A GOLD - SPECULARITE DEPOSIT,

UNUK RIVER, B.C.

A Thesis submitted in partial fulfilment of the requirements for the degree of Master of Applied Science in the Department of Geology and Geography,

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ABSTRACT

On the Gracey group of claims, Unuk River, B.C., are mesothermal-type quartz veins; (1) with specularite-gold mineralization, (2) with galena-pyrite-gold mineralization, and (3) with chalcopyrite-pyrite mineralization containing no precious metals. The veins outcrop in a band of Late Palaeozoic(?) andesite tuff, siltstone, argillite, and limestone bordered on the northeast and southwest by Triassic(?) diorite gneiss sills. The main body of Coast Range intrusives outcrops five miles southwest of the property, but several stocks are exposed about five miles east of the property.

The regional-type metamorphism, and most of the folding and faulting of the bedded rocks on the property have been caused by orogeny associated with the Coast Range intrusives; but some recrystallization of andesite-tuff can be attributed to thermal metamorphism produced by the adjacent diorite-gneiss sills. The vein-forming fluids are probably derived from Coast Range intrusive rather than the local sills.

In the quartz-galena-pyrite veins anhedral gold fragments are associated with three soft minerals, possibly tellurides, which form inclusions in the galena. In the quartz-specularite-gold veins the gold has been deposited in disruptions between specularite 'cleavage' plates. Both classes of veins contain minor amounts of gold in or near fractures in the quartz.

No veins contain both abundant specularite and abundant sulfides. The specularite probably has been deposited earlier than the sulfides but in the same period of mineralization. Specularite does not necessarily indicate hypothermal deposition, but it is usually one of the first minerals deposited from hydrothermal solutions. It is formed only under oxidizing conditions, and if exposed to later sulfide-bearing, and thus reducing, solutions, it tends to be reduced to magnetite or an iron-bearing sulfide.

ACKNOWLEDGEMENTS

Field work on the Gracey group was supervised by Dr. D.F. Kidd of Leitch Gold Mines, and much credit is due him for his sound advice on some of the field problems. The writer is indebted to Dr. H.C. Gunning and Dr. K. DeP. Watson for assistance and guidance in the laboratory work. Dr. R.M. Thompson gave many helpful suggestions on mineralogical problems. J.A. Donnan gave advice on preparation of thin and polished sections.

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INTRODUCTION

In the 1946 field season, Thomas McQuillan and Pat Onhasy, prospecting for Leitch Gold Mines, staked the Gracey group of claims on the 'South Fork' of the Unuk River. Of the eight quartz veins sampled there by the prospectors, five gave assays above one-half ounce in gold. Four of these high assays were from samples taken across mineable widths. The writer was in charge of open cutting and intensive prospecting on the Gracey group during the 1947 field season.

The five veins giving high assays were named after the prospectors' sample numbers. (Map No. 3.) Q-17 vein has been traced for four hundred feet, and averages five feet wide. At the west end the quartz pinches out but mineralized shearing continues. Thirty feet farther west quartz has again been deposited, forming Q-17 west vein. This vein averages seven feet wide, and has been traced two hundred feet to the west, where it is covered by deep glacial drift. Q-22 vein is the probable faulted eastern extension of Q-17 vein. Q-22 vein has been traced one thousand feet, to where it becomes only eight to ten inches wide and assays only traces in gold. It is suspected that Q-18 sample was cut from a large boulder of float. Float is abundant in the area where the sample was taken, but no vein was found in place, although the prospector searched for it himself. Q-19 vein was traced for seven hundred feet, but only one small possible ore shoot was delineated. Q-24 vein is not of mineable width, and is too irregular to warrant surface development under present conditions. Three additional veins, of which at least one (Q-25) warrants further development, were found.

In the latter part of August geological mapping of the major showings on a scale of two hundred feet to one inch was commenced. Inclement weather forced cessation of work in early September, but further exploration, including diamond drilling and geological mapping, will be continued in the 1948 field season.

Looking east up the valley of the
South Fork which heads in a tongue
of the Frankmackie glacier.

Geological breaks show up in
the late snow.

Outcrop of Q-17 vein.

Stripping Q-22 vein. July 4.

PURPOSE OF THESIS

To descfibe the location, accessibility, topography, climate, history, and geology of the region; and more particularly to

1. determine the age of the rocks by structural and lithological correlation of the geology with that of nearby areas.

2. determine the host rock of the veins, and the reasons for its susceptibility to mineralization.

3. analyse the structure of the region as a guide to further prospecting and development.

4. determine the probable source of mineralizing fluids.

5. determine the mineral or minerals associated with gold in the veins as a guide to further development.

6. determine the size of gold particles in the 'ore', and its association with fracturing, to indicate size of grinding necessary for milling.

7. determine the significance of specularite in the quartz veins, and its association with the other metallic minerals.

GRACEY GROUP. - Gracey Creek in background; South Fork in valley on the lower right; Gracey claims are right center.

METHOD OF INVESTIGATION

Geological mapping could not be done to best advantage until August, when most of the ground was free of snow. A claim map was made in July, using a Brunton compass and chain. This map was drawn at 500 feet to the inch. The accuracy of the surveying was about one in a thousand. Notes of the survey were kept.

When geological mapping was started each claim was drawn at 200 ft. to the inch on a separate sheet. The claims were then geologically mapped one at a time using Brunton compass and chain, as no plane table was available. Traverses were run north-east and south-west, in order to follow the trend of the outcrops. The claim posts were used for 'tie-in' points. The surveyor's helper kept notes of the survey, including topography, and the surveyor kept notes of the geology. After each five chains (500 ft.), the topography and geology were plotted on the claim sheet. A claim was mapped in about two days. The geological maps of all the claims were compiled in one map (Map No.3 in back pocket).

Rock specimens collected during mapping were labelled numerically; and the number put on the map to show where each specimen was collected. A suite of specimens was collected from the wall of Q-17 vein; specimens being taken at 8 ft., 4 ft., 3 ft., 2 ft., 1½ ft., and ½ ft. from the vein, and, as closely as could be determined, from the same bed. Lack of outcrop made it difficult to obtain other suites of altered wall rock. Specimens of 'ore' were collected from each important vein.

Thin sections were made of each of the sixty rock specimens collected, and of the 'ore' from several of the important veins. Polished sections were made of the 'ore' from each important vein. The descriptions of all sections were kept on indexed cards to facilitate reference.

Literature was searched for information on the geology of the Unuk and surrounding areas, and for information on the significance of the specularite in the quartz veins.

The geological sketch map of the Unuk by J.T. Mandy (Bibl. No. 10) has been reproduced on a larger scale (Map No. 2 back pocket). This map, with maps of Portland Canal (Bibl. No. 5), Iskut (Bibl. No. 13) and Southeastern Alaska (Bibl. No. 4) have been compiled (Map No. 1 back pocket).

Supplies dropping at campsite
from plane flying at two
hundred feet.

Boxes of dynamite dropped
from plane at camp on
South Fork.

GRACEY GROUP - LOCATION AND ACCESSIBILITY

The Gracey group is on the South Fork of the Unuk River, twenty-eight miles north-west of Premier, B.C. (see map No.1).

The natural route to the property is by the Unuk River, which drains into the Pacific at Burroughs Bay, Alaska, sixty miles north of Ketchikan. A wagon road was constructed from Burroughs Bay to the international boundary twenty-five miles upriver, and six miles beyond, in 1903, but has since fallen into disrepair. However, Boundary Lake, on the international boundary, is accessible to small aircraft. A good walking trail has been maintained upriver from Boundary Lake to La Brant Creek on the South Fork. A trail from La Brant Creek to the Gracey group was started but not completed in 1947. The trip from Boundary Lake to the Gracey group takes two days, but cabins at Glacier Creek and the mouth of the South Fork provide good overnight accommodation.

An alternate route is from Premier, B.C. to Big Missouri by road, and thence to Tide Lake by pack trail. From Tide Lake to South Fork no trail exists, but Frankmackie glacier affords a good grade over the summit to Cabin Creek on the South Fork. (See plate No. 1). This route is used only by experienced mountaineers.

Fragile equipment was back-packed to the camp from Boundary Lake. The bulk of supplies was well trussed into about seventy-five pound bundles and dumped into the snow

Glacier pass from South Fork to Bowser-Salmon valley.

PLATE NO. 1

from a low-flying plane based at Ketchikan. Recovery of dropped supplies was well above ninety percent.

TOPOGRAPHY

The topography of the Unuk is typical of the northern Coast Range. Maximum relief is seven thousand feet. Valley walls in most places are scalable. Above timberline at thirty-five hundred feet, heather slopes pass upward into domed rock ridges, or, in the higher mountains, rough serrated peaks cut by glaciers. (See plate No. 2). Tongues of glacier extend from the main ice fields into the heads of the valleys; and the main valleys exhibit the 'U' shape characteristic of glaciation.

Plate No. 3 shows the headwaters of the Unuk (also see Map No. 2). Gracey Creek in the right foreground occupies a long straight glaciated valley trending north-easterly. Two miles below its junction with the South Fork, La Brant Creek enters from the north, and the valley swings north-westerly to its confluence with the valley of Ketchum Creek and the main Unuk River. The main Unuk River is considered to be the river below the junction of Ketchum and Sulfide Creeks. It flows south-westerly, and is joindd by many tributary streams before flowing into Burroughs Bay.

All tributaries are laden with glacial silt, much of which is deposited in the lower reaches of the river. The lower river consists of many reticulating and constantly

Looking eastward from the glaciated
coast range towards the interior plateau.

PLATE NO. 2

McQuillan Ridge and the headwaters
of the Unuk.

PLATE NO. 3

changing channels, except where it plunges through four narrow canyons. It has been navigated with flat-bottomed river boats, but only at the expense of almost continuous lining.

CLIMATE

The climate is similar to that of Portland Canal area. Although no records of precipitation are available, it is estimated that winter snowfall would reach twenty feet at the property. Patches of snow from one season linger until joined by fresh snow of the next season. Above four thousand feet elevation snow flurries can be expected at any time during the summer. The abundance of snow prohibits geological mapping until late in the summer, and incessant rainfall makes it difficult even then.

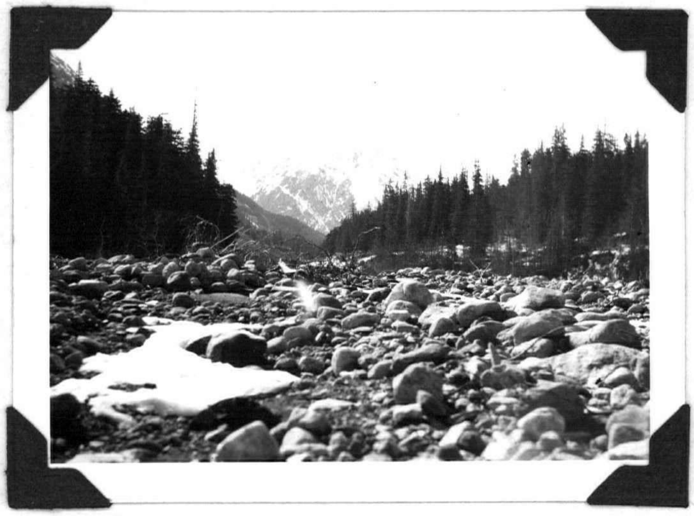
HISTORY

The first active prospecting of the Unuk was done in the eighteen nineties; but was mainly for placer on Sulfarets Creek. The Cumberland property, on Sulfarets Creek, was staked for lode gold and silver about 1900 but has never been developed. The aforementioned wagon road was built to service this property. The Globe property, near the headwaters of the South Fork, was also staked about 1900. Though a stamp mill was erected, no gold was produced.

After the death on the trail in 1903 of Ketchum, the owner of the Globe, interest in the Globe and the Unuk in

Globe glacier in June (above)
and in September (below).

Mount Pearson at the
headwaters of the South Fork.



Rough valley bottom near
head of South Fork.

Valley-bottom beaver swamps.

Campsite at timberline
on the Gracey Claims.

Plane landing on Boundary Lake at
the British Columbia-Alaska boundary to
take the crew out in September.

Looking downriver (south) from McQuillan's
cabin at the junction of the South
Fork with the main Unuk.

general waned until the nineteen thirties, when prospectors from Portland Canal entered the region. In 1933 and 1934 Premier interests diamond drilled and made open cuts on a group of claims staked in 1932 on Prout Plateau. In 1946 Canadian Exploration further developed the showings on these claims.

GENERAL GEOLOGY

Very little geology has been done in the Unuk. The only geological map is a sketch (Map No. 2 in back pocket) made in 1935 by Dr. J.T. Mandy of the British Columbia Department of Mines. A brief report (Bibl. No. 10) accompanies this map. It was compiled after a ten-day reconnaissance trip, during which Dr. Mandy had the advice and guidance of several of the 'old-time' prospectors. Dr. Mandy had previously visited Prout Plateau (Bibl. No. 11). He states 'The sedimentary and volcanic rocks composing Prout Plateau are similar in extent and character and may possibly be correlated with the Upper Bear River series of Jurassic age. In places the exposures of this series may possibly approach the younger Nass series horizon.' F.E. Wright published a short report on the Unuk in 1905 (Bibl. No. 8).

In an endeavor to determine the age of the formations in the Unuk by structural and lithological correlation, maps from nearby areas have been compiled in Map No. 1 (in back pocket). These include

1). The Iskut River Area, by F.A. Kerr of the Geological

Survey of Canada. (Bibl. No. 13.)

2). The Portland Canal Area by G. Hansen of the Geological Survey of Canada. (Bibl. No. 5.)

3). Southeastern Alaska, by A.E. Buddington and Theodore Chapin of the United States Geological Survey. (Bibl. No. 4.)

Structural Correlation - Intrusives.

The Coast Range intrusives run northwesterly through the correlated areas. The eastern contact of the intrusives approximately follows the international boundary; but contacts are irregular, with many satellites on both flanks. The intrusives show considerable heterogenity. Buddington reports granodiorite, quartz monzonite, quartz diorite, hornblende biotite diorite, monzonite, hornblendite, and gabbro from sections along Portland Canal and Chickamin river. Kerr reports diorite, orthoclase porphyry, and syenite, as well as most of the facies mentioned by Buddington, from the Iskut and Stikine sections.

The age of the intrusives is given by Kerr as Triassic to Lower Cretaceous, and by Buddington as Upper Jurassic to Lower Cretaceous. The descriptions of the Triassic intrusives given by Kerr (Bibl. No. 1) indicate they are very similar to the diorite gneiss 'sills' on the Gracey group.

Structural Correlation - Sedimentary and Volcanic Rocks.

The regional trend of the pre-intrusive sedimentary and volcanic rocks is north to northwest, parallel that of the intrusives. This trend is particularly marked on the western flank. Correlation of sediments and volcanics of the Unuk area on the east flank with those of Southeastern Alaska on the west flank is difficult because of the intervening intrusives.

Of the Iskut area Kerr states "the structure is extremely complex; intense unsystematic folding and faulting are present everywhere so that the boundaries between formations are not well defined and can be indicated only in a general way." (Bibl. No. 1, p. 48). Structural correlation with the Unuk is thus well nigh impossible.

In Portland Canal the structural trend of the Hazelton group is generally north to northwest. This trend, if continued, would bring Hazelton group rocks through at least the eastern part of the Unuk drainage basin. Mandy's observations in the Unuk indicate a northerly trend to the sedimentary and volcanic rocks, and thus substantiate correlation with Portland Canal.

<u>Lithological Correlation.</u>

Mandy has mapped three main types of pre-intrusive bedded rock in the Unuk; limestone, argillaceous sediments, and volcanics with associated hypabyssals.

The limestone is white to grey in color, and highly recrystallized. Sections of well over one thousand feet are predominantly limestone, but folding or flowage may give repetition or exaggeration of the true thickness. The limestone in the Iskut are thirty miles to the north-west is similar in extent and character, and has been called 'fairly definitely Permian' in age. Limestone is known in the Hazelton group of Portland Canal, but occurs only in a few lenses of several feet thickness. In Southeastern Alaska limestone occurs in sections hundreds of feet in thickness in Palaeozoic rocks, but only in thin lenses in Mesozoic rocks. The limestone of the Unuk River area is thus probably Palaeozoic and likely Permian.

A mile or two to the west of the limestone band the sedimentary and volcanic rocks are metamorphosed to phyllites, slates, and schists. To the east they have undergone little metamorphism; the sediments are well bedded and the volcanics massive. The metamorphism to the west may be attributed to the greater age of these rocks, or to proximity to the main body of Coast Range intrusives. However, metamorphism is not intense in sedimentary and volcanic rocks that are in contact with Coast Range intrusives in Portland Canal. The metamorphism of the Unuk rocks west of the limestone is then more likely due to the fact that they are of greater age, and have undergone more diastrophism than those on the east of the limestone.

On the east of the limestone band, and on Prout Plateau, the sedimentary rocks are well bedded argillites, sandstones, and fine conglomerates, and the volcanic rocks are massive green andesites. The assemblage, as stated by Dr. Mandy, (Bibl. No. 11) closely resembles the Bear River and Nass formations of the Hazelton group in Portland Canal.

The structural and lithological correlation suggests that the Unuk limestone is Permian, the sedimentary and volcanic rocks to the east are Hazelton group (Jurassic?) and those to the west are Pre-Permian. No fossils were found in the limestone and it is doubtful if determinable fossils will be found in the limestone or the rocks to the west because of the metamorphism.

Mineralization.

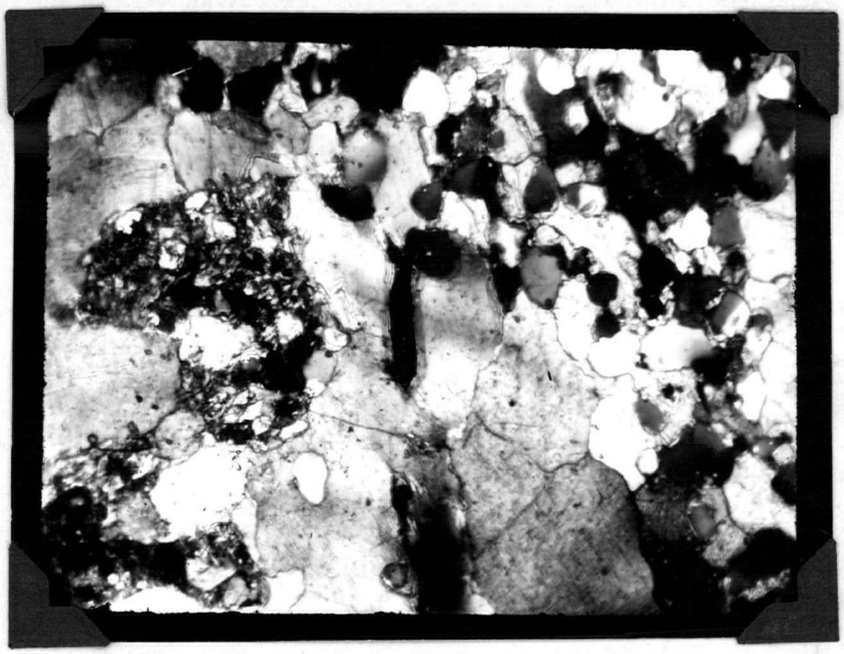
Rock exposed on the west flank of the Coast Range intrusives has undergone metamorphism of a higher grade than rock exposed on the east flank. Gneisses and schists cut by pegmatite dykes predominate on the west, indicating a deeper-seated type of metamorphism than on the east where argillites and slates predominate. Erosion has cut down to the zone of flowage on the west, and the rocks exposed now were probably at a high temperature during the period of mineralization and thus not affected markedly by mineralizing fluids. On the other hand, the rocks on the east would fracture rather than flow, and the mineralizing fluids would encounter new conditions of temperature and pressure, and deposit much of their load. Mineralization is not pronounced on the western flank of the intrusives, but on the eastern flank contact metamorphic deposits and mineralized veins are relatively abundant.

LOCAL GEOLOGY

The Gracey Group is on the mountain between Gracey Creek and the South Fork (see Plate No. 3 and map No. 2). This mountain is composed of limestone, tuff, siltstone, argillite, and diorite gneiss. The sediments, including tuff, trend north-westerly, and dip 40 to 60 degrees northeast. They grade into one another, and are in places intimately inter-bedded, indicating practically simultaneous deposition during some periods. The abundance of limestone shows marine deposition. The beds of the clastics range from a fraction of an inch to several feet in thickness. The main band of limestone has an apparent thickness of well over one thousand feet. The sediments are intruded by diorite gneiss stocks and sill like bodies, and aplite, lamprophyre, and syenite dykes.

The mountain as a whole has not been mapped geologically, but an outcrop map was made covering the most important mineral showings (Map No. 3). The most important veins lie in a thousand-foot-wide sedimentary belt trending northwesterly. The belt is bounded on the north-east and south-west by sill like bodies of diorite gneiss. The 'lower sill', on the northeast, is about three hundred feet wide and has been traced for three thousand feet. The 'upper sill', on the southwest, is more irregular and not as well delineated, but is estimated to be several hundred to one thousand feet wide. Veins occur in the sediments outside the sills, but, though similar in mineralization and attitude, have shown neither the widths nor the gold content of the veins in the central band of sediments.

In some parts of the mapped area the sediments show close folding and crenulation. The tuffs have in places been recrystallized to a fine-grained gneiss. The gneissic structure strikes northwest, parallel to the strike of the beds and the axes of the folds. To the west high angle shearing with a westerly strike is widespread. Discontinuous shears are abundant throughout most of the mapped area. No major faults were proven, but one of about one thousand feet horizontal offset, striking northerly, may occur west of Ptarmigan Hill.



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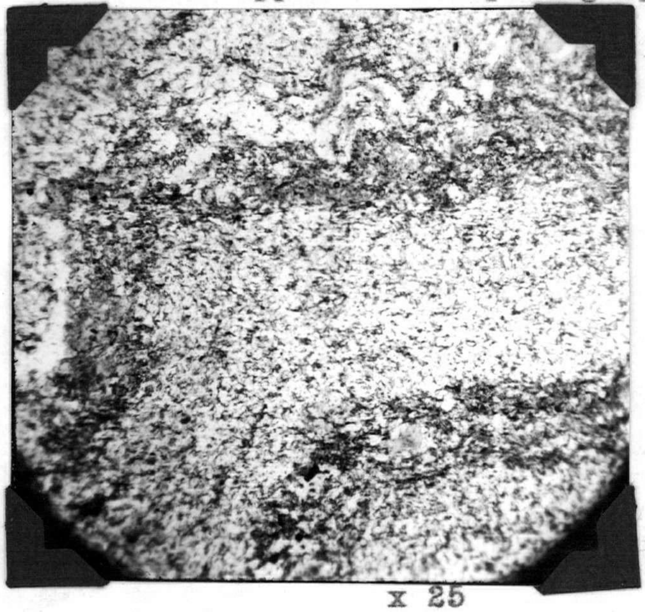
THIN SECTION PHOTOGRAPH NO. 1

Quartz and calcite have recrystallized side by side, without formation of silicates. Sericite is also present.

(see Appendix for photographic data.)



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THIN SECTION PHOTOGRAPH NO. 2

Near the contact with intrusive gneiss the fine laminae in the sediments are crenulated. Minerals are quartz, chlorite and sericite.

ROCK TYPES

Limestone.

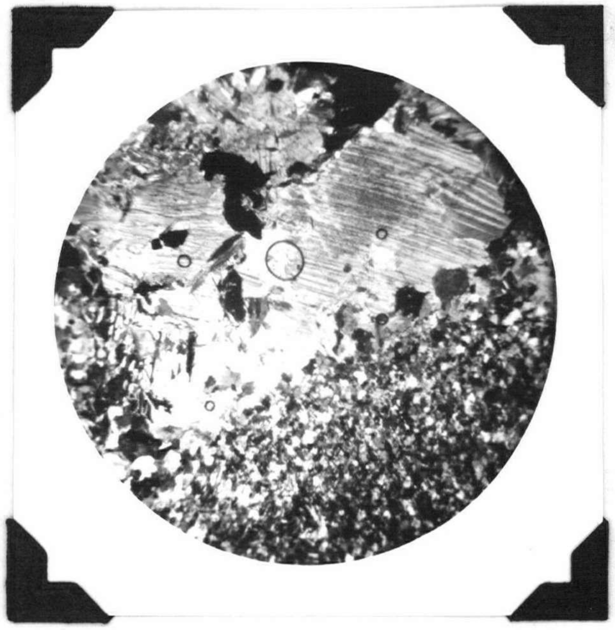
The main band of limestone lies northeast of the lower sill, outside the mapped area, but a few beds lie in the central band of sediments. All the limestone is highly recrystallized. Thin sections show an interlocking mosaic of grains up to three mm. in diameter. Many grains show strong twin-gliding. Chemical tests prove a trace of magnesium in the limestone.

Knobby protrusions up to one foot in diameter have formed from differential erosion where the limestone contains quartz. The alignment of these protrusions is parallel to the contacts of the bed and this alignment could be caused by flowage of the limestone, or may be indicative of the original bedding, or both. The quartz grains in the knobs range from .05 to .15 mm. in diameter. The larger grains are strongly fractured, strain shadowed, sutured, and intergrown. Isolated quartz grains in the limestone are of smaller average size, about .05 mm. and are strongly strain shadowed.

The quartz in the limestone could have originated as wind blown silt, water transported silt, or chert nodules. If wind or water transported, the quartz would possibly be accompanied by feldspars and/or sericite. A little sericite does occur with quartz in the limestone. Chert nodules, on recrystallization would have quartz grains of considerable size variation.

The grains here show a markedly small variation in size (.05 to .15 mm.) in spite of the recrystallization they have undergone. No beds of chert have been found in the area, but beds of siltstone, in places composed almost entirely of quartz, and in other places grading into argillite and tuff, are abundant. The quartz in the limestone is of the same average grain size as that in the siltstone, argillite, and tuff. The quartz is thus probably wind or water transported, or both. According to Twenhofel (Bibl. No. 14) more grains tend to be rounded, and rounding occurs down to a smaller grain size (.03 mm.) in wind transported silt, than in water transported silt (.1 to .05 mm.). Recrystallization, however, has changed the size and shape of the grains so much that these criteria are no longer applicable. Aeolian silt, however, tends to be better sorted than water-transported silt, and as this silt shows little variation in grain size and is predominantly quartz it is likely aeolian. The irregular knotty aggregates have formed from a 'rolling up' of the grains during the limestone flowage.

Other impurities in the limestone are sericite, tremolite, chlorite, and opaque metallics. These minerals are in minute amounts in some beds, but are abundant in others where the limestone grades into argillites and tuffs. The tremolite occurs as a few fibers replacing quartz and carbonate in a bed of silicious limestone close to the lower diorite gneiss sill.



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THIN SECTION PHOTOGRAPH NO.9.

Irregular contact of twin-glided carbonate with fine-grained tuff. Actinolite shreds have developed in the carbonate.

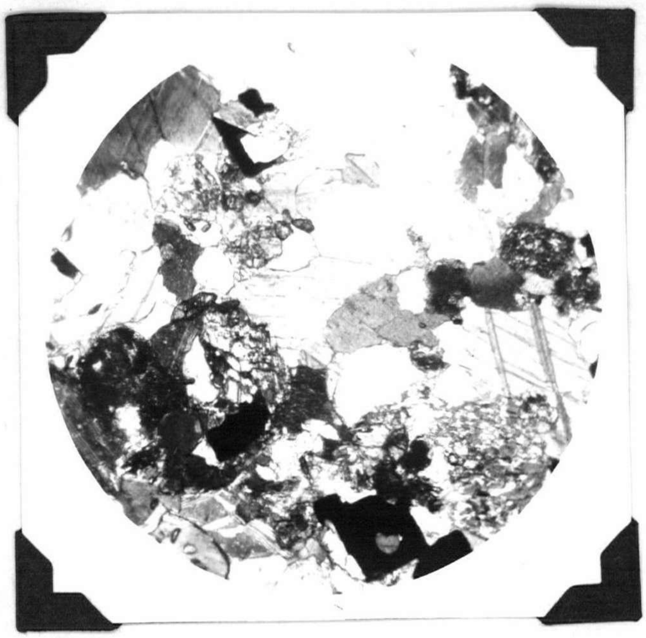
Several beds of limestone about five feet thick which outcrop twelve hundred feet north of Ptarmigan Hill are intercalated with beds of tuff, and contain inequidimensional fragments of green andesite tuff up to several inches in diameter. These fragments are probably thin lenses of tuff which have 'rolled up' in the limestone during its flowage.

The essential minerals in the tuff fragments are hornblende and plagioclase (oligoclase to andesine) in about equal proportions. Grains of these average .15 mm. in diameter. Sphene, pyrite, and apatite are minor, forming about one percent of the total.

In the interiors of the tuff fragments the hornblende grains are ragged, slightly poikiloblastic, and altered in part (about one-third) to chlorite. The plagioclase is kaolinized, particularly in the centers of the grains, and shows very little twinning. Titanite is clouded with leucoxene. One or two small epidote grains are present.

The carbonate five or ten millimeters away from the tuff fragments has recrystallized to grains several millimeters in diameter, and these grains are strongly twin-glided. Highly strain shadowed, fractured, sutured, and intergrown quartz grains up to .75 mm. in diameter are present in one or two knots in the limestone. They have probably originated in the same way as the knotty aggregates of quartz previously discussed.

At the contacts of the tuff fragments with the limestone



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THIN SECTION PHOTOGRAPH NO. 7.

Pyrite cube with inclusion of diopside and another replaced by actinolite at contact of tuff fragment with limestone.

x 80

THIN SECTION PHOTOGRAPH NO. 8.

Plagioclase (light grey) with oriented inclusions of fibrous actinolite (white).

reactions between the minerals of the tuff and the carbonate have produced diopside,-tremolite, and actinolite. Some radial aggregates of a fibrous chlorite are pseudomorphous after a pyroxene, possibly diopside, and others, with associated magnetite, replace actinolite. A few titanite grains showing much alteration to leucoxene are isolated in the carbonate. One pyrite grain has an inclusion of diopside, and others are replaced by actinolite (Thin section photograph No. 7). No pyrite is found in the carbonate away from the tuff fragments. The pyrite has thus formed before some of the metamorphic silicates, and is probably not from later hydrothermal activity.

The diopside, tremolite, and actinolite grains are most abundant in a band seven or eight millimeters wide at the contacts of the tuff fragments and limestone. They are not found in the central portions of the tuff fragments. A rough zoning has taken place. Actinolite has formed for several millimeters on both sides of the contacts. Tremolite, showing no green pleochroism, and diopside have formed only in the carbonate several millimeters away from the contacts.

Plagioclase has recrystallized at the contact. The grains are four or five times the diameter of those in the tuff, and in one place contain oriented inclusions of actinolite (Thin section photograph No. 8), thus must have replaced the actinolite. Some of the feldspar was probably originally coarse as it occurs in bands angling away from the contact.

The coarse plagioclase has the same composition as that in the tuff (oligoclase to andesine), and thus has undergone no chemical change.

No metasomatism was necessary to produce the alteration at the contacts. The iron is provided by the hornblende and pyrite of the tuff, the silica by the hornblende of the tuff, and/or the quartz inclusions in the carbonate. The magnesium comes from the hornblende or its chlorite alteration in the tuff, and from the slightly magnesian carbonate. The calcium comes from the carbonate and from the hornblende in the tuff. The titanite may be a primary constituent of the tuff, or may have its titanium derived from titaniferous magnetite or ilmenite in the tuff.

The rough zoning of the silicates supports the hypothesis that alteration is purely metamorphic. Calcium and magnesium and silica need not migrate far as they are present in both limestone and tuff. Iron, which is present only in the tuff, has not migrated far from the contacts. Ferriferous actinolite at the contact gives way to the non-ferriferous tremolite and diopside several millimeters away from the contacts.

Tuff near Q-25 vein contains disseminated carbonate grains, and no reaction has taken place here between tuff minerals and carbonate. However, the carbonate is less abundant, the rock has undergone shearing rather than flowage. The shearing may have prevented the formation of the new metamorphic minerals, particularly diopside.

Siltstone.

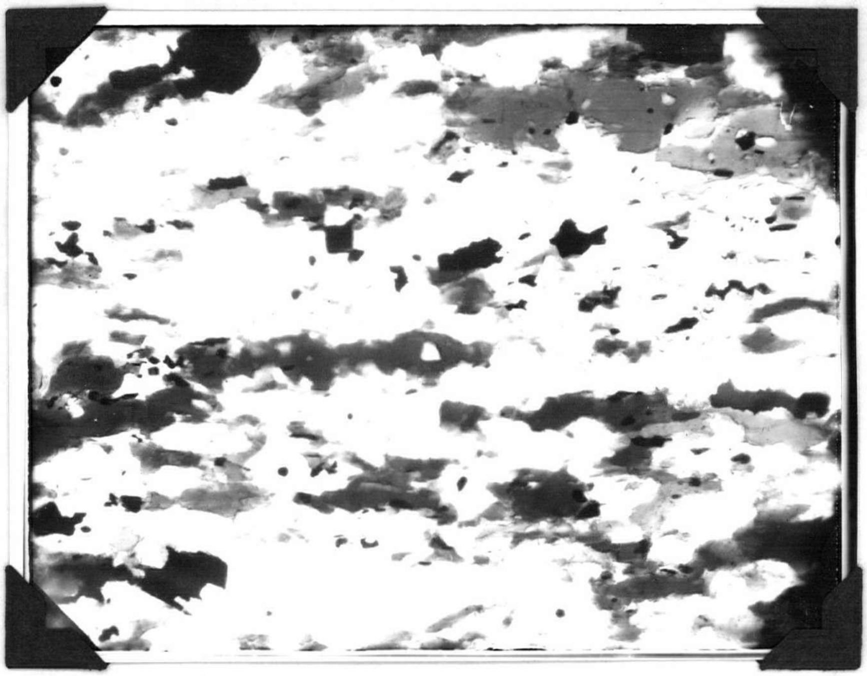
The siltstone is very thinly bedded, white to grey and green in color, and composed predominantly of quartz. Some beds contain abundant feldspar and chlorite, and grade into tuff.

The quartz grains in the siltstone have diameters up to .3 mm., but in most thin sections the maximum is .1 mm. Grains are strain shadowed, sutured, and intergrown to form a fine-grained quartzite. No evidence of accretionary growth was noted. Sericite, chlorite, and calcite fill interstices, and andesine forms minute laminae in the siltstone.

The feldspar is probably both volcanic and detrital. The siltstones grade into andesite tuffs, containing andesine but some bands in the siltstone that are high in feldspar contain no mafic minerals, and are thus likely detrital rather than volcanic in origin. The feldspar in these bands is of the same grain size as the associated quartz. The recrystallization prevents determining whether the silt is water transported or aeolian.

Tuff

Thin bedded, green to grey, water-lain andesite tuff forms the bulk of the central band of 'sediments'. Predominant minerals are andesine and hornblende. Biotite is a minor constituent. The grains average .15 mm. in diameter, and show markedly little variation in size in any one bed, and even in different beds. The original fragments have been well compacted and recrystallized; no fragmental outlines were



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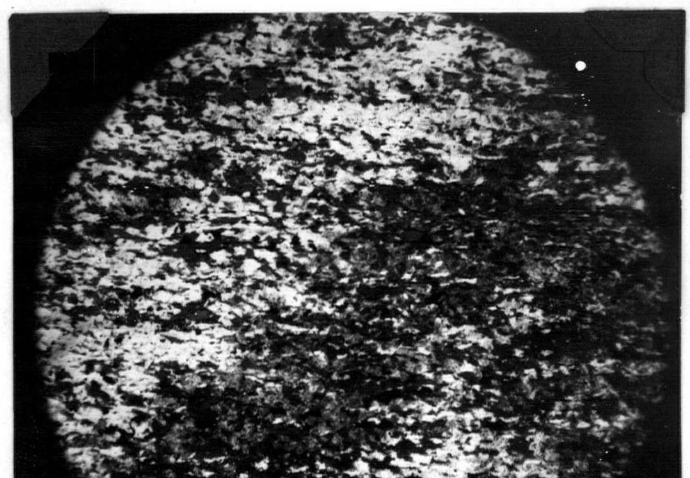
THIN SECTION PHOTOGRAPH NO. 3

Hornblende forms 'feather-amphibole' in the regionally metamorphosed tuffs. The other mineral is andesine plagioclase.



x 25

THIN SECTION PHOTOGRAPH NO. 4

The dark band cross-cutting the hornblende lineation is caused by alteration of feldspar to clay-minerals. It may represent the original bedding.

seen in the field or in thin section. Fine chloritic material interstitial to the plagioclase and hornblende is probably devitrified ash or glass. Accessory magnetite, pyrite, hematite and sphene are associated with the mafic minerals.

Although quartz is present in many of the specimens, it is considered to be detrital rather than volcanic. The relative amount of quartz varies greatly in different beds. The tuffs grade into siltstone. The quartz grains are in many places in bands and lenses rather than disseminated. The diorite sills are the intrusives nearest in age and in distance to the tuff. The sills and the tuff may represent early igneous activity associated with the Coast Range intrusives. If so, the sills, though younger than the tuff, are probably derived from the same magma as the tuff. The later sills contain no quartz, and, as late differentiates of the same magmatic facies are usually more silicious than earlier differentiates it is doubtful that the earlier tuff would contain quartz.

In places the tuff grades into limestone, and here carbonate is locally abundant in the tuff. Where carbonate grains are disseminated in the tuff no reaction between tuff and carbonate has occurred, although, as described under Limestone, in some places fragments of tuff in limestone were altered on the borders to diopside, tremolite, and actinolite.

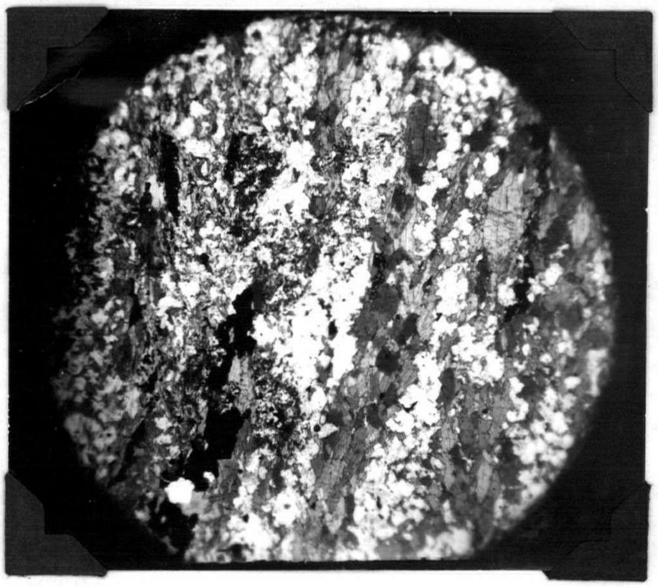
In one or two areas, and in particular in the outcrop on the north side of Ptarmigan Hill, the feldspar in the tuff has been saussuritized. Here epidote is very abundant, forming over fifty percent of the rock. It is mostly in patches associated with plagioclase, but also occurs in irregular microscopic veinlets and lenses cutting all other minerals. Albite, untwinned and with abundant inclusions, has formed in irregular masses probably replacing andesine, although andesine could not be proven. Calcite grains are disseminated throughout the slides, 'kaolins' cloud the feldspars, and small zoisite grains form inclusions in the feldspars. Chloritization of the hornblende accompanies the saussuritization of the feldspar, but some of the chlorite has been replaced by the abundant epidote.

Alteration is not confined to the tuff near the chlorite gneiss sills. Areas several hundred feet from intrusive outcrops have abundant epidote. Some of the tuff beds near the sills show crenulation, particularly where the sills cut across the bedding, but thin sections show no reconstitution of the minerals.

In some areas the tuff shows no bedding, and is indistinguishable from fine-grained intrusive diorite gneiss. These areas have been mapped as massive greenstone. Since the outcrops lie on strike of tuff beds rather than on strike of diorite gneiss sills, and since most thin sections contain quartz, which does not occur in the intrusives, the rock is undoubtedly 'sedimentary' in origin. Marked lineation of hornblende 'feather amphibole' (Thin Section photograph No. 3) indicates dynamic metamorphism was stronger here than in surrounding areas. In one thin section (see Thin Section photograph No. 4) a band of kaolinic alteration crosses the amphibole lineation, and may represent the original bedding. Why dynamic metamorphism has been more intense in these areas has not been determined. The areas are not particularly close to exposed intrusives, the bedded rocks on their margins are not severely folded, and they are too irregular to be associated with concealed faulting. The gneissic structure in them is parallel to the regional folding and foliation.

Gneiss of Tuff Origin.

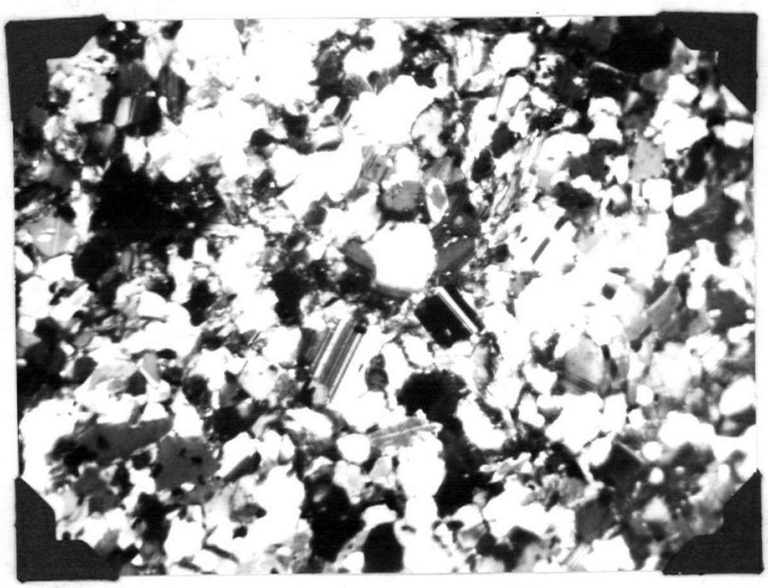
Where the sedimentary rocks are silicious the contact with the diorite gneiss sills are sharp, but where andesite tuff is the main sediment the tuff has recrystallized, bedding is obscured, and the contact with the sill is indistinguishable. Some of the rock mapped as diorite gneiss has undoubtedly formed by recrystallization of tuff under dynamic metamorphism. The gneiss in several outcrops shows bands of coarser and finer grain size and lighter and darker grey-green colors. These bands may be from multiple intrusion, but are more likely original bedding in tuff. The gneissic structure in these bands is parallel to that in the sills and to the regional lineation. This paragneiss contains the same minerals as the orthogneiss. Andesine and hornblende predominate; biotite, pyrite, magnetite, sphene, and specularite are minor



x 25

THIN SECTION PHOTOGRAPH NO. 5

Gneissic structure from lensey aggregations of hornblende crystals. Andesine comprises most of the rest of the slide but chlorite epidote, sericite and carbonate are also present.



x 80

THIN SECTION PHOTOGRAPH NO. 6

Fresh andesine in recrystallized tuff. Hornblende, quartz, chlorite, actinolite, and epidote are present.

forming about one percent of the rock. The average grain size is .2 mm. A few of the specimens contain quartz, and thus are probably sedimentary rather than intrusive. The gneissic structure is produced by aggregation of hornblende grains to parallel lenses. Andesine has been kaolinized and sericitized, and hornblende chloritized. Minute grains of epidote (.05 mm. in diameter) are associated with the kaolinic alteration of plagioclase.

Gneiss has been formed by recrystallization of the andesite tuff for twenty or thirty feet on each wall of the acid dykes. The gneiss shows no addition of material, but is coarser in grain size than the tuff. The gneissic structure has been produced by segregation of hornblende into parallel lenses. The structure is not parallel to the walls of the dykes, but is parallel to the regional foliation. The dykes must thus have been intruded before or during the orogenic period.

?

Intrusive Diorite Gneiss.

The intrusive gneiss, like that formed from tuff, is composed predominantly of andesine and hornblende, but it contains no quartz. Apatite, titanite, and ilmenite or titaniferous magnetite are accessory minerals. Euhedral crystals of hornblende up to a millimeter in diameter occur in parallel lenses in a groundmass of subhedral andesine grains of about .5 millimeters diameter. (Thin Section photograph No. 5)

At sharp contacts with the sediments the gneiss is fine grained from chilling, and in places cuts the sediments at a small angle. At one exposure the sediments have been crenulated and shattered at the contact (Thin Section photograph No. 2). Angular fragments found in boulders of gneiss may be xenoliths of tuff or autoliths.

The gneiss has undergone similar alteration to the tuff. Feldspars have been saussuritized with the production of albite, epidote, clinozoisite, and clay minerals, and have been sericitized. Hornblende has altered to chlorites and to epidote. Ilmenite or titaniferous magnetite is rimmed by titanite, and the two are altered in part to leucoxene.

Four criteria have been found to distinguish the orthogneiss from paragneiss. Quartz, probably detrital in origin, is in places disseminated and in minute lenses and bands in the paragneiss, but has not been found in orthogneiss. In places vague banding, probably bedding, can be traced into paragneiss. The orthogneiss contains xenoliths of tuff or autoliths. The orthogneiss, although sill-like, in places crosscuts the bedding of the sediments.

Dykes.

Sediments and gneiss are cut by aplite, lamprophyre and syenite dykes.

The aplite dykes are composed of about equal proportions of subhedral orthoclase, quartz and albite in grains up to five millimeters in diameter. Muscovite, chlorite, and anorthoclase are minor constituents, forming less than one percent of the dykes.

One or two grains of garnet and pyrite were noted.

Parts of some orthoclase grains have recrystallized, probably because of stress. Parallel laths, arranged en echelon and in places joined, are all of the same optic orientation, but of a different orientation than the host crystal. The laths are clearer than the rest of the crystal. In places orthoclase grains are replaced on the borders by anorthoclase. Fine flamboyant quartz grains, .1 mm. in diameter, fill irregular fractures in orthoclase and albite.

The aplite dykes have undergone little alteration. Sericite flakes replace the orthoclase, and clay minerals cloud the plagioclase. Chlorite has completely replaced the few grains of mafic originally present.

The aplite dykes have irregular walls, stringers of aplite forming reticulating veinlets in the wall-rock. The andesite tuff wall-rock has recrystallized to diorite gneiss, as discussed under 'Gneiss of Tuff Origin'.

Several lamprophyre dykes also cut both sedimentary rocks and diorite gneiss. Thin sections were made of two of these dykes.

One, a kersantite, contains twenty percent biotite in flakes averaging .2 mm. in diameter. The biotite forms inclusions in labradorite laths and partially fills interstices between laths. Augite, in phenocrysts .5 mm. in diameter, makes up two or three percent of the rock. Labradorite laths, up to 1 mm. long and forming seventy percent of the rock, have a sub-parallel disposition, giving the rock a trachytoid texture. Two or three percent of quartz in grains .15 mm. in diameter is present with biotite in the interstices between the labradorite and augite crystals. Minute grains of opaque, probably magnetite, are present.

The other, a spessartite, has sixty-five percent euhedral hornblende phenocrysts up to 2 mm. long. One percent of biotite is scattered through the slide both in hornblende phenocrysts and their interstices. Andesine in grains up to .5 mm., forms the groundmass. Minor apatite is scattered throughout the groundmass and in one place forms an aggregate of a dozen or more crystals.

Both rocks are quite fresh, augite and hornblende showing only slight alteration to chlorite, and feldspar a little clouding by clay minerals.

One outcrop of a syenite dyke was found. This dyke contains sixty to seventy percent albite laths of random orientation ranging in size from several microns to several millimeters; and thus giving the rock a seriate texture. Hornblende grains, mostly twinned and very acicular, up to .5 mm. long, form inclusions in some of the large albite grains, and are scattered through the rock with the fine albite laths. Chlorite and magnetite pseudomorph pyroxene, apatite and magnetite are accessory minerals.

Coast Range Intrusives (not including Triassic? sills).

The eastern contact of the main body of Coast Range intrusives is about five miles southwest of the property, but several stocks outcrop in the sedimentary and volcanic rocks east of the property. Specimens were taken from one of these stocks, about four miles east.

The rock is a medium-grained granite. Zoned oligoclase-albite forms fifty percent of the rock, orthoclase thirty percent, quartz ten percent, and biotite and hornblende ten percent. Some of the orthoclase enveloped the plagioclase and quartz, giving the rock a poikilitic texture. Sphene and ilmenite or titaniferous magnetite are accessory minerals.

Alteration is slight; plagioclase is somewhat clouded by clay minerals, orthoclase contains a few flakes of sericite, and hornblende shows chloritization. Sphene and the opaque mineral are bordered by leucoxene.

METAMORPHISM

Sedimentary rocks have undergone minor contact metamorphism where they are intruded by diorite sills, but both sediments and sills have undergone regional metamorphism.

Where the contacts of diorite sills are close to silicious limestone minor tremolite has formed, and where sills intrude andesite tuff the tuff has recrystallized to diorite gneiss. Where calcareous tuff is intruded a few garnets have formed, but these are localized within a few feet of the contact. No large skarn zones are found. The diorite must have been low in volatiles, and transmitted little heat to the country rock.

Dynamic metamorphism has produced a regional foliation. The gneissic structure in both the sills and the recrystallized tuff trends northwesterly. Hornblende has the feathery poikiloblastic form typical of dynamic metamorphism. Limestone is recrystallized; the carbonate grains show twin-gliding from flowage, but have not reacted with inclusions of quartz. Quartz grains in all rocks except the acid dykes show strain shadowing. Quartz inclusions in the limestone are aligned from flowage.

Most of the metamorphism is regional, from orogenic movements associated with the coast range intrusives; but some local contact metamorphism has been produced by the diorite sills.

STRUCTURE

Folding.

The central band of sediments has been folded into northwesterly-trending discontinuous anticlines, synclines and monoclines plunging to the northwest. Some of this folding may be due to the intrusion of the sills, for it becomes less intense away from the sills.

However, the sills are considered to have undergone some deformation with the sediments because: they have suffered similar metamorphism to the sediments, the gneissic structure in them is parallel to the regional foliation (although a primary flowage structure would have the same trend since the strike of the sills is parallel the regional foliation, it would not be as marked a structure, and would more likely be caused by orientation of isolated grains, rather than aggregation of grains into lenses such as has occurred here), fractures, including those mineralized are continuous from sedimentary rocks into sills, no dykes of diorite from the sills cut into the sediments.

The time of intrusion of the sills is important. If the sills were intruded while the sediments were still relatively flat-lying, they would raise the overlying sediments, but would probably not cause folding in them. On the other hand, if they were intruded after the sediments had been folded or tilted so that they dipped at moderate or high angles, folding (or further folding) in the sediments between sills would more likely take place. If, on the basis of the correlation discussed previously, the sediments are considered to be Palaeozoic, and the sills Triassic, the problem of the conformity of Palaeozoic rocks to Triassic rocks is still to be solved, to determine the amount of folding before intrusion of the sills. In the Iskut area the contact between Permian and Triassic is unconformable; and in Southeastern Alaska it is suspected of being perhaps angularly unconformable, but not markedly so (a variation of twenty degrees in dip but no change in strike is reported in one place). On the whole, there does not seem to be much orogeny before Triassic time, which would indicate that the Triassic? sills were intruded into relatively undisturbed strata, and thus would produce little further disruption in them.

On the basis of the available field information, the upper and lower are not considered to be parts of the one trough-like body which contains a shallow basin of sediments for the following reasons: at the contacts the sills do not dip under the sediments consistently, the regional dip is fairly steep, about sixty degrees northeast, the sediments between the sills, though folded and fractured, contain no dykes of diorite.

The relation of the sills to the sedimentary rocks is important because, although veins continue from sedimentary rocks into diorite, they diminish from about five feet to one foot in width. Samples taken on surface indicate a decrease in gold content where diorite is the host rock. Apparently the diorite is unfavourable to mineralization.

Regional Fracture Pattern.

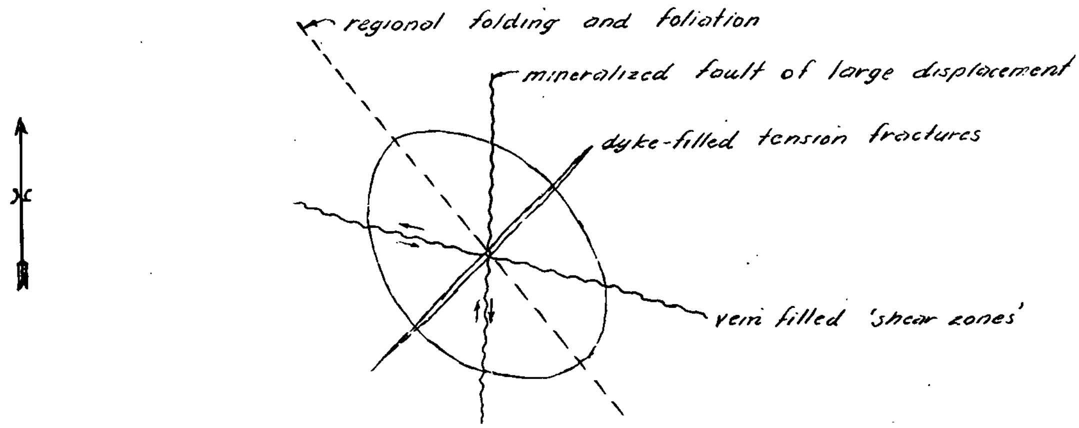
All the dykes strike from forty to sixty degrees east of north and dip vertically. The irregularity of the dykes, especially the aplite, indicate the fractures they occupy are tensional.

The quartz veins, including those outside the central band of sedimentary rocks, are closely parallel, striking south sixty-five degrees east, and dipping eighty degrees north.

A zone of abundant shearing with specularite mineralization is exposed in the outcrop north of Ptarmigan Hill. The shears vary forty degrees in strike, but those of most abundant gouge strike northerly. Dips are vertical. Bands of limestone several hundred feet wide on the east of this broken zone are not found on strike on the west of the zone. A band of limestone to the north, outside the mapped area, may be the continuation. A right-hand fault of over one thousand feet horizontal offset is suspected. The presence of specularite in stringers several inches wide in the zone indicates the faulting was in part pre-mineralization.

Q-17 and Q-22 vein are each offset several feet by left-hand faults, and a fault cutting off the west end of Q-22 vein has the same strike, north fifteen degrees east, indicating Q-17 and Q-22 are the same vein, offset by a left-hand fault.

If the structures, excluding the post-vein left-hand faults, are assumed to have resulted from one set of forces, they may be fitted into the strain ellipsoid diagram as follows:



The veins are known to have formed on shear zones, because the wall-rock, particularly the hang-wall, has abundant gouge, and where the quartz pinches out between Q-17 and Q-17 west veins sheared rock persists.

The folding, with regional foliation parallel the axes of the folds, indicates the stress causing the deformation was pressure. From the strain ellipsoid diagram above, this pressure was from the southwest or northeast.

The two evident sources of pressure are the local sills, trending northwest, and the main body of Coast Range intrusives, also trending northwest. The metamorphism is regional, thus likely produced by the orogeny associated with the Coast Range intrusives. If the fractures are produced by the same stress, they must be regional also, but a larger area will have to be mapped to verify this.

Relation of Veins to Sills.

The veins show no direct spatial relation to the sills. Q-19 vein, Q-25 vein, and several veins outside the mapped area, are well over one thousand feet from sill outcrops. No marked change is noted in the mineralogy in tracing the veins away from the sills. Vein fractures occur well into the sills rather than just on the borders. Many other mineral deposits, including one reported to contain specularite, have been found in the Unuk. Thus the mineralizing fluids probably were not derived from the diorite sills, but probably were derived from the main Coast Range intrusive or its satellites.

VEINS

General.

The quartz veins have formed in shear zones, as indicated by gouge on the walls, but no movement along the zones has been proven. The veins continue from sediments into diorite but diminish in width and gold content in the diorite. The veins contain about ten percent of metallics. In order of abundance these are galena, pyrite, specularite, chalcopyrite, sphalerite, magnetite, three soft minerals, possibly tellurides, and gold. Q-17 vein is by far the most interesting, both economically and mineralogically. Most of the surface development has been done on it. In one place it outcrops continuously for over one hundred feet.

Wall Rock Alteration.

Fairly fresh samples were obtained from Q-17 vein to determine the nature of the wall rock alteration. Specimens were taken, as closely as could be determined, from the same bed, and at 8 ft., 4 ft., 3 ft., 2 ft., 1½ ft., and ½ ft. from the vein. A specimen was taken from the shear zone between Q-17 and Q-17 west veins.

At eight feet from the vein the wall rock shows no alteration that can be attributed to hydrothermal activity. It is metamorphosed, but the metamorphism is similar to that in most tuff specimens taken from the mapped area. The andesine is in part well twinned, and although altered to clay minerals, is not more so than in tuff outcrops away from the veins.

Epidote and chlorite have developed as alteration of plagioclase and hornblende, but these minerals are also present in tuff and gneiss in most other parts of the area.

Four feet from the vein the wall rock still shows no change; andesine is well twinned, hornblende still the 'feather-amphibole' type of the majority of the tuff specimens, epidote, chlorite, and kaolins are minor. However quartz, which is usually disseminated or in thin bands in the tuff, occurs as thin introduced veinlets in the thin section.

The next section, taken at three feet from the vein, shows considerable alteration. Many of the plagioclase grains have been completely replaced by sericite. Only the larger sericite flakes show the maximum birefringence of normal (.03 mm. thick) sections; most flakes are about .01 mm. thick, and thus low in birefringence. The clay minerals are here abundant, but not as abundant as the sericite. Quartz veinlets are more numerous, forming three or four percent of the section. The few feldspars that are fresh enough to show twinning have twin lamellae of greater extinction angles (labradorite instead of andesine); and one or two grains have two sets of twin lamellae at right angles. It is doubtful, however, that this more calcic feldspar has been introduced, for it shows the same haziness as the andesine further away from the vein, and shows no veining relations to indicate replacement.

At two feet from the vein the feldspar has almost completely disappeared; and hornblende has altered in entirety to chlorite. The wall rock is here composed of quartz and one or two vague plagioclase residuals in a fine grained groundmass of sericite, chlorite, and clay minerals. A few fractures across the thin section are bordered by fairly coarse (.1 mm.) flakes of sericite.

The next section was taken one and one-half feet from the vein, in an area where there are few fractures or veinlets. It showed surprisingly little alteration when compared to the section taken two feet from the vein. About half the feldspar has been sericitized; the remainder is fairly fresh and is well twinned, andesine in composition. Hornblende is only in part (about half) replaced by chlorite. Disseminated quartz, probably residual, is strain shadowed and recrystallized, but this deformation occurs in all the sedimentary quartz.

At one half a foot from the vein all minerals except the quartz are reconstituted to a fine pulvurulent mass of sericite, chlorite, and kaolins. Some of the sericite has grown to poikiloblastic muscovite, particularly near fractures. Several regular veinlets of albite, clear but with poorly developed twinning, transect the section.

The next section was taken from the shear zone between Q-17 and Q-17 west veins, and is not from the same bed as the sections described above. The original rock, however, was similar andesite or dacite tuff. An assay of this sheared rock gave several tenths of an ounce of gold per ton. Sericite shreds, constituting about thirty percent of the slide, and chlorite (five percent) show a marked parallelism to lenses of carbonate and to the direction of elongation of the albite grains. Carbonate lenses form about thirty percent of the slide, and albite, poorly twinned and partly sericitized, forms about thirty-five percent. Highly strained quartz is present in disseminated grains and lenses. Euhedral pyrite crystals are present in the carbonate lenses, and in polished section the pyrite is seen to be rimmed and replaced by marmatitic sphalerite. A few subhedral grains, possibly apatite, are too small to identify.

Ghost-like inclusions of wall rock were found in the vein in many places. The fragments are completely altered to a soft pale green sericitic material too friable to permit making thin sections.

Wall rock alteration is thus confined to narrow limits, having progressed only three or four feet into the walls. Sericite, clay minerals, and chlorite have formed by alteration of the plagioclase and hornblende. Quartz and albite have been introduced in veinlets a fraction of a millimeter in width; and in the shear zone itself, carbonate, pyrite and sphalerite have been introduced. The hydrothermal additions needed to produce this alteration are potash, soda, (probably introduced as albite molecule as the albite occurs in definite veinlets), zinc, and sulphur. The quartz, calcite, and pyrite in the shear zone are probably hydrothermal as they occur in veinlets and lenses. The wall rock alteration is typical of that accompanying mesothermal veins.

Mineralization.

The quartz veins may be classified as follows: (1) those with chalcopyrite and pyrite with or without magnetite, (2) those with galena and pyrite, and (3) those with specularite. The first class was found to contain only traces of precious metals, irrespective of the amount of metallics, but the last two classes give good assays in gold, particularly where metallics are abundant.

In all veins found the quartz has crystallized in grains up to several millimeters in diameter. One or two small vugs were noted, and these are bordered by the coarsest grains of quartz. Except for the rare vugs, vein filling shows none of the features of open space deposition, and thus was probably deposited at moderate depth.

Chalcopyrite - pyrite Class.

Four veins containing chalcopyrite-pyrite mineralization were found on the claims, but none gave an assay above a few hundredths of an ounce in gold. In these veins the pyrite occurs in cubes up to several millimeters across, and, where magnetite is present, forms inclusions in the magnetite. Chalcopyrite, where abundant, veins and replaces quartz, and, where sparse, is found only as inclusions in pyrite. No definite paragenetic relations, other than that the sulfides were later than the quartz, could be established.

Q-23 vein is rather a zone of quartz stringers than a true vein. Associated with the quartz is a dark green chlorite, which in thin section shows the anomalous blue birefringence of penninite. The quartz contains aggregations of sericite, and is clouded by clay minerals. Magnetite constitutes five to ten percent of the polished sections.

The footwall side of Q-25 vein contains quartz-chalcopyrite mineralization, and the hangwall quartz-galena-pyrite mineralization. Gold assays in the footwall side were very low, but in the hangwall side were very encouraging. No fracture or selvage separates the two classes of mineralization.

Galena Pyrite Class.

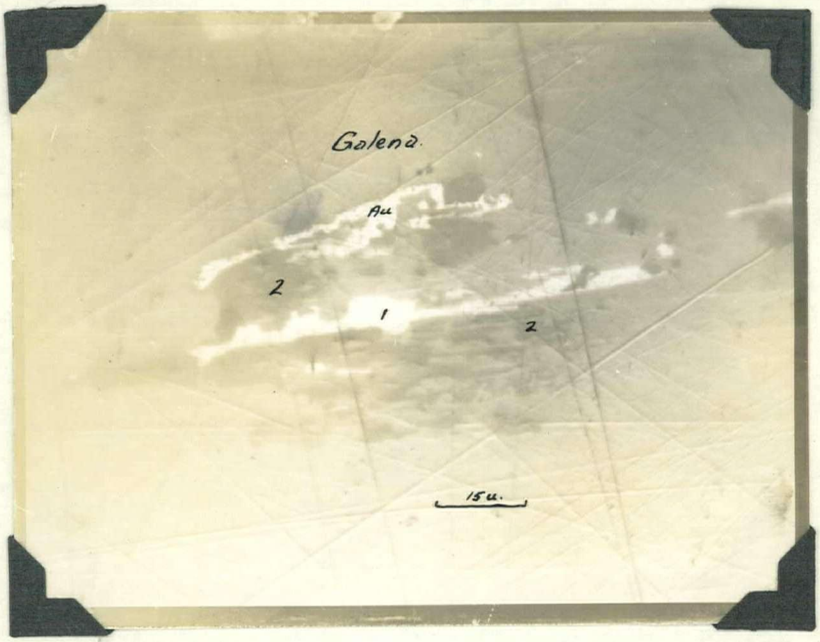
The galena pyrite veins usually carry good values in gold. The gold is generally proportional to the amount of sulfides, but may continue into sulfide-poor quartz. However, two veins found outside the central band of sedimentary rocks contain fifteen or twenty percent galena with minor pyrite, but gave assays as low as one or two tenths of an ounce per ton.

The small possible ore shoot in Q-19 vein contained very little galena but did contain a few disseminations and lenses of coarse (up to a centimeter in diameter) pyrite. The pyrite grains are oxidized on the rims so that they fall out of the quartz. Some were collected and mounted in a polished section. Although inclusions of chalcopyrite and sphalerite are abundant, no gold was found in the pyrite. One small free particle of gold was found in the section, likely a remnant after oxidation of the pyrite, or a particle that was deposited in quartz near pyrite.

Q-17 and Q-17 west veins are on the same shear zone, separated by thirty feet that is barren of quartz. As aforementioned, the sheared rock between these two quartz veins is mineralized with pyrite and sphalerite, and gave gold assays of several tenths of an ounce per ton. Q-17 west vein is mineralized with five to ten percent of galena and pyrite but contains no specularite. Q-17 vein is mineralized with about five percent specularite but contains no sulfides. The significance of this marked change in mineralization is discussed later.

The mineralization of Q-17 west vein was studied in detail as it afforded some interesting specimens. In thin section the quartz grains are found to be strongly strain shadowed and fractured, and the coarser grains (5 mm.) are cut by many veinlets of small (.1 mm.) flamboyant grains. Pyrite and galena occur in these veinlets, and replace the coarser quartz in their walls. Coarse quartz is clouded by clay minerals.

Polished sections show the pyrite to be markedly free of fractures and inclusions. The galena, however, has inclusions of gold and three other soft metallic minerals. The soft

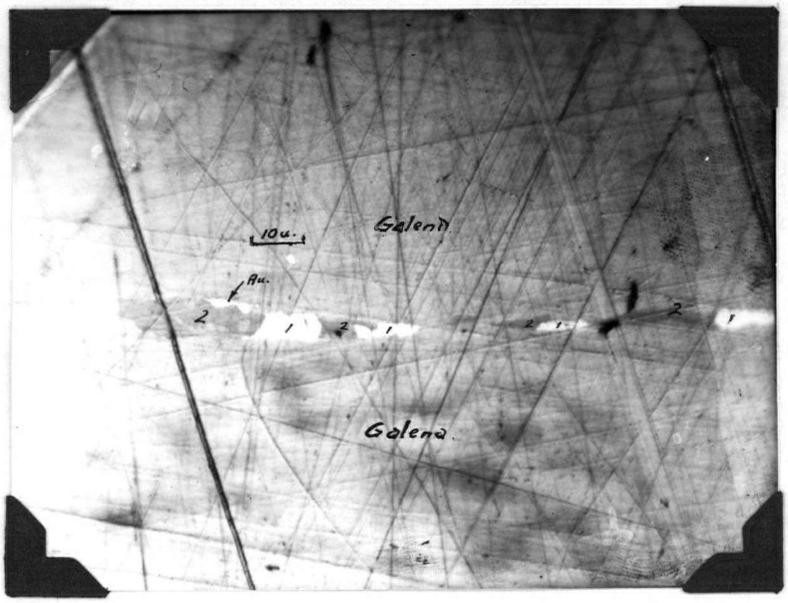


x 700

Intergrowth in galena of gold
with isotropic white mineral (No. 1)
and isotropic grey mineral (No. 2).

POLISHED SECTION
PHOTOMICROGRAPH NO. 1

(see Appendix for photographic data.)



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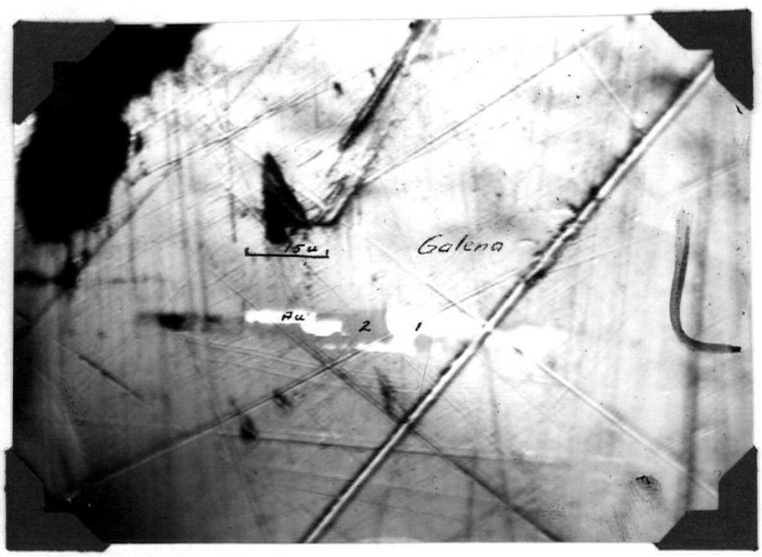
POLISHED SECTION
PHOTOMICROGRAPH
NO. 2



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POLISHED SECTION
PHOTOMICROGRAPH
NO. 3

Lensey fractures in galena, with no relation to galena cleavage, contain intergrowths of gold, isotropic white, (No. 1) and isotropic grey (No. 2) minerals.

minerals are in places found singly, but in most places are in aggregations of two or more (see Polished Section photomicrographs Nos. 1,2,3,4 and 5). The three soft metallics other than gold have not been identified owing to their small size. They can be seen under medium power (8 ocular, 3b objective) only when sections have been well polished. Their reactions to tests are as follows:

	No.1	No.2	No.3
Color	lighter white than galena	a very little darker grey than galena	moderately darker than galena with a tint of brown
Hardness	no relief from galena	no relief from galena	softer than galena
Anisotropism	nil	nil	moderate with a brownish birefringence
HNO_3	negative	negative	slight etch to neg.
HCl	negative	negative	negative
KCN	negative	negative	quick black etch
$FeCl_3$	dark brown, stronger than galena	negative	darker brown than galena

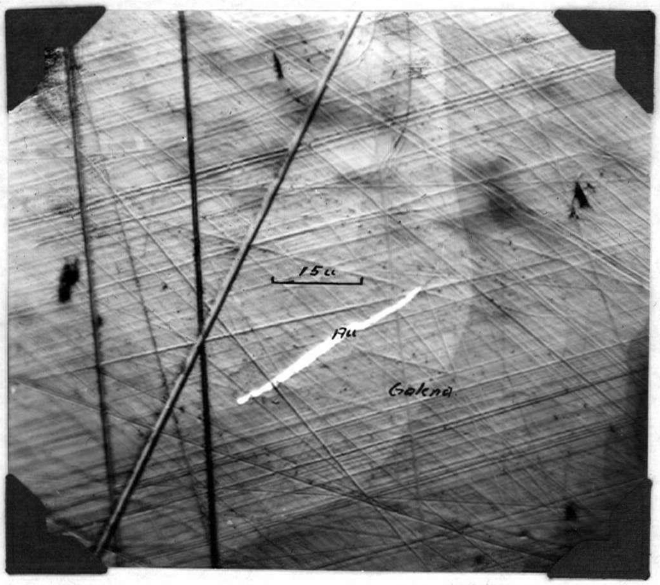
	No.1	No.2	No.3
$HgCl_2$	negative	negative	moderate brown stain
KOH	some remain clear and others turn brown, even in same reagent drop	negative	negative

A spectrographic analysis on minute amounts including some galena indicated the presence of:

	No.1	No.2	No.3
Ag	medium	medium	medium
Cu	weak	weak	weak
Pb	present but known in galena included		
Te	trace	trace	trace
As	strong	negative	negative

These reactions did not conform to those of any of the minerals listed in 'Short' (Bibl. No. 15). The fragments are so small that on etching the reagent drop overlaps onto the galena, and reactions cannot be taken as diagnostic. Spectrographic analyses were taken on minute amounts, and thus may not be entirely reliable. The minerals are hereafter referred to by their number in the above table.

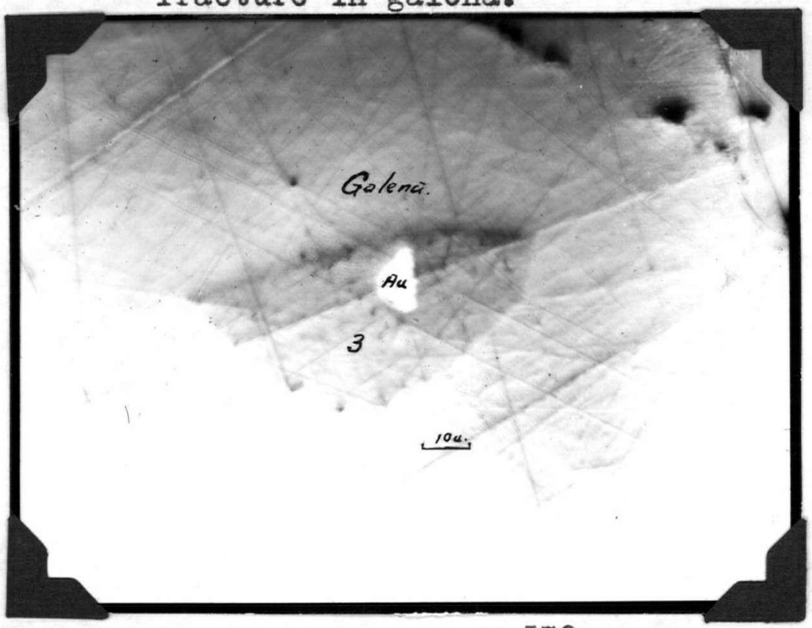
The long stringer-like form of some of the aggregations (see Polished Section Photomicrographs Nos. 2 and 3) suggests



x 700

POLISHED SECTION
PHOTOMICROGRAPH
NO. 4

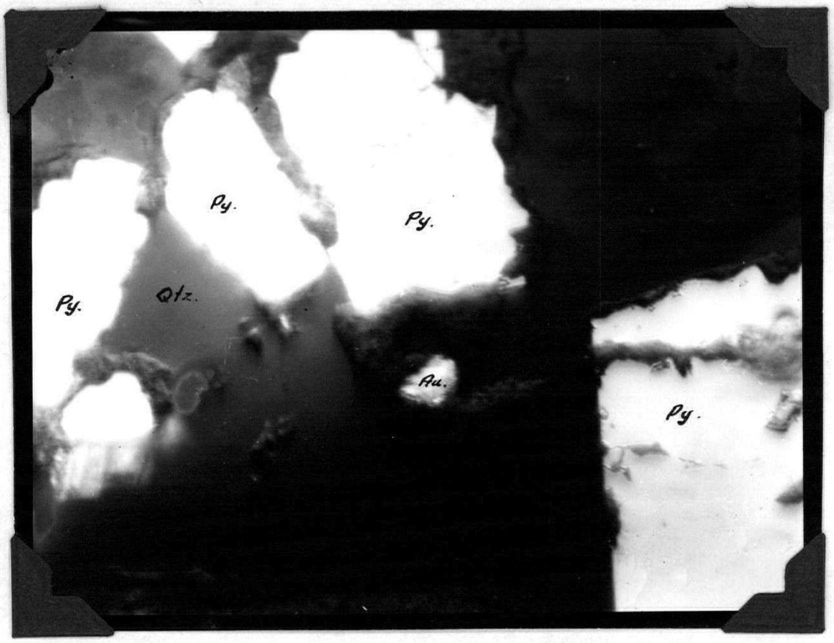
Gold filling a minute fracture in galena.



x 570

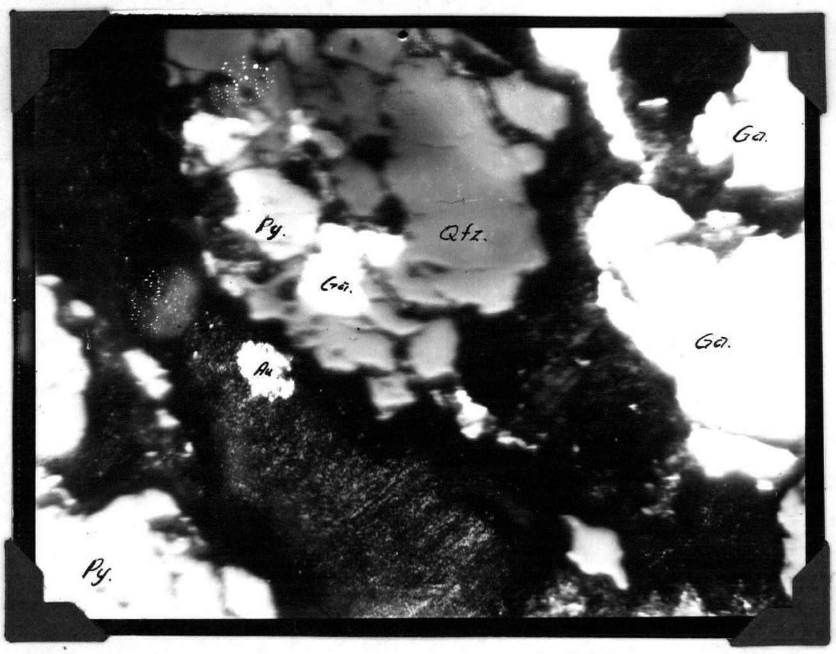
POLISHED SECTION
PHOTOMICROGRAPH
NO. 5

Gold in anisotropic grey mineral (No. 3) in galena.



x 204

POLISHED SECTION
PHOTOMICROGRAPH
NO. 6



x 204

POLISHED SECTION
PHOTOMICROGRAPH
NO. 7

The gold remains in pits formed by the oxidation of pyrite and galena.

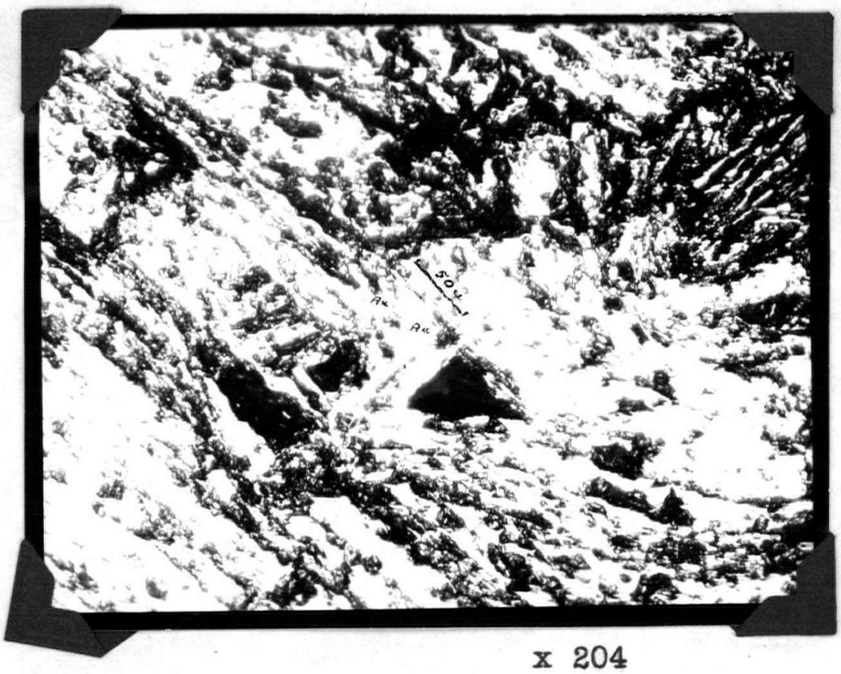
they are of later age than the galena. They do not show any relation to cleavage directions in the galena.

Besides occurring as blebs and minute veinlets both alone and with the other soft minerals in the galena, gold was found in pits where galena has oxidized (see Polished Section photomicrographs Nos. 6 and 7), and in or near fractures in the quartz.

Q-22 vein, the probable faulted eastern extension of Q-17 vein, is mineralized with galena and pyrite, but not as abundantly as Q-17 west vein. Polished sections show irregularly walled veinlets of galena cutting into pyrite grains. Chalcopyrite and sphalerite form lens-like inclusions, likely replacements, in the pyrite, and rounded grains with no apparent paragenetic relations in the galena. One small fragment of gold was found in the oxidized material at the edge of galena. A veinlet of specularite a fraction of an inch wide was noted in one trench across the vein, but the trench contained no other metallics.

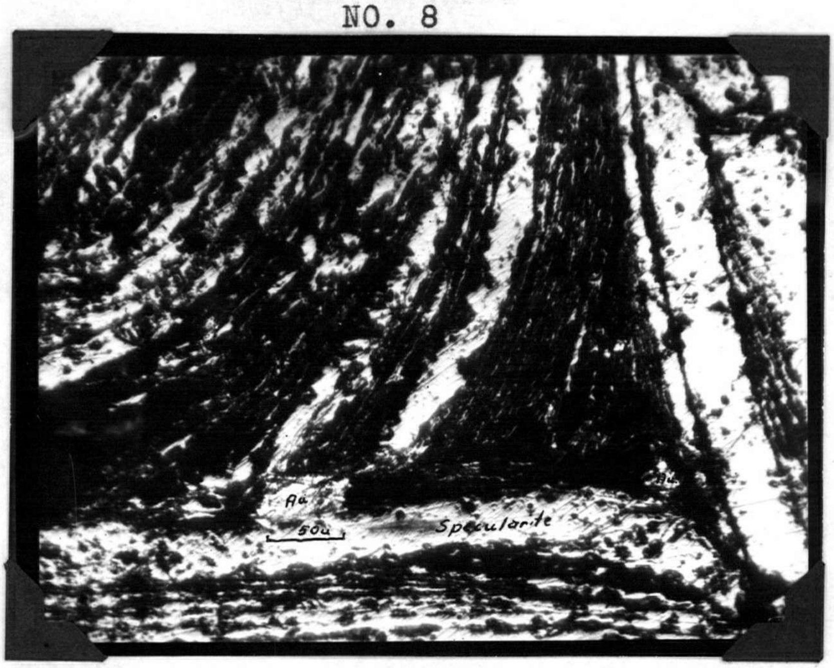
The galena-pyrite mineralization in Q-25 vein is, as found in polished section examination, accompanied by minor sphalerite, chalcopyrite, the soft mineral No. 1 and gold. Galena, in irregularly walled veinlets, replaces pyrite, and contains rounded inclusions of sphalerite and chalcopyrite. The gold was found as a small stringer in fresh galena.

Paragenetic relations in the galena-pyrite type of mineralization are (1) pyrite, (2) sphalerite and chalcopyrite,



x 204

POLISHED SECTION
PHOTOMICROGRAPH
NO. 8



x 204

POLISHED SECTION
PHOTOMICROGRAPH
NO. 9

The gold in the quartz specularite shoot occurs mostly in disruptions between specularite 'cleavage' plates, but in a few places forms lenses between plates.

(3) galena, (4) soft minerals including gold.

Specularite Class.

Only one vein, Q-17, containing abundant specularite mineralization was found on the property, although one small veinlet of specularite was noted in one of the pits on Q-22 vein. However, the presence of other quartz specularite veins is suspected because of abundant float in one or two drift covered areas.

Thin section shows the specularite to be associated with fractures in the quartz, but replacing quartz on the edges of the fractures. Plates of the specularite cut well into quartz grains, and even traverse several grains. The quartz is clouded by fine clay minerals, and in places includes masses of sericite which are likely altered fragments of wall rock.

Polished sections show the specularite 'cleavage' flakes to be markedly twisted and folded. In the open spaces or weaknesses produced by the deformation gold has been deposited. In no place was gold observed to cut across the 'cleavage' plates, and replace the specularite. It has been deposited as lenses between parallel plates, but most is found where the 'cleavage' is disrupted, leaving angular openings. (See Polished Section photomicrographs Nos. 8 and 9). A few small fragments of gold were noted in or near fractures in the quartz.

Significance of Specularite.

Although specularite in places comprises as much as ten percent of the vein filling, and sulfides in places comprise fifteen percent, in no place was specularite found in contact with the sulfides. Specularite is the only metallic, except for gold, in Q-17 vein, and yet none is found in Q-17 west vein, which is in the same 'break' with only a thirty-foot length that is barren of quartz intervening. Both specularite and sulfides are found in the eastern part of Q-22 vein, but they are neither abundant nor in contact.

Specularite, though fairly common in the 'contact metamorphic' type of deposits, is not a common vein mineral. This discussion will be primarily on the significance of hydrothermal hematite in veins. Most, but not all, hematite of hydrothermal origin occurs as specularite rather than as earthy-lustered hematite.

Lindgren (Bibliography No. 25) presents specularite as a characteristic mineral in 'ore deposits of deap-seated origin'. According to Lindgren, in these deposits it is found in the cassiterite veins, where it is commonly associated with cassiterite, arsenopyrite, pyrite, tourmaline, etc., and in the gold and silver-bearing veins, where it is commonly associated with gold, pyrrhotite, ilmenite, magnetite, galena, zincblende, etc.

The structure and the wall rock alteration of the specularite-bearing veins in the Unuk suggested the veins were formed under mesothermal conditions, rather than hypothermal. The literature was searched for examples of deposits containing specularite (or hydrothermal hematite) to see if they are consistently hypothermal, and at the same time to see what the relations are between the hematite and sulfides.

Before examples of deposits are considered, some discussion concerning the chemical relations of hematite to sulfides will give more significance to the mineralogical associations in the deposits. In the first place, sulfides are deposited only under reducing conditions, and hematite, including the weathering product, only under oxidizing conditions. In the second place, if hematite, $FeO_{2}{}_{3}$, containing trivalent (ferric) iron, is subjected to reducing conditions, it should be reduced to magnetite, $Fe_2O_3 \cdot FeO$, containing trivalent (ferric) iron and divalent (ferrous) iron or, of sulphur is abundant, to pyrite. Pyrite, according to Partington (Bibliography No. 34) is supposed to contain divalent iron. Hematite thus should not be deposited from the same solutions as sulfides, and if after deposition it is exposed to later sulfide-bearing solutions, it should be reduced to magnetite or pyrite. Gilbert (Bibliog- raphy) No. 27) mentions several deposits in which hematite has been replaced by magnetite, and magnetite by hematite, and mentions that both replacements are found in the same mineral deposit. He attributes the replacements to changes from oxidizing to reducing conditions and vice versa. In another paper (Bibliography No. 32) he mentions that the replacement of magnetite by hematite is most vigorous in ores that are sulphur poor. Reducing conditions connected with sulfides would inhibit the oxidation of the magnetite.

According to Van Hise (Bibliography No. 33) hematite is reduced by hydrogen sulfide as follows:

$$Fe_2O_3 + 2\ H_2S + CO_2 \rightleftharpoons FeS_2 + FeCO_3 + 2\ H_2O$$

to form pyrite. Hematite can form, however, by the action of alkaline carbonates on pyrite as follows:

$$8\ FeS_2 + 15\ Na_2CO_3 \rightleftharpoons 4\ Fe_2O_3 + 14\ Na_2S + Na_2S_2O_3 + 15\ CO_2$$

The latter reaction has been carried out in the laboratory.

Hydrogen sulfide and alkaline carbonates are both possible constituents of hydrothermal solutions.

There seems to be little possibility of a solid solution of magnetite and hematite. Broderick (Bibliography No. 19) shows that specimens of an iron oxide that were described as solid solutions of magnetite are in reality mechanical mixtures. The components of the mixture are visible in polished sections studied under the microscope.

The relative temperatures of crystallization of ferric oxide, ferrous oxide, and sulfides of iron may also have a bearing on the apparent antipathy of hydrothermal hematite to sulfides. Butler (Bibliography No. 23) has, on empirical evidence, constructed a chart showing the relative temperatures of formation of oxides and sulfides of the common ore metals. The temperature zones shown on this chart are fairly well in harmony with Emmons' zonal theory and with the zoning implied by Lindgren's classification of ore deposits. Ferric oxides and silicates are very largely confined to the high temperature zone. Ferrous minerals are formed at high temperatures, and continue to form, though in less abundance, to the low temperature zone. Sulfides do not form above the intermediate temperature zone, but continue to form in the low temperature zone. Thus unless a low temperature type of mineralization is superimposed upon a high temperature type, or vice versa, hematite would not be likely to occur with sulfides. The zoning suggests a gradual change in the nature of the depositing fluid, from oxidizing during its early, higher-temperature stages to reducing during its late, lower-temperature stages.

The influence of pressure may also be important in some cases. In the Ouray district of Colorado (Bibliography No. 35) laccoliths and sills have associated veins containing hematite, magnetite, chalcopyrite, and pyrite. Most of the magnetite was deposited before hematite. A decrease in pressure on the depositing liquids after they deposited magnetite is evident from the formation of filled fissures cutting magnetite-bearing lodes. The liquid is presumed to have volatilized to some extent, owing to this decrease in pressure. $FeCl_3$, being quite volatile, probably formed. This ferric iron has been deposited in fissures as hematite. The oxidation of ferrous to ferric iron provides considerable heat, and so the hematite was not necessarily deposited at a lower temperature than the magnetite, though it was deposited later in the period of mineralization.

Examples that are relavant to the above discussion are now given, tabulated according to their probable temperature of formation.

Epithermal deposits.

Some copper deposits in Tertiary sediments and volcanics in Japan are 'often intricately cut by veins and veinlets of quartz and micaceous specularite'. 'The specularite is decidedly primary in origin'. Its formation in Tertiary rocks, thus at shallow depth, was considered by Takeo Koto (Bibliography No. 26) to be worthy of comment as it refutes the general opinion that specularite is a hypothermal mineral.

On Iron Mountain, at the junction of the Coldwater and Nicola Rivers, veins of specularite are found in Tertiary(?) volcanics (Bibliography No. 26). If the deposits are Tertiary they must have been deposited at shallow depths.

At Katmai, Alaska, specularite was observed as an incrustation formed by fumaroles; thus here it formed under atmospheric pressure.

At Hickey's Pond, five miles west of the head of Placentia Bay, in Southeastern Newfoundland, are deposits of specularite associated with abundant alunite. (Bibliography No. 21) The deposits are in a silicified zone at the contact of granodiorite and volcanic schist. Specularite, alunite, and quartz in the zone are in parallel bands giving a gneissic structure to the deposit. The specularite occurs in ragged masses or individual grains and blades, lineated parallel to the gneissic structure. Small amounts of pyrite occur only in the specularite-poor silicified schist. The presence of alunite suggests the deposit is epithermal. In the same locality are specularite-bearing quartz veins containing a few grains of alunite. The sequence of deposition is (1) quartz, (2) specularite, (3) pyrite and alunite. In one or two places pyrite cubes replace specularite.

No reduction of specularite to magnetite is reported. However, the abundance of alunite ($K_2O.3Al_2O_3.6H_2O.4SO_3$), indicates sulfur rich solutions in the later stages of deposition, and the pyrite may have formed from the reduction of specularite rather than from introduction of pyrite as such. The reactions may be as follows:

$$Fe_2O_3 + 2H_2O \rightleftharpoons 2Fe(OH)_3$$

$$2Fe(OH)_3 + 3H_2S \rightleftharpoons 2FeS + S + 6H_2O$$

$$2FeS + 2S \rightleftharpoons Fe_2S_4 \text{ (pyrite)}$$

Only H_2S and S need be added in aqueous solution to cease the replacement, but they would be reducing, and a later change back to oxidizing conditions is necessary for the formation of alunite. The deposit may then be an example of reduction of hematite to pyrite by sulfur rich solutions introduced at a late stage. The alunite, introduced at a still later stage, may have formed at much lower temperature than the specularite.

Mesothermal deposits.

An example of replacement of hematite by magnetite during the introduction of sulfides is found in the George Copper deposit of Portland Canal, B.C. (Bibliography No. 28). In this deposit the paragenetic sequence is given as (1) wall rock alteration (2) pyrite (3) arsenopyrite (4) quartz (5) specularite (6) magnetite (replacing specularite) (7) chalcopyrite.

The deposition of quartz midway in the deposition of the metallic minerals suggests a change in conditions, since it is usually the first mineral deposited in a vein, and the specularite indicates this change was to oxidizing conditions. The replacement of hematite by magnetite before the deposition of chalcopyrite indicates a renewal of the reducing conditions necessary for the deposition of sulfides.

The deposit was considered to have formed under intermediate temperatures at a depth approximating eight thousand feet.

In the large quartz veins of Great Bear Lake, N.W.T. Bibliography No. 29) specularite has been deposited earlier than other metallics. It is not stated whether or not the hematite and later sulfides are in contact. The veins are considered formed at 'not very elevated temperatures'.

At the Eldorado mine, Great Bear Lake, N.W.T., hematite is associated with deposits of pitchblende (Bibliography No. 22 and No. 30). The hematite in the 'veins' was deposited after pitchblende, and before the sulfides.

Sulfides that are in contact with hematite include pyrite and chalcopyrite, and these iron bearing sulfides have formed by reduction of hematite.

The temperature of formation of this deposit is difficult to establish as the deposit shows several fairly distinct periods of mineralization.

Hypothermal deposits.

At Kalgoorlie, Western Australia, specularite is found in the 'deep vein zone' with quartz, magnetite, and ilmenite (Bibliography No. 36). These are cut by the later telluride bearing quartz veins.

In the Virgilina District, North Carolina and Virginia, primary bornite and chalcocite in quartz veins have minor associated specularite. No relation is given between the sulfides and the oxide. The veins are considered to belong to the 'deeper vein zone'.

On Tipella Mountain, near Harrison Lake, B.C. micaceous hematite occurs in a zone of lens-like bodies. Highly altered rocks on the contact of granite, and in places the granite itself is the host rock. (Bibliography No. 16.)

If the specularite is derived from the granite, its deposition in the granite indicates formation under high temperature.

Lindgren (Bibliography No. 25) states 'at many contacts of intrusive rocks not characterized by pegmatites, quartz veinlets abound and often carry crystallized specularite'.

Other Deposits.

It is perhaps noteworthy that specularite occurs without other associated metallics in many veins, and these hematite veins are probably more abundant than the literature indicates, for, since they are seldom economic, they receive little publicity. The veins at Tipella Mountain are apparently barren of sulfides. Others in which no indication of temperature of formation is given occur at Finger Lake, near Vanderhoof, B.C., and on Iron Range Mountain, near Kitchener, B.C.(Bibliography No. 16). The Kitchener deposits have been called sedimentary in origin (Bibliography No. 17), but later work shows the zone of micaceous and earthy hematite crosscuts the bedding. A small amount of magnetite occurs but as a rule little or no pyrite or other sulfide is visible.

Hydrothermal hematite is much more common in the 'contact metamorphic' deposits, but is seldom associated with sulfides in these deposits. The hematite is always in parts of the deposit that contain little sulfide, and the sulfides in parts that contain little hematite.

The almost complete lack of hematite in pyrrhotite bearing deposits has been attributed to the fact that pyrrhotite is a stronger reducing agent than most other sulfides. Since both pyrrhotite and hematite are commonly deposited in the 'deep vein zone' they would normally be associated. If an iron oxide is found with pyrrhotite it is invariably magnetite rather than hematite (Bibliography No. 27).

Further evidence of the tendency of hematite to be reduced to magnetite and/or pyrite is found in some deposits in which the hematite was probably originally sedimentary or a product of weathering. Reduction of hematite to magnetite and pyrite is considered to have occurred in the iron deposits of Michigan. Veins of pyrite indicate the presence of a reducing agent which could be organic acids (Bibliography No. 20). At Mesabi, 'graphite in considerable amounts associated with the magnetite, and siderite, indicate the former presence of reducing material which would convert the higher oxides of iron into magnetite' (Bibliography No. 31). Oxidation by hematite solutions carrying copper and sulfur is presumed to have caused deposition of native copper rather than copper sulfides in parts of the Michigan Copper Deposits (Bibliography No. 38). Bleaching of hematite from the wall rock of ore zones attests the the participation of hematite in the reactions producing deposition.

In summary, though hydrothermal hematite is commonly deposited under hypothermal conditions, it has formed in veins which appear to be mesothermal and epithermal, and in fumarole incrustations. The hematite is usually one of the first minerals to be deposited from vein-forming solutions. Where hydrothermal hematite was formed after hydrothermal (or magmatic) magnetite, an accompanying increase in temperature has likely occurred. Hematite is deposited under oxidizing conditions. If sulfur bearing, and thus reducing, solutions in contact with hematite, the hematite tends to be replaced by magnetite, or if the solutions are very rich in sulfur, pyrite or perhaps some other iron bearing sulfide. Abundant hematite thus should not occur with abundant sulfides becasue of their chemical incompatibility, and geologic evidence substantiates this theory.

Thus the sulfides of Q-17 west vein, and the specularite of Q-17 vein, could not be deposited from the same solution at the same time. No marked shearing of the quartz has taken place in either lens, thus reopening of the main 'break' by continued movement after the formation of vein is improbable. The mineralization of the two veins more likely occurred at different times in the same general period of mineralization, that of Q-17 vein occurring first under oxidizing conditions and that of Q-17 west vein occurring later under reducing conditions.

According to Schwartz (Bibliography No. 39, p. 371) the association of gold with specularite has no particular significance. He states 'A few examples of association of gold with specularite have been described. This occurrence does not seem significant except as an indication of fairly high temperature of formation at an early stage in formation of the veins'.

Mineralogical Conclusions.

In the galena-pyrite type of mineralization most of the gold is associated with three soft minerals which may be tellurides. These minerals occur as individual grains and aggregations in the galena. Minor amounts of gold are present in and near fractures in the quartz. The gold particles are up to 50 microns long, but are mostly irregular and much narrower than this.

In the specularite type of mineralization the gold occurs in disruptions between specularite 'cleavage' plates, and in minor amounts in and near fractures in the quartz. The gold particles are fairly equidimensional, and up to fifty microns in diameter.

The granularity of the quartz, and the mineralogic assemblage point to deposition under moderate temperature and pressure. Under Lindgren's classification the veins would be mesothermal.

The difference in mineralogy between Q-17 west vein and Q-17 vein is probably the result of deposition at different times during one general period of mineralization. The hematite of Q-17 vein was probably deposited first under oxidizing conditions, and the sulfides of Q-17 west vein deposited later under reducing conditions.

GENERAL CONCLUSIONS

The limestone of the Unuk Area is probably Permian, the sedimentary and volcanic rocks to the west of the limestone Pre-Permian, and those to the east Triassic and Jurassic (Hazelton).

The host rock of the veins is a dynamo-thermal metamorphosed water-lain dacite tuff, or andesite tuff containing detrital quartz. The veins do cut intrusive diorite gneiss, but diminish in both size and grade in the intrusive.

The intrusive diorite has caused recrystallization of tuff on its contacts, forming paragneiss which is difficult to distinguish from the intrusive orthogneiss. Little or no skarn has developed in siliceous limestone beds near the intrusive diorite. Actinolite, tremolite, and dippside have formed, likely by metamorphism rather than metasomatism, in bands of a few millimeters' width rimming tuff fragments in limestone. Epidote is abundant in most andesitic and dioritic rocks, both intrusive and extrusive. The area has undergone regional metamorphism of medium grade.

The quartz veins show a marked parallelism in attitude, striking 115 degrees, and dipping 80 degrees northeast, with the exception of Q-19 vein, which dips only twenty to forty degrees north-east. They have been intruded along 'breaks' caused by shearing forces. Mineralized faults, dyke-filled tension fractures, the vein 'breaks', folding, and regional foliation can be fitted into a strain-ellipsoid pattern which indicates the deforming pressure came from the southwest and/ or northeast. The source of this pressure could be orogeny associated with the coast range intrusives, or the local diorite gneiss sills, but is more likely the former. The most promising veins occur in a band of sediments between two sills, but the evidence indicates the vein-forming fluids were derived from Coast Range Intrusives rather than the Triassic(?) sills.

The wall-rock alteration produced by the vein-forming fluids has penetrated only a few feet into vein walls. Sericite, kaolin, chlorite, pyrite, albite, and quartz have formed by replacement and fracture-filling. This alteration is typical of veins of the mesothermal class.

Quartz veins are divided into three classes on the basis of their mineralogy. (1) Chalcopyrite, pyrite, magnetite veins devoid of precious metals (2) Galena pyrite veins with minor sphalerite, chalcopyrite, three soft minerals which may be tellurides, and gold. The gold occurs in irregular veinlets and segregations, usually associated with one or more of the soft minerals as inclusions in galena; and as individual grains in or near fractures in the quartz. (3) Specularite veins, containing little or no sulfides. The gold occurs in irregularities between specularite 'cleavage' flakes, and in or near fractures in the quartz. Classes (2) and (3) give good assays in gold.

The gold grains in class (2) are quite irregular, up to 50 microns long and about ten microns wide. Those in class (3) are more equidimensional, and up to 50 microns in diameter. Extraction of gold should not be difficult.

Specularite is deposited under oxidizing conditions, and thus cannot be deposited from the same fluid at the same time as sulfides, which require reducing conditions for deposition. No geologic evidence for two periods of mineralization was found, so the specularite and sulfides are considered to be deposited at slightly different times, the specularite first, in the one general period of mineralization.

The metallic minerals in the veins are members of the moderate to high temperature type of mineralization. The quartz grains are fairly coarse (several millimeters in diameter) thus not of the epithermal type. The lack of banding and other structures diagnostic of open-space deposition, except for a few vugs, indicate deposition at moderate pressure. Vein filling, wall rock alteration, and the regularity and continuity of the 'breaks' all indicate a mesothermal deposit. The veins show good promise of continuing to depth.

Theoretical sequence of events in the region is (1) Deposition of sediments - limestone, quartz siltstone, argillite, and tuff, in marine environment, at times practically simultaneously, during late Palaeozoic time. (2) Uplift, erosion, and probably some tilting or slight folding during the Appalachian Revolution. (3) Depression of the area, and continued sedimentation of tuff and probably minor limestone. Intrusion of diorite 'sills', probably as separate bodies, perhaps causing some folding in the intruded sediments during Triassic time. (4) Slight uplift and deposition of shallow water sediments as argillite, and volcanics (Hazelton) during Jurassic time, giving fairly deep burial of the Palaeozoic sediments. (5) Intrusion of the Coast Range composite batholith during Jura-Cretaceous time, producing further folding, regional metamorphism, faulting, and uplift of the bedded rocks, followed and accompanied by mineralization. (6) Erosion, in part by glaciation, till today Palaeozoic rocks are again exposed.

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37. F.B. Laney........ 'The Relation of Bornite and Chalcocite in the Copper Ores of the Virgilina District of North Carolina and Virginia', Ec. Geol. Vol. 6, p. 399. 1911

38. G.M. Schwartz..... 'The Host Minerals of Native Gold', Ec. Geol. Vol. 39, 1944.

POLISHED SECTION PHOTOGRAPHS

No.	Micro-scope	Oc.	Obj.	Mag.	Time	Filter	Nicol	Section No.
1.	H.V.W.	x8	1/7a	700	8 sec.	dark blue(#2)	not crossed	#1
2.	"	"	"	"	300 sec.	none	"	#10
3.	"	"	"	"	10 sec.	none	"	#2
4.	"	"	"	"	15 sec.	none	"	#2
5.	"	"	6a	570	8 sec.	dark blue(#2)	"	#1
6.	"	"	3b	204	13 sec.	none	"	#15
7.	"	"	6a	570	10 sec.	none	"	#19
8.	"	"	3b	204	15 sec.	light blue	"	#11
9.	"	"	3b	204	15 sec.	light blue	"	#6

THIN SECTION PHOTOGRAPHS

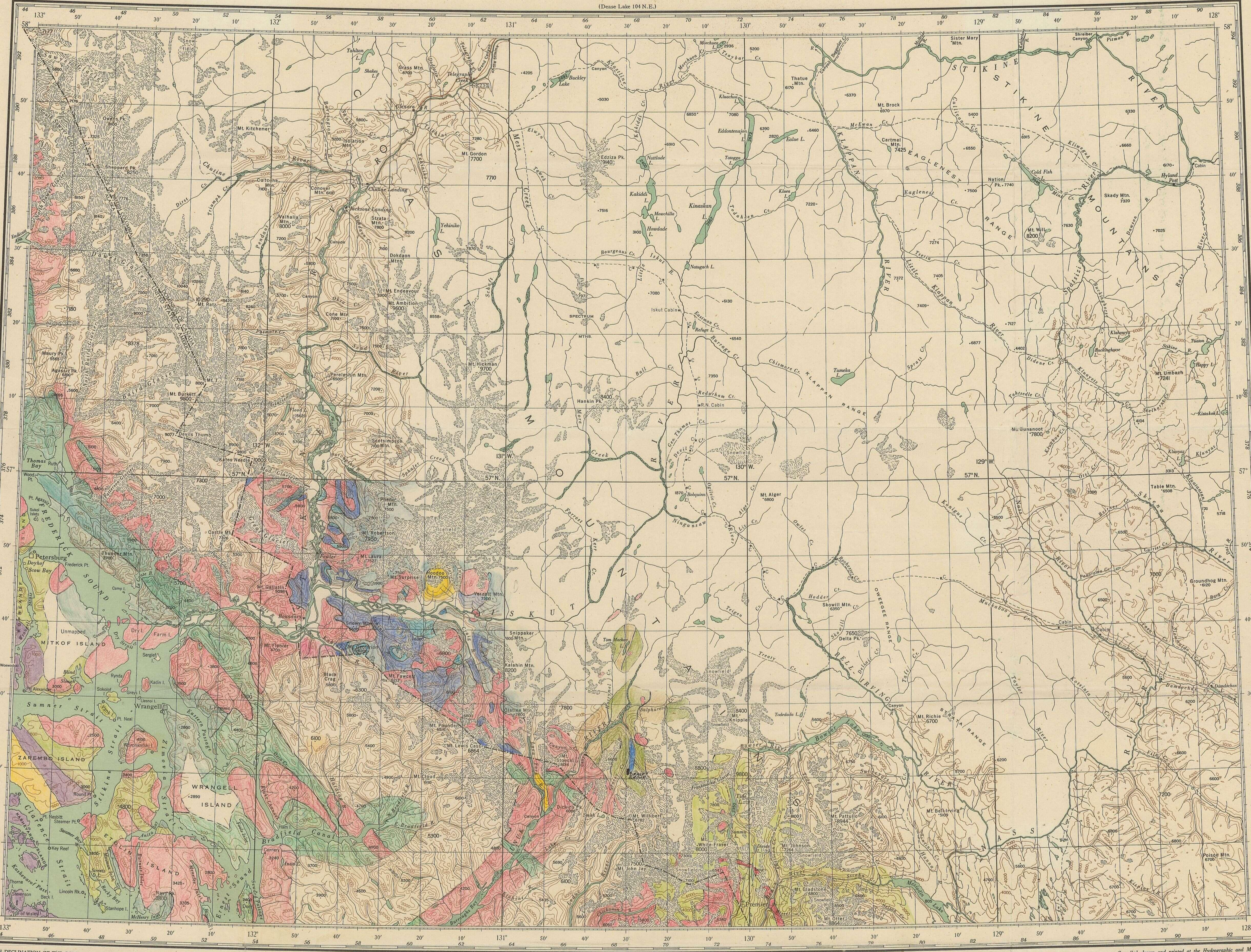
No.	Micro-scope	Oc.	Obj.	Mag.	Time	Light	Nicol	Section No.
1.	Leitz 331223	x8	3B	80	600 sec.	Lamp-box	crossed	Q-51
2.	"	"	32	25	15 sec.	"	not crossed	Q-25
3.	"	"	3B	80	840 sec.	"	not crossed	Q-40
4.	"	"	32	25	17 sec.	"	not crossed	Q-40
5.	"	"	32	25	15 sec.	"	not crossed	Q-22
6.	"	"	3B	80	840 sec.	"	crossed	Q-53
7.	"	"	3B	80	600 sec.	"	crossed	Q-26
8.	"	"	3B	80	600 sec.	"	crossed	Q-26
9.	"	"	32	25	60 sec.	"	crossed	Q-26

Canada
Department of Mines and Resources
SURVEYS AND ENGINEERING BRANCH
HYDROGRAPHIC AND MAP SERVICE

NATIONAL TOPOGRAPHIC SERIES

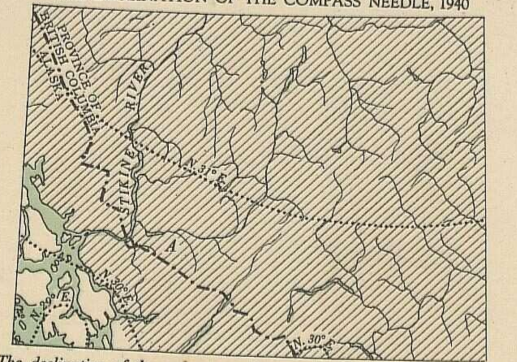
SHEET 104 S.E.

(Dease Lake 104 N.E.)



(Prince Rupert - Stewart 103 N.E.)

THE DECLINATION OF THE COMPASS NEEDLE, 1940



The declination of the compass needle at any place along a dotted line is the declination given on that dotted line. At other places the declination is between those given on the neighbouring dotted lines; thus at the place marked A, the declination is between N. 30° E. and N. 31° E. The declination of the compass needle is decreasing 4 minutes annually.

Aerial photography

REFERENCE

- *Boundary: international*
- *Secondary road*
- *Trail*
- *City or large town*
- *Town or village*
- *Settlement* — *with post office*
- *Wireless station with call letters* — CZ3G
- *Mine*
- *Glacier*
- *Sand or mud flat*
- *Rapids and falls* — R F
- *Braided stream*
- *Lighthouse*
- *Cabin* — C
- *Height in feet* — 6800
- *Contours (approximate)* — 3000

Contours are shown at 500, 1000, 2000, 3000, 4000, 6000 and 8000 feet above mean sea level.

STIKINE RIVER
BRITISH COLUMBIA
(PRELIMINARY EDITION)

Scale 8 miles to 1 inch or 1:506,880

Miles 8 6 4 2 0 8 16 24 32 Miles

NOTE: Grid squares may be drawn on this map by joining the corresponding divisions shown along the outer border. The even numbers of the squares are given along the outer border.

Price 25 cents

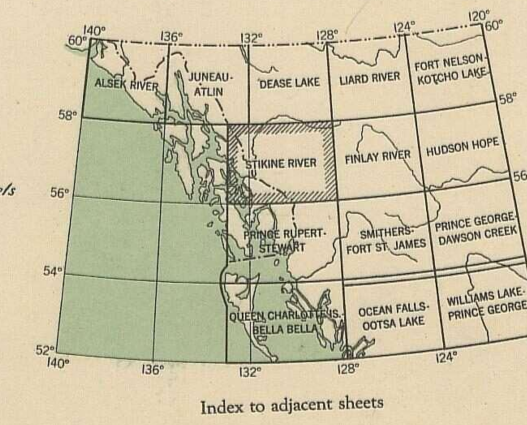
Panhandle and Portland Canal
- Cenozoic volcanics
- Mesozoic sediments and volcanics (Hazelton?)
- Mesozoic and Palaeozoic gneiss, schist, phyllite, marble
- Mesozoic and Palaeozoic slate, phyllite, schist, limestone
- Palaeozoic sediments and volcanics

Iskut
- Cenozoic Volcanics
- Triassic andesite, keratophyre basalt, agg, tuff, conglomerate
- Permian limestone
- Pre-Permian argillite, slate phyllite, quartzite, schist

Unuk
- sediments
- limestone
- volcanics with hypabyssals

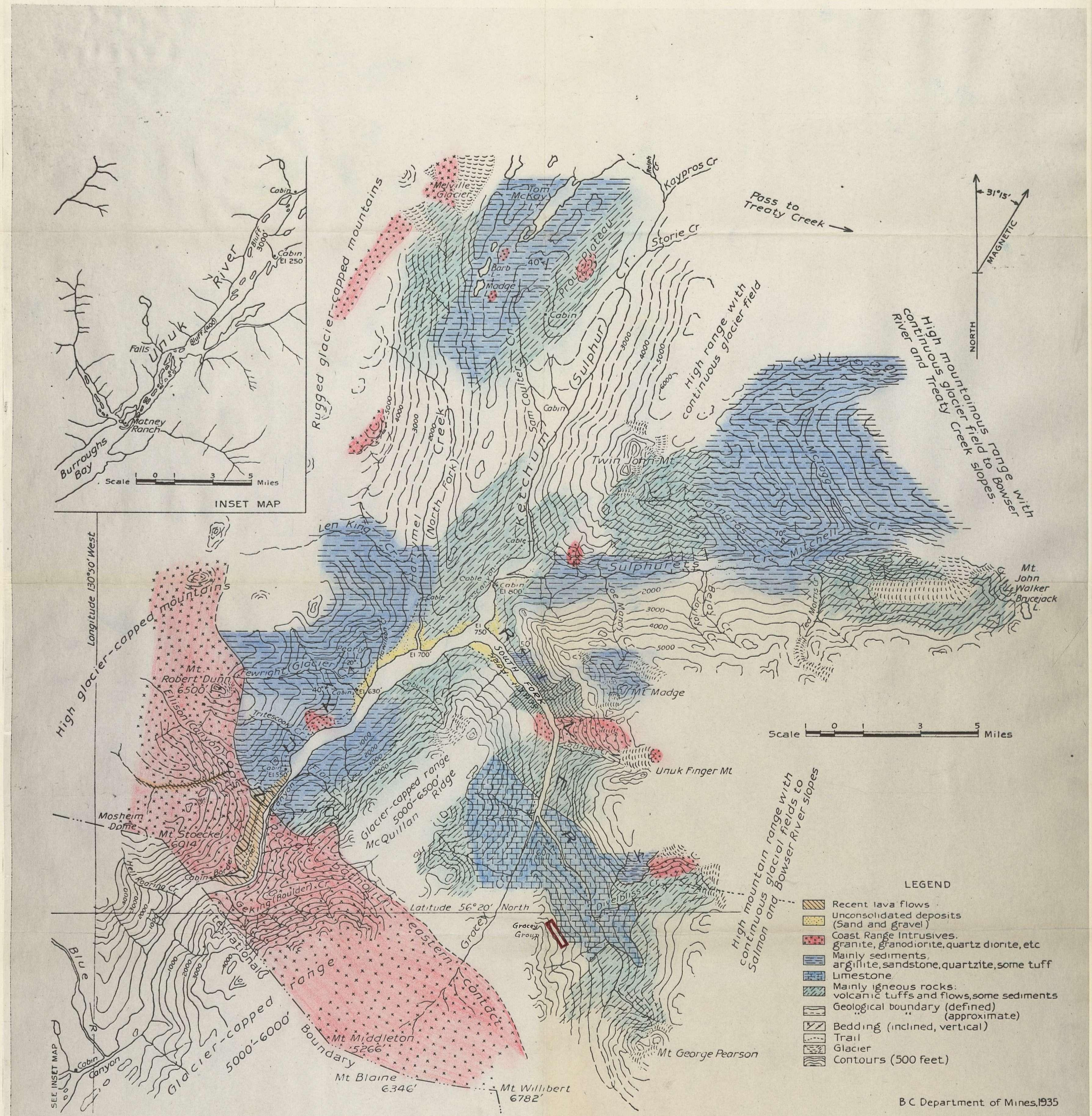
Coast Range Intrusives

Compiled, drawn and printed at the Hydrographic and Map Service, Labelle Building, Ottawa, 1945. where additional copies may be obtained. Revision of map of 1943.



Index to adjacent sheets

SHEET 104 S.E.



Geological Sketch-map of Unuk River Area.

GRACEY ~ SWANSEA
GROUP
UNUK RIVER
1 in = 200 ft.
Legend
outcrop boundary
bedding attitude
gneissic banding
contour lines
faults
quartz veins
definite probable contacts
limestone
argillite, tuff
dioritic gneiss
massive greenstone
lamprophyre dyke
aplitic dyke
Q No. location of specimen
RHS
ORTHOGNEISS 'LOWER SILL'
PARAGNEISS?
PARAGNEISS
PTARMIGAN HILL
Q 22 vein
Q 17 vein
Q 17 west vein
Q 23 vein
Q 25 vein
Q 19 vein
GLACIER BOUNDARY
ORTHOGNEISS ? 'UPPER SILL'