rocks are so near the composition of the granodiorite. There is usually no marked decrease in grain size or noticeable change in composition along the margin of the granodiorite. The quartz diorite outcropping near the edge of the granodiorite in the vicinity of the Lennox mine is the one exception which was observed.

Vicinity of Mt. Phelps

The western boundary of the granodiorite in the vicinity of Mt. Phelps is quite irregular and some of the metaandesites have a dioritic appearance similar to the appearance
of the Snoqualmie granodiorite at this point. South of Mt.
Phelps the contact is buried beneath the alluvium at the
junction of the Lennox and Snoqualmie Rivers.

Vicinity of the Lennox River to the complession

Along the Lennox River mine to market road above the Lennox mine camp there occur granitic-appearing rocks of variable texture. These are mostly fine-grained quartz diorites. However, associated with these quartz diorites are some migmatites which do not have a uniform texture but contain some dark colored streaks and patches which can be identified microscopically as recrystallized tuffaceous material, and the more leucocratic portions of these rocks

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are composed mainly of quartz in irregular veinlets and patches, with some plates of biotite one-half inch across. There is no sharp boundary between the recrystallized tuffaceous material and the quartz diorite proper. The quartz diorite extends across to the south side of the Lennox River and is well exposed in the long cross-cut being driven by the Priestley Mining and Milling Company. In several exposures along the road and also in the cross-cut the fine grained quartz diorite is criss-crossed by numerous veinlets and patches of coarser grained, more leucocratic rock. These coarser grained patches at times make up more of the rock than the fine grained quartz diorite, the latter appearing as inclusions (cf Plate 52).

The quartz diorite proper is a medium gray, fine grained, fresh appearing rock composed of subhedral elongated grains of andesine feldspar, subhedral green hornblende, nearly colorless orthorhombic pyroxene, and some inter-granular quartz. The pyroxene usually is found in the centers of hornblende grains, but one specimen from the cross-cut contains numerous euhedral grains of orthorhombic pyroxene. This is faintly pleochroic, Z = very pale green, X and Y = very pale yellow. It is probably between bronzite and hypersthene in iron content.

Locally in the tunnel the quartz diorite shows good parallel structure of the feldspar laths (of Plate 53). The veinlets and patches of leucocratic rock within the quartz

Photograph of a migmatitic border of the Snoqualmie granodicrite as exposed along the Lennox River mine to market road. The darker areas are fine grained quartz dicrite. The more leucocratic rock is coarser grained and rich in quartz.

me composed moduly of outpress in irregular valuates and parence, with some plates of biotics one-mail inch across. The most is no singly because the recoverabilities information and the quark disciple troper. The quarks series to the world side of the famous River and is well exposed to the world side of the being duiven by the cold is well exposed in the long creek-can being duiven by the riskley winning and willing Company. In account exposures along the road and also in the cross-can the the grained and also in the cross-can is the time grained average grained, note leucocom is read. These average of coarser grained, note leucocom is read. These average of coarser grained patelies at these make up to a of the room fine time grained quarts diorite, the latter appearing including (of Flate 52).

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Photomicrograph of quartz diorite from adit being driven by Priestley Mining and Milling Company. The feldspers have good parallel structure suggesting flow. The light gray mineral with high relief is hypersthene. (x-Nicols; x 15)

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diorite, mentioned above, contain abundant quartz, some of which incloses numerous feldspar and hornblende grains.

Biotite, which is almost absent in the fine grained quartz diorite, forms some large plates in these lighter colored portions. A few grains of potash feldspar are present. This leucocratic portion of the migmatites is similar in appearance to the main mass of the Snoqualmie granodiorite although it does not show as much potash feldspar as is found farther inside the main body of granodiorite.

To the east of this area of quartz diorites is an irregular area of hornfels and granulites surrounded by granodiorite, which can be seen on the map to be roughly a mile in diameter. The contact between these rocks, which are metamorphosed graywackes and tuffaceous sediments of the Calligan formation, and the granodiorite can be observed in the short tunnel now being driven on the Langer claims about a mile up the Lennox River mine to market road from the Lennox property. The rather abrupt contact here contrasts with the gradational contact with the volcanic rocks as described above.

Another locality where the contact between the granodiorite and the Calligan formation is quite conspicuous is in
the vicinity of Bare Mountain Lookout between Bear Creek and
Paradise Lake. The peak known as Red Butte consists of dark
reddish hornfelses, which contrast sharply with the light
colored granodiorite east of the peak. Some of these Red
Butte hornfelses contain tourmaline, and just west of the peak

nergy bentless out? so in the specie at your at your Percelos readil sendi mi condin spred sessa con Instituti .evous bedi mesh as aspec planatov end dita Jeni between the Bare Mountain Lookout and Paradise Lake the highly metamorphosed rocks include some narrow bands of amphibolite along with garnet biotite granulites, all indicating thermal metamorphism.

Vicinity of Sunday Lake

The western margin of the granodiorite, after crossing the ridge between Sunday Creek and the Lennox River east of the Lennox mine continues to the southwest near the south end of Sunday Lake and then is exposed in fairly open cliffs south of the lake below Twin Peaks. In a canyon just south of the lake the granodiorite can be observed in contact with the Calligan formation, which is metamorphosed with the production of some garnet. A few small dikes of aplitic character penetrate the sediments a short distance from the contact. These dikes become richer in quartz with increasing distance from the granodiorite and finally pinch out.

Vicinity of Lake Calligan

The contact continues in a nearly straight line past Lake Philippa and can be observed again on the ridge between Lake Philippa and Lake Calligan, still contacting argillites and graywackes. The strike of these rocks is nearly parallel with the contact, but the dips are variable, there being some overturning of folds (cf Plate 54). The granodicrite has narrowed here to about two miles and appears to be in part concordant with the sedimentary rocks.

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PLATE 54

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Photograph of overturned fold in argillites and graywackes of the Calligan formation east of Take Calligan near the contact with the Snoqualmie granodiorite.

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Vicinity of the CCC road

The granodicrite is about one mile wide where it crosses the ridge separating the drainage areas of the North and Middle Forks of the Snoqualmie River in the vicinity of Mt. Bessemer. Still farther south some good exposures of the contact of granodiorite with the sedimentary rocks are visible in the deep rock cuts along the GCC road north of the Snoqualmie Middle Fork. Here the main body of granodiorite has narrowed to less than a mile, but parallel to the western boundary of this main body of granodiorite and separated from it by metamorphosed argillites and graywackes is a five hundred foot wide parallel body of granodiorite. Even this small mass of granodicrite shows no chilled borders, the granodicrite remaining coarse grained to the very margin of the mass. The granodiorita appears to cut at a small angle across the structure of the sedimentary rocks and two to six inch wide veinlets and some small patches of granitic material occur in the sediments a few feet from the contact. The granodiorite ends at the alluvium along the Middle Fork of the Snoqualnie River.

Southwest of the Pratt River

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Pratt River with argillites of the Calligan formation can be well observed on the ridge southwest of the Pratt River (of Plate 55). It is fairly straight and there appears to have been some faulting connected with the emplacement. But the

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PLATE 55



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Photograph of contact between the Snoqualmie granodiorite and the Calligan formation on the ridge southwest of the Pratt River. The light colored granodiorite is on the right and the dark purplish gray metamorphosed sedimentary rocks are on the left.

thermal metamorphism of the Calligan formation with the resulting dark purple coloration, and the presence of small veinlets of granitic composition penetrating short distances into the metamorphosed argillites shows that all the crystall growth in the granodicrite had not taken place prior to the faulting.

Contacts with other granitic rocks

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The contact between the Snoqualmie granodicrite and the Preacher granite in the southeastern part of the map is exposed along the ridge west of Mt. Roosevelt. Most of the contact proper is buried under a small depression which seems to run parallel to it, but at one place above Lake Caroline an outcrop shows an irregular contact of granite and granodicrite (of Plate 56). The thin projections of Snoqualmie granodicrite into the Preacher granite suggest that this is a sharp replacement contact with the granite replacing granodicrite, which would make it appear that the granite is the younger of the two.

The contact between the Snoqualmie granodicrite and the rocks of the Quartz Creek Complex is not so well defined as are the contacts with the Preacher granite or the sedimentary rocks because the rock contrasts are not so great. However, the gray tonalites in the northern part of the Quartz Creek Complex are darker colored and usually finer grained than the granodicrite. The point of change of rock type is

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Photograph of contact of Snoqualmie granodicrite (dark) with Preacher granite (light) south of Lake Caroline.

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easily recognized on the ridge between the Quartz Creek and Sunday Creek drainage areas directly south of Sunday Lake, but the actual contact is covered. This contact can be observed to continue in an easterly direction to a point just down-stream from Mowich Lake. The exact location of the remainder of this contact as shown on the map is open to some question. The line shown on the map serves to separate the area of homogeneous Snoqualmie granodicrite occurring north of Cougar Lake and east of Marten Lake from the more heterogeneous granitic rocks of the Quartz Creek Complex. No sharp contact was observed in this vicinity but the manner in which the granodiorite east of Marten Lake cuts across the structure of the Quartz Creek Complex and the presence of considerable . brecciation in the rocks outcropping west of Marten Lake suggests that there has been some movement here and the area of granodiorite to the east has moved up with respect to the rocks to the west.

Mode of Emplacement of the Snoqualmie Granodiorite

In considering a possible mode of emplacement of this granodiorite the following field and potrographic criteria seem significant: (1) The large bodies of granodiorite within the map area are similar in megascopic appearance and in their general composition and texture. (2) The contact relations between the granodiorite and the argillites and feldspathic graywackes of the Calligan formation indicate the granodiorite

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has moved to its present position accompanied by much deformation of the sedimentary rocks and by relatively low grade thermal metamorphism. In some cases the contacts appear to be faults but in every case small veinlets of quartz and feldspar menetrating the surrounding rocks are later than the faulting. (3) There are no chilled borders and no tendency for a porphyritic texture along the border of the granodicrite. (4) Evidence of any magnatic stoping is entirely lacking and the argillites and graywackes of the Calligan formation have in general been pushed way out of the way and highly deformed rather than penetrated by apophyses of the granodiorite. (5) In some cases, as near the mouth of the Lennox River, the granodiorita has a migmatitic border. (6) There is abundant evidence in the rock of the replacement of earlier plagioclase by later orthoclase and quartz giving the rock a somewhat erystalloblastic texture. This is confirmed by crystalloblastic growth of biotite in the quartz-feldspar intergranular.

Not enough detailed petrographic study was made of the granodicrite to arrive at any final decision concerning its generis. Such a study should include the remainder of this large mass of granodicrite outcropping east of the map area. On the basis of the criteria listed above, it is believed the granodicrite within the map area moved to its present position in a plastic rather than a liquid condition. The final textures in the granodicrite appear to have resulted from the replacement of earlier plagicclase by later quartz and ortho-

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clase and by some collective recrystallization of the mafics.

Replacement has also occurred at some, but not all, of the contacts of the granodiorite with the meta-sediments and meta-volcanics. Some additional features concerning its emplacement will be discussed in connection with the regional structure.

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In the northeantern part of the area, fartheat from the Lucie grantite bedier, seed post folus are visible in the Locales reed once, accompanied by men show faithing topicaled by the formation of management sides. The Chilism traction have constate of interbedded as yourses, shales and interpreted property bediens the folding the entains the interpreted for males are accompanied as access to the chilism the interpreted as access to the folding planes will consentrated the males being bedies planes will consentrated the males being being planes will consentrated the males being being planes will consentrated the males being and the males of later properties. The miner folding and the folder or interpreted the males of later properties. The miner folding and the folder or interpreted base and novel the areas of high access a playing base and novel the areas of high properties to the force likeling

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Visible Folded Structures

Within the Calligan formation there are many variations in the trend of the folds. The fact that the folding
becomes much more intense near the granitic masses, and that
the trend of the folds tends to parallel the contacts, indicates that the structural pattern has been considerably
modified by the emplacement of the granitic rocks.

In the northwestern part of the area, farthest from
the large granitic bodies, small open folds are visible in
some logging road cuts, accompanied by much minor faulting
succeeded by the formation of numerous dikes. The Calligan
formation here consists of interbedded graywackes, shales and
tuffaceous rocks. During the folding the massive tuffaceous
and graywacke beds acted as competent members while the interbedded shales acted as incompetent members. Most of the
differential movement along bedding planes was concentrated
in the shaly beds, and was accompanied by minor folding and
contortion or intense brecciation. The thin bedded shale
often acted as a plastic mass and moved from areas of high
pressure to areas of low pressure where it now forms highly

ontorted lenses (of Plate 11). The more brittle graywacke and tuffaceous beds have suffered a considerable amount of fracturing and faulting. These fractures are often of small displacement and locally flexures can be seen to pass into faults. This relatively open folding and accompanying faulting appears to be regional in extent as no completely flat lying beds were observed even at considerable distances from any exposed granitic bodies. This regional folding was earlier than the granodiorite and probably Laramide or early Tertiary.

Nearer the granitic bodies folding is more intense. Along the CCC road near the Snoqualmic River Middle Fork the graywackes and argillites have not only been quite strongly metamorphosed but also appear to have been isoclinally folded as is suggested by their nearly uniform steep dips. Compressive forces appear to have been acting during the emplacement of the granodiorite. On the ridge east of Take Calligan the argillites and feldspathic graywackes close to the granodiorite are tightly folded and one overturned fold is visible in the cliffs (of Plate 54).

The Man Pattern

While a lack of good bedding in the massive feldspathic graywackes of the Calligan formation, and the absence of visible stratification in the massive andesite breecias of the Mt. Garfield Volcanics makes it difficult to reconstruct the pregranitic structure in the central part of the area,

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The Men Pattern

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some approximation of this structure is suggested by the map

On the basis of the petrographic evidence given in this thesis it appears that the Quartz Creek Complex is in general a migmatitic area with the following affiliations: Pirst, the Area of Heterogeneous Granitic Rocks represents an area in which some rocks of the Calligan formation have been recrystallized and irregularly granitized to form rocks of quartz dioritic to granitic composition. Where there has been appreciable potash metasomatism in the rocks the result was to produce a rock similar to the Preacher granite. Second, the tonalite in the vicinity of Mowich Lake is a rock of uncertain origin which has been considerably metamorphosed. It does not extend outside the area of the Quartz Creek Complex and its relation to both the granodicrite and the Calligan formation is in doubt. Third, the Area of Fine Grained Quartz Diorites appears to represent basic rocks, probably belonging to the Mt. Garfield Volcanics, which have been recrystallized during the formation of the Preacher granite.

The Preacher granite appears to have originated mainly by the granitization of feldspathic graywackes of the Calligan formation. The presence of bodies of quartz diorite included in the granite might be explained in several ways. They might represent portions of the Mt. Garfield Volcanies which were interbedded with or folded into the Calligan graywackes, or they may be dikes of andesite or andesite porphyry similar to

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those seen cutting the Calligan formation to the west, and during the formation of the Preacher granite they have resisted the granitization which has completely transformed the surrounding graywackes. Some bodies of quarts diorite may also owe their position to the abundant faulting which is present in the northern part of the Preacher granite, since they often have cataclastic textures at their borders.

Towards the end of the formation of the Preacher granite, but while granitization and recrystallization processes were still active, the bulk of the Preacher granite southeast of the Middle Fork of the Snoqualmie River appears to have been faulted up so that on Mt. Garfield the Preacher granite, with a narrow intervening area of quartz diorite, contacts relatively slightly altered volcanics. An extension of this fault to the southwest along the south side of the Middle Fork of the Snoqualmie River appears very likely as the map shows an offset in the southwestern boundary of the Preacher granite near the mouth of the Pratt River. In this connection there is another feature which may be considered. The contact of the granodicrite west of the Fratt River with the Calligan formation, although as a whole curved on the map, is locally quite straight (of Plate 54), and were it not for the veinlets of quartz and feldspar penetrating the Calligan formation near the contact, it would appear to be a fault. If the potach metasomatism in the granodiorite took place at the same time as the formation of the Preacher granite then these veinlets

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of quartz and feldspar could be related to this metasomatism.

On this assumption the upward movement of the granodiorite southwest of the Pratt River can be considered as a faulting up related to the upward movement of the Preacher granite as noted on Mt. Garfield. This line of movement extending from Mt. Garfield in a southwesterly direction has been shown on the map as the Garfield fault.

If an attempt is made to reconstruct the pre-granitie structure by including the Area of Heterogeneous Granitic Rocks and the area now occupied by the Preacher granite as extensions of the Calligan formation, it would appear that the Calligan formation once surrounded the Mt. Garfield Volcanics in such a way as to suggest that the volcanies occupy a synclinal trough plunging to the east. This synclinal pattern is partially destroyed by the upward movement of the southeastern part of the volcanies along the Garfield fault. The fact that the contact between the base of the Mt. Garfield Volcanics and the rocks of the Quartz Creek Complex is at 1800 feet elevation in the small area of volcanics preserved on the ridge north of the Taylor River, but is below the lowest exposures at 1200 feet elevation on the southeast side of the Taylor River suggests that the base of the volcanics dips to the southeast in that locality. The has a second as board of the second and the second as the second as

The long tongue of granodiorite extending from Goat Mountain toward Bessemer Mountain would then appear to occupy an anticlinal area. The Mt. Phelps volcanic rocks and the

and The and the contract of the action of the contract of the and an it. derilate. This disher to enveron entered . At the best o a stranger of the arts of the arts of the stranger of the st solumeter bretten ask and becamerana ente soltament asking -ittle in the season settle of the season of al profess leading a alit . Step of t po principle appears to the dants comb entire talent blockers and amous solventer and there is densitation and of sold entimeter out to one out densitation out him moon plumber aplett. It out . more Legiselve

interbedded graywackes in the vicinity of the North Fork of the Snoqualmie River in general show dips toward the northwest and thus would fall on the northwestern limb of this anticline with an increase in the volcanic admixtures in a northerly direction and upward in the section. The interpretations noted above are illustrated in a cross section in a northwest-southeasterly direction through the Quartz Creek Complex and the Preacher granite (of Plate 57).

Since the fine grained granitic appearing rocks in the southeastern corner of the map area, near the rocks mapped by Smith and Calkins (9) as the Guye formation, appear to be partially granitized feldspathic graywacks similar to some of the rocks at the northern end of the Preacher granite which were interpreted as being gradational into feldspathic graywacks of the Calligan formation, it would appear that the Preacher granite could form a possible link between the Calligan formation of the map area and the Guye formation of the Snequalmie quadrangle.

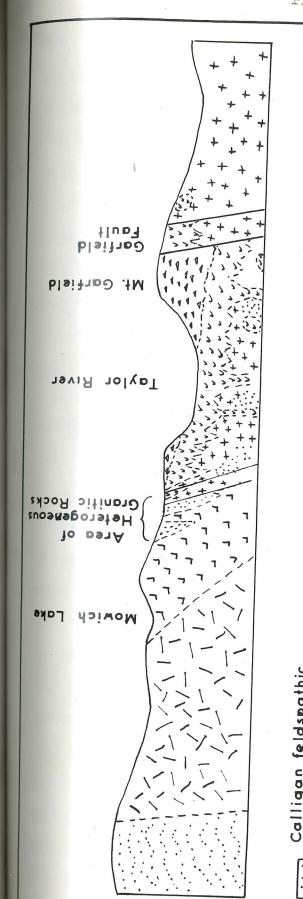
Faulting

The faults may be divided into three groups: those intimately associated with the regional folding, those near the boundaries of the granitic bodies and originating near the time of their emplacement, and finally, the more recent faults outting all the rocks of the area.

The abundant faulting of the more brittle beds in the

wax great and another and the interpret the Proposes granted (of Place 57). the companies grained grantitle appearing reads in the odf Jant terests blockit andferret magilian add. while of the contract of the caldiagon of origh happy request some could hearth of the sales and

associated with the regional foldings these near top of the grantile bodies and originating part scener mean day , valacts has fromposition who if



Calligan feldspathic graywackes

Garfield

Tonalite

Fine-grained quartz diorite Preacher

granite

Snoqualmie granodiorite Volcanics

SKETCH SHOWING POSSIBLE STRUCTURAL EXPLANATION OF RELATION BETWEEN COMPLEX, AND MT. GARFIELD VOLCANICS CREEK PREACHER GRANITE, QUARTZ

northwestern part of the area has been described. These faults have a general trend parallel to the strike of the strata.

The tight folding adjacent to the Snoqualmie granodicrite is accompanied by much faulting with the relative movement
guch that more room was provided for the invading granitic rock
masses. These faults usually have a trend more or less parallel to the boundaries of the granitic bodies. Much faulting
has occurred at the northern end of the Preacher granite, of
which that along the Garfield fault described above is the most
conspicuous. Some rocks of the neighboring Quartz Greek
Complex have suffered extreme brecciation followed by recrystallization.

part of the area are numerous faults ranging in strike from m60°W to m60°E. Locally they have lenses of quartz and sulphides along them and then they form some of the mineral deposits of the district. There are no marker beds which could provide a clue as to the relative movement, but its magnitude is believed to be small in most cases. In the lower adit on the Lennox vein grooves on the fault surface show that the latest movement was horizontal. These faults show a change in strike in the vicinity of Goat Mountain such that they tend to parallel the southern boundary of the granodiorite. They appear to be minor faults along the crest of the anticlinal uplift occupied by the granodiorite. While essentially parallel to one of the joint systems in the granodiorite, they do

atinat over part of the are had been teautibed. These faulte . strift odd to estrice out to Iniferry board Invento a second snearevon evisator eds dels galilier donn to beinsqueste at es-MOOT DESCRIPTION WAS PROVIDED TO TO THE STATE STORY OF THE PARTY OF TH -Integ sobi to one bases a ever vilgum adding could take The boundaries of the grantete boules. The transfer to to the redeposit and to have montreen one to begin be doo'd action painted the one in moor oned .acous. -parent of Levelich holdslopers courses best true over the A THE PARTY OF THE protective and all efficients eightenpond out minist, were -Luc bos attaup to sessed syst they the and sulyour to southern one to yrahard gradiune but faili

not stop at the boundary of the granodiorite. The fault along the Lennoz vein can be observed extending into the Calligan formation on the ridge southwest of the Lennox River.

Many faults in the map area have no mineral growth along them and some of these are probably of quite recent age. One strongly marked fault cutting interbedded tuffs and shales of the Calligan formation is exposed along the logging road up Big Creek (of Plate 58). Another conspicuous fault accompanied by much brecciation and gouge is exposed along the logging road above Quartz Creek where the logging company has excavated some of the brecciated rock along the fault for road surfacing. Numerous somes of sheeting consisting of numerous closely spaced parallel fractures can be observed in the more massive rocks, and these zones are usually parallel to the strongest system of jointing in the vicinity.

Jointing

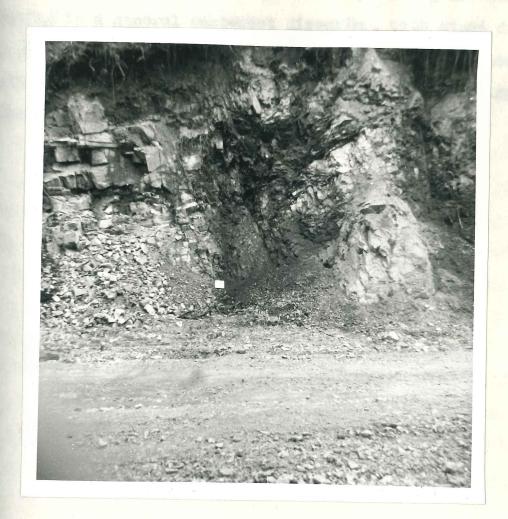
Jointing is well developed in the Smoqualmie granodiorite but is not very conspicuous elsewhere. Some bare rock cliffs in Preacher granite several thousand feet high show little jointing and tend to form rounded surfaces. On the other hand, steep bare cliffs in Smoqualmie granodiorite are criss-crossed with joints.

The minor joint systems vary considerably in strike and dip and often appear to be parallel to the exposed surface of the ground. In contrast to the minor joints which vary in

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PLATE 58 THE RESIDENCE OF THE PROPERTY OF THE



Photograph of fault outting massive tuffaceous beds along the Big Creek logging road.

of jointing in the main body of the Snoqualmie granodiorite striking in a general east-west direction, with steep dips to the south, and a weaker set of jointing in a general north-south direction, with variable steep dips. The faulting associated with these joint systems has been mentioned.

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activities in the area. The earliest work began in 1906 and 1907 when the first tunnels were driven on the prospects along Quartz Creek. Some prospecting was undoubtedly done along the North Fork of the Snoqualmie River at this time. The Bear Basin deposits were prospected quite thoroughly in the 1920's when a fifty-ton mill was constructed, but transportation facilities were poor and the operation was not a success. Activity in the district continued through the 1930's when considerable work was done on the Lennox property, aided by a mine to market road which was roughed out up the Snoqualmie North Fork as far as the Lennox River and allowed access by tractor and some trucks that far. There was lots of promotional activity and buying and selling of claims during this period but not much underground development work on the veins.

Activity in the district died down during the Second World War but was renewed in 1946. Since that time access to the deposits along the Snoqualmie North Fork has been greatly facilitated by the construction by the St. Paul and Tacoma

CHIEF TREATMENT

the door in the area. The earliest work began in 1906 and main drook. Some prospecting was anderbredly done along tsoil tell .out the frequencial sixtee at the three like Hoat s'OSQI wit at vinpoored; eding bedrequery even attaces all estation were poor and the operation was not a success. marie widen and characte benefit on the 1930's plant winding to store one special wast dade science to a long to the of record word that course divide the term new and the Sacon Day the some troot by the 't, Real and Troots

Tumber Company of a good logging road along the old mine to market right of way almost to the Lennox River. In 1949 and 1950 State of Washington mine to market road funds were used to construct a woad from the end of the logging road, up the Lennox River to the vicinity of Bear Creek.

A very small amount of hand sorted ore is said to have been taken to the Tacoma smelter from the Lennez property. Some ore was milled at the Bear Basin property and a few sacks of concentrate were found in the charred remains of the mill, which burned down, but little stoping was carried on in the mine so the production must have been very small.

The control of the co

Primary Einerals

The gangue minerals which are present in significant quantities are as follows:

Quarts - Most abundant, almost always present

Calcite - Minor, present in Lennox vein

Rhodochrosite - Important at Bear Basin Silver vein only

Tourmaline - Minor, present at Quartz Creek and on Jack Pot claims

rocks; some present in most veins

Ore minerals which have been identified include the

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Primary Minerals

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following: pyrite, ersenopyrite, pyrrhotite, chalcopyrite, jamesonite, sphalerite, galena, molybdenite, and scheelite-powellite. The presence of gold and silver has been shown by assays.

Paragenesis

Quartz was the earliest mineral to form. It is typically coarse grained and often occurs in subsectal crystals.

A coarse crustification, which is better seen in the hand
specimen than in thin section, is frequently present. Quartz
continued forming throughout the metallization.

Calcite appears to be always later than quartz, and at the Lennox property some calcite veinlets also were observed filling fractures in pyrite. In the Bear Basin silver vein some quartz lining vugs is later than the rhodochrosite, while other quartz is earlier.

Pyrite was usually the first sulphide to form, but if arsenopyrite is also present they usually do not penetrate each other and may be essentially contemporaneous. In the Lucky Strike and Goat Mountain prospects some cross-cutting veinlets of sphalerite penetrating pyrite can be seen, and at the Langer property veinlets of chalcopyrite cutting sphalerite and pyrrhotite can be observed. Along Quartz Crock some outcrops of nearly pure arsenopyrite in quartz contain very small cross-cutting veinlets and irregular grains of chalcopyrite. In the Goat Mountain prospect the small amount of

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galena present was later than the pyrite and spalerite. In the Bear Basin Alex vein jamesonite can be seen replacing both pyrite and chalcopyrite. No silver minerals or gold were identified.

The succession of sulphide minerals is thus seen to be as follows:

Pyrite

Often contemporaneous

Arsenopyrite

Pyrrhotite

Sphalerite

Chalcopyrite

Jamesonite

Galena

No criteria for relative position

This sequence is not unusual as it is in accord with that observed in most mining districts where these minerals are present.

Types and Distribution of Mineral Deposits

The mineral deposits may be put into two main groups, those within the Snoqualmie granodicrite and those occurring elsewhere. The veins within the Snoqualmie granodicrite include the following:

Bear Basin Silver Vein - Silver-bearing jamesonite in rhodochrosite

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The pineral deposits may be gut into two main groups, we within the duoqualmie granodiomits and these eccursing colours, the voice within the Engagelmie granodiomits

Bear Basin Alex Vein - Base metals with some gold and silver

Jack Pot Prospect - do

Goat Mountain Prospect - do

Lucky Strike Prospect - Arsenopyrite-pyrite-quarts vein with gold and silver

Beaverdale Prospect - do

Lennox Vein do

Devils Canyon Prospect - Molybdenite in quartz

The following deposits occur outside the Snoqualmie granodiorite:

Langer and Rainbow Claims - Pyrrhotite, chalcopyrite,
sphalerite veins in hornfels
Quartz Creek Prospect - Copper replacement deposits
in quartz diorite

The mineral deposits in the Snoqualmie granodicrite which are listed above are all found in the large mass of this rock in the northeastern part of the map area. An old tunnel along Granite Creek in the Snoqualmie granodicrite occurring in the southwestern part of the area has traces of copper minerals on the dump but the tunnel was caved and could not be entered.

All the veins in the northeastern part of the area strike in the same general direction. The mineralogy varies from vein to vein. Some of the faults are quite persistent the alon came of he alone cost - alov wolk minet wood

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but the ore occurrences are restricted to lenticular shoots along the faults where structural conditions were favorable for the maintenance of open spaces. In some cases the veins have been opened by further movement as evidenced by the fracturing of early pyrite and quartz and the filling of these fractures or replacement along them by later minerals.

Within a few miles in the northeastern part of the map the nearly parallel veins all in granodiorite show molybdenite at Devil's Canyon, sphalerite and pyrite at the Jack Pot Claims, silver bearing james onlie in rhodochrosite at Bear Basin, and arsenopyrite and pyrite in quartz at the Lucky Strike and Beaverdale prospects.

The Lennox vein is in a quartz diorite migmatitic border phase of the Snoqualmie granodiorite along the Lennox River and is similar in mineralogy and structure to some of the veins in the Snoqualmie granodiorite. The mineralization on the Langer and Rainbow claims falls within hornfelsized sediments of the Calligan formation within a short distance of the contact with the Snoqualmie granodiorite. Not much faulting occurs with these veins in hornfels and they are essentially replacement deposits with such high temperature gangue minerals as garmet, plagioclase feldspar, and amphiboles.

The other deposit outside the Snoqualmie granodiorite is along Quartz Creek in the quartz diorite complex. This

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one-fourth mile, all with different mineralogy. The principal values are in copper which occurs principally as chalcopyrite. At the three locations mentioned above the chalcopyrite occurs with considerable pyrite, arsenopyrite, and molybdenite, respectively. The deposit represents a replacement in a breciated zone, although locally some filling has occurred. Gangue minerals include quartz, scricite, chlorite and tourmaline.

Description of Individual Deposits

General Features of Bear Basin Deposits

The Bear Basin Mining Company has a group of twentyfive mining claims in the basin drained by Bear Creek. Several nearly parallel veins of two distinct types have been prospected by about 1750 feet of drifting and cross-cutting.

alpine glaciation, with Bear Creek following a step-like ascent.

At about 4200 feet elevation the valley widens out to an amphitheatre-shaped basin surrounded by nearly vertical rock cliffs about five hundred feet high. Talus slopes composed of large blocks of granodicrite have accumulated around the foot of these cliffs. Above the cliffs the slopes become more gentle with two small depressions occupied by Bear Lakes, and finally steepen again to culminate in ridges at an elevation above 5000 feet. The veins outcrop in the cliffs above 4200

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outs to main is two distinct types have been prosouts by shout 1750 feet of drifting and eross-sutting.

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than the security deprendiction occupied by Bear laige, and
they cliffs and senin to culminate in ridges at an elevation
to deep nearly contains outcome in the cliffs above bacor

feet elevation and being accompanied by faulting and alteration and generally softer than the wall rocks, form the paths for water from the melting snow on the upper slopes.

Prospecting adits have been driven into the cliffs on the veins at the top of the talus slopes. From south to north these adits are: the number three which is driven some 450 feet on the Silver vein, characterized by banded quartz and rhodochrosite with silver bearing sulphides of lead and antimony; the numbers four, five, and eight adits which prospect zones marked mainly by breeciation and alteration of granodicrite; and adits numbers six and seven which cross-cut the Alex vein, marked by strong faulting and some iron, copper, lead and antimony sulphides. Since the mineralization in the Silver and Alex veins is noticeably different they will be treated separately.

Bear Basin Silver Vein

Structure

The vein outcrops in a small ridge between two talus slopes. It is well exposed in an open cut and shows two faults five feet apart striking \$73°E and dipping steeply to the south, with a foot of banded quartz and rhodochrosite on each wall, separated by three feet of brecciated and altered granodicrite. Immediately below the west end of this open cut a drift was begun and follows the vein in an easterly direction for 450 feet. The vein, as seen in Plate 59, is

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SATISTICAL SECTION

The vein cuterope in a small ridge between two tains to these. It is well expend in an open out and shows two to tail of five feet apart atriaing appears and disping steeply to sentin, with a foot of banded quarts and risodochrosite on the well, separated by times feet of breecisted and altered and altered and altered and altered to the vein the west and of this open and follows the vein in Plate 49, is

Scale:

marked by a rather strong faulting in the plane of the vein.

Except for a slight echelon at the bend in the drift one hundred feet from the portal the fault along the south or hanging-wall side is nearly continuous and is marked by considerable gouge and has a nearly uniform dip of eighty degrees to the south. At several places along this vein, faults with a strike of about \$78°E and dips which are generally less than eighty degrees approach this hanging-wall fault from the north or foot-wall side.

Both along the intersecting faults and along the hanging-wall fault near the intersection with these faults are varying thicknesses of pink banded rhodochrosite and clear banded, and in places vuggy, quarts. In the rhodochrosite are irregular shaped grains of sulphides, mostly the silver bearing lead-antimony sulphide, jamesonite. At the portal the foot-wall fault and hanging-wall fault are nearly parallel, both in strike and dip, and about forty-two inches apart, with rhodochrosite and quartz fifteen inches wide next to the footwall fault and twelve inches wide on the hanging-wall side, separated by fifteen inches of altered granedicrite. Following the foot-wall fault eastward along the drift its dip becomes less and it separates more and more from the hanging-wall fault and in so doing the amount of Phodochrosite and sulphides along it decreases until at one hundred feet from the portal the foot-wall fault is quite weak and there is no longer any rhodochrosite.

At 220 feet from the portal another fault striking

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\$780% intersects the hanging-wall fault and there are eight inches of rhodochrosite and quartz over a length of fifty feet where the two faults are fairly close together.

tant shear, represented by the hanging-wall fault, along which are zones of tension fractures which intersect the shear at a small angle, and the banded quartz and rhodochrosite, con-taining the ore minerals, have been deposited in tensional openings near these intersections.

Mineralogy of the Silver Vein

The main gangue mineral in the vein is rhodochrosite, which is light pink in color, and delicately banded, usually symmetrical with respect to small openings, some of which still exist. The banding is partly due to a variation in grain size of the rhodochrosite, evidently due to a rhythmic changing of physical conditions, and partly due to the inclusion of some quartz and sulphide bands.

Some small openings parallel with the vein walls still exist and these are usually lined with fine druzy quarts crystals which are later than the rhodochrosite. The rhodo-chrosite shows some beautiful cockscomb structures (of Plate 60). Some fractures in this banded rhodochrosite have been filled with later quarts.

The chief ore mineral is the gray feathery lead sulphantimony mineral jamesonite. This jamesonite appears to

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Photomicrograph of banded rhodochrosite from Number 3 adit, Bear Basin Mining Company, showing cockscomb structure. (Plain light; x 12)

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have been deposited along with some late quarts, as there is usually some quarts associated with the jamesonite, and in some cases jamesonite and druzy quarts occur together along small openings. Very locally the vein has suffered from later fracturing and reopening as some quarts and rhodochrosite show undulating extinction and fractures. Still later jamesonite and quarts have been deposited along these fractures. In contrast to the scattered feathery aggregates of jamesonite, this later jamesonite is in long narrow veinlets.

Other sulphides are sparingly present in the vein filling, usually in small scattered grains. These are sphalerite, pyrite, areenopyrite, and chalcopyrite.

Beer Basin Alex Vein

Structure

. outdoor is the last Congraty, showing conjugace to the actual

of Bear Basin on the trail leading from the lower basin up to Bear Lakes. Two adits have been driven to intersect this vein at depth. The upper one, called number six adit, starts as a cross-cut at an elevation of about 4500 feet, about one hundred feet below the outcrop, while the other, called number seven adit, cross-cuts the vein about fifty-five feet lower and two hundred feet west of the number six portal.

The structure of the Alex vein, as seen in Plate 61, consists of two parallel faults, a foot-wall and hanging-wall fault, about fifty feet apart, joined in the vicinity of the

the been depended along with some late quarte, as those in comming some quarter associated with its Senerality, and in some other dependent as and druly caute open together along that of the voin was sufficient from the comming. They insality the voin was sufficient from the object industring extinction and fractures. Still later the object and quarter indeed along those fractions and quarter indeed to the scattered fracthery appreciae of the contract to the scattered fracthery appreciae of the scatter, this later them the in in long narrow voind the contract withing, weath, in small coattered grains. These are

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The standard of the Alex vein, as meet in Flate 61,

Snoqualmie granodiorite Nearly white granite Fault with gouge and 6" qtz. containing pyrite and some chalcopyrite 2'x6' lens containing pyrite, chakcopyrite and jamesonite No.6 Adit Elev. 4500' BEAR BASIN MINING CO. NO.68 NO.7 ADITS-ALEX VEIN No. 7 Adit Elev. 4445' Scale: | inch=50 feet

number six adit by a diagonal fracture zone, making an angle of about twenty-five degrees with the parallel faults. Along this diagonal fracture zone, and near its junction with the foot-wall and hanging-wall faults, there has been considerable brecciation and alteration of the granitic rock and the deposition of irregular seams and pockets of sulphides. In addition there has been some deposition of sulphides along the parallel faults themselves as seen on the map.

The number six adit, after passing through several weak faults and some weak mineralization, intersects the strong foot-well fault eighty feet from the portal. The hanging-wall fault evidently weakens before reaching this far east. This foot-wall fault, striking S510E and dipping about 720 to the southwest has been drifted on for a distance of 325 feet to the northwest. It is a very straight fault with some gouge. and for 150 feet from where it is cross-cut by the number six adit it has along it four to six inches of black sulphides with some green copper staining. Starting twenty feet west of the cross-out this fault is intersected by the diagonal fracture zone consisting of a series of fractures striking S750E and spaced several feet apart. Along these fractures are some two to six inch wide veinlets of black sulphides, and the intervening wall rock is brecciated, altered, and has numerous irregular veinlets and pockets of sulphides. These sulphides leave a black streak when the soft rock is hit with a pick. These intersecting faults are not encountered beyond sixty feet

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from the cross-cut and from there to the end of the drift
this foot-wall fault is very straight and the sulphides only
occur locally adjacent to the fault, the fault being mainly
marked by a narrow gouge.

Along the drift at a point one hundred feet west of the number six adit cross-cut another cross-cut leads off diagonally to the west. At approximately sixty feet from the drift it reveals another shear striking \$5200 to \$6200, or nearly parallel to the main foot-wall fault, but fifty feet south of it, and nearly vertical. At the place where this cross-cut first encounters this hanging-wall fault it is seen that there is some transverse fracturing between this fault and the foot-wall fault, which lines up with the intersecting fractures and sulphide seams encountered in the main drift and described above.

Wall rock in the vicinity of the Alex vain and its influence on the structure

There are two types of granitic rock exposed in the number six adit. As seen on the geologic map (of Flate 70), Bear Basin falls within the large body of the Snoqualmie granodiorite. This granodiorite is the wall rock of the Silver vein and occurs throughout most of the area. However, within this granodiorite are some areas of light colored rock, lower in mafice and higher in quartz and potash feldspar than the granodiorite. These lighter colored rocks are believed due to the work of potash metasomatism enriching the rock in

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potash and silica at the expense of iron and magnesium, and producing a rock which is in reality a granite rather than a granodicrite.

as examined in thin section shows large subhedral grains of andesine feldspar, twenty per cent quartz in irregular grains, twenty per cent orthoclase in anhedral polkilitic plates, plus about ten per cent hornblende and ten per cent biotite. The hornblende is partly in subsdral grains. The biotite forms large plates with ragged borders and is partly altered to chlorite, and partly to a peculiar green biotite. The latter is strongly pleochroic, pale brown to bright green. Also present are some grains of tourmaline, zircon, apatite, and some of the plagioclase has altered with the formation of epidote, sericite and calcite.

In contrast to the granodiorite the light colored granitic rock shows the effect of potash metasomatism. Only a few pieces of plagioclase feldspar remain as skeleton crystals surrounded by the quartz, calcite, and orthoclase which have replaced it. The rock is composed of about fifty per cent quartz, thirty per cent orthoclase, five per cent plagioclase, ten per cent calcite, and some sericite and pyrite, and can be called a granite. This potash and silica metasomatism which produced the granite from the granodiorite is earlier than the formation of the Alex vein and not the result of the ore hearing solutions, as it will be seen that the faulting

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the described in this costion shows large subsected grains of engages, this costion shows large subsected as in the crime, and the contract of the second grains, engages, the contract of the second cost of the contract of the second cost of the contract of the contract

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pattern changes on passing from the granodicrite to the granite. This same leucocratic granitic rock occurs at other spots in the basin not immediately adjacent to veins.

The contact between the granite and granodiorite is visible in the number six tunnel, running roughly north and south. It evidently dips at a low angle to the west as the hanging-wall drift of the number six adit level is in granodiorite near its west end, while fifty feet vertically below, the number seven cross-cut is in granite. Since the diagonal fracturing and sulphide mineralization discussed above appear to start where the hanging-wall or south fault passes out of the granodiorite and into the granite, it appears that the change in competency of the wall rock has affected the fracture pattern.

Mineralogy

The granite and granodiorite walls of the vein are at some places fairly fresh to within a few inches of the hanging-wall and foot-wall faults. In the vicinity of the diagonal fracturing, where the mineralization has been strongest, the granite has been highly altered to a white aggregate of quartz and muscovite with disseminated pyrite. The muscovite occurs in small radiating plates between the quartz grains and some-times penetrating the grains.

occur with quartz. In the diagonal shear zone some bunches and isolated grains of sulphides occur in the highly altered

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The grante and grancelouite walls of the vein are at the planting that the planting of the planting that the planting the planting of the planting of the diagonal facility. In the vicinity of the diagonal, the vicinity altered to a white aggregate of quarta consecute which discognize the particle and the discognization the quarta grains and course the constant of the planting pl

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and brecciated granite. The quartz is fairly coarse grained and crustification is absent. The granular quartz is crossed by numerous lines of fracturing along which the quartz is deformed and shows microbrecciation.

Pyrite is by far the most prevalent sulphide, and forms along fractures in the quartz, mainly by replacement. It occasionally forms cubes, but irregular outlines are more common. Where it has been fractured and pulverized by later movements it is friable and appears as a streak of black sulphides. A much smaller amount of chalcopyrite occurs as irregular grains scattered through the quartz or is occasionally seen replacing pyrite. This chalcopyrite is partly altered to malachite or assurite where exposed to the air in the drift or to circulating water along fractures.

In the short hanging-wall drift of the number six adit there is a pocket of sulphides about two feet wide by six feet long which seems to have arisen in a small diagonal fracture having a pattern suggesting a tensional fracture. Within this pocket some gray feathery jamesonite has been deposited along with pyrite and chalcopyrite, and this pocket produces some values in silver. A polished section of sulphides from the pocket mentioned above shows an elongated oval of sulphides containing about equal amounts of chalcopyrite and jamesonite in the center with an outer ring of pyrite. Within the jamesonite is a small cavity, suggesting the possibility of some filling of open spaces. At other places in the same

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In the short han ing-well drift of the number six and come in a posicit of sulphides about two feet wide by all fracture in a second free ture in a small diagonal fracture. This telegraphic a patient a supposition of patient six and this trip of total supposition of sulphides about produces of an aliver in aliver. A policiped accellent of sulphides and chalced about accellent of sulphides and the subting about equal about an discussion of sulphides and transcord to the content of the subting about equal answer of charge of pyrate. A fithin the content of the content with an duter wing of pyrate, and fracture of the possibility of the short equal equals. It can possibility of the same

specimen the jamesonite appears to have formed by replacement, and was the last mineral to form, replacing both pyrite and chalcopyrite.

A few grains of arsenopyrite are present. It appears
to be contemporaneous with the pyrite. The early pyrite shows
more fracturing and brecciation than the chalcopyrite, while
one area of jamesonite about one centimeter long shows no
fracturing, indicating that the shearing diminished during the
later part of the metallization. Some fractures in the pyrite
are filled with cryptocrystalline quartz with a low index of
refraction suggesting that temperatures decreased during the
last stages of mineralization.

Goat Mountain Prospect decay addesor to

of Sunday Lake. On the west side of this peak, about one mile south of Sunday Lake, a fault zone is exposed between 3000 and 3700 feet elevation in a rather narrow canyon. The owner, Robert Prufer, has a cabin and blacksmith shop along Sunday Greek near the vein. There has been no development to date, but the vein in the canyon has been prospected by blasting numerous open outs across the canyon floor.

The wall rock is Spoqualmie granodiorite. The lowest exposure of the vein in the canyon near 3000 feet shows a fault near the south wall of the canyon striking N90°V, with some gouge along it. North of this fault is a five inch seem of sulphides consisting mainly of pyrite, but some arseno-

descending the language to have formed by replacement but the board of prints and the same the same are present.

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phides are five feet of brown altered granodiorite, and then a granodiorite wall striking N70°W or at an angle of about twenty degrees to the fault on the south wall. This structural pattern is repeated on up the canyon to the east with a fault continuing fairly strong for several hundred feet and then fading out while another fault either parallel or at a small angle, and often on the opposite wall of the canyon, will become fairly strong for a few hundred feet until it too is superseded by still another fault. In this manner the fault some continues for a length of about 1000 feet.

Idlawise, the seams of quartz and sulphides are not continuous, but are somewhat lenticular and scattered at intervals along the canyon, usually immediately adjacent to one of the faults. No exposure of sulphides can be followed for over twenty feet along its strike because of limited exposures in the floor of the canyon. The widest quartz-sulphide seam observed was about six inches, but Mr. Prufer reports one seam fourteen inches wide was exposed in an open cut which was covered by slides when this property was visited. Pieces of quartz containing pyrite and sphalerite supposed to have come from this seam were lying beside this open cut and were similar to the sulphides from smaller seams observed elsewhere in the canyon.

From 250 to 300 feet east of the first outcrop at 3000 feet elevation, the creek follows the north wall of the canyon

-crime table and moves out to real at attacks Willia Bose observed was about six inches, but his Fruist

and exposes occasional one to five inch quartz stringers with some pyrite, sphalerite and a few grains of galena and chalcopyrite. About two hundred feet farther east a fault on the south side of the canyon shows some gouge and one to four inches of quarts and sulphides along it. Additional quartz—sulphide seams are exposed at 3400 feet elevation and again at 3700 feet. At this uppermost exposure well defined firm walls of granodicrite nineteen feet apart bound a fault zone showing brecciated and altered granodicrite and at one spot within it, two two-inch quartz-sulphide seams separated by six inches of gouge containing some quartz and sulphides. The paragenesis is pyrite, arsenopyrite, sphalerite, chalcopyrite, and galena.

Jack Pot Prospect

On the north and east side of Goat Mountain are some fractures which locally contain values in gold, silver and zinc. These fractures follow approximately along a line but are not continuous. The mineralized fractures have nearly the same strike as the direction of best developed jointing in the granodicrite. The mineralization frequently ends at a cross joint.

The greatest metallization is on claim number one where a vein is exposed at 4/40 feet elevation in the nearly vertical face of a cliff on the east side of a large basin below Goat Mountain. The vein is lenticular in vertical section, varying from two feet wide near the top of the cliff to about ten feet

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wide at fifty feet lower elevation. Forty feet farther down the slope in line with the vein some massive granodicrite partly exposed beneath the talus shows that the vein has again narrowed. At its widest part the vein shows from south to north the following detail: a fault striking N78°E and dipping eighty degrees south; four inches of quartz; sixteen inches of brecciated and bleached granodicrite; five inches of quartz with considerable sphalerite and pyrite; twelve inches of granodicrite; four inches of quartz with sphalerite and pyrite; two feet of soft brecciated granodicrite; six inches of quartz with some quartz druzes; three feet of soft brown granodicrite with some scattered sphalerite and pyrite grains; six inches of brecciated quartz with criss-crossing veinlets up to one-half inch wide of sphalerite.

About eight hundred feet to the west of the above exposure another outcrop shows the close association of the sulphide mineralization with jointing and also with the tourmaline veinlets which are found at numerous spots throughout the granodicrite on Goat Mountain (of Plate 62). Here mineralization ends at a cross joint and a five-inch quartz-tourmaline veinlet parallels the vein.

about 1100 feet from Cougar Creek and more or less in line with the above outcrops a vein is exposed in a small canyon.

At 3600 feet elevation in the floor of this canyon the vein is two feet wide and shows twelve inches of gouge containing

PLATE 62

GRANODIORITE Altered and brecciated granodiorite with some quartz, pyrite, and sphalerite in 1/8 inch veinlets -Quartz tourmaline vein I FOOT

This sketch of a small vein containing some values in zinc, gold and silver, which outcrops on the Jack Pot claims, illustrates how mineralization frequently diminishes at a cross joint. The tourmaline veinlets are quite common on Goat Mountain.

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breceiated quartz with some black streaks of crushed sulphides, six inches of quartz, and six inches of silicified granodio-rite. Some irregular seems of sulphides two to three inches wide occur in the quartz. The chief sulphide is pyrite but some sphalerite and small amounts of chalcopyrite and scheelite are present.

Lucky Strike Prospect

This property is located in Sections 9 and 10, Township 25 North, Range 10 East, on the slope south of the North Fork of the Snoqualmie River between 3000 and 4000 feet elevation. Development consists of a winze approximately thirty feet deep. The trail to the prospect leaves the North Fork trail about three and one-half miles above the mouth of the Lennox River and climbs for about two miles to the location of the winze.

The country rock in the vicinity of the vein is Snoqualmie granodiorite. The vein consists of two parallel faults about six feet apart, striking N73°s and dipping 78 degrees to the south (of Plate 63). The granodiorite between the faults is brecciated and altered to a light colored aggregate of quartz and sericite, with considerable pyrite disseminated through it.

During the shearing along the vein there was produced some diagonal tensional fractures between the hanging-wall and foot-wall faults, and which make an angle of about sixteen

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This property is located in Sections 9 and 10, Towninto 25 Themin, Sauge 10 Saut, on the slope south of the North

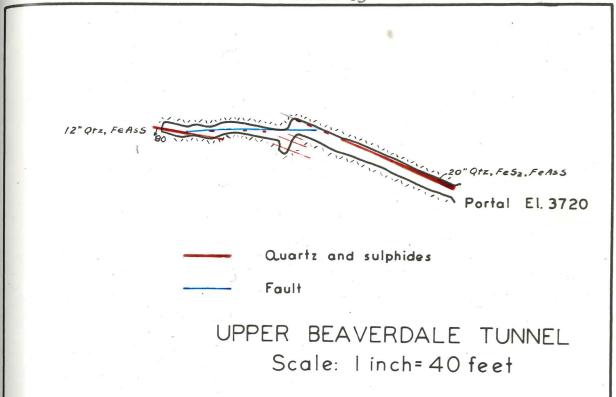
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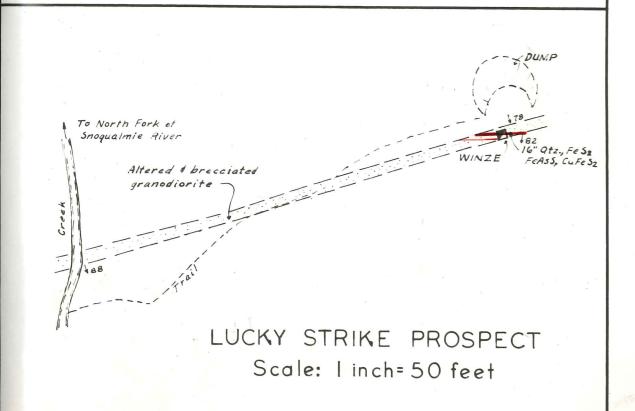
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The country wook in the vicinity of the vein is decinity of the vein is decinity of the vein occasion of two parallel and the states of the sent dispine 78 occasion to the south (of state 63). The grandicrite between the leading is brechtated and altered to a light colored transfer of quarte and seriotte, with considerable pyrite

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degrees with the strike of the main vein. Some coarse grained quarts and finer grained sulphides have been deposited along these transverse fractures. The winze has been centered on one of these bands of quarts and sulphides which varies in thickness from twelve to sixteen inches.

The owners, George and Gary Rutherford, have blasted the over-burden from the vein at the surface just west of the winze. Here the principal sulphide seam is twelve inches wide. A few other parallel quartz and sulphide seams one inch wide and one sulphide seam three inches wide are contained in the remaining five feet of altered granodicrite between the vein walls.

Mineralogy

The quarts in the veinlets is coarse grained, with elongated crystals perpendicular to the walls of the veinlets. Interstices between the larger crystals are filled with smaller quarts crystals and some arsenopyrite and pyrite. Some small openings lined with projecting quarts crystals and sulphides still exist.

In some places the transverse seams are composed of almost solid sulphides. The earliest and most abundant sulphides are pyrite and arsenopyrite in that order. Within the quarts weinlets the sulphides appear to have formed largely by precipitation in openings between quarts grains. Sometimes a crude crustification can be observed. The third most abundant sulphide is chalcopyrite, which occurs as small grains in the

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quartz, mostly along small microfractures, and as irregular grains in the sulphide seams replacing both arsenopyrite and pyrite. A polished section from the sulphide seam on the east side of the winze sixteen feet from the top shows some pyrite cubes surrounded by arsenopyrite, with irregular grains of chalcopyrite replacing both pyrite and arsenopyrite.

occur mainly in the transverse quarts and sulphide seems within the voin. On the basis of available assays the ratio of gold to silver averages about one to seventeen.

west of the winze the alteration of the granodiorite is less intense. There are a few quartz veinlets an inch wide in the altered zone but almost no sulphides. The vein is not emposed on the timbered slope to the east of the winze.

Beaverdale Prospect

Location and Structure

enters the North Fork of the Snoqualmie River in the northeastern part of the area. Along Illinois Creek at an elevation of 3000 feet an old log cabin, partly fallen in, is all
that remains of the old mine camp. The vein outcrops along a
narrow canyon which enters Illinois Creek from the west about
1000 feet up Illinois Creek from the cabin. A tunnel, now
caved, has its portal on the north side of the canyon at 3370
feet elevation, in the talus slope.

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Up the canyon from the lower tunnel is snother tunnel fifty-five feet long with its portal in the north wall of the canyon at 3610 feet elevation. Still farther up the canyon, at 3720 feet elevation, is a tunnel which follows along the vein for 140 feet (of Plate 63).

The country rock is Snoqualmie granodicrite. The deposit consists of a narrow zone of faulting, along which the granodicrite is brecciated and altered. This zone is not a continuous fault, but is a series of relatively short faults along a zone, with one fault weakening while another fault continues along the strike of the fault zone, with sometimes a diagonal fault connecting the two as seen in the map of the upper turnel. At some places along this zone some quartz and sulphides, from a few inches up to twenty inches in width, presumably containing values in gold and silver, have been deposited.

Mineralogy - Charles and Bandaledes portions of the wade, wide

The Snoqualmie granodicrite at this prospect is almost a quartz monzonite, with a mineral composition of thirty-five per cent andesine feldspar, thirty per cent anhedral orthoclase and microperthite, twenty per cent quartz, and fifteen per cent biotite and chlorite in ragged plates.

The dump outside the portal of the lower tunnel shows both fresh granodiorite and soft brown altered granodiorite containing some disseminated pyrite. At the side of the portal is a pile of soft yellow stained brecciated quartz with

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visible pyrite, some in the form of small cubes, and some streaks of soft black crushed sulphides. These soft black sulphides are mainly arsonopyrite, but also include some brecciated pyrite, and some small irregular sheared grains of soft gray sulphide, probably galena.

In the fifty-five foot turnel at 3610 feet elevation the voin strikes 8800% and dips 76 degrees to the south. It shows the following detail from north to south: twelve inches of soft gouge, sixteen inches of soft altered and brecciated granodiorite, and sixteen inches of quartz and sulphides. The quartz is granular, and the chief sulphides are pyrite, in grains one to two millimeters in size, and finer grained arsenopyrite.

In the portal of the upper tunnel at 3720 feet elevation (of Plate 63) are twenty inches of brownish yellow
stained, rather porous quartz, containing pyrite and arsenopyrite. This quartz and sulphide portion of the vein, which
is twenty inches wide at the portal, narrows to ten inches at
thirty feet from the portal, and to six inches at fifty feet
from the portal. At eighty feet from the portal the vein
pinches out and the drift turns and follows a diagonal fault
to another quartz-sulphide vein en echelon to the first. The
face of the drift along this vein shows twelve inches of quartz
and sulphides, and twelve inches of soft altered granodicrite
containing some one-fourth to one-half inch criss-crossing
veinlets of sulphides. The chief sulphide here is arsenopy-

The lode cuts across a rather vide contact zone between the Snoqualmie granodiorite and the tuffaceous sediments
and tuffa to the south. The eastern end of the lode as exposed in the low level cross-cut is in a rather fine grained
quartz diorite which occurs in this contact zone. This quartz
diorite is much finer grained and fresher appearing than the
normal granodiorite, and in many places shows marked allignment of its elongated feldspar laths (of Plate 53). In places
it is actually a migmatite, containing irregular patches of
coarser grained more leucocratic rock.

Structure

a mineralized fault zone. The principal fault is usually on the south or hanging-wall side of the fault zone, and in the western end of the lode, where the structure is best exposed, the ore occurs mainly as seams rich in sulphides which occur in subordinate fractures in the country rock near the principal fault but usually at a slight angle to it.

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Exposures along the vein

The most westerly, and also the uppermost, exposure along the vein is at an elevation of 2700 feet where the vein occurs in the floor of a steep canyon leading up from the Lennox River. Some of the earlier workers have blasted the over-burden from the vein. The fault zone here is about twelve feet wide. The hanging-wall is marked by a fault,

The lock outs series and the tuffscoom community of the intersection to the south. The entern mid of the lock as expected in to the south. The entern mid of the lock as expected in the lock level order-out is in a rather film grained outsit it is low lock of outsit of this contact come. This quarts to which of the which of the midh films quarts and freehor expecting than the cottal translation of the slong test films and the slong test films alligned of the slong test films along test films and films patched of the score test for the recount of the second test rocks.

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 striking 8760E, dipping fifty degrees to the south, with a soft gouge containing scattered veinlets of sulphides. The foot-wall side of the vein is a fault striking S870E, or at an angle of eleven degrees with the hanging-wall fault. Along this foot-wall fault are four feet of hard bluish quartz with disseminated pyrite and arsenopyrite. On the out-crop this quartz has a greenish yellow and a black stain. It is reported to carry values in gold. This quartz ends and the fault on its north side fades out as the distance from the principal fault increases, so that it has a rather lenticular shape. From this open-cut the principal fault continues down the center of the steep canyon to the east and is marked chiefly by a gouge. The hanging-wall of the vein next to the principal fault is highly altered and consists mainly of sericite and quartz with some inch-wide black seams of finely divided pyrite.

The next place where some development work has been done is about 150 feet east and 140 feet lower than the open-cut described above. The principal fault in the open-cut at 2700 feet elevation has continued down the center of the campon but is quite weak here and nearly vertical. A twenty-cix feet long tunnel has been driven on a subordinate fault fifteen feet north of the campon and approaching the fault in the campon at a very small angle. Fairly fresh quarts diorite occurs between these two faults. On the south wall of this tunnel, at the portal, there is exposed a flat seam of

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massive sulphides one foot wide. Pyrite is the most abundant mineral, but arsempyrite and sphalerite are also prominent. This seam dips at thirty-five degrees as compared with a dip of seventy-seven degrees for the fault in the tunnel, and appears to be a filling of a diagonal tensional opening in the diorite between the fault in the tunnel and the principal fault in the canyon. Ten feet from the portal of the tunnel the seam approaches the fault in the tunnel and narrows to six inches in width. Some of this heavy sulphide ore has been stock-piled outside the portal and is reported to carry good values in gold.

eighty feet east and fifty feet lower in elevation than the above tunnel. About thirty feet from the portal it encounters a weak fault with about two inches of pyrite along it, and follows it to the west. No larger seams of sulphides were encountered along this fault and 110 feet from the portal the drift was turned sharply to the south and at approximately ten feet from the fault which the drift had been following it encountered a one foot seam of massive sulphides and six inches of brecciated quartz. This is about fifty feet below and thirty feet west of the sulphide seam in the twenty-six foot tunnel described above, and they may be the same.

The canyon which has been following a course along the easily eroded fault mone new leaves the line of the vein and drops down to the Lennox River. Which, if any, of the

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faults exposed by the upper tunnels continues out of the canyon toward the east is not known, but on the timbered slope in line with the upper portion of the vein and 370 feet farther east from these upper tunnels are two old tunnels, now caved. One appears to be a drift and the other a cross-cut which intersect about twenty feet from their portals. No ore was visible on the dumps.

at an elevation of 2210 feet, there is another old tunnel, now partly caved, but which can be entered on hands and knees. It follows along a fault in quartz diorite and reveals six inches of gouge and some disseminated sulphides in the brecciated and altered wall rock. A six inch wide quartz vein dipping at a low angle follows the north wall of the drift for a short distance.

The next exposure along the Lennox vein is in another small canyon which leads up from the Lennox River. Here an open cut blasted out of the east wall of this canyon exposes a strong fault striking N87°S and dipping fifty-two degrees to the south. On the foot-wall side of this fault are twenty-six inches of quartz and some calcite, with the eighteen inches nearest the fault showing considerable brecciation. The six inches of quartz adjacent to the fault contains a considerable amount of sulphides, mostly pyrite and exsenopyrite. The vein exposed in this open cut is said by the present operators to contain values in gold.

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The long cross-cut being driven by the Priestley
Mining and Milling Company intersects the vein at about 1900
feet elevation about two-thirds of the way between the opencut described in the preceding paragraph and the caved tunnel
at elevation 2210 feet. The vein as exposed in the cross-cut
shows strong faulting and considerable quarts and some calcite,
but no massive sulphides. On the west wall of the cross-cut
the vein is twelve feet wide and shows the following detail in
passing from the north or foot-wall side of the vein toward
the hanging-wall side:

- F.W. to 1 Coarse grained massive quartz with some vugs lined with later calcite.
 - 1' to 5' Altered diorite, with much disseminated pyrite and some quarts veinlets.
 - 5° to 6° Inter-grown quartz and calcite.
- At 6* Strong fault striking N90°E and dipping 58 degrees south, with slickensides on which grooves indicate the principal movement was horizontal.
- 6 to 8 Quarts and calcite. Is is cut by the
- At 8: Veinlet one inch wide of pyrite, sphalerite and chalcopyrite along minor fault striking N62°B and dipping 85 degrees south.
- 8 to 12 Altered and breceiated quartz diorite with criss-crossing quartz veinlets containing scattered grains of pyrite and an occasional grain of chalcopyrite and sphalerite. There are some included blocks of fresh quartz diorite.
 - At 12 Fairly definite hanging-wall at a fault having considerable gouge but not as strong as the fault at the six foot point.

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Wall Rock Alteration

The alteration of the quartz diorite is more intense where the faulting has been strengest and not necessarily where metallization has been greatest. The wall rock near the vein in the tunnel at 2510 feet where some massive sulphides are emposed shows a limited alteration. The rock is still hard and black and alteration consists of a partial replacement of the feldspars by calcite, epidote and chlorite. Along a fault in the lower cross-cut about 350 feet from the portal there is a forty foot wide bleached zone in which the quartz diorite has been altered with the production of a rock consisting primarily of quartz and sericite with considerable calcite and some chlorite, pyrite, and hematite. This bleached zone has no ore minerals.

Mineralogy

Among the gangue minerals quartz is the most common but considerable calcite is present. The inter-grown quartz and calcite occurring in the vein where it is cut by the Priestley cross-cut is interesting because of the peculiar graphic pattern produced by later filling in of calcite around well formed quartz crystals (cf Plate 65). The massive yellow stained quartz in the open-cut at 2700 feet elevation has been mentioned. It is also clearly the result of filling, with arsenopyrite and pyrite in the interstices between quartz grains. A few later fractures have been filled with fine grained quartz but brecciation is limited and at least eighty

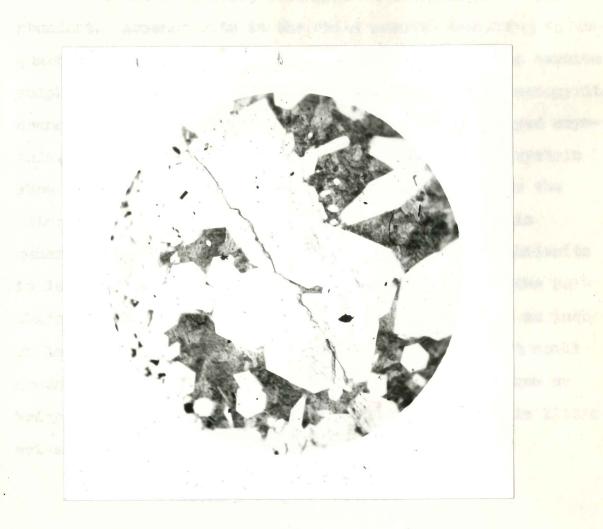
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PLATE 65



Photomicrograph of quarts and calcite stringer from the Lennox vein showing subsdral quarts crystals surrounded by calcite. (Plain light; x 12)

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per cent of the quartz is aclastic.

of the sulphides, arsenopyrite and pyrite are most abundant. Arsenopyrite is the chief mineral occurring in the quartz veins while pyrite is the chief mineral in the massive sulphide seems and in the altered well rock. The arsenopyrite commonly forms exceptionally well formed diamond shaped crystals, with the brachydomes striated. A few of the crystals show twinning. The pyrite often forms small cubes in the altered wall rock, but in the seems of sulphides it is generally massive and often somewhat brecciated. Sphalerite is less abundant than pyrite but usually present in the sulphide seems. It forms in irregular cleavable masses an inch or less across intimately inter-grown with pyrite. A small amount of galena is often present in the sulphide seems as bright gray grains with good cubic cleavage. There is little evidence of replacement of one sulphide by another.

Devil's Canyon Prospect

Location and General Description

about one-half mile northeast of the confluence of the Lennox River and Cougar Creek. The melybdenum deposit follows the course of a steep walled canyon called "Devil's Canyon," and for many years has been known as the Devil's Canyon mine.

Development consists of one tunnel 160 feet in length that has its portal in the side of the canyon at 3200 feet elevation and then curves so that at seventy feet from the portal it

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Of the sulphides, areacopyrite and popular and some enter available. Areacopyrite is the cidef alsoral economics in the massive courts wells prite in the cidef allocal in the massive enteride sense and in the altered well rook. The areacopyrite constit forms assembly well formed dismond shaped orystals. Which the brackydenes statisted. A few of the crystals also the the crystals also brackydenes statisted. A few of the crystals also the the cidef the brackydenes statisted. A few of the crystals also the third profits in the seam of sulphides in the court in the same of sulphide seams. It forms in irregular dismonstration and an inchest of limit cores in the crystal inter-grown with pyrate. A small column of galend is often present in the culphide seams as inches and column of galend is often present in the culphide by another.

Devil's Camon Prospect

This property consists of a group of claims looging

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dress and Cougar Creek. The melybdeman deposit follows the

cotton of a steep walled campon called "Fevil's Campon wile

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The property consists of one thankel 160 feet in length that has

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the corress so that at seventy feet from the portal in

intersects the vein under the center of the canyon and then drifts along it to the southeast for ninety feet.

The deposit consists of a fault zone in Snoqualmie granodicrite, striking approximately N57°W and dipping steeply to the northeast. Some molybdenum mineralization is exposed along the fault at two widely separated points as shown on the map (of Flate 66).

Granodicrite in the vicinity of the property

The Devil's Canyon deposit falls within the area of the Snoqualmie granodicrite, and the rock in the vicinity of the lower tunnel is similar to the granodicrite occurring elsewhere, but somewhat richer in orthoclase. A thin section of a specimen from the northeast wall of the canyon by the portal of the tunnel shows the rock to consist of thirty per cent subhedral grains of oligoclase, twenty-five per cent orthoclase in large anhedral grains, twenty-five per cent quartz, ten per cent subhedral green hornblende, ten per cent of biotite in large plates, and minor amounts of tourmaline and magnetite. Some of the large grains of orthoclase and quartz enclose the earlier plagioclase. Farther up the canyon between the lower and upper mineralized zones the wall rock is light brown in color and contains numerous cavities lined with quarts druses. A few cavities are lined with calcite in a radiating, sheaf-like structure. This light brown rock when examined under the microscope shows the effects of hydrothermal alteration on a normal granodiorite with replacement of the

 $Z \ll$ VEIN Scale: I inch = 100 feet ANYON Consolidated

Molybdenum mineralization

Fault

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amodierite, striiding approximately myos and digains steeply the modierite at the steeply string the mortheast. Some colybdenum stressistion is exposed atom the fine the fact at two widely separated points as shown on the cop (of Plate 66).

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oligoclase and orthoclase by sericite. The orthoclase is almost completely replaced and the plagioclase partly replaced. The original hornblende and biotite is largely altered to chlorite. This light colored rock does not occur as an alteration halo around the vein, but extends off to the northeast for a considerable distance, a similar rock outcropping about one-third mile distant on the trail from Devil's Canyon to Anderson Gap.

Just northeast of the canyon and about two hundred feet in elevation above the trail leading from the cabin to the tunnel portal this altered granodiorite outcrops in a high cliff. This granodlorite contains many veinlets of quartz and numerous cavities filled with quartz druzes, and some lighter quartz rich patches with no apparent continuity. Examination of a thin section of this rock shows it to consist of fifty per cent quartz, thirty per cent sericite, formed from alteration of feldspars, about ten per cent unaltered orthoclase and plagicclase, five per cent biotite and five per cent chlorite. It is probable that some of the quartz was formed as a product of the reaction whereby feldspar was altered to sericite. In some of these quartz druzes the individual quarts crystals are more than an inch across and some interest has been shown in this occurrence as a possible source of optical grade quartz. A talus slope, to the north of this outcrop, which reaches to the trail leading from the cabin to the tunnel is composed largely of this light colored

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The association of tournaline with metallization at several localities throughout the area, such as at the Quartz Creek and Jack Pot properties suggests that the occurrence of molybdonum can be genetically associated with this area of sericitized granodicrite with its relatively high tournaline content.

Structure

The faulting in the canyon corresponds with the regional strike of the most important jointing in this part of the Snoqualmie granodicrite. The fault zone is more easily eroded than the surrounding rock due to breeciation and alteration which has occurred along it, so that it forms the course of a small stream. The action of running water in the spring and summer and freezing and thawing at the margins of the snow which lies in the canyon in winter has formed a canyon with a very steep and step-like profile (of Flate 67), and in places nearly vertical walls. Ropes have been placed by the owners at two locations to aid in climbing the steep canyon.

The fault zone follows the floor of this canyon and is exposed in some places and covered by fallen rock in other places. Over part of its length the faulting is concentrated in a one-foot wide zone marked by gouge and brecciated wall rock. At a point about mid-way along the deposit another parallel fault to the northeest of the main fault appears and

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ONGITUDINAL mineralization

causes a branching of the canyon at this point, with a fault in each branch. These faults dip toward each other and would undoubtedly come together a short distance below the surface.

as seen on the map (Plate 66), the mineralized portions of the fault zone have a strike of approximately N65°W while the fault zone in between these zones strikes throughout most of its length N57°W. It is possible this slight change of direction of the fault zone has resulted in the openings which have been filled with quartz.

Mineralization

The lower mineralized zone is much smaller than the upper zone. It is exposed where the tunnel intersects the fault zone after traversing through massive and fairly fresh granodicrite from the portal in the northeast wall of the canyon. Here the fault zone is dipping eighty degrees to the northeast and consists of a fault on the foot-wall or northeast side with five inches of gouge containing fragments of quartz with scattered molybdenite flakes, and also some black streaks of finely divided molybdenite. Next to the gouge is twenty-two inches of brecciated granodiorite followed by another fault on the hanging-wall side with a small amount of gouge. It is estimated that the five inches of gouge would average about three per cent molybdenum. At fifty feet east of where the turnel first intersects the vein the gouge containing molybdenite is two inches wide. Near the face of the tunnel no molybdenum mineralization is present. A "Minerabluce has redo does heaved did to sale and would also at the sale of the sale

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light" reveals the presence of some tungsten in the form of scheelite-powellite along with the molybdenite in the gouge.

The upper mineralized zone is four hundred feet higher in elevation and about six hundred feet east of the lower zone. It is exposed in the floor of the canyon for a distance of approximately two hundred feet. Mid-way along this length the vein is vertical and strikes N650w. Starting at the south wall of the canyon the vein shows eight inches of quartz containing flakes of molybdenite, then eight inches of brecciated and altered reddish colored granedicrite, three inches of quartz containing about ten per cent molybdenite, three inches of gouge, two inches of quartz with some molybdenite, and finally eight inches of gouge, with reddish colored and altered granodicrite on the north side of the vein. Along the vein to the northwest the quartz stringers spread out gradually and finally die out. To the southeast the walls of the vein gradually converge and the amount of quartz and molybdenite decreases. One hundred feet southeast of the section described above the vein has narrowed appreciably and the canyon floor rises vertically for a considerable height and the mineralization has not been followed on the surface beyond this point.

Molybdenite is the only conspicuous ore mineral. In the quarts stringers it appears as foliated grains, usually one-eighth to one inch in size (of Plate 68). Occasionally the molybdenite occurs along fractures in even larger plates and there are reports of plates many inches long having been taken from the upper mineralized section. to creat and at majorage case to compared oil alcover their

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Thotograph of quartz containing large flakes of molybdenite from upper mineralized zone of Devil's Canyon prospect.

The quarts is coarsely granular and appears to be largely the result of filling. In thin section the molybdenite can be seen to occur between the quarts grains and along fractures in the quarts. The vein has suffered from some recurrent fracturing and locally the molybdenite is strung out in elongated streaks of the pulverised mineral. Some scheelites powellite occurs in the quarts with the molybdenite. It is nearly white in color and very hard to locate without an ultraviolet light.

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Langer and Rainbow Claims

Along the Lennox River above the Lennox mine the Snoqualmie granodicrite is in contact with tuffaceous sediments and argillites and graywackes of the Calligan formation. These sedimentary rocks are metamorphosed to fine grained hornfelses and coarser biotite quarts granulites, including some with red garmets. At some spots within these metamorphosed rocks are veins of sulphides. These sulphide veins have a strike similar to that of the other veins within the map area but the faulting associated with the veins in the granodicrite is not present in these deposits. Quarts is absent and the metallization is quite variable within short distances. There is no noticeable low temperature alteration of the wall rock, which, together with the association of the sulphides with garnet zones near the contact, is taken as evidence that the temperatures at the time of vein formation were high.

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about one and one-half miles above its confluence with the North Fork of the Snequalmic River. A seem of sulphides outcrops in a low cliff of metamorphosed sediments just north of the Lennor River mine to market road. This seem is about four inches wide and consists chiefly of very dark brown sphalerite, but there is some chalcopyrite and pyrrhotite. The owners have built a camp and started a tunnel at the foot of the cliff to prospect this showing of sulphides. This four inch wide seem of sphalerite does not extend down to the tunnel level twenty feet below, but some scattered chalcopyrite occurs along with some garnet in the metamorphosed rocks in the portal of the tunnel. About twenty feet from the portal the face of the tunnel is now in Snequalmic granedicrite. No faulting is present.

Lennox River from the Langer tunnel. A seam of sulphides is exposed at 2460 feet elevation in a small canyon leading south from the river. The seam varies in width from one to six inches where exposed, and is not accompanied by visible faulting. The chief sulphide is pyrrhotite, with some chalcopyrite, and, according to one of the owners, Edwin Sauers, a spectrograph showed a trace of tim. The vein strikes N83°E which almost puts it in line with the sulphide seam on the Langer claims. The well rocks are highly metamorphosed argilatics and light colored tuffaceous sediments with a very

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observed on the Rainbow claim were observed in a canyon south of Sunday Lake. The pyrrhotite-chalcopyrite seams were found in pieces of dark colored fine grained hornfels. This canyon cuts across the contact between the granodicrite and the Calligan formation. Similar pyrrhotite-chalcopyrite seams, but contained in fine grained quarts dicrites, occur in the bed of Quartz Creek a mile above the Taylor River.

Quartz Creek Copper Deposits

General, features

of Quarts Greek below the Quarts Greek logging road about three-fourths mile from the Taylor River. The rocks in this vicinity are mostly quarts diorites of the Quarts Greek Complex. A quarts diorite of fairly uniformly medium grain size starts at the first switchback in the Quarts Greek Road and extends westward up Quarts Greek for at least a mile. Within a distance of 800 feet within this quarts diorite are several outcrops containing copper sulphides (of Plate 69). The min-eralisation is peculiar in that the association of minerals is different at the different exposures.

The greatest amount of prospecting has been done on a body of iron pyrite with some chalcopyrite and bornite which outcrops in a low cliff just above Quartz Creek in Section 16,

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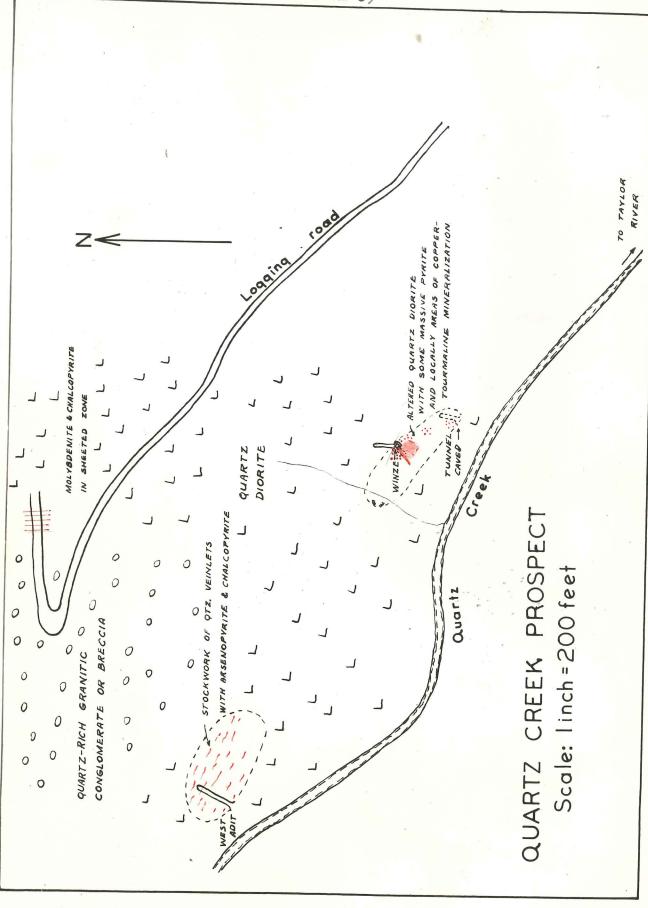
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Township 24 North, Range 10 East. A prospecting adit has been driven for a distance of fifty feet into this cliff. Just inside the portal of this adit a winze has been sunk to a depth of about forty feet, but the winze is filled with water. The material on the dump which probably came from this winze is estimated to carry two and one-half per cent copper, prin-cipally as chalcopyrite.

About 800 feet west from the above outcrop a stockwork of crise-crossing quarts veinlets and lenses in fine to medium grained quarts diorite outcrops at several places over an area of roughly 100 by 200 feet. The area is in heavy timber and outcrops are few. About 100 feet from the bank of Quarts Creek an eighty foot adit bearing N37°S has been driven to cross-out this stockwork at a depth of about forty feet. The chief sulphides are arsenopyrite and chalcopyrite.

The third cutorop of interest occurs at the first switch-back in the Quartz Creek logging road. In blasting the road out there was exposed some fine grained quartz diorite with a zone about forty feet wide through which closely spaced fractures striking nearly north-south are lined with quartz, pyrite, chalcopyrite, argencepyrite and some molybdenite and schoolite.

Mineralogy and structure at the winze adit

In an area at least 200 feet long and at least forty
feet wide around the winze adit the quartz diorite has been
irregularly altered to a light colored aggregate of quartz and

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There are places within this altered zone where the quartz diorite is quite fresh so that it appears that the alteration is controlled by the presence of brecelation and faulting. On the east wall of an opencut leading to the portal of this adit there is exposed an irregular shaped outcrop of massive pyrite about thirty feet in diameter. This pyrite has formed by replacement of the wall rock and relics of quartz and sericite and partially altered quartz diorite are contained in it. The only megascopically visible evidence of copper in this massive pyrite is a thin coating of a blue mineral, probably covellite, on some fractures in the pyrite.

On the west wall of the opencut is a seam about one foot wide in the massive pyrite which contains considerable copper, partly as chalcopyrite and partly as bornite and covellite. The bornite and covellite appear to be secondary. This seam and also some pieces of ore on the dump which apparently came from the winze contain some white to light grayish green colored crystals up to two inches across. These crystals are completely altered to sericite and a lesser amount of chlorite. A continuous x-ray spectrum on one of these crystals showed no trace of any constituents other than sericite and chlorite. The crystals, which are exceptionally well formed, are elongated and usually asterated due to penetration twins of two triangular shaped prisms such as tournaline. The crystals usually pull free from the sulphides rather easily and reveal

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the impression of their crystal outline on the surrounding partly pyrite and chalcopyrite. The crystals are commonly partly replaced by chalcopyrite. This seem of copper sulphides fades out near the portal of the adit and appears to be striking out near the portal of the adit and appears to be striking almost perpendicular to the general trend of the brecciated and altered some.

On the west wall of the adit opposite the winze are ten feet of quarts and sericite containing disceminated pyrite and black needles of tournaline, and also about two and onehalf per cent copper in the form of chalcopyrite partly altered to bornite. The form of this mineralization is very irregular and shows no inclination to follow any particular direction. The adit continues beyond the area of copper mineralization on which the winze has been sunk, but beyond the winze it shows only a stockwork of small quarts veinlets in the quartz diorite with traces of chalcopyrite but with little alteration and no tourmaline. Assuming that the esterated six pointed prisms were tourmaline it appears that the strongest copper mineralization is at places where tournaline is present. This association of copper with tournaline has been described from numerous places in North and South America. They represent deposits formed at fairly high temperatures although in this case the fact that part of the tourmaline is completely altered to sericite and chlorite indicates temperatures dropped during the later stages territing about revenuenting to a passer of this fragment quarte of the mineralization. Allerents An hair while is become an benefit to be be better exercit tolores when

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Mineralogy at the west adit

At the adit 800 feet west of the winze adit the alteration of the quartz diorite is much less intense. The quartz veinlets of the stockwork out fresh appearing quartz diorite and no tourmaline was observed. A small amount of chalcopyrite is disseminated through most of the quarts diorite near the adit. The most conspicuous sulphide is arsenopyrite which occurs in the quartz veinlets, sometimes in fairly coarse grains up to one inch in size. Associated with the arsenopyrite in the veinlets is some chalcopyrite, and polished sections of the arsenopyrite show the chalcopyrite to be later and to be replacing the argenopyrite along fractures. A small amount of molybdonite was also observed associated with chalcopyrite. Although the quartz veinlets are slightly more numerous and they contain more sulphides in the twenty feet near the face of the adit there is no local concentration of chalcopyrite such as observed in the winne adit. Also the low temperature alteration and the development of secondary copper sulphides are not apparent here.

Mineralogy at the road out outcrop

tained in a fine grained dark gray rock of quartz dioritic composition. This rock over a width of about forty feet has been fractured so that it has developed a sort of sheeting striking about north-south. If a piece of this fractured quartz diorite is hit with a harmer it tends to break apart along the

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fracture planes and the surfaces are lined with small grains of chalcopyrite, molybdenite, and arsenopyrite. Hany of the fractures have small quarts veinlets less than an inch wide and these quarts veinlets sometimes contain larger flakes of molybdenite up to one-half inch across. Some scheelite was also observed.

A thin section of the quartz diorite from near one of the quartz veinlots shows the quartz diorite to have been fractured and recrystallized. Buch of the feldspar has been altered to sericite, with the release of some quartz. Chlorite is scattered through the more altered parts of the rock, while the less altered parts show considerable reddish brown biotite.

Immediately west of this outcrop along the road is an outcrop of the granitic conglomerate described in connection with the Quartz Creek Complex.

Structural features

This is not a simple vein or fault zone but appears
to be an irregular shaped replacement deposit in a brecciated
zone. The deposit is in an area of considerable timber and
overburden and the true outline of the deposit is in doubt.
However, the strikes of some minor fractures in the winse adit
and the adit to the west are along a general east-west direction. The outcrop at the bend in the Quartz Creek logging
road shows the small mineralized fractures striking about
north-south. Thus this latter outcrop and the east-west
striking zone including the two other outcrops form a triangle

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around the nose of the outerop of granitic conglomerate. It appears that the brecciation in the granitic conglomerate (of above) and the fracturing in the quartz diorite in which most of the mineralization occurs took place at the same time and the concentration of copper sulphides in the quartz diorite is mainly due to the ability of this fairly uniformly textured quartz diorite to maintain open fractures through which the ore solutions could move.

As the copper mineralization as exposed in the winze adit appears to be localized in part by minor faults and fractures which cut across the general trend of the outcrop pattern it is likely the ore shoots will not be tabular in shape but will tend toward an irregular pipe- or lens-shaped body. It is also probable the copper mineralization will stay rather close to the semi-circular area around the granitic conglomerate where the outcrops described above occur.

Geology as an Aid to Prospecting

hard, brittle rocks are more common as wall rocks
because they could support more open fractures. This accounts
for the fact that almost all of the veins are in such rocks as
granodicrite and quarts diorite. Only small amounts of metallisation are found in the hornfelses and these are higher
temperature veins with pyrzhotite. There is little evidence
in them of any original fracturing and they lack the regularity
of the veins in the more brittle rocks.

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The veins in the granodiorite are closely related to the strongest joint system and in some instances the veins appear to be mineralized joints. Since the intersection of two faults, or the intersection of a fault and a joint, or small tensional fractures between two shears were more apt to be open than simple fractures they provided better access to the ore bearing solutions and thus we find such places as favorable spots for the localization of ore shoots. In some cases a slight change in direction of a fault appears to have resulted in an open space which was filled by later vein material as in the case of the Devil's Canyon prospect. In the cases where the ore shoots are localised by the intersection of fractures the pitch of the ore shoot will be determined by the dip and strike of the two fault planes and the resulting direction of their intersection, which usually will not be vertical.

alteration of the wall rock has in many cases been earlier than the metalization and therefore somes of sericitization and pyritisation, while often showy looking, do not mecessarily surround ore shoots. Some wide somes of alteration are barren while some seams of ore have relatively slightly altered walls.

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 Horace Lloyd Bethel, son of Joseph and Ruth Bethel, was born October 29, 1916 at Tacoma, Washington. He attended grammar, intermediate, and high schools at Tacoma, Washington and graduated from Educoln High School in 1934. He matriculated at the University of Washington and graduated in 1939 with a bachelor of science degree in mining engineering.

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