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GEOLOGY OF HYDER AND VICINITY SOUTHEASTERN ALASKA

WITH A RECONNAISSANCE OF CHICKAMIN RIVER

BY

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FOREWORD

By Philip S. Smith

Among the important duties of the United States Geological Survey in Alaska have been the exploration for mineral deposits and the critical examination of those that have been found. Southeastern Alaska has long been known to contain valuable mineral deposits, many of which have been developed by producing mines, and most of them have been studied more or less thoroughly by the geologists of the Alaskan branch of the Geological Survey. The region near the head of Portland Canal was early known to be one of the places where there were indications of valuable ores. However, not until the discovery in 1918 of the phenomenally rich silver and gold ores of the Premier mine, on the Canadian side of the international boundary, was much public interest in the district aroused. To meet the call for information as to the possibility of similar ores occurring on the American side, L. G. Westgate, geologist, in 1920 spent a month in field work in the district and prepared a report of his observations, which was published in Geological Survey Bulletin 722. The amount of prospecting that had been done on the American side at that time was so slight that no definite prediction as to the future of the district could be made. Enough information was obtained, however, to show that further prospecting and development were fully justified.

In 1924 the Geological Survey prepared a topographic map of Hyder and vicinity to serve as a base on which the geology could be mapped in some detail, and in 1925 A. F. Buddington, who had spent several years examining the geology and mineral deposits in many parts of southeastern Alaska, was assigned to study the district. The results of Mr. Buddington's studies, as well as the observations and interpretations by other geologists who have authoritative information on the problems involved, are set forth in the accompanying report.

Without attempting to summarize or brief the contents of the report it may be pointed out that the region is of great scenic and geologic interest, as it lies within the eastern portion of the Coast

Range and includes part of the eastern contact of the Coast Range batholith. In the main the rocks are of igneous origin, and probably the most significant determination by Mr. Buddington is that the igneous rocks belong to three rather distinct divisions—(1) a granodiorite which forms the Texas Creek batholith and was intruded into a series of greenstone, tuff, graywacke, and slate called the Hazelton group, (2) a pink quartz monzonite that forms the Hyder batholith, (3) a pink granodiorite that forms the Boundary stock. The ore deposits are intimately and probably genetically associated with the Texas Creek batholith, which is the oldest of these igneous members. Five types of veins are discriminated—quartz fissure veins of lead-silver-gold type, veins and veinlike replacement deposits of silver-gold type (not yet recognized in the American part of the district), veins of the gold type, disseminated and lenticular replacement deposits, and mineralized fissure zones approximately parallel to the structure.

As a whole the region is still in a prospecting stage, though a small amount of ore has been shipped from some of the claims. Much further prospecting and study will be required before the real value of its mineral deposits can be determined. In the search and development, however, the numerous suggestions made by Mr. Buddington in the section of the report entitled "Notes on prospecting" should focus attention on the areas where efforts are most likely to be successful and prevent waste of time and money on those areas where geologic conditions are not regarded as favorable.

GEOLOGY OF HYDER AND VICINITY, SOUTHEASTERN ALASKA

WITH A RECONNAISSANCE OF CHICKAMIN RIVER

By A. F. Buddington

INTRODUCTION

The drainage basin of Salmon River lies in part within southeastern Alaska in the Hyder mining district and in part within British Columbia. It has been known for 25 years that mineral deposits occur within the Alaskan part, but until the development of the Premier mine in adjoining British Columbia the country, which was relatively inaccessible, attracted but little capital for prospecting. Within the last few years, however, the outstanding success of the Premier mine and the active prospecting and development work being prosecuted in the Canadian part of the Salmon River and adjoining Bear River drainage basins have stimulated interest in prospecting and in the development of prospects within the American part of the Salmon River Basin. A number of new mineral deposits that warrant the expenditure of capital in prospecting have been discovered, several properties have undergone active development, and the Riverside mine has been brought to a stage of production within this period.

In 1925 geologic mapping of the Hyder district was undertaken by the writer to obtain a more complete picture of the geologic setting and mode of occurrence of the mineral deposits as an aid to intelligent prospecting of the area and development of the discovered deposits and to present for public information a systematic account of the known mineral deposits and the work done on them. A reconnaissance of the Chickamin River Valley was made in order to evaluate the possibilities of that region as an area for prospecting.

FIELD WORK

In 1920 L. G. Westgate was engaged from July 19 to August 17 in making a geologic investigation of the country between Salmon River and the international boundary. In 1924 a topographic base map of the Hyder district was prepared by R. M. Wilson. (See pl. 1.) In 1925 the writer was engaged from July 8 to September 19 in making a geologic map of this district and in an investigation of the mineral deposits. (See pl. 2.) The time was too short to penetrate the country south of Thumb Creek and to map accurately the northern border of the Hyder quartz monzonite west of Salmon River; this contact is therefore inferred and is indicated by a dotted line. In 1925, between August 25 and September 16, Willard B. Jewell made a geologic reconnaissance of the country lying along Chickamin River from Behm Canal to the head of the West Fork of Texas Creek. (See pl. 3.) The detailed description of the mines and prospects covers only the development up to 1925. Since that date considerable additional work has been done at many of the properties, and a number of them have passed into the hands of other owners.

ACKNOWLEDGMENTS

The writer is deeply indebted to Willard B. Jewell for able assistance in the field and in the laboratory. Mr. Jewell made a reconnaissance and prepared a report on the geology along the Chickamin River Valley and subsequently in the laboratory made an intensive study, followed by a report upon the nature and relations of the metalliferous minerals of the Salmon River area as studied with the microscope. The parts of the present report that deal with the geology of the Chickamin River Valley and the microscopy of the ore minerals are based on his work.

The writer is also under obligations to E. M. Jones and Malcolm Smith, of Hyder, for their satisfactory services as packers, and to George King and Wesley Myers, of Ketchikan, for their efficient aid as boatmen on Chickamin River. The prospectors and men in charge of the development of prospects were uniformly obliging in giving information and assistance whenever requested.

The report on the Salmon River district by Westgate[1] has been of the greatest assistance to the writer, and much of Westgate's material has been incorporated in this report.

The photographs reproduced in Plates 5, 6, and 9 were taken by R. M. Wilson in connection with his phototopographic survey of the district.

HISTORY

A brief summary of the history of the district has been given by Westgate,[2] who writes:

> Metal-bearing lodes, chiefly of gold and silver, were found in the Canadian portion of this region about 1898 [the year of the great Klondike gold rush], and similar discoveries had been made on the Alaska side of the boundary by 1901. These deposits received relatively little attention until 1909, when a small

[1] Westgate, L. G., Ore deposits of the Salmon River district, Portland Canal region: U. S. Geol. Survey Bull. 722, pp. 117–140, 1921.

[2] Idem, p. 117.

boom was started in the Canadian district. This boom subsided in a few years, but meanwhile the town of Stewart and some 12 miles of railroad were built. Interest was revived in 1917 by the discovery of some rich silver ores on the Canadian side of the line, and in 1918 a commercial ore body was found at the Premier mine, which, though in the Salmon River Basin, is also in Canada. As a result, many claims were staked on both sides of the boundary, and the town of Hyder sprang up.

In their search for placer gold the early prospectors proceeded into the Chickamin River Valley in part by way of Salmon and Chickamin Glaciers. Old stakes indicate that incidentally they took their way along the branches of Chickamin and Texas Glaciers and along the West Fork of Texas Creek, but without any intensive search for vein deposits.

In 1923 employees of the United States Forest Service, who were engaged in building a prospector's trail up the West Fork of Texas Creek, recognized quartz fissure veins with shoots of auriferous and argentiferous lead ore. About 30 prospectors rushed to the district, and over 100 claims were recorded by the middle of September. In 1925 a 60-ton mill for the concentration of gold-silver-lead ore was completed at the Riverside property and put into operation for a couple of months in the early part of the year. The property was then idle for several months pending arrangements for its operation by a new company, after which a small additional production was made in the later part of the year. The newspapers reported that 218.5 tons of concentrate was produced in 1926 from the Riverside mine.

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GEOGRAPHY

LOCATION AND TRANSPORTATION FACILITIES

The Salmon River area of southeastern Alaska lies at the head of Portland Canal, a steep-walled fiord which cuts obliquely across the Coast Range for some 90 miles from Dixon Entrance, at the southern border of Alaska. Its limits are defined on the east and north by the international boundary, and on the west by the drainage divide between the headwaters of the streams tributary to Salmon River and those tributary to Chickamin River. (See pl. 1.) The area lies in the northeastern part of the Hyder mining district, and the mine recording office is at Hyder.

The portion of the Salmon River area that lies in British Columbia has been well described by Schofield and Hanson.[3]

The town of Hyder is situated at the head of Portland Canal, at the mouth of Salmon River and on the international boundary, at

[3] Schofield, S. J., and Hanson, George, Geology and ore deposits of Salmon River district, B. C.: Canada Geol. Survey Mem. 132, 1922.

approximately latitude 55° 55′, longitude 130° 1′. (See pl. 4, *A*.) A spur of the Reverdy Mountains extends south to the coast, where the delta and tidal flats built out into the canal by Salmon River extend around the base of the steep mountain slope. Part of the town is built on piling over the tidal flats, but the newer part is on the gravel-floored valley of Salmon River, to the northwest. The original settlement was called Portland City, but it was renamed in honor of George Hyder, engineer for the Alaska-Gastineau Mining Co., which had an option on the Big Missouri property on the Canadian side in 1915. A wharf about two-thirds of a mile long has been built over the tidal flats to deep water, and Hyder is accessible to ocean vessels throughout the year. It may be reached by means of the regular steamship service to Stewart from Vancouver and Prince Rupert, B. C. (135 miles), by regular weekly mail boats from Ketchikan (155 miles), and by occasional steamships direct from Seattle.

The town of Stewart lies about 2 miles to the northeast, on the British Columbia side of the boundary, and although older than Hyder it is of about the same size. It is connected with Hyder by a road suitable for automobiles.

The district has been opened up by a road suitable for automobiles from Hyder to the Premier mine, on the Canadian side. This road runs along the east side of Salmon River most of the way, and about 11 miles of its course is in American territory. It affords the only practical mode of access to the mineral deposits in the upper part of the drainage basin of Salmon River, a factor that has contributed to the growth of Hyder.

A pack trail has been built by the United States Forest Service up the West Fork of Texas Creek, one of the major tributaries of Salmon River, from the bridge across Salmon River above Ninemile, at an altitude of 335 feet, to Chickamin Glacier, at the head of the West Fork Valley, at an altitude of 2,350 feet, a distance of about 11 miles. A branch trail goes over a low saddle, at an altitude of 870 feet, to the foot of Salmon Glacier, at an altitude of 535 feet. Another pack trail has been built by the Forest Service up Fish Creek from the Salmon River Road, and a branch from it to the Titan property.

CLIMATE

The Salmon River district lies within the Pacific coast climatic province, where there is abundant rainfall and relatively moderate temperature. From November to March the precipitation at sea level is chiefly in the form of snow. The rainfall is least in late spring and early summer; it is greatest in July, August, September, and October, when rain falls on about half the total number of days. A summary of the climatic conditions at Stewart, B. C.,[4] is equally applicable to Hyder.

Summary of meteorologic observations at Stewart, British Columbia, 1911–1921

Month	Temperature (°F.)	Rainfall (inches)	Snowfall (inches)	Days of precipitation
January	19.3	7.23	58.20	13
February	25.9	5.87	37.17	9
March	30.5	4.59	17.05	10
April	39.2	3.69	5.10	10
May	48.2	2.07		9
June	54.4	1.99		8
July	57.4	3.24		10
August	55.8	7.88		13
September	50.0	7.72		15
October	41.9	11.35		19
November	31.7	8.42	25.90	17
December	26.0	9.68	60.68	16
Year	40.0	73.73	219.56	149

The snowfall is much heavier at most places inland than at Stewart. At the Premier mine it is reported to have amounted to 40 feet in 1923 and 60 feet in 1924. On the other hand, it is much less at the foot of Chickamin Glacier, where it is reported to have been only 6 feet in 1923.

VEGETATION

All the valley bottoms, except those occupied by glaciers or the immediate flood plains of the rivers, are well wooded. In general, the slopes, up to an altitude of 3,000 feet and in favorable places 3,500 feet, are clothed with a dense growth of forest, except where it has been swept away by snowslides. (See pl. 4, *B*.) Above the timber line to a height of about 4,000 or 4,500 feet there is a belt which is covered by heather, with here and there straggling patches of stunted and scrawny trees. Above the heather is a zone of alternating bare rock, rock flakes, and angular glacial débris, with patches of snow, which extends to the lower limit of the glaciers and the snow or ice caps. On comb ridges too narrow to support a snow field this zone may extend as high as 6,400 feet.

The forests consist chiefly of hemlock and spruce, commonly with hemlock predominating. Yellow cedar is found locally. There is sufficient timber along Salmon River, Texas Creek, West Fork, and the mouth and head of Thumb Creek to supply all mining needs.

The slopes at the ends of the ridges between Through and Greenpoint Glaciers, between Greenpoint and Ferguson Glaciers, and

[4] Schofield, S. J., and Hanson, George, Geology and ore deposits of Salmon River district, B. C.: Canada Geol. Survey Mem. 132, pp. 6–7, 1922.

between Texas and Chickamin Glaciers are covered with timber as high as 3,000 to 3,500 feet; but near the head of Skookum Creek, east of Salmon River, the forest extends only to a height of 2,800 feet.

WATER POWER

There are water-power sites on Thumb Creek, the West Fork of Texas Creek, Salmon River, and many of the smaller mountain streams. Development of water power on the three major streams, however, would necessitate consideration of the fact that in the spring and summer they carry considerable glacial flour, which would tend to silt up the reservoirs. Adequate power for prospecting can usually be developed from the mountain streams on most of the properties.

TOPOGRAPHY

GENERAL FEATURES OF THE RELIEF

The Salmon River district lies within the eastern part of the Coast Range. The topography of the district is one of great relief, with the highest peaks 4,000 to 5,000 feet above the valley bottoms. (See pl. 5, *A* and *B*.) The scenery is bold and striking and is particularly grand in the vicinity of the international boundary just west of Mount Bayard, where the highest sharp-pointed peaks reach altitudes of over 7,000 feet above sea level, and though they rise above great uniform fields of snow and ice that cover many of the lower mountain tops and partly fill all the valleys, yet they themselves bear, carved in their sides, large amphitheaters occupied by glaciers.

The mountains in general have been glacially rounded to a height of about 6,000 feet or more, and sharp-pointed, serrate peaks are found only above this altitude. Snow or ice caps cover all large areas above 5,000 feet that are not too steep, and on protected divides they occur locally as low as 4,600 feet. Glaciers are found in protected basins at still lower levels. The valley walls have been glaciated and usually have very steep slopes or, in some parts of the region, sheer cliffs. Except where broken by these cliffs or by the narrow gorges and gulches cut in postglacial time, the slopes, though steep, are generally smooth. At the base of the steeper slopes in the valleys that are now free of glaciers there are large accumulations of talus which, with the alluvial fans built up at the mouths of gulches, have flattened the lower slopes and have tended to give a V-shape to what were previously glaciated U-shaped valleys.

Most of the area shown on Plates 1 and 2 lies within the drainage basin of Salmon River, but the extreme western parts lie within the drainage basin of Chickamin River. The major tributaries of Salmon River are Cascade Creek, Texas Creek, Thumb Creek, Fish Creek, and the creek that enters from the southwest on the west side of the river about 3½ miles northwest of Hyder. The divide between the drainage basins of Chickamin and Salmon Rivers trends, in general, almost true south parallel to Salmon River and Salmon Glacier. The West Fork of Texas Creek has, however, pushed its headwaters far back into this divide and has produced in it a big bend to the west. Indeed, the West Fork would not have to cut its bed much lower and advance headward much farther to capture the drainage of the upper part of Chickamin Valley, now occupied by Chickamin Glacier.

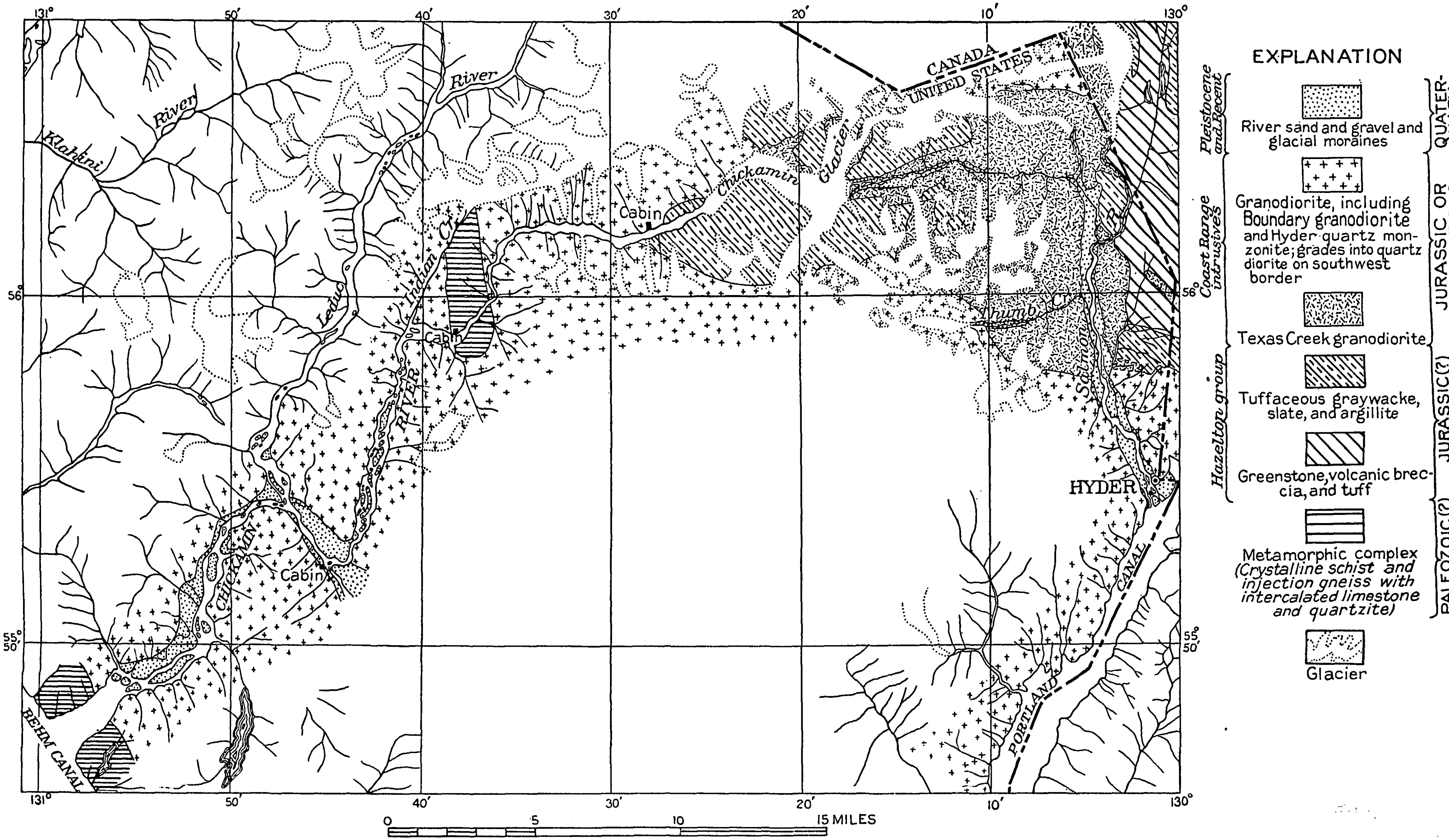
The dominant elements of the relief are the Bear River Ridge, between Salmon and Bear Rivers, the unexplored group of mountains south of Thumb Creek, the ridge between Thumb Creek and the West Fork of Texas Creek, the ridge between the West Fork of Texas Creek and Texas Glacier, and the ridge between Texas Glacier and Boundary Glacier. The Bear River Ridge trends north; the other ridges trend west.

The part of the Bear River Ridge that is within this district is rounded and flat-topped. It has a general altitude of about 5,000 feet and culminates on the south in the snow-capped peak of Mount Dolly, at an altitude of 5,475 feet. This ridge rises with steep slopes from the valley floor of Salmon River.

The divide between the drainage to Thumb Creek and Greenpoint Glacier and the drainage to the West Fork is 1½ times as far from the West Fork as from Thumb Creek. It has a length of about 5 miles, and for a third of this distance it is 6,000 feet or more in altitude. The lowest pass accross it is Ferguson Glacier, at an altitude of about 4,600 feet. Several peaks rise to heights of 6,300 feet. Snow fields and ice caps cover most of the divide, and from it flow five major glaciers—Hidden, Casey, and Ferguson to the West Fork, and Gray and Thumb to Thumb Creek.

The divide between the West Fork and Texas Glacier is three times as far from the West Fork as from Texas Glacier. It is about 4½ miles long, and nearly half of it is above 5,000 feet in altitude. There are two ice caps with their crests at about 5,800 feet, separated by a pass at the head of Ibex Gulch at an altitude of about 4,800 feet.

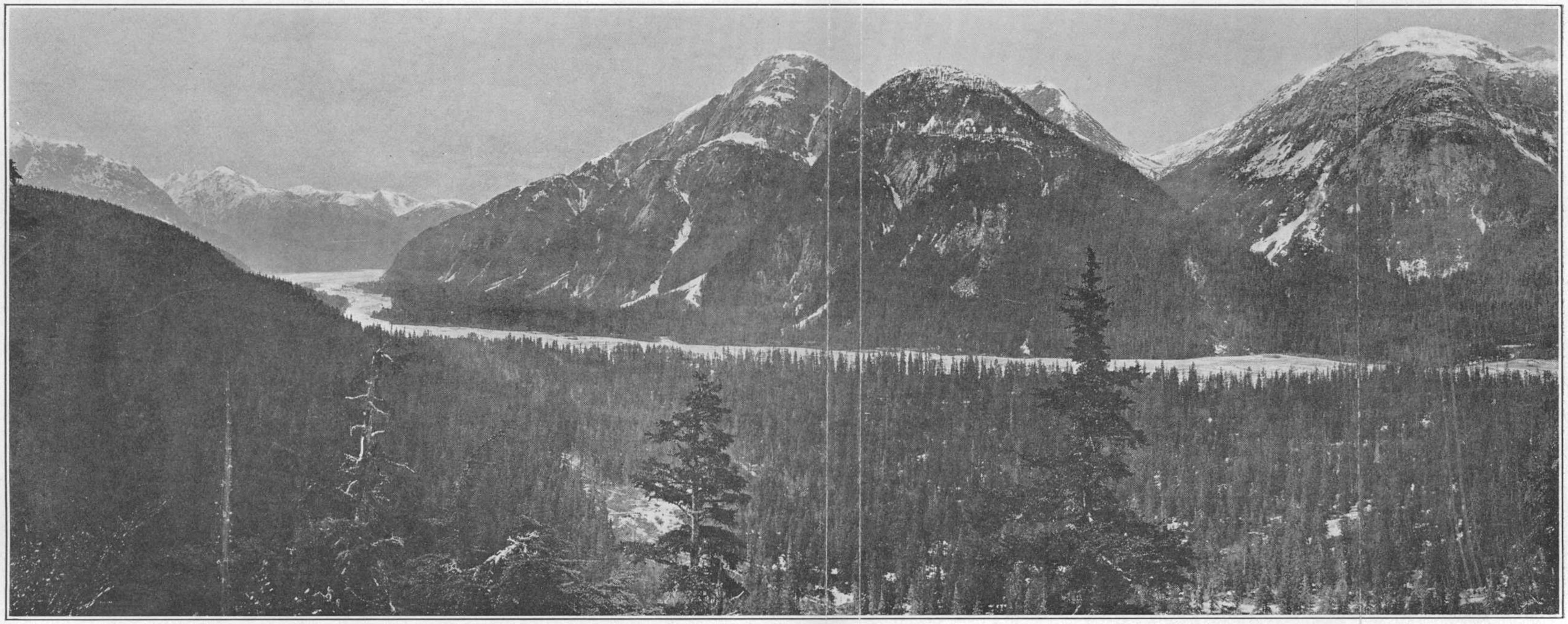
The ridge between Texas and Boundary Glaciers in general slopes from a maximum of 6,100 feet at the head of Boundary Glacier to 4,700 feet just west of the international boundary. Practically the whole ridge is capped with snow throughout the year.



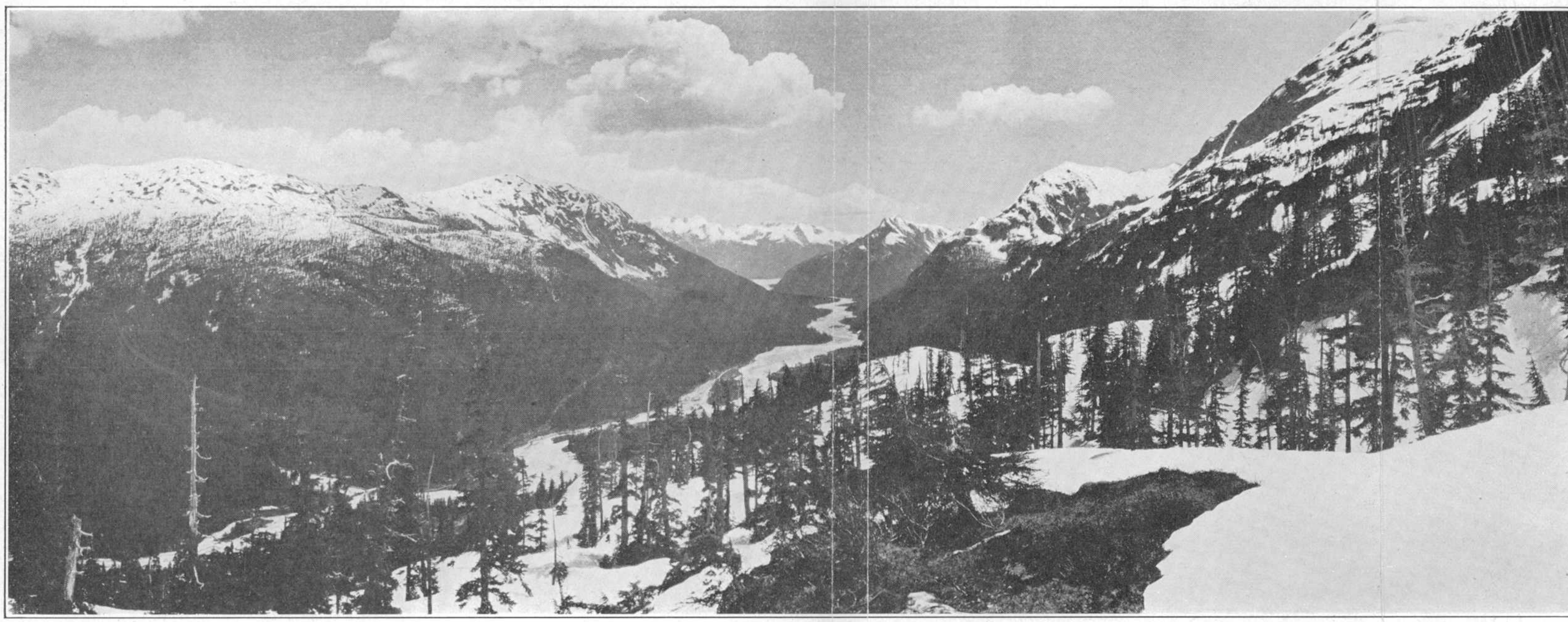
GENERALIZED SKETCH MAP OF THE UPPER PORTLAND CANAL AND CHICKAMIN RIVER REGIONS

A. TOWN OF HYDER, AT THE HEAD OF PORTLAND CANAL AND THE MOUTH OF SALMON RIVER

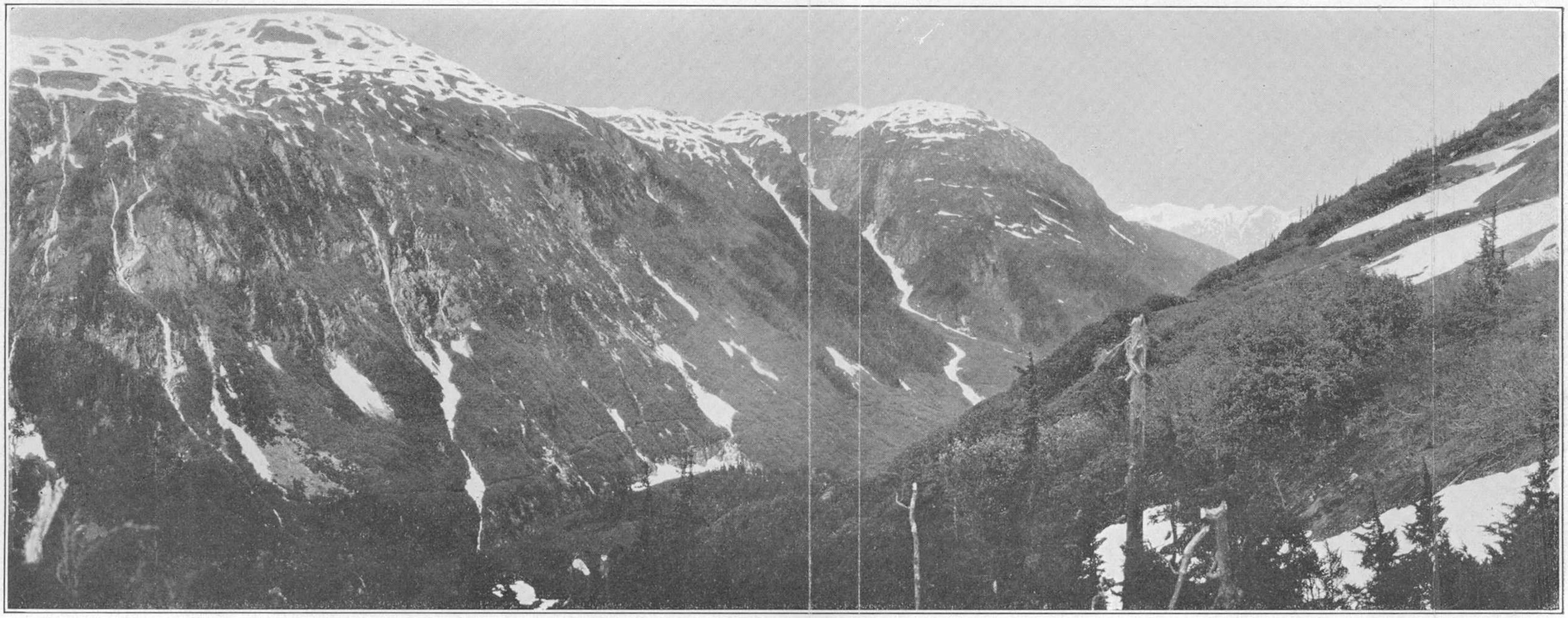
B. DENSE FOREST GROWTH ON SLOPES BELOW AN ALTITUDE OF 3,000 FEET, SALMON RIVER VALLEY



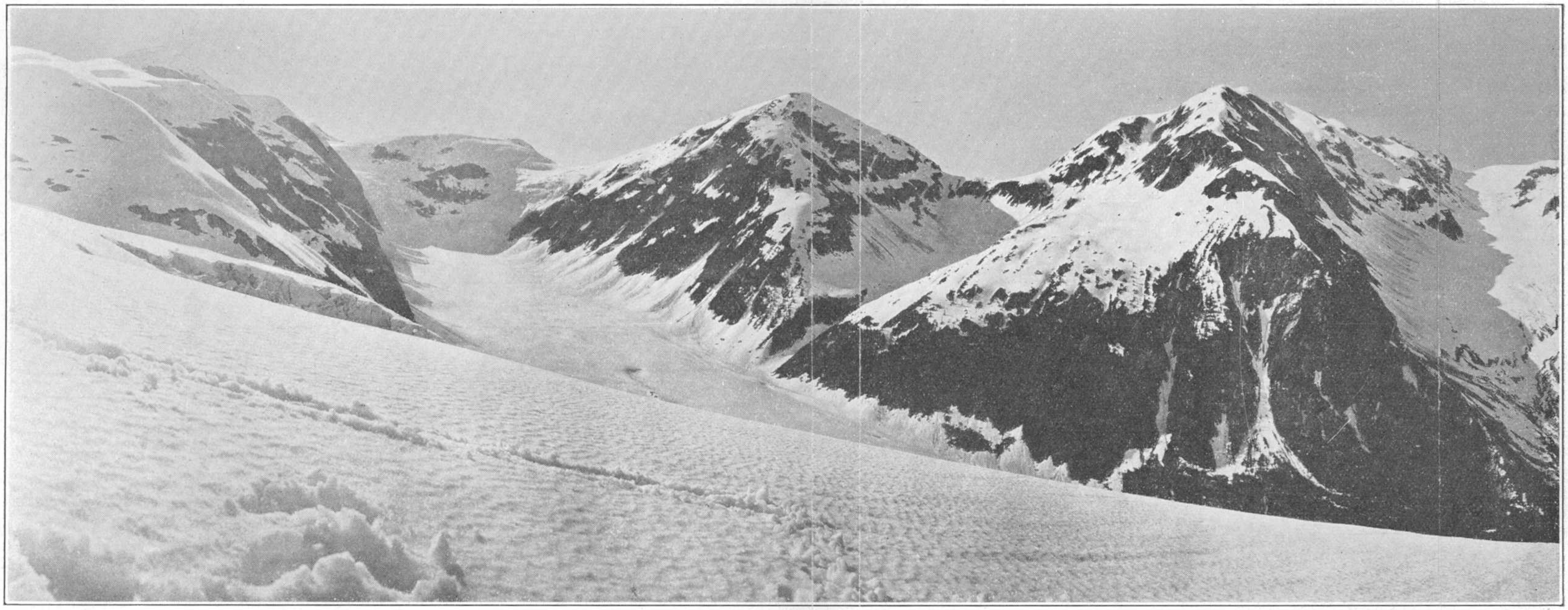
A. MOUNTAINS OF COAST RANGE ON WEST SIDE OF SALMON RIVER, NORTHWEST OF HYDER



B. VIEW OF VALLEY OF SALMON RIVER



A. VALLEY OF WEST FORK OF TEXAS CREEK BELOW CASEY GLACIER



B. HEAD OF HIDDEN GLACIER

STREAMS

Salmon River is the master stream of the district. It heads in Salmon Glacier (see pl. 7, *A*), which heads against the Nass River divide. Salmon River from the foot of the glacier to Portland Canal is approximately 13 miles long. For about 1¾ miles from its head the river flows in a flat gravel-floored valley, below which it flows through a rock gorge to the point where Cascade Creek comes in. There is another gorge 100 feet deep where Boundary Creek cascades into the river. From the Daly-Alaska property, at Elevenmile, the river flows again in a flat-floored, gently sloping valley to the junction with Texas Creek, at an altitude of 300 feet. From this point the valley is about three-fifths of a mile wide and has an average slope of about 31 feet to the mile. In this stretch the river is a winding stream, flowing rapidly in a network of channels cut through gravel bars and low islands that are constantly being built up and destroyed. The river is subject to considerable floods and at high water occupies the greater part of the valley floor.

Texas Creek heads in Texas Glacier. The valley of the creek is wide, flat floored, covered with gravel, and gently sloping. It may be readily forded with horses above the junction of the West Fork.

The West Fork is larger than Texas Creek where the two come together. The valley of the West Fork is about 8 miles long and consists of several broad gravel-floored flats with intervening long, narrow, deep postglacial rock gorges that have steep gradients. One flat extends from the upper end of Texas Lake, at the head of the valley, to the Government cabin. Here the creek has been forced over against the cliffs on the north side of the valley by the old rough moraines of Ferguson Glacier that extend for half a mile or so beyond the present front of the ice. Another flat extends for three-quarters of a mile opposite and west of Casey Glacier. Most of the drainage carried by the West Fork comes from the south side and mainly from the three glaciers, Hidden, Casey, and Ferguson. The steeply sloping sides of the valley have been scarred over half their area or more by slides, which are mostly covered with well-nigh impassable thickets of fern, alder, salmonberry, and blueberry. (See pl. 6, *A*.) Below Hidden Creek the West Fork flows for a short distance in a rock chasm 100 feet deep.

Thumb Creek is relatively inaccessible, as Salmon River normally can not be forded during the summer and the lower 1¾ miles of the Thumb Creek Valley is an impassable gorge, the floor of which slopes within this distance from an altitude of about 1,000 feet to the level of Salmon River at 250 feet. Several prospectors have entered the upper valley of the creek by way of the West Fork of

Texas Creek, Ferguson Glacier, and the pass at the head of the glacier at an altitude of 4,600 feet. A few have gone in from the east by back-packing over the tops of the mountain shoulders north or south of the gorge. If supplies could be transported in the spring over the snow to a point above the gorge the upper valley would be easily prospected, as the rock exposure is favorable. The morainal hillocks at the head of the creek are well timbered and would afford good camp sites. About one-third of the water of Thumb Creek comes from Gray Glacier, near the head, and the larger part of the remainder comes from Thumb Glacier. An old terminal moraine, breached by the creek, extends in a semicircle across the valley about in a line with Gray and Red Glaciers. The hillocks in the head of the valley are all morainal material. With the exception of these hillocks a great boulder flat extends from the foot of Thumb Glacier for about 2 miles to the alluvial fan of the stream that enters from the south at an altitude of about 1,450 feet. The total fall in this 2 miles is about 500 feet. Between the altitudes of 1,450 and 1,000 feet the slope is much steeper. At 1,000 feet there are benches of bouldery gravel in which the creek has cut a deep valley, and below is the rock gorge through which it flows to Salmon River. At some places snow arches persist across the creek until early summer. The north side of the valley is very steep, with many sheer cliffs, and is completely lined along its base by a coalescing body of talus, slide débris, and gulch deposits. Some of the slides have brought down giant fragments. Nowhere else in southeastern Alaska has the writer seen slides and talus developed on so extensive a scale.

GLACIATION

Above an altitude of 5,000 feet most of the broader ridges are covered with snow and ice caps from which glaciers creep down the mountain sides.

The major glacier of the Salmon River drainage basin is Salmon Glacier, which lies almost wholly in Canada, with its tip just crossing the international boundary at an altitude of somewhat over 500 feet. (See pl. 7, *A*.) Pack trains are taken up over Salmon Glacier to its head, and the trail is indicated by tripod markers.

Boundary Glacier is about 4 miles long and may be reached by way of Salmon Glacier. About a mile of the lower part of the glacier is in Canadian territory. The glacier is readily traversed from its foot to an altitude of about 4,200 feet, at the base of the ice cascades at its head. (See pl. 7, *B*.)

Texas Glacier, which fills the valley north of the West Fork, is a through glacier. It flows from the divide at an altitude of 5,300 feet eastward 5¾ miles down to an altitude of a little over 1,000 feet.

It also flows westward from the divide 2½ miles and joins Chickamin Glacier at an altitude of about 2,800 feet. Texas Glacier can be traversed from its eastern foot to the divide, except for a deeply crevassed portion about 2 miles from the foot, where there is a drop of several hundred feet within a short distance. Here it is necessary to climb over the rock shoulder on the north side and regain the glacier at an altitude of about 3,300 feet. The part of the glacier that flows westward into Chickamin Glacier is so crevassed as to be practically impassable above an altitude of 4,000 feet. The south wall of the valley of Texas Glacier, on both the Chickamin and Texas Creek sides, is uniformly precipitous, with many high, sheer cliffs.

Hidden Glacier occupies a hanging valley whose edge is 700 feet above the bottom of the valley of the West Fork. The glacier is fed by two great ice cascades, which descend at a gradient of about 2,000 feet to the mile. (See pl. 6, *B*.) The glacier is readily traversed to an altitude of about 4,200 feet, at the foot of the ice cascades. Hidden Creek has cut a gorge 20 to 50 feet deep in the old morainal material and the bedrock at the foot of the glacier.

Casey Glacier, like Hidden Glacier, occupies a hanging valley which, at the foot of the glacier, is about 500 feet above the bottom of the valley of the West Fork. Casey Glacier is easily traversed up to the foot of the ice cascades at its head, at about 4,000 feet. The peaks above may be reached with difficulty by way of the southeast arm, which affords access also to Thumb Creek by way of Gray Glacier.

Ferguson Glacier (pl. 8, *A*) is about 4 miles long. The head of Thumb Creek may be reached by going up Ferguson Glacier to the divide at about 4,600 feet and over the snow field and down a steep snow-filled gulch which opens on the lower slope of Thumb Glacier. From this point it is possible to travel up Thumb Glacier and over the divide at its head to Greenpoint Glacier, a tributary of Chickamin Glacier.

The northern tributaries of Chickamin Glacier head against those of Salmon Glacier. Chickamin Glacier is about 17 miles long, and about 10 miles of it lies in Alaska. The upper part flows south and the lower part in a general westerly direction. (See pls. 3; 9, *A*; 14, *A*.)

Several other glaciers are shown on Plates 1 and 2, and a view of two small glaciers west of Ferguson Glacier is given in Plate 10, *A*.

At the heads of the valley glaciers and in the high mountain ridges and peaks there are great basins and amphitheaters, which have been excavated by processes connected with the presence or activities of the glaciers that have occupied them in the past or are now occupying them and with the snow fields that partly cover their steep back walls and side slopes. These basins, known as cirques, are found as low as 4,100 feet and are still locally in process of formation at altitudes of 4,500 feet or higher. (See pl. 8, *B*.) The area south of the West Fork and west of Salmon River is a "fretted upland" whose riblike ridges have been produced by the headward and sideward erosion of the cirques. (See pl. 9, *B*.) The lateral ridges between adjoining glacier basins have been worn away near their heads until many of them are not more than 100 feet wide. Locally they are covered with snow and are in the process of being reduced to cols or low divides. A few isolated mountain peaks have been left with one or more radiating short, narrow ridges. Narrow as are the ridges between the glaciers, some of them afford good traveling. Unusually fine examples are the ridges at the head of Hummel Glacier, the ridge between the glacier above the Keno group of claims and the first small glacier west of Ferguson Glacier, and the higher part of the ridge on the east side of Ferguson Glacier on which the Sunset claims are located. These ridges are, to a considerable extent, coated with rock spalls. There is relatively little evidence of the formation of cirques either in the past or in the present in the Bear River or in the ridges north of the West Fork.

Most of the valley glaciers can be easily traveled up to altitudes of 3,900 to 4,200 feet, where crevasses usually make further progress difficult or impossible.

The well-rounded form of the mountain ridges up to and locally above 6,000 feet and the glacially grooved and striated walls of the valleys indicate that the whole district has in the past been flooded with ice as high as 6,000 feet. The ice must have flooded the valleys to a height of about 4,100 feet until a relatively recent time and then melted away very rapidly to a condition approximately like that of the present time. This conclusion is based upon the fact that below 4,100 feet there is little or no evidence of the cirques that must certainly have been formed to some extent had the valleys not been filled with ice, which later withdrew too quickly to permit the excavation of cirques at the lower altitudes. It is probable that in the Salmon River district cirques were formed at low levels during the first part of the last glacial epoch, while the snow line was descending and before the valleys were completely filled, but such cirques must have been obliterated by the valley glaciers during the time of maximum ice flooding.

In the West Fork Valley opposite Ferguson Glacier steep bluff faces below and a marked smoothing of slope and rounding of shoulders above indicate that the ice here filled the valley to an altitude of 4,400 feet for a considerable time. On the north side of the West Fork glacial striae parallel to the valley were noted up to altitudes of 4,000 feet, and this altitude corresponds to a line above which there is a marked decrease in the steepness of the slope.

Every glacier in the district, whether large or small, shows marked evidences of retreat within recent years, and the universal testimony of prospectors is to the effect that the glaciers are melting back at the present time.

Boundary Glacier is shown on the maps of the International Boundary Survey as joining Salmon Glacier, and this relation is reported to have continued up to 1922. In 1925 there was no connection between the two glaciers; Boundary Glacier had melted back, and a deep depression lay between its terminal moraine and the lateral moraine of Salmon Glacier. Some branches of Chickamin Glacier are similarly in the process of dismemberment from the main glacier. Hummel Glacier no longer joins Chickamin Glacier, and the west branch of Texas Glacier is melting away so that a lake has now formed on each side of its junction with Chickamin Glacier.

All the glaciers show bare rock surfaces along their sides for a hundred feet or more above their present surface. The surface of the glaciers has melted down so recently that vegetation has not yet had a chance to get a foothold. Old lateral moraines are conspicuous along the sides of Ferguson and Greenpoint Glaciers 100 feet or locally as much as 250 feet above the level of the present lateral moraines. Remnants of lateral moraines extend down both sides of Texas Creek for three-quarters of a mile below the present foot of the ice. Old terminal moraines are conspicuous in front of Ferguson, Chickamin, and Thumb Glaciers. R. M. Andrews reports that in 1902 the foot of Chickamin Glacier was only a few feet from an old terminal moraine 20 to 30 feet high, which in 1925 was 4,600 feet from the ice front. Malcolm Smith reports that the ice front of the Chickamin Glacier retreated 600 feet between July, 1923, and July, 1925. (See pl. 14, *A*.)

GEOLOGY

GENERAL FEATURES

The Salmon River area in Alaska lies adjacent to and includes a portion of the northeastern border of the Coast Range batholith. This batholith extends for some 1,100 miles from the southern boundary of British Columbia northwestward into Yukon Territory and ranges from 20 to 110 miles in width. Within the latitude of southeastern Alaska it is in most places 35 to 60 miles in width. In the adjacent country rock near its northeastern border there are local outlying stocks and dikes of igneous rock that belong to the same general period of intrusion as the main batholith. Mineral deposits have been found in this border belt wherever it is more readily accessible to prospecting, as at the head of Alice Arm and Portland Canal and on Unuk, Stikine, and Taku Rivers. This belt is often referred to as the eastern or interior belt of mineralization, as distinguished from a western belt of mineralization which occurs along the southwestern border of the Coast Range batholith.

The predominant rocks of the area are summarized in the geologic table below. They consist of (1) a great central mass of gray granodiorite composing the Texas Creek batholith intrusive into (2) the Hazelton group, of probable Jurassic age, comprising greenstone, tuff, volcanic breccia, graywacke, slate, argillite, quartzite, and rare limestone, which borders the Texas Creek batholith on the east and the west; into both the Texas Creek granodiorite and the Hazelton group are intruded (3) a pinkish quartz monzonite, the Hyder quartz monzonite, composing the Hyder batholith, which forms the northeastern border portion of the main Coast Range batholith and which here lies along the southern border of the Texas Creek batholith, and (4) a pink granodiorite, the Boundary granodiorite, composing the Boundary stock or apophysis, which occurs along the northern border of the Texas Creek granodiorite and the Hazelton group and is a facies of the main Coast Range batholith. Small stocks and dikes of gray sheared porphyry, genetically allied with the Texas Creek granodiorite, occur in the beds of the Hazelton group. At many places dikes of pink to white granodiorite or dark diorite porphyry intrude both the Texas Creek batholith and the sedimentary and volcanic rocks of the Hazelton group. These are genetically associated with the Hyder quartz monzonite and the Boundary granodiorite. The Texas Creek batholith and associated stocks and dikes, the Hyder batholith and associated dikes, the Boundary stock and associated dikes, and the rocks of the Hazelton group are all cut by narrow dikes of dark to black lamprophyre and malchite. The major river valleys are floored with recent gravel and sand and locally with morainal deposits. Here and there benches along the river valleys at a considerable height above their floors are covered with morainal gravel, clay, and sand of Recent age. A thin veneer of glacial drift occurs locally in some of the valleys and on the gentler mountain slopes.

Formations in the Hyder district

Quaternary (Pleistocene and Recent).		Glacial moraines and drift. River gravel, sand, and clay. Local terrace deposits.
Unconformity		
Jurassic or Cretaceous.	Coast Range intrusives.	Lamprophyre and malchite dikes. Intrusive contact Hyder quartz monzonite, Boundary granodiorite, and associated granodiorite and diorite porphyry dikes. Intrusive contact Texas Creek granodiorite and associated porphyry dikes.
Intrusive contact		
Jurassic (?)	Hazelton group.	Tuffaceous graywacke, slate, argillite, quartzite, and rare limestone. Greenstone, tuff, volcanic breccia, and sparse slate.
Base not exposed.		

The economically important mineral deposits of this area, so far as found, are connected exclusively with the Texas Creek batholith and its associated outlying stocks and dikes. They occur largely within the Texas Creek granodiorite or within the bedded rocks near the contact. They are cut by granodiorite and diorite porphyry dikes that are genetically associated with the Hyder quartz monzonite and with the Boundary granodiorite and also by the still younger malchite and lamprophyre dikes.

In southeastern Alaska the dominant structural features of the formations older than the Coast Range intrusive rocks consist of northwestward-striking folds, in part overturned or isoclinal. The gneissic structure of the Coast Range batholith similarly has a northwest strike. The folds immediately adjacent to the batholith on the southwest border are closely folded and in part overturned toward the southwest, and the foliation of the batholith dips uniformly steeply to the northeast. Similarly, in the Salmon River area in British Columbia, just to the north of the area considered in this report, the formations are folded into a series of anticlines and synclines with a north-northwest strike.[5]

In the Salmon River area of the Hyder district there are beds along the international boundary east of Salmon River that strike north-northwest and dip steeply southwest; but in general within the area covered by this report the trend of the folds of the bedded rocks, of the gneissic structure of the Texas Creek batholith, and of the schistose structure of the greenstones is within 20° of true east and is therefore completely out of harmony with the prevailing structure of the surrounding country.

The granodiorite that forms the core of the Texas Creek batholith has a marked fine banding or gneissic structure. There are many slickensided planes of movement within the rock; but thin sections examined with the microscope usually show no evidences of crushing or metamorphism such as might have produced the foliation. The gneissic or banded structure is due in large part to the parallel orientation of the conspicuous crystals of black hornblende and of the large phenocrysts of potash feldspar and therefore had its origin in flowage currents within the magma during its crystallization and consolidation. As this foliation is of primary origin and strikes N. 60°–90° E., it follows that the peculiar structural trend of this area had its inception prior to the intrusion of the younger Coast Range magmas which formed the Hyder quartz monzonite and the Boundary granodiorite. It is thought, nevertheless, that the prevalent approximately east-west structure of the bedded rocks of this area is in considerable part due to the thrusts exerted by the intru-

[5] Schofield, S. J and Hanson, George, op. cit., p. 34.

sion of these younger Coast Range magmas. The northeastern contact of the Coast Range batholith as a whole usually trends northwest, but in this area it swings around to more nearly east-west, probably as a result of the control exerted by the older structure of the Texas Creek batholith and the surrounding rocks, which had a similar strike.

There is abundant evidence of the great pressure exerted by the younger magmas at the time of their intrusion. The Texas Creek granodiorite along its southern boundary adjacent to the Hyder quartz monozonite is partly or completely pulverized as a result of the pressure exerted by the intrusion of the magma that consolidated as the Hyder quartz monzonite and grades away from the contact through an augen gneiss into the normal granodiorite. To the west of the Texas Creek granodiorite the Hyder quartz monzonite magma came into contact with the graywacke-slate division of the Hazelton group and produced in those rocks close folds overthrust toward the north. On the north side of the area the magma of the Boundary granodiorite similarly exerted a thrust upon the graywacke-slate division of the Hazelton group and produced close folds overturned toward the south. The bedded rocks were thus pinched between the Hyder quartz monzonite magma on the south and the Boundary granodiorite magma on the north, and folds overturned in opposite directions were the result. Microscopic examination shows that locally, near the contacts with the intrusive masses, grains that compose the bedded rocks and the intrusive aplite dikes belonging to the Texas Creek batholith have been severely mashed and pulverized. It is probable that part of the schistose structure in the porphyry dikes associated with the Texas Creek granodiorite, the gneissic structure in some of the sulphide masses, and the crushing of some of the mineralized quartz veins also resulted from the pressure attendant upon the intrusion of the younger Coast Range magmas.

On the east side of Salmon River the contact between the Texas Creek batholith and the greenstones of the Hazelton group strikes about north. The gneissic structure of the granodiorite, however, and the foliation of the greenstone both strike approximately east. The mineralized quartz fissure veins cross the structure of both rocks at an angle. There must have been, therefore, an epoch of marked deformation and folding slightly preceding and accompanying the intrusion of the Texas Creek batholith. Subsequently both the Texas Creek granodiorite and the Hazelton group were affected by a second epoch of deformation accompanying the intrusion of the Hyder quartz monzonite magma.

The mapping is not sufficiently detailed to indicate the general direction of strike of the porphyry dikes in the rocks of the Hazelton group. The granodiorite porphyry dikes connected with the younger Coast Range intrusive rocks that cut both the Texas Creek granodiorite and the Hazelton group, however, have in general a northwest strike ranging usually from N. 20° W. to N. 70° W., but at some places their strike is northeast. Along the international boundary the dip is usually 45°–60° SW. In the district to the north these dikes have a northwest strike.

HAZELTON GROUP

GENERAL CHARACTER

No fossils have been found in the sedimentary and volcanic beds of this area. The beds are assigned to the Hazelton group because of their lithologic similarity to the formations of that group to the southeast and north in British Columbia and because of similar structural relations to the Coast Range intrusive rocks. The Hazelton group has been described by Hanson[6] as consisting of a lower formation comprising volcanic tuff, breccia, and flows of green or gray to purplish andesitic rock and an upper formation comprising argillite, quartzite, and tuffaceous sandstone. The argillite of the upper division carries fossils which are referred to the Jurassic.

The sedimentary and volcanic rocks found north of this area, on the British Columbia side of the international boundary, are assigned by Schofield and Hanson[7] to three conformable formations of probable Jurassic age, as indicated below:

Formations in the Salmon River district, British Columbia

	Feet
Nass formation: Slate, fossiliferous	1,000+
Salmon River formation: Conglomerate	300+
Bear River formation: Agglomerate and tuff	2,000+

The greenstone, tuff, and volcanic breccia of the Alaskan side along the international boundary east of Salmon River are continuous with the similar rocks of the so-called Bear River formation on the Canadian side and correspond to the lower division of the Hazelton group as shown on Plate 2.

A bed resembling the Salmon River conglomerate of the Canada Geological Survey was seen at one locality. This is a thin bed of fine conglomerate included in a porphyry dike at an altitude of about 4,500 feet on the slope of Bear River Ridge east of the mouth of Thumb Creek. Cobbles and boulders of similar conglomerate are found here and there along the lower slopes of the ridge, indicating that perhaps other lenses may be or may have been present here.

[6] Hanson, George, Reconnaissance between Skeena River and Stewart, B. C.: Canada Geol. Survey Summary Rept. for 1923, pt. A, pp. 32–36, 1924.

[7] Schofield, S. J., and Hanson, George, op. cit., pp. 10–13.

A tuffaceous graywacke formation, which very locally is conglomeratic, appears to overlie the greenstone on the American side and to occupy a position stratigraphically similar to that of the Salmon River conglomerate of British Columbia.

Schofield and Hanson describe their Nass formation as consisting "mainly of argillites which in many places, especially near the Coast Range batholith, show a slaty cleavage. Beds of sandstone and fine conglomerate occur here and there through the formation." Fossils of probable Jurassic age are found near the base of the formation. It seems probable that the slate and fine quartzitic beds of Mineral Hill and the slate and argillite of the region near the head of the West Fork and Chickamin Glacier are the equivalent of the Nass formation of British Columbia.

The slate in the American part of the Salmon River Basin is so completely infolded and interbedded with graywacke that the writer was unable to map the beds separately without further and more detailed work. The graywacke and slate are therefore mapped and treated together in this report. In the absence of fossils and the lack of exact knowledge as to the structural relations it is not known whether the graywacke should be grouped as a separate formation, or whether it is the equivalent of one or more of the formations found on the Canadian side. The evidence at hand seems to indicate that the graywacke formation is not the equivalent of the Bear River formation but overlies it and that the graywacke is in turn overlain by a formation characterized by slaty argillite.

GREENSTONE AND ASSOCIATED ROCKS

East of Salmon River, along the international boundary, north of the Mountain View property, there is a belt of rock consisting predominantly of more or less schistose greenstone. The dominant type is a soft green and gray fine-grained chloritic rock of indeterminate origin. With it are associated locally bands of thin-bedded dark slate with layers of quartzite or graywacke. On the slope of Bear River Ridge, just west of the international boundary and east of the Titan property, between altitudes of 4,500 and 4,750 feet, there is a bed of coarse purplish to green-gray andesitic volcanic breccia several hundred feet thick, striking a little west of north and dipping steeply west. Tuff, clearly recognizable as such, both in the field and with the microscope, is also found in this vicinity. Large boulders of the breccia are abundant along the lower slopes of the mountain. Rarely a bed is found that consists of angular fragments of greenstone in a matrix of slate. This formation continues north across the international boundary into British Columbia. Schofield and Hanson[8] describe it as follows:

This group of rocks is almost entirely of volcanic origin, and the name "greenstone" commonly applied to it is suitable in a general way. The lower members are largely fragmental rocks of agglomerate character. Their constituent fragments are angular purple and green masses of andesite in an undesitic matrix. They vary in size from minute particles to pieces a foot or more across. In thin section they show phenocrysts of a plagioclase, * * * probably an andesine, scattered through a highly altered matrix in which hornblende and plagioclase are the main constituents. The rock is highly altered, and many secondary minerals, such as calcite, epidote, and chlorite, are present. * * * The agglomerates are overlain by fine-grained tuffs that form the upper part of the Bear River formation. The tuffs are massive in appearance and, as a rule, green, but purple bands occur at irregular intervals in the green. * * * Under the microscope the rock is seen to be highly sheared and altered. The minerals are chiefly secondary and consist of sericite, calcite, chlorite, quartz, altered plagioclase, rutile, pyrite, and leucoxene. coxene.

Westgate[9] thus describes the greenstone on the American side:

Throughout most of the area * * * the greenstone is a gray or green fine-grained soft calcareous rock, indistinctly banded and specked with minute grains of pyrite. Thin sections show aggregates of quartz, calcite, sericite, chlorite, and feldspar, and usually pyrite and leucoxene or granular titanite. The micas are not abundant enough to give a foliation. The rock is rather uniform over considerable areas and ordinarily does not show any structure in the outcrop. Neither in the outcrop nor in the thin section is the original character of the rock to be seen. A real variability in some thin sections suggests a tuff. There is nothing to suggest sedimentary origin. The uniformity of the rock and its mineral character indicate that it is probably either an altered tuff or lava. * * * As it is difficult to destroy the structure of a porphyry completely, the general absence of any recognizable porphyritic structure in the greenstone is taken to mean that most of them are tuffs.

GRAYWACKE-SLATE DIVISION

The graywacke-slaty argillite division of the Hazelton group occupies most of the country along the upper part of the West Fork and around Chickamin Glacier and its branches. It forms the roof over the Texas Creek batholith, which here plunges to the west. The mountain ridges are usually composed of the graywacke-slate series, but the valleys at many places have been cut below the roof of the batholith and into the underlying quartz diorite, so that the lower part of the slopes and the valleys usually expose the Texas Creek batholithic igneous rock. Near the contact with the batholith there are dikes of granodiorite porphyry in the sediments, and within 500 feet of the contact aplite dikes are common. Dikes of pink to

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[8] Schofield, S. J., and Hanson, George, op. cit., pp. 11–12.

[9] Westgate, L. G., Ore deposits of the Salmon River district: U. S. Geol. Survey Bull. 722, pp. 122–124. 1921.

white granodiorite porphyry that are offshoots from the Hyder quartz monzonite and the Boundary granodiorite are common at most places throughout the bedded rocks and the Texas Creek batholith.

The beds forming the mountain ridges between Casey and Ferguson Glaciers are predominantly of the graywacke type. Thick-bedded massive graywacke and local beds of conglomerate preponderate at the north on the slope to the West Fork. They are adjoined on the south by beds which in general are somewhat finer grained and have considerable associated argillite, but coarse graywacke is common throughout. The ridge on which the Sunset claims are located is composed of argillite and graywacke.

The bedded rocks of the south slope of the valley of the West Fork west of Ferguson Glacier consist almost wholly of graywacke with very little slate. The first big beds of slate occur at an altitude of 5,100 feet on the northeast slope of the ridge north of Hummel Glacier, where they are interbedded in thick zones with graywacke. Slate forms the crest of this ridge. Beds consisting of fragments so long and coarse that the structure seems breccia-like are common in the graywacke. The ridge just west of Ferguson Glacier is composed of graywacke-like beds, predominantly medium grained, with intercalated sparse slaty and thin argillaceous layers and one band of greenstone. In this ridge between altitudes of 4,800 and 5,100 feet there is a belt of greenstone schist with intercalated beds of graywacke, which locally has a breccia structure. These beds dip steeply to the north, though the prevailing dip is uniformly steep to the south. Graywacke beds with only a little slate form the slope northeast of Hummel Glacier and the north spur of the mountain between Hummel Glacier and Through Glacier. The top and south slope of the ridge between Greenpoint and Hummel Glaciers, however, are composed of banded slate and very fine grained graywacke and quartzitic beds, with intercalated thick beds of graywacke and dark blue-gray fissile limestone. The slates are crinkled and show a tendency toward pencil structure.

Banded Mountain, which rises between Chickamin Glacier and Through Glacier, and the shoulder between Greenpoint and Through Glaciers are composed of graywacke with a very few thin beds of argillite. They strike about N. 60° W. and dip 30°–50° S.

The ridge between the West Fork and Texas Glaciers west of Ibex Creek is composed predominantly of argillite, in part of a slaty character, thinly banded with fine to coarse graywacke or quartzitic layers and with sparse interbeds of graywacke. Locally there are beds of coarse graywacke with a structure similar to that of volcanic breccia, and rarely a bed of dark fine-grained limestone.

Beds of argillitic character are dominant. At the west end of the ridge, below 4,500 feet, graywacke beds are dominant.

The mountains in the angle north and west of Chickamin Glacier are composed of graywacke with a little interbedded argillite.

The mountain spur that extends southwest from the international boundary between Texas and Chickamin Glaciers is composed of graywacke and argillite, intruded on the northwest by a stock of Boundary granodiorite and on the southeast tip by an extension of the Texas Creek quartz diorite. The mountain at the head of the spur appears to consist of a syncline of thin-bedded slate and graywacke overturned toward the south and riven by great dikes of granodiorite. A belt of graywacke with an east-west strike and a northerly dip forms the mountain spur to the foot of the glacier that covers much of it. The narrow neck of the spur and the steep slope up to the foot of the glacier at the north are composed of slaty argillite. On the west side of the spur the contact between the slaty argillite and the predominant graywacke formation lies on the north side of the shoulder that projects to the west. The southwesternmost part of the spur, for a length of three-quarters of a mile, is composed of metamorphosed graywacke.

The rocks here called graywacke are compact, massive, green-gray to gray, and fine to coarse. At many places they are so uniform that bedding is indistinguishable even within thick masses. Some of the beds are coarse and show a somewhat modified agglomeratic structure. The materials of which the rocks are composed are almost wholly volcanic, and it is probable that they are waterworn andesitic tuff and breccia. They are so wholly volcanic in nature that it may be possible that some portion of the beds are of direct volcanic origin; but their bedded character, the intercalation of argillite, the complete absence of anything that might be considered a flow, and the somewhat waterworn character of the materials in the coarser beds suggest that they are predominantly only indirectly of volcanic origin. The term tuffaceous graywacke might be appropriate for them. They probably correspond in part to what Hanson calls tuffaceous sandstone. The finer-grained beds, interlayered with the argillite, are much more quartzitic in nature.

The typical graywacke is distinctly tuffaceous. It consists almost wholly of green hornblende and plagioclase with associated secondary alteration products. Hornblende is approximately equal in quantity to the plagioclase. Locally a little orthoclase is present, and occasionally accessory apatite. In the freshest specimens both the hornblende and the plagioclase show many crystal faces. The feldspars are partly altered to sericite and epidote. The ferromagnesian minerals are chloritic. A little calcite is not uncommon, and rarely there is a trace of secondary quartz. A little residuum of augite is left at the core of many of the hornblende crystals, suggesting that the original ferromagnesian mineral was in part, if not wholly, a pyroxene.

There are three main belts in which beds of slaty argillite or argillite that is in part thin banded with light green-gray to dark quartzitic layers and with intercalated graywacke predominate. Mineral Hill is composed of such beds. A second belt forms the crest and southern slope of the ridge between Greenpoint and Hummel Glaciers and the southern part of the area of sediments between Casey and Ferguson Glaciers. A third belt forms the whole ridge north of the West Fork and west of Ibex Creek except for its west end. This belt may also include the band of slaty argillite that forms the narrow part of the spur between Texas and Chickamin Glaciers. Rarely a dark blue-gray limestone is thin bedded with the argillite and quartzitic layers or occurs intercalated as a bed. The two belts of slaty argillite in the vicinity of the upper part of the West Fork and of Texas and Greenpoint Glaciers appear to represent the same formation isoclinally infolded within the predominant graywacke formation which stratigraphically underlies them. The southern belt dips prevalently to the south, whereas the northern belt dips prevalently to the north or is vertical, though minor folds locally give dips in the opposite direction in both belts. In the absence of detailed structural study it is impossible to estimate the thickness of either the graywacke or the slaty argillite.

COAST RANGE INTRUSIVES

TEXAS CREEK BATHOLITH AND ASSOCIATED DIKES

CHARACTER AND EXTENT

A batholith of igneous rock with a few outlying cupolas and dikes occupies most of the area shown on Plate 2. This is known as the Texas Creek batholith. The rock is chiefly a granodiorite and is intimately and probably genetically connected with most of the ore deposits of this district. The mass is therefore very important because of its relation to the mineral deposits, and its contacts will be described in detail.

The core of the Texas Creek batholith is a porphyritic granodiorite, here named Texas Creek granodiorite, but the border facies and the outlying stocks are in general nonporphyritic quartz diorite. Locally, immediately adjacent to the contact, diorite or monzodiorite is found. These less alkalic and more basic facies are probably due to quicker cooling, which resulted in a less advanced stage of differentiation.

The Texas Creek batholith is cut by dikes of granodiorite and granodiorite porphyry genetically associated with the Hyder quartz monzonite and the Boundary granodiorite, by a few light-colored dikes of quartz porphyry, and by dark-colored dikes of malchite and lamprophyre. Within 500 feet of the borders or roof of the batholith aplite and pegmatite veins are common in both the batholith and the country rock. Where small dikes of the Texas Creek batholith occur in the country rock the dike rock has a fine to dense grain and a porphyritic aspect, so that it is difficult or impossible to discriminate between such dikes and the quartz porphyry dikes that cut the Texas Creek batholith. The quartz porphyry dikes must be genetically associated with the Texas Creek batholith, as they have suffered the same metamorphism, are cut by the metalliferous veins, and are older than the Hyder quartz monzonite and Boundary granodiorite. It is probable that the porphyries with which the Premier ore bodies in British Columbia are associated are outlying stocks genetically associated with the Texas Creek batholith.

The southern boundary of the Texas Creek batholith is against the Hyder quartz monzonite and runs almost due west for 4½ miles. From an altitude of about 3,500 feet on the southwest slope of Mount Dolly it crosses the Salmon River road just north of Fish Creek and probably follows the ridge on the south side of Thumb Creek, though the contact here was not traced. All of the valley of Thumb Creek to a point within three-quarters of a mile of the foot of Thumb Glacier is in Texas Creek granodiorite. The head of Thumb Creek Valley is in the Hyder quartz monzonite. The boundary of the Texas Creek granodiorite strikes northwest along the east side of the valley of Red Glacier and crosses Thumb Creek, then just below the foot of Gray Glacier it swings more toward the west, crosses Thumb Creek at the head of Ferguson Glacier, and continues nearly along the crest of the ridge to a point about 2 miles to the west, where it turns north and then a little east of north to a point on the west side of Ferguson Glacier about three-quarters of a mile from its foot, at an altitude of about 3,000 feet.

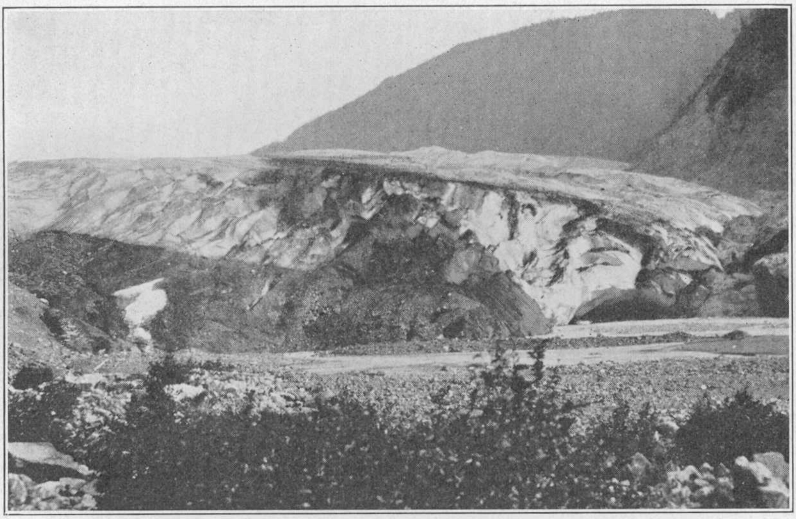
West of an approximately north-south line passing through the head of Ferguson Glacier, Casey Glacier, and Ibex Gulch the Texas Creek granodiorite plunges beneath a roof of tuffaceous graywacke and slate and is exposed only on the slopes and in the bottom of the valleys of Ferguson Glacier and the West Fork, which have been eroded below the level of the roof of the batholith, and locally farther west where upward bulges or cupolas of the batholith have been partly unroofed or trenched in the valleys of Texas and Chickamin Glaciers.

From the west side of Ferguson Glacier the contact between the Texas Creek granodiorite and the tuffaceous graywacke strikes west and rises to 3,300 feet on the slope facing the West Fork and to 3,600 feet on the east side of the first small glacier west of Ferguson Glacier. It drops to about 3,500 feet where it crosses very near the foot of this glacier, and then rises to about 3,800 feet or a little more on the spur between the two small glaciers, again dropping where it crosses the second glacier. On the ridge west of the second glacier the contact is at about 3,900 feet. In the second gulch farther west the contact descends abruptly to an altitude of about 3,340 feet and then swings northwest around the west spur, descending to about 2,600 feet in the gulch southwest of Blasher's cabin. It then strikes west to the bend of Chickamin Glacier, at an altitude of about 2,350 feet.

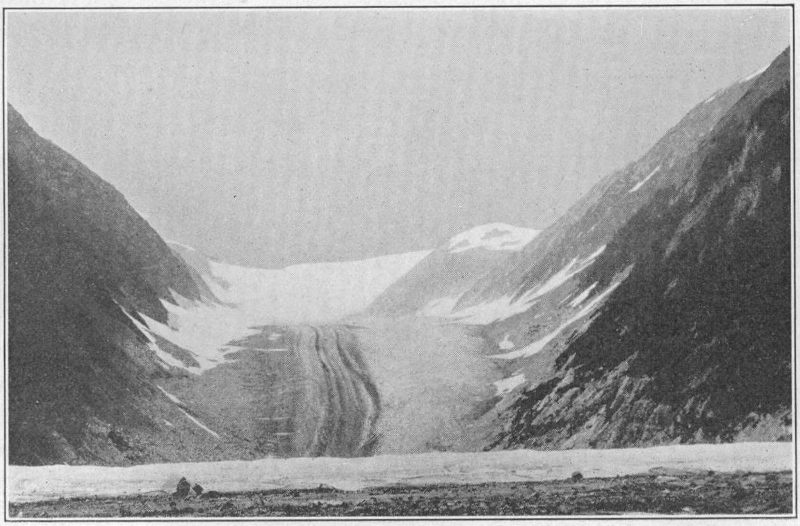
North of the West Fork the boundary of the granodiorite is at an altitude of about 2,400 feet near the east end of Disappearing Lake. From this point it strikes a little north of east along the slope and reaches an altitude of about 3,650 feet on the shoulder between Ibex Creek and the West Fork, just south of the Ibex tunnel. It swings north up the west slope of Ibex Creek, passing about 125 feet below the Ibex tunnel. Above the head of Ibex Gulch it passes beneath Texas Glacier at an altitude of about 4,500 feet.

Cupolas of the Texas Creek batholith are exposed on the west side of Texas Glacier near its junction with the Chickamin; on the east side of Chickamin Glacier about half a mile north of Disappearing Lake; on the west side of Chickamin Glacier 1¼ to 2 miles north of the turn; and on the north side of Chickamin Glacier in the vicinity of the creek about 1½ miles west of the turn. None of these cupolas reach an altitude much above 3,500 feet, and at the level of exposure they are small in diameter.

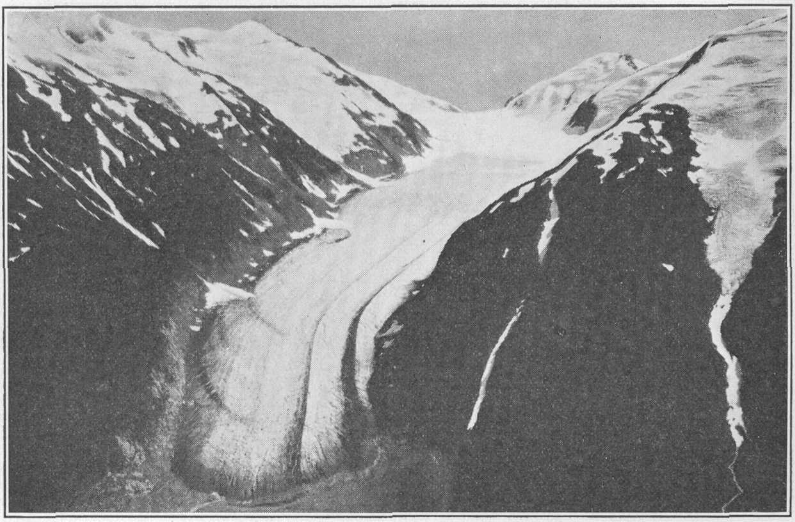
The Texas Creek granodiorite forms the south slope of the ridge north of Texas Glacier for about 3 miles west of the international boundary. It is bordered on the west and north by the Boundary granodiorite, which is intrusive into it, except where a narrow band of argillite about a mile long intervenes, capping the ridge just above the shoulder that produces the impassable crevasses in Texas Glacier about 2 miles above its foot. Just west of the international boundary the Boundary granodiorite comes down as low as 3,300 feet. The Texas Creek granodiorite forms the low pass between Texas and Salmon Glaciers and the north slope of the pass up to the contact with the Boundary granodiorite at an altitude of 3,300 to 4,000 feet. The contact between the Boundary and Texas Creek granodiorites turns at about the international boundary and approximately parallels it, passing a little to the west of the peak of Mount Bayard. The lower part of the south side of the valley of Boundary Glacier is in Texas Creek granodiorite.



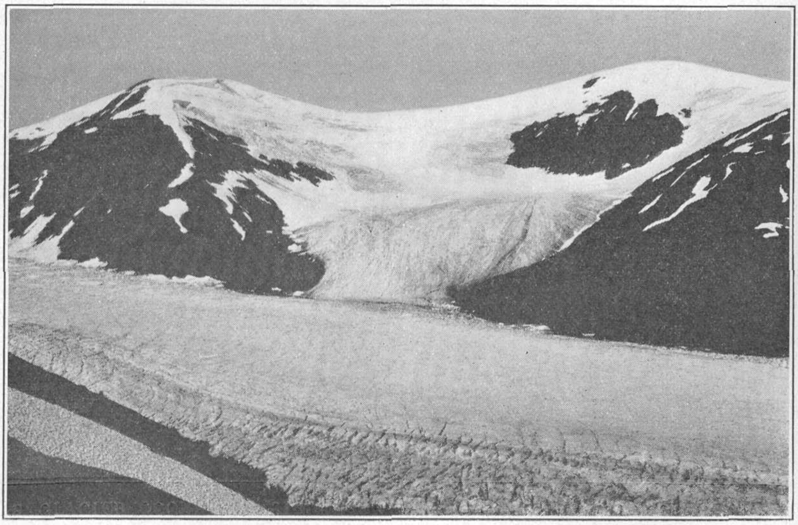
A. FOOT OF SALMON GLACIER AND TUNNEL FROM WHICH SALMON RIVER EMERGES



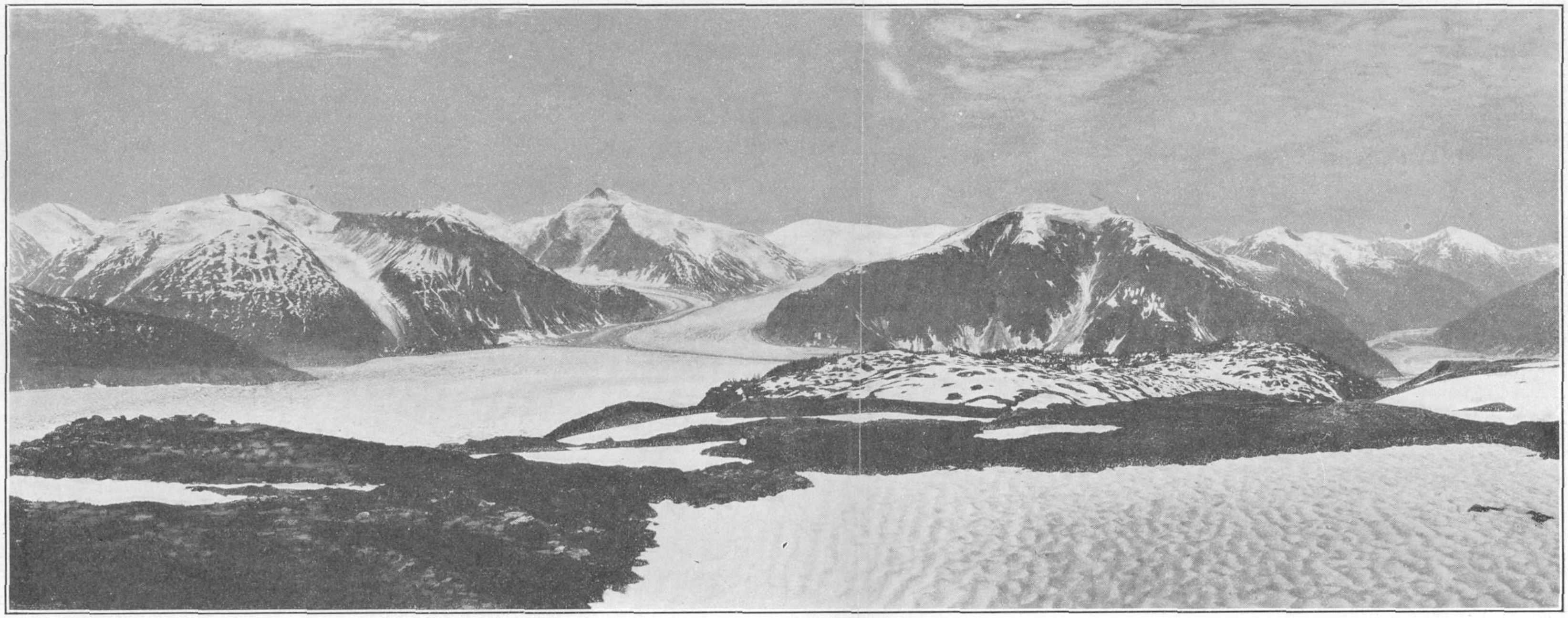
B. VIEW UP BOUNDARY GLACIER FROM MORAINE ON SALMON GLACIER



A. FERGUSON GLACIER FROM TOP OF RIDGE ON THE NORTH SIDE OF WEST FORK OF TEXAS CREEK



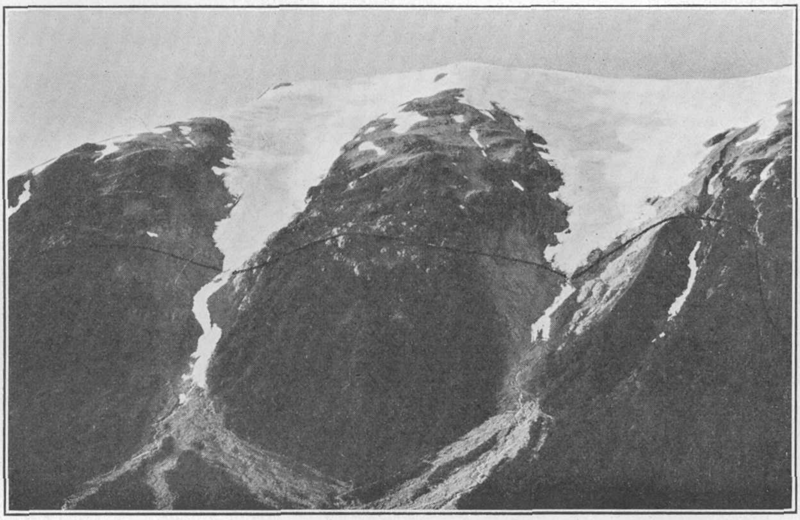
B. GLACIER OCCUPYING CIRQUE ON THE WEST SIDE OF THROUGH GLACIER



A. CHICKAMIN GLACIER, IN LEFT FOREGROUND; THROUGH GLACIER, IN CENTRAL BACKGROUND; AND CHICKAMIN VALLEY, AT EXTREME RIGHT

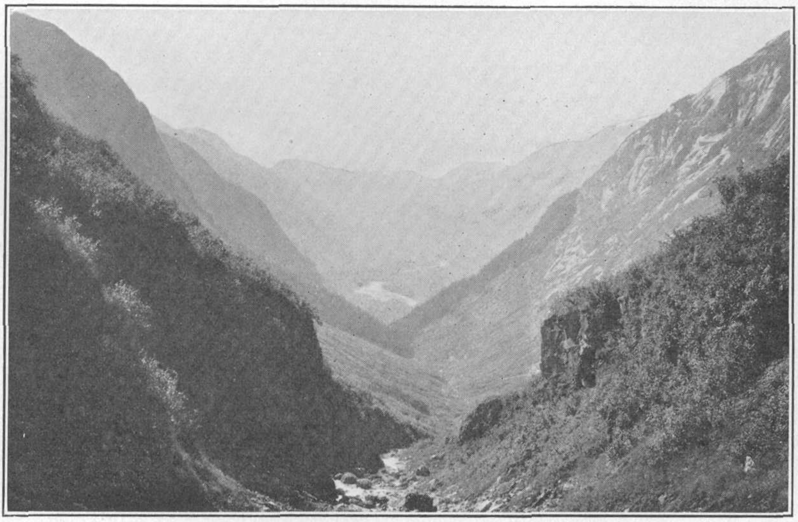
B. MOUNTAINS OF THE COAST RANGE

A "fretted upland"; view looking west from the upper end of Ferguson Glacier



A. GLACIERS ON SOUTH SIDE OF WEST FORK OF TEXAS CREEK WEST OF FERGUSON GLACIER

Black line marks contact between Texas Creek granodiorite below and rocks of Hazelton group above



B VALLEY OF INDIAN CREEK, LOOKING TOWARD CHICKAMIN RIVER VALLEY

The eastern contact of the Texas Creek granodiorite with the rocks of the Hazelton group probably lies beneath Salmon Glacier. For a mile below the foot of Salmon Glacier the contact follows the valley of Salmon River; then it makes a jog to the west across the pass between Salmon River and Texas Creek and extends along the west side of Mineral Hill to a point about half a mile north of the south end of the hill; here it turns southeast and strikes across Salmon River to a point about half a mile above the Salmon River bridge, whence it strikes southwest for a quarter of a mile to an altitude of about 850 feet, then turns and strikes southeast for a mile to an altitude of about 3,100 feet on the west slope of Bear River Ridge. It then turns a little west of south and with several small jogs through the Fish Creek and Mountain View mining properties strikes approximately along the valley of Skookum Creek and the lower part of Fish Creek to a point about 1⅕ miles above the Salmon River road. It then turns at right angles and strikes up the mountain side until it is cut off by the Hyder quartz monzonite at an altitude of about 3,500 feet.

GRANODIORITE CORE

The core of the Texas Creek batholith occupies the area from Texas Glacier on the north to the contact with the Hyder quartz monzonite, south of Thumb Creek. Its approximate western border is a line through the shoulder east of the intersection of the Homestake and West Fork trails, Casey Glacier, and the head of Ferguson Glacier; from this line it extends east to Texas Creek and Salmon River and up the lower part of the slope of Bear River Ridge. The rock forming this core is in general a medium-grained porphyritic rock with large phenocrysts and is dull greenish gray to light gray, mottled with black. The phenocrysts, which usually form several per cent of the rock, are crystals of dull-pink orthoclase 1 to 3 centimeters in length. The rock nearly everywhere shows abundant black prisms of hornblende as much as 1 centimeter in length, many of them oriented in common planes so as to give a gneissic structure or grain to the rock. The large crystals of orthoclase are also usually oriented with their longer diameter parallel to the gneissic structure. Rarely the rock is almost free of dark minerals. Some of the granodiorite has a distinctly greenish hue due to mashing and chloritization, or a pale yellowish green hue due to epidotic alteration.

The average composition of 20 specimens from the core of the Texas Creek batholith, as determined by the Rosiwal method, is given as No. 1 in the following table. The relative percentages of hornblende and biotite are difficult of determination, owing to the extensive alterations which the ferromagnesian minerals have suffered. It is probable, however, that the biotite ranges from 2 to 5 per cent and that the ferromagnesian minerals are predominantly hornblende.

Mineral composition of Coast Range intrusive rocks in the Hyder district

		Andesine	Oligoclase	Potassic feldspar	Hornblende	Biotite	Quartz	Magnetite	Accessory minerals
	TEXAS CREEK GRANODIORITE								
1	Average of 20 specimens from core of batholith	48	-------	20	12.5		19	0.5	
2	Average of 5 specimens from quartz diorite facies of batholith	60	-------	5	14.5		20	.5	
3	Contact facies of batholith, south side of West Fork of Texas Creek	66	-------	11	17.4	1.6	4	-------	-------
	HYDER QUARTZ MONZONITE								
4	Average of 4 specimens from Salmon River Valley north of Hyder	-------	39	30.5	-------	5	23.7	.75	1.1
5	Average of 4 specimens taken along Greenpoint Glacier	-------	36	34	-------	2.5	24.5	-------	.3
6	Average of 8 specimens taken along Chickamin River north of Indian Creek	-------	37	33	.15	4.3	24	.64	.65
7	Average of 2 specimens of contact facies from Mount Dolly	-------	45	30	4	6	14	-------	1
8	Average of 3 specimens of aplite associated with Hyder quartz monzonite	-------	22	43	-------	-------	35	-------	-------
	BOUNDARY GRANODIORITE								
9	Average of 5 specimens of Boundary granodiorite	48	-------	17	7	6	19.5	2	.5
10	Aplite from dike at east end of ridge north of Texas Creek	-------	14.5	50	-------	-------	34	-------	.5

The plagioclase is a typical andesine. Andesine and hornblende (and biotite) appear to have been the first of the major minerals to crystallize. The andesine occurs in stout lath-shaped crystals of euhedral to subhedral form. The hornblende is in well-formed columnar crystals many of which show perfect euhedral cross sections.

The potassic feldspars include orthoclase, microcline, and microperthite. The microcline occurs predominantly in the groundmass, and the phenocrysts are usually orthoclase. The orthoclase phenocrysts inclose disseminated small euhedral crystals of hornblende and plagioclase, and the potassic feldspars in general occur interstitial to hornblende and andesine. The microperthite usually shows only a very slight amount of the plagioclase phase.

The quartz is in part contemporaneous with the other minerals and in part was the last mineral to crystallize and occurs interstitially.

The accessory minerals are usually sparse, and only here and there do they form as much as 1½ per cent of the rock. Titanite, magnetite, and apatite are the common ones. Pyrite is rarely present. Titanite and magnetite may each form as much as 1 per cent of the rock. The titanite is in good euhedral crystals, some of which inclose small crystals of magnetite and apatite; it tends to occur predominantly within the quartz and potassic feldspars, suggesting that it belongs to the last half of the period of crystallization. The magnetite and apatite occur in groups of crystals and also as disseminated crystals in the hornblende.

The rock is usually more or less extensively altered. The hornblende and biotite are partly or completely altered to chlorite and epidote, with chlorite predominant. Near the contact with the Hyder quartz monzonite or the Boundary granodiorite the hornblende is commonly replaced by an interlocking fine-grained aggregate of biotite. The plagioclase is usually altered to a sericitic aggregate or to an aggregate of sericite and epidote, with locally a little chlorite. The potassic feldspars are commonly fresh and unaltered. Veinlets of chlorite and calcite or of epidote and calcite traverse the minerals. Along such cracks local replacement of the potassic feldspars has occurred.

QUARTZ DIORITE BORDER FACIES

The border facies of the Texas Creek batholith and the outlying stocks are usually medium-grained and nonporphyritic and contain less potassic feldspar than the core. West of the line through the shoulder east of the intersection of the Homestake and West Fork trails, Casey Glacier, and the head of Ferguson Glacier the rock is in general a medium-grained nonporphyritic quartz diorite. The outlying stocks to the west along Chickamin Glacier are believed to be quartz diorite also, though they have not been carefully studied, except locally.

The average composition of several specimens of quartz diorite from the head of West Fork is given in the table as No. 2. The rock differs from the granodiorites of the core in being nonporphyritic and in the marked relative increase of plagioclase over potassic feldspar. The minerals have suffered extensive alteration similar to that in the granodiorite.

DIORITE CONTACT FACIES

Locally, immediately adjacent to the contact, the quartz diorite border facies passes into diorite or monzodiorite. An example of this transition is found on the mountain slope on the south side of the West Fork, just west of Casey Glacier, at an altitude of about 4,550 feet. The composition of a specimen taken 20 feet from the contact is given in the table as No. 3. The marked features are a decrease in quartz and an increase in plagioclase and hornblende, as compared with the average rock farther away.

GRANODIORITE AND QUARTZ PORPHYRY DIKES

Adjacent to the borders of the main Texas Creek batholith there are outlying dikes and small masses of granodiorite porphyry that are genetically connected with this batholith. These dikes are gray and are characterized by large crystals of pink to white orthoclase in a fine-grained groundmass. There are a number of such masses in the sedimentary and volcanic rocks on the west slope of Bear River Ridge. Quartz veins, locally metallized with shoots of ore, occur at many places along the contacts of these dikes or within or across them. There are, on the other hand, younger granodiorite porphyry dikes which are connected with the Hyder quartz monzonite and which cut the metalliferous quartz veins. These younger dikes are pink, are of much fresher and more massive appearance, and are in places finer grained and only inconspicuously porphyritic. The tunnel at the Titan prospect starts in a dike of the porphyry of the Texas Creek batholith.

A typical specimen of the porphyry from the dikes associated with the Texas batholith, as seen with the microscope, is found to consist of phenocrysts of plagioclase, orthoclase, hornblende, and rounded quartz in a dense groundmass of quartz and feldspar that consists in part of a micrographic intergrowth of the quartz and potassic feldspar crystals. The rock is usually highly altered; the plagioclase is mostly altered to sericitic aggregates with some epidote, and the hornblende and biotite to chlorite and epidote. Titanite, apatite, and magnetite are present as accessory minerals.

At a few localities dikes of quartz porphyry cut the rocks of the Texas Creek batholith and also the near-by sedimentary and volcanic rocks. These dikes are so much altered that their original nature can not be determined. They evidently consisted of phenocrysts of quartz and feldspar in a dense groundmass. The quartz is in euhedral crystals and unaltered, but the groundmass is partly altered to sericite, and the feldspar phenocrysts are almost wholly altered to aggregates of sericite and quartz. Sparse ferromagnesian minerals have been altered to chlorite and muscovite. In some of the freshest specimens of these dikes both orthoclase and plagioclase phenocrysts are present in addition to quartz; in others only remnants of plagioclase can be identified, and quartz phenocrysts are sparse. At the Cantu prospect on Salmon Glacier and at the upper workings of the Daly-Alaska mine such porphyry dikes are cut by metalliferous veins.

APLITE AND PEGMATITE

Aplite dikes are usually common within 500 or 600 feet of the roof or borders of the batholith. They tend to occur more abundantly and to extend farther from the contact in the country rock than in the batholith. As a rule, they are practically restricted to the immediate vicinity of the contacts of the batholith or its outlying stocks. The aplite is generally white and fine grained. A few of the dikes are shattered and veined and impregnated with sulphides. On the Mountain View property an aplite dike is impregnated with molybdenite, and on the Dugas claims, north of the West Fork, an aplite dike is veined and impregnated with pyrite, galena, and sphalerite. Pink aplite dikes are found in the Texas Creek batholith and the sediments and volcanic rocks of the Hazelton group, but these belong to the younger Hyder and Boundary batholiths.

The aplite dikes consist almost wholly of quartz, microperthite or microcline, and albite; but the proportions of these minerals are highly variable. Quartz ranges from a trace to 40 per cent, albite from 25 to 75 per cent, and potassic feldspar from 12 to 60 per cent. The more sodic varieties may be associated with the more sodic (quartz diorite) facies of the batholith, but further study would be necessary to verify this suggestion. The microperthite has only a very slight intergrowth of the plagioclase phase, and microcline is often present. Calcite is a very common secondary mineral facing fractures in the rock. Otherwise the rocks are fresh and chemically unaltered. Physically, however, they are severely mashed and locally pulverized.

The pegmatite dikes are relatively few and small and were not studied.

HYDER AND BOUNDARY BATHOLITHIC INTRUSIONS AND ASSOCIATED DIKES

CHARACTER AND EXTENT

The rock about the town of Hyder is a quartz monzonite that forms a part of the eastern border of the main Coast Range batholith. The rock around the head of Boundary Glacier is a granodiorite that is either an apophysis or an outlying stock of the eastern border of the main Coast Range batholith. Both these intrusive masses send off dikes of granodiorite porphyry far into the surrounding country. Dikes of aplite and pegmatite, malchite, and lamprophyre cut the intrusive rocks as well as the sedimentary and volcanic rocks and are believed to have originated as late facies of the Hyder and Boundary batholithic magmas. The aplite and pegmatite dikes in general are not found in the country rock far from the contact of the main intrusive masses, but the malchite and lamprophyre dikes may occur a score of miles or more away.

HYDER QUARTZ MONZONITE

The southern portion of the Salmon River area is formed entirely of quartz monzonite that is a part of the northeastern border section of the Coast Range batholith. Between Portland Canal and Chickamin River it forms a belt 10 to 14 miles wide and about 25 miles long. On the south it is bordered by the granodiorite of the core of the main Coast Range batholith.

This rock is here named the Hyder quartz monzonite, as it is well exposed at Hyder and along the Salmon River road as far north as Fish Creek. On the east side of Portland Canal, in British Columbia, the Hyder quartz monzonite appears to form the coast line, though the Texas Creek (?) granodiorite and the sedimentary and volcanic rocks of the Hazelton group form the mountains farther back. On the Marmot River trail to the Porter-Idaho property the Hyder quartz monzonite occurs up to the first bench, and a rock resembling the Texas Creek granodiorite thence up to an altitude of 2,000 feet. The contact of the Hyder batholith appears to strike a little east of north for about 2½ miles, and to lie just back from the coast line. At the international boundary on Mount Dolly the contact strikes a little north of west at an altitude of about 4,700 feet. It lies at about 4,800 feet on the south slope of Mount Dolly and runs almost due west, crossing the Salmon River road just north of Fish Creek. It probably keeps to the ridge on the south side of Thumb Creek Valley as far west as Red Glacier. The head of the valley of Thumb Creek is in the Hyder quartz monzonite, and the contact with the Texas Creek granodiorite strikes northwest across the valley about three-quarters of a mile from the foot of Thumb Glacier, then north-northwest to the head of Ferguson Glacier, follows the crest of the ridge between Ferguson and Greenpoint Glaciers for about 3 miles, and then strikes west across the glacier to the northern part of the ridge between Through and Greenpoint Glaciers. The contact on this ridge is at an altitude of about 4,000 feet. It has not been traced farther, but in general it strikes west to Chickamin River at a point about 4 miles below the present foot of Chickamin Glacier. The heads of Greenpoint and Through Glaciers are both in quartz monzonite. To the south the Hyder quartz monzonite passes into the granodiorite or interbanded granodiorite and quartz monzonite that forms most of the core of the Coast Range batholith.

The Hyder quartz monzonite is essentially a massive medium-grained rock with a very inconspicuous gneissic structure due to the alinement of biotite crystals. The rock on fresh surfaces is light pink to white and is sprinkled with small black biotite crystals. A few minute honey-colored titanite crystals can usually be distinguished. Quartz and feldspar form practically all of the rock. The average composition of four specimens from the vicinity of Hyder and the Salmon River road to the north, four taken along Greenpoint

Glacier, and eight taken along Chickamin River north of Indian Creek is given in the table on page 26 as Nos. 4, 5, and 6, respectively.

The plagioclase is conspicuously zoned and is often found in euhedral crystals. Many of the smaller crystals are inclosed in the potassic feldspar. Locally, the plagioclase is replaced to a trifling extent by sericite. The tendency of the plagioclase to occur in euhedral forms is in part due to its early crystallization but is probably due also to a very considerable extent to its strong crystallization forces.

The ferromagnesian minerals are represented almost exclusively by biotite. Rarely a little hornblende is present. The biotite tends to occur irregularly segregated in streaks, often with several crystals grouped together. The individual crystals are chunky and are locally corroded on the edges by potassic and plagioclase feldspars or quartz. They appear to have started crystallization later than some of the plagioclase but to be contemporaneous with much of it. Here and there a crystal of biotite is inclosed in the plagioclase and is corroded by it. A few crystals of biotite have thin leaves of chlorite intergrown parallel to the cleavage as a result of alteration. In a few places the biotite is completely altered to chlorite with a trace of epidote.

The potassic feldspars include microcline with a well-developed gridiron structure, microperthite with only a slight amount of the plagioclase phase, and a clear feldspar that may be orthoclase but is probably microcline. The potassic feldspar occurs in grains of about the same size as the plagioclase, but it does not show good crystal faces as often, and it includes small crystals of plagioclase. It therefore must have begun crystallization somewhat later than the plagioclase, but it is in major part contemporaneous. The accessory and ferromagnesian minerals occur commonly inclosed in the potash feldspar.

The accessory minerals are in small euhedral crystals. In part they tend to be segregated together and to be associated with the ferromagnesian minerals, within which they may occur, and in part they tend to occur at the borders between the quartz and feldspar. Such relations suggest that their period of crystallization was long, starting early and finishing late. Locally apatite crystals are inclosed in magnetite and both in titanite. The magnetite crystals commonly occur in groups of as many as a score, some separate, some impinging, and some interfering with one another.

The quartz is for the most part in grains of size similar to the feldspars and of the same period of crystallization; but in part it was the last mineral to finish crystallization. Much of it shows strain shadows and incipient crushing.

Locally the minerals are considerably crushed and reduced to a granular aggregate. Practically no hydrothermal alteration accompanied this mashing.

BOUNDARY GRANODIORITE

A mass of granodiorite forms the northeast corner of the Salmon River area between the top of the ridge north of the eastern part of Texas Glacier and the international boundary. The eastern border of this mass appears to coincide almost exactly with the international boundary and to pass just west of the peak of Mount Bayard. The rock is well exposed along both sides of Boundary Glacier at its head and to a point about a mile above its foot, also on the top of the ridge north of the eastern part of Texas Glacier. It is therefore here named the Boundary granodiorite.

This granodiorite is medium grained, and on the fresh surface it is seen to be composed predominantly of white plagioclase with scattered grains of pink orthoclase, glassy quartz, crystals of black biotite and hornblende, and sparse minute crystals of yellowish-brown titanite. Epidote faces some fractures in the rock. In contrast to the older Texas Creek granodiorite, into which it is intrusive and with which it may be confused, the Boundary granodiorite is much more massive, is lighter colored, with a pinkish hue, and contains conspicuous biotite plates. The rock exposed on the Canadian side along the lower part of Boundary Glacier is the Texas Creek granodiorite. The average composition of five specimens of granodiorite, as determined in this section, is given in the table as No. 9.

Narrow green-gray and dark-gray dikes of sparsely porphyritic malchite and of pink aplite are common in the Boundary granodiorite and are locally very abundant near the southern and eastern boundaries on the ridge north of Texas Glacier. The malchite dikes strike in general northwest.

Biotite and hornblende both occur as euhedral crystals, locally slightly replaced and corroded on the borders by the feldspars or split by the feldspars and quartz. The plagioclase is zoned, but its average composition is about that of a typical andesine. It is in part contemporaneous with the ferromagnesian minerals, and in part its period of crystallization overlapped, beginning slightly earlier and finishing later. The potassic feldspar contains included crystals of plagioclase, hornblende, and biotite and occurs in part interstitial to the plagioclase. It contains a small amount of plagioclase in microperthitic intergrowth. The quartz overlaps the microperthite in its period of crystallization. The apatite tends to be associated in considerable degree with the magnetite and in part occurs as crystals included in the magnetite. Titanite crystals are sparsely disseminated through the rock, and a few of them include crystals of apatite and magnetite. They are present both as euhedral crystals and as rounded grains. Rarely a trace of zircon is present. Chlorite and magnetite secondary after the ferromagnesian minerals are locally common. Sparse grains of secondary epidote are usually present. The chlorite in part has the appearance of being intergrown with the biotite.

The geology of the area north of the international boundary has not been studied, so that it is not known whether the Boundary granodiorite forms an apophysis from the main Coast Range batholith or is a separate stock. In either case it represents a less advanced stage of differentiation than the Hyder quartz monzonite.

GRANODIORITE PORPHYRY DIKES

Light-colored dikes, genetically associated with the Hyder quartz monzonite here collectively grouped as granodiorite porphyry dikes, are common and locally abundant everywhere throughout the Texas Creek granodiorite and the sedimentary and volcanic rocks of the Hazelton group of this district, except in a belt between Casey Glacier and the ridge top between Ferguson and Greenpoint Glaciers and west of the Salmon River between the ridge at the heads of Ferguson, Casey, and Hidden Glaciers and a line within a mile of the southern boundary of the Texas Creek granodiorite in the western half and within 2 miles of the boundary in the eastern half. They are abundant within a belt 1¾ miles wide along the southern border of the Boundary granodiorite. Many of these dikes are exposed along the Salmon River road north of the mouth of Fish Creek and along the international boundary on the bare ridge extending north from Mount Dolly. The cream-colored bands which from a distance are seen to cut across Mount Dolly in such conspicuous fashion are the granodiorite porphyry dikes. They cut across the zones of rusty-weathering rock impregnated with iron sulphide but are not themselves affected by the metallization. More than a dozen large dikes are exposed along the Salmon River road between the bridge at Ninemile and the international boundary.

The granodiorite porphyry dikes range in width from 10 to 1,200 feet and have in general a northwest strike, usually between N. 20° W. and N. 70° W., though here and there they strike northeast. Along the international boundary they dip in general 45°–60° SW.

At some places there are dikes 10 feet or less in width of a fine-grained, inconspicuously porphyritic dark-gray rock. The narrower granodiorite porphyry dikes usually show borders of similar rock. These dark-gray dikes and borders are less siliceous and alkalic than the granodiorite porphyry and have the composition of a typical diorite or a quartzose diorite. A number of such dikes are shown on the map by Schofield and Hanson [10] of the adjoining Salmon River area in British Columbia, where they are termed granite dikes; they are described more specifically as quartz diorite dikes. These dikes also show the persistent northwest strike.

The granodiorite porphyry is much more resistant to weathering than the country rock, so that the percentage of boulders of rock of this type found in glacial moraines or stream gravel may give a misleading impression of the relative extent of these dikes in the drainage area from which the fragments have come. The boulders are, for instance, very abundant in the material brought down by Texas Glacier, though they are not unusually abundant in the country along the course of the glacier. Furthermore, they tend to weather out in relief, so that below timber line in that part of the country covered by vegetation they may form the predominant outcrops. This is conspicuously the case on Mineral Hill, where most of the exposed bluffs and outcrops are of the granodiorite porphyry dikes, which are not representative of the country rock.

The granodiorite porphyries are pink to white or light gray and, owing to the abundance of plagioclase phenocrysts, they resemble granodiorite in appearance. In hand specimens the rock is characterized by the presence of biotite or hornblende crystals, or both, and occasionally orthoclase or quartz may be distinguished. The interstitial groundmass is dense to fine grained. The plagioclase phenocrysts are 1 to 2½ millimeters in diameter. Under the microscope the plagioclase shows a zonal character, but its average composition is about that of andesine. In the dikes that have been somewhat quickly chilled plagioclase forms the predominant phenocrysts, with associated biotite, hornblende, and a little magnetite and apatite. In a more coarsely crystalline type orthoclase and quartz and locally titanite occur as phenocrysts in addition to the other minerals mentioned. The biotite and hornblende are partly or completely altered to chlorite, with a few associated grains of epidote and secondary magnetite.

The groundmass consists usually of a micrographic intergrowth of quartz and potassic feldspar or a microgranitic aggregate of quartz, potassic feldspar, and plagioclase. The composition of the rocks may vary toward a diorite or quartz diorite porphyry, on the one hand, or toward a granite porphyry, on the other hand. Calcite veinlets commonly traverse the rock and locally replace it. The plagioclase crystals are in local portions partly altered to sericite.

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[10] Schofield, S. J., and Hanson, George, op. cit., p. 26 and map.

APLITE AND PEGMATITE

Aplite dikes are present but not abundant in the Hyder quartz monzonite and in the adjacent country rock. The aplite is fine grained and has a characteristic pink hue. It consists of the same minerals as the quartz monzonite but in different proportions. The percentage of quartz and potassic feldspar is much higher in the aplite than in the quartz monzonite. The dikes are fresh and unaltered and thus are in marked contrast to the aplite dikes associated with the Texas Creek batholith, which are shattered and crushed. In thin section the aplite shows a hypidiomorphic granular aggregate of microcline, in part with a trace of microperthitic intergrowth, rounded quartz grains, and subhedral plagioclase. A trace of biotite is locally present. Accessory minerals are sparse; the most common is magnetite. The average composition of three specimens is given in the table on page 26 as No. 8.

Small dikes of pink fine-grained aplite are abundant in the Boundary granodiorite near the south contact. Only one was examined. Its composition, as shown by No. 10, is very similar to that of the aplite associated with the Hyder quartz monzonite (No. 8).

MALCHITE DIKES

Dikes of a green-gray or medium to dark gray rock of felsitic to sparsely porphyritic felsitic texture cut the sedimentary and volcanic rocks, the Texas Creek granodiorite, the ore veins, the Boundary granodiorite, the Hyder quartz monzonite, and the granodiorite porphyry dikes that are genetically connected with the Boundary granodiorite and the Hyder quartz monzonite. Rock of similar appearance is found here and there as a chilled border zone along each side of the granodiorite porphyry dikes. The dikes must therefore be of two ages. Rarely the rock has a greenish-gray hue, and there is scarcely any ferromagnesian mineral present. A dike of this kind cuts both granodiorite porphyry of the Boundary type and the ore vein at the Ibex prospect. The rocks are the same as those which have been described by Westgate[11] as diorite porphyry, and by Buddington[12] as andesite porphyry and are in part the same as those described by Schofield and Hanson[13] as lamprophyre.

The writer is here adopting the name malchite for these dark to medium gray dike rocks because (1) they are not sufficiently coarse grained to satisfy the requirements for a typical diorite porphyry; (2) the term andesite porphyry is undesirable, as it commonly sug-

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[11] Westgate, L. G., op. cit., pp. 126–127.

[12] Buddington, A. F., Mineral investigations in southeastern Alaska: U. S. Geol. Survey Bull. 773, p. 86, 1925.

[13] Schofield, S. J., and Hanson, George, op. cit., p. 27.

gests an association with volcanic extrusives, whereas these dikes are definitely associated with batholithic intrusives; (3) more typical lamprophyre dikes are also present, and it appears preferable to restrict the use of that term to such dikes; (4) the rocks correspond in part to typical malchite, which is defined as a microdiorite in which phenocrysts are not conspicuous. In some of the dikes, however, the hornblende has a brownish-green hue and the rocks grade toward a lamprophyre.

When examined microscopically the malchite is seen to consist typically of small phenocrysts of plagioclase, or rarely of plagioclase and hornblende, in a felsitic groundmass composed of a mat of plagioclase laths with subordinate hornblende rods and a little interstitial quartz and potassic feldspar. Abundant minute crystals of magnetite are distributed throughout the groundmass. Apatite is occasionally seen. The hornblende is, as a rule, partly or completely altered to chlorite, commonly with a little associated epidote and calcite, and the plagioclase is in places slightly sericitized. Pyrite in well-formed crystals occurs locally along fractures in some of the dikes.

The variety of plagioclase is difficult to determine but appears to range from an albite-oligoclase to andesine. Rarely a little biotite is present. The hornblende in some of the freshest dikes has a brownish-green hue. Hornblende or its alteration products form usually less than 25 per cent of the rock.

LAMPROPHYRE DIKES

The lamprophyre dikes are dark-green to gray-black rocks of fine grain, which cut both the batholithic intrusive masses and the country rock. With the possible exception of certain basaltic dikes they are the youngest intrusive rocks in the district. The most common type of lamprophyre in this district belongs to the spessartite group. Spessartite is typically composed of brown or basaltic hornblende and plagioclase feldspar with some pyroxene. In this district the feldspar is almost wholly the oligoclase or andesine variety of plagioclase, locally with some labradorite. Plagioclase appears to be more abundant in most of the spessartite of this area than is typical elsewhere, and to this extent the rock varies toward malchite. Hornblende may form only 10 to 30 per cent of the rock, but types in which the hornblende forms 30 to 50 per cent are also common. Here and there the hornblende occurs as long black rods in a fine-grained groundmass and gives to the rock a porphyritic aspect.

The predominant type of lamprophyre consists of long prismatic rodlike crystals of brown hornblende with or without a few crystals of augite in a groundmass formed by a felt of oligoclase or andesine laths with or without associated rods of brown hornblende. In places a little biotite is present. Magnetite is usually present as abundant disseminated small crystals, and apatite in long, slender rods. Titanite is found in a few specimens. There is commonly a trace of interstitial quartz. Secondary minerals due to alteration are invariably present and may be very prominent; they comprise calcite, chlorite, and epidote. Calcite is usually abundant in the groundmass, and much of it shows replacement relations to the other minerals, but in part it is interstitial to the plagioclase crystals and is molded against them. It probably belongs to a late magmatic stage and an early phase of alteration.

BASALTIC DIKES

Near the head of Casey Glacier, on the west side, at an altitude of about 4,300 feet, there are dark basaltic dikes in the Texas Creek granodiorite. One of these consists of labradorite and augite with some interstitial altered greenish glass and small phenocrysts of labradorite. This rock is not a typical lamprophyre and is probably of Tertiary or Quaternary age.

CONTACT METAMORPHISM

TEXAS CREEK INTRUSIVES

One of the most amazing features of the geology of this district is the almost complete failure of the Texas Creek intrusives to produce any observable contact metamorphism in the country rock. This is the more striking when contrasted with the contact-metamorphic effects which the Boundary granodiorite, the Hyder quartz monzonite, and their associated porphyry dikes have produced in the same kind of country rock and in the Texas Creek granodiorite itself. The writer could see little or no difference between the slate and graywacke immediately in contact with the roof of the batholith and that several thousand feet above. In the vicinity of the Riverside mine, however, there are slabs and fragments of schist included in the Texas Creek batholith. These appear to consist of thin intrusive sheets of a porphyritic facies of the Texas Creek granodiorite alternating with thin layers of recrystallized sedimentary or tuffaceous material. Subsequent movement has been localized along some of these layers so that the porphyritic schist has been puckered and plicated and the minerals crushed. The Lindeborg vein on the Riverside property is in such a schist band. In thin section the schist is found to consist of phenocrysts of oligoclase and quartz and rare hornblende in a microcrystalline groundmass of quartz and feldspar. There is considerable secondary epidote, chlorite, calcite, and sericite.

HYDER AND BOUNDARY INTRUSIVES

The Hyder quartz monzonite, the Boundary granodiorite, and their associated dikes in the older country rock have locally produced contact metamorphism. Mechanical, thermal, and hydrothermal alterations and replacements have been effected. The chemical metamorphism, though noteworthy, is nevertheless not comparable with what might be expected along the contact of so large a body as the Coast Range batholith or even the Hyder quartz monzonite portion of it.

The pressure and thrust attendant upon the intrusion of the Hyder quartz monzonite magma, with the resultant mashing, have produced schist, gneiss, and augen gneiss from the Texas Creek intrusive rocks where they border the younger igneous mass. This mechanical mashing of the Texas Creek rocks may or may not be accompanied by hydrothermal alterations of the minerals. Some of the rock shows merely the effects of mechanical crushing, pulverization of the minerals, and production of mortar structure, without noteworthy alteration. At most places the plagioclase feldspars are partly or completely altered to epidotic aggregates or to sericitic or muscovitic aggregates with a little associated chlorite and epidote, and the hornblende is altered to aggregates of fine flaky biotite with some associated epidote, chlorite, magnetite, and sericite. Usually a little calcite is present. Generally there are numerous schistosity planes, parallel to which streaks or bands of chlorite or epidote or both replace or vein the rock. Rarely a little garnet is associated with the epidote, and a few grains of green spinel (hercynite) and chloritoid have been found with the chlorite. Usually a little magnetite is associated with the chlorite. The potash feldspars are uniformly fresh and unaltered.

On the west slope of Mount Dolly solutions from the Hyder quartz monzonite magma have locally produced high-temperature alterations for a distance of 1½ miles north of the present contact. The greenstone and graywacke are locally banded with epidote, and there are quartz lenses and veinings, both parallel and across the bedding, which carry associated garnet and epidote and in places a little chalcopyrite. To the north, on Bear River Ridge, there are a number of granodiorite porphyry dikes, which are offshoots from the Hyder quartz monzonite. Locally, in the greenstone adjoining the dikes, there are fractures along which the rock has been altered to epidote, with which are commonly associated pockets of crystalline hematite (specularite).

On the north side of Greenpoint Glacier the contact between the graywacke and Hyder quartz monzonite is exposed in a gulch. Here graywacke is much disturbed and metamorphosed. Epidote, hornblende, and garnet are common. The quartz monzonite adjacent to the contact is white and contains gash veins a few inches long with disseminated chalcopyrite, also small fracture surfaces faced with molybdenite. On the mountain slope northeast of Greenpoint Glacier the slate has a pencil structure in the vicinity of the contact with the Hyder quartz monzonite.

On Chickamin River the slate is changed to crinkled phyllite near the contact, and both graywacke and slate are predominantly hornblendic, chloritic, and locally biotitic. Quartz veins, in part with garnet and chlorite parallel to the schistosity, are common. The Boundary granodiorite and its associated dikes have caused the argillite in the band on the top of the ridge north of Texas Creek to be metamorphosed to tactite. There are great irregular masses and veinlets of epidote, garnet, and pyroxene, and abundant small veinlets of quartz, calcite, and unidentified minerals.

SUPERFICIAL DEPOSITS

PLEISTOCENE AND RECENT DEPOSITS

A considerable part of the area, particularly along the lower slopes, is covered with glacial drift, and glacial erratic boulders are common.

Along the Salmon River road between the Daly-Alaska camp and the international boundary there is a series of beds of interlaminated clay and fine sand up to an altitude of about 450 feet, which pass into and are overlain by gravel and sand toward the boundary. Pebbles and boulders are scattered here and there through the sand and clay. On the west side of Salmon River, about opposite the Daly-Alaska camp, there is a bench crossed by the Premier tramway at an altitude of about 600 feet. This bench is underlain by bedded gravel corresponding to that on the east side of the river a little to the north. McConnell [14] found stratified clay and sand at an altitude of 500 feet at Bear Lake on Bear River. Fossiliferous beds with a marine fauna were found by him at an altitude of 345 feet. These beds indicate post glacial uplift of as much as 500 feet.

In the valley of Thumb Creek above the rock gorge there are benches of boulder gravel at an altitude of about 1,000 feet, in which the creek has cut a deep valley. These gravel benches appear to be older river deposits which have been trenched by the creek during its canyon-cutting activities consequent upon the uplift of the area.

Remnants of bench gravel are also found locally along the West Fork of Texas Creek and a few of its tributaries. On the trail west of the cable crossing coarse waterworn bedded gravel occurs at an

[14] McConnell, R. G., Portions of Portland Canal and Skeena mining divisions, Skeena district, B. C.: Canada Geol. Survey Mem. 32, p. 22, 1913.

altitude of 700 feet, and along the valley of Ibex Creek there are deposits of bench gravel that have been deeply dissected by recent erosion.

Salmon River and Texas Creek are depositing great quantities of gravel upon the floors of their valleys, except in the gorge of Salmon River just above Cascade Creek, and Salmon River is building forward a delta into the head of Portland Canal. The upper valleys of Thumb Creek and the West Fork and of their main tributaries below the points where these streams emerge from the glaciers are likewise being aggraded with gravel deposits. Terminal and lateral moraines are being formed at the borders and sides of the many glaciers. Talus accumulations and landslide aggregates are common at the foot of the steeper mountain slopes.

STRUCTURE

BEDDED ROCKS

Most of the bedded rocks within this area have an approximate east-west strike, but two narrow belts of bedded rock with an approximate north-south strike were noted. One of these is high on Bear River Ridge opposite the mouth of Thumb Creek, and the other, which comprises slate interlayered with graywacke and greenstone, extends north, with some interruptions, from a point southwest of the upper workings of the Daly-Alaska claim to the Doggat claims on the Salmon River road. Superimposed on the greenstones east of Salmon River, however, there is a schistose structure which trends N. 70°–90° W. The beds of tuffaceous graywacke and slate in the southern part of this belt of bedded and volcanic rocks east of Salmon River also have a strike that ranges from N. 80° E. to N. 75° W. The foliation of some of the porphyry dikes associated with the Texas Creek granodiorite in this belt likewise has an approximately east-west trend. O'Neill [15] describes the shearing near the Premier mine as striking nearly due east.

In the vicinity of Chickamin Glacier and its tributaries and of the upper part of the West Fork the beds are closely folded, with uniform dips to the south on the south and west and to the north on the north. The major structure appears to consist of an anticlinal axis on which the graywacke of the south slope of the West Fork is exposed; a syncline overturned toward the north, in which the slate of the northeast slope of the valley of Greenpoint Glacier is infolded in the graywacke; and a syncline overturned toward the south, in which the slaty argillite of the ridge north of the West Fork and along Texas Glacier is infolded in the graywacke. Along the west

[15] O'Neill, J. J., Salmon River district: Canada Geol. Survey Summary Rept. for 1919, pt. B, p. 9, 1920.

side of Chickamin Glacier and along Through Glacier the beds dip almost uniformly to the south, except for minor local drag folds. These beds form the roof of the Texas Creek batholith, which here plunges to the west, and they are cut off down the dip by the batholithic rock. The strike of the beds ranges prevalently from N. 60° W. to N. 70° E., with a general trend of about N. 80° E.

In the north half of the area between Casey and Ferguson Glaciers the strike of the beds ranges from N. 25° E. on the east to N. 60° E. on the west, and the dip is almost vertical. In the southern half of this area the beds on the west strike N. 65°–90° E. and dip 60° N. to vertical. In the vicinity of the small glaciers just west of Ferguson Glacier, as far west as the west side of the second glacier, the beds strike N. 75°–85° E. and dip 55°–90° S. From this point to Through Glacier the beds strike N. 55°–75° W. and dip 40°–60° S. On the west side of Through Glacier the strike is N. 50°–70° W. and the dip 40°–70° S. On the west side of Chickamin Glacier, south of the conspicuous gulch just below the ice cascades, the beds strike N. 70°–90° E. and dip 25°–75° S.; north of the gulch the beds strike N. 60°–70° W. and dip 30°–65° S. On the west end of the ridge between the West Fork and Texas Glacier the beds strike N. 70°–95° E. and dip 45°–90° both north and south; at the east end of this ridge the strike is N. 75°–90° W. and the dip usually vertical. Only a few observations were made in the mountains north of Texas Glacier, but the prevalent dip appears to be north.

TEXAS CREEK BATHOLITH

In the part of the Texas Creek batholith east of Salmon River the strike of the gneissic banding varies between N. 80° E. and N. 80° W. with an average about east-west. Between Salmon River and Chickamin Glacier the strike of the banding is N. 50°–90° E., with N. 60°–70° E. very common, and an average of N. 67° E. for 17 observations. In the outlying mass of Texas Creek quartz diorite bordering Chickamin Glacier the strike of the foliation is N. 50°–55° E.

The Texas Creek granodiorite is mashed to a schist along its southern contact with the Hyder quartz monzonite. To the north this schistose facies grades through an augen gneiss into the normal porphyritic granodiorite, which has gneissoid structure resulting largely from orientation of the minerals during a stage when the rock was not yet completely consolidated. Microscopic examination of the schist and augen gneiss, on the other hand, shows that they have resulted from the mechanical crushing and pulverization of the minerals by pressure exerted presumably by the thrust of the Hyder quartz monzonite magma at the time of its intrusion. Shearing planes and slickensiding are common in this highly foliated border of the Texas Creek batholith. The width of the belt of the Texas Creek granodiorite in which the rock shows marked effects of mechanical crushing and shearing ranges from a quarter of a mile to 1½ miles. A band of augen gneiss and schist 1½ miles wide resulting from such mashing is well exposed along the Salmon River road north of Fish Creek.

FAULTS

Within the rocks of the Hazelton group there is a great deal of offsetting of the beds on a small scale, but no fault of any considerable magnitude was identified. Within the Texas Creek batholith some of the veins are offset 5 to 100 feet by small faults. On the Fish Creek property a group of veins is offset by a series of faults that run N. 30° E. and dip steeply northwest. The valleys of Skookum and Fish Creeks appear to have been eroded along a fault zone.

JOINTS

The observations on the joints in the Texas Creek granodiorite show no well-defined groups. The strike varies markedly in different localities, and there appears to be no constancy in the direction of the dip except for local areas. If any groupings in direction are more common than others they are N. 20°–50° W. and N. 30°–60° E., though strikes of N. 10° W. to N. 20° E. are about equally common. Joints that strike N. 50°–60° W. are found, and joints that strike N. 60°–90° W. or N. 60°–90° E.—that is, within 30° of east-west—are present though not numerous.

In the Hyder quartz monzonite the joints commonly strike N. 30°–35° E. and have predominantly a vertical dip. Other joints, which may belong to the same genetic group, strike N. 10° E. to N. 30° E., with a dip 70° to vertical. Some others noted strike N. 60°–65° E., with dip usually 60°–90° N., N. 10°–30° W., N. 50° W., and rarely east-west.

MINERAL DEPOSITS

CLASSIFICATION

The mineral deposits of economic importance in the Salmon River district in Canada have been classified by Schofield and Hanson,[16] and those in the Alaskan part of the district by Westgate.[17] The following classification is a combination of both of these, somewhat modified by the writer:

[16] Schofield, S. J., and Hanson, George, The Salmon River district, B. C.: Canada Geol. Survey Summary Rept. for 1920, pt. A, pp. 9–12, 1921.

[17] Westgate, L. G., Ore deposits of the Salmon River district, Portland Canal region: U. S. Geol. Survey Bull. 722, pp. 127–129, 1922.

1. Quartz fissure veins of lead-silver-gold type: The principal value is in lead, the silver ranges from moderate to high, and gold is in moderate amounts but high for this type of vein. The veins occur principally within the Texas Creek granodiorite but are found also in the rocks of the Hazelton group and with outlying stocks and dikes of porphyry associated with the Texas Creek granodiorite. Nearly all of them cut across the structure of the rocks in which they occur. The sulphides occur in shoots within the quartz veins. The predominant metalliferous minerals so far as quantity is concerned are galena and pyrite. Sphalerite and chalcopyrite are present as accessory minerals in practically all the veins, and tetrahedrite, pyrrhotite, and native gold occur in small amounts in many of them. Scheelite is locally present in a few of the veins. Barite is a common gangue mineral in about half of them. Examples of this type are found on the Fish Creek, Mountain View, Riverside, Homestake, Cantu, and Texas Comstock properties, and they constitute one of the major types of veins in the district.

2. Veins and veinlike replacement deposits of silver-gold type in porphyry and in tuff near the contacts or included within the porphyry: The Premier ore body in Canada is described by Schofield and Hanson as of this type. This ore body occurs within a stock of granodiorite porphyry that contains numerous inclusions of greenstone. Burton[18] describes its relations as follows: "Fracturing has been concentrated along the contact between the porphyry stock and the greenstone, and the main ore zone, striking N. 40° E., follows this contact, with a dip of 50°–75° N. W. The northwest ore zone is ill defined, but where it joins the southwest end of the main ore zone, mineralization has been particularly intense, and the sulphide body is unusually wide, due to the porphyry being rendered highly permeable in that locality." The large ore shoots are lenticular. The minerals present are pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, freibergite, polybasite, pyrargyrite, argentite, stephanite, native silver, and gold. The predominant mineral is sphalerite. The gangue is rather abundant and is almost entirely quartz. Deposits of this type, characterized by the rich silver minerals, have not been found in the Alaskan part of the district.

3. Veins of the gold type: Schofield and Hanson refer a body of ore in the Premier mine in Canada to this type. It is a siliceous heavy-sulphide deposit. Quartz and pyrite are the predominant minerals. Small quantities of chalcopyrite, sphalerite, and galena are present. Assays show moderate to high value in gold and practically no silver. A similar mineral aggregate appears to occur in the Texas Creek batholith on the Cantu property on the Alaskan side.

4. Disseminated and lenticular replacement deposits: These occur mainly in the greenstones parallel to the schistose structure and are principally of base-metal types. The predominant metalliferous minerals are pyrite, galena, sphalerite, and pyrrhotite, or pyrrhotite with minor amounts of chalcopyrite and arsenopyrite and a very little sphalerite. Chalcopyrite is present in practically all the veins and is the predominant ore mineral in some. Tetrahedrite and arsenopyrite are found in a considerable number of them. The sphalerite carries gold, but the quantity ranges from very low to very high. Some secondary rich silver minerals are found in these deposits on the Canadian side, and a trace of native silver has been found in deposits of this type on the Alaskan side. The gangue commonly consists of the altered country rock, quartz, rather abundant calcite, and at some places barite. Examples of this type are found on the Daly-Alaska, Virginia, Hobo, and Stoner properties. Analogous deposits

[18] Burton, W. D., Ore deposition at Premier mine, B. C.: Econ. Geology, vol. 21, p. 588, 1926.

on the Canadian side are found on the Big Missouri and Forty-nine properties. Deposits of this character form one of the major types of occurrence throughout both the Alaskan and Canadian portions of the district.

5. Mineralized fissure zones, approximately parallel to the structure, in slate and tuffaceous graywacke of the Hazelton group: These zones consist in part of fissure fillings and in part of partly replaced country rock. The amount of gangue is extremely variable. The mineralization consists predominantly of galena or sphalerite, or both, with variable amounts of pyrite, chalcopyrite, pyrrhotite, tetrahedrite, and arsenopyrite. Examples are found on the Silver Bell and Iron Cap claims.

RELATION TO COUNTRY ROCK

TYPE OF VEIN

The deposits made up of veins and veinlike replacement lodes and the disseminated deposits are practically limited to the greenstone. The veins that are approximately parallel to the structure and consist for the most part of fissure fillings and in slight part of replacement deposits are predominantly restricted to the graywacke, argillite, and slate. The mineralized quartz fissure veins that lie at an angle to the structure (that is, the gneissic structure of the Texas Creek batholith, the bedding of the sediments, or the foliation of the greenstone) occur predominantly in the Texas Creek batholith. Westgate [19] has described the relations of the type of deposit to the nature of the inclosing rock. He writes:

> The softer greenstones, at the prospects mainly altered tuffs, are thought incapable of retaining open fissures, so that in them the deposit was formed by replacement along shear zones. The granite [Texas Creek batholith] seems to have been firmer and able to retain open fissures; hence it holds typical veins. At the depth of the deposits at the time of their formation the granite was in the zone of fracture, and the greenstone in the zone of flowage.

The graywacke appears to have been more favorable for the formation of fissure veins than the greenstone or argillite, and a number of veins occur within it. The outlying dikes of porphyry in the rocks of the Hazelton group also appear to have been brittle, and many veins of quartz occur in them or along their contact with the country rock.

STRIKE AND DIP

Observations on the strike and dip of 125 veins in the district were obtained. Almost half of the veins strike N. 30°–60° W. and dip 45°–70° E. One-fifth of the veins strike between north and N. 30° W. and dip 45°–70° E., and another fifth strike within about 15° of east-west. A few veins have different strikes. Veins with strikes between N. 30° E. and N. 75° E. are rare. In the Texas Creek granodiorite

[19] Westgate, L. G., op. cit., p. 129.

about two-thirds of the veins strike N. 30°–60° W.; in the graywacke, tuff, slate, and greenstone about half the veins strike N. 75° E. to N. 70° W.—that is, parallel to the cleavage or schistose structure or to the bedding planes.

The northwestward-striking veins in the Texas Creek granodiorite are oriented at angles of about 45°–70° to the gneissic structure. Within the West Fork area the strike of the gneissic structure averages about N. 70° E. and that of the northwest veins about N. 40° W.; east of Salmon River the gneissic structure averages about N. 85° E. and the northwest veins about N. 50° W. These northwestward-striking veins and the veins that strike between N. 35° E. and N. 30° W. not only cut across the grain or structure of the Texas Creek batholith but also across the bedding or structure of the sedimentary and volcanic rocks. They are all fissure veins. The east-west group of veins in the sedimentary and volcanic rocks, on the contrary, are approximately parallel to the bedding or cleavage and were formed both by fissure filling and by partial or complete replacement of the country rock.

Several belts or areas may be defined in which the strike of the veins shows a certain uniformity or systematic grouping. One such area lies between Salmon River and the international boundary, south of the junction between Texas Creek and Salmon River and north of the Hyder quartz monzonite. In the Texas Creek granodiorite of this area two groups of veins predominate and are about equal in number: One group strikes N. 50°–60° W. and dips 45°–70° E.; the other strikes N. 10°–30° W. and dips similarly 45°–70° E. The small percentage of veins that differ strike north, N. 80° W., or N. 60°–80° E. East of Salmon River in the sheared sedimentary and volcanic rocks there are two groups and types of veins. One group consists of metalliferous veins similar in type to those found in the Texas Creek granodiorite, and occurring as fissure fillings in the rocks. Some of these veins lie along the contacts of the dikes of granodiorite porphyry with the country rock or within the dikes. Almost all these veins strike N. 40°–60° W. and dip 45°–60° NE., though a few dip southwest. The veins of the other group lie more or less parallel to the foliation or slaty structure of the rocks and consist of replacement and disseminated deposits and fissure fillings. They strike almost uniformly between N. 80° E. and N. 70° W.; about half of them strike east-west. They may dip either south or north, though a southward dip is more common.

Between Salmon River and Texas Creek, north of their junction, is an area in which the strike of the veins within the Texas Creek granodiorite, so far as observed, shows no uniformity or system. The strike is N. 10°–20° W., N. 50° W., N. 70°–80° W., or N. 70° E.

A belt in which the veins in general strike between N. 5° W. and N. 35° E. was noted in the vicinity of Casey Glacier and Ibex Gulch. Here the veins dip east, most commonly at angles of 40°–70°.

West of the Casey Glacier–Ibex Gulch belt, at the head of the West Fork and including in particular the Texas Comstock ridge and the valley of Ferguson Glacier, is an area in which the veins in the granodiorite and quartz diorite have a very uniform strike, trending almost exclusively N. 30°–50° W. and dipping 45°–80° E.; the dip is about equally divided between 45°–50° and 60°–80°. In the graywacke and slate of the same area there are three groups of veins; about half the veins have the same general strike as the veins in the granodiorite, N. 30°–50° W., and most of the other half fall into two groups, one north to N. 20° W., the other N. 75° E. to N. 70° W. The veins that strike north to northwest in general dip 45°–70° E., cut across the bedding of the sediments, and carry mineralization of about the same type as the northwest veins in the granodiorite. The veins within 15° or 20° of east-west are approximately parallel to the bedding, though they may cross it at a slight angle, and they carry a somewhat different mineralization. The dip of these veins is variable, both in amount and in direction.

CHARACTER OF THE VEINS

FISSURE VEINS AT AN ANGLE TO THE STRUCTURE

Quartz veins occur at altitudes ranging from sea level on the Riverside property to 5,100 feet on the east side of Ferguson Glacier. The mineralization is similar at the different altitudes.

The total length of only a few of the mineralized quartz fissure veins has been determined. The Cross vein on the Riverside property is 750 feet long; a vein on the Sunset claims has been traced for 900 feet; the Lindeborg vein is reported to have been traced for 1,800 feet; and a considerable number of veins have been traced for 450 to 600 feet without ascertaining their total length. Like most quartz veins, they show local contractions and expansions. They range from mere stringers to veins 15 feet in width but predominantly are between 1 and 5 feet. Locally they consist of a breccia of the country rock intersected by a network of veinlets. The sulphides occur mostly in shoots within the quartz but in part are disseminated through the quartz in sufficient quantity to constitute a milling ore. The heavy sulphide ore shoots range from several feet to 150 feet in length and from 6 inches to 5 feet in width. Considerable quartz, barren or with only sparse sulphides, may intervene between the concentrated shoots of ore; and the major portions of some of the veins are relatively barren. None of the veins have been prospected to any great depth. A shaft has followed the Cross vein on the Riverside property down the dip for 350 feet; the Olympia Extension vein on the Fish Creek group of claims has been developed for a difference in altitude of 250 feet; the Lindeborg vein on the Riverside property is reported to be exposed for a difference in altitude of 700 feet; and veins on the Texas Creek Comstock property are exposed for a difference in altitude of 500 feet.

VEINS PARALLEL TO THE STRUCTURE

The veins and veinlike replacement deposits in the greenstone and in the porphyry dikes of the Texas Creek batholith have been but little prospected. The greatest amount of development work on deposits of this type has been done on the Daly-Alaska property. Small shoots of ore have been found here, but not in sufficient number or continuity to warrant the installation of a mill or attempts at mining.

Practically no development work has been done on veins approximately parallel to the structure in the graywacke, argillite, and slate beds, as contrasted with the fisssure veins at an angle to the structure in the same beds. One vein aproximately parallel to the bedding has apparently been traced for about 600 feet and found to consist of mineralized quartz stringers in a narrow fissured zone in the argillite, but most of them have not been definitely traced for more than 150 feet because of the overburden and lack of prospecting. The veins consist of stringers of mineralized quartz and calcite or of solid sulphide in fissured zones ranging in width from a few inches to 15 feet. The stringers may be at considerable distance apart, or they may be close together and interlock to form a more definite vein.

Pyrrhotite is sparse or absent in the veins in the Texas Creek batholith and in the slate and argillite of the Hazelton group, but it is common in the veins in the graywacke and is one of the chief minerals in the veins in the greenstone. As the veins in the greenstone were probably formed at a lower temperature than those in the Texas Creek batholith, it is improbable that the relative abundance of pyrrhotite in these veins in the greenstone, as contrasted with the predominance of pyrite in the fissure veins, can be due to differences in temperature during their formation. It is probably due to some influence of the country rock, though just how this influence has operated is not clear.

MINERALOGY OF THE DEPOSITS

CLASSIFICATION OF THE MINERALS

The ore and gangue minerals of the Hyder district are listed below.

Native elements	Gold, silver.
Sulphides	Galena, pyrite, pyrrhotite, sphalerite, chalcopyrite, molybdenite, chalmersite, covellite, marcasite.
Sulphosalts	Tetrahedrite, freibergite, arsenopyrite, proustite.
Sulphates	Barite, anglesite.
Oxides	Quartz, magnetite, specularite, limonite.
Carbonates	Calcite, ankerite, malachite, azurite.
Tungstate	Scheelite.
Undetermined minerals.	

METAL CONTENT

The content of the principal valuable metals in these mineral deposits is indicated by assays of representative samples given in the table below.

Content of gold and silver in different minerals in the Hyder district

Sample	Gold (ounces per ton)	Silver (ounces per ton)	Lead (per cent)	Copper (per cent)
Pyrite, nearly pure, Fish Creek No. 2 vein, Mountain View	0.20	0.80		
Pyrite, solid, Fish Creek No. 3 vein, Mountain View	1.50			
Pyrite from disseminated deposits in quartz, Fortuna claims, Texas Creek	Trace.	Trace.		
Pyrite, six-mile group	.02	1.2		
Pyrite, nearly solid, Cantu No. 8 claim	1.40	6.8		
Galena ore, Homestake vein	.18	13.1	62.0	0.9
Galena, Joe-Joe vein, Texas Creek Comstock group	.18	16.9	72.8	.5
Galena concentrate, test sample, Riverside mine	.40	58.0	74.0	
Galena, Riverside mine	None.	21.36	60.9	
Tetrahedrite, Monarch group	1.4	266.0		
Tetrahedrite, nearly pure, lower adit, Olympia claim, Fish Creek group	.84	598.0		
Tetrahedrite, Homestake claim	1.30	40.2	.6	11.6
Ore about one-half tetrahedrite, average of assays on 2 samples, Fish Creek No. 2 vein, Mountain View	.92	232.5		
Sphalerite, nearly pure, Hummel group, West Fork of Texas Creek	.03	22.78		1.13
Chalcopyrite, nearly pure, Fish Creek No. 2 vein, Mountain View	.44	13.16		

NATIVE ELEMENTS

Gold (Au).—Practically all the mineral deposits in the district carry at least a little gold. Gold is known to occur in part as the native metal, at some places in coarse flakes, but its mode of occurrence at other places has not been ascertained. Native gold has been observed in abundance locally in certain quartz veins on the Riverside property. On the Sixmile group of claims it occurs in narrow quartz stringers and in the granodiorite wall rock adjacent to the contact of the veins. It has also been observed in quartz veins on the Monarch, Crest, and Cantu properties and in a boulder of float on the Texas Creek Comstock. All the quartz veins that carry free gold have local shoots heavily mineralized with sulphides.

Silver (Ag).—Native silver is very rare on the Alaskan side of the international boundary, though it is very plentiful in the Premier ore and is found on the Spider, Silver Tip, Porter-Idaho, and other properties on the Canadian side. Native silver has been found in small amounts near a fault plane on the Daly-Alaska property and in a vein on the Mountain View group of claims.

SULPHIDES

Galena (PbS).—Galena is the predominant ore mineral of the district and has been found in every vein. The galena is usually of medium grain, but locally it has been mashed and crushed by movement to a fine-grained aggregate called steel galena. Such dense galena may show a flowage relation toward other minerals. The galena generally occurs concentrated in local shoots in the quartz fissure veins, but in the mineralized bands that constitute the replacement veins in the lower part of the Hazelton group it is more uniformly distributed. It carries moderate quantities of silver and usually $2 to $4 in gold to the ton. Several representative assays are given in the table on page 48.

Pyrite (FeS_2).—Pyrite is probably the most abundant metallic mineral in the district, and it, too, has been found in every vein. Where the mineralization is sparse, pyrite may be of the only metallic mineral present. In such places it occurs usually in good crystals, commonly in the form of pyritohedrons or cubes in the quartz fissure veins and in the form of cubes in the disseminated deposits in the Hazelton group. At many places it is associated in considerable amounts with the galena in localized ore shoots in the quartz fissure veins. The amount of gold and silver in the pyrite is variable. Several representative assays are given in the table. Some pyritic quartz veins in the Texas Creek granodiorite and some pyritic impregnation and replacement deposits in the beds of the Hazelton group carry considerable gold; others do not. At some places the silver content of the pyrite is high.

Pyrrhotite (Fe_nS_{n+1}).—Pyrrhotite has been found as a minor accessory mineral in about one-third of the quartz fissure veins in the Texas Creek granodiorite, is common in the veins in the graywacke and slate, and is one of the chief minerals in every vein in the greenstone. The amount of gold and silver contained is usually very low.

Sphalerite (ZnS).—Sphalerite is present in practically every vein in the district, but in the quartz fissure veins within the Texas Creek granodiorite that are more than 1,000 feet from the contact of the diorite with the rocks of the Hazelton group sphalerite is sparse or is present only in very local shoots associated with other sulphides. It is more abundant in veins within the Texas Creek granodiorite that are not more than 1,000 feet from its contact with the Hazelton group. In veins in the Hazelton group sphalerite is one of the principal minerals. Usually it is associated with other sulphides, but locally it may form narrow almost solid stringers. At many places the sphalerite is dark brown and presumably has considerable iron in solid solution. At other places it is of a light resin color. The resinous sphalerite is usually associated with tetrahedrite. The gold and silver content of the sphalerite is exceedingly erratic. In the greenstones of the Hazelton group and the associated porphyry dikes the gold content ranges from very little to 35 ounces to the ton. At the Premier mine sphalerite shoots have been found with a gold content of 60 ounces to the ton. Assaying appears to be the only means known of gaining an idea as to the amount present. An assay of a sample from the Hummel group is given in the table.

Chalcopyrite ($CuFeS_2$).—Chalcopyrite is present in practically every vein examined but usually in small amounts only. An assay showing the gold and silver content of a sample from the Fish Creek No. 2 vein is given in the table.

Molybdenite (MoS_2).—Molybdenite has not been found in the normal vein deposits. It is abundant in an aplite dike associated with the Texas Creek granodiorite on the banks of Fish Creek on Fish Creek No. 2 claim of the Mountain View property. In the vicinity of the head of the West Fork many of the thin quartz veinlets facing fractures in the Texas Creek quartz diorite carry pyrite and molybdenite. In the vicinity of Greenpoint Glacier fractures in the Hyder quartz monzonite adjacent to the contact with the graywacke and slate are coated at some places with molybdenite.

Chalmersite ($CuFe_2S_3$).—Chalmersite was observed in but one of the veins in the Hyder district, where it occurs as laths in chalcopyrite associated with pyrrhotite.

Covellite (CuS).—Covellite occurs as a secondary mineral only, in sparse veinlets in tetrahedrite, chalcopyrite, and rarely other minerals, as a result of weathering and the action of surface water.

Marcasite (FeS_2).—Marcasite in this area is entirely secondary and is found locally where it has replaced pyrrhotite in or near surface outcrops.

SULPHOSALTS

Tetrahedrite ($Cu_8Sb_2S_7$) *and freibergite* ($(CuAg)_8Sb_2S_7$).—Tetrahedrite has been found in about half the veins examined. Although present in minor amounts, it is an important ore mineral because it usually carries much gold and silver. Representative assays are given in the table. Native gold in flakes of microscopic size was found in one specimen. With an increase in silver content tetrahedrite grades into freibergite. Most of the sulphantimonide of copper in this district is tetrahedrite, but freibergite was identified in the veins on Fish Creek Nos. 2 and 3 claims of the Mountain View group, the Olympia claim of the Fish Creek group, and the Last Shot group. At all these places the freibergite is associated with tetrahedrite.

Arsenopyrite ($FeAsS_2$).—Arsenopyrite is very rare in the quartz fissure veins in either the Texas Creek granodiorite or the Hazelton group, but it is a common mineral in replacement deposits in the greenstone and in vein deposits parallel to the structure in the graywacke and slate. It is usually well crystallized.

Proustite (Ag_3AsS_3).—Proustite, one of the ruby silvers, was identified only at a prospect pit on Fish Creek No. 2 vein on the Mountain View property. It is rare here and occurs as a secondary mineral in minute veinlets along fractures in the ore.

SULPHATES

Barite ($BaSO_4$).—Barite, though only locally abundant, occurs in a large percentage of the mineral deposits and must be considered a common gangue mineral. Where barite occurs in considerable quantities tetrahedrite is usually also more abundant.

Anglesite ($PbSO_4$).—Anglesite is a common alteration product along the cleavage surfaces of galena in or near the surface outcrop.

OXIDES

Quartz (SiO_2).—Quartz is the predominant gangue mineral of the fissure veins and is one of the chief gangue minerals in the replacement deposits. The quartz is usually massive, white and milky.

Magnetite (Fe_3O_4).—Magnetite has not been found within the fissure veins associated with the Texas Creek granodiorite. It is, however, one of the principal minerals, associated with pyrite, in quartz fissure veins in the Hyder quartz monzonite. In this association it also occurs in a bladed form pseudomorphic after specularite.

Specularite (Fe_2O_3).—The crystalline variety of hematite—specularite—is found in zones of contact metamorphism on Bear River Ridge adjacent to the granodiorite porphyry dikes genetically associated with the Hyder quartz monzonite. It also occurs in quartz fissure veins within the Hyder quartz monzonite, where it is associated with magnetite and pyrite.

Limonite ($2Fe_2O_3.3H_2O$).—The iron hydrate limonite is present as a surface alteration product in the outcrops of the mineral deposits and also occurs to considerable depths along weathered fracture surfaces.

CARBONATES

Calcite ($CaCO_3$).—Calcite is a very common and rather abundant gangue mineral in the mineral deposits and veins within the Hazelton group, but it is rare in the quartz fissure veins.

Ankerite ($Ca(MgFe)(CO_3)_2$).—Ankerite is present locally in small amounts in a few of the veins, but on the whole it is sparse.

Malachite ($(CuOH)_2CO_3$).—Malachite is common in the surface croppings of veins that carry chalcopyrite.

Azurite ($Cu(OH)_2.(CuCO_3)_2$).—Azurite is rare but occurs in sparse amounts associated locally with malachite in the surface outcrops.

TUNGSTATE

Scheelite ($CaWO_4$).—Scheelite was identified in four different fissure veins in the Hyder district and probably occurs in others. It has been found in abundance locally in one of the veins at the Riverside mine and in Fish Creek No. 2 vein on the Mountain View property. It occurs disseminated in quartz and in association with barite as a result of veining and replacement of the quartz by the barite.

UNDETERMINED MINERALS

Five minerals that were distinguishable only by microscopic examination and chemical tests and that could not be positively identified with any known mineral were found in the ores. They occur in small amounts and in but few of the veins, associated with tetrahedrite and galena. In some places they seem to bear a definite relation to the tetrahedrite-galena contacts.

INTERRELATION OF ORE MINERALS

Study of samples of ore with the reflecting microscope shows that the ore minerals in considerable part were not formed simultaneously but successively, and that earlier minerals of deposition are partly replaced, corroded, or veined by later minerals. A study by W. B. Jewell [20] shows that the succession or paragenesis and interrelations of the ore minerals are the same in all the veins studied, irrespective of their position relative to the contact between the Texas Creek granodiorite and Hazelton group, the altitude, or the type of country

[20] Jewell, W. B., Mineral deposits of the Hyder district, southeastern Alaska: Econ. Geology, vol. 22, pp. 494–517, 1927.

rock. In a few places reversals occur, but all these are where the minerals concerned were deposited very nearly together and some overlapping might therefore be expected. The order given below is that noted in a great preponderance of the veins, with the oldest mineral listed at the top:

1. Scheelite.
2. Pyrite and arsenopyrite.
3. Arsenopyrite.
4. Pyrrhotite.
5. Sphalerite, chalcopyrite, and chalmersite.
6. Chalcopyrite.
7. Galena, chalcopyrite, tetrahedrite, freibergite, gold (?), and the undetermined minerals.
8. Tetrahedrite, freibergite, and the undetermined minerals.

The earlier minerals (1, 2, 3, and 4) are such as form typically at relatively high temperatures, and the later minerals (7 and 8) such as form characteristically at intermediate temperatures. In this district, however, it seems at least possible that arsenopyrite and pyrrhotite were formed under conditions of intermediate temperature.

In practically all the fissure veins that contain only one metallic mineral in sparse amounts the mineral is pyrite. Where the mineralization is slightly greater, chalcopyrite may accompany the pyrite. In the heavily mineralized sulphide shoots galena or galena and pyrite are usually predominant. Tetrahedrite and sphalerite are generally associated with the veins in which galena forms most of the sulphides and pyrite is minor in amount. All combinations, however, may occur along the same vein. Chalcopyrite does not necessarily increase in amount correspondingly with total increase in sulphides, and whereas sphalerite may rise to noteworthy amounts, chalcopyrite may still remain minor. Where antimony was present in the solutions the copper tends to form tetrahedrite, and where tetrahedrite is common chalcopyrite is usually sparse.

GENESIS

RELATION OF THE MINERAL DEPOSITS TO THE INTRUSIVE MASSES

TEXAS CREEK BATHOLITH AND ASSOCIATED PORPHYRY DIKES

Most of the mineral deposits so far discovered in the Alaskan part of the Salmon River Basin occur near the contact between the Texas Creek batholith and the rocks of the Hazelton group or in association with outlying stocks and dikes of porphyry. The deposits occur both within the igneous rock itself and also in the bedded rocks and the greenstone. At a few places they are cut by dikes believed to be offshoots connected with the Hyder quartz monzonite and the Boundary granodiorite. They must therefore belong to a period of mineralization that followed the intrusion of the Texas Creek batholith and its outlying dikes and stocks of porphyry and preceded the intrusion of the younger Coast Range intrusives. It is thought that the mineral deposits were formed from residual solutions released by the crystallization and consolidation of the magma that formed the Texas Creek batholith.

Along the east side of Salmon River mineralized veins are found within the Texas Creek batholith at depths of 3,000 to 3,500 feet beneath its roof. Mineralized veins are also found in the bedded rocks 1,000 feet above the roof, both along the West Fork and east of Salmon River. Most of the known mineralized veins, however, occur within 1,500 to 2,000 feet of the contact.

At many places the solutions probably rose from large igneous masses which are not exposed at the surface but whose presence at considerable depth is indicated by stocks or dikes that crop out in the rocks of the Hazelton group at the present erosion levels. Those associated with the main Texas Creek batholith may in part have come from the core of the mass now exposed.

RELATION OF THE PORPHYRY DIKES OF THE TEXAS CREEK BATHOLITH TO THE PREMIER ORE BODIES OF BRITISH COLUMBIA

The mineralization in the Canadian part of the Salmon River Basin has been ascribed by Schofield and Hanson [21] to a genetic connection with the closing stages of the Coast Range igneous activity. They write as follows concerning the relation of the ore deposits and the porphyry dikes:

> In studying the age relationships of the primary ore deposits and the various dike series, it was found that primary mineralization affected some of the quartz porphyry dikes belonging to the "belt of dikes," but that the ore bodies were cut by dikes of quartz diorite, lamprophyre, and some of the dikes belonging to the "belt of dikes."

The conditions described by Schofield and Hanson are duplicated on the Alaskan side; but the interpretation placed upon these relations by the present writer is somewhat different. The porphyry dikes older than the ore bodies and the Premier granodiorite porphyries on the Canadian side are believed by the writer to be the equivalent of the porphyry masses on the Alaskan side and to be genetically connected with the same general magma that gave rise to the Texas Creek batholith. The quartz diorite dikes that cut the ore bodies on the Canadian side are, on the other hand, believed to be the younger Coast Range intrusive rocks and to be connected genetically with the same general magma that formed the Hyder quartz monzonite. The writer believes that the porphyry dikes on the

[21] Schofield, S. J., and Hanson, George, op. cit., p. 42.

Canadian side, as on the Alaskan side, belong in general to two different epochs of magmatic intrusion and that most of the mineral deposits are genetically associated with the magma that gave rise to the older dikes—the Premier and those associated with the Texas Creek batholith. The mineral deposits are therefore not strictly associated with the closing stages of the Coast Range igneous activity but with an epoch preceding the closing stages.

YOUNGER COAST RANGE INTRUSIVE ROCKS

No mineral deposits of economic importance have yet been located within the younger Coast Range intrusive rocks (Hyder quartz monzonite and Boundary granodiorite) in this district, though they have been found in association with them elsewhere, as at Anyox, B. C. A few mineral deposits of no present value have been noted in connection with them in this district, but they are vastly different from those related to the Texas Creek intrusive rocks. Narrow glassy quartz veins carrying magnetite, pyrite, and specularite are common locally, in the Hyder quartz monzonite, and small amounts of specularite are found locally in the country rock adjacent to offshooting granodiorite porphyry dikes on Bear River Ridge. Quartz veins with molybdenite and in places a little chalcopyrite or pyrite also occur within the Hyder quartz monzonite. About 3 miles south of Hyder on Portland Canal, on the Ebb Tide group, a 60-foot adit is reported to have been driven on a fissured zone in the quartz monzonite. This zone is said to carry disseminated pyrite, a trace of chalcopyrite, and rare galena and to yield a little gold. On the Glacier group, at the foot of Chickamin Glacier, quartz veins with pyrite and small amounts of pyrrhotite and chalcopyrite and rare galena occur in graywacke in genetic association with the Hyder quartz monzonite. In the slates of the ridge on the north side of Greenpoint Glacier there is a large quartz vein with pockets of galena and pyrite and locally disseminated garnet and a little epidote. This vein may also be genetically connected with the Hyder quartz monzonite. In the schist inclusions within the younger Coast Range intrusive rocks there are bands with disseminated pyrite, pyrrhotite, and a little chalcopyrite and locally sphalerite.

TEMPERATURE AND PRESSURE

The fissure veins were formed under conditions of temperature and pressure that varied within wide but definite limits. Many of the quartz veins that are barren or sparsely mineralized with pyrite or scheelite belong to the high-temperature type, whereas those that carry shoots consisting predominantly of pyrite (or more rarely pyrrhotite) and galena, with some sphalerite and tetrahedrite and considerable barite, are typically of intermediate-temperature type. The prevalent type of vein, mineralized dominantly with pyrite and galena and locally with native gold, probably belongs within the higher limits of the intermediate-temperature veins. Many of the veins are of composite character, as is well illustrated by the Fish Creek No. 2 vein, on the Mountain View property. This vein began as a large quartz vein of early stage high-temperature type mineralized with pyrite, pyrrhotite, scheelite, and a little chalcopyrite. Later galena and sphalerite were introduced locally, and finally the vein matter was partly replaced by barite and tetrahedrite, which are minerals typical of intermediate-temperature conditions. The older scheelite and quartz show marked evidences of corrosion and replacement by the later barite and tetrahedrite, which form a distinct shoot. There must have been repeated movements of mineralizing solutions along the fissure, which caused the character of the vein matter to change with progressive decrease in temperature.

The veins parallel to the structure of the bedded rocks of the Hazelton group and the veinlike replacement deposits in the greenstone were formed under conditions of temperature that are difficult of estimation. Pyrrhotite is a common mineral in the veins in the graywacke and is one of the chief minerals in the veins in the greenstone. Arsenopyrite is very rare in the fissure veins in the Texas Creek batholith but is common in the veins in the Hazelton group. These two minerals suggest that the veins are of high-temperature type. On the other hand, calcite is a very abundant gangue mineral in the veins in the greenstone and is common to abundant in the veins in the slate and graywacke. Sericite and chlorite are also abundant gangue minerals in the altered country rock and, together with calcite, suggest that the deposits are typically of intermediate-temperature type. The spatial relations of the veins with respect to the Texas Creek batholith also indicate that they are of intermediate type. They lie outside of and above the batholith, where it might reasonably be expected that cooler temperatures would prevail than within the batholith. The veins are therefore assigned to the intermediate type. The occurrence of so much pyrrhotite is ascribed to the influence of the country rock. The arsenopyrite is believed to have been formed at intermediate temperature, though slightly earlier than the other minerals. The tendency for mineralizing solutions in the same area to form pyrrhotite in andesitic rocks and pyrite in siliceous rocks has been noted also in the Rouyn district, in Quebec, by Cooke,[22] who suggests that it may be due to the influence of the larger percentage of iron already present in the more basic rocks.

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[22] Cooke, H. C., Ore deposits of the Rouyn area, Quebec: Canadian Min. Jour., vol. 47, pp. 572–575, 1926.

All the mineralization noted in connection with the younger Coast Range intrusive rocks is of the high-temperature type, in contrast to the prevalent intermediate-temperature types associated with the older or Texas Creek intrusives.

Veins are found now at altitudes ranging from sea level to 5,000 feet. After making a reasonable allowance for the erosion of overlying material that must have taken place during the Tertiary and Quaternary periods, it seems probable that the veins were formed at depths below the surface ranging, at a minimum estimate, from 4,000 to 10,000 feet. They therefore originated under a considerable load, such as is characteristic of intermediate to deep-seated types.

A number of veins have been affected by pressure subsequent to their formation, and there have been local adjustments through movement and slickensiding of the walls. A few of the veins have yielded slightly through crushing. On the Homestake property the so-called steel galena is what was originally coarsely crystalline galena now reduced to a pulverized mass by crushing. It has flowed like a plastic mass under the deforming pressure, and the other minerals have been broken up and occur as knots or eyes in the groundmass of galena. In superficial appearance the ore resembles an augen gneiss. The quartz of this vein, when examined with the microscope, shows that it also has been crushed. The gneissic structure of the galena appears to be due to the varying orientation of the cleavage along adjacent bands. Steel galena and a banding or gneissic structure in the galena have been observed in a number of other veins.

COMPARISON OF DEPOSITS OF THE TEXAS CREEK BATHOLITH WITH SILVER-LEAD DEPOSITS OF THE BOULDER BATHOLITH, MONTANA

The mineral deposits of the fissure veins associated with the Texas Creek batholith seem to have many points in common with the fissure veins carrying silver, lead, and zinc (as distinguished from the copper ores) of the Boulder batholith in Montana. A short description of these veins, summarized from a paper by Billingsley and Grimes,[28] is given below.

The veins occur both within the quartz monzonite of the Boulder batholith and in the country rock immediately adjacent to the contact. Most of the veins, however, are within 1,000 feet of the contact or original roof of the batholith and occur within the quartz monzonite. The few veins more deeply placed within the batholith

[28] Billingsley, Paul, and Grimes, J. A., Ore deposits of the Boulder batholith of Montana: Am. Inst. Min. Eng. Trans., vol. 58, pp. 284–361, 1918.

contain little but quartz and suggest the eroded roots of veins that were of the normal mineralized type above. The typical vein aggregate is pyrite, galena, and sphalerite in a gangue of quartz. Pyrite and galena exceed any other combination. Chalcopyrite, tetrahedrite, bornite, stibnite, and argentite also occur. High-grade ores carry as much as $11 a ton in gold. The universal trend in the composition of these veins has been an increase in the proportion of quartz to ore minerals with increasing depth. There is also a change of sulphide mineralization with depth. The galena is usually found in the higher parts of the ore shoots, most of the zinc occurs below the lead zone, and this in turn gives way within a short distance to lean pyrite accompanied by small amounts of copper sulphides. Veins in which lead is predominant are found above the contact or within 1,000 feet below the former or present roof of the batholith. Whatever zinc is present is just below the lead zone, which places it between 1,000 and 1,200 feet from the roof. Pyrite is present throughout but persists to greater depths than the zinc. The best-known veins are several thousand feet or more in length, strike usually about east, and dip steeply. Their strike is about at right angles to the elongation of the batholith. A very large amount of aplite (about 10 per cent) is associated with the quartz monzonite of the Boulder batholith, whereas very little aplite is associated with the Texas Creek batholith. Again, about one-sixth of the veins associated with the Boulder batholith carry tourmaline or rhodochrosite, or both, whereas neither of these minerals has been noted in the Hyder district. The Boulder veins consist of many reticulated and parallel fissures, rather than of the filling in a single large opening. Similar mineralization appears to have occurred throughout a greater range in the veins of the Texas Creek batholith than in those of the Boulder batholith.

NOTES ON PROSPECTING

It is important that one engaged in searching for mineral deposits in this region, or in developing them, should be familiar with the distinguishing characteristics of the Boundary granodiorite, the Hyder quartz monzonite, the younger granodiorite porphyry dikes, the malchite and lamprophyre dikes, and the Texas Creek granodiorite and its variations and associated dikes.

The areas occupied by the Hyder quartz monzonite and Boundary granodiorite are shown on the map. The quartz monzonite and granodiorite are pink to white and are much more massive than the dull-gray fractured and locally sheared Texas Creek intrusive rocks. The Hyder quartz monzonite characteristically shows a small amount of biotite, whereas the Texas Creek granodiorite usually shows abundant black hornblende rods in parallel orientation, giving rise to a gneissic or banded structure, and is usually marked by many slickensided fracture surfaces with green chlorite and yellowish-green epidote.

The distinction between the older porphyry dikes and the younger Coast Range intrusive rocks should be borne in mind. The older dikes are green to gray, are sheared and altered, and are associated at many places with ore deposits. The younger dikes are pink to white, massive, and little altered; they are not known to be associated with ore deposits and at several localities cut the ore bodies. A younger dike of granodiorite porphyry in the Texas Creek granodiorite is well shown in a road cut just opposite the Salmon River bridge above Ninemile. There is a fissured zone in the younger dike, but practically no alteration other than weathering is observable.

The distribution of the discovered mineral deposits indicates that the zone within 1,500 to 2,000 feet of the contact of the Texas Creek batholith with the rocks of the Hazelton group is a favorable belt for prospecting. Mineralization is also common in the immediate vicinity of the porphyry dikes and stocks of the Texas Creek batholith, especially along their contact. The map shows, however, that along considerable portions of the contact no mineral deposits have yet been located. This may be due in part to the fact that those areas are mostly covered with vegetation, which has hindered prospecting. Mineral deposits probably occur there.

An area that from its geologic relations should be favorable for prospecting lies above and in the vicinity of the practically buried ridge of Texas Creek quartz diorite that extends a little north of west from the head of the West Fork of Texas Creek. This area is about 2 miles wide and 3½ to 4 miles long and includes the lower part of the valley of Texas Glacier and the mountain slopes west and north of the abrupt westward bend of Chickamin Glacier.

The rocks of the Hazelton group in the block that forms Banded Mountain and the mountains on the west side of Through Glacier and that extends to a point 3½ miles below the foot of the Chickamin Glacier are also geologically suitable for prospecting. Though no economically valuable deposits have yet been found here, mineralized float is common. The area of graywacke west of Through Glacier and south of the lower part of Chickamin Glacier, however, has the disadvantage of being separated from the West Fork trail by the glaciers. It would be necessary to find here either evidence of high-grade ore or large bodies of low-grade ore to warrant extensive development work.

A part of the mountain ridge on the north side of Texas Glacier is capped by a narrow band of argillite, which is intruded on the south by the Texas Creek granodiorite and on the north by the Boundary granodiorite. Part of this band of argillite lies directly above the first ice cascades met in going up Texas Glacier from Texas Creek. The mountain slope in this vicinity deserves careful surface prospecting.

The core or central area of the Texas Creek batholith between Casey and Gray Glaciers on the west and Salmon River on the east and between the West Fork on the north and the Hyder quartz monzonite on the south is relatively inaccessible and has been only slightly prospected. No mineral deposits of importance have been located within it, but whether the reason is that little or no mineralization has occurred within the core of the batholith or that the area has been so little prospected is not known. In making a quick trip up Thumb Creek the writer picked up several pieces of good float consisting of quartz heavily mineralized with galena and a little pyrite. Theoretically, however, it is to be expected that the borders of the batholith near the older rocks would be more favorable zones for the occurrence of ore bodies than the interior core. In prospecting the core of the batholith the portions at the higher altitudes should be prospected most carefully.

On the south the Texas Creek batholith is in contact with and is intruded by the Hyder quartz monzonite, which is believed to be younger than the ore deposits. This contact is therefore wholly dissimilar to the contacts of the Texas Creek batholith with the older rocks of the Hazelton group and, so far as our knowledge goes, is as unfavorable for prospecting as any other part of the core of the Texas Creek batholith.

Where large milky-white quartz veins with little or practically no sulphides are found their foot and hanging walls should be carefully examined for shoots of ore, for there may have been later movements between the vein and its inclosing rocks that afforded places favorable for the introduction of subsequent sulphide solutions. Quartz veins carrying green chlorite or calcite, or both, have been found locally in the Hazelton group and in the Texas Creek granodiorite, but none of them were mineralized.

The continuity of the veins and the quality of their mineralization are, of course, most important considerations. The veins are of intermediate to deep-seated type, and the chances are therefore good that the stronger veins in the granodiorite and graywacke, which have been traced on the surface for several hundred feet and more, will persist in depth for at least several hundred feet, the depth being probably in similar proportion to the length. A few veins are exposed in natural section for depths of 500 to 700 feet, but mining developments have not yet followed veins down for more than a few hundred feet. The slate alone is unfavorable for the formation of strong continuous veins, but along the contact between a thick massive graywacke bed, or series of graywacke beds, and a slate formation conditions are more favorable. The data are insufficient to warrant a generalization as to the usual conditions where the veins pass down from overlying graywacke and slate into the Texas Creek granodiorite. On the Texas Comstock property several veins were observed to cross the contact and go deep into the quartz diorite without diminution in size. The known length and depth of a number of the veins and their arrangement in a definite system indicate that they occupy fissures which are not of a gash type.

The mineralized veins are known to occur throughout a vertical range of over 5,000 feet. The ore minerals are almost exclusively primary, and only traces of enrichment have been found. From these facts it is highly probable that the same general quality and quantity of mineralization which is shown at the surface in the vein as a whole will be found to persist in depth unless the character and kind of country rock changes in depth, and that any change in mineralization occurring in depth must be due to peculiarities of original deposition. On the Texas Comstock property there are several veins which, as exposed, are practically barren in the Texas Creek quartz diorite but contain good ore shoots in the overlying graywacke. In many other veins within the Texas Creek batholith, however, there are good ore shoots, so that the exact significance of the facts cited is not apparent, though the facts are worth bearing in mind.

There is also the question as to just what the chances are for the occurrence on the Alaskan side of rich silver ores such as some of those found in the adjoining areas in British Columbia. Unfortunately this question can not be answered from the information now available. The controlling conditions in the origin of the Canadian high-grade silver deposits are not known with sufficient definiteness. Some of them, such as the upper part of the veins now being worked at the Porter-Idaho, are certainly due predominantly to weathering and enrichment; others, such as those at the Premier mine, appear to have resulted from original primary deposition of rich silver minerals combined with some enrichment; and still others may be wholly primary.

Stocks, dikes, and sills of premineral porphyry are reported to occur in the Salmon River drainage basin in British Columbia at least as far north as the Big Missouri mine, and the writer believes that they are genetically connected with the Texas Creek intrusive rocks. There is a possibility that some of the mineralized veins that occur farther away from the main Texas Creek batholith in association with these far outlying porphyries may carry minerals richer in silver; this, however, is only a hypothesis.

The Coast Range batholith in the Hyder district consists of quartz diorite, granodiorite, and quartz monzonite, with included belts and fragments of schist and injection gneiss and small quantities of associated diorite and more basic rocks. Very few mineral deposits have been discovered within the core. In the past this has commonly been ascribed to an actual scarcity of metallization there, but it is now being recognized as possibly due in part to the exceeding ruggedness of the country and its inaccessibility, with consequent slight prospecting. Mineral deposits of economic importance occur in the belts of metamorphic complex inclosed within the batholith, and there is no doubt that others will be found. In the writer's opinion, however, the chances are slim for any individual prospector to find an ore deposit of economic importance under present conditions within the Coast Range batholith along a valley as inaccessible as that of Chickamin River. If prospecting is carried on within the batholith, the bands of schist and the extreme borders of the batholith would in general appear to be the more favorable localities.

The predominant types of metalliferous deposits within the belts of crystalline schist and injection gneiss included within the core of the Coast Range batholith include replacement and impregnation deposits carrying copper (chalcopyrite) and zinc (sphalerite). Quartz fissure veins with copper or rarely molybdenite and mineralized schist bands with galena, sphalerite, and tetrahedrite, are also present. Within the belts of schist and gneiss bands of oxidized, rusty-weathering, sulphide-impregnated rock are also common. Predominantly these bands carry only pyrite or pyrrhotite or both, with a little chalcopyrite and a very low content in gold, and under present conditions they are of no value. But some carry combinations of pyrrhotite, chalcopyrite, sphalerite, and galena and deserve consideration. Both types of deposit—the iron sulphide impregnated bands and the base-metal bands—have a similar weathered appearance, and the pyrite-pyrrhotite bands are so predominant that the base-metal bands carrying chalcopyrite, sphalerite, or galena, or a combination of these minerals, are liable to be passed over through lack of careful examination of the fresh rock.

Sphalerite and pyrrhotite are the predominant minerals in several metallized zones in the schist and gneiss belts at or near the western border of the batholith. It seems highly probable that other similar deposits will be found as these belts of metamorphic rocks are more thoroughly prospected.

The low-grade copper deposit of the Hidden Creek mine, at Anyox, British Columbia, occurs in a belt of greenstone and argillite inclosed within the central part of the batholith. Dolmage[24] reports that 13,215,000 tons of copper ore averaging 2.14 per cent copper has been developed. About 7 miles west of the Hidden Creek mine, at Maple Bay, on the east side of Portland Canal, another copper mine is being developed in the same belt of schist. This schist is reported to occur also on the west side of Portland Canal. The common metallic minerals are pyrite, pyrrhotite, chalcopyrite, zinc blende, magnetite, and arsenopyrite. They are believed to be the result of the replacement of greenstone and argillite.

Wright[25] reports a 2-foot copper vein in a belt of schist included within the Coast Range batholith on Unuk River about a mile below the international boundary. The vein consists of pyrite, pyrrhotite, and chalcopyrite.

A vein carrying considerable quantities of sphalerite is reported to occur on Taku River about a mile from the international boundary. The predominant minerals are pyrrhotite and sphalerite with a little pyrite, galena, and locally chalcopyrite. The ore gives low assays for gold and silver.

On Quartz Creek, a tributary of Iskoot River, about 30 miles from its mouth, there are bands of schist metallized with sphalerite and galena and locally with stringers of tetrahedrite carrying considerable silver.

At the Whiting River prospect, in the Juneau district, there is a quartz fissure vein in a belt of marble inclosed in quartz diorite. The metallic minerals comprise arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite, with arsenopyrite predominant. The silver content is moderate, but there is considerable gold. Quartz porphyry dikes cut the marble near the vein.

MINES AND PROSPECTS

As stated on page 2, the following descriptions cover only the developments to 1925.

MOUNTAIN VIEW

The Mountain View group (see pl. 11) comprises eight claims and a fraction and lies mainly between Skookum and Fish Creeks just above their junction but in part below it. Five of the claims are patented by John Hovland. The property has been undergoing active development since June, 1925, in charge of Arthur Moa. In 1926 the purchase of the property by a group of Ketchikan business men was reported.

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[24] Dolmage, Victor, Coast and islands of British Columbia between Douglas Channel and the Alaskan boundary: Canada Geol. Survey Summary Rept. for 1922, pt. A, p. 20, 1923.

[25] Wright, F. E., The Unuk River mining region of British Columbia: Canada Geol. Survey Summary Rept. for 1905, p. 50, 1906.

The eastern contact between the Texas Creek granodiorite and the rocks of the Hazelton group runs through the middle of the property. The veins occur both in the granodiorite and in the sedimentary beds. Most of the work has been done on three veins, but several other quartz veins and stringers are found on the property.

On Fish Creek No. 3 claim a quartz fissure vein with mineralized shoots has been prospected by several open cuts and stripping, and an adit 325 feet in length driven on the vein had been completed by December 8, 1925. The vein is in granodiorite and has been traced for 400 feet with a strike of about N. 7° E. and a dip of 45°–50° E. The southern 250 feet of the vein ranges between 3 and 4 feet in width. The northern part splits into two branches about 10 feet apart. The upper branch is several inches thick and carries shoots of ore. The lower branch is the main one; for 75 feet it ranges from 6 inches to 2 feet in width, averaging about a foot, and for the next 75 feet it is between 5 and 9 inches wide. About 120 feet north of the adit portal the vein is cut by a malchite dike. Along the northern part of the vein a large barren vein of milky-white quartz strikes in toward it and from the point of contact runs parallel to it. The barren vein is the older, as it is intersected by a narrow offshooting stringer from the mineralized vein. An open cut has been made where the two veins touch. The mineralized vein pinches to narrow stringers beyond the open cut, and its possible extension is covered; the large barren quartz vein continues beyond. In the adit the first 110 feet of the vein averages about 4½ feet in width and carries seams and pockets of sulphide throughout. As exposed at the surface the vein shows many moderately to heavily mineralized shoots. The adit will give a maximum depth of about 100 feet. About 200 feet north of the adit portal a 60-foot mineralized shoot with an average width of 2 feet is exposed at the surface. It is reported to average about $14 to the ton. The sulphides include pyrite (which in one local shoot several inches thick assayed $30 to the ton in gold), pyrrhotite, galena, chalcopyrite, sphalerite, a little tetrahedrite and freibergite, and a trace of arsenopyrite.

On Fish Creek No. 2 claim a vein has been traced by a series of open cuts for a length of 475 feet. It is in the Texas Creek granodiorite, strikes N. 50° W., and dips 40° NE. Mr. Moa reports that the vein has an average width of about 4 feet and that it is 4½ feet wide at the northwest end and 5 feet wide at the southeast end; its extensions in each direction are buried under overburden. The southeastern part of the vein consists of pyritic quartz with some chalcopyrite, galena, and tetrahedrite. In the northwestern part the sulphides comprise mainly pyrrhotite and pyrite, with some galena and chalcopyrite and a little sphalerite, tetrahedrite, freibergite, and scheelite. The vein material breaks free from the country rock and is separated by a surface of gouge. A 40-foot crosscut adit has been driven to the vein about 20 feet below the outcrop. At the end of the adit there is a 1½-foot vein of quartz, heavily mineralized, with pyrite and small quartz stringers in the hanging wall. A short drift on the vein 3 feet to the west is reported to have shown 3 feet of solid quartz with mineralization similar to that at the surface. In the open cut above the tunnel the vein zone is 6 to 8 feet thick, with 5 to 6 feet of mineralized quartz and the remainder included bands and fragments of country rock. The quartz is heavily mineralized with layers and disseminated deposits of coarsely crystalline pyrite, which may form as much as half the vein by volume. A noteworthy feature of this vein is a mineralized shoot about 15 feet long and as much as 18 inches wide, composed of interbanded fine-grained barite and quartz with seams of tetrahedrite and freibergite, considerable disseminated scheelite and pyrite, and a little chalcopyrite. This shoot is well exposed in the open cut about 15 feet northwest of the cut above the adit. In the southeast wall of this cut the vein consists of two parts. One is a quartz vein 2 feet thick, very heavily mineralized with pyrite, which pinches to a narrow stringer on the northwest, in the face of the open cut. The other is the baritic shoot, which is here 12 to 18 inches thick but which to the northwest passes into a quartz vein 10 inches thick, with only a few thin interbands of barite in the hanging wall, and about 8 feet to the southeast thins to a few inches. In the face of the open cut the vein is offset several feet by a thrust fault. Mr. Moa reports that recent work has shown that a little barite occurs in the vein for a length of 100 feet, and that tetrahedrite in varying amounts occurs throughout a length of 400 feet. Moil samples across this vein for widths of 9 to 32 inches are reported by Mr. Moa to show assay values ranging from $5 to $12 in gold to the ton and from 1 to 70 ounces in silver, with an average of about 15 ounces to the ton. The pyritic quartz vein shows the smaller assay returns in silver, and the baritic shoot the higher. A few general assays are given below to show the character of the ore.

Assays of general samples from Fish Creek No. 2 vein, Mountain View property, Hyder district

Source of sample	Lead (per cent)	Silver (ounces to the ton)	Gold (ounce to the ton)
East end of vein	(a)	21.24	0.28
Old ore pile from vicinity of baritic shoot	(a)	39.84	.36
Open cuts made in 1925	2.5	10.20	.60

a Not determined.

On Fish Creek No. 1 claim a mineralized quartz vein that strikes N. 60° W. and dips 55°–70° NE., has been prospected by a series of small pits and a stripping and has been traced for a length of 450 feet. In the Texas Creek granodiorite at the northwest end there is a fissured zone 1½ feet wide with 8 inches of quartz. A malchite dike cuts across the vein here. In the first open cut east of the trail the vein is along the contact between granodiorite and contact-metamorphosed brown quartzitic slate. The vein is 12 to 20 inches thick and contains a few small pockets heavily mineralized with galena, pyrite, and sphalerite. To the southeast the vein is in the quartzitic beds, where it occupies a fissured zone apparently at an angle to the bedding. The vein is cut by a 75-foot dike of pink granodiorite porphyry, which is connected in origin with the Hyder quartz monzonite. Southeast of the dike a 25-foot cut has been made along the vein, which occurs here in a light-colored granitic facies of the Texas Creek granodiorite that is probably a dike with small inclusions of quartzite. Still farther southeast the vein cuts white aplite dikes. Here the fissured zone is 15 feet or so thick, and within this zone there is a 2-foot quartz vein with bands of galena, pyrite, or sphalerite and narrow stringers of quartz, some of which are moderately mineralized. In the face of the slope to Fish Creek two adits have been driven on a vein that belongs to this fissured zone. The upper adit is 50 feet long and follows a sparsely mineralized quartz stringer. The country rock is mostly a light-colored facies of the Texas Creek granodiorite with practically no ferromagnesian minerals. About 70 feet vertically below this adit another 50-foot adit follows the vein, which ranges from 3 inches to 2½ feet in width and is locally heavily mineralized with sphalerite, pyrite, and galena. Molybdenite flakes are present here and there in the aplite and pegmatite dikes. About 60 feet vertically below this adit another has been driven for 90 feet along a stringer that lies slightly to the southwest and below the vein zone in which the upper two adits were run. This lowest adit starts in a granitic rock and ends in quartzitic beds. The rock at the mouth of the adit appears to be an altered aplite. The vein is 6 inches to 2 feet in width. An 8-foot crosscut at the end of the adit exposes a stringer of quartz 4 to 6 inches thick carrying free gold.

Slightly to the northeast and above the main Fish Creek No. 1 vein on the bank of Fish Creek there is a small mineralized quartz vein in an aplite dike. This vein strikes N. 80° W. and is exposed for a vertical distance of 35 feet. It is moderately to heavily mineralized with pyrite, galena, sphalerite, and tetrahedrite.

The veins along the bank of Fish Creek that have been described may be considered as all belonging to the same fissured zone, over

100 feet thick, in a complex of Texas Creek granodiorite and aplite dikes and baked quartzitic slate.

The Mountain View property is equipped with a bunk house and kitchen, cabin, assay office, a 50-horsepower water wheel operating under a 100-foot head and fed through 750 feet of 14-inch wooden pipe, a compressor, and a 4,000-foot aerial tramway running from the cabin to the Salmon River road.

LUCKY BOY EXTENSION

The Lucky Boy Extension claim is held by John Coghlan, of Vancouver, and is just east of the junction of Skookum and Fish Creeks, adjoining Fish Creek No. 5 claim of the Mountain View group. On the bank of a small creek southeast of Fish Creek, at an altitude of about 650 feet, a 50-foot crosscut adit has been driven to cut a vein about 30 feet below its outcrop. From the end of the adit a 50-foot drift has been run on the vein. The country rock is brown thin-bedded slaty quartzite. The vein consists of a fissured zone 2 to 3 feet thick with quartz stringers aggregating 6 to 12 inches in thickness, locally mineralized with pyrite, galena, and sphalerite. At the surface an open cut exposes a 2-foot fissured zone with as much as 16 inches of quartz moderately mineralized with pyrite, a little galena and sphalerite, and a trace of pyrrhotite and chalcopyrite. The vein strikes N. 60° W. and dips 40°–55° N.

BISHOP

The Bishop claim is north of the Mountain View property, on the west side of Skookum Creek. It is patented by Pete Low. A strong quartz vein, which is as a rule 15 to 27 inches wide but is 6 to 7 feet wide on the slope to Skookum Creek, has been prospected by several open cuts and on surface exposures. It has been traced for 600 feet with a strike of N. 45° W. and a dip of 50° NE. and is exposed for a difference in altitude of 100 feet. The country rock is the Texas Creek granodiorite. The mineralization is relatively low, and the sulphides comprise pyrrhotite and pyrite with a little chalcopyrite. Galena is rare, and the content of gold and silver is reported to be low.

VICTORIA

The Victoria group comprises 25 claims held by the Adanac Syndicate, with offices in Victoria, British Columbia. Of these claims 15 were staked in 1921 as the Adanac group and 10 are claims belonging to what was formerly known as the Mammoth group, relocated in 1924. These claims are four deep along the international boundary west of Mount Dolly. Several short adits have been driven to fulfill assessment requirements, but only local sparse mineralization has been found.

FISH CREEK

The Fish Creek group (see pl. 12) comprises 18 claims, of which 3—the Olympia, Nevada, and Starboard—are patented. They lie mainly on the ridge between Fish and Skookum Creeks but extend to both sides of these creeks, particularly west of Skookum Creek. On the south they are joined by the Mountain View group and on the west by the Monarch group. The property is under the control of the British American Holding & Development Co.

The contact between the Texas Creek granodiorite and the Hazelton group of greenstone, graywacke, and slate crosses the property in a direction a little west of north. The veins are predominantly in the granodiorite, but in part they cross the contact and occur to a minor extent within the Hazelton group. Mineral deposits of two types occur in this group of claims—(1) quartz veins with shoots of galena, sphalerite, pyrite, tetrahedrite, and chalcopyrite; (2) lenticular bodies of pyrrhotite with small amounts of chalcopyrite, pyrite, and arsenopyrite. The quartz veins are predominant and so far as known are the only ones of value.

Most of the work has been done on the Starboard, Olympia, and Olympia Extension claims. Several tunnels and drifts on the Olympia Extension claim are not shown on the claim map, owing to lack of a survey. On these three claims there are four approximately parallel quartz veins lying just at the contact of the granodiorite and the Hazelton group but almost wholly within the granodiorite. These veins occur within a distance of 2,000 feet, measured on a horizontal plane at right angles to the strike.

The vein nearest the cabin on Starboard No. 1 claim has been prospected by two adits, Nos. 1 and 2, which are 50 and 40 feet in length on the vein at altitudes of 1,510 and 1,410 feet, respectively. The vein strikes N. 35°–40° W. and dips 65°–70° NE. It has been traced for a length of 400 feet from the upper adit to Skookum Creek. On the slope to Skookum Creek and at the portal of the lower adit the vein is 3 feet wide. At the portal of the upper adit it is 2 to 3 feet wide, but along the adit to the southeast it breaks up into a number of quartz stringers. The vein carries local shoots mineralized with sulphides but is lean for considerable portions.

About 450 feet northeast of this vein is another on the Starboard No. 2 claim, which strikes N. 60° W. and dips 65° NE. At an altitude of about 1,600 feet a 70-foot adit (No. 3) has been driven on this vein. At the portal the vein is 3 feet 9 inches thick, but at about

50 feet from the portal it breaks up into a zone of fractured country rock and narrow quartz stringers. At this point large quartz stringers shoot off into the footwall. About 30 feet vertically below this adit an open cut has been made on the vein. The vein here consists of a fissured zone in granodiorite with stringers of quartz, some of which carry shoots a few inches to 8 inches thick and heavily mineralized. In general shoots of good ore occur in this vein, but much of it is lean. To the northwest it can be traced across Skookum Creek. The visible minerals it carries are galena, tetrahedrite, pyrite, and some chalcopyrite and sphalerite.

On the Olympia claim, about 350 feet northeast of this vein, at right angles to the strike, is another vein, which has been prospected by three adits (Nos. 4, 5, and 6) at altitudes of about 1,930, 1,900, and 1,800 feet, with lengths of 60, 109, and 185 feet, respectively. The vein strikes N. 50° W. and dips 45°–50° NE. Its width at the portals of the three adits is 19, 24, and 15 inches. A raise connects the middle and upper adits, and the vein has been partly stoped for 30 feet above the upper adit. In these upper workings it averages less than a foot in thickness but contains shoots of ore up to the full width. Locally, many quartz stringers occur in the footwall at a wide angle to the main vein. Most of the upper two adits are in Texas Creek granodiorite, but the ends of the adits are in intensely fractured slickensided brown hornstone, which is a metamorphosed facies of the Hazelton group. Westgate reports that the vein in the middle and lower adits is cut off by a fault that strikes N. 30° E. and has an approximately vertical dip. The lower adit was filled with water at the time of the writer's visit. Westgate [26] gives the following description:

> On the Olympia claim the longest tunnel on the property goes in on the vein 240 feet, to a point where the vein is cut off by a fault that strikes N. 30° E. and dips 60° NW. Drifts have been driven parallel to the fault in both directions, but the vein has not been recovered, unless a composite vein, offset about 50 feet to the southwest, is its continuation. The work had not been carried far enough to demonstrate this. From the mouth of the tunnel the vein can be followed on the surface northward perhaps 30 feet, to a point where it is cut out by a fault and broken zone that seems to have much the same direction as that at the face of the tunnel. The vein system in this part of the property is thus cut by a series of faults which run N. 30° E. and dip steeply northwest.

The visible sulphides comprise galena and pyrite with tetrahedrite, sphalerite, and a little chalcopyrite. Microscopic examination shows a little freibergite also present locally.

North of the Olympia vein, on the Olympia Extension claim, a mineralized quartz vein in the Texas Creek quartz diorite has been traced for 600 feet by prospect pits and trenches. The vein strikes N. 60°

[26] Westgate, L. G., op. cit., p. 136.

W. and dips 40°–50° NE. It ranges from an inch or so to 10 feet in width and averages about 3 feet. The vein matter breaks freely from the wall rock, and the walls show marked slickensiding. A narrow dike of dense black lamprophyre cuts the vein. At the longest surface trench the vein is 4 to 6 feet wide and consists of quartz with 5 per cent or more of disseminated sulphides and with stringers of solid sulphides so localized as to constitute rich ore shoots. The gangue is mostly quartz, with some ankerite and here and there a little barite. The visible sulphides include galena, tetrahedrite, chalcopyrite, pyrite, and sphalerite. The tetrahedrite occurs in solid stringers as much as 2 inches wide. At an altitude of 2,800 feet on the west side of the ridge west of Skookum Creek a crosscut adit 125 feet long is driven to intersection with the vein. Near the end of the adit is a winze on the vein 42 feet deep and a drift that extends 87 feet to the southeast and 12 feet to the northwest. Near the southeast end of the drift there is another winze on the vein and a raise. Along the drift the vein ranges from 2 to 6 feet in width. In the winze the vein is reported to narrow and the tenor to decrease. In the face of the northwest end of the drift there is 6 feet of quartz with inclusions of the country rock; 2 feet of the quartz is heavily mineralized. It is reported that a sample across the face of the drift here averaged $20 to the ton. At the southeast end of the drift the vein is 3½ feet thick, and a sample across it is reported to have averaged $64 to the ton. A shipment of 64 tons of sorted ore from this drift sent to the Tacoma smelter is reported to have averaged $90 to the ton.

The following figures are taken from assay reports furnished by the mining company representing lots of sorted ore taken from veins on the Starboard and Olympia claims and shipped to the Tacoma Smelting Co. in 1916 and 1917, also samples across the Olympia Extension vein.

Assays of ore from Starboard, Olympia, and Olympia Extension claims, Hyder district

	Material represented by sample	Gold (ounces to the ton)	Silver (ounces to the ton)	Lead (per cent)	Copper (per cent)
Starboard No. 1	15 (?) tons	0.40	376	32.4	3.30
Starboard No. 2	5 tons	.21	161.1	18.3	1.96
Do	do	.18	103.4	21.4	1.51
Do	½ ton	.90	706.7	32.2	7.68
Do	10 tons	.18	216.0	18.0	2.79
Olympia	20 tons	.37	316.0	38.9	3.08
Do	5 tons	.15	110.4	32.5	Trace.
Do	do	.30	205.4	17.0	3.90
Do	8 tons	.27	299.96	26.	3.36
Olympia Extension	1½ feet across vein	Trace.	3.0	6.5	Trace.
Do	3½ feet across vein	.36	12.0	(a)	(a)
Do	6 feet across vein	1.42	94.8	(a)	(a)
Do	4 feet across vein	.92	72.5	14.5	2.0
Do	2 feet across vein	.32	4.4	2.5	Trace.

[a] Not determined.

On the west slope of Skookum Creek the Olympia Extension vein has been prospected by two tunnels, giving a maximum depth on the vein of 250 feet. On the east side of Skookum Creek, at an altitude of about 2,400 feet, an adit (No. 8) has been driven 175 feet in the greenstone with the intention of cutting the projected extension of the Olympia Extension vein.

On the Nevada claim a quartz fissure vein in the greenstone has been prospected by several pits and a 44-foot crosscut adit (No. 7) with a 25-foot drift. The vein strikes N. 70° W. and dips 45° N. The surface rock looks like greenstone, but the rock in the tunnel is a brown fractured, slickensided hornstone. A dike of Texas Creek quartz diorite cuts the beds at the portal of the adit. At the east end of the drift the vein is 15 inches wide, and at the west end it is several inches wide. There are many quartz stringers in the footwall zone, some of which are as much as 2 feet in width. Pits expose the outcrop of the vein 50 feet vertically above the adit. The sulphides comprise galena and a little chalcopyrite, sphalerite, and tetrahedrite.

On the Summit claim at its north end, at an altitude of about 2,850 feet, a body of pyrrhotite has been prospected by a shaft and pits. A dike of Texas Creek quartz diorite cuts the Hazelton group north of the shaft. Westgate[27] gives the following description:

> Here the country rock is a greenish-gray fine-grained greenstone marked by veins of calcite and abundant small crystals of pyrite. The microscope shows it to be composed almost wholly of secondary minerals, chiefly quartz and sericite. Abundant chlorite and calcite occur along seams, with leucoxene, pyrite crystals, and a little fine-grained orthoclase. A few large rounded quartz grains resemble the phenocrysts in rhyolite and suggest that the original rock may have been a quartz porphyry. An indistinct bedding bears N. 70° E. and is nearly vertical. In this greenstone are masses of almost pure pyrrhotite. The largest measures about 5 by 12 feet at the surface and stands 6 feet above the water level in a shaft that was sunk in all 10 feet without reaching the bottom of the pyrrhotite. With the pyrrhotite there is a little chalcopyrite and quartz. A polished section of the ore shows mainly pyrrhotite, with small amounts of pyrite, arsenopyrite, chalcopyrite, and a little gangue, mainly quartz. The order of mineral formation seems to be pyrite, arsenopyrite, quartz, pyrrhotite, and chalcopyrite, the last two essentially contemporaneous. A polished section of the immediately adjoining country rock, which contains abundant sulphides, shows mainly quartz and some arsenopyrite, irregularly cut by pyrrhotite, finely veined by later pyrite, and chalcopyrite. The arsenopyrite appears to have been fractured before the introduction of the quartz and other sulphides. An assay of samples from this body was reported by the owner to give gold, 0.36 ounce to the ton; silver, 4 ounces to the ton; copper, 2 per cent.

The property is equipped with a bunk house, cookhouse, office, blacksmith shop, and compressor, favorably located for the development of the Olympia Extension vein.

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[27] Westgate, L. G., op. cit., pp. 137–138.

HYDER JUMBO

The Hyder Jumbo group of claims includes 18 surveyed claims lying adjacent to the international boundary north of the Titan group. This group was restaked in 1924. Practically no work has been done on the property, and no mineralization of importance has been found. Gash veins of quartz with some chlorite occur but are not known to be of value.

HYDER SKOOKUM

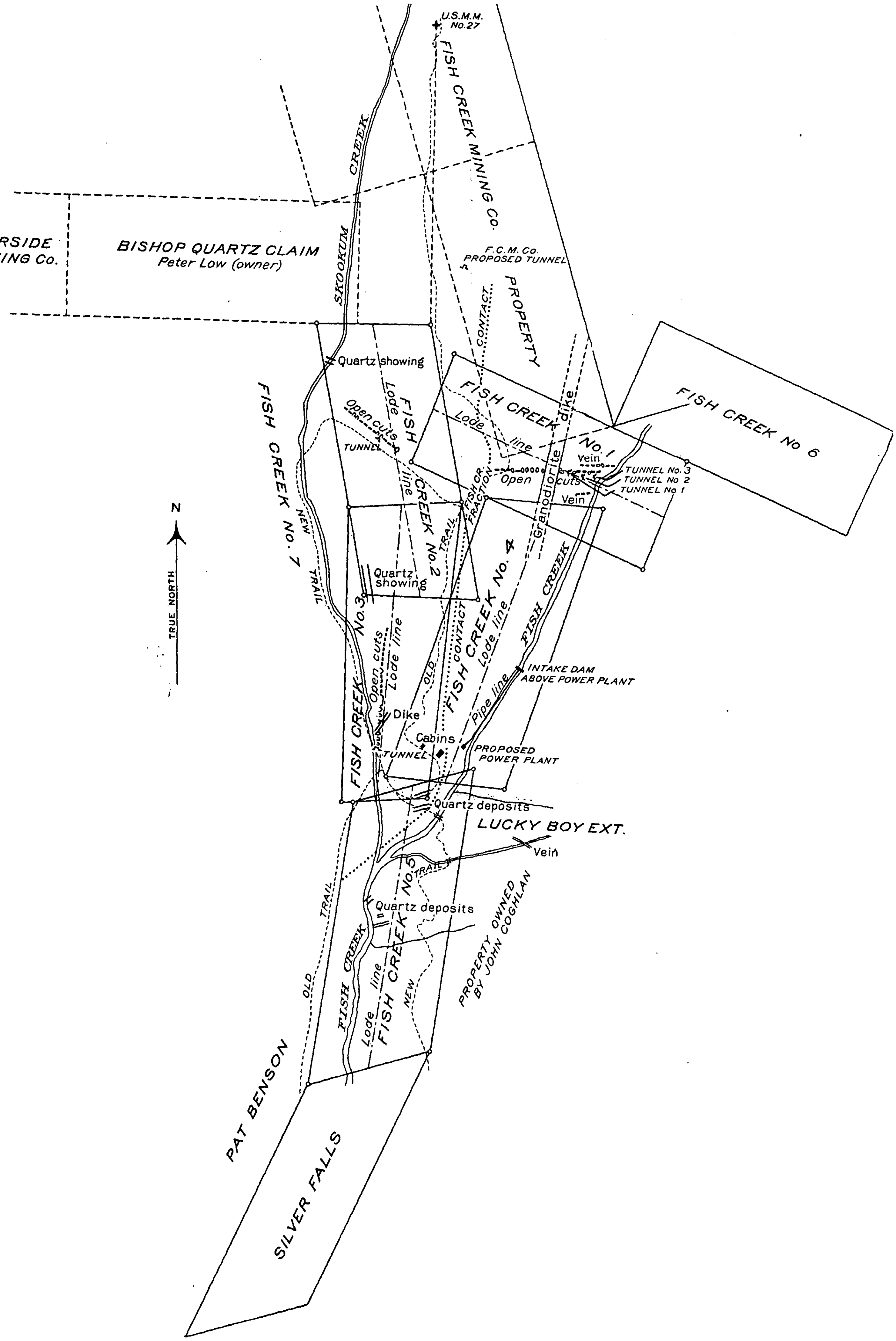
The Hyder Skookum group comprises 12 claims that lie on the flat-topped ridge and slope west of Fish Creek and adjoin the Fish Creek, Titan, and Hyder Jumbo groups. At an altitude of about 3,200 feet there are two very strongly defined approximately parallel quartz veins striking northwest and dipping steeply to the south. Both veins locally form a breccia with the country rock. The southern vein is in part in a dike of porphyry belonging to the Texas Creek batholith and in part in greenstone of the Hazelton group. A small stringer in the greenstone carries a little disseminated sulphide. The northern vein is wholly in the greenstone. Locally fragments of country rock, forming a breccia with the quartz, are impregnated with pyrite. The veins have a width of as much as 7 feet. As exposed at the surface they carry a little calcite but are mostly barren of sulphides.

At an altitude of 3,200 feet, just northeast of the cabin, an open cut has been made on a sulphide replacement deposit in a schistose zone in greenstone near the contact with a dike of porphyry of the Texas Creek batholith. The sulphides occur as solid masses and seams in the greenstone and as disseminated deposits in quartz within the zone. Pyrrhotite predominates, and with it are associated a little chalcopyrite and arsenopyrite. The vein is 2½ feet wide, strikes N. 50° W., and dips 60° S.

TITAN

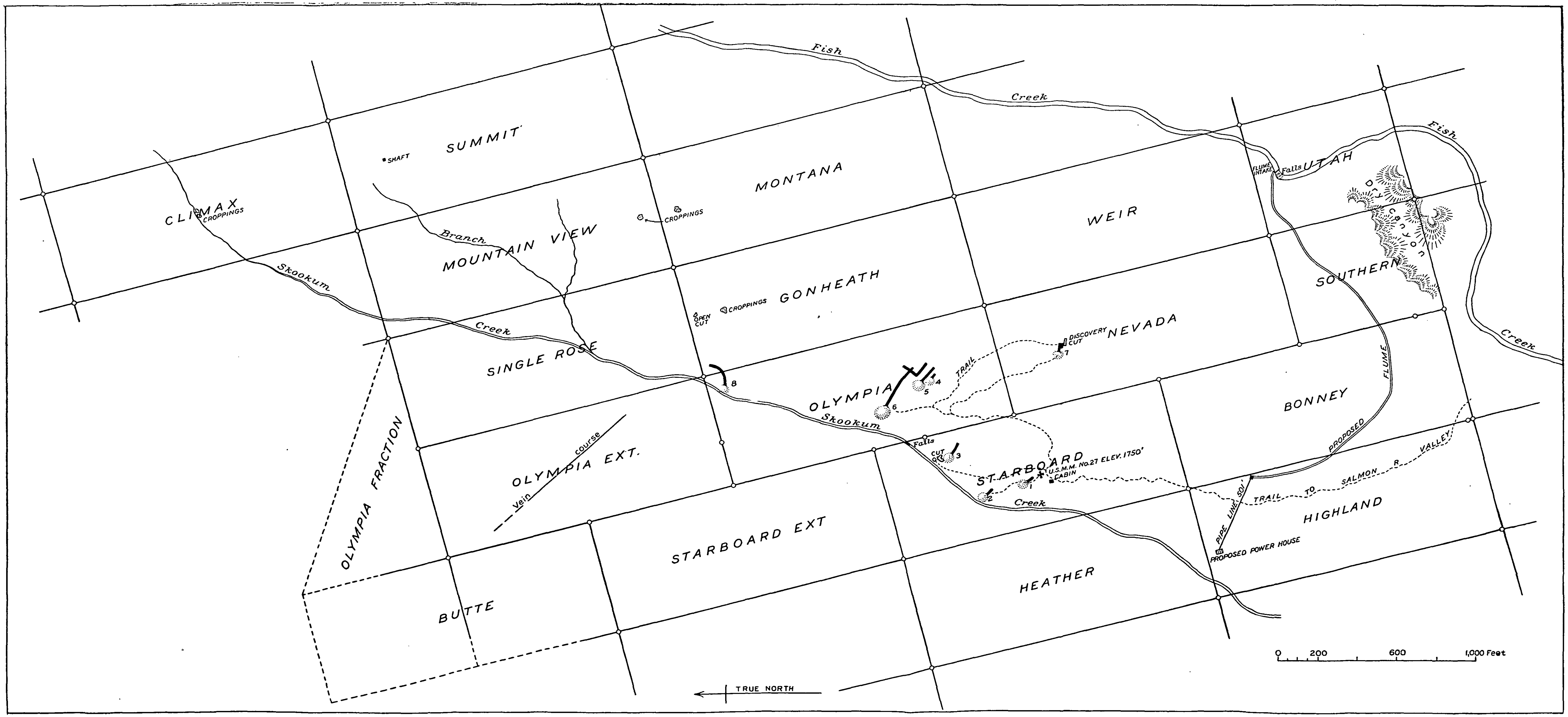
The Titan group comprises 10 claims between the upper part of Fish Creek and the international boundary. They were staked in 1917.

The country rock here consists of greenstone and intercalated beds of slate, belonging to the Hazelton group, with dikes of gray sheared porphyry of the Texas Creek batholith and dikes of pink to white fresh, relatively massive granodiorite porphyry of the Hyder batholith. Just west of the international boundary, at altitudes of 4,500 to 4,700 feet, there is a bed of coarse purplish to green-gray volcanic breccia several hundred feet thick, which extends in a direction a little west of north.



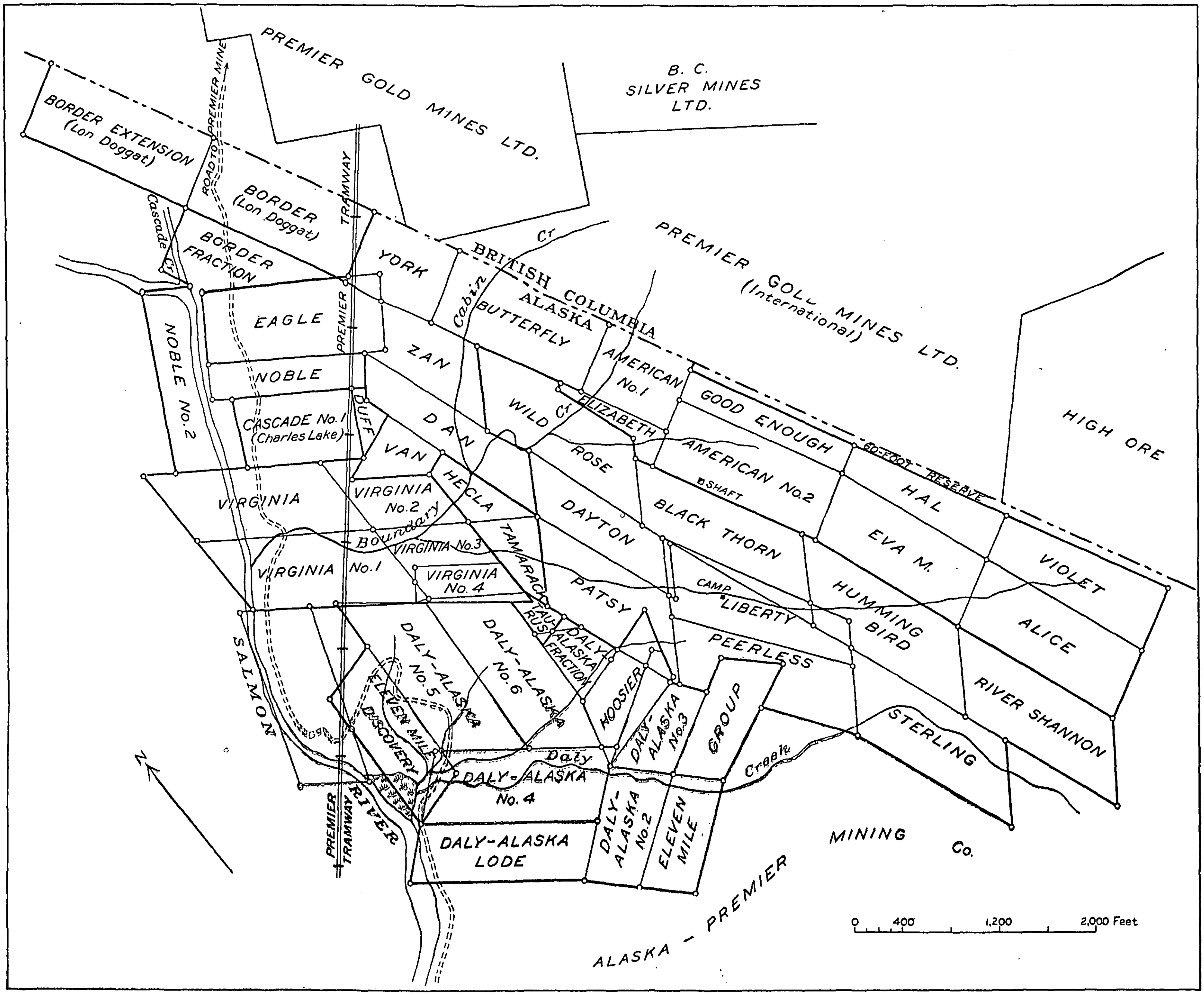
SKETCH MAP OF MOUNTAIN VIEW GROUP OF CLAIMS

Adapted from map by A. O. Moa

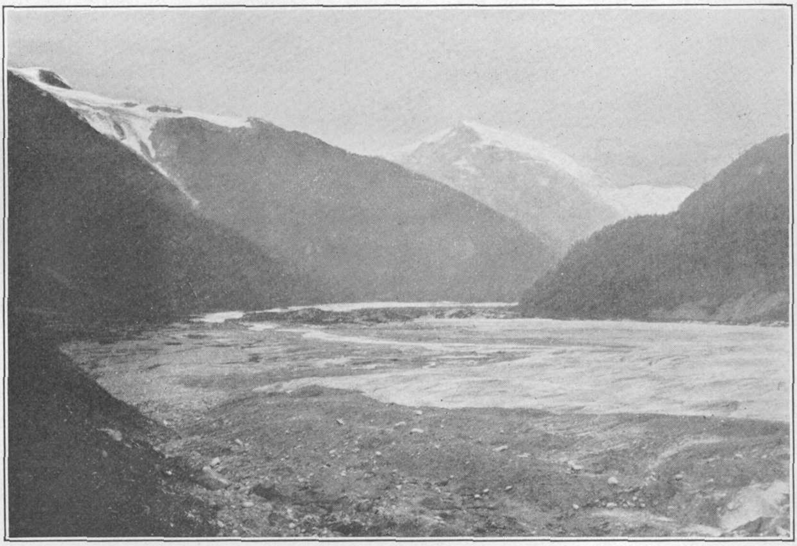


SKETCH MAP OF CLAIMS NEAR FISH CREEK

Adapted from map by F. J. Wettrick, United States mineral surveyor

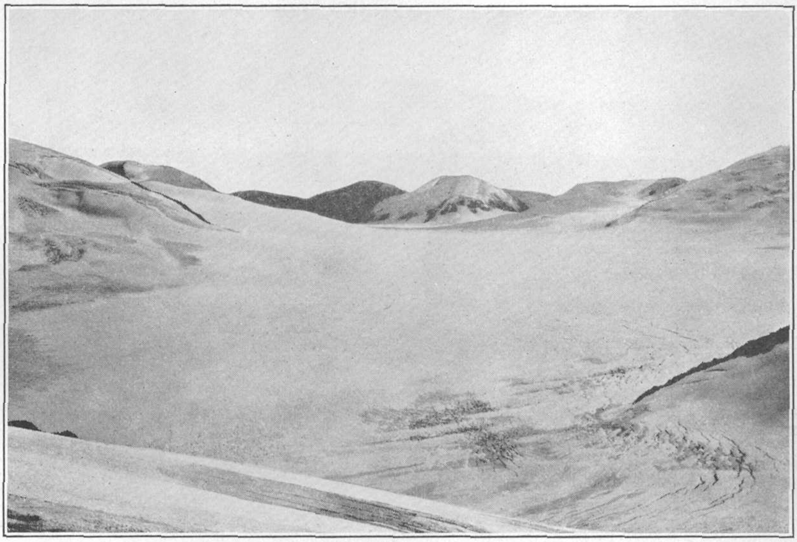


SKETCH MAP OF STONER, DALY-ALASKA, VIRGINIA, AND OTHER CLAIMS



A. VIEW AT HEAD OF CHICKAMIN RIVER

Showing the foot of Chickamin Glacier in the foreground and old terminal moraine in center



B. SNOW FIELD AND TRIBUTARY GLACIERS ON THE PASS AT THE HEAD OF THROUGH GLACIER

Most of the development work has been done to prospect a vein in a big northwestward-trending dike of sheared and altered porphyry, which includes many thick layers of slaty rock and greenstone. It is impossible to delimit the southwestern boundary of the dike owing to the interlamination of the rock and to its covering of moss. The porphyry is an offshoot from the Texas Creek batholith, which probably underlies the country at a depth of not more than a few thousand feet. The porphyry contains some large crystals of feldspar, but for the most part it shows small quartz and feldspar phenocrysts in a dense pale-green sericitized and silicified groundmass. Hornblende crystals are seen where the rock is not too fine grained.

The vein is being prospected by an adit and several crosscuts with a total length of 540 feet and by a couple of open cuts at the surface. It has been traced by intermittent outcrops for 250 yards and for a difference in altitude of 275 feet. The vein strikes N. 50°–60° W. and dips 45° SW. At the southeast end there is a 10-foot fissured zone containing 1 to 2 feet of quartz in stringers and a narrow band of slate. At an altitude about 180 feet above the adit level there is a wide zone in which narrow quartz stringers and a band of slaty rock 12 feet thick are exposed. A band of the porphyry several feet to 5 feet wide contains quartz stringers, some of which are 8 inches thick. The porphyry is impregnated with pyrite, and the quartz contains disseminated sphalerite, galena, pyrite, and chalcopyrite. Sphalerite is by far the most abundant. Quartz stringers occur also in the foot and hanging walls of the slate. The vein has no definite walls. To the northwest and at an altitude about 30 feet lower another open cut exposes a band of porphyry about 20 feet wide impregnated with pyrite and containing reticulating narrow quartz stringers. The slate band found in the upper open cut is absent here. From its portal, at an altitude of about 3,350 feet, the adit starts about N. 70° E., turns southeast, and in 1925 was being driven about S. 30° W. Two crosscuts from the adit run in a general northeasterly direction. The vein had not yet been cut, but if it continues to that depth with the same dip as that at the surface it should be intersected by the adit within a short distance. The irregular course of the adit resulted from difficulties in correctly tracing the course of the vein down the hillside above the tunnel. It now appears that what may be the continuation of the vein zone was cut near the portal of the adit and that the adit has been driven wholly in the footwall country rock. In the adit, 100 feet from the portal, there is a 5-foot pyritized zone with quartz stringers, and at 60 feet in there is a 1½-foot quartz vein with included stringers of rock. If this is the vein zone in depth, then the maximum difference in altitude exposed on the vein is 450 feet. The slate band exposed at the surface evidently is cut off in depth. Assays of average samples of the vein are not available. Picked samples from the mineralized surface outcrops are reported to run high in gold and silver. Low assays in gold and silver are reported from mineralized bands intersected in the adits and crosscuts.

About three-eighths of a mile east of the camp, at an altitude of about 4,000 feet, in the bed of a gulch, a quartz vein 7 to 10 feet thick is exposed. This vein appears to strike northeast and dip 30° SW.; but it is crossed by a dike of granodiorite porphyry belonging to the Hyder batholith, which has caused considerable disturbance, as indicated by the pronounced slickensiding within the quartz vein. Local shoots in the hanging wall and footwall of the quartz carry a little disseminated galena, sphalerite, pyrite, and chalcopyrite. The vein occurs within slate and tuff and is cut off on the northeast, on the downstream side, by a dike of the same granodiorite porphyry, which strikes northwest. Another dike of the porphyry lies about 125 feet to the south and strikes north-northwest. Above the outcrop of the vein, between these two granodiorite porphyry dikes, there are two dikes of the older porphyry in the slate and greenstone tuff of the Hazelton group. One of the younger dikes on the northeast side appears to terminate at an altitude about 300 feet higher than the quartz outcrop, and it forms the northeast bank of the gulch above the outcrop. The vein is exposed for a vertical difference in altitude of 75 feet. The strike and dip of this vein are uncertain; it is exposed for only a short distance, and more surface prospecting is necessary before any extensive underground development should be undertaken.

In the south bank of the gulch, north of the Titan adit and at about the same altitude, there is exposed a shear zone in schistose greenstone heavily mineralized with arsenopyrite and a little galena. This has not been prospected.

Between altitudes of 4,450 and 4,800 feet there is an immense quartz vein in the slate, tuff, and greenstone, which lies near the contact of a porphyry dike. The vein is about 4 feet thick at the lower altitude and 10 to 15 feet thick at the higher. At the higher altitude the vein consists of interbanded very coarse calcite and quartz. The calcite forms more of the vein than the quartz. A branch vein runs off to the northwest at this locality. The vein strikes N. 35°–40° W. and dips 65°–75° NE.

MONARCH

The Monarch group comprises 10 claims held by Moa, Ickis & Hovland. They lie between the group of the Fish Creek Mining Co. and the Riverside group. A series of northwestward-striking quartz veins in the Texas Creek granodiorite, with local narrow shoots mineralized with sulphides, are being prospected, but practically no development work has been undertaken.

At an altitude of 2,400 feet on the North Star and Alaska claims, below the old upper Fish Creek camp, there is an open cut on a quartz vein several inches to 10 inches thick, with local shoots heavily mineralized with galena, pyrite, tetrahedrite, sphalerite, and chalcopyrite. Locally there is considerable barite and sparse grains of scheelite. The mineralized shoots are reported to give assays of $20 to $30 to the ton in gold. A specimen of the clear tetrahedrite is reported to have assayed 266 ounces in silver and $28 in gold to the ton. The vein strikes N. 55° W. and dips 75° NE.

At an altitude of 2,000 feet, in the bed of a small gulch, an open cut has been made along the strike of a fissured zone in granodiorite. This zone is about 6 feet wide, with about 2 feet of quartz as stringers or as masses with many layers of the country rock. There are sparse local shoots of galena in the quartz, and disseminated crystals and thin bands of pyrite are common. The vein strikes N. 55° W. and dips 70° NE.

About 1,000 feet southwest of the camp, at an altitude of 2,100 feet, a big vein of milky-white quartz has been traced for 500 to 600 yards on the Wano claim. Grains of pyrite are present here and there, and rarely grains of galena, but no ore shoot has yet been found.

On the Extenuate claim, about a quarter of a mile a little south of west of the camp, in the bed of a small gulch, at an altitude of 1,550 feet, a quartz vein has been exposed by stripping for 25 yards and can be traced for a length of 200 feet. It ranges from 5 to 16 inches in width and carries local shoots of galena and pyrite with a little chalcopyrite. The vein strikes N. 50° W. and dips 45° N.

LAST SHOT

The Last Shot group comprises two claims patented by Charles Fehring. They adjoin the Monarch and Riverside groups and lie about three-quarters of a mile southeast of the Riverside. There are two veins exposed on the group, only one of which has been prospected. Both veins are in the Texas Creek granodiorite and strike northwest.

A quartz vein has been traced by surface exposures, pits, and open cuts for a length of about 150 feet and is exposed for a vertical difference of 75 feet. This vein strikes N. 60° W. and dips 45° NE. At the southeast end, where stripped, it is only a couple of inches thick and contains disseminated sulphides. About 35 feet northwest it is 1½ feet thick and has inclusions of country rock; 12 feet farther northwest it is exposed in the face of a bluff, where it is 12 feet thick, with the hanging wall not exposed. This thick cap of quartz is exposed for a length of 50 feet. A shoot of almost solid sulphide 8 to 18 inches thick is exposed for a length of 30 feet in the footwall of the thick quartz cap. At an altitude of about 1,300 feet, a 25-foot crosscut adit has been driven just below the surface outcrop. In the breast of this tunnel it is seen that the thick quartz cap passes downward into a series of stringers in the country rock. The mineralized shoot persists. The granodiorite for 4 or 5 feet beneath the vein at the portal of the tunnel contains many narrow reticulating quartz veins inclosing pyritized fragments of the granodiorite, which are locally so altered as to resemble schist. To the northwest of the adit each of two small pits shows about 3 feet of quartz with sparse disseminated sulphides. The sulphides of the mineralized shoot comprise galena, pyrite, sphalerite, pyrrhotite, and chalcopyrite. Microscopic examination shows that tetrahedrite and freibergite are also present.

At an altitude about 100 feet lower than the tunnel there is a large quartz vein 10 to 15 feet thick, with a strike of N. 10° W. and a steep dip to the west. At one point a small pocket of mineralized quartz is exposed in the footwall.

HOWARD

The Howard claim lies to the north of the Sixmile group and adjoins the Riverside claims. The vein, at an altitude of about 630 feet, is in granodiorite, strikes N. 30° W. and dips 40° NE., and consists of a fissured zone of indefinite thickness with many quartz stringers. The vein is exposed for about 150 feet by several open cuts and stripping. A few of the quartz stringers are locally mineralized with sulphides or barite, or both. One such shoot consists of a body of quartz 10 feet long and 12 to 15 inches wide, moderately mineralized with galena, pyrite, and sphalerite.

SIXMILE

The Sixmile group comprises three claims at Sixmile, staked by Davis & Elvigion in October, 1924. They are at the foot of the mountain on the east side of the Salmon River road.

The ore at this place was discovered when the rock was blasted out along the line of the new Salmon River road. Narrow stringers of quartz, phenomenally rich in visible free gold, were first found in loose fragments of the broken rock. One small picked sample assayed 1,080 ounces of gold and 200 ounces of silver to the ton. The gold occurs within the borders of the quartz stringers and in the adjacent granodiorite. Some of the stringers carry galena, and flakes of gold occur also within the galena. The country rock on the property is the Texas Creek granodiorite.

An average of five samples taken from the granodiorite, without visible quartz, in the wide zone where the narrow quartz stringers with free gold occur, gave 0.05 ounce of gold and 2.5 ounces of silver to the ton. A little pyrite is disseminated through the granodiorite. The quartz stringers are only one-sixth of an inch to an inch wide; the adjoining country rock is impregnated with pyrite, and some of its fractures are faced with pyrite and galena.

Two adits were being driven in 1925 on narrow quartz stringers. The southern vein strikes N. 50° W. and dips 70° NE. An adit 35 feet long shows the vein at the portal a fraction of an inch wide; this thickens to 6 inches in the adit, and at the breast there is a shattered zone several feet thick, with quartz stringers and shoots of sulphides consisting of galena with a little pyrite and chalcopyrite. Free gold has been found in a pocket at the portal of the adit.

Another adit 15 feet to the north is 35 feet long and follows a fissured zone, which in the breast of the adit is 5 feet wide and contains narrow stringers of quartz. The main quartz vein, 1 to 8 inches wide, has shoots of galena and pyrite with a little chalcopyrite and sparse sphalerite. Free gold is obtained by panning a narrow band of gouge exposed at the breast of the adit.

At an altitude of about 260 feet, in the bed of a gulch, an open cut exposes a fissured zone, 15 to 20 inches wide, with quartz stringers, some of which carry shoots of galena and pyrite. The vein strikes N. 42° W. and dips steeply to the northeast. A heavy pyritic quartz stringer is reported to have assayed 0.06 ounce in gold and 0.6 ounce in silver to the ton; where galena was associated an assay gave 0.68 ounce of gold and 8.4 ounces of silver to the ton and 8.7 per cent of lead.

RIVERSIDE

The Riverside group comprises ten claims on the east side of the Salmon River road, a little north of Sevenmile. The property has been developed to a stage more advanced than any other on the Alaskan side of the boundary in the Salmon River district. In 1924 a 50-ton mill was installed for the concentration of the ores, using both tables and flotation, and in 1925 there were over 5,000 feet of underground workings. This mill was put into operation in the early part of 1925, and in a two months' run 109 tons of galena concentrate, carrying gold and silver, was produced. The property was idle for several months, pending arrangements for its operation by a new company. A small additional production was made in the later part of the year. The altitude of the main adit is about 260 feet.

The country rock is the Texas Creek granodiorite, with sparse included bands of rocks of the Hazelton group, which have been metamorphosed and recrystallized to injection gneiss. Pink to white granodiorite porphyry dikes associated with the Hyder quartz monzonite cut the country rock but have not been found in contact with the mineral veins on this property. Dark malchite dikes cut the country rock and also the veins.

Three mineralized quartz veins are being prospected, known as the Ickis vein, Cross vein, and Lindeborg vein or main lead. The Ickis and Cross veins are in the granodiorite; the Lindeborg is in a band of crumpled schist or injection gneiss included in the granodiorite.

The Ickis vein has been prospected by three adits; the lowest one is about 15 feet long; the middle one (now covered by the dump from the upper adit) is 35 feet higher and about 20 feet long; and the upper one, about 70 feet above the lowest adit, is 500 feet long. In the upper adit the vein is about 20 inches wide at the face and is reported to be 4 to 5 feet wide in front of the entrance, where it is now covered by the dump. The adit was driven on the vein, which narrows to a stringer a fraction of an inch wide at about 200 feet from the entrance and does not thicken again within the length of the adit. The vein within the adit averages about 8 to 10 inches in width, with local pinches. The country rock is a shattered, slickensided gneissoid granodioritic rock. The vein occupies a fissure and consists of quartz with local bunches strongly mineralized with pyrite and galena and rarely with sphalerite. The vein has a general northwest strike, though varying considerably, and a steep northeast dip. Assays as high as $20 to the ton in gold, silver, and lead are reported. The vein matter breaks free from the walls. Stringers (droppers) of quartz several feet long shoot off into the wall rock.

The Cross vein has an approximate north-south strike and lies between the Ickis and Lindeborg veins. It was cut in the underground workings when a crosscut was driven from the drift on the Ickis vein with the intention of reaching the Lindeborg vein. It has been explored by drifts on the level of the adit and two lower levels, and one ore shoot has been partly stoped and run through the mill. The vein, as known, has a total length of about 750 feet in the drift on the level of the adit, but it splits into small stringers at each end; the main body of the vein is 650 to 670 feet long. It varies in thickness, both along the strike and along the dip, ranging from 6 or 8 inches up to 4½ feet. At the north end on all three levels the vein pinches out abruptly as it nears the schist band in which the Lindeborg vein occurs. Much of the vein averages 2 feet or more in thickness. The vein has been explored along the dip for 100 feet above the main level and 250 feet below, a total of 350 feet. The vein dips 30° E. below the main level but steepens to 45° in the raise. It is possible that the vein may widen again south of the present end of the drift. The vein is in considerable part frozen to the walls. The ore occurs in shoots with intervening barren or lean portions.

On the level of the adit of the Cross vein three shoots of ore have been found—a small one north of the crosscut tunnel, a larger one south of the crosscut tunnel, and another, 70 feet in length, still farther south. About 150 feet of sparsely mineralized quartz intervenes between the two main shoots. The southern part of the vein is sparsely mineralized and of low tenor. A raise has been driven in the southern ore shoot for 100 feet above the main level. This shoot is about a foot thick at the main level, thickens to 2 feet up the raise, and pinches to the merest stringers at the top. The central shoot, for about 50 feet south of the crosscut tunnel, ranges from 1½ to 3 feet in width, is well mineralized with sulphides, and is reported to average locally $40 to the ton in lead, gold, and silver. A raise has been driven 40 feet on this shoot from the main level. but the shoot pinches out at the top. A winze has been sunk on the vein from the adit level 140 feet to the first level, and 110 feet from the first level to the second. On the first level drifts have been run 200 feet to the south of the winze and 90 feet to the north. North of the winze, where the vein consists mainly of stringers, the mineralization is lean, except for a shoot 15 feet in length. A shoot that starts 25 feet south of the winze has a length of 70 feet. On this level its width averages more than 3 feet, ranging from 2 to 5 feet. Its value is reported to average $46 a ton, with variations from $36 to $100 a ton. This ore shoot has been partly stoped toward the main level, and the upper part averaged 10 to 18 inches in thickness. A sample from a muck pile accumulated while driving the drifts yielded about 25 per cent of concentrates. The ore of this muck pile is reported to have averaged about $7 or $8 to the ton in gold and an ounce of silver to the ton for each per cent of lead. On the second level an ore shoot north of the winze is 15 feet long and 10 inches thick and averaged $60 to the ton. The last 20 feet of the vein to the south on this level averages about 5 inches in thickness and shows a little galena and pyrite. It comes against a dike at the south end. A 14-foot raise has been driven to get into the ore shoot exposed above on the first level. The ore shoots are believed to pitch to the southeast on the dip of the vein. All the ore that has been treated in the mill and all the concentrates shipped came from stopes on this vein. The galena concentrates are reported to have assayed as high as $240 to $300 to the ton in lead, gold, and silver. The sulphides are predominantly galena and pyrite. Chalcopyrite, sphalerite, tetrahedrite, and pyrrhotite are also found. Locally there are pockets and crystals of barite in the gangue.

The Lindeborg vein is a locally mineralized quartz vein in a narrow band of crumpled injection schist included in the Texas Creek granodiorite. The schist band, which is 50 feet wide at the portal of the Lindeborg adit, constitutes a weak zone along which movements have taken place, and the vein is in a shear zone. The vein in part of its length crosses the foliation of the schist at a slight angle and strikes about N. 60° W. Through underground workings and open cuts it has been explored for a length of 800 feet and a depth of 250 feet. It is reported to have been traced at the surface for 1,800 feet, and in that distance it has a difference in altitude of 700 feet. At the outcrop and in its west end exposed on the mountain slope the vein is a well-defined mineralized quartz vein, but the underground workings, as far as they have gone, indicate that as it goes down and in to the southeast from the mountain side the vein splits up into stringers and bunches of quartz in schist. There is, however, a probability that mineralized quartz may come in again, either in depth or along the vein to the southeast, though no prediction can be made as to the depth or the distance to the southeast. The vein has been prospected by two adits driven on the vein, a 400-foot drift along the vein southeast from the main crosscut tunnel, a 180-foot drift northwest from this tunnel, and a 70-foot raise between the upper adit and the intersection of the main crosscut tunnel and the drifts. The lower adit is about 90 feet below the Lindeborg adit, is 150 feet long, and is driven on the vein. At the portal the vein is 2 feet wide, but within 50 feet it pinches markedly. Stringers of quartz occur in the adjacent country rock, and stringers and veins of quartz are found along the remainder of the adit. There is here no well-defined persistent mineralized vein, but sulphides, mainly pyrite and galena, are present locally in considerable quantity. On the main adit level the vein in the drifts for 400 feet to the southeast and 175 feet to the northwest of the intersection of the crosscut tunnel consists of scattered narrow stringers and bunches of quartz and sparse lenses and seams of sulphide in the schist. Pyrite is common, and one small pocket of arsenopyrite was found. At the face of the drift, about 180 feet northwest from the crosscut tunnel, the vein is about 40 inches wide, is of milling grade, and consists of mineralized quartz with included fragments of schist and angular fragments of Texas Creek granodiorite. The sulphides are mainly pyrite and galena with a little chalcopyrite and sparse sphalerite. It was reported in the Hyder Herald early in 1926 that this drift had been extended to the northwest and had shown that the vein continued with ore of milling grade and locally with shoots of high grade. Two ounces of free-milling gold to the ton of concentrates is reported to have been recovered from a shipment of 65 tons from a shoot on this portion of the vein. The two malchite dikes that were cut in the Lindeborg adit higher up were also crossed here. The Lindeborg adit is about 70 feet above the main tunnel and is driven on the vein for about 350 feet. The first 250 feet of the vein is mineralized quartz that contains inclusions of schist, and its average width is about 3 feet. It is reported to average about $14 a ton in lead, gold, and silver. The sulphides are pyrite and galena, usually localized in bands, with here and there a little sphalerite and chalcopyrite. The vein is cut by two malchite dikes. At about 250 feet in from the portal the quartz vein splits into a number of narrow stringers and lenses in schist. Seams of sulphide also occur in the schist, but taken as a whole this part of the vein is leanly mineralized. In one of the surface exposures the vein is 5 feet wide and consists of quartz with 18 inches of fine-grained galena that assayed 27 ounces of silver to the ton.

BUTTE

The Butte group comprises six claims restaked by W. C. Peterson and Nils Olson. They lie just to the south of the Crest group and extend southeastward up the mountain side from the Salmon River road. The property was not seen by the writer, and the following data were reported by the owners.

The lowest open cut is 450 feet from the road. The vein has been traced for about 500 feet with a west-northwest strike and is 1 to 2 feet thick. High assays in gold are reported. At an altitude of 350 feet, on the south bank of the gulch, a shaft 25 feet deep has been sunk on a quartz vein. The vein strikes N. 32° W. and dips 65° NE. At the top of the shaft the vein is 2 feet wide, and at the bottom 10 inches wide. It has been traced for about 400 feet to the southeast and is 3 feet wide on the side of the gulch. Mineralized shoots and inclusions of wall rock occur in the quartz. The sulphides are predominantly pyrite with galena subordinate. An assay of a sample that contained 11.4 per cent of lead yielded 0.24 ounce in gold and 10.2 ounces in silver to the ton; another sample that contained 14.1 per cent of lead yielded 0.6 ounce in gold and 20.6 ounces in silver to the ton.

CREST

The Crest group (see fig. 1) consists of six claims held by Moa, Ickis & Hill, of Hyder. They lie on the mountain slope on the east side of Salmon River, about three-quarters of a mile below the Salmon River bridge.

A narrow but persistent vein, at an altitude of about 1,400 feet, is being prospected. It strikes N. 50° W., dips 55°–70° NE., and has been traced for 350 feet by a series of open cuts and strippings. It consists of a fissured zone several feet thick in Texas Creek granodiorite, with stringers or a solid vein of quartz aggregating several inches to 2 feet thick, which carry local shoots heavily mineralized with galena and some associated pyrite and a little chalcopyrite. The quartz exposed would indicate an average width of less than 9 inches.

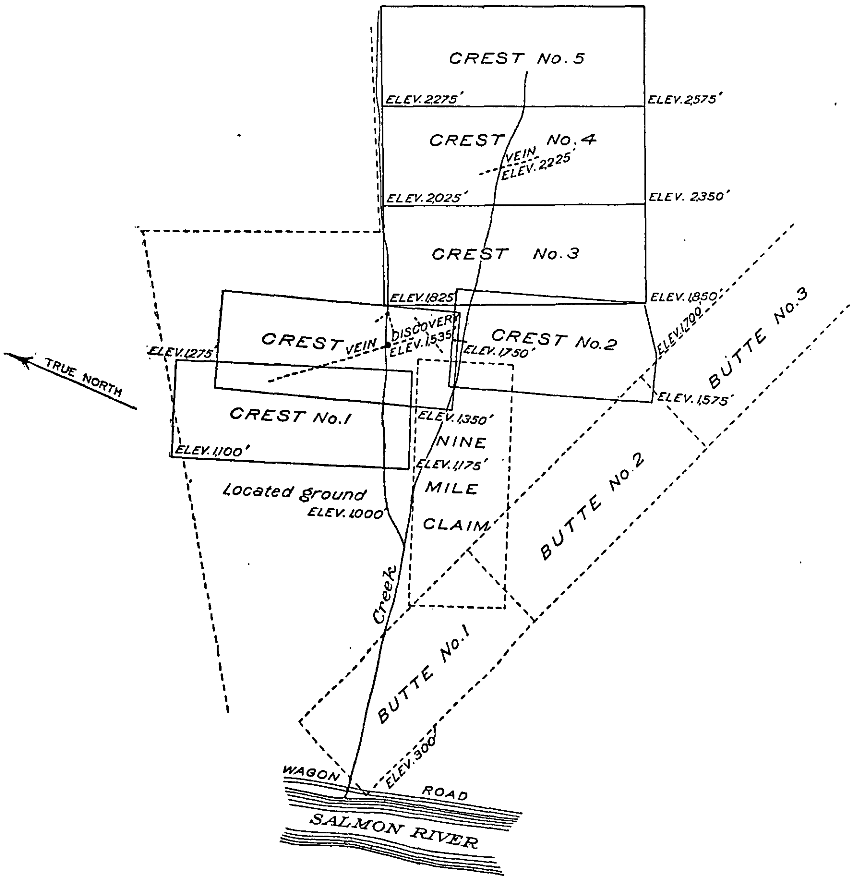


FIGURE 1.—Sketch map of Crest group of claims. (Adapted from map by A. O. Moa)

Along much of the vein the country rock is impregnated with disseminated pyrite, and fracture surfaces are coated with pyrite and galena.

At one open cut, in the bed of a small gulch, the vein consists of a number of small quartz stringers, some of which carry free gold. Assays of the quartz have yielded as high as $105 in gold to the ton. At another open cut a moil sample of the country rock and quartz stringers, 2 feet in width, averaged $4.80 in gold to the ton. The mineralized shoots run from $7 to $12 in gold to the ton.

CRIPPLE CREEK

The Cripple Creek group comprises eight claims and a fraction. They are on the east side of the Salmon River road, just below the bridge across Salmon River at Tenmile. The property has been taken over by the Brigadier Mining Co.

Two types of deposit are being prospected, both in the Texas Creek granodiorite—a quartz fissue vein containing local shoots of sulphide and a fissured zone in which narrow stringers of quartz and the intervening rock contain pyrite in seams and disseminated.

Just beside the road an adit has been driven 45 feet along a vein, with an 8-foot crosscut at the end. The vein consists of a sheeted zone, 10 to 15 feet wide, with quartz stringers and a large quartz vein in the footwall portion. Some of the granodiorite is so sheared as to resemble greenstone. In the bed of the gulch, on the south side of the portal to the adit, there is 8 feet of quartz in which local sparse pockets are mineralized with galena. The adit parallels the main quartz vein and is run in the hanging-wall portion of the fissured zone. A cross section of the vein is exposed only in the crosscut at the end of the adit. At the breast of the adit the quartz vein is 3 feet wide at the bottom and pinches toward the top. About 15 feet in altitude above the adit stripping exposed 4 feet of fissured granodiorite with a quartz vein 1 to 2 feet wide, and small quartz stringers, one of which is several inches thick and is heavily mineralized with galena and a little pyrite and sparse chalcopyrite. The vein is exposed for about 65 feet; it strikes N. 73° W. and dips steeply to the north. In the adit a stringer has along its footwall seams of sulphides consisting of galena and a little pyrite and sphalerite. A little tetrahedrite is also found locally in the vein.

About 175 feet uphill from the adit portal is a 20-foot open cut on a vein that strikes N. 70° E. and dips 40° S. The vein consists of a fissured zone 4 to 5 feet thick with quartz stringers 1 inch to 3 feet thick. There are abundant slivers of altered country rock in the thicker portion of the vein.

On the Salmon River road just above the bridge there are several fissured zones with many narrow quartz stringers in the Texas Creek granodiorite. A few of the stringers carry shoots with disseminated galena and pyrite several inches to a foot thick. The country rock carries considerable disseminated pyrite.

At an altitude of 450 feet just beneath the tram line a stripping and two open cuts expose a breccia vein several feet wide, consisting of narrow reticulating quartz veins and fragments of Texas Creek granodiorite impregnated with pyrite. Locally there is a little disseminated galena and sphalerite. Narrow quartz stringers occur within a zone wider than the main breccia vein. The vein strikes N. 50° W. and dips 45° S. At an altitude of 480 feet a stripping shows similar pyritized granodiorite with narrow quartz stringers.

PORTLAND

The Portland group comprises three claims adjoining the Hobo group. They were staked in 1919 by Ickis & Moa. On the Hobo and Portland groups, at an altitude of 2,200 to 2,250 feet, between the cabins on the two groups, there is a dike of granodiorite porphyry belonging to the Texas Creek batholith, which cuts across the greenstone and slate with a strike of N. 60° W. On the Portland group, at an altitude of 2,200 feet, an open cut has been made on a quartz vein along the contact between the dike and the black slate. The quartz contains inclusions of both slate and dike. On the Hobo group there is a quartz vein 2 to 3 feet wide in the dike itself. At an altitude of 1,750 feet a 15-foot adit has been driven along a 2-foot quartz vein in slate. The vein strikes N. 60° W. and dips 52° S. It has been traced for 500 yards by pits and surface exposures. It contains sparse disseminated fine grains of pyrite, galena, and blebs of sphalerite and a little chalcopyrite. Other quartz veins and stringers are found in the slate.

HOBO

The Hobo group comprises two claims staked in 1919 by Morris Pederson and Albert Johnson. They lie to the south of the Alaska-Premier group.

At an altitude of 2,400 to 2,450 feet a mineralized zone of greenstone is being prospected in which three open cuts have exposed shoots of sulphides forming veins or veinlike replacement deposits. The shoots have an almost east-west strike. At an altitude of about 2,400 feet, in the bed of a gulch, a 10-foot open cut exposes greenstone with seams and stringers of sulphide consisting of 1 foot of rock with pyritic seams and disseminations, 2 feet with quartz lenses and stringers of solid sulphide, mostly sphalerite, 5 feet of relatively barren greenstone, and 2 feet with seams and fracture facings of sphalerite and a solid pyrrhotite vein several inches thick with a little chalcopyrite. Two other open cuts show similar mineralization. Quartz and some calcite are the predominant gangue minerals. Pyrite and pyrrhotite are the predominant sulphides. Sphalerite is next in abundance; some samples are reported to carry 9 ounces in gold, but the gold content is extremely variable. Galena is sparse. Chalcopyrite is usually present but minor in amount. A little arsenopyrite is also present. The gold content is low in the pyritic and pyrrhotitic ore, and the silver content is in general low.

Another mineralized shoot in greenstone is exposed at an altitude of about 1,315 feet and consists of pyrite and pyrrhotite with a little arsenopyrite, in a quartz gangue, in a vein that is as much as 1 foot wide. The vein strikes east-west and dips south. It is exposed in the bed of a gulch for 100 feet. The sulphides are reported to average $4 to $12 to the ton in gold.

On the Red Rose claim, at an altitude of 1,050 feet, an open cut has been made on slate that contains disseminated pyrite and abundant reticulating veinlets of pyritic quartz. A band 6 feet wide is heavily mineralized with pyrite. The strike is about N. 75° W. The pyritic slate at this locality is just above the contact with the Texas Creek quartz diorite.

South of the cabin, in the bed of a small gulch at an altitude of about 2,900 feet, there is a fissured zone in greenstone with reticulating quartz veins. This zone is several feet thick, strikes N. 25° W., and dips 60° S. Several inches of quartz in the hanging wall is heavily mineralized with pyrite, galena, and sphalerite. The writer is not certain that this vein is on the Hobo claims.

ALASKA-PREMIER

The Alaska-Premier group (not to be confused with the Premier mine, which is on the Canadian side of the boundary) comprises 25 claims lying to the southeast of the Daly-Alaska and southwest of the Stoner-Clegg-O'Rourke groups.

The general country rock is greenstone with intercalated beds of slate and graywacke. Three sheets of felsite occur within the greenstone and the sedimentary rocks. It is not certain whether these are intrusive quartz porphyry sills or facies of the greenstone. Development work is being done within two of these sheets in hope of finding an ore body. The northern sheet, on the Alaska claim, is about 40 feet thick, strikes about N. 60° W., and dips 50° E. A short prospect tunnel 15 feet long, at an altitude of 1,400 feet, has been driven on a mineralized zone in the sheared felsite. Veinlets of quartz several inches thick containing pyrite, sphalerite, galena, and a little pyrrhotite and carrying considerable gold have been found. On the Ready Money claim the second sheet of felsite is being prospected. Open cuts have been made, and a tunnel is being driven. At about 40 feet above the tunnel an open cut was made on a very rich pocket of altered felsite. The rock is shattered, veined with quartz, and much silicified. Veinlets and blebs of sulphides occur throughout the pocket and comprise pyrite, sphalerite, galena, and a little pyrrhotite and chalcopyrite. As much as 35 ounces of gold to the ton is reported to have been obtained on assays of selected specimens. A crosscut tunnel at an altitude of about 1,300 feet driven to cut the felsite sheet goes in about 200 feet and has cut about 30 feet of the felsite. The country rock at the entrance to the tunnel is a dark-gray to brown hornlike stone of uncertain origin. The tunnel passed through about 50 feet of a light-colored granodiorite porphyry dike, belonging to the Hyder batholith, which does not show at the surface. The whole zone of felsite is fractured, and the fractures are faced with small pyrite cubes. These small cubes are also disseminated throughout the felsite. Rarely a bleb of pyrrhotite occurs. Such rock is reported to average $2 to $3 in gold and about 1 ounce of silver to the ton.

In the bed of the gulch just below the cabins there is a mineralized shear zone striking east-west at an altitude of about 1,215 feet. The sulphide-bearing sheet is about 3 feet wide and comprises pyrite, galena, sphalerite, chalcopyrite, tetrahedrite, pyrrhotite, and arsenopyrite.

At an altitude of 900 feet, in the bed of the gulch, there is a big dike of porphyry belonging to the Texas Creek batholith, with associated quartz stringers.

DALY-ALASKA

The Daly-Alaska group (see pl. 13) comprises 10 claims and a fraction. The first claims were located in 1912 and 1913. They lie southwest of the Stoner groups and south of the Virginia group and extend from the flat of Salmon River at Elevenmile up the mountain slope to an altitude of 1,800 feet. This group has also been known as the New Alaska and Elevenmile property. The country rock consists of greenstone, which is cut by dikes of quartz and feldspar porphyry belonging to the Texas Creek batholith; and both the greenstone and the older porphyry are cut by dikes of granodiorite porphyry of the Hyder batholith and by malchite and lamprophyre dikes. Westgate[28] summarizes the occurrence of mineralization as follows:

> Two kinds of mineral deposits occur on this property; one carries sphalerite, galena, and pyrite, and the other chiefly pyrrhotite. Only those of the first type are being developed. They lie in a system of fracturing, in which certain zones are richer in sphalerite, galena, pyrite, with a very little chalcopyrite, than the others. These richer zones carry gold and silver. The greenstone [also the older porphyry] lying within the zone of fracture is lighter colored than the normal country rock and carries a large amount of introduced silica and calcite. The difference between ore and country rock is a difference in the degree and kind of mineralization. There are no well-defined walls to the deposits, and the richer portions grade into the country rock. The introduction of the sulphides and silica seems to have been contemporaneous.

[28] Westgate, L. G., op. cit., p. 132.

At the upper workings on this property two adits have been driven. At the upper adit the country rock is a schistose mass of quartz porphyry with feldspar crystals oriented in flowage lines. This is probably an intrusive offshoot from the Texas Creek batholith. An open cut has been made at an altitude of about 1,500 feet. The porphyry here is highly silicified, with associated seams and disseminations of pyrite, a few gash veins of milky quartz or of calcite, and locally a little sphalerite. About 50 feet below the open cut is an adit 150 feet in length with 15 feet of drift about 75 feet in from the portal. The drift appears to be on a shoot mineralized predominantly with pyrite but with some sphalerite and galena. A careful examination also reveals the presence of tetrahedrite, chalcopyrite, pyrrhotite, and arsenopyrite.

At an altitude about 60 feet lower than this adit is another one about 220 feet in length. Westgate[29] describes the first 114 feet of the adit, driven before 1921, as follows:

> For the first 50 feet from the portal the rock is a light greenish-gray fine-grained rock, here more siliceous, there more calcareous, and everywhere somewhat pyritized. Then follows 27 feet of a similar rock containing bands and patches of sulphides (sphalerite, galena, and pyrite). This is followed in turn by 15 feet of less mineralized rock and 10 feet of mineralized rock. The remainder of the tunnel is in barren rock like that at the entrance. The rock structure at the entrance strikes N. 80° E. and has a nearly vertical dip, and the indistinct banding farther in agrees with this attitude.

Near the bend of the gulch, at an altitude of about 600 feet, two open cuts have been made on a mineralized shoot in the greenstone. There is a vein 3 feet wide here, consisting of greenstone streaked with stringers of fine granular galena, pyrrhotite, and sphalerite, with some chalcopyrite and pyrite and a little arsenopyrite, together with calcite and quartz veinlets carrying some sulphides. The sulphides may form about 20 per cent of the shoot. The vein strikes about N. 80° W. and dips 60° S., and it is reported to average 30 to 40 ounces of silver to the ton. In another open cut on the same zone, about 10 feet above, the sulphides consist mainly of pyrite with local sphalerite stringers that assay high in gold.

Just above the camp at Elevenmile a great deal of underground prospecting has been done within the last few years. At the time of the writer's visit work had been suspended and accurate information as to what had been found could not be obtained. The mineral deposits here are in altered greenstone and consist of shoots similar to those in the higher prospects already described. No large ore body has been found. Material on the dump would indicate that a dike of older porphyry of the Texas Creek batholith was cut in the tunnel. The sulphides comprise pyrrhotite, sphalerite,

[29] Westgate, L. G., op. cit., p. 133.

pyrite, galena, tetrahedrite, and chalcopyrite. Some of the tetrahedrite is the silver-rich variety freibergite. Assays of selected samples are reported to have yielded as high as 500 ounces of silver to the ton. A fault was cut in one of the tunnels, and it is reported that a little native silver was found near the fault.

STONER-CLEGG-O'ROURKE

The Stoner-Clegg-O'Rourke group comprises nine claims southwest of the Stoner group and adjoining the Daly-Alaska group.

Above the cabin on the Liberty claim, on the bank of a gulch, at an altitude of about 1,350 feet, a tunnel 75 feet long has been driven N. 65° E. in greenstone. The material on the dump shows veinlets of calcite with sphalerite, pyrite, and galena. Small amounts of pyrrhotite, chalcopyrite, and tetrahedrite are also present. Open cuts have been made at other localities on bands in the greenstone carrying disseminated pyrite and pyrrhotite and seams of calcite, sphalerite, pyrite, and galena.

VIRGINIA

The Virginia group (pl. 13) comprises four claims and a fraction staked in 1919. The claims are mainly east of the Salmon River road along Boundary Creek and are bordered on the south by the Daly-Alaska group.

Mineralized shoots in greenstone are being prospected. On the banks of Cascade Creek a crosscut adit has been driven 50 feet to a mineralized body and a drift extended 225 feet to the southeast and 30 feet to the northwest. The mineralized shoot strikes N. 50° W., dips south, and is in a highly altered basic porphyry or porphyritic greenstone, and is in a sheared zone several feet thick exposed along the northwest end of the drift for about 50 feet. At the northwest face of the drift there is a shoot of almost solid sulphide, consisting of pyrrhotite, sphalerite, pyrite, and a little galena in a quartz gangue. A little tetrahedrite is also present. To the southeast, mineralized bands are exposed in the roof of the drift, and quartz veins and calcite seams are common. Southeast of the mineralized shoot the drift follows a dike. A malchite dike was crossed near the portal of the adit. Selected samples of ore are reported to have run as high as 4½ ounces of gold to the ton.

About 125 feet east of the road, southeast of the adit, an open cut at an altitude of about 670 feet has been made on altered porphyritic greenstone. This exposure shows numerous stringers of barren to sparsely mineralized glassy quartz, fractures faced with sphalerite, and stringers, threads, and blebs of galena and pyrite. About 150 feet upstream from the portal of the adit another adit has been started in mineralized greenstone, which contains many seams and stringers consisting mostly of pyrrhotite, with some pyrite and a little chalcopyrite and sparse sphalerite and galena, and which also shows a notable quantity of epidote in bands and veins. Two other open cuts have been made on the property on schistose bands of greenstone mineralized with disseminated deposits and veinlets of pyrite and a little pyrrhotite and locally a little sphalerite and galena. Several granodiorite porphyry dikes on the property have produced local contact-metamorphic minerals, especially epidote and rarely garnet, in their immediate vicinity.

STONER

The Stoner group (see pl. 13) comprises 14 claims, originally staked by H. B. Stoner and sold by him to Matthew Lodge, of Moncton, New Brunswick, who has incorporated them under the name Stoner Gold & Silver Mining Corporation. The claims lie along the international boundary southeast of Cascade Creek. The Stoner-Clegg-O'Rourke group of nine claims borders them in part on the southwest. The development work consists of a number of open cuts and a 15-foot shaft.

The country rock on this property belongs to the Hazelton group, with greenstone predominating. In this there are dikes of quartz porphyry, quartz diorite porphyry of the Texas Creek batholith, and granodiorite porphyry of the Hyder batholith. There are three types of deposits—(1) veins and disseminated deposits in greenstone, (2) sparsely mineralized quartz fissure veins within or along the contact of a dike of quartz diorite porphyry with slate, and (3) seams, disseminated deposits, and fracture facing of fine crystalline pyrite in quartz porphyry at an altitude of about 850 feet on Cabin Creek. Practically all the work has been done on the mineralized greenstone.

At an altitude of about 1,450 feet on American No. 2 claim a mineralized band in the greenstone has been prospected by a shaft and two open cuts. The western open cut measures 30 feet across the greenstone, and most of it shows seams and disseminated crystals of pyrite. There is a shoot several inches thick of pyrite and sphalerite, with a little galena, tetrahedrite, and pyrrhotite. Calcite is an associated gangue mineral. About 50 feet up the hillside and 20 feet vertically above the open cut, a 15-foot shaft has been sunk on a shoot of sulphide. This shoot is 7 feet wide at the top of the shaft and consists of greenstone with many seams parallel to the schistose structure mineralized with pyrite, sphalerite, and galena. The vein strikes about east and dips north, so that only the north wall of the shaft is mineralized with sulphides other than pyrite. There is considerable quartz with the sulphides, and the greenstone is somewhat silicified. At 25 feet to the east a 40-foot open cut exposes 3 feet of similar mineralized greenstone.

Specimens obtained from mineralized shoots on other claims are reported to have yielded $6 to $8 to the ton in gold and silver, in addition to the lead in the galena.

BORDER

The Border group consists of two claims adjacent to the international boundary on the Salmon River road. They are held by Lon Doggat.

The country rock is interlayered dark-gray slate and fine graywacke. Scattered seams and narrow stringers of mineralized quartz are distributed through a wide zone in the form of gash veinlets at an angle to the bedding. The sulphides comprise galena, sphalerite, pyrite, and a little chalcopyrite and occur in heavily mineralized shoots as much as 6 inches wide. The ore minerals are not in uniform association but tend to occur with one or another predominant. Considerable carbonate occurs with the ore minerals. An adit has been driven 70 feet for the purpose of cutting the mineralized fissured zone, which lies between two dikes of granodiorite porphyry.

GOLD CLIFF PREMIER

The Gold Cliff Premier group comprises 24 claims lying along both sides of Salmon River above the junction of Cascade Creek and includes the east side of Mineral Hill. The claims were staked in 1920 and regrouped in 1925. The bedrock consists of quartzite, tuff, and intercalated slate, with a few dikes of older porphyry of the Texas Creek batholith and younger dikes of granodiorite porphyry of the Hyder batholith. Locally the quartzite is intensely fractured, the fractures are lined with pyrite, and the rock is impregnated with pyrite. Usually such pyritic rock yields only very low assays in gold and silver, but on the east side of the river a 20-foot open cut made on a shear zone several feet thick in greenish fine-grained tuffaceous rock has shown a pyritized band carrying considerable gold. Some calcite and quartz is associated with the pyrite. This heavily pyritic band is 2½ feet wide, and samples are reported to assay as much as 1 ounce in gold and 3 to 4 ounces in silver to the ton. On the west side of the river, at an altitude of about 800 feet, there is a narrow stringer of galena and also a 1-inch stringer of sphalerite, chalcopyrite, tetrahedrite, and pyrrhotite.

CANTU

The Cantu group consists of 17 claims adjacent to the international boundary, on the west side of Salmon Glacier, extending from a point just west of its terminus to the north side of the low pass north of Cantu Mountains and occupying the east side and the crest of Cantu Mountain. These claims are held by Cronholm & McDonald and were located July 2, 1925. No work had been done on them when they were seen by the writer.

The country rock of the whole of Cantu Mountain except its southernmost tip and the base of the cliffs below Salmon Glacier is the Texas Creek granodiorite. On the west side of the mountain the rock is usually porphyritic, with large crystals of potassic feldspar, but on the crest and east side it is generally even grained and only locally porphyritic. The gray Texas Creek granodiorite is cut by many dikes of pink to white granodiorite porphyry and dark dikes of malchite that are genetically connected with or are offshoots from the Boundary granodiorite intrusive mass which lies to the north along Boundary Glacier. The contact between the Texas Creek granodiorite and the Hazelton group of greenstone and sedimentary rocks probably lies in the valley of Salmon Glacier, and the Cantu group of claims therefore lies close to the eastern border of the Texas Creek batholith. Greenstone containing some pyrrhotite and cut by dikes of the granodiorite porphyry of the Boundary batholith, crops out at the base of the mountain below the foot of the glacier. Quartzitic beds are exposed in the pass between Salmon River and Texas Creek.

On Cantu No. 4 claim, at an altitude of about 1,200 feet, a vein is exposed for about 20 feet in length. It ranges from 4 inches to 2½ feet in width. The country rock is the Texas Creek granodiorite. About 10 feet below the vein is a dike of quartz porphyry. This is locally shattered and reticulated by stringers of highly mineralized quartz, and the rock is much altered to sericite. The chief metallic mineral produced by the mineralization of the veins here is granular galena. With the galena are associated in subordinate amounts resin-colored sphalerite and veinlets of tetrahedrite. Pyrite and chalcopyrite are sparse. Quartz is the predominant gangue mineral, but barite is common and locally is equal in amount to the quartz. A little calcite is present. The vein strikes north to N. 20° E. and dips 30°–50° E.

About 300 yards to the south, on No. 6 claim, at an altitude of about 1,350 feet, there is a vein of heavily metallized quartz exposed in the bed of a small gulch for a difference in altitude of 30 feet. The vein is 6 inches to 3 feet thick, with local stringers and shoots of galena as much as 6 inches thick. Coarse to medium crystalline galena predominates. Tetrahedrite, resin-colored sphalerite, and pyrite are associated with the galena. There is more pyrite and less barite here than in the other veins. Stringers of quartz, slightly metallized and containing plates of barite, occur in the footwall. The vein strikes north-northeast and dips 40° SE. This vein may be an extension of the vein on Cantu No. 4 claim, though no prospecting has been done to prove it.

On Cantu No. 8 claim, according to B. W. W. McDougall, another vein is exposed at altitudes between 1,960 and 2,180 feet and can be traced for more than 500 feet. The part examined by Mr. McDougall was 30 to 35 feet wide and consisted of grayish quartz with pyrite disseminated and in solid streaks. A grab sample of chunks knocked off at random is reported to assay 0.8 ounce in gold and 1.2 ounces in silver to the ton. The vein is thought to strike about N. 20° W., the dip is not known.

A test shipment of 20 tons of carefully sorted ore from the Cantu group was sent to the Selby smelter. The returns on this shipment are given below, together with assay by Mr. McDougall on grab samples.

Assays of ore from Cantu group of claims, Hyder district

[Blanks indicate percentages not determined]

	1	2	3	4	5	6	7
Gold......ounces per ton..	0.30	0.175	0.42	0.10	0.40	0.01	0.80
Silver......do....	13.80	31.05	61.2	27.1	17.0	5.20	1.20
Lead......per cent..	37.20	44.1	29.3	43.4	38.8	19.8	....
Insoluble matter......do....	38.80	22.8	....	....	....	....	....
Iron......do....	3.30	.9	....	....	....	....	....
Zinc......do....	5.60	12.2	16.4	12.2	5.2	....	....
Sulphur......do....	10.70	13.5	....	....	....	....	....
Copper......do....	....	....	4.5	2.75	1.20	....	....

1. Smelter assay on about 6½ tons of sorted ore from Cantu No. 6 claim.
2. Smelter assay on about 12 tons of sorted ore from Cantu No. 4 claim.
3. Grab sample from 30 sacks of sorted ore with considerable tetrahedrite, Cantu No. 4 claim.
4. Grab sample from 180 sacks of sorted galena ore with less tetrahedrite, Cantu No. 4 claim.
5. Grab sample from 150 sacks of sorted ore, Cantu No. 6 claim.
6. Sample across vein, width 12 inches, Cantu No. 6 claim.
7. Grab sample from vein on Cantu No. 8 claim.

The gross value of the sorted ore from Cantu No. 6 claim, with silver at 69¼ cents an ounce and lead at 9¼ cents a pound was $88.10 a ton, and the net value, after deduction for smelter charges, was $59.83 a ton. The gross value of the sorted ore from Cantu No. 4 claim was $108.79 a ton, and the net value, after deduction for smelter charges, was $76.76 a ton.

BARTHOLF

The Bartholf claims lie mainly on the Canadian side of the international boundary on the west side of Salmon Glacier, in the valley north of Cantu Mountain, at an altitude of about 1,430 feet. The vein strikes N. 18° W. and dips 55° W. It consists of quartz with disseminated chalcopyrite and local shoots of pyrite and galena. Chalcopyrite predominates. The quartz contains many vugs, and barite plates are common. The vein ranges from several inches to a foot in width and averages 6 inches.

NINETY-SIX

The Ninety-six group comprises six claims located just above the Texas Creek trail on the west side of Mineral Hill about 1¼ miles north of the Salmon River bridge. They are held by Ray Snyder and Pete Wilson. At an altitude of about 500 feet a 63-foot adit has been driven to crosscut the vein at about 30 feet below the outcrop. The vein occurs in a dike of Texas Creek granodiorite which cuts interbedded slate and quartzite. The vein consists of interlacing mineralized quartz stringers in a brecciated or shattered zone of the granodiorite. There are no well-defined walls to the vein. At the outcrop above the tunnel the vein is about 5 feet thick with stringers of sparsely to heavily mineralized quartz aggregating about a foot in thickness. In the breast of the adit there is 12 to 15 inches of quartz heavily mineralized with galena, sphalerite, tetrahedrite, pyrite, and chalcopyrite. Galena predominates. The vein strikes about N. 10° W. and dips 40° E.; it has been traced at the surface for a length of 200 feet.

SILVER BAR

The Silver Bar claim is north of the West Fork trail and about 1¼ miles east of the Homestake trail, in a gulch, at an altitude of 1,930 feet. It was staked by David McVey in 1923. The vein is in the Texas Creek granodiorite; it strikes N. 30° W., dips 45° E., and is exposed for a length of 250 to 300 feet and a difference in altitude of 175 feet. It consists of quartz, with local shoots and small pockets and bands sparsely to moderately mineralized with sulphides and barite. Much of the vein is barren. The sulphides consist predominantly of chalcopyrite with a little associated galena and pyrite. The vein ranges from several inches to 3 feet in width. At the discovery stake there is a 5½-foot fissured zone in the granodiorite with a 15-inch vein on the footwall that consists of quartz and barite sparsely to moderately mineralized with small pockets and stringers of sulphides.

LIBERTY

The Liberty claim is on the east side of Casey Glacier, just below its foot. It was staked by Joe Jackson. The vein is exposed in the bed of a small stream at an altitude of about 1,800 feet. It ranges from several inches to 2 feet in width and is exposed for about 200 feet in length, with a strike of N. 50° E. and a dip of 70° E. The vein occurs in the Texas Creek granodiorite and is probably cut by a 25-foot dike of granodiorite porphyry with dark chilled borders. The vein consists of quartz, with local shoots of galena. The claim was staked in September, 1925; no work has been done on it.

NOTHIGER

On the west side of Casey Glacier, just above its foot, an adit has been driven to cut an intensely sheared zone in the Texas granodiorite. The shear zone is 20 to 40 feet thick and contains one main quartz vein and abundant small stringers of quartz. The main vein strikes about N. 40° E. and dips 38° E.; it is 2½ feet thick at the adit and 6 feet thick at the discovery stake. The adit is at an altitude of about 2,240 feet, and it has been driven 12 feet through the main vein into the footwall. There is only a trace of galena and pyrite in the quartz. Surface prospecting for a possible shoot of ore within or along the walls of the quartz vein would be advisable before further underground crosscutting or drifting is done.

EVENING AND MORNING STAR

The Evening and Morning Star claims are on the east side of the gulch, just above the cabin of Carlson & Hewitt; they were staked by McVey & Connors in 1923. A short 10-foot adit has been driven along a narrow stringer of steel galena in the Texas Creek granodiorite, which strikes N. 15° W. About 100 feet up the mountain slope this stringer is paralleled by a quartz vein.

HOMESTAKE

The Homestake group comprises eight claims staked in 1923 and held by J. H. Hewitt and C. Carlson. The claims lie about 1¼ miles north of the West Fork on the creek that flows into Ibex Creek. A pack trail for horses has been cut almost to the site of the vein.

At an altitude of about 3,550 feet an adit 25 feet in length has been driven to cut the vein about 25 feet below the outcrop. The vein, which is in the Texas Creek granodiorite, strikes about N. 15° E. and dips 45° E. It has been traced for a length of about 250 feet. The northern 150 feet is strongly mineralized, but the southern 100 feet is milky-white quartz very sparsely mineralized. The vein is 5½ feet thick in the tunnel and ranges in general from 4 to 5½ feet. At the north end it pinches abruptly; its projected line of extension is covered by snow. At the south end the vein strikes toward a bluff face but does not show in the bluff and is covered for a narrow width at its base by débris. Inclusions of granodiorite occur in the vein. In the adit the walls of the vein are slickensided and the upper foot of the vein consists of shattered country rock with stringers of quartz and ore. Stringers of tetrahedrite are found in the hanging wall. In the mineralized portion of the vein bands of solid sulphide occur in widths of as much as a foot. The sulphides consist predominantly of dense steel galena with some pyrite and chalcopyrite and locally a trace of sphalerite.

A test shipment of 9½ tons of sorted ore from this vein sent to the American Smelting & Refining Co. at Selby, Calif., in 1925, had an average total gross value of $116.80 and a net value of $83.72 a ton after deduction of the smelting company's charges and the cost of freight from Hyder to Selby. Representative assays from this vein are given below.

Assays of samples from the vein on the Homestake group, Hyder district

[Blanks indicate percentages not determined]

	1	2	3	4
Lead per cent	50.0	43.8	5.5	0.5
Silver ounces to the ton	22.87	5.8	1.3	24.3
Gold do	.29	.26	.22	.14
Copper per cent		1.0	.84	.4
Zinc do	.7		1.20	
Iron do	6.3			
Insoluble matter do	24.0			
Sulphur do	12.5			

1. Smelter assay on 9½ tons of sorted ore.
2. Sample across 20 inches, 12 feet south of discovery post.
3. Sample across 5 feet, 25 feet south of discovery post.
4. Grab sample from slightly mineralized part.

SILVER COIN

The Silver Coin claim is on the east side of the western gulch tributary to that on which the Homestake is located about 700 feet above it. It was staked by Paul Meagher and Ray Snyder. The vein is in granodiorite and is about 50 feet in length. It strikes N. 5° W. and dips 45° E. The northern 25 feet of the vein consists of a shoot of ore that widens abruptly southward from a few inches to 5 feet. At its south end the vein passes into practically barren milky-white quartz; the quartz splits into stringers, and an extension to the south can not be traced. The quartz vein zone at the south end is 10 feet or more thick and has no well-defined hanging wall or footwall. The quartz stringers appear to pinch and stop abruptly down the dip. The granodiorite shows many slipping planes, and along the footwall of the ore shoot these are coated with malachite. The mineralized shoot of the vein consists of quartz containing a high percentage of galena with a little pyrite and chalcopyrite.

IBEX

The Ibex group is on the west side of Ibex Gulch. It comprises six claims staked by Carlson & Hewitt in 1923 and now held by Day Bros., of Wallace, Idaho, and their associates; also one claim, Ibex No. 7, staked in 1924 by Carlson & Hewitt. Three veins are exposed on this group, all within 200 feet of the contact of the Texas Creek granodiorite and the overlying sediments. The veins occur in both the argillite and quartzite, as well as in the granodiorite.

On Ibex No. 1 the vein is exposed where it is crossed by a small deep gulch. The country rock consists of thin-bedded gray to black argillite and quartzite cut by dikes of granodiorite porphyry. The vein is of the fissure type. It strikes N. 5° E., dips steeply eastward, and cuts across the strike of the bedding. The vein is exposed for a length of about 100 feet, with a difference in altitude of 75 feet. It pinches and swells but is 15 inches to 2 feet in width for considerable portions. As exposed at the bottom of the gulch the vein contains about 18 inches of sulphides with only a little quartz gangue. The sulphides consist almost wholly of interbanded pale-colored sphalerite and coarse-grained galena. The vein is cut by a dike of pink granodiorite porphyry, along which it is offset a few feet, and by a dike of fine-grained green-gray malchite, which cuts both the granodiorite porphyry and the vein. The vein is also offset by a fault striking N. 30° W. At an altitude of 3,700 feet, about 100 feet lower than the outcrop, an adit 131 feet in length was driven to cut the vein, but the vein was not found, and work was abandoned. It is not known whether the failure to find the vein was due to faulting, to pinching out downward, or to local cutting out by a dike of granodiorite porphyry younger than the vein. The top of the Texas Creek batholith, which is older than the vein, lies about 125 feet below.

On Ibex No. 3 claim, southwest of the tunnel on Ibex No. 1 and at an altitude of about 3,650 feet on the West Fork slope, an 8-inch vein of quartz, heavily mineralized with galena and a little associated pyrite and chalcopyrite, occurs in the Texas Creek granodiorite. The vein is barely exposed, and no work has been done on it. It probably lies below the top of the Texas Creek batholith, just beneath its contact with the overlying argillite.

In the bed of Ibex Gulch on Ibex No. 7, upstream from the position of the crosscut adit on No. 1 claim, a vein is exposed in the Texas Creek granodiorite. It has been traced for several hundred feet and ranges from 5 inches to 2 feet in width. The vein strikes about N. 5°–10° W. and dips east. At the north end, where it passes under the snow, it forms a fissured zone 3 feet wide with stringers of quartz. Heavily mineralized shoots consisting of galena with a little pyrite occur along the vein. One such shoot is 20 feet long and 8 inches to 2 feet wide. The vein is offset by faults of small displacement.

SILVER STAR

The Silver Star group comprises two full claims and two fractions, lying between the Iron Cap on the west and the Ibex group on the east, on the mountain slope north of the West Fork trail, about 1,600 yards west of the trail to the Homestake group. They were staked by McVey & Connors in 1923. The contact of the Texas Creek granodiorite with the argillite crosses the claims, and mineralized veins are found both below and above the contact.

At an altitude of 2,900 feet a 30-foot adit has been driven along a vein in the footwall portion of a fissured zone in the Texas Creek granodiorite. The vein strikes about north and dips 55° E. It can be traced up a gulch for about 100 feet, to a point where it is offset about 30 feet to the west. Its extension is covered. About 100 feet above the adit entrance the fissured zone is about 7 feet wide, with mineralized quartz as much as 9 inches wide in the footwall portion and over a foot of quartz with sparse mineralization in the hanging-wall portion. The heavily mineralized shoots in the quartz consist predominantly of galena and pyrite.

At an altitude of about 3,760 feet stringers of quartz occur along a narrow fissured zone in the argillite, which is traceable by exposures in gulches for a length of 600 feet. The quartz stringers are locally mineralized with galena or sphalerite or pyrite. Small quantities of pyrrhotite, arsenopyrite, and freibergite are also present. The vein zone strikes about N. 70° W., approximately parallel to the bedding.

SILVER BELL

The Silver Bell group comprises two claims north of the West Fork trail and northwest of the Silver Star group, at an altitude of 4,600 feet. They were staked by Joe Connors on August 4, 1925. The vein is in a brecciated fissured zone in argillite and graywacke. It strikes N. 80° W., in general at a slight angle to the bedding, and dips north. It is exposed for a length of 50 feet and consists in part of quartz 2 feet thick, with inclusions of country rock and sparsely disseminated sulphides, and in part of a solid shoot of sulphide, predominantly galena, that is 13 inches thick at its widest parts. The sulphides disseminated in the quartz are pyrite and chalcopyrite, with a little galena and sphalerite at some places. The galena shoot has some tetrahedrite associated with it. The vein was seen by the writer at the time of staking, and no work was done on the property.

TEXAS DISCOVERY

The Texas Discovery claim is on the West Fork trail at an altitude of about 2,000 feet. It was staked in 1923. The vein is in the Texas Creek granodiorite; it strikes N. 15°–30° W. and dips 45°–60° NE. It ranges from 1 to 14 inches in width, has been traced for 100 feet, and pinches out at the northwest end. The sulphides comprise galena, pyrite, pyrrhotite, and sparse chalcopyrite, with galena predominant. A 4-inch stringer of quartz a short distance away strikes N. 50° W., dips 45° NE., and is mineralized with galena and chalcopyrite. An assay of a picked sample from the main vein is reported to have given 30 per cent of lead, with $22 in gold and $6 in silver to the ton.

IRON CAP

The Iron Cap group comprises three claims at an altitude of about 3,800 feet, north-northwest of Malcolm Smith's cabin on the West Fork trail. The claims were staked in 1923 by David McVey. An open cut 12 feet wide has been made across an 11-foot zone of fine-grained graywacke and slate that contains stringers and veins of sulphides. The vein zone strikes N. 75° E., approximately parallel to the bedding, and dips about vertically. On the northeast wall there is a 2-foot vein of quartz and coarse calcite with shoots of solid pyrrhotite and chalcopyrite, pockets of solid sphalerite, and a little arsenopyrite. Stringers several inches to a foot wide occur here and there in the remainder of the fissured zone. The vein is exposed for a length of about 50 feet. The contact of the sedimentary beds with the Texas Creek granodiorite lies at an altitude of a little more than 100 feet below the open cut.

HUMMEL

The Hummel group comprises six claims at an altitude of about 4,250 feet, on the north side of the West Fork, opposite the foot of Ferguson Glacier. They were staked by Harry Hummel in July, 1925. The vein consists of a shear zone in argillite and slate that strikes N. 50° E., at a small angle to the bedding, and dips 35° W. The fissured zone contains stringers of sulphides and some quartz and is at least 2 feet wide. The vein has been uncovered for 12 yards by stripping. On the hanging wall there is a maximum of 6 inches of solid sulphides consisting predominantly of dark sphalerite with some associated galena, pyrite, and chalcopyrite and a little tetrahedrite.

DOUBLE ANCHOR

The claims that make up the Double Anchor group lie at an altitude of 4,000 feet, near and at the head of a steep gulch, due north of Texas Lake, near the head of the West Fork. They were staked in 1923. The deposit is a shear zone in banded argillite and fine-grained graywacke, with seams and stringers of quartz and sulphides. The strike is about east, and the dip is flat. The sulphides comprise brown sphalerite, galena, pyrite, and chalcopyrite. Pyrite-bearing quartz is common; pyrrhotite is sparse. One mineralized shoot, consisting of country rock with quartz and stringers of galena and pyrite is 30 feet in length and as much as 2½ feet in width, but pinches out into thin seams at each end. On the whole, there are only a few seams of sulphides in the vein zone, and these are usually less than an inch thick. Thick quartz veins are exposed in the gulch to the west, but they are only sparsely mineralized.

DUGAS

Jerome Dugas holds five claims on the west end of the ridge north of the West Fork, in general at altitudes between 3,700 and 4,200 feet. The country rock is graywacke with an intercalated zone of black slate. The prevalent strike of the bedding is N. 70°–80° E. and the dip is north.

The mineral deposits consist in part of fissure veins in shattered zones at an angle to the bedding, in part of mineralized quartz in stringers in shear zones parallel to the bedding, and in part of stringers of solid sulphide (usually brown sphalerite) parallel to the bedding. At one place there is a fractured aplite dike in which the fractures are faced with galena, pyrite, and chalcopyrite. The sulphides on these claims, so far as now exposed at the surface, are sparse or occur in scattered narrow stringers. No ore shoot of any size is exposed.

On the Copper Claim there is a fissured zone in graywacke 10 to 15 feet wide, which strikes N. 30° W. and dips 45° W. Stringers of sulphides with a little quartz gangue several inches wide are scattered through this zone, but they are not close together. The sulphides comprise galena, sphalerite, pyrite, and chalcopyrite. Two open cuts have been made on the fissured zone, and it has been traced for about 50 yards.

SILVER KING

The Silver King group comprises six claims at the west end and on the north slope of the ridge north of the West Fork. It was staked by Angus Kennedy, August 28, 1925. Mineralized quartz is exposed in graywacke and argillite at two places about 200 yards apart; these exposures may be on the same vein. The vein crosses a dike of quartz diorite of the Texas Creek batholith that cuts the sedimentary rocks. At an altitude of 3,800 feet the vein has been stripped for 50 feet. There it ranges in width from 6 to 30 inches and has on the footwall 2 inches of solid sulphides comprising brown sphalerite, galena, pyrite, chalcopyrite, and a little arsenopyrite. At the upper exposure a stripping 8 feet in length has exposed a quartz vein with 8 inches of solid sulphides consisting of galena with some associated pyrite, chalcopyrite, sphalerite, tetrahedrite, and a little barite. At both exposures the quartz vein strikes N. 35° W. and dips 35° NE. and is a typical fissure vein at an angle to the bedding of the graywacke. A specimen sample of the galena ore from the upper outcrop is reported to have assayed 1.28 ounces of gold and 5.96 ounces of silver to the ton, 55.2 per cent of lead, and 2.2 per cent of copper.

CHICKAMIN

The Chickamin group consists of two claims at an altitude of 3,000 feet on the slope southeast of Texas Glacier near its junction with Chickamin Glacier. They were staked in 1925. A fissured zone in graywacke, striking N. 25° W. and dipping 50° NE., contains quartz stringers mineralized with galena, chalcopyrite, sphalerite, pyrite, and a little pyrrhotite and tetrahedrite. A quartz vein 3 feet wide, striking N. 30° W., is also present on the claims. Practically no work has been done, and the veins are exposed only for very short lengths.

BLASHER

Frank Blasher holds four claims on the north side of the West Fork near its head. The vein is below timber line and therefore mostly covered with forest litter and vegetation. An open cut shows a 10-foot shattered and fissured zone in fine-grained brownish quartzite. About 4 feet of the hanging wall is almost solid quartz, and stringers of quartz are common in the rest of the fissured zone. Many of the stringers are heavily mineralized with galena, pyrite, sphalerite, and a little chalcopyrite. Mineralization is reported to have been traced for a length of 500 yards. The strike is N. 20° W., and the dip 45° E. This strike is at an angle to the prevailing trend of the bedding in this vicinity, and the vein is evidently of the crosscutting fissure type. An adit at an altitude of 2,700 feet has been driven 14 feet with the intention of cutting the vein in depth. The adit starts in argillite, which contains quartz veinlets with disseminated molybdenite. The outcrop of the vein is probably not more than 200 feet vertically above the contact with the Texas Creek quartz diorite.

LAKE

The Lake claim lies on the West Fork trail about a mile east of Chickamin Glacier, at an altitude of 2,400 feet. It was staked in July, 1923. The vein is in the Texas Creek quartz diorite just below its contact with the overlying sediments. The vein is exposed beside the trail, where it is 11 inches wide, strikes N. 35° W., dips 60° E., and is heavily mineralized along the footwall with abundant galena and less pyrite. It has not been traced.

MORNING

The Morning group comprises four claims near the head of the West Fork just above Texas Lake, at an altitude of 2,300 feet. They are held by Frank Blasher. The country rock is the Texas Creek quartz diorite, and the vein consists of quartz 2 to 4 feet wide, heavily mineralized with pyrite and with sparse pockets of galena. At one end the vein passes into a highly schistose zone several feet thick of quartz diorite moderately impregnated with pyrite and containing narrow stringers and knots of quartz. The vein is exposed by stripping for 40 feet; it strikes N. 40° W. and dips 45° NE.

EDELWEISS AND JUMBO

The Edelweiss claim is near Through Glacier, just north of the northernmost glacier on its west side. The claim was staked by Hummel, Blasher, and Mross in September, 1925. The vein is reported to be 1,500 to 2,000 feet in altitude above the glacier and to consist of quartz with galena and pyrite. A picked sample assayed $32 in gold and 10.2 ounces in silver to the ton.

The Jumbo group, which comprises two claims, is at a lower altitude, just above Through Glacier. It was staked at the same time as the Edelweiss and by the same group of men. This property was not visited by the writer after the claims were located.

Mr. W. B. Jewell reports that a number of quartz veins occur in graywacke on the mountain slope just northwest of the glacier. They strike about N. 10° E., dip steeply, range from 6 inches to 2 feet in width, and locally carry shoots mineralized with pyrite and galena. The graywacke strikes N. 60°–70° W. and dips steeply; it is cut locally by dikes of highly altered gabbro.

HECKLA

The Heckla group comprises five claims on the mountain slope southwest of the junction of Greenpoint and Through Glaciers. It was staked by Hummel, Mross, and Blasher in September, 1925.

The vein was not seen by the writer. It occurs in graywacke and is reported to be exposed for 75 feet. A ton of ore was broken from the surface outcrop and sledged down over the glacier to the West Fork trail in September, 1925, for a test shipment to the smelter. The ore consists of galena, pyrrhotite, sphalerite, and chalcopyrite. A picked sample yielded $1.60 in gold and 54.3 ounces of silver to the ton, 21.6 per cent of lead, 32.1 per cent of zinc, and 4.1 per cent of copper.

TEXAS CREEK COMSTOCK (HYDER LEAD)

LOCATION AND CHARACTER OF THE DEPOSITS

The Texas Creek Comstock group of 20 claims lies on the mountain slope on the south side of the West Fork in the vicinity of the two small glaciers between Ferguson Glacier and Hummel Glacier. The original claim, the Joe-Joe, was staked on July 15, 1923, by Joe Jackson and Joe Neary. In 1926 the name of the company controlling the group was changed from Texas Creek Comstock Mining Co. to Hyder Lead Mines (Inc.).

The predominant rocks exposed on the property consist of thick-bedded graywacke or waterworn tuff with a little intercalated slate forming the upper part of the mountain and a portion of the Texas Creek batholith forming the base. (See pl. 10, *A*.) The character of the contact indicates that the batholith has here an upward bulge into the graywacke, forming a cupola-like protuberance. On Ferguson Glacier the contact is at an altitude of 3,000 feet; farther west it rises to 3,300 feet at the first main gulch and to 3,600 feet on the ridge above the first small glacier; it crosses very near the foot of this glacier; between the two small glaciers it is at about 3,800 feet, and on the west side of the second glacier at 3,900 feet; west of the second glacier the contact bends sharply to the north and goes down to an altitude of about 3,340 feet, where it swings northwest and descends still lower. The graywacke here forms the roof of the batholith, which plunges to the west. Coarse, breccia-like beds composed of elongate fragments of volcanic rock are common. The strike of the bedding is usually N. 75°–80° E.; the dip is usually 60° S. but ranges from 50°–80° S. The Texas Creek batholith here has not been carefully examined to determine its composition, but it is believed to be quartz diorite. It has an inconspicuous banding or a gneissic structure which is about vertical and strikes N. 70° E. The Texas Creek quartz diorite sends off dikes into the overlying graywacke. Many of these dikes are coarsely porphyritic. Aplite and pegmatite dikes are found in the quartz diorite for 200 feet or so below the contact and for 500 or 600 feet above it.

More than a dozen veins have been found on the property. They have a northwest strike and a steep northeast dip in both the quartz diorite and the graywacke and therefore strike uniformly across the structure. They also cut across the dikes of aplite and porphyry but are themselves probably cut by the dark-gray malchite dikes. Some of the veins occur in the Texas Creek quartz diorite, some in the graywacke, and some cross the contact and occur in both. As now exposed at the surface, the veins in the graywacke are more highly mineralized than those in the quartz diorite; most of the latter are barren or sparsely to moderately mineralized with pyrite, but some contain locally small shoots mineralized predominantly with galena.

VEINS ON THE FORTUNA CLAIM

On Fortuna No. 1 claim, in the first little gulch to the east of the eastern of the two small glaciers, between altitudes of 3,200 and 3,300 feet, there is a shear zone in the Texas Creek quartz diorite that is 5 to 10 feet thick and is exposed for a length of 50 yards. This zone contains a number of small quartz stringers and in the footwall portion a well-defined vein 1 to 3 feet thick, consisting of quartz sparsely to very heavily mineralized with pyrite. At many places the pyrite crystals are associated with pockets or stringers of calcite in the quartz. The vein strikes N. 50° W. and dips 60° E. About 20 feet above this fissured zone there is another quartz vein, 15 to 24 inches thick, sparsely mineralized with pyrite disseminated in cubic crystals. The veins are at an altitude 300 to 400 feet lower than the contact of the Texas Creek quartz diorite and the graywacke.

Two veins that may be parts of a single vein with the southeastern portion offset to the west have been traced by several strippings from the contact of the Texas Creek quartz diorite with the overlying graywacke, at an altitude of about 3,540 feet, southeastward up the hillside to an altitude of about 3,850 feet. At 3,700 feet a stripping shows the quartz vein 2½ feet wide where it crosses an aplite dike that is intrusive into the graywacke. The quartz vein carries a shoot moderately mineralized with galena and pyrite. At an altitude of a little over 3,800 feet an open cut has been made on the vein, which is here in banded slate and graywacke, strikes northwest, and dips 70° E. For about 50 feet above the open cut the rock is a porphyry, part of an upshooting dike from the Texas Creek quartz diorite, which lies about 300 feet deeper. In the open cut there is a vein of quartz a foot wide, very heavily mineralized with sulphides. The hanging wall of the vein is not exposed. In the porphyry dike the vein splits into a number of stringers throughout a width of 20 to 25 feet. For this width the fissured zone is composed of 10 to 15 per cent of quartz in stringers. On the lower side of the dike two of the larger quartz stringers, which are nearly a foot thick, are moderately mineralized. One of these extends across the dike and carries many small shoots of sulphide several inches thick in addition to being sparsely mineralized throughout. On the upper side of the dike there is a narrow band of slate and graywacke in which the vein pinches to a few stringers, and then an aplite dike in which the stringers practically die out. The sulphides comprise galena, pyrite, and a little chalcopyrite. Locally there is considerable barite.

JOE-JOE VEIN

The discovery stake on the Joe-Joe vein is on the west side of the ridge between the two small glaciers, at an altitude of about 4,500 feet. The vein probably consists of at least three parts successively offset by faults for short distances to the west. If these are considered to be parts of the same vein, the vein as a whole strikes N. 35°–50° W., dips 80°–60° E., and is exposed for a total difference in altitude of 340 feet and a horizontal length of about 200 yards. It is a fissure vein in thick-bedded, massive, tuffaceous graywacke, whose bedding strikes prevalently N. 80°–85° E. and dips 55°–60° S. The gangue is almost wholly quartz, and large portions of the vein are barren or but sparsely mineralized with pyrite. The sulphides occur in local shoots and comprise galena, pyrite, chalcopyrite, and sphalerite, with galena predominant. The largest shoot exposed at the surface is near the discovery stake.

Just above the discovery stake the vein is 4¾ feet wide and consists of quartz heavily mineralized with sulphides throughout. About 20 yards up the slope, southeast from the discovery stake, there is a highly fissured zone in graywacke 15 feet or so wide, with many sparsely mineralized quartz stringers and a vein of quartz 7 feet wide, 15 inches of which is moderately to heavily mineralized. The vein strikes N. 35° W. and dips steeply to the northeast. The projected line of extension up the mountain side farther southeast is covered for some distance. A quartz vein at an altitude of about 4,640 feet has been exposed by stripping for a length of 40 feet; it is 9 to 15 inches wide and contains a shoot several inches thick heavily mineralized with galena and pyrite and showing a trace of sphalerite. If this vein is the same as the Joe-Joe it is offset to the east, but it is probably a different vein. About 15 feet northwest of the discovery stake the Joe-Joe vein is sparsely mineralized and is offset to the west. The part of the vein between this offset and the covered portion to the southeast is exposed for a vertical difference of 60 feet and a length on the hill slope of about 40 yards. A dike of malchite with a strike of N. 65° W. occurs along the line of offset, then makes a sharp bend and follows the northwest offset extension of the Joe-Joe vein for a distance of 50 yards, striking N. 45° W. The vein thus occurs here along the contact between the malchite dike and the graywacke. Its contact with the dike is slickensided, and for about 35 yards down the hillside it is poorly exposed and at places very narrow. For the next 30 feet the vein is exposed by stripping and has a width of 2 to 3 feet with a shoot on the footwall as much as a foot in width and moderately mineralized with sulphides. Below this is an open cut which shows that the vein breaks up into moderately mineralized quartz stringers in a fissured zone 2½ to 3½ feet wide in the graywacke adjacent to the malchite dike. Below the open cut the vein is in graywacke for about 25 yards, with a strike of N. 50° W. and a dip of 70° E. The lower 15 yards is stripped and shows a quartz vein that has an average width of about 4 feet and is sparsely mineralized. A small shoot, moderately mineralized with sulphides, occurs at intervals in the hanging wall of a portion of the vein below the open cut. The total length of this second part of the Joe-Joe vein, as exposed on the surface, is about 75 yards. At its lower end, at an altitude of about 4,380 feet, the vein is again offset to the west, and this third part has been traced by two strippings for 100 yards and a difference in altitude of 160 feet. The upper stripping shows a fissured zone 2 to 3 feet wide with stringers of quartz and one vein several inches to a foot wide. The quartz is mineralized here and there with galena, pyrite, and a little sphalerite. The lower stripping exposes a strong quartz vein for a length of 30 feet. It ranges from 2 to 5 feet in width and is sparsely mineralized with pyrite.

OTHER VEINS

At altitudes of 3,400 to 3,900 feet on the west side of the hogback between the two small glaciers, on the edge of the slope above the west glacier, there are three parallel veins that strike northwest. Beginning with the southwesternmost vein and going northeast each has a successively steeper dip to the northeast, which results in their joining at altitudes of about 3,800 and 3,480 feet. These veins in their upper parts are in the graywacke, but they pass down across the contact at an altitude of about 3,820 feet into the underlying Texas Creek quartz diorite. They are here called Nos. 1, 2, and 3 veins for purposes of identification. As exposed within the Texas Creek quartz diorite these veins are in general wholly barren or sparsely mineralized with pyrite, but in the graywacke they carry shoots mineralized with galena and other sulphides. Rarely, very small shoots mineralized with galena are found also in the veins within the Texas Creek quartz diorite.

The lower vein, No. 1, is exposed at an altitude of about 3,820 feet by an open cut on the slope above the glacier. It strikes N. 40° W. and dips 50° NE. The deposit here consists of a 7-foot fissured zone in graywacke with a vein 14 to 18 inches wide in the hanging wall moderately mineralized throughout a length of 25 feet. At the southeast end beyond the face of the open cut the quartz veins pinch out into little stringers a quarter of an inch to 1 inch wide. The vein is covered for a space and then 35 feet northwest of the face of the open cut it crosses a 4-foot dike of porphyry in the graywacke where it is sparsely mineralized. Just beyond, at the contact of the graywacke with the mass of Texas Creek quartz diorite, the vein is offset about 7 feet along a fault that strikes N. 30° E. In the Texas Creek quartz diorite the vein, for a vertical distance of 20 feet below the contact, ranges from 1 to 2¼ feet in width and is sparsely mineralized with pyrite and chalcopyrite and locally a little galena in the hanging wall. At an altitude of about 3,800 feet a narrow stringer connects it with No. 2 vein, which at higher altitudes has a steeper dip and lies to the northeast and above it. At the junction of the two branches there is a mass of calcite with considerable disseminated pyrite. Below the junction the vein bulges to 3 feet in thickness and carries narrow bands mineralized predominantly with pyrite but with a little associated galena. About 35 feet vertically below the junction the vein splits into stringers; the one on the hanging wall is heavily mineralized with pyrite. The vein extends down nearly to the foot of the glacier, at an altitude of about 3,440 feet, and is from 1 to 2 feet in width locally, with included stringers of country rock. Sparse small pockets in the vein are mineralized with stringers and disseminations of pyrite.

No. 2 vein is exposed in an open cut on the slope above the glacier at an altitude of 3,900 feet. It is in graywacke, strikes N. 30° W., and dips 65° NE. The vein is stripped for 25 feet above the open cut, is about 20 inches wide, and contains many small lenses or stringers of solid sulphide averaging 6 inches in thickness. Galena predominates, with a little associated pyrite and chalcopyrite. Beneath the open cut the vein is sparsely mineralized and passes across an aplite dike, where it splits into a number of stringers through a width of 3½ feet and forms one-half to three-fourths of the total volume. The vein then passes through about 10 feet of graywacke, becoming smaller in depth, to a porphyry dike. Only a half-inch stringer enters the dike, but about 12 feet below the dike quartz begins to come in again, and 25 feet below there is 2 feet of milky quartz with a little chlorite and a few pockets sparsely mineralized with pyrite and a trace of chalcopyrite. The vein is covered below this along the strike of the band where No. 1 vein develops a mineralized shoot. No. 2 vein is 8 to 10 inches thick in the graywacke just above the contact with the Texas Creek quartz diorite. It is offset by the same fault that offsets No. 1 at the contact of the graywacke and Texas Creek batholith. In the Texas Creek quartz diorite the vein ranges from several inches to a foot in width and is practically barren.

No. 3 quartz vein occurs in the Texas Creek quartz diorite and is poorly exposed. It is connected by a narrow stringer with No. 1 vein at an altitude of about 3,480 feet and dips 60° NE. near its junction. About 300 feet in altitude above the junction the vein is about 50 feet from No. 2 vein, strikes N. 50° W. and dips 80° NE., is 2 to 3 feet wide, and at one spot contains a 1½-foot shoot mineralized with stringers of galena and pyrite. This vein was not traced upward into the graywacke.

About 50 yards east of the water in the gulch below the west glacier, at an altitude of 3,100 feet, a vein of quartz 9 inches to 2½ feet in width is exposed. It strikes N. 30° W., dips 55° E., and extends up the hillside for probably several hundred feet. It is barren except for small local patches with disseminated pyrite.

On the edge of the bluff face above the west glacier, at an altitude of 4,000 feet, a vein in graywacke is exposed for a length of 50 feet by stripping and an open cut. The graywacke beds strike N. 75° E. and dip 50°–60° S.; the vein strikes N. 10° W. and dips 40° E. The vein is 20 to 27 inches thick and consists of quartz with bands moderately to heavily mineralized with galena, pyrite, chalcopyrite, sphalerite, and a little pyrrhotite. These sulphides occur in widely varying ratios to each other. Some ankerite and a little barite are present in a few of the adjacent quartz stringers.

Several veins are exposed along the ridge just west of the west glacier. In the first gulch west of the glacier, at an altitude of 3,560 feet, there is a fissured zone several feet thick in the Texas quartz diorite, with several small stringers and a quartz vein 8 inches to a foot thick exposed for a length of 150 feet. The vein strikes N. 50° W. and dips 45° NE. It consists of quartz with a little chlorite and calcite, seams of pyrite, and rarely a little galena. The walls of the vein are impregnated with pyrite and weather to a rusty color. At an altitude of 3,700 feet in the same gulch a quartz vein in the Texas Creek quartz diorite has been traced for 50 feet by several small strippings. A band several inches thick along one wall is heavily mineralized with sulphides, predominantly galena, with some associated pyrite and a little sphalerite and chalcopyrite. Pyrite appears to predominate in the vein as a whole. A little tetrahedrite is also found.

A short distance west of the west glacier, at an altitude of 4,420 feet, a vein in graywacke is exposed for 30 feet. The deposit consists of a fissured zone that contains stringers of quartz and a vein 3 to 10 inches wide; it strikes N. 40° W. and dips 40°–50° E. Some of the stringers consist of quartz with chlorite and calcite. Seams of pyrite and small shoots of solid sulphides, comprising galena, sphalerite, pyrite, and chalcopyrite, occur in the vein. Several hundred feet higher, just at the edge of an ice-filled gulch there is another fissured zone 3 to 6 feet wide in graywacke, with stringers of quartz from a fraction of an inch to a foot wide. The quartz is in part heavily mineralized with galena and pyrite. The veins are exposed for only a short length, as they pass under the ice in one direction and pinch out in the other.

A boulder of graywacke with narrow stringers of quartz carrying visible flakes of free gold was found by Mr. Hummel at the foot of the west glacier, but the place from which it came has not been located.

KENO

The Keno group comprises 10 claims on the west side of Ferguson Glacier, at an altitude of 3,800 feet, about 1½ miles south of the foot of the glacier. They were staked in 1923. An adit 50 feet in length has been driven along a quartz vein in Texas Creek granodiorite. This vein strikes N. 42° W. and dips 70°–80° NE. It ranges in width from several inches to 4½ feet, but the average is from 3 to 4 feet. It has been traced by trenches and natural exposures for a length of 400 feet and a difference in altitude of 300 feet. The vein appears to be offset by faulting at its northwest end, just before it passes beneath a glacier. At the surface one shoot of almost solid sulphide 25 feet long and as much as 7 inches wide occurs in the vein, usually in its center. Other similar shoots are present. Except for these sulphide shoots, the quartz normally carries only a little disseminated cubical pyrite, with locally some disseminated barite. The sulphide shoots consist predominantly of galena but contain also a little pyrite, chalcopyrite, sphalerite, and tetrahedrite. The adit has not reached the point below the sulphide shoot that is exposed at the surface.

JUNEAU

The Juneau group comprises two claims at an altitude of 4,100 feet, about half a mile northwest of the Sunset group. These claims were staked by a man named Murphy. A large quartz vein in the Texas Creek granodiorite ranges from 3 to 6 feet in width and is reported to have been traced by interrupted outcrops for 1,300 feet.

The quartz is predominantly milky white, with limonite facing the fractures and rarely a little stain of malachite. Locally there are small shoots heavily mineralized with chalcopyrite. The vein strikes N. 40° W. and dips 50° NE. A quartz vein mineralized with galena and pyrite is also reported to crop out on these claims.

SUNSET

The Sunset group comprises two claims on the east side of Ferguson Glacier 2½ miles from its foot, at an altitude of about 5,100 to 5,200 feet. They were staked by Murphy & Stevens. Two mineralized quartz veins are exposed here in the Texas Creek granodiorite, near an isolated roof pendant of argillite and graywacke. Both veins strike about N. 50° W. and dip steeply to the northeast. Only a little surface stripping has been done.

The upper vein appears to be exposed at three different places and is thus traceable for a length of about 300 yards. At the southeast end there is a quartz vein a foot wide exposed for 10 yards, with local shoots moderately mineralized with galena and pyrite. Northwest of this, at the second exposure, a quartz vein has been uncovered by surface stripping for 10 yards. The vein ranges in width from 1 foot at the southeast end to 3 feet at the northwest. On the footwall or in the center there is 6 inches of the quartz heavily mineralized with galena and pyrite, and several inches on the hanging wall is similarly mineralized. Galena predominates. At the northwest exposure there is a shattered zone in the Texas Creek granodiorite 20 feet in width, about one-fourth of which consists of stringers of milky quartz. At the southeast end of this zone there are quartz stringers moderately mineralized with galena and pyrite.

The lower vein is 3½ feet wide in one place and averages about 3 feet. It can be traced by interrupted outcrops for 200 yards. Most of the vein is barren quartz with locally disseminated cubic crystals of pyrite. One lens of pyrite and galena 12 feet long and 4 inches wide was observed. Considerable barite is locally associated with the galena.

ENGINEER

The Engineer group comprises five claims on the east side of Ferguson Glacier about a mile from its foot, at an altitude of 4,000 feet. They were staked by Dominick Bervaqua in 1924.

The vein is in the Texas Creek granodiorite, with included blocks of sediment very near the contact of the batholith with the argillite and fine-grained graywacke. It strikes N. 30°–40° W., dips 60°–75° NE., and is exposed by a series of surface strippings for a length of 75 yards and a difference in altitude of 200 feet. The vein ranges from 1 foot to 4½ feet in width but is generally from 2 to 4 feet. It consists of quartz with local shoots moderately to heavily mineralized with sulphides. An adit 30 feet long has been driven on the vein. In this adit the quartz is sparsely mineralized with blebs of chalcopyrite, cubic crystals of pyrite, little pockets of galena, and rare grains of scheelite. The walls are slickensided. About 20 feet above the adit, in an open cut, the vein is 3 feet wide. A foot of the hanging wall is heavily mineralized with pyrite and galena and a little chalcopyrite, and the remainder of the vein is sparsely mineralized with pyrite cubes and chalcopyrite blebs. The heavily mineralized shoot is short and passes into quartz moderately mineralized with pyrite and chalcopyrite along both the dip and the strike. The hanging wall here is an included block of graywacke that appears like greenstone. An open cut 40 feet above the adit exposes a fissured zone in the granodiorite 10 feet wide, with the main quartz vein near the footwall and occasional quartz stringers in the upper part. In the hanging-wall part of the main quartz vein there is a small shoot 5 inches wide and 5 feet long that consists of chalcopyrite and pyrite.

At an altitude of 150 to 170 feet above the adit a good ore shoot has been revealed by two strippings. The northwestern stripping exposes the vein for a length of 25 feet, where it has an average width of about 3½ feet and contains a shoot 1 to 4 feet wide, heavily mineralized with galena and pyrite. To the southeast about 18 feet of the vein is covered, and then another 35 feet is exposed by stripping. The vein here ranges from 2 to 4 feet in width, and the mineralized shoot from 1 foot to 2½ feet. The sulphides are galena and pyrite in about equal amounts. The wall rock of this part of the vein is a block of graywacke included in the Texas Creek granodiorite.

Assays of seven specimens from the mineralized shoots show gold to range from 0.04 to 0.64 ounce ($0.80 to $12.80) to the ton, silver from 7.6 to 26 ounces to the ton, and lead from 11.3 to 55.3 per cent.

NORTH STAR

The North Star claim lies at an altitude of 3,850 feet, southeast of the foot of Ferguson Glacier. It was staked by Dominick Bervaqua, The vein is a fissure vein in graywacke. It strikes N. 40° W. and dips 70° E. The graywacke strikes N. 60° E. and has a vertical dip. The vein is only about 50 yards, measured on the surface, from the contact of the graywacke and Texas Creek granodiorite. It is 1 foot to 2½ feet wide, is exposed for a length of 50 feet, and consists of quartz with local shoots of galena and a little associated pyrite.

JUMBO MINING

The Jumbo mining group comprises six claims on the south slope of the West Fork of Texas Creek, between altitudes of 3,500 and 4,000 feet, about halfway between Casey and Ferguson Glaciers. The claims were staked by Kennedy & Provinse in 1925. The country rock is graywacke, which forms a downward-projecting tongue into the granodiorite of the Texas Creek batholith. The strike of the beds is N. 85° E. and the dip is vertical. The contact with the batholith at the lowest points is at an altitude between 3,000 and 3,200 feet. Mineralization has occurred along a shear zone striking N. 30° E. and dipping 75° E., which extends between altitudes of 3,100 and 4,100 feet. The vein consists of a breccia of graywacke with quartz stringers ranging from 1 foot to 3½ feet in width. These stringers, which carry the greater part of the sulphides, range from 1 inch to 2 feet in width and are well mineralized locally, though no seams of solid sulphide more than 2 inches wide were observed. The graywacke in the shear zone is impregnated with pyrite and a little chalcopyrite. The sulphides of the vein are mainly galena, pyrite, and chalcopyrite. They are not continuous but occur in local shoots. The vein follows the general trend of an aplite dike.

Another narrow fissured zone strikes into the larger zone. It trends north and dips 75°-80° E., is 10 inches wide, and has 6 inches of quartz mineralized with galena, pyrite, and a little chalcopyrite and sphalerite.

COMMONWEALTH

The Commonwealth group is about 14 miles in a straight line southwest of Hyder, on a creek about 3 miles north of Cascade Creek, west of Round Point, on Portland Canal. The prospects lie within a narrow belt of limestone and schist included in the quartz monzonite of the Coast Range batholith. The metamorphosed sediments are several hundred feet thick and include interbedded quartzite, dark-gray micaceous schist, and impure crystalline limestone. The belt is exposed in a gulch about a mile up the creek from the coast. A narrow dike of mica lamprophyre is exposed at several places in the gulch; it cuts both the quartz monzonite and the crystalline schist series. At an altitude of 580 feet an adit has been driven on this dike for 80 feet, the intention being to crosscut and sample the walls for evidences of mineralization in the schist. The dike is in quartz monzonite at the portal, but crosses into the schist a short distance within the adit. It strikes N. 30° E. and has an average width of 6 to 7 feet. The walls of the dike at the inner end of the adit consist of micaceous schist and masses of epidote of contact-metamorphic origin. Above the adit a thick bed of quartzite with disseminated pyrrhotite is exposed, dipping about 40° NE. Between the quartz monzonite and the quartzite there is a pocket-shaped aggregate of quartz, garnet, and epidote. On the west side of the gulch a pegmatite dike lies along the footwall of the extension of this mass. At one locality west of this gulch seams of sphalerite occur in an epidotic rock. The limestone contains nodules of pyroxene, much disseminated tremolite, some quartz, and seams, masses, and disseminations of pyrrhotite. An 11-foot adit was driven in the limestone on the east side of the gulch and exposed a small stringer of quartz reported to yield gold. A dike of mica lamprophyre is again exposed in the gulch at an altitude of about 860 feet, where an open cut has been made along it. The rocks of this belt of schist and limestone have been metamorphosed by the intrusive quartz monzonite; the garnet-quartz-epidote masses are typical of such metamorphism. Weathered pyrrhotite gives the rusty color to the surface outcrop. Molybdenite and seams and disseminated deposits of sphalerite and sparse chalcopyrite occur locally. No mineralized shoot of any size has been found, and extensive underground workings here appear wholly unwarranted unless something more promising can be discovered by surface prospecting.

GEOLOGIC RECONNAISSANCE ALONG CHICKAMIN RIVER

The writer is indebted to his assistant, W. B. Jewell, for the data on which the following report on the geology and topography along Chickamin River is based.

GEOGRAPHY

Chickamin River is one of the larger rivers of southeastern Alaska. It flows from Chickamin Glacier, which lies about 30 miles from the coast, and empties into Behm Canal about 16 miles south of Unuk River and 70 miles north of Dixon Entrance. Leduc River and Chickamin South Fork, its two main tributaries, join it a few miles above its mouth. The small bay into which the river flows is being gradually filled with sand and silt brought down by it. (See pl. 3.)

The main valley of Chickamin River is broad and flat. The river flows in a braided channel with numerous rapids, sloughs, and shifting sandbars. It is subject to sudden floods, and log jams are common. The river is navigable with a small boat and outboard motor for about 25 miles, from Behm Canal up to the foot of its canyon, but only with great difficulty and through the exercise of exceptional skill. The canyon is about 12 miles below the foot of Chickamin

Glacier; it is about a mile long and has a maximum depth of 50 feet. The river boils through it in a series of small falls and rapids. This canyon is the result of the river being forced against the steep southeast wall of the valley by a great rock slide from the mountain on the northwest.

A foot trail was built by the United States Forest Service in 1923 from the lower end of the canyon 13 miles to the foot of Chickamin Glacier, but it is now overgrown with tall ferns and bushes. Landslides, windfalls, and brush have made it impassable in places. Tripods have been erected on Chickamin Glacier to mark the best route to the West Fork of Texas Creek, but many of them fall after a short time. In 1924 the Forest Service built two stretches of foot trail, about 2 miles apart and each about 3 miles in length, starting from a cable crossing over Leduc River about 1½ miles above its junction with the Chickamin. There is a Government cabin at the foot of the canyon and another at the foot of Chickamin Glacier.

The flats in the lower valley of Chickamin River are heavily timbered with tall spruce trees 3 and 4 feet in diameter. A few hemlocks and cottonwoods are present, together with the usual jungle-like underbrush of devil's-club, blueberry, salmonberry, and willow. In protected areas, where the slopes are not too steep, the forests extend continuously up to altitudes of 3,000 feet and over. The valleys of the tributary creeks are all heavily forested. The river flat above the canyon is covered with dense underbrush but with very few trees, chiefly cottonwoods, some of which are 1 foot in diameter. The slopes of the upper part of the valley are covered in protected places as high as 3,500 feet with large hemlock and spruce trees and scattered cedars.

The topography along the entire length of Chickamin River is extremely rugged. (See pl. 10, *B*.) The mountains rise abruptly above the valley floor to heights of 4,000 to 7,000 feet. Practically all these mountains up to 6,000 feet are well rounded, but those over 7,000 feet in altitude are serrate. There are no long, continuous ridges; the rounded peaks are separated by steep-walled valleys. Many of the higher peaks are covered with fields of snow or ice. The slopes up to 3,000 feet in altitude are everywhere extremely steep, at some places 50° or more. Some of them are bare of vegetation and have been grooved and fluted by ice action. Along the sides of the main valley are many U-shaped hanging valleys, from each of which pours a creek in a series of falls and rapids that may have an aggregate drop of as much as 1,000 feet. Steep cones of rock débris and snow are found at the mouths of many of the gulches.

Chickamin Glacier heads against glaciers that flow toward Nass River. It flows slightly west of south to a point near the head of the West Fork of Texas Creek, where it turns sharply toward the northwest. A large tributary, Through Glacier, joins Chickamin Glacier from the south-southwest at this turn. Through Glacier is fed by many tributary glaciers and is continuous across a divide (see pl. 14, *B*) with a glacier that flows for 15 or 20 miles to the southwest.

A broad terminal moraine 30 feet high extends across the valley 4,600 feet downstream from the present front of Chickamin Glacier. (See pl. 14, *A*.) This moraine is now covered with alders several feet high. Robert Andrews, of Hyder, states that in 1902 the glacier stood within a very few feet of the moraine. Malcolm Smith reports that the glacier retreated 600 feet between 1923 and 1925.

GEOLOGY

GENERAL FEATURES

The Chickamin River Valley cuts completely across the great Coast Range batholith. On the southwest flank of the batholith for 2 miles up the valley from Behm Canal the rocks consist of crystalline schist and injection gneiss with sparse intercalated beds of marble. These rocks may be grouped together under the general term "metamorphic complex," as they represent sedimentary beds which have been recrystallized under stress and have in part been injected with aplite and pegmatite veins given off by the underlying Coast Range batholith. The beds may belong to the Prince Rupert formation (Carboniferous or Triassic) as mapped by Dolmage [30] to the south in British Columbia, but this assignment is far from certain. On the northeast flank of the batholith, along Chickamin Glacier and 3½ miles below its foot, the rocks consist of tuffaceous graywacke with intercalated slate and quartzitic beds that probably belong to the upper division of the Hazelton group. The Coast Range batholith, between the metamorphic complex on the southwest and the little-altered beds of the Hazelton group on the northeast, has a width in this area of about 30 miles. The batholith comprises a narrow band of quartz diorite on the southwest, a broad belt of granodiorite in the core, and a broad belt of quartz monzonite on the northeast. Throughout the batholith there are varying amounts of crystalline schist, the inclusions ranging in size from small shreds to large blocks several miles long. Near the included fragments pegmatite and aplite dikes are common, and there are all gradations between clean intrusive rock and crystalline schist. A series of dikes of dark fine-grained lamprophyre of the

[30] Dolmage, Victor, Coast and islands of British Columbia between Douglas Channel and the Alaskan boundary: Canada Geol. Survey Summary Rept. for 1922, pt. A, pp. 9–34, 1923.

variety spessartite cut all the other rocks throughout the length of the valley and have a remarkably uniform northeast strike.

On Portland Canal, to the southeast, quartz diorite forms the southwest border of the batholith and quartz monzonite the northeast border; but the core of the batholith there consists of granodiorite interbanded on a broad scale with quartz monzonite and a little quartz diorite. Along Stikine River, to the northwest, as on Chickamin River, quartz diorite forms the southwest border of the batholith, granodiorite the core, and quartz monzonite the northeast border. The occurrence of quartz diorite 5 to 15 miles wide in the southwest border of the batholith, of granodiorite 15 to 25 miles wide in the core, and quartz monzonite 8 to 15 miles wide in the northeast border portion therefore seems to be a general relation through at least 150 miles of the length of the batholith.

Westgate [31] states that the batholith is not a simple body resulting from a single intrusion but a "composite batholith" that consists of materials of different composition intruded in two or more distinct stages of an eruptive period. On the southwest border, in the vicinity of Behm Canal, he reports the series to consist of

> (1) an earlier darker gneissoid diorite, more contorted and rustier in outcrop than the later rock, and (2) a light or dark gray gneissoid diorite, often banded and contorted but even then appearing massive in the ledge, which is by far the most abundant type. * * * The transition from one variety to the other is sometimes through a belt of several hundred feet. On one side we have the later diorite; then isolated masses of the earlier rock, which become more and more abundant until they make a breccia cemented by intersecting veinlike bands of the later rock; then these bands die out and there is the continuous mass of the older rock.

The rock referred to by Westgate as diorite is described by him elsewhere more specifically as quartz diorite.

The writer has not seen such definite evidences of successive intrusions within the Coast Range batholith as those described by Westgate, but he has no doubt that the batholith is composite and that there were successive intrusions of magma.

METAMORPHIC COMPLEX

The belt of the metamorphic complex adjacent to Behm Canal consists principally of hornblende-quartz-biotite schist with sparse beds of marble. Locally the rocks have been converted into injection gneiss by the intrusion of abundant veinlets of pegmatite, aplite, and glassy quartz. The rocks weather a reddish brown. The foliation strikes generally N. 35°–45° W. and dips steeply, though variably, to the northeast. The innumerable pegmatite dikes that cut the

[31] Westgate, L. G., The geology and mineral resources of the area east of Behm Canal (unpublished manuscript).

schist are composed of quartz, hornblende or biotite, and feldspar. The feldspar includes both oligoclase and potassic varieties. Biotite flakes as much as 3 inches in diameter and hornblende crystals as much as 2½ inches long are common. Biotite is much more abundant than hornblende. Garnets are plentiful in some parts of the schist.

A large block of schist nearly 2 miles wide and 4 miles long occurs within the quartz monzonite near the canyon. It makes up most of the mass of the mountain 4,000 feet in altitude just north of the river and extends across the river. It is sparsely mineralized locally with the iron sulphides, pyrite and pyrrhotite. This large block has a north-south trend. It is not so intensely altered as the rock of the metamorphic complex on the southwest, and the bedding is quite apparent on the top of the mountain.

Along Behm Canal the metamorphic complex includes also quartzitic beds, amphibolite, and calcareous schist.

COAST RANGE INTRUSIVES

On the southwest border of the batholith the contact between the quartz diorite and the schist is a zone more than a mile wide rather than a sharply defined line. In this contact zone the amount of intrusive material increases toward the northeast and the schist inclusions become fewer and fewer. The belt of quartz diorite is 2 to 3 miles wide. The number of samples collected here was not sufficient to afford data on the average composition of the belt; for this reason the average composition of quartz diorite, as given in the table on page 118, is that of samples from the western portion of the Coast Range batholith along Stikine River, where the rock is similar to that on Chickamin River. Locally the percentage of quartz varies; it may be as much as 30 per cent. Hornblende may be practically absent. The plagioclase is usually andesine, locally oligoclase, and ranges from 50 to 65 per cent. The potassic feldspars range from 1 to 8 per cent and include microperthite, microcline, and orthoclase. The orthoclase is usually minor. The accessories include magnetite, apatite, titanite, and a trace of zircon. The biotite and hornblende occur usually in practically equal abundance.

The core of the batholith in the vicinity of Chickamin River is composed of granodiorite, which forms a belt 13 to 14 miles wide from the quartz diorite northeast to a line about 4 miles below the mouth of Indian Creek. Throughout this belt there are large areas of rock that shows a marked gneissic structure and banding and in part resembles injection gneiss. This structure has probably resulted from the partial or complete disintegration and assimilation of belts of schist by the intrusive magmas and pegmatitic solutions. Small inclusions of schist are abundant. Some of the larger inclusions are altered to great masses of garnet and epidote, locally with disseminated pyrite and pyrrhotite. Locally the granodiorite gives place to quartz diorite, but these areas of quartz diorite are generally small, and many of them are in the vicinity of schist inclusions. Some of the gneiss resulting from the interaction between the granodiorite magma and the schist has the composition of quartz diorite. The average mineral composition of the granodiorite, as determined by Rosiwal analyses on specimens from 10 different localities, is given in the table as No. 2. The potassic feldspars include microcline, microperthite, and orthoclase, but the orthoclase is relatively sparse. The accessory minerals comprise magnetite, titanite, and apatite. The plagioclase is predominantly andesine, commonly of a sodic variety.

The northeastern part of the batholith from a line about 4 miles below Indian Creek to the eastern contact, a distance at right angles to the banding of 8 to 14 miles, is composed of practically massive medium-grained quartz monzonite very similar to that near Hyder. The average mineral composition, as determined by Rosiwal analyses on specimens from eight different localities along the river, is given in the table as No. 3. The plagioclase in the quartz monzonite is oligoclase. The potassic feldspar includes microcline, microperthite, and subordinate orthoclase. The accessories include magnetite, titanite, and apatite. Schist inclusions and pegmatite stringers occur, but they are relatively sparse aside from the large block of schist near the canyon referred to above.

The average composition of two specimens of pegmatite is given in the table as No. 4. These pegmatites occur within the core of granodiorite and grade into coarse-grained masses resembling the quartz monzonite of the adjacent belt on the east.

It seems probable that the quartz monzonite is a later intrusion than the granodiorite, though belonging to the same magmatic epoch. No positive evidences of intrusive relations were seen, however, though in a hurried reconnaissance they might easily be overlooked.

The lamprophyre dikes cut the batholithic intrusions. They are fresh in appearance, black to dark greenish, and brittle. Under the microscope they are found to consist usually of needles of brown hornblende and very sparse biotite in a dense microcrystalline aggregate of highly altered plagioclase with small amounts of potassic feldspar and interstitial quartz. They usually contain also abundant grains of well-crystallized magnetite. The plagioclase is largely andesine, with small amounts of labradorite. The hornblende generally forms from 20 to 30 per cent of the rock and is extensively altered to chlorite. The plagioclase is much altered to sericite and carbonates. All the lamprophyre dikes examined were of the variety spessartite except one, which contained abundant biotite and only sparse brown hornblende. The dikes are relatively narrow, few being more than 4 to 6 feet wide, and they have a remarkably uniform strike. Of the many observed only one had a strike that varied much from N. 50° E.

Mineral composition of Coast Range intrusives along Chickamin River

	Andesine	Oligoclase	Potassic feldspars	Quartz	Hornblende	Biotite	Accessory minerals
1. Average of 5 specimens of quartz diorite from western part of batholith along Stikine River	61	--------	2	18.5	11	6.5	1
2. Average of 10 specimens of granodiorite from core of batholith along Chickamin River	50	--------	14	21	5	9	1
3. Average of 8 specimens of quartz monzonite from eastern part of batholith along Chickamin River	--------	37	33	24	.2	4.3	1.5
4. Average of 2 specimens of pegmatite in granodiorite along Chickamin River	--------	26.5	25.5	45	--------	3	Trace.

STRUCTURE

The prevailing trend of the Coast Range batholith is northwest. Along Chickamin River, especially in its lower portions, the foliation of the metamorphic complex in the main belt and in the larger inclusions has a strike that ranges from N. 5° W. to N. 50° W. with an average of N. 30° W.; its dip, though variable, is generally about 50° NE. The northeast dip is also common to the foliation of the Coast Range batholith itself.

On the northeast flank of the batholith the contact of the quartz monzonite with the graywacke is irregular and crosses more than it parallels the strike of the strata. A large block of graywacke forms a deep reentrant into the east border of the batholith along Chickamin Valley, forming Banded Mountain and extending to a point about 3½ miles below the terminus of Chickamin Glacier. The beds in this block strike predominantly N. 60°–90° W. Close to the contact the dips are vertical; farther away they are southwest.

The rocks of the Coast Range batholith, especially on the southwest, have a gneissoid structure. The character of this structure is such as to suggest either that it has arisen from flow in the yet unconsolidated magma and is primary or that it is due to inheritance from reaction with schist inclusions. The texture of the rock is the result of crystallization on cooling and not of dynamic action. The quartz monzonite shows only a slight gneissic structure and much less abundant inclusions of schist. No evidence of crushing of the mineral grains of the intrusive rock was seen under the microscope. The quartz and locally some of the feldspar show strain shadows, but that is all.

The beds must have been folded in part before the intrusion of the Coast Range magmas, which appear to have in part penetrated the earlier rocks along these structural planes. On the southwest the magmatic residual solutions permeated and very intimately injected the beds and, aided by the intense heat, changed them to crystalline schist and injection gneiss. On the northeast, although the intrusion of the magma appears to have been guided by the older structure of the beds, in the Hyder district at least the contact line shows the effect of block fracturing rather than penetration along bedding or foliation planes.

METAMORPHISM

On the southwest border of the Coast Range batholith in the latitude of Chickamin River there is a belt 35 miles wide, measured at right angles to the strike, composed of crystalline schist and phyllite with numerous bodies of intrusive quartz diorite. On the northeast side of the batholith, however, the area of metamorphosed rocks is relatively small and the metamorphism is of the local contact type. The beds of the Hazelton group adjacent to the quartz monzonite have locally been mashed, or more commonly foliated and recrystallized, but for only a few hundred feet from the contact in many places and rarely for more than a quarter of a mile; though slight crinkling, pencil structure, or intensification of slaty cleavage may extend to greater distances.

The Wrights [32] have ascribed the greater metamorphism on the southwest to deeper burial at the time of the intrusion of the igneous masses. Schofield [33] thinks that the difference is due to the shape of the batholith—its vertical relations to the country rock—combined with a subsequent tilting of the Coast Range block. The writer is of the opinion that the great belt of metamorphic complex on the southwest is due to contact metamorphism on a regional scale consequent upon the proximity of the Coast Range batholith, which must everywhere underlie it at no great depth, as indicated by the abundant protrusions or cupolas of igneous rock that are exposed at the present surface. The contact on the northeast side may, on the other hand, be approximately vertical, as Schofield suggests, and therefore plunge down so abruptly that the zone of metamorphism is very narrow. The zone of metamorphism is similarly narrow north of Juneau, where the west border of the Coast Range batholith is doubtless very steep. There seems to be no necessity for assuming

[32] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, pp. 67–68, 1908.

[33] Schofield, S. J., and Hanson, George, op. cit., pp. 65–66.

a tilting of the Coast Range block to explain the phenomena. The moderate metamorphism of the block of schist near the canyon of Chickamin River and of a similar block of country rock along Iskut River, both within the core of the batholith, in contrast to the extreme metamorphism of the belt of country rock on the southwest border of the batholith, however, is not satisfactorily explained by any of the suggestions made.

MINERALIZATION

A few of the glassy quartz veins near the contact of the Coast Range batholith with the metamorphic complex on the southwest contain small amounts of pyrite and molybdenite. Low yields in gold are also reported from them. About 2½ miles up the South Fork, above its junction with Chickamin River, there is a large shear zone approximately 100 feet wide. It strikes N. 50° W. and dips 50° NE. This zone is mineralized with narrow veinlets of solid pyrite, and examination with the microscope revealed small amounts of chalcopyrite and magnetite. The rock of this zone weathers to a rusty color by which it can be traced for miles across the country, with a difference in altitude of at least 4,000 feet. In certain bands of the metamorphic complex within the batholith there are disseminated sulphides consisting of pyrite, pyrrhotite, and chalcopyrite, but nothing of apparent value has been found within them. If prospecting is carried further, however, the schist blocks and their vicinity and the shear zone should be examined.

PROSPECTS

GNAT

Four miles from Behm Canal, on the north side of the river, there is a glassy quartz vein averaging 8 feet in width in the granodiorite. It strikes N. 30° W. and dips 60° NE. The vein is slightly mineralized with pyrite and molybdenite on the hanging wall. The claim is reported to have been staked in 1900, but no work has been done on it.

GLACIER

The Glacier group consists of seven claims on the north side of Banded Mountain, at the foot of Chickamin Glacier, at an altitude of 1,200 feet. They were located in 1923 by Andrews & Schonburg, of Hyder. The deposit consists of numerous narrow quartz veins ranging from 2 inches to a foot in width, in graywacke, with some andesitic tuff and breccia. Bands of barren country rock usually intervene between adjacent veins, which may be several feet apart. The veins are heavily mineralized with coarsely crystallized pyrite and small amounts of pyrrhotite, chalcopyrite, and very rarely galena. Most of the veins seem to occupy two main sets of cross fissures; one set strikes N. 50° E. and dips 45° SE., the other strikes N. 20° W. and dips 45° NE. The beds strike east and dip 60° S. The veins are cut by a dike of lamprophyre 3 to 4 feet wide. The development work consists of 25 feet of stripping and 8 feet of tunnel. There is a log cabin on the property. Assays have shown 80 cents in gold and 6 ounces of silver to the ton and 3 per cent of copper.

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