BRITISH COLUMBIA
DEPARTMENT OF MINES AND PETROLEUM RESOURCES

BULLETIN No. 58

GEOLOGY
and
MINERAL DEPOSITS
of the
STEWART AREA
Northwestern British Columbia

by
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1971

Ore train from Porter Idaho, Ryan Glacier, 1930.

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ABSTRACT

The Stewart map-area, one of the major metal-mining districts in western Canada, located 100 miles north of Prince Rupert, covers an area of about 220 square miles in the Boundary Ranges in northwestern British Columbia. It lies within a terrain of Mesozoic rocks across the contact between plutonic rocks of the Coast Crystalline Belt and the west-central portion of the Bowser Basin. The purpose of this study was to determine the lithological and structural relationships of these rocks to the younger mineral deposits and to obtain background information essential to the study of the Stewart Complex.

The oldest Mesozoic rocks in the district are non-marine Hazelton volcanic epiclastics and sedimentary strata that constitute part of a thick-layered Lower Jurassic succession. This succession is overlain by predominantly marine sedimentary Bowser strata of Middle to Upper Jurassic age. The two assemblages are separated by lower Bowser rhyolite flows, limestones, littoral materials, and red beds which mark the onset of basin subsidence and rapid, dominantly marine sedimentation.

A variety of intrusive rocks comprising part of the Coast Crystalline Belt cuts all the layered rocks of the district. Individual plutons range in composition from augite diorite to quartz monzonite and in size from discrete dykes and stocks to extensive batholiths. Plutons of the Coast Crystalline Belt have been shown to represent at least two episodes of intrusion in the Stewart area. One is represented by the Mesozoic Texas Creek granodiorite and the second by the Tertiary Hyder quartz monzonite. The dyke swarms, which have been divided into four textural and compositional groups, represent the latest phases of igneous activity in the area.

The Mesozoic rocks are folded along arcuate northerly trending nearly horizontal axes. The major fold involving Hazelton rocks is an upright, broad anticline upon which Bowser rocks are preserved as structural remnants. The major fold in the Bowser rocks is an upright, canoe-shaped syncline that bisects the map-area. The majority of minor folds and the cogenetic lineations in the Hazelton rocks are nearly at right angles to the major structure. Minor folds in the Bowser rocks include styles varying from simple to complex or confused, which express deformation resulting from gravity sliding and from extensive igneous intrusion.

Cataclasites form extensive northerly trending zones cutting Hazelton volcanic epiclastics. The major Cascade Creek zone has been intruded and altered by igneous material and extensively mineralized. Numerous extensive fractures which cut all the country rocks and major structures have been grouped into four major systems along which most of the known vein deposits have been localized. The mechanical competency of the lithologic units has been examined in terms of structural studies and certain volcanic conglomerates have been shown most favourable to deformation, alteration, and mineralization.

More than 50 properties in the Stewart district produced in excess of 5.6 million tons of gold-silver-lead-zinc ore between 1910 and 1968. Of this total the Silbak Premier mine alone produced over 4.7 million tons and paid in excess of $21 million in dividends. In addition there are at least 100 more known mineral deposits which have not been mined.

The mineral deposits are mainly simple quartz-breccia veins and transitional vein-replacement systems which contain irregular lenses and shoots of sulphide mineralization. The primary sulphide minerals are pyrite, galena, and sphalerite, with accessory gold and silver minerals. Native silver, electrum, and gold are locally important and contributed significantly to mine production. The veins and vein systems form three well-defined groups related to well-defined fracture systems in both Hazelton and Bowser rocks.

Wallrock alteration related to the mineral deposits includes simple silicification, carbonatization, and pyritization, as well as examples of propylitization, hornblendization, and potassium feldspar alteration. Country rock alteration patterns are generally simple and relate to igneous intrusion and low-grade deformation coupled with crystalloblastesis, as well as to the mechanical nature of the materials involved. Variable induration, silicification, pyritization, hornblendization, and potassium feldspar alteration are common contact and shear-zone effects. Evidence for regional metamorphism is slight and consists of rare, sporadic fine-grained andalusite developed in certain Bowser siltstone units, as well as extensive medium-grained hornblende developed in Hazelton volcanic conglomerates spatially unrelated to known or visible plutons. This suggests a lower amphibolite facies environment but may imply selective metasomatism.

This study of the Stewart area has revealed in part the complex interplay between elements of the Coast Crystalline Belt and the Bowser Basin and the relationship of mineral deposits to specific structural and lithological situations in that environment.

GEOLOGY AND MINERAL DEPOSITS OF THE STEWART AREA, NORTHWESTERN BRITISH COLUMBIA

CHAPTER 1

"To the eyes of the men of imagination, Nature is imagination itself."
—*William Blake.*

Introduction

The Stewart map-area is at the head of Portland Canal, a fjord 70 miles long, which marks the boundary between the southeastern extremity of the Alaska panhandle and northwestern British Columbia. The communities of Stewart, British Columbia, and adjacent Hyder, Alaska, which serve the area, are at present reached by boat or plane, and will in future be linked to the Interior of British Columbia by the Stewart–Cassiar and Alaska highways. The area of this report includes about 220 square miles of rugged country which lies geologically and geographically near the eastern margin of the Coast Mountains. Bear River Ridge forms the backbone of the map-area, and separates the Bear and Salmon Rivers, which flow south along its flanks into the head of Portland Canal. Both the Salmon and Bear Rivers have large valley glaciers as their source. Ice and snow are conspicuous in the area and important in terms of access.

Geologically, the map-area lies adjacent to the east margin of the Coast Crystalline Belt near the northern end of the Stewart Complex, a deformed belt of volcanic, sedimentary, and metamorphic rocks which lies along the west edge of the Bowser Basin. The Complex, which extends from Alice Arm on the south to the Iskut River on the north, includes major northerly trending structures which are complicated by complex plutonism and partly obscured by the extensive ice, snow, and rock debris. The tectonic situation of this lithologic complex and the Stewart map-area are illustrated on Figure 1. Regionally, the Stewart Complex dips east under the main bulk of thick marine Bowser assemblage sediments and forms an integral part of the Bowser Basin. The western contact of the Stewart Complex is largely delineated by the contact of the Coast Range Intrusives, while the eastern limits are marked by the main body of the overlying Bowser assemblage.

The importance of this complex has been relatively significant to British Columbia's economy in the past and should continue so in the future. The development and exploration of the Premier, Granduc, Anyox, Alice Arm, Lime Creek, and other mine areas has served to focus attention on the whole Stewart Complex, which is one of the most mineralized, most productive parts of British Columbia.

Mine products from this district have included gold, silver, copper, lead, zinc, cadmium, selenium, tungsten, iron, molybdenum, limestone, and quartz. Mineral deposits presently under development will produce significant quantities of copper and molybdenum, as well as gold and silver.

Geological studies have shown that most if not all of the known mineral deposits in the complex are controlled by both the lithology and structure of the enclosing rocks. Because of the resurgence of mining activity in the Stewart area and the complex in general, the present study was initiated to develop geologic concepts which would provide an aid to intelligent prospecting and mineral exploration.

TOPOGRAPHY, CLIMATE, AND ACCESS

At Stewart and in the surrounding country, one is constantly reminded of the intimate relations between climate and topography and their strict control over accessibility. The entire map-area lies within the northern Coast Mountains of British Columbia near the eastern margin. The topography of the map-area is dominated by Bear River Ridge, which rises abruptly out of the Portland Canal at Hyder and trends north, finally culminating in the towering ramparts of Mitre Mountain and Mount Jancowski, just north of the Stewart map-area. West of Bear River Ridge a parallel feature, the Indian-Big Missouri Ridge, rises sharply from the Salmon River valley and trending northerly blends into the domical height of Mount Dillworth. The Long Lake valley, which lies between these two ridges, provides one of the few routes of easy access to most of the adjacent alpine areas. The east side of Bear River Ridge is flanked by the Bear River-American Creek valley, which is floored by glaciofluvial alluvium. The entire east slope of the ridge presents the aspect of a wall ornamented with cascading waterfalls and snow chutes rising from sea-level toward the rounded ridge top at 6,000 to 7,000 feet. Access to this side of Bear River Ridge is impeded by the braided Bear River and the precipitous glacially scoured lower slope. At the present time there are no bridges or means of crossing the rushing stream above the main Bear River bridge at Stewart, so that access is limited to helicopter transport. On the other hand, the east side of the Bear River, a fairly gentle wooded slope cut irregularly by westerly flowing tributary streams confined by deep canyons, is well serviced by the all-weather Stewart-Cassiar Highway, except for the portions south of the Stewart bridge and north of the American Creek junction. Here again the old bridges and trails have yielded to erosion, and access to the upper slopes must be by foot or helicopter. Most of the Bear River valley reflects the moist, marine, west coast climate with its abundant vegetation up to tree-line at about 3,400 feet. The valley bottoms and west- or south-facing hillsides are luxuriant with salmonberry, devil's club (*Echinopanax horridum*), stinging nettle, and slide alder, as well as the larger western hemlock and spruce. The accessible areas in the valley have been largely logged.

Until 1965 the only easy access to the western half of the map-area was by road from Hyder to Premier, from which branched a wagon-road to the Big Missouri mine and Long Lake and a foot trail from Big Missouri along the west slope of Mount Dillworth to Summit Lake and Tide Lake Flats. The Salmon Glacier also provided much needed access to the western part and outlying areas up until late 1965 when the Granduc road was completed connecting the Hyder–Premier road to

Tide Lake Flats, where an air-strip was constructed in 1965. Now the entire area between the Bear River and the Salmon Glacier can be reached with only minor difficulty, while the area west of the Salmon Glacier can be reached by helicopter or by following the glaciers.

Variations in climate and vegetation are well exhibited in the section from Stewart-Hyder to Tide Lake Flats. The yearly snowfall averages 180 to 200 inches at Stewart, about 400 inches at Premier, and roughly 1,000 inches at Tide Lake Flats. The dense coastal vegetation thins rapidly at Indian Lake, where it is controlled by the combined effect of high elevation and adjacent glacial ice. Despite the apparent thick vegetation in the Bear River and Cascade-Salmon Valleys, the overburden is thin and rock exposures are relatively abundant. The area between tree-line and perpetual snow and ice, which includes about half the map-area, is generally open rock or rock with thin, scattered moraine. Snow or ice caps much of the area above 5,000 feet and small hanging glaciers are found at low levels in protected basins. The effects of glacial modification of topography are abundant. The walls of the main valleys have been scoured and polished, and coated by thick moraine debris which has only recently been largely washed off by water and wind action, leaving steep, step-like cliffs. Except for plucking and polishing, the upper and high slopes suggest a less intense glacial modification. Influence of rock type on the present landform development is well illustrated above the tree-line. In volcanic terrain the various weathering effects have combined to produce sharp ridges and serrate peaks, while rounded crests and peaks indicate a sedimentary or granitic country rock. Debris resulting from mass wasting has piled up on benches or accumulated along portions of the lower valley walls and has modified the U-shaped channels. These are most prominent near Portland Canal.

The fauna of the map-area is also a measure of climate and topography. Among the large animals only mountain goat, black bear, and the odd grizzly are widespread. Moose and deer have not yet made their appearance, although they are increasing in number outside the immediate drainage area. The various small mammals noted in the area recently include lynx, wolverine, fox, porcupine, marmot (siffleur), marten, mink, squirrels, and packrats. Game birds such as Franklin's grouse and mountain ptarmigan are present but not plentiful. Salmon run in both the Bear and Salmon Rivers from July through September and Dolly Varden trout are common. Amongst the many small alpine lakes, only Summit Lake, which generally drains north to the Bowser, was found to have had a few small, thin Dolly Varden trout which probably failed to survive when the lake drained in 1965.

Ice worms have been seen in considerable number in the various meltwater pools, filling cracks and ablation hollows along with unidentified abundant tiny, black water beetles. Although not readily apparent except in late August and September, the ice worm (*Mesenchytræus solifugus*) population of the local glaciers appears to be concentrated in the elevation range 2,500 to 3,200 feet.

HISTORY

Mining and prospecting have been the prime activities and nourishment of the Stewart-Hyder population since prospectors first invaded the area in 1898. Since mineral exploration began in the area Stewart has served the surrounding area as supply centre and terminus. Stewart has shared the fortunes of the local mines until 1956, when construction of the Pacific end of the Cassiar–Stewart Highway commenced and a new activity was introduced. This construction has continued sporadically, but the main impetus to commerce has been the development of the Granduc Mines, Limited project which dominates the local scene. The population centres are now at Stewart, Hyder, and Granduc's Tide Lake camp; other camps having only seasonal occupancy. Exact population figures are not known because of the highly variable construction demands. The village of Stewart, including the Granduc Mines townsite, had a permanent population of about 400 persons in 1964, just prior to the main Granduc construction period. Since then the village and mine townsite has expanded considerably and new services such as a new school and post office, and other amenities, have been added to serve the 800 or more people now permanently living there. Nearby Hyder has a community of about 60 permanent residents, who co-operate with the Stewart people in local affairs. Granduc's Tide Lake tunnel project and mill construction increased the area population by upwards of 650 men and about 150 more were housed at the mine west of the map-area during 1968. Additionally, the surrounding region as far north as Telegraph Creek and south to Anyox has relied on the Stewart facilities for transportation services, supplies, communications, hospital, and occasional recreation.

The history of the Stewart area is entirely tied to the mineral industry. The first parties of adventurers were led to the head of Portland Canal in search of placer gold in 1898. A ship named the *Discovery* left Seattle in the spring of 1898 with 68 men and six months' provisions, under the leadership of a man named Bruges who claimed to have visited Portland Canal and knew of gold placers equal to the Klondike. They landed near the present site of Stewart and dismissed the ship, but the promised placer was never disclosed. After six weeks of inactivity and to avert imminent trouble, Bruges took the party's only boat and hastily departed for the healthier climate of northern Alaska. The marooned group, which contained a few practical miners, broke up to search for the placer deposits and to whipsaw lumber for boats. Later, two men in the party named Brightwell and Cook found mineralized float and vein material just north of Stewart. On his way out of the district, Cook met " Dad " Rainey and told him of the occurrences. Rainey found the area, located his claims, and then settled on what became the Stewart townsite at the base of Mount Dolly, where he lived and prospected for many years without notable success. In 1902 the isolated Rainey was joined by William Noble and " Pop " Stewart, who associated in a venture mining for placer gold at Bitter Creek. Some of their workings are still visible on the shoulder of the hill immediately south of Bitter Creek. The Roosevelt and other claims were staked along Bitter Creek in 1899, where extensive gossans still contribute iron sulphate to the waters and probably account for the notably " bitter " taste of the creek. Later in 1902, John Stewart arrived and was subsequently joined by his brother Bob and it was after these two men that the town was named.

The " poor man's " placer which attracted the prospectors has never materialized but, like other camps, once attention had been drawn to the area, mining and exploration increased and are still in progress. It is likely that the main source of the Bitter Creek gold was found in 1965 when native gold was identified at McAdam

Point in veins uncovered by the rapid melting of Bromley Glacier (*see* Grove, Ann. Rept., 1965, pp. 52–55). The Red Cliff property located in 1898 by the early placer men, because of visible gossan, eventually stimulated the building of a 12-mile long railway, the Portland Canal Short Line, in 1910, from wharf facilities at Stewart to the mine location near the junction of Bear River and American Creek. There was insufficient ore to maintain production and the mine and railway were abandoned and visions of a rail link from Stewart to the Groundhog coalfields vanished. The former railway grade has been largely used by the recent Stewart–Cassiar Highway, and a string of derelict pilings mark the Portland Canal terminus.

The year 1910 marked the end of a surge of wildcat speculations which left the district in ill repute among mining circles. Prospectors had been active in the Salmon River valley, as well as along the east side of Bear River Ridge, and gossans which mark the famous Silbak Premier mine were developed by the Salmon Bear River Mining Company. The locators of the original mineral showings were Charles Bunting and William Dillworth, after whom local peaks have been named. In 1929, after a period of very prosperous years at Premier, at least 40 mining companies and syndicates were active in the district. Most of the mining properties located in these early years have not been as successful as the Silbak Premier, but collectively the various mines have produced substantial quantities of ore and made Stewart one of the major gold-silver districts in British Columbia.

PREVIOUS GEOLOGICAL WORK

The Stewart district received considerable geological attention in the years 1906 to 1932 by members of the British Columbia Department of Mines, the Geological Survey of Canada, the United States Geological Survey, and various mining companies and groups. Members of the British Columbia Department of Mines have visited mines since 1906, when H. Carmichael, Provincial Assayer, made his first report on the Stewart area. McConnell, of the Geological Survey of Canada, carried out mapping of the general area in 1910 and 1911 and produced the first comprehensive geological map of the Portland Canal mining district, which includes part of the present Stewart map. At that time mining activity was concentrated in Bear River valley and some gold placer was being explored to the east on Nelson, Porter (Del Norte), and Willoughby Creeks. McConnell instituted the first tentative subdivision of the local rock formations. He also visited the Salmon River section and made the first geological investigation of the Premier and Indian mines when they were in the initial stage of surface development.

In 1919, J. J. O'Neill commenced detailed geological mapping of the Salmon River district, which was completed by Schofield and Hanson (1922). Hanson continued work in the Bear River and Stewart areas in 1926–27 and incorporated this into his major study of the Portland Canal area (Hanson, 1935). Meanwhile, Westgate (1920) and Buddington (1929), of the United States Geological Survey, were responsible for studying and mapping the Alaskan side of the Salmon River district. The above works represent the major studies of the district and they include significant information on both the general geology and the mineral deposits. Other reports concerning detailed examinations of the various mining properties have been written and these are referred to in the various parts of this bulletin.

SCOPE OF THE PRESENT STUDY

This report is based on field work in the area during 1964, 1965, and a short period in 1966, as well as on considerable supporting research. Field-mapping was plotted on base maps (scale, 1 inch=1,320 feet; contour interval, 50 feet) prepared from 1956 British Columbia Government air photographs by the Photogrammetric Section of the Department of Lands, Forests, and Water Resources. The topographic maps (Long Lake, M-131 and Stewart, M-176) are generally excellent, but it should be noted that since 1956 the ice and snow outlines have changed considerably and fluctuate from year to year.

As previously indicated, access to much of the area is dependent on helicopter or footwork. The opening of the Granduc road to Tide Lake Flats in August, 1965, made the study of the Salmon River district considerably easier. During the investigation, most of the known mineral deposits were visited, but many of the trenches or adits are 10 to 40 years old and have filled in or caved. The main producing mines were studied in more detail, but these also have deteriorated from neglect, and in addition the ore has been mined, leaving only a few pillars or remnants of low-grade sections for study. For these reasons the old reports still have considerable value and in some instances constitute the only record.

In addition to this detailed study of the Stewart area, the writer undertook a regional study of the whole of the Stewart Complex, which was completed in 1968. The conclusions presented here are based on this regional knowledge and have implications beyond the Stewart map-area.

The intent of this study has been to assist exploration in the area by revising the general geology and working the mineral deposits into the resulting scheme.

ACKNOWLEDGMENTS

Able assistance was rendered during the 1964 field season by Brian Moore, and during the 1965 season by Wolfgang Schamberger. The writer is indebted to many of the residents of Stewart and mining men in the district for information and other courtesies, and especially to Mr. Don McLeod, mine manager at Silbak Premier Mines Limited; Mr. Harry Swan, prospector; and Mr. Ian McLeod, hotel manager. J. T. Fyles edited the manuscript.

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CHAPTER 2

"Happy is he who has been able to learn the cause of things."—*Virgil.*

Physiography—Glacial and Recent Geology

PHYSICAL FEATURES

The Stewart area lies entirely within the Boundary Ranges of the northern Coast Mountains. The region is one of complex mountainous topography at a stage of early maturity. The topography has considerable relief, with ridge crests and peaks 4,000 to 6,000 feet above deeply incised valley bottoms. At Stewart the east wall of Portland Canal rises abruptly from sea-level to more than 6,400 feet elevation on snow-capped Mount Rainey. The lower peaks and ridges are generally well rounded with steep sides typical of the Coast Mountains. Above 5,500 feet in elevation the higher peaks and ridges have been modified by alpine glaciation and commonly present sharp or jagged crests. Very generally the lower north- and east-facing slopes are steeper than the south- and west-facing slopes. Elsewhere above 3,500 feet elevation, especially in the Long Lake section, the country is park-like and during the short summer very picturesque. The glaciers and permanent snowfields which cover much of the high ridges often aid access and provide splendid scenery.

DRAINAGE

Run-off from the Stewart map-area reaches the Pacific Ocean by way of four main rivers. Three of these, the Bear, Salmon, and Marmot, drain directly into the Portland Canal near Stewart. The fourth, the Bowser River, which has its source in the northwest quadrant of the map-area, takes a very circuitous path to the ocean. From the source area it flows north past Frankmackie Glacier then heads east to Bowser Lake. From Bowser Lake the waters flow into the southeasterly draining Bell-Irving River which in turn joins the Nass finally reaching Portland Inlet near Kincolith, just 60 south of Stewart. Thus the waters of Summit Lake, which lie just 20 miles north of Stewart, travel nearly 200 miles to reach the sea. This drainage pattern, arranged by recent glacial events, was disrupted in December, 1961; December, 1965; September, 1967; and again in November, 1968, when Summit Lake reversed its normal flow and discharged directly south under the Salmon Glacier into the Salmon River. This phenomenon, sometimes called "jokulkaup," entails the sudden outburst of ice-impounded water. Other ice-dammed lakes once found in the area included Tide Lake north of Summit Lake and Strohn Lake which was located in Bear River Pass at the head of Bear River.

SUMMIT LAKE

Summit Lake is one of the few existing ice-dammed lakes found in the Stewart district which have been active in recent years and have been responsible for considerable damage to property. It lies at the head of Salmon Glacier, about elevation 2,700 feet, 18 miles north-northwest of Stewart. Overflow from the lake normally flows north across a rock sill into the Bowser River system, which heads here at the toe of Berendon Glacier. Summit Lake water has followed the northerly path since its origin when the receding Salmon Glacier left an enclosed basin between the valley walls.

On December 26, 1961, the entire volume of Summit Lake coursed south under Salmon Glacier into the Salmon River and then into the head of Portland Canal at Hyder, Alaska. The dumping of the lake waters was not seen, but two watchmen on duty at the Silbak Premier mine heard the roar of the escaping water and the crashing of ice blocks. Most of the Silbak Premier road from Thirteen Mile to Riverside was washed out, leaving the watchmen stranded. Small Dolly Varden trout living in Summit Lake were dumped out, and a few were found in pools alongside the rearranged Salmon River. Fortunately, dykes of snow bulldozed into place held the river from overflowing into the village of Hyder.

The lake began filling again the following May, and remained more or less static until December 1, 1965, when the entire lake again discharged under the ice into the Salmon River, this time destroying 6 miles of the road just reconstructed by the Granduc company. This road, which connects Hyder to Tide Lake Flats, was opened in August, 1965, and follows the east side of the Salmon Glacier and Summit Lake. Drivers commuting regularly between Stewart and the Tide Lake camp reported that two to three days previous to the dumping of Summit Lake, the Salmon River turned almost black with silt.

Summit Lake filled for the third time, beginning in late May, 1966, and discharged on September 17, 1967. During the discharge the Granduc company and ice-research crews of the Hydrology Division, Department of Energy, Mines and Resources of Canada, recorded hydrological data.

A fourth discharge took place from November 10 to 13, 1968. The lake had partly filled during the abnormally brief summer and heavy rain and snow in September and October raised the water to a high level, but not as high as the levels recorded prior to the previous outbursts. In this discharge the Salmon River rose about 8 feet above normal, but road and other damage was largely averted.*

Numerous similar ice-dammed lakes are found in the Boundary Ranges as well as in other glacial areas. The mechanism triggering the floods appears to be similar. The lake water rises until it is deep enough to lift the ice barrier, which floats, and the water rushes out under or along the glacier, rapidly draining the lake. Because of yearly ablation the confining ice barrier gets thinner and the lake waters do not require as great a depth to trigger the next flood. In time the ice barriers no longer form dams and the lakes are permanently drained.

Recent observations of Summit Lake indicate that it has a flat, south-dipping, somewhat stepped, or terraced bottom which, when finally exposed, probably in the next few years, will resemble the nearby Tide Lake Flats. At the present time Summit Lake water is used at Granduc's Tide Lake camp for general purposes and had been considered for the mill water supply.

* Summit Lake discharged for the fifth time August 17, 1970.

Many of the factors influencing the self-dumping process at Summit Lake have not been recorded, but significant known factors are the position and height of the ice dam, the weather, and the level of the lake. Figure 2 shows several stages in the recent retreat of the ice barrier and the accompanying increase in size of Summit Lake. Stages of toe retreat of Salmon Glacier are also indicated. The 1961 front does not appear separately, but roughly corresponds to the 1957 line. The dam remained at approximately this position until 1964, when retreat accelerated. Crude measurements also suggest that increased vertical ablation in the barrier area accompanied the horizontal withdrawal. The 1965 and 1967 dumpings were both accompanied by extensive ice sloughing in contrast to narrow marginal breakage associated with previous dumpings. As a result, simple water-escape tunnels were not visible but may not have existed. During the 1964–67 period the writer observed surface ponding of water on the upper Salmon Glacier along the east ice margin. Farther south surface water escapes under the ice via channels at Big Missouri and Boundary Glaciers. The main stream escaping from the Salmon Glacier emerges from an ice cave on the west side of the toe. Escaping lake waters from the 1961, 1965, and 1967 outflows all used the same tunnel-like exit. The above clues indicate that both the normal as well as flood drainage is largely subglacial.

The ice dam at the south end of Summit Lake is about 5,000 feet wide. In the period 1961 to 1968 the dam as a whole has retreated about 2,800 feet south, and even farther at the southeast corner, where considerable meltwater enters the present lake. The ice has also thinned substantially at the centre and along the east side of the Salmon Glacier south of the lake, increasing the tendency of the ice barrier to float at high-water level, which normally occurs in late fall or early winter.

Survey records on the size and movements of Salmon Glacier are sparse up until about 1957. However, 1910 maps show the elevation of the ice barrier at the south end of Summit Lake as about 3,400 feet. The present elevation is roughly 2,900 feet, indicating a thinning in this general area of about 500 feet in 58 years. The effect of thinning is clearly shown at the old Outland Silver Bar property on the west side of the glacier, where veins originally worked by adits from the ice before 1920 are now 700 feet above the present ice surface.

Ablation of Salmon Glacier is continuing, and the demise of Summit Lake to a hummocky clay-gravel flat is predictable for the near future.

Tide Lake

Tide Lake Flats, immediately north of Summit Lake, represents the bottom of a recently emptied ice-dammed lake, one of several found along the Salmon-Bowser River valley. Tide Lake was held in check by Frankmackie Glacier (*see* p. 27), but because of glacial ablation and recession during the period 1921 to 1931, the lake has permanently emptied, leaving a large, virtually flat valley bottom upon which an air-strip was constructed in 1965 to serve the Granduc tunnel project and mill construction. Waters draining from Summit Lake, Berendon Glacier, Betty Glacier, and small tributaries were impounded by the toe of Frankmackie Glacier, forming a lake 6 miles long, 1 mile wide, and at least 500 feet deep at its highest level. This level is still marked conspicuously by a sharp trim-line. With the retreat of the Frankmackie, the lake level dropped to about 160 feet at its north end where it was impounded by a cross-valley moraine. Subsequently the moraine dam was breached and the lake disappeared for the last time in 1930–31. The lake derived its name from the seasonal and annual fluctuations in water level brought about by oscillations of the Frankmackie ice dam which impeded outward stream flow. Various local inhabitants indicate that the Bowser Valley was subject to periodic flooding probably related to these oscillations.

Bear River

The Bear River, which drains the greatest part of the map-area, has caused considerable flood damage in recent years. In the period 1958 to 1962 Strohn Lake, which lies in Bear River Pass just east of the Stewart map-area, overflowed Bear Pass Glacier and rushed down the Bear River valley at least five times, taking out all bridges except the main Stewart bridge. Stewart itself is protected from the Bear River by the road-bed of the old Portland Canal Short Line Railway as well as by additional rock levees along the air-strip. The Bear River heads at Bear Pass Glacier, which acted as an ice dam to impound Strohn Lake. When the lake water reached a maximum level, usually in October, the lake disgorged westerly under the glacier and down Bear River. On July 23, 1967, the toe of Bear Pass Glacier melted through, marking the end of Strohn Lake and this local flood threat.

In addition to this main event, various tributary streams in Bear River valley, such as Fitzgerald Creek, Glacier Creek, and Barney Gulch, have added water and debris to the Bear River. Glacier Creek's outlet was rerouted in 1958 after gravel sloughed near Maude Gulch and dammed the main stream. When this dam broke the material was carried down Glacier Creek and deposited in a large fan across the east side of Bear River valley, completely filling the old channel, burying timber as well as some buildings at the Dunwell mill. The creek now empties into a large swamp between the highway and the hillside and discharges above Barney Gulch. A similar occurrence has been noted at Fitzgerald Creek where the Red Cliff mine buildings and lower tunnel have been buried by stream gravels and at Barney Gulch where an old access road has been completely buried. These two events are not dated but probably occurred about the same time as the 1958 Strohn Lake flood and Glacier Creek mudflow.

These incidents are part of an over-all picture of change in the drainage system related to historic glacial ablation. The present drainage systems are the product of glacial recession and the various stream systems can be expected to react as the ice retreat continues. The main streams and their tributaries follow lineaments controlled by rock structures which predated and partly guided valley glaciation. The present valley floors were formed during glacial retreat and have been modified by stream action.

GLACIERS AND SNOWFIELDS

Although glaciation did not initially constitute an essential part of this study, it became of interest because the geological work required travel on ice and snow and the use of maps and air photographs ranging from 10 to 50 years old. The dateable outlines of glacier toes have been plotted on Figure 2, to show the known stages of glacial ablation. In addition, the change in extent of the Bear River Ridge snowfield can be appreciated if one examines the geological maps of McConnell (1913), Schofield and Hanson (1922), Buddington (1929), and Hanson (1929), with Figures 2 and 3.

Parts of at least four main snowfields impinge upon or overlie a large part of the Stewart map-area. One of the most extensive of these is the Cambria Snowfield, which is mainly southeast of the area and extends from Bear River Pass to Kitsault Lake, 25 miles to the south, and encompasses an area of about 300 square miles. The northwest edge of this field overlaps the Stewart map-area just east of Stewart, where several small alpine glaciers overhang the Portland Canal. Bear River Ridge is capped by the southern extension of a small snowfield which extends northward to the Bowser River valley. The largest local snowfield, the Frankmackie, with an area of about 400 square miles, impinges on the western limits of the map-area and feeds the Berendon and Salmon Glaciers. The fourth snowfield, which just touches the northeasterly edge of the map-area, lies north of Bear River Pass and has an area of about 60 square miles. All these snowfields lie above 4,000 feet in elevation and generally exhibit a smooth, rolling surface through which project numerous rock ridges and jagged peaks. Extensive areas are only seldom broken by crevasses, but toward the outlets crevasses and other fracture features develop, resulting from ice movement. All of these snowfields give rise to glaciers of which the Salmon Glacier is the largest and most accessible in the Stewart map-area. Besides the major glaciers there are innumerable small ones, almost all of which occupy depressions leading from the snowfields. Some of these, such as the Silverado Glacier above Stewart, appear to cling precariously to smooth, precipitous rock slopes, occasionally dropping huge blocks of ice and producing icy torrents of meltwater which cascade thousands of feet to the valley below.

Historically, the first glacier study in the area was recorded by McConnell (1913, pp. 8–10), in which he noted that stakes were planted on Bromley Glacier to measure ice flow and recession. The writer collected other information from local prospectors who have used the glaciers for many years to gain access to various mineral deposits. Together these bits of information suggest that glacial ablation in the Stewart area has been continuous but oscillatory for a considerable time. Until about 1927 the rate of toe recession was about 50 feet per year and at the 3,000-foot level the ice was lowering at about 3 feet per year. Since then the process has speeded up considerably until the present, when glacier toes are receding at more than 150 feet per year and ice at the 3,000-foot level is ablating at 30 to 50 feet per year. Studies by Granduc Mines, Limited confirm these rates and also suggest the rate of ablation is increasing.

As far as could be determined without detailed studies, all of the glaciers in the area are normally receding. An exception to this norm during 1966 was a small glacier, called August Mountain Glacier, at the southwest corner of Summit Lake. As a result of the lake being lowered in December, 1965, the toe of this glacier advanced or dropped toward the new lake level some hundreds of feet below with a concommitant surge of snow and ice from the upper levels. Since then the lake level has risen and the glacier has calved to regain equilibrium.

Detailed studies of the ice movements have been in progress in the general area for some years in connection with the Granduc mine project. Holes were drilled through the Berendon Glacier by the " hot point " method to test the depth of ice above the proposed mine tunnel which leads from a portal near the toe of the Berendon toward the Granduc mine, 11.6 miles to the west. The tunnel and two ice holes are indicated on Figure 3. Near the centre of the glacier the ice was determined to be about 1,500 feet thick. The only recent published glaciological study relating to work on the Salmon Glacier is that of Mathews (1959), which was based on the deep drilling of Salmon Glacier by Granduc Mines, Limited in June, 1956. The location of the ice drilling-sites and resultant glacier cross-section have been reproduced on Figure 5. As indicated by the ice contours, the study area lay adjacent to the west edge of the Stewart map-area. The results of the 1956–57 investigation indicated the surface velocity of the ice at three points averaged 91 metres per year, with an over-all average velocity of 77 metres per year. Mathews calculated that the annual transport of ice, omitting water, was about 75×10^6 cubic metres per year. Since 1956 the terminal zone of Summit Lake and the toe of Salmon Glacier have retreated at an average of about 42 metres per year, with the meltwater enter-

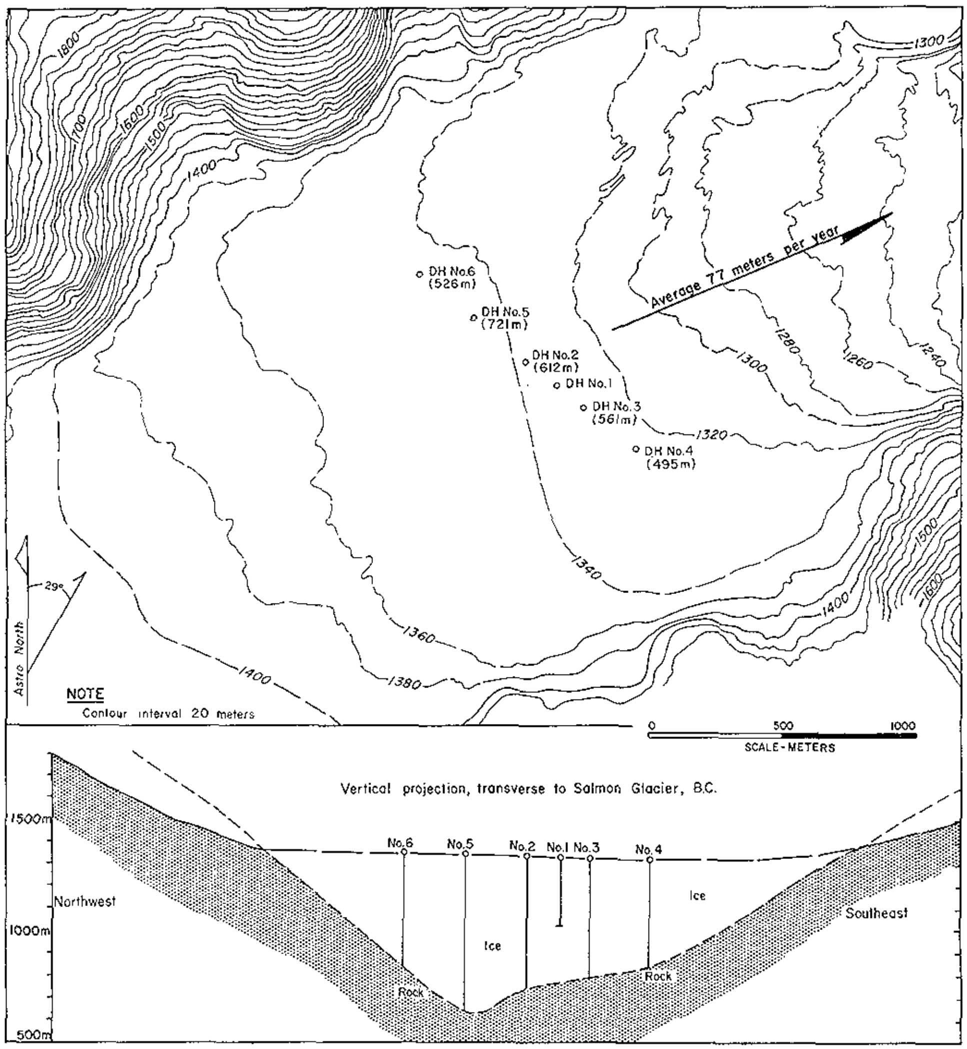


Fig. 5. Salmon Glacier, plan and vertical section.

ing the Bowser and Salmon River drainage systems in unequal amounts. Estimates of probable glacier outlines which are shown on the various geological cross-sections that accompany this report were generally inferred from slope measurements except for the lower Berendon.

GLACIAL DEPOSITS

Remnants of an old high-level moraine on the west side of Summit Lake which has a low northerly slope possibly accounted for by " rebound " suggests a dormant glacial phase previous to the more recent one (*see* Plate IIA). Tree growth-ring measurements on the high terrace in Bear River valley indicate an approximate age of 485 to 500 years, suggesting a local ice advance about 1500 A.D. Later stages have not been dated in the immediate area.

As the present Salmon Glacier retreats, it leaves behind a flat-floored, gravel valley bottom which is reworked by the issuing river. The smaller glaciers have little or no load and leave only polished rock flanked by marginal moraines to mark their existence. Likewise, melting snowfields floored with ice leave behind either bare polished rock or thin patchy moraine consisting of rubble which is well rounded and which is generally more abundant where siltstones form the country rock.

Apart from the minor excavations of a few small, alpine cirques, the most apparent effect of glaciation on the map-area has been the smoothing and rounding of the country rock and transport of morainal materials. Transported talus is prominent on the larger glaciers (Plate IVA), as moraines on the ice, and plastered along steep valley walls where glaciers existed only recently.

Other glacial deposits include lake sediments at Tide Lake Flats and those recently exposed for a short time under Summit Lake. The Tide Lake glacial silts have been reviewed by Hanson (1932), who examined cutbanks of the Bowser River which flows through the old lake-bed. He suggested that although only about 15 feet of silts and varved clays were exposed the lake sediments were possibly 150 feet thick near the outlet. From this estimate and assuming the varves averaged less than 1 inch thick, Hanson calculated that the maximum sediment thickness represents a possible 2,000 years' accumulation or more. Hanson mentioned that the varves were intercalated with reddish fluvial material and noticed the pink colour of the tributary streams in warm weather, both of which phenomena can still be observed.

Since Tide Lake disappeared more than 35 years ago, the natural processes of erosion have been active in the valley. Bowser River has wandered across the flats and cut through the clays into gravels at the south end. At the north end near the barrier moraine the river is deeply incised into varved clays and sands. The normal regimen of ice retreat suggests that as ablation proceeds glaciofluvial materials are left, immediately forming the valley floor and lacustrine sediments are deposited over these as a thin blanket, such as at Summit Lake. Tributary streams, especially those on the east side of the valley, have spread extensive alluvial deposits across the valley and are intercalated with the lake sediments. Since 1967 the hydrology of the Tide Lake sediments has been investigated by the Granduc Operating Company, which drilled a number of water wells at Betty Creek and along the Tide Lake Flats airstrip. The water potential of the small basin has become important in light of the near future demise of Summit Lake.

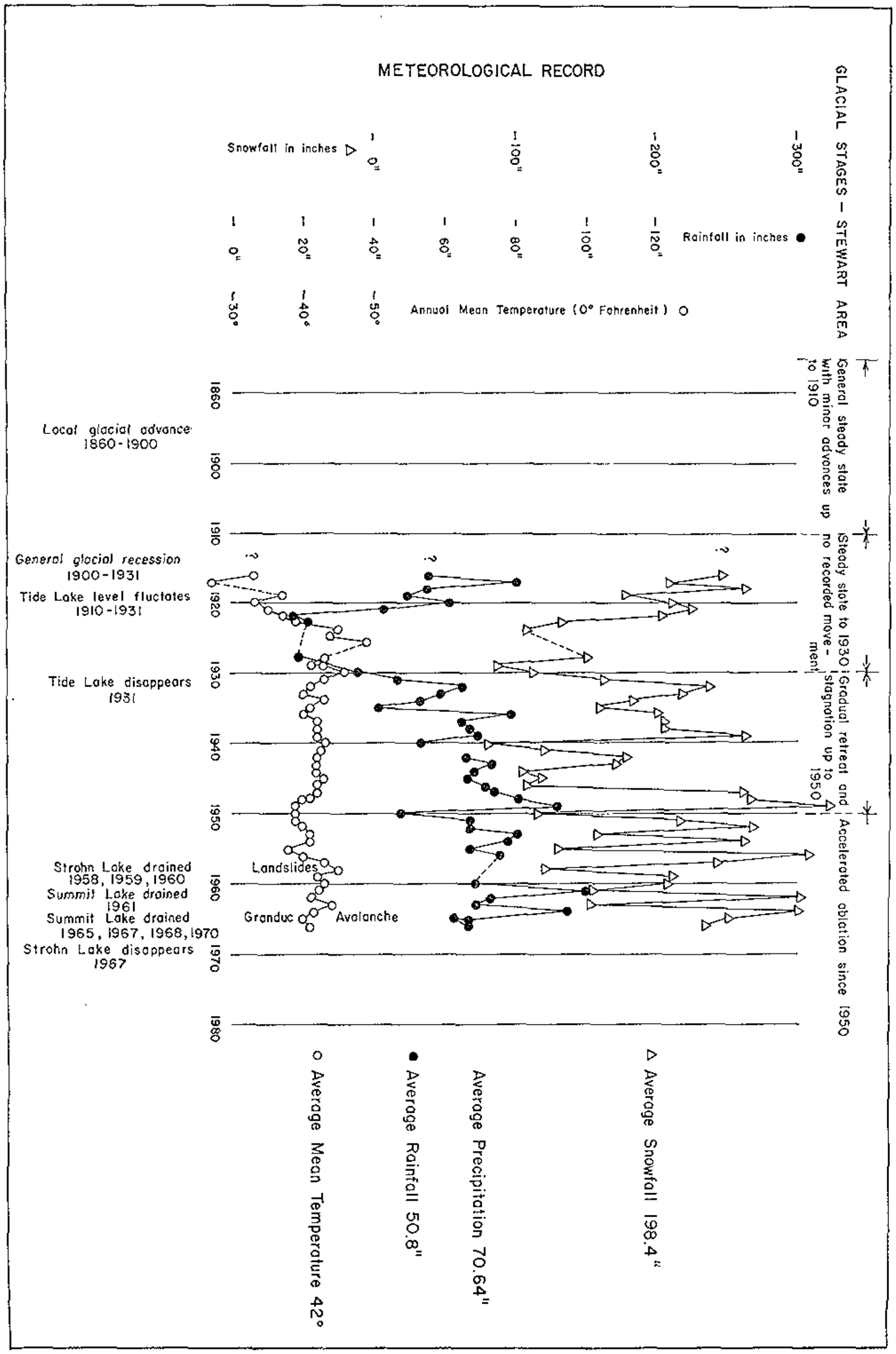


Fig. 6. Glacial-climatographic chart, Stewart area.

CLIMATE

A summary of the local weather records and glacial movements has been presented on Figure 6. Data for the plots were derived from Department of Transport meteorological reports. The records for the Stewart station are incomplete, but they are the only extensive ones available. Weather records were maintained at Premier during the periods 1926–48, 1951–52 and they are also somewhat fragmentary, but fluctuations at Premier appear to be comparable to those at Stewart. The apparent comparability of the two widely separated stations has been taken here to indicate that the single Stewart station can serve to indicate fluctuations throughout the present map-area. Analysis of the plots indicate an increase in average temperature with a corresponding increase in average winter snowfall. Other factors controlling climate have not been investigated, so that for the present the available temperature precipitation plots must suffice and are considered evidence regarding historical regional thermal vagaries controlling local glaciation. From the precipitation plot a number of self-evident climatic variations are visible. Between 1910 and 1920 a fairly steady increase in average mean temperature was recorded, which has since been followed by a more or less uniform warmer climate. As generally follows, the average precipitation has increased since 1930 and appears to have levelled off, paralleling temperature. The decade 1920–1930 shows as an anomalous deviation of low precipitation with accompanying higher mean temperatures and as shown in the notes on the plot (Calendar of Events) the sudden disappearance of Tide Lake resulted. The general stages and events recorded in the area have been related to temperature and precipitation on Figure 6 along with some significant local events. Detailed interpretation is left to the reader.

Studies in coastal areas of adjacent Alaska (Klotz, 1907) and the nearby Stikine (Kerr, 1948) indicate a recession up until the 1860's, then a short rapid ice-front advance, followed by a recession which has continued to the present. Presumably the glacial events in the Stewart district have followed this pattern.

Changes in the local macroclimate have been substantial in the last 90 years, as evidenced by such events as the shrinking of the glaciers, the formation and drainage of Tide Lake, and the events which are now leading to the extinction of Summit Lake.

During the summer of 1968, pieces of tree trunks frozen into one of the glaciers north of Tide Lake Flats were recovered from the ice at an elevation of 2,500 feet. A section of one tree submitted to the Federal Forestry Laboratories in Vancouver was identified as a yellow cedar (*Chamœcyparis nootkatensis*) about 120 years old. Special studies performed on the wood indicated the tree had been buried in fresh water for about 500 years and then frozen into glacial ice for a subsequent 500 to 1,000 years. At present yellow cedar grows locally only on the coast, and this discovery suggests that yellow cedar previously grew well inland at a fairly high elevation where only moss and scrub brush are now found. In the past 1,500 years the climate has apparently varied considerably; glaciers have formed and receded periodically as part of complex stade-interstade events.

ICE WORMS

As an adjunct to continuing glaciological research in the area by the writer, specimens of ice worms have been collected from several localities. These have been identified as *Mesenchytrœus solifugus,* but specific varieties are so far unnamed and await detailed research. They abound in portions of the major ice areas in the region, specifically the Cambria and Frankmackie snowfields. Generally they are black or brownish-black, have a distince earthworm-like appearance, and commonly attain a length of one-half to three-quarters of an inch, rarely exceeding 1 inch (Plate VB). They have been seen most commonly in surface sinkholes in the ice and along meltwater channels where the ice and water are mainly clear and free of rock debris. They have been found in these locations in bright summer sun and have been seen to leave their ice channels and move onto the clean ice surfaces in direct warm sunlight. This environment appears to exist best between elevations of 2,500 to 3,500 feet and glaciers with gentle north slopes appear to be preferred. Ice worms have also been found at lower elevations (1,500 to 2,500 feet) in the glacier toe areas, living about 2 feet under the ice surface. Like their life cycle, the ice worm's diet is largely unknown; however, micro-organisms such as " red snow " (the algæ *Chlamydomonas nivalis*) may play a part, and additionally vitamin A from the atmosphere may dissolve in the ice water to provide sustenance.

“ Do not become a mere recorder of facts, but try to penetrate the mystery of their origin.”—*Ivan Pavlov.*

CHAPTER 3

General Geology

GENERAL FEATURES

The Stewart area includes moderately folded volcanic and sedimentary rocks intruded by a succession of plutons. Evidences of regional metamorphism are slight and indicate a relatively low amphibolite-grade environment. Dynamic metamorphism along the intrusive contact areas is important, especially in regard to the localization of mineral deposits. The sedimentary and volcanic rock formations in this area have been treated recently by the Geological Survey of Canada and included in Map 9-1957. From this, the rock-stratigraphic names “Hazelton” and “Bowser” have been adopted rather than an ambiguous terminology of early workers. To maintain local continuity, Buddington’s plutonic nomenclature in the Hyder area has been retained where possible.

Correlations of the major rock units of this area are based upon lithology and structural sequences tied into the regional framework which has been closely examined as part of the concurrent areal project. Exposures are generally sufficient to completely delineate rock units and their stratigraphic and structural relationships.

The structure of the area, if taken as part of the over-all tectonic framework, is relatively simple. Taken in detail, the structure is complex and the study of folding and lithologic relationships requires the recording of many factual observations and a broad regional knowledge.

The Stewart district lies adjacent to and includes part of the eastern margin of the Coast Crystalline Belt, which forms the western limit of the Bowser Basin. Until recently, in publications concerning this district, the terms “Coast Range Batholith” or “Coast Range Intrusions” were used, but these have been superseded by the term “Coast Crystalline Belt,” used in this report. The term “Bowser Basin” as currently used refers to a tectonic depression bounded by the Cassiar Crystalline Belt and Coast Crystalline Belt. The terms “Nass Basin” and “Skeena Basin” have been used in a few publications in reference to this geological feature, but they should be used only in the geographic sense as defined by Holland (1964). Figure 1 illustrates the major tectonic units and outlines the basic regional geology.

The Stewart district lies within what has been referred to as the Eastern or Interior belt of mineralization as distinguished from the Western belt of mineralization, which includes the western border of the Coast Crystalline Belt (*see* Schofield, 1921; Dolmage, 1920; Mandy, 1930). Mineral deposits have been discovered in this belt where it was easily accessible to prospecting, such as on the Taku, Stikine, and Unuk rivers and at the head of Portland Canal and Alice Arm. Clothier (Ann. Rept., 1923, pp. 34, 35) introduced a “ Central Belt ” into the scheme and attributed certain minerals to each of these “natural belts.” The western belt was a copper (gold-quartz) belt; the central belt, copper; and the eastern, noted for gold, silver, and lead deposits. The Anyox copper deposits were erroneously included with the central belt instead of the eastern to which they actually belong, and other deposits were omitted. Significant omissions were apparently made to facilitate this belt concept, but more recently economic manifestations as well as more complete geological information have largely shown this mineral belt hypothesis to be invalid.

A summary of the predominant rock types and their apparent relations is given in the accompanying stratigraphic correlation chart (Table 1). The plutonic rocks include marginal members of the Coast Crystalline Belt: The grey Texas Creek batholith, the pink to white Hyder batholith, and the grey Summit Lake stock, all of which are intrusive into the Hazelton assemblage of volcanic and sedimentary rocks. Although these plutons occur along only the western fringe of the map-area, they are considerably more extensive. Both the Hyder quartz monzonite and Texas Creek granodiorites have been delineated by Buddington and carefully described in his Hyder bulletin (1929).

One of the most prominent features of the area is the wide swarm of granitic dykes which traverses the map-area from the Salmon Glacier on the west across Bear River Ridge to Bitter Creek at the east and extends beyond the area southeast approximately 25 miles to Mount Trevor near the centre of the Cambria snowfield. The predominant dyke rocks in this complex are granodiorite and quartz porphyry, but they range in composition from granite to diorite. Other dykes are also very prominent in the Stewart map-area, especially at the Premier, Big Missouri, Summit Lake, and Glacier Creek areas. All rock types in the area are cut by one or more varieties of dykes which range in age from Jurassic to Tertiary and in size from a few inches to 400 feet wide and up to several miles long.

Another important group of intrusives includes augite porphyry plugs, stocks, and dykes. Within the Stewart area these are prominent along a broad zone near the major swarm of dykes from Long Lake in the central part of the map-area to Glacier Creek at the southeast corner. Hanson (1935) mapped similar rocks as far south as Alice Arm lying along the same general zone.

The oldest and most extensive formations in the area are volcanic and sedimentary rocks of the Hazelton and Bowser assemblages. The volcanic rocks of the Hazelton assemblage include a great variety of sandstones, conglomerates, and breccias as well as minor intercalated tuffs, siltstones, and flow material. These rock units, which together exceed a minimum 6,000 feet in thickness, vary individually from a few inches to several hundred feet thick and extend as traceable units for miles. Within the map-area the Hazelton assemblage is partly overlain by volcanic sandstones, tuffs, siltstones, and greywackes of the lower Bowser assemblage which occur as isolated structural remnants. Contact relations in the Stewart area between the main rock units are readily apparent because of the generally excellent exposures.

As previously suggested, the major structural features of the Stewart district are relatively simple. The eastern part of the area is dominated by an upright north-trending anticline with a shallow plunge to the north whose axis lies along American Creek valley. Within the map-area this structure, called the American Creek anticline, is truncated on the south by the Portland Canal dyke swarm and the Glacier Creek augite porphyry. Northward, the major axis swings slightly west and the anti-

TABLE 1.—STRATIGRAPHIC CORRELATION CHART OF ROCK FORMATIONS OF VARIOUS INVESTIGATORS

Era	Period and Epoch	McConnell, 1913	Schofield and Hanson, 1922	Hanson, 1929	Buddington, 1929	Hanson, 1935	This Report	Period and Epoch	
Cenozoic	Quaternary.	Superficial deposits.	Pleistocene and Recent.	Recent and Pleistocene.	Pleistocene and Recent.	Recent and Pleistocene.	Unconsolidated deposits. Basaltic dykes.	Quaternary.	
	Tertiary.					Tertiary—basaltic lava flows.	Hyder quartz monzonite, etc.—dyke swarms.	Tertiary.	
Mesozoic		Later diorite-porphyry dykes.	Lamprophyre dykes. Quartz-diorite dykes. Augite-porphyrite stock.	Dykes.	Coast Range intrusives.	Dykes.		Cretaceous.	
			Coast Range batholith. Premier sills.	Coast Range intrusives.		Coast Range intrusives.	Bowser assemblage.	Upper	Jurassic
				Augite-porphyrite and related intrusives.				Middle	
		Nass Formation.	Nass Formation.	Nass Formation.	Not mapped.	Hazelton Group.	Texas Creek granodiorite.	Lower	
		Bear River Formation.	Salmon River Formation. Bear River Formation.	Bear River Formation.	Hazelton Group.		Hazelton assemblage.		
		Bitter Creek Formation.	Not mapped.	Bitter Creek Formation.					

cline spans the Mitre-Jancowski massif. In the central part, a doubly plunging or canoe-shaped, slightly overturned syncline includes most of the Mount Dillworth-Bear River Ridge section terminating just north of the map-area on the south slope of Mitre Mountain. Between this major syncline and the intrusive Coast Crystalline Complex which forms the western margin of the map-area, the rocks are generally strongly deformed, cut by extensive dyke swarms, and variably metamorphosed. Thus, the major tectonic elements found in the map-area include, from west to east: The intrusive margin, the strongly deformed buffer zone, and the large northerly trending folds. These also form the major elements of the regional structure. The local structural features are discussed in Chapter 4.

TERMINOLOGY

The terminology used in this report differs from that found in most of the earlier reports describing the area. The problem of terminology has arisen for several reasons, but mainly because, too commonly, mine terminology has been applied to areal features. The term " Premier Porphyry," for example, was coined for a specific rock unit within the Premier area, but has been used indiscriminately in many reports for any rock beyond that area with vaguely similar characteristics. This study, in which the lithology and structure of a large area have been studied in detail, has shown the lack of consistent terminology in the previously mapped units. Consequently, most of the old local terms have been dropped in favour of a simple but applicable textbook terminology. The rock classification used generally conforms to that of Williams, Turner, and Gilbert (1954) with exceptions, which will be noted.

CORRELATION AND NOMENCLATURE

Discrepancies in the naming and correlation of the formations have grown up with each study in the Portland Canal area since McConnell initiated his classification in 1913. The general stratigraphy of the Mesozoic rocks of central British Columbia was reviewed by Tipper (1959) and many problems remain to be clarified. A correlation chart of previous investigations in the Stewart area is shown in Table 1. The table deals only with major rock-stratigraphic units, but further complications prevail as a product of innumerable areal, mine, and property reports.

The terminology for the igneous plutons is somewhat less equivocal than that for the volcanic-sedimentary rocks, largely because of the unusually clear intrusive relations. Correlation with other plutonic masses within the Coast Crystalline Belt and elsewhere in British Columbia or Alaska will remain problematical until better geological maps and more isotopic age determinations become available. Buddington's formation names, such as " Hyder Quartz Monzonite " and " Texas Creek Granodiorite " for intrusive igneous rocks, have been maintained where possible. New names have been coined for some distinctive plutons, using local geographic names.

At the present state of knowledge neither " Hazelton " nor " Bowser " have been established as Groups according to the code of the American Commission on Stratigraphic Nomenclature (American Association of Petroleum Geologists, 1961).

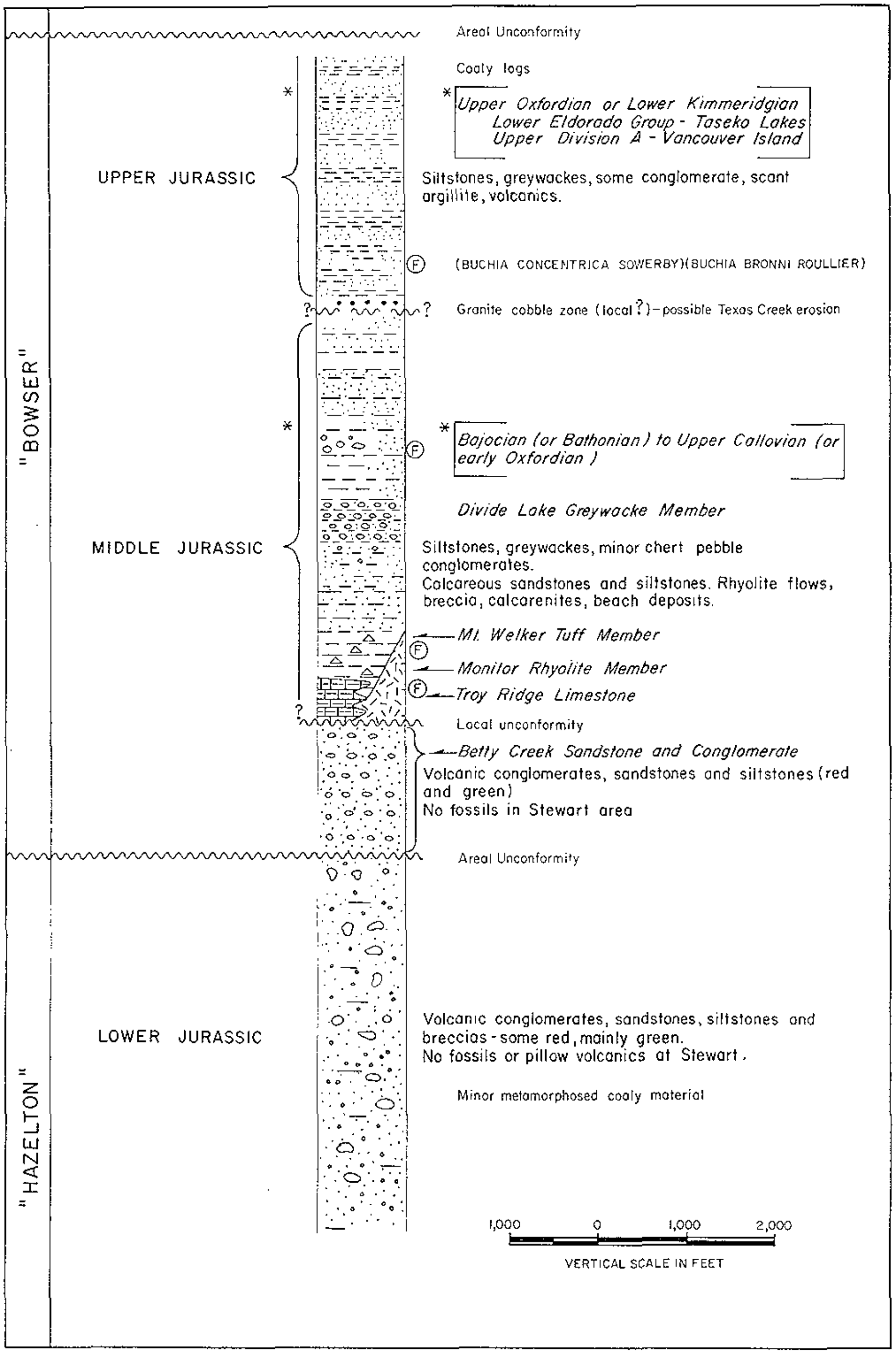


Fig. 7. Composite lithologic-stratigraphic section, Stewart area.

In the present study the natural tendency to introduce new formational names has been submerged and the terms " Hazelton " and " Bowser " are used as informal assemblage designations because they reflect popular usage and express local relationships. The present purpose is to outline mappable units and to describe their characteristics. When more such studies have been made the regional picture can be reviewed and a proposal for a new stratigraphic nomenclature can be made.

HAZELTON ASSEMBLAGE

Within the Stewart map-area the Hazelton assemblage includes an extensive sequence of volcanic and sedimentary formations limited by the overlying Bowser assemblage and with no apparent lower natural boundary. Regionally the assemblage is sufficiently well bounded by fossiliferous formations to indicate that rocks of only the upper Hazelton formations are present. Areally the Hazelton extends well beyond the Stewart area, where the lower limit has been distinguished by fossil and structural evidence. Generally the Hazelton rocks are lithologically similar to the underlying Upper Triassic assemblage.

The Hazelton assemblage in the Stewart area is dominated by interfingering clastic sedimentary units of predominantly volcanic origin. Siltstones and lithic greywackes are intercalated with coarsely layered volcanic clastic rocks. The assemblage is monotonously green and the siltstones and greywackes provide formational markers as well as significant structural evidence. Most of the formations delineated on the accompanying geological map have been traced on foot in the field. The simple conglomerates, breccias, and sandstones are differentiated by such macroscopic characters as grain size, colour, texture, as well as structural contacts. The fine-grained tuffs and similar cataclasites require study under the microscope in order to clarify and discriminate the many types.

Distribution

The geologic map shows that the Hazelton assemblage extends over most of the area and forms the steep valley walls. The upper stratigraphic limits are accurately recognized where the assemblage is overlain with apparent angular unconformity by the Bowser sedimentary and volcanic rocks.

In the Salmon Valley the Hazelton members exposed along the valley walls trend northerly and have a steep westerly dip. These rocks are within the buffer zone and are marked by considerable intrusion as well as deformation and alteration. Hazelton rocks also form the steep walls along the valley of the Bear River and American Creek. These rocks lie along the axis of the American Creek anticline and are generally less deformed than those in the Salmon Valley, which will be described in the following in terms of geographic locations.

Lithology

The distribution of Hazelton rock formations in the Salmon River valley is illustrated on Figures 3 and 8. It is readily apparent in the field that the majority of the formations in Salmon River valley have been affected by dynamic metamorphism and are mainly cataclastics. In general, sufficient primary structures and textures are preserved to allow the sedimentary character of these rocks to be identified. The least altered or deformed formations are east of Cascade Creek on the upper slopes of Bear River Ridge, where they are partly overlain unconformably by lower Bowser assemblage sediments.

The various rocks described here as members of the Hazelton assemblage have apparently been imperfectly understood by previous investigators. Summary descriptions of McConnell (1913), Schofield and Hanson (1922), Westgate (1921), and Buddington (1929), are quoted in Appendix I, and from them one concludes the Hazelton is composed of greenstone, agglomerate, tuff, and (or) breccia. The sedimentary or epiclastic character of the members and the extent and kind of local deformation and metamorphism have been neglected or relegated to small importance in the past. One important contribution of the present study is the understanding of these rocks and their significance in terms of mineral deposits. It will be emphasized in this report that the major ore deposits in the area have been formed in altered, deformed volcanic epiclastics, where specific spatial and structural relationships have coincided. Recognition of the cataclastic nature of the prime host rocks and the processes leading to physicochemical ground preparation must be made before mineral exploration can proceed on a sound geologic basis.

Volcanic Epiclastic Rocks

Hazelton Assemblage in the Salmon River District

It has been pointed out that most of the Hazelton assemblage in the Salmon River district are cataclasites derived from pre-existing volcanic sediments. The essentially undeformed and unaltered Hazelton rocks in the area are primarily the products of the erosion of older volcanic pyroclastics, tuffs, and flows, and are epiclastic sediments *sensu stricto*. Some mixtures of pyroclastics and epiclastics are probably present and where doubt occurs the rocks can be classified as " tuffaceous sediments " (*see* Williams, Turner, and Gilbert, 1954, p. 252).

Most of the early workers in this area have generally classified the Hazelton members as agglomerates, flows, and tuffs. Brightly coloured units have been mentioned but have remained unexplained. The volcanic rock types just mentioned are produced directly by volcanic explosion or outpourings and are distinct from those produced indirectly by normal erosion and deposition of rock debris. Recognition of the epiclastic nature of the Hazelton assemblage was made difficult because fossils are scarce if not entirely absent and good sedimentary structures are not always at hand.

Distribution.—The areas of largely undeformed epiclastic rocks are outlined on the geological map (*see* Fig. 3 map units H1–H4). The main and perhaps best exposed area of Hazelton rocks is found on the west slope of Bear River Ridge above Premier. This section is overlain by lower Bowser sediments and trends north into the cataclasite sequence. Volcanic conglomerates and sandstones are prominent along the west slope of Big Missouri Ridge, but the exposures are commonly masked by oxide coatings. One can view a fairly good section of these rocks by climbing up the tote road alongside the remains of the Big Missouri surface tramway. Other slightly distorted or altered sections are found as lenses in the cataclasites.

Macroscopic Features.—Colour, grain size, and texture have been the principal parameters used in this study to discriminate the lens-like units outlined on the geologic map. With rare exception all the underformed Hazelton (Bear River Formation, *see* Table 1) rocks in the district exhibit a clastic or apparent fragmental texture. The fragments are angular and unsorted and all of these members of the local Hazelton rocks represent detrital, mostly non-marine, materials transported in an aqueous medium and accumulated under the influence of gravity in depositional sites. With minor exceptions the fragments and matrix are composed of relatively uniform porphyritic andesitic rock, angular quartz, and plagioclase. In general the individual lenses shown on Figure 3 are distinguished by predominant particle size and colour. However, none of the members are completely homogenous. Breccias, for example, include thin, fine-grained units and commonly grade laterally into conglomerates and sandstones with intercalated siltstone lenses. The colour variations are more readily defined and in case of poor outcrop the colour can with spatial restrictions be used as the distinguishing characteristic.

Fairly typical volcanic breccias are illustrated in Plates VIA and VIC from the Mount Dillworth and Premier areas. In these two examples the former represents a purple breccia in which porphyritic purplish cobble- and boulder-sized fragments are enmeshed in a reddish-purple sandstone matrix which forms less than 40 per cent of the rock. In the second type, which marks the other extreme, green angular boulders up to 3 feet long are embedded in a green sandstone-conglomerate matrix. Between these two extremes a number of colour and particle-size combinations exist. Significantly, these coarse members, which have undergone only slight cataclasis, stand up as cliffs and form the backbone of Bear River and other ridges.

Volcanic conglomerates and sandstones are present as minor lenses intercalated within the breccias (for example, map unit H4) as well as mappable units (map units H1, H2, H3). Slightly or undeformed sandstones and conglomerates in the Salmon River area are prominent along the west side of Summit Lake, where they are found as thick, green massive units intercalated with scattered thin siltstones, sandstones, and rarely lenticular green pebble conglomerates. Red and green volcanic conglomerates, with intercalated sandstones and breccia, are shown on the geologic map along the east side of Summit Lake where they are readily accessible from the Granduc road system.

Volcanic sandstone and tuff are ubiquitous throughout most of the Hazelton, occurring as thin-bedded, commonly well-laminated members. All the sandstones are relatively thin-bedded greenish members exhibiting fair sorting and angular grain. Red sandstones are present as distinct members within green sandstone-conglomerate assemblages, but are most prominent as intercalations with and within massive breccias. The major red beds are noted on the geologic map.

Most of the Hazelton sandstones and conglomerates in the Salmon River district exhibit prominent angular plagioclase clasts, which in indurated members give the rocks a pronounced porphyritic appearance. Hornblende clasts are almost ubiquitous in the green sandstones and conglomerates, but have not yet been identified in the red beds. Clasts of hornblende, described first by Buddington (1929, p. 21), are a common constituent of the sediments. Sphene and apatite are common accessory minerals in almost all the sandstones. Many of these sandstones are in part classifiable as lithic or crystal tuffs by virtue of their predominant rock or mineral fragment content. Field differentiations of the thin-bedded or laminated silty sandstones are generally difficult and require microscope assistance. In fact, most of the distinguishing textures of the fine-grained epiclastics and various cataclasites are discernible only in thin-sections.

Microscopic Features.—Microscopic studies of Hazelton epiclastics in the Salmon River district have revealed a fairly uniform texture and composition of the rock and mineral fragments. Most of the angular rock particles are fine-grained porphyritic andesite in which plagioclase is ubiquitous as lath-like phenocrysts. Quartz, plagioclase feldspar, hornblende, and very rarely alkali feldspar are typical mineral clasts. Quartz, present in only scant amount, is one of the few particles to show rounding. Hornblende, although apparently common as angular clasts, is generally altered to chlorite in pseudomorphs, which are difficult to distinguish from augite. Augite, however, is uncommon apart from the augite porphyry stocks at Glacier Creek, Long Lake, and Bear River Pass. Plagioclase is common to all the rocks and in the Hazelton epiclastics has a relatively uniform composition. Numerous optical determinations indicate a range of An_{27} to An_{35}, with $An_{32}\pm_{2}$ the predominant composition suggesting an andesitic parent. Unlike the plagioclases in the local igneous rocks, the volcanically derived feldspars in the epiclastics exhibit only normal zoning, not cyclic zoning. Alkali-feldspar clasts are rare in most of these rocks, but accessory zircon, apatite, and iron oxide are common. The red and purple colouration in some of the various volcanic sedimentaries has generally been related to the state of oxidation during the depositional episode. Iron oxides are present in varying amounts in all the purple, red, and green epiclastic members. Although the exact proportions of the iron oxides have not been determined chemically, some red sandstone samples contain up to about 40 per cent by volume. Judicious detailed geologic mapping and sampling would outline the iron-rich members.

Most of the undeformed or slightly deformed epiclastics are relatively unaltered. Minor sericite, chlorite, and carbonate alteration is essentially universal in the rock and mineral clasts forming the matrix.

Fossils.—Indurated coal fragments found in green epiclastics of the Big Missouri Ridge area were the only fossil materials discovered in any of the Hazelton members in the Salmon River district. The apparent absence of invertebrate marine fossils, the repetition of red beds possibly denoting strongly oxidizing conditions, and the scattered evidence of coal fragments appear to indicate a general non-marine environment of deposition.

Hazelton Assemblage in the Bear River District

McConnell (op. cit., p. 64) originally designated the name " Bear River Formation " for volcanic rocks in both the Salmon River and Bear River valleys. This terminology was clouded by Schofield and Hanson (op. cit., p. 11) when they introduced the term " Salmon River Formation " for part of McConnell's sequence. Later, while remapping the Bear River and Stewart map-area, Hanson (1929, pp.

7, 8) disposed of the name "Salmon River Formation," and in 1935 he (op. cit., pp. 4–6) instituted the name "Hazelton Group" for the volcanic assemblage in both districts.

Distribution.—With the exception of the Bowser assemblage, all of the bedded or layered rocks in the American Creek, Bear River, and Marmot River valleys are Hazelton assemblage. Like the Salmon River valley section, the Hazelton rocks in the Bear River district include siltstones, sandstones, conglomerates, breccias, and diverse metamorphosed equivalents. Cataclastic rocks are essentially restricted to the lower east slope of the Bear River valley and to plutonic margins. Probably, these deformed or crushed rocks underlie the main part of the Bear River floodplain. Like the narrow Salmon River valley zone, these relatively incompetent rocks have channelled glacial and stream erosion to help produce the over-deepened narrow trough of Bear River and American Creek that extends at least 35 miles north from Portland Canal to the Bowser River valley.

In the preparation of the present geologic map a crude, somewhat arbitrary, lithological division of the Hazelton rocks was made in the Bear River section (*see* Figs. 3 and 8). For purposes of this report the southern assemblage is termed the "Bear River valley member," and the overlying northerly beds the "American Creek member." The former consists mainly of green volcanic conglomerates with intercalated thin-bedded siltstones and irregular massive green volcanic breccias. These are locally overlain by the American Creek member, which is bedded, red and green volcanic sandstones and conglomerates. All of these rocks are overlain by recognizable members of the Bowser assemblage on both sides of the main valley.

Relatively few significant differences exist between epiclastics in the Bear River and those in the Salmon River valley. The geologic map attempts to illustrate the lenticular nature of the individual epiclastic members on the Bear River side and their relationships to rock units in the Salmon River valley. Overlying Bowser sediments and snow have obscured some of the lenticular nature of the Hazelton rocks, but there is sufficient continuity to show that the Bear River and the Salmon River valley sequences are all part of the same assemblage. None of the early geological studies extended across Bear River Ridge because of an extensive low snowfield, but this has diminished to a great extent and correlations are now possible.

Lithology.—Most of the previous descriptions of the volcanic sandstones, siltstones, conglomerates, and breccias of the Salmon River valley apply directly to the Marmot River-Bear River epiclastic assemblage. Although differences in the thickness of beds, colour, composition, and gross lithology do occur, detailed rock descriptions will not be repeated.

In the Marmot River area, most of the epiclastics are buff-weathering, well-bedded, green conglomerates with intercalated breccias and sandstones. Thin-bedded, dark-grey siltstones and red and purple sandstones as well as minor tuffs and limestones are present, but appear to form less than 20 per cent of the assemblage. Toward the Bear River the thin-bedded units become interspersed between massive, almost structureless, green conglomerates and breccias and minor green cataclasites. Very coarse massive green volcanic breccias in the Mosquito Creek (Le Sueur) area are somewhat unusual in that they have a scattered minor development of chrysotile along irregular fractures; otherwise they are not particularly distinctive. North of Bitter Creek the Hazelton assemblage changes perceptibly from a generally thick-bedded green conglomerate-breccia unit to a mixed red and green essentially conglomerate sequence. This change crudely makes the distinction between the southerly Bear River valley and northerly American Creek members.

Thin-section examination of the various rock units in the eastern map-area served to distinguish the minor thinly laminated green and buff cataclasite members along this edge of the Bear River from the bedded fine-grained green epiclastics. These deformed rocks are present along the river-road section as thin lenticular divisions within the indurated conglomerates and breccias and do not form large enough units for the present maps.

The majority of the epiclastics are composed of andesitic rock fragments as well as quartz, feldspar, and some hornblende clasts. Rock colour, which varies from green to red to black, appears on the basis of simple field relationships and laboratory tests to depend upon the state or degree of oxidation of the variable iron oxide content in the matrix. The so-called feldspar-porphyry flows and pyroclastic units mentioned in the old literature are for the main part indurated volcanic epiclastics. No true rhyolite members were found and flow material forms only minor intercalations within a predominantly non-marine epiclastic assemblage.

Metamorphic Rocks

Cataclasites

Macroscopic Features.—These rocks are largely composed of deformed, partially crushed, poorly bedded, fine- to medium-grained volcanic conglomerates or breccias, with thin intercalated sandstones.

The cataclasites include various mylonites, phyllonites, kakirites, as well as some schists, all of which occur as non-discrete zones cross-cutting mappable primary lithologic groups. The cataclasites include rocks which are shades of green, black, red, and purple, whereas the associated well-developed schists are a homogeneous buff or light green.

The coarse cataclasites, which seldom show their original sedimentary nature, on some weathered surfaces can be recognized as a heterogeneous accumulation of angular to subangular fragments of andesitic composition embedded in a clastic volcanic sandstone matrix generally of andesitic composition. Some of these coarse cataclasites retain the original sedimentary colours. The fine-grained cataclasites are commonly marked by a crude inch-scale layering which resembles primary bedding and, because of the feldspar clasts, have been described as tuffaceous or porphyritic. These rocks are noticeable in the Premier area (e.g., on the Big Missouri road below the Indian mine tramline) and are commonly marked by prominent bands of feldspar clasts, the larger of which crudely resemble phenocrysts. The metamorphic banding generally trends northerly, dips at a low angle to the west, and can be misconstrued as relict bedding. Lenses bearing coarse feldspar clasts intercalated within finely layered zones have the appearance of porphyritic sills injected within a predominantly volcanic assemblage.

Deformation.—All of these cataclasites, whether they are altered fine volcanic sandstones or coarse volcanic breccias, have a foliated appearance and are marked by a submetallic greyish to greenish aspect in addition to the primary rock colour. The foliation is variably developed, depending on the spatial proximity to intrusive contacts and zones of shearing. Areas of schist are noted on the geological map as discrete lenticular zones as at Summit Lake, or as in the broad area between Big Missouri and Premier. On the Alaskan side of the border, as noted by both Westgate (op. cit.) and Buddington (op. cit.), these cataclasites are apparently featureless in outcrop. On the Premier side, however, deformation has not been so completely pervasive and the textures of the original rocks are commonly visible as in Plate VII, which shows a typical greyish-green altered volcanic conglomerate.

Alteration.—Alteration is a prominent feature of the deformed parts of the Hazelton succession. Quartz, potash feldspar, pyrite, and hornblende are common as alteration products in the cataclasites, either as discrete mineral grains or as colour and textural variations. Cataclasis itself was low grade and merely caused crushing and distortion of the volcanic sediments. Metasomatism related to intrusion in the nearby Coast Crystalline Belt has variably altered some of these cataclasites, producing either simple silicification and pyritization or a variety of minerals. Only in the well-developed schists or in the Noname Lake area, however, have the rock textures been sufficiently obscured by metasomatism to hide their true character. The study of alteration requires the use of a microscope, but some minerals resulting from recrystallization can be identified macroscopically. A crude measure of the nature of such microscopic alteration is given by the colour of the cataclasites. The dark-green foliated rocks generally have chlorite as an important constituent, whereas the very light green are usually sericitic or quartzose. Quartzose varieties are distinguished by hardness.

Microscopic Features.—The true nature of the Cascade Creek cataclasites is revealed in thin-sections where the texture, composition, and alteration can be observed. In the great majority of the cataclasites of the district the parent material is still recognizable. These are referred to as kakirites or more generally as cataclasites. A few, recognized under the microscope, have reached an extreme stage of granulation and are referred to as mylonites.

Mylonite

Mylonites are found in the district at a number of places as transitional phases of the cataclasite units. Readily accessible locations include the rock cut at the north side of the mine manager's house, No. 4 level area Premier, a contact zone 550 feet north of the intersection of the Big Missouri road and the Indian mine tramline, and a zone 1,000 feet northwesterly from Cobalt Creek on the Big Missouri road. Other general areas include Big Missouri Ridge between Noname Lake and Hog Lake, where numerous lenses of mylonites are preserved within the schists.

Macroscopically these mylonites are black, red, or purple and vary considerably in colour. They are generally recognized by a dense, fine-grained pseudoporphyritic texture. The relict crystals are either plagioclase or quartz (one predominates), comprising from 8 to 50 per cent of the rock. The plagioclase clasts all fall within the composition range An_{28-32}, with plagioclase of composition An_{30-32} forming the bulk of the specimens examined. They are typically angular, with marginal strain effects and are enveloped within a very fine-grained granulated matrix composed of quartz, feldspar, sericite, or chlorite, as well as iron oxide " dust " which imparts either black, red, or purple tones to the rock. The quartz eyes are always ovoid with clear sharp outlines that seldom exhibit marginal strain effects but commonly contain undulatory extinction bands.

Most of the mylonites have quartz or feldspar as eyes but a few samples taken from lenses south of Hog Lake have relict rock fragments as eyes and are termed kakirites. In these the augen consist of plagioclase (An_{30}) porphyry fragments, embedded in a finely granulated feldspathic matrix containing abundant iron oxide which envelopes each fragment and imparts a black colour to the rock.

Relict hornblende crystals have been recognized either as partially altered fragments or as vague ghosts in several of the black mylonites in which inclusions and fragments of apatite and rarely sphene are ubiquitous. These rocks occur as lenses within the extensive schist zone west of Silver Lakes and the parent material is not preserved, but it was probably a medium- to coarse-grained hornblende quartz diorite similar to the nearby Texas Creek granodiorite.

The grain size of these mylonites appears to be fairly uniform, disregarding alteration. The augen of quartz, plagioclase, or rock fragments consistently average about 1.5 to 2 millimetres. The matrix particles consisting of granulated minerals, iron oxides, and alteration products are generally one-twentieth the size of the eyes or less.

Alteration has primarily affected the matrix of the mylonites, which is commonly traversed by very fine-grained replacement quartz, carbonate, or epidote. Sericite and chlorite are common minor constituents of the matrix, which introduce a weak, lamellar fabric to these rocks and may have been in part produced by indirect componental movements, that is, as a result of intergranular diffusion and crystalloblastesis. The fact that the mylonites are spatially related to the schist zones suggests tectonic deformation was operative and was aided in recrystallization by selective chemical processes.

There are no significant mineral deposits known to occur in unaltered mylonite, but mylonite lenses are present near or within ore zones at several deposits, notably the Big Missouri mine.

Cataclasites

Fine-grained cataclasites are difficult to distinguish from mylonites except where textures are unusually well preserved. In thin-section the cataclasites may have augen of parent rock (kakirite), but the matrix itself, if preserved, is also composed in large part of rock fragments with various proportions of admixed mineral particles. Quartz or feldspar augen and rock fragments are enclosed in a fine-grained matrix of rock and mineral fragments and iron oxide in which the constituents vary between clearly recognizable parent fragments and largely altered material of questionable origin. The large relict particles in these rocks average 2 to 3 millimetres or about 10 to 20 times larger than matrix fragments. Dust-size green, red, or black iron oxides are ubiquitous and, although they seldom account for more than 1 or 2 per cent by volume, they coat most matrix grains and determine the rock colour.

The differences between the fine- and coarse-grained cataclasites are merely caused by the degree of fragmentation. The initial composition and texture of parent material appears to have partly contributed to the formation of the product as indicated by the presence or absence of quartz, feldspar, or rock particles as augen. Alteration (metasomatism) has commonly affected the fine-grained matrix material in preference to the coarse eyes and coarse-grained cataclasites. A marked foliation of the majority of the cataclasites and some of the mylonites has been imparted by the development of sericite and chlorite. These minerals are poorly developed as in the phyllonites.

Cataclasites are the most significant rock units in the Salmon River district. All of the major ore deposits, including the Premier, have been found in altered cataclasites derived from green volcanic conglomerates and sandstones. The localization of economic mineralization in these rocks has been elaborated on in Chapters 4 and 5.

Schists

Distribution.—Schists developed in the Hazelton assemblage are areally next in importance to the cataclasites. The areas in which mappable schists are found have been outlined on Figure 3 (map units M and M3) and are most prominent east of Summit Lake. The schists form complex shear zones in the Hazelton country rocks and commonly include lenses or horses of mylonites and cataclasites. These shear zones are economically important because of the mineral deposits which lie within them.

Macroscopic Features.—The schists can usually be distinguished from the associated cataclasites on the basis of colour and texture. They are almost inseparable from phyllonite schists of the Bowser assemblage except for their uniform light buff or greenish coloration, which also distinguishes them from the surrounding dark-green, volcanic cataclasites and dark mylonites. True coarse-grained or well-developed schists are rare and the term " semischist " (*see* Williams *et al.*, op. cit., p. 205) is probably a more accurate description. Schistosity or foliation, however, is well developed and readily measured. A few scattered relict plagioclase clasts up to 5 millimetres are discernible in the schists. They all contain 5 to 10 per cent fine- to medium-grained cubic pyrite as well as varying small amounts of fine magnetite. Carbonate appears to be ubiquitous and is found as scattered grains or veinlets with quartz cutting the schistosity. The surface expression of these schist zones has been manifested as extensive bright red, orange, or yellow gossans and as weak depressions that are particularly prominent on the extensive open slopes above the Salmon Glacier. In hand specimen the schists are commonly friable and marked by vug-like pores where sulphide and carbonate grains have been leached.

Microscopic Features.—In thin-section the schists consist of very fine- to fine-grained aggregates of muscovite, plagioclase, chlorite, quartz, and carbonate, as well as accessory pyrite and black oxide. " Sericitic " muscovite generally makes up 25 to 40 per cent of the matrix with the other components varying widely. A few small remnants of parent rock are commonly visible and indicate the low grade of the dislocation metamorphism which produced these schists from original volcanic sandstones and conglomerates. Residual plagioclase clasts are extensively altered and general examination suggests a composition range of An_{28-32}, indicating an essentially andesitic composition similar to the surrounding cataclasites. Quartz and carbonate (calcite) are common alteration minerals which together comprise from 10 to 70 per cent of the schists. These latter carbonate-rich rocks have a faint greenish-white colour and lack the well-defined fissility of the normal schists.

On the basis of macroscopic and microscopic examination, the schists can be classified mineralogically as quartz-feldspar-sericite schists with more or less accessory pyrite, magnetite, and carbonate. Rock fragments, although of minor importance volumetrically, determine the origin and grade of metamorphism. It is concluded that these schists have been produced from Hazelton volcanic sandstones by low-grade dislocation metamorphism accompanied to some degree by metasomatism. The intercalation of kakirite and mylonite with schist suggests that the kinetic process was selective favouring volcanic conglomerate and breccia while the chemical processes likewise selectively aided the development of muscovite, chlorite, etc., in the more homogenous sandstones.

Origin of the Deformed Rocks

In the foregoing descriptions it has been indicated that the extensive and important cataclasites, mylonites, and schists have been derived from a pre-existing sedimentary sequence of volcanic debris. Abundant relict textures still evident in spite of dynamothermal metamorphism leave little doubt as to their origin. Surface weathering and limited recrystallization have locally obscured the diagnostic features and have led in the past to various erroneous identifications which have stressed a simple volcanic origin and have disregarded metamorphism.

The dynamothermal metamorphism which has produced these rocks was essentially restricted to a buffer zone along the margin of the intrusive Texas Creek granodiorite and Hyder quartz monzonite, where the volcanic sediments were crushed and reconstituted by the plutonic invasion. The event was low grade, as indicated by the relict structures and textures, but it involved a complex interplay of cataclastic and crystalloblastic processes. These produced the various mylonites, cataclasites, and low-grade schists which now comprise most of the rocks of the Hazelton assemblage in this zone. Textures in the schists suggest that recrystallization outlasted the deformational events. Undeformed micas are aligned in the schistosity planes produced during cataclasis and recrystallized quartz and plagioclase grains show no obvious signs of strain or granulation. That these minerals are undeformed indicates that large scale deformation was restricted to the Texas Creek plutonic invasion.

Correlation and Thickness

No recognizable base of the Hazelton has been located in the Stewart district on structural evidence, and without fossils it is very doubtful that any separation between the Triassic and Jurassic rocks is possible because of the similarities in lithology.

Thickness estimates can be misleading in the Stewart district. The effect of structure is relatively minor, but the lenticular nature of the various members of the Hazelton requires separate measurements for individual locations. The accompanying geologic sections illustrate a somewhat approximate rock sequence which, although difficult to measure or scale directly, indicates a thickness of about 15,000 feet. The importance of plutonism cannot be ignored in this matter because it appears that much of the local country rock merely overlies an extensive plutonic basement complex.

East of Stewart in the main west margin of the Bowser Basin recent estimates based on extensive fieldwork (Pan American 1960, private exploration report) indicate that the thickness of a complete Jurassic section approaches 20,000 feet. Along the axis of the basin these rocks are overlain by probably 15,000 feet of younger sediments. Within the same basin similar estimates place the Triassic column at about 13,000 feet and these are in turn underlain by thick Palæozoics.

BOWSER ASSEMBLAGE

The various rocks included in this group comprise a series of non-marine and marine sediments and minor volcanics. These rocks are individually almost indistinguishable from underlying members of the Hazelton assemblage, but fortunately excellent exposures and fossiliferous horizons combined with structural disconformities have permitted the separation of the two assemblages. Structural remnants of the Bowser rocks now remaining in the Stewart area would have been difficult to interpret had the companion study of the regional geology between Alice Arm and the Iskut River not made it possible to separate the Bowser and Hazelton assemblages with some assurance.

The Bowser rocks occupy parts of the Stewart area from the Marmot River to Tide Lake Flats. They include an accumulation of coarse to fine vari-coloured clastic material forming individual beds from a few inches to tens of feet thick. Conglomerates, sandstones, and siltstones predominate with the coarse materials most prominent at the base. Fossils are restricted to a few horizons in this area and the state of preservation is usually poor. To the north and east the units are well developed and fossil assemblages are extensive and fairly well preserved.

The name " Bowser Group," as proposed by Duffell and Souther (1964, p. 28) as an outcome of Operation Stikine (1957), referred to certain rock exposures at Bowser Lake. Previously the extent of the Bowser Basin had not been fully recognized and a diversity of local terms had been applied to the same formations. This problem of nomenclature has been reviewed by Duffell and Souther (op. cit., p. 27), who argued that as the early names applied to only small parts of the main sedimentary basin these names were redundant and could logically be replaced by a unifying term, namely Bowser " Group." As part of the writer's regional project (*see* p. 20), the Bowser Lake as well as several other sections between the Iskut River and Alice Arm were mapped in detail. The name " Bowser " is used here until the problem has been examined thoroughly and resolved on a basin-wide approach and " Group " has been dropped in favour of the non-specific term " assemblage."

Distribution

In the Stewart map-area, rocks included here as Bowser assemblage generally occur as isolated structural remnants of the vast basin formations that lie to the east. The various areas of probable Bowser rocks are shown on the geologic map (Fig. 3) and on the Bowser distribution map (Fig. 9). Exposures of all the patches are good, but some are highly deformed. The main zone perched along the top of Bear River Ridge north of Mount Bunting has undergone the least deformation, has the greatest diversity, and provides the most information. Except for the Mount Dillworth snowfield, the rock exposures are almost complete and a good section is available along Betty Creek and Betty Glacier. This patch of Bowser extends northward beyond the map into the Bowser River area where it eventually merges with the main basin formations. Several of the other patches at the edge of the present area can also be traced into or joined to the basin.

In the Hyder area, Buddington (op. cit., p. 17) assigned a greywacke-slate division to the Hazelton because he found no fossils and because of their similarity to rocks immediately across the border. However, Buddington (op. cit., p. 18) stated:

> The evidence at hand seems to indicate that the greywacke formation is not the equivalent of the Bear River formation but overlies it and that the greywacke is in turn overlain by a formation characterized by slaty argillite.

In the Hyder district these rocks occur as pendants which, on the basis of present information, probably represent structural remnants of the Hazelton assemblage which, prior to intrusion and erosion, extended much farther than has been assumed in the past. Recent work in southeastern Alaska (Brew, *et al.*, 1966, pp. 149–170) indicates that there is at present no known record of Early or Middle Jurassic sedimentation in that area. Succeeding Upper Jurassic and Lower Cretaceous sedimentation was largely concentrated in the Pacific Coastal trough and the Hyder greywacke-slate division has only been included in Brew's grouping on the basis of Buddington's 1929 report. Fossil evidence presented by Hanson (1935, p. 25) for the sediments at Divide Lake indicated a Middle Jurassic age. Latterly these same sediments have been grouped as Upper Jurassic-Lower Cretaceous (*Geol. Surv. Canada,* Map 9-1957 and by Brew, *et al.*). Obviously, the fossil and other conflicting evidence required reviewing.

Lithology

Reference to the geologic map and the Bowser assemblage distribution map illustrates the variable nature and occurrence of the Bowser sediments in this area. Only the uppermost siltstone-sandstone unit maintains an apparent continuity throughout the district. The lowermost Bowser rocks have a lenticularity similar to underlying Hazelton units, and facies changes within relatively limited distances are notable. In the Betty Creek area the relationship between Hazelton epiclastics and sediments, and the overlying Bowser conglomerates and sandstones, is clearly an unconformable one. This basal conglomerate-sandstone unit is in turn overlain disconformably by the siltstone-sandstone member, which in itself shows facies changes within limited distances. In this general section the lower conglomerates and sandstones lens out to the south and west but are continuous to the north and east beyond the map-area. This unit appears to be missing in the Bitter Creek and Salmon Glacier sections, where only the dark siltstone-sandstone member has been recognized. The lenticular nature appears to be a characteristic of this lower unit along the fringes of the Bowser Basin between Alice Arm and the Iskut River.

In summary, the Bowser sediments found in the Stewart area have been divided into two main units on the basis of structural and lithologic relationships. The lower unit overlies the Hazelton epiclastics unconformably and consist of predominantly red and green sandstones and conglomerates. These are in turn overlain disconformably by a siltstone-sandstone assemblage marked at the base by rhyolite, limestone, and conglomerate members. Locally, identifiable fossils have been found in the basal siltstone unit in the mixed or transitional zones and other fossil assemblages so far unidentified have been located in the siltstones in stratigraphically higher positions.

Except for clear structural relations, it would have been difficult to separate the lower Bowser Betty Creek epiclastic member from the underlying Hazelton assemblage. This member extends into the Stewart area from the north as a wedge-like mass which thins and disappears in the Summit Lake section. Upward, in section, the green-red volcanic conglomerates and sandstones blend conformably with thin-bedded dolomites and sandstones, and then rapidly grade into the predominantly black Bowser marine siltstones. To the south in the Long Lake valley, at an approximately equivalent horizon, the epiclastics are missing, but a lens-like rhyolite mass is represented. The Monitor rhyolite has its maximum exposure south of Long Lake, but has been traced to Divide Lake, where it has been found as thin layers intercalated with bedded dolomites, sandstones, and volcanic conglomerates. Dolomites and sandstones were also identified as intercalated with the rhyolite flows in the main area. Bowser siltstones immediately above the Monitor rhyolite are marked by a basal fossiliferous littoral unit which has been traced from the south end of Summit Lake, around Mount Dillworth to the north end of Divide Lake, and then south past Long Lake into the crest of Bear River Ridge. These various members have been shown diagrammatically in the composite lithologic column for the Stewart map-area (Fig. 7).

Betty Creek Epiclastic Member

At Betty Creek the lowest units consist of intercalated beds of non-marine red and green sandstone and conglomerate. On the geologic map these have been subdivided into four mappable members mainly on the basis of colour, which readily sets them apart in the field. Typical examples of all four members are shown on Plate VIIIA which illustrates green conglomerates with intercalated red sandstones and siltstones as lenticular separations. Plate VIIIB is a close-up view of bedded, green conglomeratic sandstone. Most of the rock fragments forming these rocks consist of andesitic volcanics similar in colour and composition to the underlying Hazelton volcanic epiclastics. Cross-bedding and graded-bedding are typical primary features found throughout the sequence. Fossils are totally unknown in these units so far. The rapid variation from red to green with red becoming the predominant colour suggests a non-marine origin not unlike that proposed for the Hazelton epiclastics. Scattered coal or metamorphosed coaly fragments have also been found in these units, but the amount of such material is scant.

As illustrated on Plates VIIIA and VIIIB, the fragments in the conglomerates and conglomeratic sandstones are angular and vary considerably in grain size. The largest pebbles or cobbles are up to 4 inches, but the average is probably one-half to 1 inch. The sandstone particles, like the cobbles, are angular, probably indicating rapid deposition. Thin-section examination shows these volcanic sandstones to consist largely of rock fragments and from 10 to 40 per cent plagioclase clasts. Alteration of the particles varies but commonly includes minor chlorite and sericite. The oxide which gives these rocks their colour lies in the intragranular material forming up to 20 per cent by volume of the matrix of bright brick-red sandstones.

The red sandstone member (Map Unit B4) underlying the dark siltstone on the west side of Troy Ridge forms a conspicuous unit which has been traced north of the map-area into the main Bowser section. To the south the same member thins out and finally disappears toward the south end of Summit Lake. East along Betty Glacier the upper green conglomerate increases in apparent thickness then thins toward American Creek. Along American Creek the red and green intercalation is repeated, but is thinner than in the Betty Creek section. The red and green members continue south along the upper part of Bear River Ridge as easily traced units disconformably underlying the dark siltstones. At Mount Bunting a rapid facies change from conglomerate-sandstone to red breccia is accompanied by a great increase in apparent thickness. To the west the red breccia lenses out rapidly into a thin red sandstone.

This red breccia is one of the competent rocks cut by the Portland Canal dyke swarm (main swarm) and the emplacement of the dykes may have produced the anomalous thick section merely by displacement. The breccia is composed largely of angular green andesitic (porphyry) volcanic fragments forming up to 50 per cent of the rock surrounded by a bright-red conglomeratic volcanic sandstone. Other large fragments embedded in the red matrix include purplish-red sandstone blocks and minor scattered black scoria. Blocks up to 3 feet long are common and blocks about 1 foot across predominate.

At Betty Creek the measured thickness of sandstone and conglomerate is about 2,500 feet. Elsewhere these members measure from a few feet or less to a few hundred. The irregularity in extent of these members, their local diversity, and colourful aspect mark the characteristics of the lower Bowser wherever it has been found in this area. In addition, the vari-coloured sandstones and conglomerates in the area east of Divide Lake are distinguished by having thin, irregular lenses and blebs of pale-blue or brick-red chert in the matrix. Commonly these lenticles conform to the bedding planes and produce a bright striping. These rocks were not studied in sufficient detail to determine the nature and origin of the chertification or its apparent localization.

Monitor Lake Rhyolite

The rhyolite and rhyolite-breccia members mapped at the south end of Long Lake represent the only large area of such rocks recognized in the entire map-area. Rhyolites noted by Hanson (op. cit., p. 8) in the Porter Idaho area in the Hazelton on close examination are clearly epiclastic.

Massive rhyolite and rhyolite-breccia that surround Monitor Lake lie unconformably on Hazelton epiclastic sandstone and conglomerate and are disconformable below the prominent, dark, Bowser siltstone-greywacke sequence. In aspect the rhyolite member is conspicuous because of the light greyish-green colour with scattered light-buff plagioclase phenocrysts, but especially because of numerous pipe vesicles (gas tubules) that traverse the rock. For the most part the vesicles are perpendicular to the layering, and cross-sections are elliptical in the plane of a very weakly developed schistosity. The void in these rocks produced by the tubes amounts to about 10 per cent. These tubes average one-eighth inch in diameter and appear to extend for several inches as discrete individuals through most of the rock. In thin-section the rock is composed of very fine-grained quartz and sodic plagioclase. Minor carbonate, sericite, and scattered chlorite were found in all thin-sections.

A similar bed about 2 feet thick and of minor extent intercalated with finely bedded sandstones and conglomerates was located at the northeast end of Divide Lake, also at the base of the Bowser siltstone.

At Monitor Lake the vesicular rhyolites are intercalated with thin fine-grained dolomitic limestones, sandstone, and striped siltstone. The total thickness of this zone is difficult to measure at this particular section because of fairly close folding and the lenticular nature of the members. An estimate of thickness is about 2,000 feet. Within the massive white-weathering rhyolite, flow tops as well as indications of flow banding are apparent and suggest that the individual flows averaged 10 feet thick. Several of the flows are intercalated with thin, lenticular masses of dense aphanitic limestone. Feldspar and quartz clasts, as well as rhyolite fragments, form about 1 per cent of the limestone which are conspicuous in hand specimen as well as thin-section. Under the microscope the limestone is a thinly laminated fragmental rock, with undetermined, distinct, dark spheres measuring 0.2 millimetre in diameter scattered throughout. It appears from the fine laminations in the limestones that they were deposited by erosion rather than as simple precipitates between rhyolite extrusions. Whether the flows themselves are marine or non-marine was not determined.

The rhyolite breccia which underlies the thin-bedded rhyolite-limestone sequence at Monitor Lake was judged to be about 500 feet thick, but the very irregular nature of the deposit suggests a complex outline partly determined by the uneven topography of the underlying Hazelton epiclastics. The breccia, which weathers white, is characterized by irregular, closely packed, angular blocks producing coarse, pavement-like texture. In outcrop and thin-section the rocks forming the breccia and massive flows are similar in composition. Where traversed by local shears, both the breccia and flow rocks have a greenish cast indicating sericitization. Minor siltstones as lenticles are common in both the breccia and the flows. On the west side of Troy Ridge, one lens of thinly laminated, tuffaceous, green sandstone and dolomitic limestone 80 feet thick is well exposed. It lies between the lower red sandstones-conglomerate unit and the upper black siltstones and greywackes in approximately the same stratigraphic position as the rhyolite-limestone-breccia unit. This tuffaceous zone is shown on Plate XB, which clearly illustrates the sedimentary nature of the sequence. This zone probably represents a transitional phase between the relatively restricted environment of the rhyolite flows and breccias and similarly restricted sedimentary deposition, and suggests a platform-type environment. Elsewhere in the map-area this stratigraphic interval is marked by a sharp and pronounced colour contrast or by a disconformity underlying coarse, unsorted, clastic materials resembling beach deposits. These are described in the following pages.

Siltstone-Sandstone Members

The siltstones and sandstones of the Bowser assemblage were previously described as the Bitter Creek Formation (McConnell, op. cit., p. 6), the Nass Formation (Hanson, 1922, p. 13), the Salmon River Formation (Hanson and Schofield, op. cit., p. 12), the Hazelton Group (Hanson, 1935, pp. 6–13), and latterly the Bowser Group (*Geol. Surv., Canada,* Map 9-1957). A swift perusal of the available literature will readily indicate the lateral variations in these sediments which have led to diverse interpretations. Most commonly the rocks have been called argillites, slates, slaty argillite, shale, greywacke, and sandstone, with conglomerate, limestone, quartzite, tuffs, etc., included as minor elements. The present interpretation of the stratigraphic sequence in the Stewart map-area applies only to a restricted west central part of a very complex assemblage which covers the Bowser Basin.

Distribution.—The siltstone and sandstone members of the Bowser assemblage apparently formed a continuous blanket-like mass, at one time completely covering the Stewart district. Tectonism, plutonism, and erosion have since combined so that only scattered structural remnants have survived. The present distribution of these patches is shown in detail on Figure 3 (Map Units B1, B2). Complex folding within the members and the lack of area marker beds has made mapping and close correlation problematical. In addition, these siltstones and sandstones can be easily confused with the restricted lenses of similar rock in the underlying Hazelton.

Lithology.—In the Stewart map-area the components of siltstone-greywacke division are a prominently bedded assemblage of mostly marine clastic rocks derived from the erosion of predominantly volcanic terrain.

Conspicuously colour-banded siltstones form the most prevalent rock type. The term " argillite " has been applied almost exclusively to these rocks but, in examination under the microscope, clay-size material appears to be restricted to the grain matrix and few argillites in the petrologic sense were encountered (*see* Williams, *et al.*, op. cit., p. 279). Colour variations in the siltstones are limited to combinations of shades of grey, buff, and black, with dark greyish-black most common. The colour generally indicates the grain size and approximate composition. Black usually suggests a carbonaceous high-clay matrix with very fine silt-sized quartz, feldspar, and rock clasts. With an increase in rock and mineral fragments and a concomitant decrease in clay and organic material, the colour generally goes from black through grey to buff. As with other sediments in the area a black colour in the siltstone sometimes implies an iron oxide-rich matrix rather than fine grain size or organic-rich material. Graded bedding is typical of laminæ and beds throughout the assemblage. Most of the siltstones examined were poorly sorted rocks composed of roughly equal (but variable) quantities of very fine-grained mineral and rock fragments. Lenses of well-sorted calcarenite and quartzite were found interspersed within the drab siltstone sequence. These occur as thin lenses and minor beds that blend with the siltstones and are most prominent within the lower or basal siltstone member. Black and white chert-pebble conglomerates were found within the basal siltstones on the ridge at the northwest end of Long Lake and along the west slope of Mount Dillworth. At Long Lake, indurated black and white pebble beds about 30 feet thick are intercalated within banded siltstones. Elsewhere in the area pebble conglomerates are restricted to thin layers, mostly in the main greywacke member.

In the Mount Dillworth-Divide Lake area a possible beach deposit at the base of the siltstones in unconformable contact with underlying conglomerates has special significance. These dark, poorly bedded, irregular deposits consist of a great variety of gravel and cobble-sized sedimentary and commonly vesicular volcanic fragments. This is the only major fossiliferous horizon in the Stewart area in either the Hazelton or Bowser rocks. The locality first noted by Schofield and Hanson (1922) at Divide Lake has been extended north and south of Divide Lake, and new fossil locations on the west side of Mount Dillworth in the same beach deposit zone were uncovered in 1965. The unsorted, irregular nature of the deposits, the lack of graded bedding, and the abundance of fossils suggests deposition in a littoral zone.

Above the beach deposit the siltstones and associated minor pebble conglomerates, quartzites, and calcarenites persist over a fairly extensive part of the central map-area. Without the beach deposit or the equally obvious Monitor Lake rhyolite member it would often be difficult to delineate the base of the siltstone member in the Stewart district.

Two main areas of impure sandstone generally classed as greywacke have been outlined within the Mount Dillworth-Bear River Ridge section of the Bowser siltstone-sandstone sequence (Figs. 3, 6). Possibly the two areas which flank Mount Dillworth merge, but continuity is obscured by heavy snow, high cliffs, and complex structure. Both areas of sandstone lie within the siltstone several hundred feet above the siltstone base. These impure sandstones are predominantly dark-grey lithic wackes (Williams *et al.*, op. cit., pp. 289–291) that are wholly volcanic in nature and differ only in grain size from the siltstones. Feldspathic wackes, quartz greywackes, greywackes (op. cit., pp. 293, 294), and arkosic wackes are included in the sequence. Most of these rocks form fairly massive beds several feet to a few tens of feet thick, intercalated within thin-bedded striped siltstone. In the general area outlined, these sandstones form from 20 to 80 per cent of the country rock and probably average about 40 per cent over all. Thinly layered pebble conglomerates with graded bedding and siltstone breccias are common in the thick sandstones. Without exception all these grey sandstones appear to lens out within the limited areas shown and are not found elsewhere in the Stewart map-area. Buddington (1929, pp. 20, 21) mentions similar greywacke belts in the Hyder district where they are intercalated with siltstones (argillite). At this time it is not a simple matter to correlate these greywackes or similar sandstones which recur throughout the area with those on Mount Dillworth because of the general paucity of macro-fossils and the lack of distinctive lithologies in the enclosing siltstones.

In general, Bowser rocks in the Stewart area are only weakly indurated or locally phyllitic. Sporadic fine-grained andalusite developed in thin-bedded argillaceous lenses suggests a regional low-amphibolite grade of metamorphism. On Slate Mountain, striped siltstones have been weakly metamorphosed to platy phyllites, not slates as the name implies. Minor graphitic zones related to faults are common but relatively unimportant. The significant local metamorphism and deformation are related to plutonism and are discussed on page 71 and in Chapter 4 on the structure of the area.

Fossils

Fossils collected from the west slope of Mount Dillworth near the base of the siltstone member and from the other sites shown on the geological map have been studied by J. A. Jeletzky, of the Geological Survey of Canada. Most of the collections included poorly preserved fragmental material and are not specific enough to be definitive. The Mount Dillworth locality of marine invertebrate fossils has been subsequently revisited and more extensive collections were made in 1967.

IDENTIFICATIONS

FIELD NO. I — GSC loc. 69403

From: Lat. 56° 09′ N. Long. 130° 02′ W. Salmon River Area. West slope of Mount Dillworth. Elevation 5,000′.

Cylindroteuthis (*Cylindroteuthis?*) sp. indet.
Trigonia (*Haidaia?*) sp. indet.

Pelecypods, genus and species indet.
Solitary corals, genus and species indet.

Age and Correlation.—Presumably of the Middle (Bajocian or Bathonian) to early Upper (Callovian to early Oxfordian) Jurassic age, but cannot be dated definitively because of extremely poor preservation of all fossils available.

FIELD NO. II — GSC loc. 69404

From: Lat. 56° 11′ N. Long. 129° 58′ W. Divide Lake, east shore. Elevation 3,440′.

Generically indeterminate representatives of Trigoniidæ of general Jurassic or Cretaceous affinities.

Age and Correlation.—According to E. T. Tozer (*pers. com.*) these generically indeterminate trigoniids could hardly be Triassic in age. They must, therefore, be of a general Jurassic or Cretaceous age. Cannot be dated any closer.

FIELD NO. III

From: Lat. 56° 07′ N. Long. 129° 58′ W. Bear River Ridge. East side of Long Lake. Elevation 4,300′.

Indeterminate belemnite-like Coleodea.
Indeterminate pelecypods.

Age and Correlation.—Presumably Mesozoic. Cannot be dated any closer.

The fossils collected from Divide Lake (Field No. II) were first described by Hanson (1935, p. 25).

> Fossils were also collected from two or three horizons close together and near the base of sediments overlying the Bear River igneous body at Divide Lake, Bear River district. F. H. McLearn examined them and reports as follows:—
>
> *Trigonia* sp. No. 1, *Trigonia* sp. No. 2, *Trigonia* sp. No. 3.
>
> Three are new species of genus Trigonia, section *undulatæ*:—
> *Belemnites* sp., too fragmentary for identification.
> *Gryphæa* sp., too immature to permit specific determination.
> *Pecten entolium* sp., too poor for identification.
> *Cucullæa* sp., probably new species.
>
> The Trigonia specimens suggest but do not prove a Jurassic age.
>
> Crickmay has described two new species of Trigonias from Divide Lake. He names them *Vaugonia veronica* and *Vaugonia mariajosephinæ* and dates them as Middle Jurassic.
>
> A fossil was collected from the sediments underlying volcanic rocks of the Bear River igneous body on Kate Ryan Creek. The fossil is very poorly preserved and is placed doubtfully by McLearn in the genus Calamophyllia. The age suggested is Triassic to Jurassic. An indeterminate fossil was collected from Glacier Creek, Bear River district.

The difficulties inherent in identifying Jurassic marine invertebrate fossils, coupled with the general paucity of good material, forces one to assume for the present an apparent Middle Jurassic age for Bowser sediments in the Stewart map-area. Fortunately, work in progress based upon more extensive fossil material should help resolve the Bowser age locally, at least.

The siltstones in the Salmon Glacier, Glacier Creek, and Bear River Pass areas were examined fairly closely but no fossil collections were made. The correlation here of these rocks with the Middle Jurassic Mount Dillworth-Divide Lake assemblage has been made mainly on structural evidence coupled with their gross similarities. It is still not possible to date either the sandstone-conglomerate assemblage that underlies the fossiliferous siltstones or the ubiquitous Hazelton epiclastics locally, and their placement in the stratigraphic sequence is based upon regional relationships.

DISCUSSION OF LITHOLOGY

This study of the geology of the Stewart area has drawn attention to various features that require comment and interpretation, and which bear on geological evolution and the manner of origin. The sedimentary and volcanic rocks represented here were developed and deposited within the Bowser Basin, a major unit in the tectonic framework of British Columbia, about which only preliminary information is presently available.

BOWSER BASIN

The location and approximate extent of the Bowser Basin is illustrated on Figure 14.

Very generally the Bowser Basin can be described as a successor basin, one of several which occur within the Basin and Belt province of the northwestern cordillera. The parent Bowser sub-trough (Brew, 1968) apparently joined the northerly Whitehorse sub-trough, and also extended south to include the successor Central Interior Basin, forming what Gabrielse and Wheeler (1961) termed the "Central Belt." The northerly sections of this feature, the Tagish Belt, including the Atlin Horst, are fairly well known and have received a considerable amount of geologic attention in the last two decades. The Bowser Basin, lying roughly between the Stikine River and Babine Lake, has not attracted the same concentration of effort because of the generally poor weather, difficult topography, lack of access, and, more importantly, the presumed low economic potential. In general, the limits of the Bowser Basin (Nass Basin of some reports) have not been well defined and have been variously indicated as a structural depression partly bounded by high-angle faults, the apparent depression covered by Mesozoic Bowser assemblage, or the depression lying between the Coast Crystalline Belt and the Cassiar-Omineca Plutonic Belt.

In the broad sense the Bowser Basin has evolved from the sub-trough by a complex interplay of tectonic, volcanic, sedimentary, and igneous events which have produced a northwest-trending sedimentary basin about 100 miles wide and 200 miles long. It is visualized as a relatively unmetamorphosed, thick, sedimentary-volcanic succession bounded along its periphery by Palæozoic rocks and apparently in part at least underlain by an early Palæozoic-Precambrian(?) igneous-metamorphic-sedimentary complex, comparable to the Horseranch-Wolverine Complexes. Recent geologic mapping in the southern half of the Bowser Basin shows a complexity of plutonic intrusion ranging in age from Triassic to Tertiary. The general geological features of this area and the distribution of known plutons are illustrated on Figure 1. Intrusives within the basin have been referred to as the Skeena plutons, a relatively general term including several types and ages of pluton. As indicated on the map (Fig. 1), a large part of the better-known basin area has been invaded by swarms of igneous bodies in part limiting the potential hydrocarbon areas but at the same time increasing the potentially metalliferous area. As exploration and mapping throughout the basin continue, it appears likely that the known number and extent of Skeena plutons will be enlarged. At present these plutons include a great compositional variety, including granite, granodiorite, quartz monzonite (which appear to predominate), quartz diorite, gabbro, syenite, monzonite, diorite, as well as most textural types. Structurally they include plugs, stocks, batholiths, sills, dykes, diapirs, and deformed tadpole-shaped masses. Apart from the obvious plutonic concentration in the basin margin areas, other zonation is still undefined.

Palæozoic rocks, which for present purposes form the basal succession, include Mississippian, Pennsylvanian, and Permian formations. They outcrop along the basin periphery or within marginal uplifts such as the Bear River Uplift (Oweegee Dome) and probably underlie much of the depression. The Permian carbonate rocks unconformably overlie Mississippian and Pennsylvanian sedimentary and volcanic rocks and are in turn unconformably overlain by thick Mesozoic strata.

The Mesozoic succession comprises the main outcrops within the somewhat ill-defined limits of the successor Bowser Basin. That the Mesozoic basin was considerably larger is indicated by the widespread extent of Mesozoic rocks as pendants or remnants within the bounding plutonic belts. The complexities of basin evolution are well illustrated by the Mesozoic stratigraphy, in which continental and marine lithologies are intercalated and are complicated by contemporaneous erosion and deformation. Known Triassic rocks are predominantly fragmental volcanic rocks, andesitic flows, tuffs, epiclastic volcanic rocks. In the western basin area, lenticular carbonate and quartzite members suggest periodic stability in latest(?) Triassic prior to the deposition of coarse clastic debris interspersed with extensive pillow lavas in earliest(?) Jurassic. Generally, Jurassic rocks overlie all the older rocks unconformably, except in the Bear River Uplift or west central basin, where, with the exception of intercalated limestones, Triassic-Lower Jurassic clastic-volcanic sedimentation was essentially continuous up to Middle Jurassic, when fine-grained marine deposition became dominant. From the central basin area, Jurassic marine shales and sandstones grade to coarse epiclastic rocks, agglomerates, and volcanic flows around the margin. Marine sedimentation continued into the early Lower Cretaceous, whereupon marine and continental sedimentation alternated. Along the eastern margin of the basin, non-marine shales, sandstones, and conglomerates with coal unconformably overlie the deformed older Mesozoic and Palæozoic assemblages.

During the development of the successor basin, periods of deformation and plutonism mark regional periodic tectonic activity, and are represented by major unconformities in the pre-Mississippian, pre-Triassic, pre-Lower Jurassic, pre-Upper Cretaceous, and Recent. Plutonism during Late Palæozoic or Early Triassic, Middle-Late Jurassic, and Tertiary has been concentrated along the basin margins. Deformation is obvious in most rocks within the basin, especially the Bowser assemblage, which forms the main surface exposures. This superficial cover is characterized by what can best be described as "confused" folding with disharmonic relationships that may largely result from gravity tectonics. However, despite the surficial complexities, major subsurface (even basement) features have been outlined along the western side of the basin (for example, Oweegee Dome, Ritchie anticline, etc.), where extensive petroleum and natural-gas permits were acquired in 1968.

Hazelton Assemblage

The bulk of the Hazelton rocks were derived from monotonously uniform andesitic volcanics which, after erosion, were deposited by sedimentary processes as lenticular overlapping beds. Many of these units display lateral fragment size gradation from large breccia chunks through conglomerate to sandstone and siltstone. Several small isolated breccia masses within finer-grained units display characteristics similar to diatreme pipes. It therefore appears that volcanism took place within the immediate Bear River Ridge area and was locally concentrated in the Mount Bunting-Shorty Stevenson area. Intercalated siltstones and tuffaceous horizons suggest explosive volcanism and sedimentation proceeded together. Coaly material found in the volcanic conglomerates at scattered locations suggests an intermittent upper bathyal marine environment. Many of the epiclastics are dominantly green, but toward the upper part of the local sequence, red coloration which, like other red bed deposits, has commonly suggested subaerial conditions becomes obvious and locally dominates along the Bear River section.

The lenticular nature of the rock units, the lateral grain-size variation, the rock coloration, and the woody fragments suggest volcanic highlands were eroded and sediments were deposited rapidly along marine pediments. Minor lulls marked by the banded siltstones and with recurring explosive volcanism are indicated by the laminated tuffs and diatreme necks. The red beds are not clearly indicative of an arid climate nor of subaerial conditions, but presumably represent iron-rich horizons which, through diageneses, have been converted from browns, oranges, and yellows to various reds and purples which indicate the present oxidation state of the iron compounds.

Bowser Assemblage

Two major sedimentary and one volcanic unit have been presented as unconformably overlying an irregular, eroded Hazelton basement. Locally the Bowser rocks have been preserved largely as structural remnants expressing involvement in the regional Bear River Uplift as areas of local trough-like sedimentation on the irregular Hazelton basement. The details of the lithologic features in these rocks and their apparent origins discussed earlier in this chapter suggest that local uplift in the Stewart area was initiated in early Middle Jurassic, producing an erosional highland about which epiclastic sedimentation continued until downwarp and marine sedimentation persisted.

The bulk of the marine Bowser rocks consist of dark siltstones, but a sandstone unit located above the base has been shown on the accompanying geological maps. The apparent evenness and lateral persistence of bedding in the marine beds suggests the area represents part of the true floor of the Middle Jurassic basin where the bulk of the sediments accumulated. The section of sandstone indicates sedimentation was episodic, recording varying sets of sedimentary conditions and time intervals. Graded bedding, common in most of the Bowser members, is generally found associated with interlaminations. Sedimentary structures, presumably the products of turbidity currents, such as flame structures, sole marks, graded bedding, and disturbed bedding, indicate steep paleoslopes with currents acting primarily along the axes of the troughs with the apparent sense of movement a simple infilling. The later Bowser sequence is incomplete in the Stewart area because of extensive uplift and erosion which has primarily affected the western margin of the Bowser Basin.

COAST CRYSTALLINE BELT

Plutonic Rocks

The distribution of the major plutonic rocks of the Coast Crystalline Belt in the Stewart and adjacent Hyder districts is shown on Figure 10, and the regional relationships are indicated on Figure 1.

The essential features of the plutonic rocks have been described by Hanson (1929, 1935), Schofield and Hanson (1922), McConnell (1913), and Buddington (1929). The International Boundary roughly corresponds with the eastern margin of the plutonic belt and consequently Buddington worked well within the complex. His nomenclature has therefore been retained where applicable in this report.

Texas Creek and Related Plutons

Character and Distribution.—Within the Stewart map-area the Texas Creek batholith is well exposed along Salmon Glacier. In addition, the contact area on the west slope of Bear River Ridge in the Silbak Premier mine-area has been recently opened to ready examination by the Granduc road as well as by extensive recent ablation of the Salmon Glacier. A comparison of the present geologic map to any of the old maps of the Salmon River area plainly shows how ice ablation and good access have made it possible to map the border zone of the Texas Creek batholith more accurately. Rather than being hidden under the Salmon Glacier, as shown on the old geologic maps, a complex marginal zone has been outlined which extends eastward up the slope of Big Missouri Ridge almost to the site of the Silbak Premier mine. The importance of the Texas Creek mass and its relationship to mineral deposits was pointed out by Buddington (op. cit., p. 22), who also first recognized the occurrence of these plutonic rocks near the Premier orebodies (op. cit., p. 23). He stated, " It is probable that the porphyries with which the Premier orebodies in British Columbia are associated are outlying stocks genetically associated with the Texas Creek batholith."

Buddington's Boundary Granodiorite, which he mapped as occupying the area south of Mount Bayard in the Boundary Glacier area, has been included as a separate unit on the present map. Resampling suggests that it is one of the several younger intrusive bodies found within the general outline of the Texas Creek pluton. The complexity of phases and their nature only hinted at in surface outcrop of the plutons has been superbly exposed in the new Granduc tunnel which cuts through the Summit Lake pluton, a granodiorite related to Hyder intrusion rather than Texas Creek, which it closely resembles. Several other smaller bodies equivalent to and probably related to the Texas Creek pluton have been mapped on Bear River Ridge north of Mount Dolly.

Very generally, the core of the main Texas Creek pluton can be described as a medium-grained variably porphyritic granodiorite. The rock was not as thoroughly mapped west of the boundary as along the eastern margin, so the reader is referred to Buddington's Bulletin 807 (1929) for details. The main phase appears to be typically massive, mottled grey to greenish-grey with potash-feldspar phenocrysts up to one-half inch long comprising less than 15 per cent of the rock. Mafics in which dark-green altered hornblende predominates make up 12 to 15 per cent of the major phase. Of this amount, brown, fine-grained biotite comprises up to one-third or about 5 per cent; magnetite, and sphene, together form only about 1 per cent of the rock. In summary, the most noticeable characteristics of the main phase or " core " of the Texas Creek pluton are the coarse, pink, potash-feldspar phenocrysts, and the coarse-grained dark-brown hornblende crystals embedded in a generally grey andesine plagioclase matrix. The mineral content does not appear to be uniform and the macro-variations are commonly sharp.

Border Phases of the Texas Creek Granodiorite.—The rocks referred to under this heading essentially comprise all that portion of the Texas Creek pluton found along the margins of the Salmon Glacier. The contact zone as shown on the accompanying maps (Fig. 3) is irregular in both nature and composition and consists not only of intrusive Texas Creek rocks but altered country rock inclusions, and gradational metasomatic equivalents. In this restricted area the general limits of the complex border zone lie between the lower slope of Big Missouri Ridge on the east and the Cantu-Mount Bayard Ridge on the west. On the Alaska side south of the Salmon Glacier this contact zone does not appear to be as irregular or as complex. In his paragraph on contact metamorphism, Buddington (op. cit., p. 37) noted:—

> 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 dykes have produced in the same kind of country rock and in the Texas Creek granodiorite itself.

West of and along the Salmon Glacier the border phase of the Texas Creek pluton has a generally massive green or muddy green spotted appearance, with irregular slashes of orange-red generally representing zones of altered country rock inclusions. At the south end of Cantu Mountain near the Mineral Hill complex, the granodiorite is a fine- to medium-grained, grey hornblende biotite granodiorite similar in appearance to the core rocks. This phase grades rapidly away from the pendant to the common green porphyritic hornblende granodiorite-quartz diorite border phase which extends north along the Salmon Glacier. The spotted or blotchy appearance is caused by the dark-brown hornblende and pink-grey potash-feldspar phenocrysts set in a green matrix. Quartz as blebs up to one-eighth inch in diameter is common, but recognizable biotite is rare. Where weathered, the rock has taken on a spotted light grey to almost white appearance except in pyritic fractured zones where oxide coats the surface.

East of Salmon Glacier and Salmon River the same mottled-green Texas Creek border phase grades perceptibly into green Hazelton volcanic conglomerates. The outcrops are generally clean below the glacier trim-line and the distinction between intrusive and country rock is fairly easy. This is also true of the new road section where the rock cuts are deep and almost continuously expose fresh rock. In the surrounding bush the distinction is somewhat more difficult, especially in the Cascade Creek area. Thus, away from the good exposures, modification of the presently outlined contact and associated alteration phases can be expected if detailed new mapping and microscopic examination is undertaken.

The essential distinctions between the core rock and marginal phases of the Texas Creek granodiorite are the variations in composition and colour. The grain size, porphyritic texture, mineral content, and general structure are crudely uniform and suggest a unit plutonic mass. The border phase is distinguished by the green colour, the lower content of potash-feldspar phenocrysts, and the near absence of biotite. Buddington's petrographic work (op. cit., p. 26) suggested a deficiency of quartz in the contact facies of the Texas Creek mass, which is also noted along the Salmon section.

Generally the border zone of the Texas Creek pluton possesses an over-all uniformity of texture, grain size, mineral composition, and general mineral relationships. A common intense alteration of the entire plagioclase feldspar content to an intimate mixture of very fine-grained sericite and epidote plus minor chlorite, carbonate, and scant biotite causes striking colour variations. The other constituent minerals show only feeble alteration effects of a similar type. Most of the perthitic potash-feldspar grains in the border phase are rimmed and veined by albite. In six thin-sections the feldspar was found only partly altered and the composition was determined as $An_{40\pm2}$. One sample doubtfully correlated with the border phase taken from near the Premier No. 6 level portal contains euhedral complexly zoned plagioclase with composition $An_{31\pm2}$, which is similar to the composition of the country rock plagioclase and strongly suggests metasomatism of the country rock. It will be noted on Figure 3 that areas of Texas Creek granodiorite of probable metasomatic origin are indicated by symbol (*h* showing the presence of metasomatic hornblende). The distinction between intrusive and country rock is often difficult in the Premier area and plotting of the contact has been finally on the basis of microscope studies.

Another somewhat dubious characteristic of the border zone which distinguishes it from the core is the apparent degree of alteration of the country rock inclusions. Siltstone inclusions in the core phase are little altered in general, while those found in the green marginal zone are typically indurated and hornfelsic. They are also commonly pyritic or cut by pyrite veinlets and upon weathering have readily produced gossan.

Hyder Pluton

Character and Distribution.—The Hyder quartz monzonite is the most accessible of all the plutons in the Stewart area. The extent of this rock type near Stewart and Hyder is illustrated on Figure 10, which also shows its relationship to other plutons. The quartz monzonite is well exposed by rock cuts along almost the entire Bear-Salmon River section and is also easily seen along the shore of Portland Canal and in the many stream gullies entering this area.

The pluton has been described in part by both Buddington (op. cit., pp. 29–32) and Hanson (1929, pp. 13–15).

The Hyder mass is generally readily distinguishable from the older Texas Creek granodiorite on the basis of mineral composition and colour. In over-all aspect the rock is medium-grained, porphyritic, and light pink to light grey, speckled with fine-grained black biotite or dark-brown hornblende or both. A predominantly biotitic phase lies north and west of Marmot Bay, while a hornblende-rich phase lies to the south and along the Marmot River (*see* Fig. 3). Buddington (op. cit., p. 30) noted the relationship west of the Salmon River where the quartz monzonite grades into interbanded granodiorite and quartz monzonite forming the interior of the Coast Crystalline Belt in this area.

In past and recent years the Hyder quartz monzonite has been quarried near Hyder and near Stewart for road ballast and dykes. Molybdenite has been identified as a megascopic accessory mineral at both quarries as well as at other scattered points.

In thin-section, specimens of the Hyder pluton are granitic in texture and composition. The plagioclase which forms from 20 to 55 per cent of the rock typically has euhedral grains with strong oscillatory zoning which are variably altered to very fine-grained sericite. The general composition of the plagioclase is about An_{36-38}, but the range $An_{20\pm2}$ to $An_{46\pm2}$ has been recognized between the leucocratic to melanocratic phases. The potash-feldspars which commonly form large phenocrysts generally consist of microcline, microperthitic potash-feldspar, and perthite, and form 35 to 55 per cent of the rock. The potash-feldspar content varies from 65 per cent in leucocratic phases to 10 per cent in the melanocratic phases.

The ferromagnesian minerals are represented by both fine-grained biotite and fine- to medium-grained hornblende. Together these two minerals generally comprise from 2 to 10 per cent of the rock, but they are seldom extensively altered and can usually be discerned even in hand specimen. In addition to the variation in amount of predominant ferro-magnesian mineral in the rock already noted above there is also a crude indication of grain-size variation apparently associated with the texture of the rock. That is, in the fine, even-grained quartz monzonite near Hyder, described by Buddington, the biotite is black and fine grained, whereas in the strongly porphyritic rock described by Hanson to the east at Stewart the brownish-black biotite is medium- to coarse-grained. The gradation from porphyritic biotite quartz monzonite to hornblende granodiorite is readily apparent in the excellent rock exposures between Stewart and the Marmot River. The transition here from biotite to hornblende granodiorite is fairly sharp and the phases are distinct in aspect and composition from Texas Creek granodiorite.

Quartz is readily visible in all phases. The content is usually about 15 per cent, but varies from 8 to about 35 per cent.

Accessory minerals include the ubiquitous, fine-grained sphene, magnetite, and apatite, as well as occasional molybdenite.

In summary, the Hyder pluton is pinkish, commonly porphyritic, medium-grained hornblende-biotite quartz monzonite.

Glacier Creek Plutons

Character and Extent.—In the Stewart map-area, stocklike porphyritic augite-diorite plutons are found at Glacier Creek, Long Lake, and at the entrance to the Bear River Pass. The distribution of this rock type is shown on Figure 10.

These intrusives were orginally outlined and described by McConnell (1913, pp. 16, 17) and Hanson (1929, pp. 12, 13; 1935, p. 20). The bodies shown on the present map appear to form the northwesternmost part of a zone tentatively thought to extend at least as far southeast as Alice Arm. They are essentially the same bodies as those shown on previous maps except that the small augite diorite stock located by Schofield and Hanson (1922, *see* map 1829) about one-half mile north of Long Lake is at the northeast end of Long Lake, as shown on the present map.

In general appearance these augite diorites are distinct from the nearby Texas Creek and Hyder batholithic masses. They are much smaller than these masses in terms of outcrop area but are probably extensive at depth. This applies specifically to the Glacier Creek pluton, especially where several outcrop areas are satellitic to the main mass. These outcrop areas are probably part of a larger mass which underlies most of the area bounded by Bitter Creek, Bear River, and Mount McGee. This conclusion is based upon field evidence that shows contact metamorphic alteration like that developed in the siltstone-greywacke sequence where similar rocks are intruded by the Glacier Creek augite diorite.

The augite diorite is massive, dark brownish-green, and spotted or mottled by coarse euhedral crystals of dark-brown augite which commonly forms 15 to 25 per cent of the mass. The matrix is generally fine- to medium-grained and dark green. Apart from the augite phenocrysts, the mineral content of the rock is difficult to determine macroscopically because of a pervasive alteration. Exposures of these plutons are excellent and the uniform aspect from area to area is impressive. Like all the other intrusives in the area they vary in composition, grain size, and apparent alteration in detail.

Thin-section studies of these dark-green rocks reveal that commonly all the component minerals are intensely altered. The degree and type of alteration appears to be fairly uniform from pluton to pluton, but complicating additional factors such as post-intrusive shearing, faulting, and mineralization have left their imprint. Generally, in thin-sections the augite-crystal form has been preserved but the crystals have been replaced by chloritic sheaf-like bundles of fine-grained quartz. The matrix in which these " phenocrysts " are set commonly consists of a very fine-grained, felted mass of secondary sericite, black oxides, epidote, and plagioclase needles. The whole is traversed by fine veinlets of ramifying quartz and calcite infilling hair-line fractures and tiny vugs. Pyrite grains or clots are disseminated throughout the matrix and phenocrysts as well. Where primary pyroxene and plagioclase have been crudely preserved these were tentatively determined as augite and calcic andesine. Primary quartz or alkali feldspar was not recognized, although Hanson (1929, p. 13) refers to orthoclase as a primary constituent and termed the rock on Glacier Creek an augite syenite. As previously indicated, most of the plutons in this area are characterized by phase variations. Although the Glacier Creek plutons have been termed " augite diorite " for the sake of simplicity, monzonitic and perhaps even syenitic phases may be present, but over-all extensive alteration of the primary material has made precise identification difficult. McConnell (op. cit., p. 18) termed these rocks " augite porphyrite " which, although not academically acceptable now, certainly still provides a useful classification locally.

Bitter Creek Pluton

Character and Extent.—The Bitter Creek pluton is that granitic mass shown on Figures 3 and 10 near the Bear River-Bitter Creek junction. In all previous papers or reports the Bitter Creek body has been included in the description of the large swarm of dykes which traverse the countryside from the Salmon Glacier area across Bear River Ridge, Bear River valley, and from there southeast in the direction of Alice Arm. In this report, partly because of the scale of the accompanying maps, it has been possible to differentiate between the dykes and the associated stock-like mass from which they appear to emanate.

Outcrop and exposure are excellent in rock cuts along the Bear River road and in the adjacent area. Much of the area has been logged off and bare rock now predominates. Additionally, the Bitter Creek canyon cuts through the centre of the mass, but the old trail has disintegrated and access is limited to the side hill or gravel bars at low water. A small quarry on the road near the south margin of the pluton provides easy access to fresh, massive material.

Like the plutons previously described, the Bitter Creek intrusive is marked by impressive variations in texture and apparent composition. At the quarry-site the rock is uniform grey to mottled pinkish-grey granite specked with black biotite. The rock is coarse grained and invariably porphyritic along the contact and to the southeast. Watery grey quartz, as blebs up to one-quarter inch, comprises about 20 to 25 per cent of the rock, while the remainder is largely coarse-grained, pink alkali feldspar which is commonly twinned. Medium-grained biotite which forms less than 2 per cent of the rock is the only apparent mafic mineral and medium-grained molybdenite is the most readily observed accessory mineral. In this zone the rock is fresh, typically hypidiomorphic, with perthite forming 60 to 65 per cent by volume, plagioclase (An_{20-22}) about 15 per cent, quartz about 20 per cent, slightly chloritic biotite about 1 per cent, and sphene, apatite, and black opaque minerals present in only minor amounts. The molybdenite appears to be confined to quartz veinlets filling hair-line fractures and has not been found in commercial quantities.

Northward, toward the central portion of the stock, the texture grades perceptibly from coarse-grained granitic to a fine-grained porphyritic. This porphyritic phase has been termed "quartz porphyry." Only quartz blebs up to one-eighth inch and fine-grained, greenish biotite are discernible in hand specimen of the porphyry. The groundmass is pink with faintly recognizable cream-coloured plagioclase grains scattered at random. Microscopically, the porphyry consists mainly of quartz and microcline-perthite as phenocrysts in a very fine-grained quartz, alkali feldspar, and plagioclase ($An_{28\pm2}$) matrix. Chloritic fine-grained biotite and black opaque minerals form less than 2 per cent of the rock. The alkali feldspar content is about 40 per cent, and this central phase is therefore a quartz monzonite.

The northeast narrow margin of the Bitter Creek stock is unlike the main quartz porphyry central zone and the coarse-grained, porphyritic south edge. In contrast to the predominantly pink rocks to the south, this phase is greenish grey with medium-grained, buff feldspar and brown biotite as phenocrysts in a fine-grained matrix. In thin-section the buff phenocrysts which form about 35 per cent of the rock are strongly zoned plagioclase with a composition of about $An_{32\pm2}$.

The matrix is predominantly a similar plagioclase, some alkali feldspar, 15 to 20 per cent fine-grained interstitial quartz, 3 to 5 per cent biotite, about 1 per cent black opaque minerals, and minor apatite. This phase can be termed a " porphyritic quartz diorite " but, because of the highly variable alkali feldspar content, the average composition is difficult to determine without thorough sampling and may approach quartz monzonite.

In summary, the Bitter Creek pluton consists primarily of medium- to coarse-grained biotite quartz monzonite which is gradational into very coarse, pink granite on the west through pink quartz porphyry into a fine-grained, marginal, grey-green quartz diorite on the east. Outward and upward from the main mass, the stock has sent out innumerable dykes which form the main belt of dykes in the Portland Canal area.

Dyke Rocks

Character and Extent.—Single dykes, families of dykes, and swarms of dykes are one of the most striking geologic features in the Stewart area. Dykes within the area number in the thousands and are only part of an extensive dyke complex which extends from the South Unuk area on the northwest to Alice Arm to the southeast. The central portion of the main Portland Canal swarm of dykes which cuts across the centre of the Stewart map-area has a probable length of about 28 miles and averages about 1½ miles wide. This and other mappable swarms are outlined on Figure 11, which shows the general distribution, extent, and predominant type in the Stewart area.

Two swarms of dykes have been outlined on the accompanying geologic map (Fig. 3) in as much detail as possible—the Premier swarm because of its relationship to ore mineralization, and the Portland Canal swarm because of its impressive size. The other swarms were not specifically mapped in detail and have been outlined on Figure 11 to show spatial relationships and extent.

Relevant features apart from the size and extent of the dykes are their trends, variation in trend, variety of composition and texture, and age relationships. These features will be discussed in the light of present experience with regard to swarm groupings.

The Portland Canal Dyke Swarm.—Previously, the diverse dykes found in the Stewart area have been referred to as the " Belt of Dykes " (Schofield and Hanson, op. cit., p. 27) or locally as the " Portland Canal Belt of Dykes " (author unknown). In this report the large swarm outlined on Figure 1 and on Figure 11 will be known as the Portland Canal dyke swarm.

Both McConnell (1913) and Hanson (1935) showed the Portland Canal swarm as a single unit extending from Mount Dickie, east of Stewart across the Bear River valley and Bear River Ridge. Hanson extended the western limit to the lower slopes of Mount Bayard where the swarm is beautifully exposed (*see* Plate XVIIA and Fig. 35). As a result of work in the Stewart district and remapping of the Portland Canal area by the writer, the Portland Canal dyke swarm has been shown to be one of several *en échelon* swarms spatially related to the margin of the Coast Crystalline Complex. The Portland Canal swarm is the most extensive of these and has been traced in detail from Mount Bayard to Mount Dickie and extended another 9 miles to Mount Trevor, located in the centre of the Cambria Snowfield. Southeast from Mount Trevor, outcrop is poor, but similar dyke material, possibly part of the Portland Canal swarm, has been traced into the west Kitsault Glacier area. The known length of the Portland Canal dyke swarm is 28 miles and the inferred length about 35 miles, making it one of the most extensive in the Cordillera.

Many individual members of the Portland Canal swarm have been shown on Figure 3, especially west of Long Lake where they are mappable units. East of Long Lake across Bear River Ridge and toward the Bitter Creek stock the swarm has been shown diagrammatically by coloured lines which each represent from 10 to 15 subparallel dykes. The spacing and length of these lines indicates the complexity of the swarm.

On the east side of Bear River Ridge, thick-bedded volcanic conglomerates and breccias which form the country rock show stratification, but within the zone of dykes these primary features have been completely obscured by the hundreds of dykes which form up to 90 per cent of the total rock mass. Toward the valley bottom in the Bitter Creek section this myriad of tentacle-like dykes coalesces to form the Bitter Creek stock. Eastward the dyke swarm again spreads from the stock into the country rock extending for many miles to the southeast. In the Stewart district this dyke swarm can be illustrated as a multi-fingered hand with the palm at Bitter Creek and the fingers extended upward and outward. The terminal parts of these fingers are shown in Plate XVIIA.

The attitude of the dykes and dyke swarm is strongly influenced by the structure and competence of the country rocks. As shown on Figure 3, the dykes in the Portland Canal swarm apparently curve arc-like between Bear River Ridge and Salmon Glacier, where the country rocks are Bowser siltstones and greywackes. The most prominent curve, a sharp northward bulge between Long Lake and Cascade Creek on the south slope of Mount Dillworth, marks the area of injection into fairly flat-lying, thin-bedded sedimentary rocks forming the axial zone of the Dillworth syncline. To both the east and west of this trough, where the dykes crosscut steep, massive volcanic epiclastics, the dykes are nearly vertical and have a constant trend. But in the flat sediments the dykes have been intruded sill-like along bedding planes to produce the layer-cake effect.

Some indication of apparent size of the large dykes in this swarm are given on the geologic map. The largest are up to 450 feet thick and extend for thousands of feet in length and depth. Probably some at least extend down into an underlying larger mass like the Bitter Creek pluton. The multitude of small dykes included in the swarm, measuring from a few feet to 200 feet thick which are not shown separately on the map, appear to form a complex, almost reticulated, network which encompasses the pluton core. The spacing decreases and the number of dykes increases toward the main pluton.

Within the swarm the individual dykes vary in both texture and composition. Granite, quartz monzonite, granodiorite, and quartz diorite are the common compositional types. In texture they are fine- to coarse-grained porphyries, equigranular to brecciated. Changes or variations in the texture and composition take place within the individual dykes as well as within the swarm. A general dyke composition is estimated to be granodiorite or quartz diorite which is somewhat more basic than the quartz-monzonite core phase of the Bitter Creek stock.

Premier Dyke Swarm.—In this report the swarm of northwest trending dykes along the International Boundary between Cantu Mountain and Mount Willibert has been named the " Premier dyke swarm " because the Premier orebodies are within the swarm. The dykes of this swarm are not to be confused with " Premier Porphyry " and " Premier Sills " referred to in the older literature. It has been already indicated in this report that the Premier porphyry appears to be a unique metasomatic phase related to the Texas Creek granodiorite. The " Premier Sills " is the term used by Schofield and Hanson (op. cit., pp. 21, 22) for a variety of rocks in the Premier mine area that they felt were primarily characterized by the presence of pink alkali feldspar phenocrysts (orthoclase). In distribution they were localized in the International Boundary area between Premier and Indian Lake within the present Premier swarm of dykes. Hanson (1935, p. 21) envisioned a stock of orthoclase porphyry about 2 miles in diameter from which sill-like tongues extended north for several miles. Other investigators (Burton, 1926; Means, 1923) regarded the sill-like " Porphyries " as stock-like intrusions.

These early workers all stressed the difficulty of recognizing these sills, especially in zones of deformation, because of their highly variable textures. They all failed to recognize the epiclastic nature of the volcanic country rocks and as a result failed to recognize that the Premier Porphyry and its related sill-like extensions were actually metasomatized, deformed epiclastics.

It can be seen on Figure 11 that the Portland Canal dyke swarm and the Premier dyke swarm have the same general northwesterly trend and both are somewhat complicated by other crosscutting dyke swarms. The Premier swarm has been isolated here because of its distinct textural characteristics and economic significance and the dykes are shown on Figure 3 in as much detail as possible. Several dykes of the Premier swarm can be viewed along the Silbak Premier mine roads and along the new Granduc road as well as in the Cascade Creek canyon.

In general the Premier dykes are up to 150 feet thick, and are distinguished primarily by their porphyritic texture and colour from members of other swarms. Their texture and colour are well displayed in a rock retaining-wall built along the east side of the Premier mine road east of the old mine manager's house. A sample is also shown in Plate XVIc. Pinkish to buff plagioclase ($An_{40 \pm 2}$) phenocrysts one-eighth to one-quarter inch long form up to 45 per cent of the work. The greenish-grey to dark-grey matrix generally consists of fine-grained plagioclase, quartz and accessory apatite, sphene, zircon, and black opaque minerals, largely magnetite. Other phenocrysts present include quartz, hornblende, and alkali feldspar, but these are relatively unobtrusive except in good fresh outcrop. Blebby quartz averages about 10 to 15 per cent; acicular hornblende, 5 to 15 per cent; and alkali feldspar (myrmekitic orthoclase), 15 to 20 per cent. Secondary alteration is variable and is indicated in outcrop by shades of green. Most of the dykes are quartz diorite, but minor monzonitic phases are present. Although the dyke rock is generally fairly uniform in grain size, coarse-grained phases marked by large alkali feldspar phenocrysts are evident and have an appearance suggestive of the marginal phases of the Texas Creek pluton. Otherwise the predominant plagioclase porphyry looks somewhat like the marginal grey phase of the Bitter Creek pluton. Regionally a swarm of dykes indistinguishable from the Premier swarm has been found near the Granduc orebody on the South Leduc Glacier, 15 miles to the northwest. Dyke swarms of this type may therefore have regional significance for mineralization.

Like the Portland Canal dyke swarm, the trend of the Premier swarm and of individual dykes within it indicates changes in competency and in fracture patterns in the country rock. In the Cascade Creek section, sharp curves in trend occur where the dykes cross from massive epiclastics to cataclasites or into massive, altered country rock. The branching of the dykes illustrates the presence of persistent local fracture patterns with northwesterly, easterly, and northerly components. For these various reasons the dyke-swarm patterns and their lithologies are indicators of physical-chemical conditions and possible guides to mineralized areas.

Bear River Pass Dyke Swarms.—A number of other small dyke swarms are shown on Figure 11 in the same symbol as the Premier swarm. These are at Summit Lake, Mount Dolly, Bitter Creek, and the American Creek-Bear River Pass area. They are all quartz diorite to quartz monzonite, similar to the Premier dykes, but they all differ from the Premier dykes in texture and appearance. Generally they are dark, fine grained, and have diverse trends, but in common with the Premier swarm they are apparently localized in areas of significant mineralization. Several of these dykes are described in the property notes in Chapter 5.

Lamprophyre Dyke Swarms.—Lamprophyre dykes are fine-grained, dark-green to dark-grey rocks which cut all the competent rock units in the map-area with the exception of relatively minor basaltic dykes. The lamprophyres are common to most of the area, but the zones of apparent concentration have been outlined on Figure 11 to indicate their relationship to the Portland Canal and Premier swarms. The most common lamprophyre in the area is a spessartite typically composed of brown acicular hornblende and plagioclase in a dense matrix. Physically they are distinguished from the country rock by their rusty weathering, spotted-grey colour, and blocky joint habit.

Microscopically, the spessartite dykes are characterized by lath-like andesine plagioclase, rod-like brown hornblende crystals, and minor augite set in a felted matrix of very fine-grained andesine plagioclase and acicular hornblende with minor accessory apatite, sphene, and magnetite. Alteration of both phenocrysts and matrix to sericite, chlorite, epidote, calcite, and quartz is typical, with the result that original quartz in the matrix is difficult to distinguish from secondary quartz. In composition these dykes are dioritic and are readily distinguished in the field from all other intrusives.

Like the other dykes, the lamprophyres have responded to country rock conditions and are found with three distinct trend patterns. These are northwest, easterly, and northerly, and are commonly crosscutting. Unlike the Portland Canal and Premier swarms which have a single prominent northwest trend, the lamprophyres appear to be more or less evenly distributed in all three directions except at the east margin of the area where the northerly direction predominates. The relationships between the lamprophyres, other intrusions, and mineralization are well illustrated in the field in the Stewart area and have served to separate the more recent geologic episodes. An example of mineralized lamprophyre dyke cutting a diorite-dyke which has in turn cut a Portland Canal granodiorite dyke shown in Plate XVIIB.

Basaltic Dykes.—Small, irregular, black basaltic dykes are most readily observed near the Government wharf at Stewart, where they cut pink Hyder quartz monzonite. They are relatively widespread but insignificant in size and volume. They appear to be similar in age and composition to Cenozoic basaltic intrusives and extrusives found sporadically from Alice Arm to the Iskut River.

Relative Age Relations Indicated by Dykes and Plutons

Within the present area the Hazelton-Bowser country rocks have been intruded by the Texas Creek granodiorite, Hyder quartz monzonite, Glacier Creek augite diorite, and the Bitter Creek-Portland Canal stock-dyke complex. Except for the Texas Creek pluton, all the plutons obviously cut Middle to Upper Jurassic sediments. The preceding order of plutons is also the apparent order of plutonism as presently known. The Premier dykes cut rocks of the Texas Creek pluton and are in turn cut by lamprophyre and Cenozoic basalt dykes. However, relationships between the Hyder quartz monzonite, the dyke swarm, and the Premier-Bitter Creek-Portland Canal complex are not obvious. It is suggested here that the strong similarities between these latter dykes and plutons implies a consanguineous igneous event which followed the Texas Creek intrusions and preceded the lamprophyre and basalt dyke invasions.

Details of the rock structures and mineralization are left for the ensuing chapters, but sufficient data have already been presented in the preceding lithologic descriptions to permit a brief interpretation of the interplay between country rock, plutonism, and mineralization.

The folded, complex, sedimentary-volcanic sequence has been intruded by a number of plutons with the imposition of cataclastic deformation and metasomatic alteration in the Salmon Glacier-Summit Lake section. Along this valley the country rocks have been deformed in a narrow north-south zone limited by the batholith contact on the west. The zone is widest in the Premier section, then narrows north along the lower west slope of Mount Dillworth and tapers out at the north end of Summit Lake. The south end of the zone has been truncated by the Hyder quartz monzonite. The relationship of the plutons to this narrow, deformed zone is illustrated in the geologic cross-sections (Fig. 4). Field and laboratory studies previously cited show that the cataclastic zones were fully developed before metasomatism took place. The implication is that Texas Creek plutonism at various depth levels induced both the deformed zones and the later metasomatic events.

Texas Creek plutonism was followed by further intrusion of the country rocks by the Tertiary Hyder batholith, Glacier Creek and other small stocks, and the complex of dyke swarms. Low-grade deformation and alteration has been recorded associated with all these igneous phases. Most of these mesozonal plutons were apparently controlled by structures which are now illustrated by the northwesterly trend of the igneous complex and the attendant dyke swarms. The late lamprophyre and basalt dykes representing epizonal injection have been controlled by northerly and northeasterly fractures indicating the change in physical constants between the two environments.

Various types of quartz-barite-sulphide mineralization cut all the plutons with the exception of the basaltic dykes. Northwesterly, northeasterly, and northerly trends are prominent in the mineralized zones as shown on Figure 18. It appears from the evidence of relationships between the multiple dyke intrusions that four major periods of mineralization followed intrusion and alteration by the Texas Creek pluton.

Relations Indicated by Absolute Age Determinations

Absolute ages determined by the United States Geological Survey on the Hyder quartz monzonite and Texas Creek granodiorite by radiometric K/A methods confirm the relative intrusive relationships first recognized by Buddington. Three determinations on good Hyder quartz monzonite give dates of 47–51 million years (±2–3 million years), and one sample of fresh Texas Creek granodiorite gave a discordant age.

The results from this recent study by the United States Geological Survey are reported by J. D. Smith as follows (*pers. com.*):—

> Potassium argon determinations by the U.S. Geological Survey on five samples of granitic rocks from the Hyder area indicate two intrusive episodes. The younger episode took place 45–50 million years ago.
>
> The numbers for the Hyder and Boundary rocks are firm, but all we can say at this point about the Texas Creek is that the Texas Creek is older than the other Coast Mountain intrusions and its K/Ar clocks were affected by the 45–50 m.y. intrusions.

Sample No.	Mineral	Age* (m.y.)	Location and Unit
68ASj-52	Bio	49.2	U.S.-Canadian border on Hyder–Stewart Road. Hyder qm.
68ASj-163	Bio	49.2	Small nunatack in Chickamin Glacier, about 1 mile
68ASj-163	Hbl	48.7	NNW. of Mount Jefferson-Coolidge. Hyder qm.
68ADn-75	Bio	50.9	Ridge between Boundary Glacier and Texas Gla-
68ADn-75	Hbl	50.3	cier. Boundary grd.
68ASj-196A	Bio	43.7	Porphyritic quartz monzonite, a separate intrusive
68ASj-196A	Hbl	52.5	from the Hyder qm. Mouth of Davis River.
68ASj-160	Bio	106	Texas Creek granodiorite. East side Ferguson
68ASj-160	Hbl	206	Glacier.

* All analytical results ±3%.

Contact Relationships of the Plutons and Dykes

The plutonic rocks described in this report present a diverse array of contact relationships with their wallrocks. Although the accompanying geologic maps display the large-scale features, inherent limitations must leave the small or subtle contact phenomenon to description. Contact phenomena are important in the Stewart district because the significant economic mineralization is localized at or near unusual or irregular contact areas.

Plutons.—Within the confines of the Stewart geologic map the various igneous plutons have transected mechanically and chemically different rock types. The general result of intrusion, as shown on Figure 3 and as noted by the many early workers, has been the formation of apparently smooth, steep contacts with little or no extensive metamorphic effects (*see* Hanson, 1929, pp. 13–15; Buddington, 1929, pp. 37–39). In the over-all view, dynamic metamorphism observed as limited to within tens of feet of the contacts is reflected by narrow, chlorite schist zones. Thermal metamorphism has been regarded as negligible with the exception of a limited garnet-epidote mineral assemblage recognized on the west slope of Mount Dolly, and regional metamorphism has been ignored completely.

The Glacier Creek augite diorite plutons have intruded siltstones, greywackes, and volcanic breccias with interesting results. The Bear River Pass plug (*see* Fig. 10) and country rock Hazelton andesitic breccia are both noticeably schistose, especially at their common contact and, apart from a weak, narrow, pyrite halo, the intrusive metamorphic effects are negligible. In the Long Lake and Glacier Creek areas, where stocks of similar texture and composition have intruded siltstones and greywackes, shearing and alteration have been limited to the wallrocks. Here bleaching, induration, and pyritization of the dark country rocks are visible a few tens of feet outward from the plutons. At Long Lake the augite diorite stock has been cut by part of the extensive Portland Canal dyke swarm with only limited induration and minor microscopic silicification. These minor contact effects contrast strongly with the extensive component mineral alteration of the diorites themselves and suggest in these plutons widespread autometasomatism at the time of intrusion.

The Bitter Creek stock cuts sharply and steeply across volcanic conglomerates and equivalent cataclasites without significant visible contact effect. Outward and upward the members of the ramifying or digitated dyke complex exhibit an increasingly greater extent and degree of wedging, crushing, shearing, and alteration along their contacts. This suggests the process involved passive emplacement of the stock at one level while the offshoot dykes were emplaced forcefully with related erratic quartz-sulphide alteration and veining.

The Hyder quartz monzonite batholith has a steep, narrow, low-grade contact zone where it has cut the various country rocks. Along the contact with the Texas Creek, granodiorite cataclasis is most notable, with erratic attendant mineral alteration of the intruded material. On Mount Dolly, where apophyses of the Hyder pluton cut epiclastic rocks, the country rocks have been extensively indurated, partially epidotized, and variably silicified up to a mile away from the main contact. Sporadic tactite zones are evident but have a limited extent. To the southeast of Stewart, where the Hyder pluton becomes dominantly hornblendic, the contact zone is extensive where hornblende gneisses developed from country rock epiclastics form a contact zone up to one-half mile wide south of Kate Ryan Creek. In this section the gneisses grade eastward into well-developed sericite schists apparently marking the change in country rocks from volcanic sandstones and conglomerates to siltstones and sandstones.

In the Stewart area the Texas Creek granodiorite pluton has had considerable if variable contact effect on the country rocks, not negligible, as stated by the early workers. This irregular zone appears to be related directly to the compositional variations of the pluton (*see* p. 60) which, combined with strongly contrasting country rocks, formed areas marked by exceptional gold, silver, lead, and zinc mineralization.

The Salmon valley contact zone is now well exposed, showing the complex relations between the Texas Creek pluton and the country rocks. Areas of hornblendization, feldspathization, silicification, and pyritization as well as structural features are indicated by symbol on Figures 3 and 4. The limit of the Texas Creek pluton contact metasomatism along the Salmon Glacier section is an arbitrary line (the silica line) drawn southeasterly along Noname Lake to the east side of Cascade Creek, then southeast past Premier where it swings southwest to the International Boundary. This line roughly separates the country rocks on the basis of microscopically recognizable silicification. Visual evidence as well as thin-section study also shows that the amount or degree of alteration decreases from the contact eastward to this line. Along Cascade Creek the actual contact is vague, and the intrusive grades almost imperceptively from coarse-grained hornblende granodiorite through medium-grained granitized country rock into altered country rock. In this section the granitized country rocks have been completely recrystallized to porphyritic hornblende granodiorites. Alkali feldspar porphyroblasts spot these greenish rocks randomly or occasionally as elongate zones such as in the Premier area where the name "Premier Porphyry" has been applied (*see* p. 68 and pp. 155–157). Apart from the obvious hornblende and alkali feldspar alteration, the country rocks are variably indurated, silicified, and pyritized. The amount of visible pyrite appears to decrease eastward from the main contact. The decrease is not regular because of variations in the country rock and other complicating features such as dykes. Intense silicification extends outward from the general contact to the silica line crudely following the over-all alteration boundary. Within this area, the country rocks in certain zones such as along Indian Ridge have been almost completely replaced by fine-grained quartz, but the green coloration remains.

The Summit Lake stock, which is probably a satellite body of the main Hyder batholith, has an aureole of alteration similar to that at the margin of the Texas Creek granodiorite. This can be readily observed at the north end of Summit Lake and along the nearby road. Again the contact effect is variable depending on the country rock. Very coarse hornblende crystals up to about 3 inches long have developed in massive volcanic conglomerates near the intrusive contact and outward the rocks are pyritized, silicified, and indurated. The induration extends eastward about one-half mile. The western contact of the Summit Lake stock, where encountered in the Granduc Mine tunnel beneath the Berendon Glacier, is complicated by a dyke zone. Between the Summit Lake stock and Big Missouri some of the red, black, or purple mylonites and cataclasites have been extensively hornblendized as indicated on Figure 3. An intrusion like the Texas Creek pluton which may underlie much of this area possibly induced this hornblendization.

Dykes.—Contact relationships between the various dykes and numerous country rocks are commonly quite insignificant. Because the dykes occur singly or in swarms, the contact deformation and alteration can be either almost a skin shear effect or a compound shattered, highly deformed zone. The latter is common in the large swarm where it cuts the Bowser siltstones. Where the more basic dykes cut some of the massive green rocks the dykes are bordered by well-defined bands of red to purple country rock. This can be seen easily at the toe of the Salmon Glacier in the green Texas Creek granodiorite or in the less-deformed epiclastics east of Premier. In the red volcanics the dykes produce a purple contact zone and in the purplish country rocks the colour change is to black. These changes appear to be oxidation effects reflecting changed proportions of the mixed valency iron compounds. Generally the contact relations are restricted to simple shearing, limited induration, and minor development of fine-grained pyrite. Along the Salmon Glacier, where the main belt of dykes crosses the marginal deformation zone of the Texas Creek batholith, the country rocks are exceptionally blocky or broken.

SURFICIAL DEPOSITS

Pleistocene and Recent Deposits

The superficial deposits in the map-area are mainly in the river valleys, deltas, and along ice margins. Deposits on the hillsides are normally thin and deposits on the glaciers are scattered. Above timber-line the veneer is limited to rock rubble and erratics.

From American Creek south the Bear River valley is floored by sands and gravel deposited by the present braided stream. Tributary streams loaded with sand and gravel dump part of their load along alluvial fans and small deltas that coalesce with the main stream. Talus and rubble brought down by snowslides as well as material sloughing away from the steep rock slopes mantle the edge of the valley floor. At the head of Portland Canal the Bear River has formed a broad delta which merges with the nearby Salmon River deltas. Both Hyder and Stewart are built on river sediments elevated a few feet above high tide. Hanson (1929, p. 16) mentioned that in one period, 1909–1927, the Bear River delta advanced a total of 540 feet along the west side of Portland Canal. At the present time estuarine deposits are accumulating but pilings of the old Portland Canal Short Line Railway wharf are now submerged at high tide. It appears that the sediments have undergone compaction or have slumped along this section of the delta.

The retreat of the Salmon Glacier since 1910 has disclosed a flat gravel- and sand-filled narrow valley. Downstream the wider parts of the valley are also floored by sand and gravel. The recent outburst of Summit Lake has had scant influence on the stream regimen or sedimentation.

Some of the marine sands and silts that represent old estuarine deposits flank the hillsides, indicating that the area has undergone post-glacial uplift of up to 500 feet. These sediments are located at Bear Lake in the Bear River valley and on the west side of the Salmon River at Elevenmile. McConnell (op. cit., p. 22) and Hanson (1929, p. 16) have discussed the Bear River clays, and Buddington (op. cit., p. 39) mentioned the marine material along the Salmon River.

CHAPTER 4

"Seek simplicity and distrust it."
—*Alfred North Whitehead.*

Structural Geology

TECTONIC FRAMEWORK

The tectonic elements of that part of the Cordilleran region embracing the southeastern tip of Alaska and adjacent British Columbia are known in only a general sense. The relative position of the major elements is presented on Figure 1 employing current terminology. The position of the sedimentary Bowser Basin in its relative extent and possible economic significance in British Columbia follows on Figure 14. From west to east the idealized elements are the Revillagigedo Metamorphic Belt, the Coast Crystalline Belt, the Bowser Basin, and the Bear River Uplift, which includes major local elements such as the Stewart Complex, Oweegee Dome, and the Ritchie Anticline. The name "Stewart Complex" has been coined to describe the diverse types of rocks marked by complicated structures (especially in detail) which constitute the rock mass lying between the Iskut River and Alice Arm, immediately adjacent to the margin of the Coast Crystalline Belt. The abundance of mineral deposits and mineral occurrences is one of the prime features of the mass. The Revillagigedo Metamorphic Belt and Coast Crystalline Belt of southeastern Alaska were outlined by Buddington and Chapin (1929) some time ago. Small parts of the Coast Crystalline Belt and the Bowser Basin have been studied in this report, but the geology of the Bowser Basin itself has never been synthesized in full. Souther (1966) has recently produced a synopsis of the north-central portion of British Columbia which is limited because of incomplete knowledge, and Brew (1968) has summarized the tectonic history of southeastern Alaska and adjacent British Columbia using inadequate data from the basin section.

In light of present knowledge, a detailed tectonic synthesis of the Coast Crystalline Belt and Bowser Basin is impossible. By combining the published material with available unpublished data, parts of a succession of tectonic events can be conceived in which the recent geological study of the Stewart area forms a small but significant part. The following comments are largely restricted, therefore, to the eastern margin of the Coast Crystalline Belt in the area involving the Bowser Basin.

Presumably the tectonic depression presently known as the Bowser Basin (Fig. 14) was initiated by mid-Palæozoic times. Rocks exposed along the periphery of the basin include Middle Mississippian, Pennsylvanian, and Permian, which in part are known to unconformably overlie an older complex of the Horseranch-Wolverine type. This Carboniferous assemblage includes predominantly fine-grained volcanics and marine sediments. Carbonates occur as lenticular masses which become important late in the Permian. The thickness of the Permian is variable, but appears to be greatest along the west margin of the basin. Indications of post-Permian deformation are present at the Oweegee Peaks area where overturned middle Permian carbonates are overlain by upright Triassic sediments. In the western part of the basin, Triassic rocks are thick, predominantly non-marine volcanics and epiclastics with intercalated marine sediments. Pillow volcanics, bedded cherts, limestones, and quartzites are common in the Bowser-Iskut section of the Upper Triassic. These are largely overlain unconformably by Lower Jurassic marine sediments, pillow volcanics, and epiclastics. Lower Jurassic rocks, which at most places lie unconformably on all other formations, consist principally of clastics and diverse volcanics along the western margin of the basin, whereas fine-grained marine shales and sandstones appear to be dominant in the central section. Middle Jurassic pillow volcanics, epiclastics, and marine sediments have been outlined throughout the length of the Stewart Complex, roughly along the Meziadin Hinge as well as within the central portions. The Monitor Lake rhyolite unit appears to be the most extensive acid volcanic mass so far located within the complex, although thin, extensive correlatives have been mapped in the central Bear River Pass section. Areally these rhyolite flows and stratigraphically equivalent andesitic to basaltic pillow volcanics mark widespread volcanism prior to the onset of mainly marine Bowser sedimentation. Upper Jurassic sediments, named the " Bowser Group," now cover a large part of the original basin. In the eastern area these sediments are generally overlain by Cretaceous and Early Tertiary non-marine sediments which include some coal members forming the generally homoclinal Sustut Basin. During the evolution of the basin the margins were marked by intrusive activity in the Early Palæozoic, Triassic, Jurassic-Cretaceous, and Tertiary. Oligocene and recent volcanic activity is apparent along the western margin, indicating that evolution of the basin is still in progress. Although relatively small in area, the Bowser Basin includes a great thickness of sediments and may be termed a " hyperbasin." Its depositional character is still evident although the margins have been deformed by complex events.

The Stewart area within the Stewart Complex lies along the western mobile part of the basin, where some recent tectonic events have been recorded. The Stewart Complex is one of several important mineralized areas found at intervals along the basin margin which are characterized by diverse rocks and moderately complex structure. The Stewart Complex includes a variety of plutons, gneisses, schists, cataclasites, marine and non-marine sediments, and a variety of volcanics. Copper, gold, silver, lead, zinc, molybdenum, nickel, and iron are the principal metals. Within the complex the exposed rocks are Triassic to Recent, with the Jurassic assemblage dominating the sedimentary-volcanic sequence. Plutonic rocks along the west side of this complex are typically granodiorite, whereas within it they are quartz monzonite and syenite. The larger plutons, such as the Texas Creek granodiorite and Hyder quartz monzonite which constitute an essential part of the Coast Crystalline Belt, are typically synorogenic mesozonal intrusives. Possible pre-orogenic catazonal bodies are present farther north in the South Unuk area, but none are known in the Stewart district. Most or all of the small plutons in this basin-rim feature are post-orogenic supracrustal intrusives. Basic and ultrabasic intrusives are rare in the Stewart Complex except as small lenticular or pipe-like masses concentrated along the fringe of the Coast batholithic margin. Most of the basic plutons reported in the older and even recent literature are in reality variably indurated pillow volcanics or even " granitized " epiclastics, not for instance amphibolite, as reported by Hanson (1935) at Anyox.

Within the complex, Upper Triassic and Lower Jurassic epiclastic sequences are separated by thin fossiliferous marine sediments. No Permian has been recognized as yet other than at Oweegee Peaks. Presumably the Permian lies at depth elsewhere or has been partly removed by erosion during the Mesozoic. The Triassic sediments occur along the northern margin of the complex in the Unuk River area and also as very small fensters in the Treaty Creek-Bowser River section, as well as Oweegee Peaks. No Triassic has been identified in the immediate Stewart area or to the south. Jurassic rocks of the Hazelton assemblage, which are mainly non-marine epiclastics, pillow volcanics, siltstones, and minor limestones, are the most extensive members in the Stewart Complex, but the age of these rocks is uncertain in the half of the complex south of Stewart. In this section of the Bowser Basin some of the Lower Jurassic appears to be conformable with Upper Triassic. The Hazelton-Bowser unconformity found in the Stewart map-area is present throughout a large part of the complex, indicating an extensive erosional interval. This was followed by a prominent " red bed " succession, volcanic extrusion, and subsequently by extensive marine sedimentation. During this time of Hazelton-Bowser deposition at least, areas such as Oweegee and Delta Peaks appear to have been highlands along the western side of the basin which shed debris into the adjacent basins. Granodiorite pebbles and cobbles in probable Upper Jurassic siltstones indicate nearby granitic masses (such as the Texas Creek granodiorite) older than most of the plutons observed in the Stewart area. All of the Triassic-Jurassic and Cretaceous rocks in the complex have since undergone plutonism, variable metamorphism, and deformation of diverse styles.

LOCAL STRUCTURE

Without exception the early workers in the Stewart district elected to almost completely disregard structural geology. Schofield and Hanson (1922, p. 34) suggested:—

> Salmon River area, in harmony with the other parts of the Coast range, has dominantly a folded structure, the folds trending in a northwesterly direction.

Hanson (1929, p. 16) made almost no reference to local structures except that " faults are probably numerous in the area." Later, Hanson (1935, p. 24) indicated a syncline was present in the Salmon River district and an anticline in the Bear River district, but these features were linked to folds outlined at Alice Arm! These few statements constitute almost the entire knowledge of the structural geology of the Stewart area up until this study.

The main problem involved in determining structure in both the Bowser and Hazelton rocks has been the lack of extensive marker horizons. By walking out rock members, the writer compiled sufficient information to reveal the significant features which are illustrated on Figures 3, 4, and 12.

The Stewart map-area lies on the west flank of the American Creek anticline, a northerly trending, slightly arcuate regional structure truncated southeast of Stewart by the Hyder pluton. North of the map-area this fold plunges under Bowser sediments. Hazelton structure is partially concealed in the Stewart area by overlying thick Bowser strata now found as structural remnants on ridges and in some valleys. In detail the rock structures are complex but fit into the tectonic pattern of successor basin development. Extensive deformation, as well as metasomatism which has partially veiled rock structures in the Salmon River district in particular, is related to the development of the Coast Crystalline Belt lying along the west side of the map-area. The relationship of economic mineralization to structural features such as deformed zones, minor folds, and fractures has been found significant.

MAJOR FOLDS

American Creek Anticline

Two major northerly trending folds involve most of the sedimentary and volcanic rocks in the Stewart area. The largest of these, the American Creek anticline, has been outlined on the basis of geological mapping in the Stewart area as well as on a larger regional basis. As shown on Figures 3 and 12, a portion of the axis of this fold crudely lies along American Creek. This fold is one of many idiomorphic regional warps which have involved Hazelton rocks and possibly even some of the lower Bowser epiclastic members. The open, slightly inclined, nature of the American Creek anticline is shown on Figure 4 (sections A-A′ to D-D′), which also illustrates the thickening and thinning of strata, thereby exhibiting fold disharmony. The northern axial section of the anticline is well exposed in American Creek and in Bear River Pass. North of the Stewart map-area the anticline plunges at about 15 degrees under capping Bowser sediments. To the southeast outside the map limits the American Creek structure is partly exposed in deep valleys where overlying Bowser rocks have been eroded.

The anticline has been weakly deformed by numerous dykes and plutons as well as faults which have combined to partly obscure the main structure southeast of Bear River Pass.

Mount Dillworth Syncline

The Mount Dillworth syncline lies almost entirely within the Stewart map-area. It involves only Bowser rocks and lies in a structural trough paralleling the American Creek anticline (Fig. 12) and astride the westerly limb (Fig. 4). The fold is open, somewhat inclined, and exhibits fold disharmony typical of structures involving strata of variable competency and extent. Over all, the fold has a canoe shape with the ends resting on Mount Mitre just off north limit of the map-area, and on Bear River Ridge at Mount Shorty Stevenson. From the northerly apex of the fold on Mount Mitre the structure plunges south into Betty Creek at about 40 degrees. The axial plane or keel section has the maximum thickness in the Mount Dillworth section (*see* Fig. 4, sect. C-C′). The plunge of the syncline from Mount Shorty Stevenson north into the main trough is about 25 degrees. Apart from the perpetually snow and ice covered areas, the strata comprising the Dillworth syncline and their structural relationships are well exposed. The contact between Bowser and Hazelton rocks outlining the Dillworth syncline shown on Figure 3 outlines some complex digitations. Bowser siltstones and greywackes overlying competent Hazelton epiclastics illustrate such fold attenuation in the Troy Camp section, whereas the smooth, apparently conformable, zone along the west side of American Creek represents contact between mechanically similar rock types. Strong attenuations within the trough rocks between different strata are well developed in the area between Long Lake and Mount Shorty Stevenson. The geologic sections also illustrate the comparative degree of disharmonic folding within rocks of the syncline as related to variable rock competency. The various major rock units comprising the Dillworth syncline have been outlined on Figures 3, 4, 7, and 9. Satellitic parts of the syncline occur on Bear River Ridge north of Mount Welker and at the northeast side of Summit Lake (Fig. 3, Fig. 4, sect. F-F′), whereas the Bowser rocks shown southeast of the Dillworth syncline represent other structural remnants of a similar structural trough.

The Dillworth syncline has been intruded by dykes and plutons with varying degree of deformation. Faulting has been extensive, but displacements appear to have been minor. The lack of good marker units precludes recognition of significant stratigraphic repetition by fault mechanisms.

Minor Folds

Folds in Hazelton rocks at a scale less than the American Creek anticline were not recognized by any of the early workers in the Stewart district. Detailed mapping has shown that they exist throughout the area and that they are important in terms of mineral-deposit localization.

In Bowser rocks, on the other hand, minor folds are visible on all scales and present an interesting display of disharmonic features. In these rocks and within the Dillworth Syncline in particular the minor folds are complex and particularly difficult to trace because of the general lack of marker horizons. The scatter of fold symbols on Figures 3 and 12 illustrates the multitude of mappable minor folds as well as their disharmonic nature. The minor Troy Camp fold located at the southeast end of Summit Lake represents one of several digitations developed in Bowser siltstones and sandstones overlying the Hazelton. The complex folds mapped west of Little John Lake on Troy Ridge are perhaps the best expression of disharmonic folds in the sequence (*see* Plate XI).

Mount Rainey Syncline

The structure on Mount Rainey consists of thick-bedded Hazelton volcanic conglomerates, sandstones, and breccias with irregularly intercalated thin-bedded limestones, siltstones, and tuffs which serve as the principal means to delineate the fold. The syncline represents a structural remnant underlain by intrusives and unconformably overlain by deformed Bowser rocks. Exposed strata along the Portland Canal east slope present an apparent continuous homoclinal succession of green volcanic conglomerates dipping easterly at a moderate angle. Thin-bedded members intercalated with these rocks were traced into the Ryan Glacier area where steep north dips prevail, outlining the structure as a northeasterly trending asymmetrical fold overturned to the east and plunging northeasterly at about 60 degrees. Dragfolds and lineations mapped in thin-bedded sandstones in the Prosperity-Porter Idaho section show a steep northerly plunge.

Mount Bunting Syncline

The Mount Bunting syncline represents the second northerly trending minor fold mapped in Hazelton rocks in the Stewart area. The fold has been partially exposed on the upper east slope of Mount Bunting by the recent ablation of ice and snow. The rocks forming the synclinal remnant consist of well-bedded red and green

Hazelton volcanic sandstones, conglomerates, and minor breccias. Only part of the structure was traced because of snow overlying Bowser rocks and because the Portland Canal dyke swarm obliterates rock structure to the north. Well-bedded strata forming the west limb trend north-northwest with steep to vertical dips, and along the easterly limb the beds dip north at 30 degrees to 70 degrees. The axial plane of the syncline trends north-northeast and minor structures show that the fold plunges northeasterly at about 80 degrees. At the head of Donahue Creek, clear stratigraphic relations show that the strata forming this minor trough unconformably overlie part of the Bear River-Hazelton succession.

Summit Lake Folds

Westerly trending folds forming a second set of minor structures in Hazelton volcanic epiclastics occur along the west side of Summit Lake and in the Big Missouri Ridge section. Most of the epiclastics west of Summit Lake are thick-bedded, generally featureless, conglomerates. Thin-bedded siltstones intercalated within part of the succession are well exposed to the north of August Mountain Glacier, where westerly trending folds generally plunging at 60 degrees west have been mapped (Fig. 3). Similar trending west-plunging minor folds were also mapped in fine-grained volcanic sandstone strata on Big Missouri Ridge west of Fetter Lake, where quartz-sulphide lenses similar to Big Missouri type mineralization have been explored. In this section the mineralization appears to be localized along axial plane fractures developed in the thin-bedded folded strata.

STRUCTURES IN HAZELTON ROCKS

Members of the Hazelton rocks in the Stewart area have been mapped as elongated, lenticular masses. In the third dimension they are apparently lenticular as well and illustrate what can be termed grossly a " mackeral structure," in which each lens overlaps the others. Weak foliation, minor folds, and some lineations are present to some degree in all the members of the assemblage. It appears that these structures have developed variably throughout the Hazelton assemblage, exhibiting in many instances a sense of selection based upon rock-particle size and competency. The pattern of foliations, lineations, and small-scale folds is summarized on Figure 12, along with the major structures.

Foliation

Foliation, which in this report includes all secondary planar structures, has developed in a number of ways with varying degrees of complexity. In the Hazelton assemblage, foliation is restricted to zones of deformation and is present in the various cataclasites, mylonites, schists, and gneisses. In the least-deformed cataclasites, foliation has been caused by smearing of the matrix with the production of shiny green, grey, or purplish laminations that transect primary features (*see* Plate VIIA). Where mylonites have been produced, the foliation laminæ are more pronounced and are accentuated by crude inch-scale mineral layering (*see* Plate XVIIIB). Most of the so-called purple tuffs and " Premier Porphyries " outlined in old reports in the Salmon Valley area are really well-foliated, banded mylonites (*see* Plate IXC). Semi-schists and schists developed in the Salmon Valley exhibit planar structure resulting from the development of metamorphic minerals. Well-foliated gneisses are rare, but alternating feldspar-hornblende laminations along the plutonic margins are sometimes recognizable. The foliate rock structures are largely related to plutons or dykes as contact effects. The large cataclastic zones were developed in certain Hazelton members prior to actual magmatic penetration by plutonic wedging.

Folds

Small, open folds appear to be characteristically developed in the fine-grained epiclastic members, whereas only major folds affect the thick, coarse-grained members. As a result, small folds are concentrated in the Big Missouri Ridge and Summit Lake sections, where fine-grained members are prominent. As indicated on Figures 3 and 12, west of American Creek-Bear River valley, the minor folds in the Hazelton, which have upright axial planes, plunge steeply toward the west, where the rocks are medium grained. East of American Creek valley, outside the map limits, the minor folds are open undulations plunging easterly at a moderately high angle. South and east of Bear River the rocks are generally coarse and massive except in the Marmot River area, where minor folds in thin-bedded, fine-grained sediments plunge steeply north.

Lineation

Lineation is not a conspicuous structural element in Hazelton assemblage in the Stewart area. Linear elements in the deformed epiclastics are largely elongate rock or mineral clasts, or elongate grooves lying in the foliation planes reflecting lenticular clumps of mineral grains (*see* Plate VIIA). Reference to Figure 3 will indicate the generally uniform attitude of the lineations throughout the area. In the Cascade Creek section, lineations are more variable than elsewhere, but show a crude subparallelism with the minor fold axes.

Summary

The heterogeneous nature of the various members of the Hazelton assemblage has been amply illustrated by their variable response to destructional deformation. The over-all uniformity of the minor structural elements is expressed by their symmetry. Lineations, for example, which have formed as a result of local pressure gradients would have a much more complex pattern if the rocks had flowed freely or if discrete segments of the area had responded at various times. It therefore seems likely that the Hazelton rocks as a whole have been subjected to non-hydrostatic overpressures. Except for local schist development, mineral recrystallization has not been a major feature of the over-all deformation. Usually, recrystallization is considered a thermally activated process initiated by any number of devices such as nucleation at certain energy levels. With high-strain energy available, the temperature requirement of nucleation to initiate recrystallization would be lowered. In this area, metasomatosis has been found almost exclusively in limited zones where tthe combination of temperature, local overpressures, and a suitable diffusion gradient persisted. The Premier area, where metasomatism has been described, is one of the best local examples where exacting physical-chemical conditions were met. Studies of the minor structural elements which indicate that deformation was uniform, combined with the evidence for limited recrystallization, suggest that the areal deformation of the Hazelton assemblage was largely produced by the Texas Creek plutonism.

STRUCTURES IN BOWSER ROCKS

The pattern of folds and foliation in the Bowser assemblage has been summarized on Figure 12, and the local setting is shown on Figures 3 and 4. Two major and distinct separable units—one an epiclastic (the lower Betty Creek unit), and the second (the upper Mount Dillworth unit) a siltstone-sandstone assemblage—, have been found to unconformably overlie older folded Hazelton rocks. The Bowser sediments and minor volcanics have been preserved as structural remnants lying in contorted trough-like or canoe-shaped depressions in the underlying Hazelton. These troughs are partly tectonic, but they also appear to reflect pre-Bowser erosion as indicated by the local basal beach or littoral deposits and rhyolite flows. The fold structures developed within the Bowser rocks have been produced by their response to the depositional basin environment and to later deformation.

Cleavage

Cleavage is best developed in the thinly laminated argillaceous siltstones of the Bowser assemblage. Phyllites are prominent in the Slate Mountain section of the map-area where Bowser siltstones unconformably overlie Hazelton epiclastics and cataclasites. The cleavage is parallel to the unconformity, but was presumed to have developed as a response to folding (slaty cleavage), thus, Slate Mountain. However, observations in the area lead to an alternative, especially as the phyllite member extends across the Bowser-Hazelton contact as an imposed, weak, secondary foliation on the underlying Hazelton rocks. At Slate Mountain the Bowser rocks extend tongue-like across steep Hazelton conglomerates and mylonites. This irregular slab of thinly banded siltstone forms a crudely homoclinal structure dipping north toward Long Lake. In detail the siltstones are complexly folded with overturned, asymmetric folds dominant. At the extreme south end of the tongue, attitudes of the axial planes are predominantly east-west with steep north dips. Toward the south end of Long Lake the axial plane attitudes swing to northwesterly and the folds plunge at a shallow angle to the west. At the Long Lake dam the folds are upright with northeasterly trending axial plunges and they plunge steeply north. The primary bedding planes have been partially obliterated in the phyllitic zone and weathering has accentuated the thinly striped bedding features sufficiently to allow the structure study.

In this section, cleavage is best developed in the southern and western limits of the Slate Mountain overlap. At the south tip the cleavage and contact are almost uniformly horizontal, cutting directly across the steep axial planes of the minor folds. Cleavage in the thin phyllitic zone in the underlying Hazelton rocks is essentially parallel. Northerly through Slate Mountain, cleavage patterns show no direct relationship to the minor folds. Well-developed cleavage south of the dam and along the west side of Slate Mountain cuts across all visible minor fold axes and parallels the small fault shown on Figure 3. Slate-like phyllitic siltstones are well developed along this section where the steep northerly trending fault-related cleavage has been superimposed on the undulating contact controlled cleavage. The foliations exhibited are not flow cleavage, but instead are related to faulting and to the undulating main contact, indicating mass epidermal sliding on the old surface with the production of slip cleavage. " Slip Mountain " would possibly be more apropos than " Slate."

The fault contact between Bowser siltstones and sandstones on the north side of Betty Creek represents also a section where limited slip cleavage has developed. Steeply inclined competent sandstones overlain by thinly layered siltstones have parted producing a high-angle fault with adjacent narrow foliated zones which dies out where the contact flattens.

Elsewhere, foliated zones have been developed in Bowser rocks at the margins of the numerous intrusions and along the many fault zones.

The Portland Canal Fissure Zone described by McConnell (op. cit., p. 30) represents an irregular shear zone developed along a northeasterly trending steep fault best developed in Bowser siltstones. On Figure 3 the fault is shown extending from the Bear River Bridge across Glacier Creek toward Bitter Creek. Areally it represents one of the minor shears, but it has assumed importance because of the occurrence of mineralized quartz-breccia veins.

Exposures along Glacier Creek and in the nearby underground workings show complex minor isoclinal folds. Cleavage in these rocks is generally steep and parallels the fault zone, cross-cutting the axial planes of the minor folds. Rather than a simple fault the zone consists of numerous closely spaced faults and intersecting cleavages which generally tend to obscure primary S-planes. Eastward along the Glacier Creek section the upright, northerly plunging minor folds are variably obscured by well-developed cleavage that transects axial planes. In the Maude Gulch section, intersecting cleavage systems appear to be related to faults, isoclinal fold axes, and to the intrusive contact zones.

Conditions responsible for the imposition of foliate structure upon bedded Bowser rocks appear to have been very simple. The few requirements were adjacent rock masses of different competency and a differential movement which resulted either from intrusion or tectonic deformation.

Folds

Folds at various scales are visible in almost all the Bowser rocks, and the style of the folds varies widely. The complexity of folding depends upon the scale, the intercalation of strata of different competency, the proximity to plutons and to competent parts of the underlying Hazelton. Outcrop areas of Bowser rocks are abundant and readily accessible and excellent vertical as well as horizontal exposures have allowed the complex nature of the folding to be analysed.

Fold structures in the Dillworth syncline and the other structural remnants of Bowser strata encompass the geometric spectrum. In size the minor folds range from inch-scale enterolithic-like features to nappe-like structures nearly 1 mile long, to simple troughs up to 5 miles long. The sheer multitude of structures precludes the simple naming practice used for the minor folds in Hazelton rocks. Instead, generalized groups of folds will be described in the following.

Small-scale, ripple-like structures have been observed in thinly striped, alternating, gray-buff argillaceous siltstones such as exposed at the south end of Slate

Mountain. In flat-lying beds the ripple-like structures are upright with an amplitude seldom exceeding one-quarter to one-half inch. In all the laminæ examined the flat bottom of the layer-marked bottom and the peaked crests indicate stratigraphic tops. Where completely exposed the ripple-like cross-sections exhibit separate peaks rather than the normal elongate ripple wave form. In equivalent foliated laminæ, the ripple-like structures are asymmetric and present a disharmonious fold form. This small-scale feature possibly represents structures developed both by slip cleavage and by compactive forces which generated true enterolithic structures in certain favourable layers.

Folds larger than inch scale but less than 100 feet in amplitude are found in all the Bowser siltstones. These vary in form from simple, open, upright flexures to complex recumbent folds. They are generally restricted to thin-bedded siltstones intercalated between sandstones. The small-scale isoclinal folding is typically found where the containing sandstone members are strongly flexed, such as on the crest of a fold. Such flexural folds are common on Mount Dillworth in siltstones intercalated within the sandstone unit.

Complex isoclinal fold zones are common in the thick siltstone units where deformation is associated with faulting and intrusion. The Glacier Creek-Maude Gulch section exemplifies such a zone where confused large-amplitude isoclinal folds abound. Similar zones are also shown on Figure 4, sections B-B′ to D-D′, along the Salmon Glacier section in the buffer zone along the east side of Long Lake.

Folds with amplitudes greater than 100 feet are common in the siltstone members within the Dillworth syncline. These can be mapped on the ground by outlining marker horizons and can also be traced on air photographs. Figures 3 and 12 show the most prominent of these minor folds. Along the west side of the main trough these folds are generally asymmetric and exhibit Z-fold or box-like geometry. From Long Lake the folds plunge northerly, and from the north slope of Mount Dillworth they plunge southerly into the trough. To the east toward Bear River Ridge the folds become more or less upright. Within the siltstone units these folds show a mixture of common concentric and similar styles. Canoe-shaped folds at outcrop and large scales are common in the Divide Lake area.

The large amplitude minor folds such as the upright trough structures located along the east side of Summit Lake present few problems. The large, recumbent folds mapped in the sandstone unit west of Little John Lake require detailed mapping and analysis. One such nappe-like structure is shown in Plate XI to illustrate a north-south section through the folds. These can be described geometrically as nonplanar noncylindrical folds with noncylindrical axial surfaces (*see* Badgley, 1965). "Confused fold" is the term used here. These folds are best developed in the sandstone unit where the competent sandstone layers (grey, Plate XI) are sandwiched within sandy siltstones (black, Plate XI). The cross-sections on Figure 4 are at too small a scale to illustrate the east-west section through this section adequately.

The characteristic disharmonic folding found in the Dillworth trough is exemplified by the structure shown in Plate XI. Faults related to these curvilinear folds which can be seen at the left side of the photograph add to the complexity of these structures. With regard to fold size, these folds demonstrate the relationship of the large minor-fold structures to competent rock units.

SUMMARY

Kinetic implications indicated by the fold structures described include the role of plutonic emplacement and gravity tectonics. The first can be judged quickly from the geology maps and cross-sections to have played a significant role at the margins of the plutons and in the dyke swarms. The maximum observed effect of intrusion along the Salmon Glacier section is about 1 mile. The over-all complex style of folding, the detailed confused folding, and the various primary sedimentary structures all suggest gravity tectonics played the primary role in the active stage of basin development in this area.

CATACLASITE ZONES

Several major cataclasite zones have been mapped in the Stewart area (*see* Fig. 8). These structures had not been recognized by the early workers and their importance in localizing mineral deposits has been stressed in this report.

The Cascade Creek cataclasite zone lies along the lower west slope of Bear River Ridge between Mount Dolly and Mount Dillworth for a known length of about 8 miles. The maximum width of the zone, about 1 mile, is along the Cascade Creek section immediately north of the Alaska border. The Bear River zone mapped north from Stewart along the lower valley slopes toward Mount Bunting (Figure 3) appears to be less extensive than the Cascade Creek zone. A number of small but well-defined cataclasite zones have also been shown on Figure 8.

It is significant that none of the cataclasite zones mapped was found to extend into Bowser assemblage siltstones and greywackes. Also, as shown on Figure 8, the cataclasites are largely if not exclusively confined to predominantly green epiclastic conglomerate and sandstone.

The major Cascade Creek and Bear River cataclasite zones include cataclasites, mylonites, minor kakirites, semi-schists, and country rock panels, described in Chapter 2. Both zones trend northerly with easterly convexity and minor structures developed within the zones indicate an over-all moderate to steep west dip. Foliations measured within the zone vary widely, but lineations show a consistent westerly plunge.

The relatively small cataclasite zones shown on Figure 8 north of Bear Lake, along American Creek, and in the Bear River Pass sections are more or less discontinuous zones not confined to continuous strata and do not form discrete units. They are difficult to trace on the ground because of the stream-bed locations and cross-cutting dyke swarms. Rock types in these zones are various cataclasites similar in aspect to those in the major zones.

A second set of deformed zones trending westerly to northwesterly with steep dips are also shown on Figure 8. They form discrete mappable units within the Hazelton rocks, but unlike the Cascade Creek type are not confined to certain strata. Rather, they cut across all lithologic boundaries with the exception of Bowser rocks which show an apparent overlapping relationship. The principal rock types in these zones are schists with minor mylonites as described in Chapter 2, pp. 44 to 47, as opposed to the simple rocks forming the extensive northerly trending zones.

In the Stewart area about 20 per cent of the known mineral deposits are localized within the narrow cataclasite zones. Significantly, the two largest ore deposits occur within rocks of the major Cascade Creek zone, pointing out the economic importance of these structures.

FAULTS, LINEAMENTS, AND FRACTURES

The study of faulting in the Stewart map-area has been mainly confined to field observations during the course of mapping the general geology and the mineral deposits. Air-photograph interpretations made in the initial preparation stages of the project indicated a complexity of apparent faults which upon field study proved to be largely lineaments produced by erosional processes. The most apparent air-photo lineaments have been shown on Figure 3 along with the major faults. The faults have also been displayed in the distribution-map (Fig. 12) which illustrates the structural trends. This study has shown that for the Stewart area the air-photograph fracture-interpretation technique can be applied only with considerable diligence and close ground control.

Four fault systems can be deduced from the geologic map which shows dominant northwesterly, northerly, and northeasterly trending sets. However, in any attempted stress analysis the time factor if included would show that each set has been reactivated during the local geologic development with the earliest and latest being the northerly trending system. The later faults affecting the majority of the rocks in the area mainly represent simple displacement features where rock competency has played a role in determining amplitude and attitude. Both strike slip and thrust faults are prominent in the Bowser rocks, but the former type are more extensive, involve the underlying Hazelton as well, and include most of the faults shown on Figure 12.

The northerly trending fault system includes the structures which strike between 15 degrees west of north to 15 degrees east of north, and have steep west to vertical dips. Apparent movement along these northerly trending faults has been measured where possible, and where significant shows as contact offsets on Figure 3. The Long Lake fault (*see* Plate III) has the greatest continuous length of all known faults in the Stewart district and like most exhibits a predominantly strike-slip movement. The measured offset along this fault between the Bowser-Hazelton contact north of Divide Lake is approximately 1,500 feet. No appreciable vertical movement is recognized. North of Divide Lake the Long Lake fault extends under an extensive snowfield, but regional mapping indicates a probable continuity as far north as the Bowser River. South of Monitor Lake the Long Lake fault splits into several components which offset Hazelton mylonites and cut off a northwesterly mineralized fault zone. In the Cooper Creek section the Long Lake fault may terminate in the black mylonite band, but its possible extension is marked by a strong lineament which probably extends into the Premier area to join the Fish Creek system which has been traced to Portland Canal. The measured length of the fault is about 10 miles, but it has an apparent regional extent of almost 40 miles from the Bowser River through Premier to the Portland Canal.

The distal portions of the Stewart section of the Long Lake fault which transect Hazelton rocks show minor offset, while the maximum apparent movement occurs within the Dillworth trough section. Along the length of the fault it is marked by only a narrow gouge zone seldom exceeding a few feet. No significant mineralization was found along the Long Lake fault zone.

Northwesterly trending faults are prominent in the Bear River and Salmon valley districts. This system includes those structures trending between about 25 degrees west of north to 60 degrees west of north and have generally steep dips. Field relationships show that these faults cut all the country rocks and cut or are cut by the other fault systems. The northwesterly faults are not as extensive as the northerly faults and generally show less apparent strike-slip movement. The Fitzgerald Creek and Dundee Creek faults on the west side of the Bear River opposite Bear Lake are significant examples of the northwest fault system. Fitzgerald Creek has been eroded along the narrow fault zone which transects the Bowser-Hazelton contact as well as the Portland Canal dyke swarm. Strike-slip movement appears to be relatively minor and the sense of dip slip is indicated by offset tuffaceous beds in Bowser sandstones at the head of Lydden Creek. Here the offset beds along the fault indicate a down movement on the east side and a fault scarp preserved at the head of the small cirque is over 100 feet high. The extreme complexity of the dyke swarm in this area has obscured the stratigraphy, precluding an accurate estimate of movement. Snow has filled in most of the fault zone, but steep gully walls up to 100 feet apart appear to mark the width of the zone. The Fitzgerald Creek fault offsets quartz veins and northeasterly faults, and does not appear to be mineralized.

The Dundee Creek fault zone lies parallel to Hazelton volcanic epiclastic strata and forms a wedge-shaped zone which widens toward the crest of Bear River Ridge where it is hidden by snow. The upper section of the wide zone is visible from the Bear River road as a bright gossan. The zone includes altered fragments of country rocks, phyllonites, and chloritic schists, and all the rocks are pyritized, including the wallrocks. Scattered chalcopyrite as well as quartz-sulphide veins are found in the zone and mineral exploration has been extensive in the area. The Dundee Creek zone appears to terminate along the ridge where it is overlain by Bowser sediments. However, it is similar to the northwesterly schist zones along Summit Lake and may be related.

In the Summit Lake section the country rocks, including the extensive schist zones, are cut by limited northwesterly faults which show strike-slip movement. The somewhat sinuous Goat Creek fault represents a partly contact controlled structure that appears to be confined to the Troy Camp trough. The Mineral Gulch fault lies along the stratigraphic contact between competent lower Bowser sandstones and overlying thin-bedded siltstones. It is offset by both northeasterly and westerly faults.

The northeasterly fault system includes structures which trend from north 30 degrees east to north 50 degrees east and have steep dips. These faults also cut most of the country rocks and cut off other faults. They are dominantly strike-slip structures which, although less extensive than the Long Lake fault, have similar measurable movement.

The Bowser-Hazelton contact along the west slope of Mount Dillworth has been offset by a number of short northeast-trending faults which exhibit lateral offsets up to 1,500 feet. The Myrtle Creek fault offsets a nose of the Texas Creek pluton, but dies out as a weak lineament in altered cataclasites at Noname Lake. The Cobalt Creek fault cuts dykes, granodiorite, cataclasites, and altered country rocks with minor strike-slip and no recognizable vertical movement. It appears to die out in volcanic epiclastics, but a lineament suggests that it continues to the south end of Long Lake. In the Silver Creek section the country rocks and cataclasites are offset by a number of northeasterly faults which cut late lamprophyre dykes and are erratically mineralized by late quartz-sulphide veins.

The Portland Canal fissure zone which extends from the Bear River Bridge toward Bitter Creek cuts a variety of country rocks and is one of several northeasterly faults mapped in the Bear River valley section. At the south end, the Portland Canal fissure sharply marks a smooth contact between Hyder quartz monzonite and Hazelton volcanic conglomerates and breccias. Where it swings into Bowser siltstones south of Glacier Creek the dip decreases to about 45 degrees west and the simple fault becomes part of a complex fault zone at least 1,500 feet wide marked by extensive shearing. The zone continues northeasterly along Dunwell Creek. The width and complexity of the zone decreases to the northeast and the dip steepens to 70 degrees west. The fault apparently dies out in Bowser siltstones south of the Bitter Creek pluton. The Bear Lake fault is the most extensive northeasterly fault structure in the Stewart area. It extends from Bear Lake to Bear River Pass as a steep-walled gully and continues through the Mosquito Creek section where its dip flattens to the west along the contact between volcanic breccia and Bowser siltstones. In the Bear River Pass section the fault disappears in a complex dyke zone.

The westerly trending faults trend from 15 degrees north of west to 20 degrees south of west and have steep dips. One westerly fault extends between Divide Lake and American Creek, but no movement was recognized. These faults are more prominent along the west slope of Mount Dillworth, where they offset northeasterly and northwesterly faults and the Bowser-Hazelton contact. Strike slips of 200 to 500 feet were measured on these structures. These faults appear to extend from the competent Hazelton rocks into the more plastic Bowser strata, where they die out as minor folds.

The thrust faults observed in the Bowser rocks are primarily break thrusts such as seen in Plate XI and although numerous are not readily mappable at the scales used in this report, and have little local economic significance. These are clearly dependent upon pre-existing folding and can merge with local axial-plane thrusts.

The simple strike-slip faults which dominate the area are best developed in the Bowser rocks and were formed at an intermediate to late stage.

Faults confined to Hazelton rocks include the simple, normal type as well where deformation has been localized between contrasting rock types. Normal faults with small apparent movement are common at plutonic-country rock contacts and especially numerous in the dyke zones.

The various dyke swarms have been intruded along fracture zones, the attitudes of which swing with inhomogeneities of the country rocks. The Premier dykes are good examples of this feature where they bend in the Cascade Creek cataclasite zone. The main Portland Canal swarm generally has a nearly vertical dip in Hazelton rocks, but where it enters fractured Bowser members the dykes bend abruptly, often following gently dipping bedding-plane fractures. This is well illustrated in the section between Long Lake and the Salmon Glacier.

Within the ore deposits, faults are common and have little apparent displacement. With the possible exception of the Big Missouri property, faults have not been serious impediments to normal mining.

SUMMARY

Field studies here have amply shown that rock deformation has been determined by the bulk behaviour of the various country rocks. The competency of the rocks involved in the deformation has also been shown to have been determined by such macroscopic factors as rock type, grain size, and layer thickness. Other possible factors such as thermal buildup, diffusion, recrystallization pressure, and rock vapour pressure command some thought but must remain unknown at the present.

Faulting, as defined by loss of cohesion, displacement, or loss of resistance, has been recognized as a major structural feature in the Stewart area in regard to simple landscape evolution as well as the complex formation of ore deposits. The cataclasite zones outlined along Cascade Creek and Bear River represent the most extensive fault zones in the area (*see* Fig. 12). Less-extensive deformation zones are shown on the same map where the confinement to medium-grained Hazelton assemblage epiclastics is demonstrated. In these zones the faulting consists of the granulation of mineral and rock fragments and the movement has been largely intergranular without extensive recrystallization. Timing, on the basis of field studies, shows that these zones were induced prior to the physical intrusion of the major plutons (wedging) and have been metasomatized, mineralized (in part), and further deformed in stages at later periods.

A regional statistical analysis of the attitudes of fractures has not been possible, mainly because the field data collected have too wide a scatter. The air-photographs of the Stewart area are not of a sufficiently high quality to permit an office compilation of the fractures. On a few of the mineral properties (*see* Chapter 6), fractures have received some study and have been found to be useful in distinguishing between certain rock types. For example, at the Silbak Premier property it was found that fracture sets could be used to differentiate between altered cataclasites and the metasomatic Premier Porphyry.

"Ye shall not judge of the great operations of the mineral kingdom from having kindled a fire and looked into the bottom of a little crucible."
—*Hutton.*

CHAPTER 5

Mineral Deposits

INTRODUCTION

Settlement and human activity in the Portland Canal district has been entirely related to the development of the mineral industry of the Stewart area. The placer miners of the ill-conceived '98 expedition led the rush into this rugged area and were immediately followed by the " hard rock " prospectors who stayed on to settle and explore. The slow progress of these men in the early years has been recorded in the Annual Reports of the British Columbia Minister of Mines, starting with a brief note in 1898 concerning the staking of gold-quartz claims on Bitter Creek by H. B. Connors and partners. In 1902, Stewart and Brightwell located mineralization at American Creek which reportedly gave assays of 600 ounces per ton silver as well as gold and copper. In 1904, silver-bearing mineralization was found in the Salmon River section and a permanent International Boundary monument was established at Eagle Point to delineate the disputed border. By 1908 the surge in prospecting demanded the construction of the Bear River Bridge, wagon-roads, and trails to the Bear River district, where prospecting was concentrated. By 1910 the British Columbia portion of the Salmon River district had attracted notice and William Dillworth and the Bunting brothers had discovered and staked the original Premier mine showings. The location of high-grade ore at Premier in 1918 led to the development of one of the richest mineral deposits in British Columbia and provided the incentive for exploration and development in the area which continues today.

The Stewart map-area has been the key to the development of the much larger mineralized region within which it is situated. The Stewart Complex, stretching along the east margin of the Coast Crystalline Belt from Alice Arm through Stewart to the Iskut, has proved a very significant producer of gold, silver, lead, zinc, copper, and molybdenum. The continually changing economic emphasis on various metals precludes the exclusion of " mined-out " deposits from regional or local mineral deposit appraisals. Although it has not been possible to map all of the mineral deposits recorded in the Stewart area, the properties which have had recent attention have been checked and in some instances new information and ideas have been forthcoming. At most properties where the underground workings have been extensive, new maps have been compiled from the old records. Unfortunately at most old properties complete geologic mapping has been impossible because of caved workings, ice, water, and bad air. It has not been possible to examine the details of the various mined-out ore-shoots, but some attempt has been made here to update mineralogy and ore environment from studying material that remains. The Crown-grant claim maps (Fig. 15) for the Stewart map-area have been included in order that properties referred to in old reports can be located, a somewhat difficult problem otherwise. Most of the properties and prospects in the area have been described in the Annual Reports of the British Columbia Minister of Mines; Geological Survey of Canada, Memoir 32 (McConnell, 1913); Geological Survey of Canada, Memoir

132 (Schofield and Hanson, 1922); and Geological Survey of Canada, Memoir 175 (Hanson, 1935). Properties contiguous to Stewart in the Alaskan section were described and compiled by Buddington (1929) and should be regarded geologically as important to the whole.

The success of the Silbak Premier deposit has provided impetus to mineral search in the area, but at the same time its pre-eminence has resulted in too narrow a geological approach to further exploration. Indiscriminate use of Premier mine terminology and apparent ore controls permeates old stock promotions, reports, and descriptions and, combined with other misinformation, has led in the past to some curious concepts about the mineral deposits and the region.

TABLE 2.—RECORDED MINE PRODUCTION, STEWART AREA

Property	Year	Ore Shipped or Treated	Au (Oz.)	Ag (Oz.)	Cu (Lb.)	Pb (Lb.)	Zn (Lb.)
Bear River—Stewart							
Bayview	1925	10	1	1,539		2,970	3,870
Big Four	1947–50	48	3	9,128		15,184	13,214
Black Hill	1930–35	49	2	7,010	480	14,738	
Dunwell	1926–41	50,387	9,876	329,805	27,014	1,847,838	2,444,627
Evening Sun	1913	7					
Glacier Creek	1937	13	4	250		6,157	
Kansas	1915–37	9	4	144			
Kenneth	1930	1	1	1,644	32	934	
L & L	1924, 1925	67	6	12,161		18,148	21,095
Lakeview	1913–36	66	9	5,274		14,747	
Lucky Seven	1911, 1912	9,000	612	25,869		280,090	
Marmot Metals	1913–30	25	5	4,688	21	7,481	6,534
Mayflower	1910	4		144			
Mayou	1929	2		233	952	1,327	
Melvin	1929	4		776			
Mobile	1949	8	1	1,538		1,192	1,483
Montana	1913–30	25	5	4,688	21	7,481	6,534
Morning	1936	1		43		71	
Mountain Boy	1929–38	60		32,810	3,843	3,773	
North Fork Basin	1924	8		900		2,000	
Ontario	1937	20	1	3,034		12,615	
Oral M	1940, 1941	320	22	112	4,575		
Porter Idaho	1924–31	5,256	276	563,466	5,235	723,781	
Portland Canal Mining Co.	1907–11	7,000					
Prosperity	1926–39	26,628	568	1,765,598	52,444	2,277,658	6,070
Ranier	1940	1		121		160	86
Red Cliff	1912–40	1,283	160	38	88,949		
Ruth	1939, 1940	13	2	1,200			
Saddle	1929	3		84	97	3,165	
Silverado	1922–32	106	17	22,009	2,357	34,675	
Silver Hill	1925	1		282		92	
Silver Star	1919, 1920	36	1	3,396		7,873	
Sunshine	1922	2		770			
Terminus	1925–49	27		6,115		9,017	11,513
United Empire	1934–36	169	10	4,418		23,451	16,918
Virginia K	1935	16		1,574	125	3,892	
Salmon River—Bear River Ridge							
B.C. Silver	1924–27	1,103	2,218	88,058	290	10,787	
Big Missouri	1927–42	847,615	58,384	52,677		2,712	3,920
East Gold	1949–53	30	984	2,816	60	3,334	1,231
Indian	1925–53	14,187	1,258	49,514		1,246,894	1,559,405
Little Joker	1934–50	15	21	1,729	36	140	
Morris Summit	1947	1,500					
Outland	1926–29	4		107	28	1,118	
Premier	1918–37	2,817,327	1,380,906	33,652,118	2,329,630	22,673,075	3,194,284
Silbak Premier	1936–68	1,852,845	436,038	7,292,860	1,967,247	36,236,085	13,050,522
Premier Border	1950–53	42,995	3,104	86,695		3,586,976	4,344,069
Silver Crest	1925	1		282		92	
Silver Tip	1915–51	29	10	2,208		8,026	11,232
Spider	1925–33	11	6	3,902		1,701	1,890
Woodbine	1929	5	8	80		292	
Totals		5,678,361	1,894,565	44,043,907	4,483,436	69,091,742	24,698,497

TABLE 3.—RECORDED PRODUCTION OF THE RIVERSIDE MINE

Year	Ore Milled (Tons)	Au (Oz.)	Ag (Oz.)	Cu (Lb.)	Pb (Lb.)	WO_3 (Units)[1]	Zn (Lb.)
1925	105[2]						
1927	6,500	419.5	15,210	none	460,200		
1941	3,368					1,320	
1942	1,381	23	830	none	29,000	372	
1943							
1944						976	
1945	1,300	(3)	(3)	(3)	(3)	(3)	(3)
1946	1,819	70	6,996	4,000	230,000	415	
1947	5,064	697	22,284	24,000	510,000	(4)	
1948	4,005	736	25,290	28,000	634,000	(4)	2,100
1949	2,100	151	3.500	7,700	97,000	(4)	3,800
1950	3,500	356	12,700	12,000	298,000	99	12,000
Totals	29,142	2,452.5	86,810	75,700	2,258,200	3,500	17,900

[1] A unit is 20 lb. of WO_3.
[2] Tons concentrate, grade unreported.
[3] Not reported.
[4] Small quantities of tungsten concentrates produced, according to *Minerals Yearbook*, 1947–49.

Mineral Production

The total published production of individual mines and properties in the Stewart map-area up to 1968 is compiled on Table 2 from British Columbia Department of Mines and Petroleum Resources records and company records. Unfortunately, complete analyses of the various ores are not available, so that in most instances only the major metals have been listed. Alaska data are incomplete, particularly for the period 1938–46. Fairly complete statistics for the Riverside mine, the Hyder district's main producer, follow on Table 3 (U.S.G.S. Bull. 1024-F, p. 129). Table 4, showing the recorded production from major British Columbia mining divisions, has been included to illustrate the relative position of the Stewart area. In the Premier camp, production was divided between several companies during the various stages of mine exploration. The combined production for the vein system has been shown on Table 6, page 155. From the above statistics (Tables 2, 4) it is clear that the Stewart area has been primarily a gold-silver district and, apart from the Silbak Premier mine, many of the producers were small, high-grade operations. The statistics also suggest some similarities as well as differences which can be better explained after considering the general mineral deposit classification.

In terms of British Columbia gold and silver production it is of interest to note the relative standing of the Stewart district and the Premier vein system in particular. Total production from the Stewart district ranks high in relation to other mining areas of British Columbia. A table listing net total production for six major mining divisions as well as the Stewart area follows:—

TABLE 4.—TOTAL RECORDED PRODUCTION OF MAJOR MINING DIVISIONS TO THE DATE INDICATED

Mining Division	Date	Au (Oz.)	Ag (Oz.)	Cu (Lb.)	Pb (Lb.)	Zn (Lb.)
Cariboo	1966	1,196,770	145,634	2,352	24,560	505
Fort Steele	1966	6,863	224,619,929	28,592	12,573,756,398	9,352,321,446
Lillooet	1967	4,027,027	960,010	400	62,513	15
Nelson	1967	1,337,651	9,038,258	14,915,405	456,208,897	1,200,946,401
Slocan	1967	16,085	74,756,427	13,662	1,031,460,552	849,974,195
Trail Creek	1967	2,984,561	3,673,072	122,561,732	146,421	133,571
Stewart area	1967	1,894,565	44,043,907	4,483,436	69,091,742	24,698,497

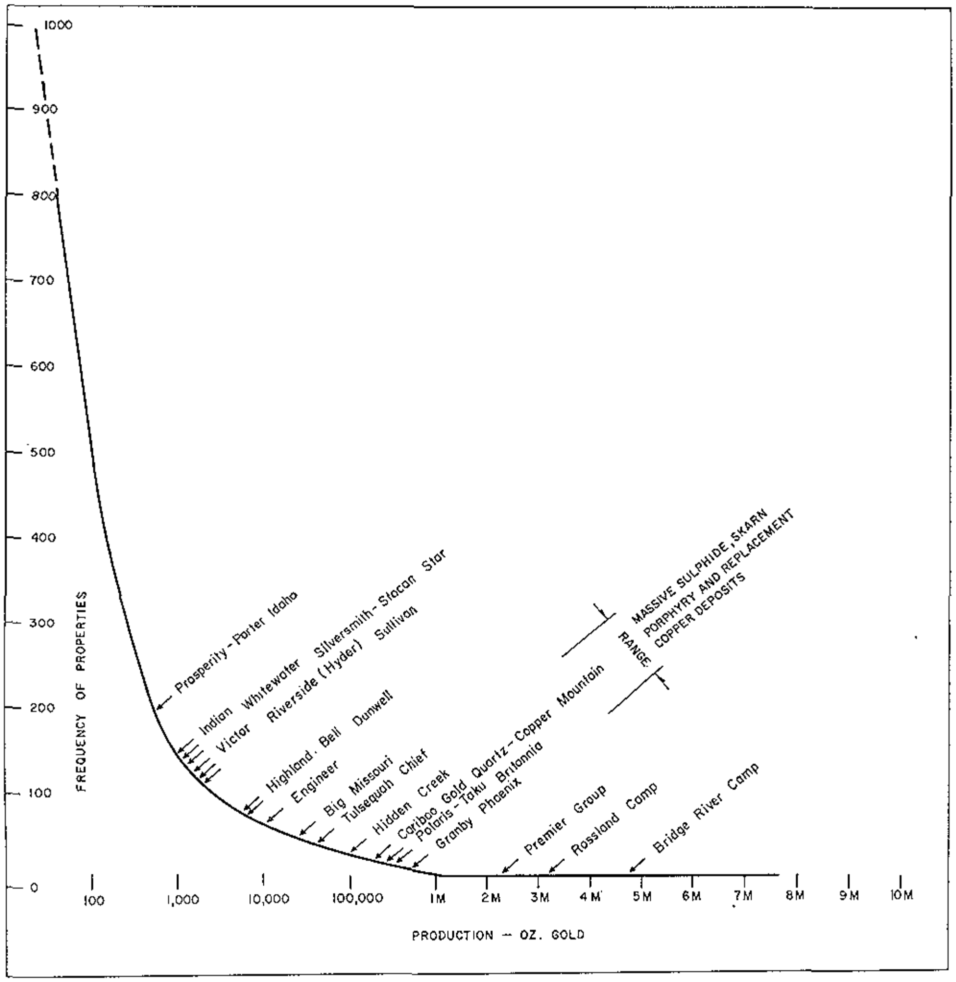


Fig. 16. Frequency distribution, British Columbia gold producers.

In terms of vein systems the Premier ranks third in gold production after the Bralorne-Pioneer mine in the Lillooet Mining Division (No. 1) and the Rossland (No. 2) mines in Trail Creek. Together these three vein systems, dominated by three producers, have accounted for slightly more than half the total British Columbia gold production of about 16.7 million ounces. The relative position of these three camps in relation to approximately 880 other British Columbia lode-gold producers has been illustrated on Figure 16. The graph is a frequency plot of gold production against the number of producers. Several mines, as well as the three largest camps, are listed. The graph shows the relative scarcity of the big primary gold producers, the importance of copper mines as gold producers, and the fact that the majority of multi-metal mines have produced relatively small amounts of gold.

With regard to the future of gold in British Columbia, mines such as the Premier, Rossland, and Bridge River camps have proved to be rarities, with production dependent on mining economics and new exploration concepts. Likely, the bulk of the future gold production in British Columbia will come from large-scale copper-molybdenum operations. The multi-metal deposits, which are highly sensitive to the economic climate, will continue to contribute a small share of the future gold production.

Total British Columbia silver production to 1967 was roughly 466 million ounces, of which the Sullivan mine alone produced almost half (223 million ounces), from about 98 million tons of ore. The Premier system, which has produced 41,119,000 ounces from 4.7 million tons (*see* Table 6), ranks second only to the Sullivan, and has no close rival. In comparison to the Silbak Premier, other mines in the Stewart area have been considerably less productive but many have earned profits and have contributed to sustaining mining interest in the immediate area and the Stewart Complex as a whole.

A graph (Fig. 17) showing the relative position of the significant British Columbia silver mines has been presented here to complement the graph for gold. The rarity of the big silver producers is shown, especially the anomalous Sullivan mine. The lode and porphyry copper mines are grouped in an intermediate position, followed by the typical gold and multi-metal producers. Silver production will continue to be dominated by the Sullivan for many years, but new large-scale developments will add significant quantities in the future. In this category the Granduc mine, near Stewart, presently coming into production, will produce about 700,000 ounces of silver per year as a by-product from copper ore.

Together the two graphs (Figures 16 and 17) illustrate several groupings of gold, gold-silver, silver, porphyry copper-molybdenum, and multi-metal mineral deposits. The frequency of occurrence of mineral production from the groups is indicated and the probability of such occurrences can be crudely deduced. Also the graphs show the uniqueness of the Premier vein system.

Distribution and Occurrence of Mineral Deposits

Figure 13 indicates the distribution of known mineral deposits in the Stewart map-area which have been of significant interest since 1930. The deposits or prospects are listed according to their most current name used in the Annual Reports of the British Columbia Minister of Mines and Petroleum Resources. To view the relationships of the deposits indicated on Figure 13 with geological features such as proximity to intrusions, structural features, etc., the distribution-maps can be used as overlays. Although it is not readily apparent from the distribution-map, many of the prospects and mines are along accessible river or stream valleys and below the old limits of ice and snow. Almost all of the known deposits have been found by examining gossans sighted from the valleys in areas of negligible vegetation. The areas with no deposits represent areas hidden by permanent ice and snow or covered by lush vegetation. A geologically significant reason for blank areas is the extensive cover of non-productive Bowser rocks.

In good weather many of the more interesting local deposits can be visited using the various road systems which cut northerly into the map-area from Stewart. The Silbak Premier mine can be easily reached by the new Salmon River road to Tide Lake Flats, and the Big Missouri from a road connecting to the Premier-Salmon River road system. Two short, easy trails from the same new highway lead to the

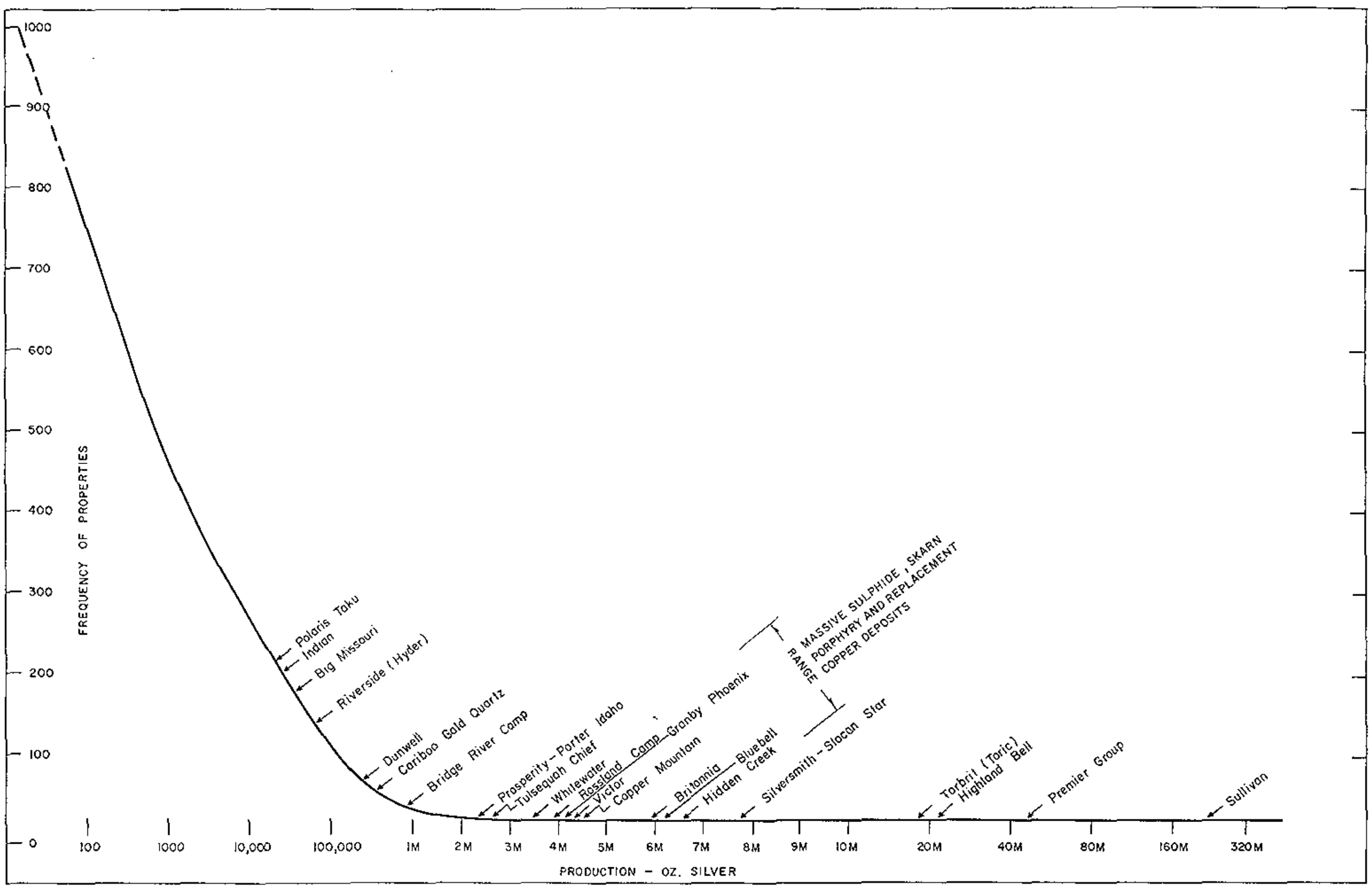


Fig. 17. Frequency distribution, British Columbia silver producers.

Indian mine northwest of Premier. With the exception of properties along the west side of the Salmon Glacier, most of the area west of Bear River Ridge requires only a vehicle and fairly easy climbing. Properties on the east side of the ridge above Bear River can be reached by helicopter or by extended foot-trips. The highway north from Stewart to the Bear River Pass gives fairly good access to a number of small properties such as the Dunwell. Mineral occurrences in the Marmot River area southeast of Stewart are essentially cut off from easy access except by helicopter or by combined boat- and foot-trips.

Most of the known mineral deposits in the Stewart area have been formed within the Hazelton assemblage. The Silbak Premier, Big Missouri, Prosperity-Porter Idaho, and Indian mines are the outstanding vein-replacement deposits in the map-area and are found in deformed and altered equivalents of volcanic epiclastic Hazelton members. A good number of vein and fissure-zone deposits have been explored in Bowser sediments, primarily in the Glacier-Bitter Creek area. Of these the Dunwell mines quartz-breccia-sulphide deposit has so far proved the largest producer. Many of the prospects and small producers lie within the confines of the major Portland Canal dyke swarm. At some of these properties, notably the Silver Tip (upper workings) and Outland Silver Bar, the dykes as well as the country rocks have been mineralized. As a general rule in this area, as well as in the Stewart Complex as a whole, the close spatial relationship between dyke swarms and mineral deposits is readily apparent. Other deposits have been found in the various plutons. The Texas Creek granodiorite has been extensively examined in Alaska and the Riverside mine is the major deposit within the granodiorite. Vein deposits found in the augite-porphyry stocks include the Spider at the northeast end of Long Lake and the L and L Group veins in the Glacier Creek area. Minor silver-bearing quartz-sulphide veins were intersected in the Granduc tunnel while driving through the Summit Lake hornblende diorite stock, but to date few of the other small plutons have been found to contain significant mineralization.

In summary, it can be stated that with the exception of the Tertiary basalt dykes mineralization of some sort has been disclosed in all the major rock units. Less than 100,000 tons of silver ore has been mined from the Bowser assemblage, whereas over 5 million tons of gold-silver ore has been taken from members of the Hazelton. Over 4.6 million tons of this production came from the Premier vein system from metasomatized cataclasites derived from medium-grained green andesitic epiclastics and tuffaceous epiclastics. Details and apparent controls of mineralization are discussed in Chapter 6.

Character and Extent of the Mineral Deposits

Attempting to characterize anomalies or freaks of nature such as the mineral deposits of the Stewart area involves statistical problems similar to rationalizing any mixed population where many of the significant factors remain unknown. Within the immediate map-area, certain apparent similarities of form and structure stand out and may in effect represent meaningful physical-chemical features. Silver- and gold-silver-bearing mineral deposits form the bulk of the exploited occurrences in the Stewart area. The overwhelming majority of the prospects and producers are tabular quartz-breccia veins formed as fissure-fillings. Gradations from vein to replacement deposits are part of the general picture and the inherently simple nature of individual deposits stands out. In almost all known instances the oreshoots or bodies of significant sulphide mineralization have been found within the veins as blebs, streaks, pods, or lenses of irregular size, shape, and attitude. In regard to the major ore deposits, the oreshoots appear to have been localized by various kinks within the vein structure. The Premier has been considered representative of the gold-silver ores of British Columbia (Cooke and Johnston, 1932, p. 39). They imply that the bonanza ore mined at the Premier before 1930 was common, and that the shallow depth of the deposits compared to Precambrian gold deposits was typically related to topographic features and resulted in part from the process of secondary enrichment. The production statistics included here (Table 2), as well as the two graphs (Figs. 16 and 17), indicate that the Premier bonanza ore cannot be considered characteristic of British Columbia gold-silver ores or even of the Stewart district.

Mineral deposits in the Stewart area contain a rather common group of fairly simple ore and gangue minerals. Types of wallrock alteration, although generally simple, cannot be defined as a characteristic of the district because of the great variety of country rocks in which the mineral deposits formed. Secondary enrichment has not been significant in the formation of any of the high-grade orebodies. The mined orebodies are typically shallow and crudely related to surface topography, but this fact is controlled by the economics of mining and the limited geological exploration. Orebodies of the Premier system represent the maximum extent to which any of the Stewart deposits have been mined. In this system a series of overlapping lenticular shoots have been developed over a strike length of almost 5,500 feet and through a vertical range of 2,000 feet. At the Dunwell mine the main ore zone consisted essentially of one oreshoot measuring 120 feet long by 4 feet wide by 380 feet deep, lying within a fissure vein having a traceable surface length of almost 1,000 feet and a known vertical depth of 550 feet. Generally, however, the mined oreshoots of the other deposits formed a smaller fraction of the vein or vein system.

The frequency distribution diagram of the attitudes of the veins and vein systems in the Stewart district has been shown on Figure 18. Buddington (1929, pp. 44–47) observed the distribution of about 125 Hyder area veins and noted:—

> Almost half of the veins strike north 30 degrees to 60 degrees west and dip 45 degrees to 70 degrees east. One-fifth of the veins strike between north and north 30 degrees west and dip 45 degrees to 70 degrees east, and another fifth strike within about 15 degrees of east-west. A few veins have different strikes. Veins with strikes between north 30 degrees east and north 75 degrees east are rare. In the Texas Creek granodiorite about two-thirds of the veins strike north 30 degrees to 60 degrees west; in the greywacke, tuff, slate, and greenstone about half the veins strike north 75 degrees east to north 70 degrees west; that is, parallel to the cleavage or schistose structure or to the bedding planes.

Figure 18 shows the distribution patterns for veins in the various country rocks as well as the district patterns, and illustrates the mineralized fracture systems. Northwesterly trends dominate in the plutons and Hazelton rocks, whereas northerly and easterly trends dominate in the Bowser rocks (Hyder sediments, etc., included). Although northeasterly veins show only as a small fraction of the known veins in the Stewart district, a significant volume of ore produced at Premier was from this group.

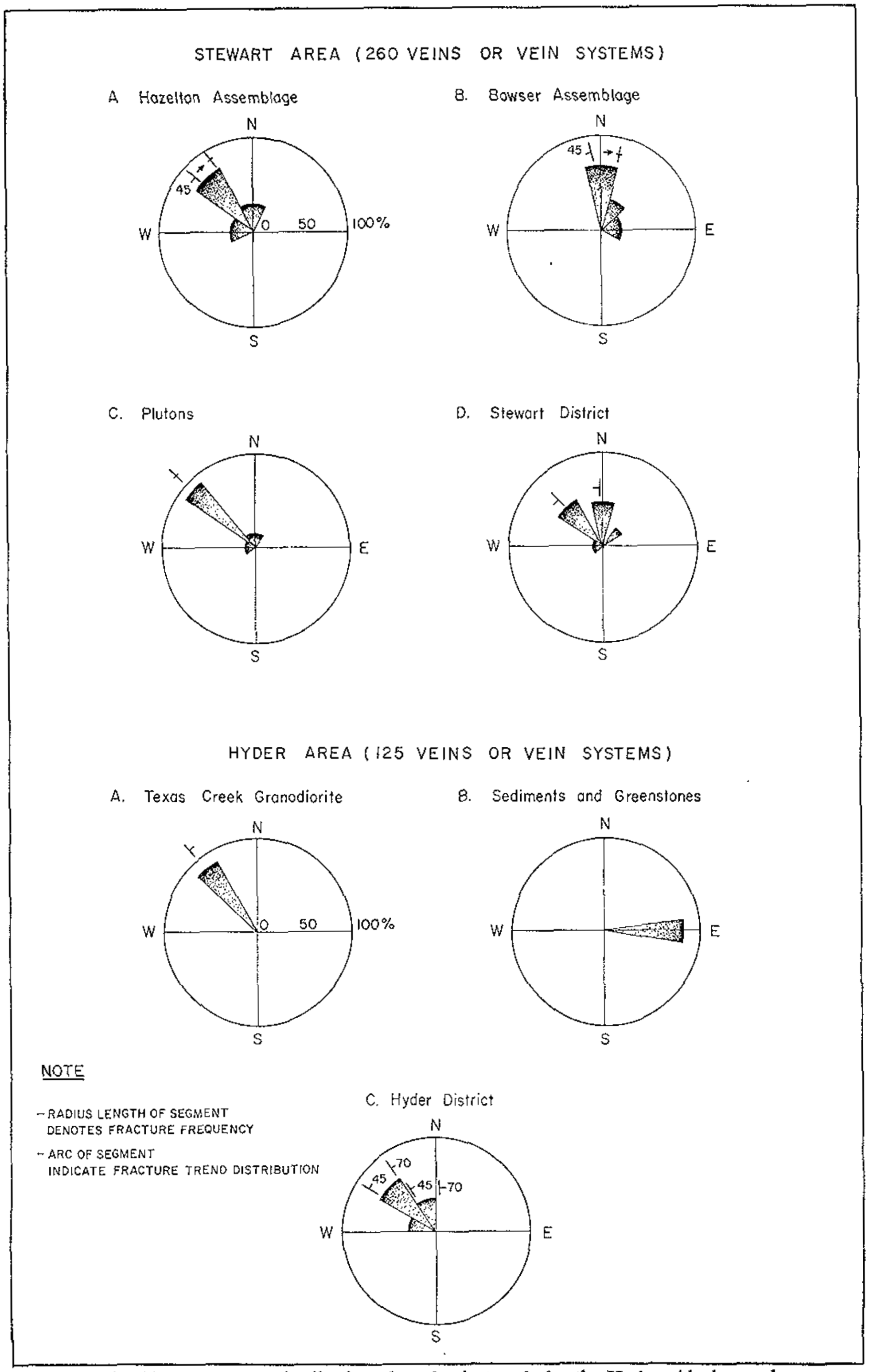


Fig. 18. Frequency distribution plot of vein trends for the Hyder, Alaska, and Stewart, British Columbia, area.

CLASSIFICATION

McConnell (1913) instituted a simple general grouping for the mineral deposits known in the Stewart area in the pre-1912 era. His classification included two groups—(1) veins and fissure zones; (2) replacement deposits—, and he noted that the two were rarely sharply definable. By the early 1920's many of the presently known mineral deposits had been located and preliminary exploitation started. Schofield and Hanson, working in the Salmon River district, and Westgate in the adjacent Alaskan section, each produced classifications as follows:—

Schofield and Hanson (1922, p. 35):

> The ore deposits fall into three main groups:—
>
> A low-grade, complex, siliceous type, with values in the base metals, copper, lead, and zinc, Province, Big Missouri, Hercules, Forty-nine (some orebodies).
>
> A silver-gold type rich in gold and silver minerals, including native silver, tetrahedrite, pyrargyrite, freibergite, argentite. Premier, Silver Tip, certain orebodies in the Forty-nine, Big Missouri, and Mineral Hill.
>
> A pyritic siliceous type with high gold values (an orebody in the Premier).

Westgate (1921, p. 128):

> 1. Disseminated replacement deposits of galena, sphalerite, and pyrite, mainly in the greenstones. Example, the deposits now being opened on the New Alaska property.
>
> 2. Disseminated and lenticular replacement deposits of pyrrhotite, with minor amounts of chalcopyrite and pyrite and a very little sphalerite in the greenstone. Example, the pyrrhotite deposits on the New Alaska property just above Elevenmile and that on the east side of the Fish Creek Mining Co's property, on Fish Creek.
>
> 3. Quartz fissure veins carrying pyrite, galena, sphalerite, and locally tetrahedrite and a little chalcopyrite. In places barite is associated with quartz as a gangue mineral. Nearly all the quartz veins occur in the granitic rocks. Examples, the veins on Fish Creek and near Sevenmile on Salmon River.

These new groupings were in part based on the studies of O'Neill (1919) and Chapin (1916), who both devised classifications which described the ore deposits as of two general types—(1) disseminated deposits of low metallic content; and (2) quartz veins containing shoots of very high-grade ore.

Buddington (1929, pp. 42–44), arriving in the area a few years later, had the advantage of time and was able to produce the most comprehensive ore-deposit classification in which he combined and modified the earlier attempts of Schofield and Hanson, and Westgate. His main classes were as follows:—

> 1. Quartz fissure veins of lead-silver-gold type.
>
> 2. Veins and veinlike replacement deposits of silver-gold type in porphyry and tuff near the contacts or included within the porphyry.
>
> 3. Veins of the gold type.
>
> 4. Disseminated and lenticular replacement deposits mainly in the greenstones parallel to the schistose structure and are principally of base-metal types.
>
> 5. Mineralized fissure zones, approximately parallel to the structure, in slate and tuffaceous greywacke of the Hazelton Group.

Later, Hanson (1935, p. 45) revised the 1922 classification to include five groups:—

> 1. Deposits containing gold, silver, lead, zinc, and copper.
> 2. Gold-quartz veins.
> 3. Deposits consisting of closely spaced gold-quartz veinlets.
> 4. Gold-pyrrhotite deposits.
> 5. Copper deposits.

All of the preceding classifications were produced by field geologists who categorized their observations with the intent of facilitating description and generalizing localization. Like most past attempts at classification, these have emphasized form, mineral content, and to a lesser extent the physical environment with the apparent understanding and agreement that all the primary deposits were of simple hydrothermal origin. Presently acceptable modern concepts emphasize theories of ore genesis and depositional environments, but there is still no universally acknowledged epigenetic deposit classification in spite of the vast amount of data available.

None of the efforts involved in producing these various classifications have really helped to expose the environment and processes which led to the locus of economic mineral deposits in the Stewart district. Too few facts were compiled, leaving the emphasis to hypothesis. Without adequate background geological investigations, these mineral deposit classifications merely present a pleasant diversion. It is still probably best to accept the fact that types of ore deposits grade into each other and that individual oreshoots within a unique system can differ widely in texture, mineralogy, and apparent environment.

In this report a simple classification limiting the mineral deposits studied to veins, breccia veins, replacement deposits, and transitional types is recommended. The basic problems which classification may help to solve are the problems of ore control. The simple classification given here is adequate for general description and exploration purposes.

In actual fact the various above classifications all utilize the primary grouping of McConnell with the addition of mineral content, form, and environment such as was known at the time to provide secondary grouping. In the preceding chapters on the local geology it has been shown that the lithology and structure of the rocks are considerably different than originally reported. In the ensuing descriptions of the mineral deposits they will be updated as far as possible with respect to environment, mineralogy, texture, and other features prerequisite to a workable field mineral-deposit classification.

Mineralogy of the Mineral Deposits

With few exceptions, mineral deposits in the Stewart map-area have been developed for their potential gold and silver content, but significant quantities of copper, lead, zinc, and cadmium have been produced as by-products (Table 2). The ore and gangue minerals of the Stewart area are listed in the following summary and the frequency distribution of the minerals has been shown on Figure 19:—

Native elements and alloys	gold, electrum, silver, silver amalgam(?).
Sulphides	galena, sphalerite, pyrite, chalcopyrite, pyrrhotite, molybdenite, argentite, bornite, covellite, stibnite.
Sulphosalts	tetrahedrite, freibergite, polybasite, pyrargyrite, arsenopyrite, boulangerite, proustite, stephanite(?).
Sulphates	barite.
Oxides	quartz.
Carbonates	calcite, malachite, azurite.
Tungstate	scheelite.

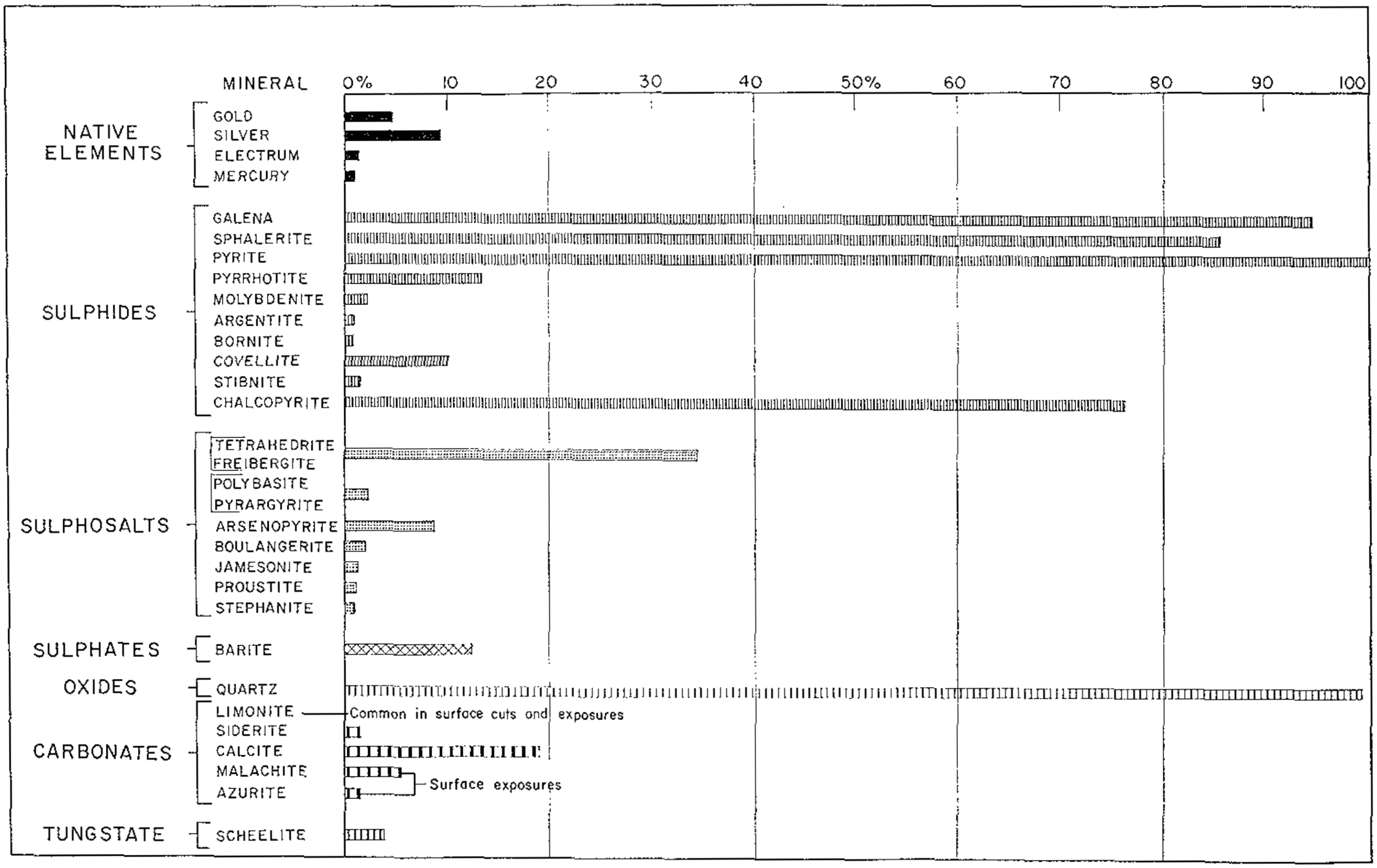


Fig. 19. Frequency of mineral occurrence, Stewart area.

Native Elements

Native Gold (Au) has been identified in a number of mineral deposits in the Stewart area. With the exception of a few selected samples from Silbak Premier the range of compositions has not been determined. The metal has been identified in mineralization at the Morris Summit, Big Missouri, Spider, Silbak Premier, Riverside, Gold Bar No. 1, and Prince John as visible specks or blebs in a quartz or sulphide host. Elsewhere its mode of occurrence has not been determined. Apart from the rarity of the metal, all the samples display the usual physical characteristics, except the Premier gold, which has a greyish-yellow cast. Gold occurs as minor and trace amounts in a great variety of minerals, including the common sulphides which make up from a few per cent to 75 per cent of some of the ore deposits. Published assays of minerals indicate quite an erratic gold content in galena, sphalerite, pyrite, chalcopyrite, and tetrahedrite. The assays are few and the sample purity is unknown in all cases. None of the ores in the Stewart district required roasting prior to cyanidation, suggesting some of the gold and silver in the sulphides was held as a simple mechanical mixture.

Electrum (Au, Ag), an alloy of gold and silver, is more abundant in the area than native gold. At Premier, one-quarter-inch-thick plates occurred in bonanza-type sulphide ores (*see* Plate XXB). Electrum has been reported from several other deposits in the immediate area and has been noted immediately to the north at prospects on Tide Lake Flats and on American Creek. At the Premier, where electrum constituted the principal gold mineral, it has been found to range from 49 per cent gold to 65 per cent gold, the remainder being silver. Samples from near surface contain about 5 per cent mercury probably held in alloy rather than as a discrete mineral. In colour the Premier electrum assayed varies from pale yellow (65:35 Au:Ag) to a silver grey (50:50 Au:Ag) with a feeble yellow cast.

Native Silver (Ag) commonly occurs in many of the mineral deposits. Native silver is a prominent mineral at Silbak Premier, Prosperity-Porter Idaho, Silverado, Silver Tip, Spider, Silver Crest, Forty-Nine, Portland Canal, Mobil, O.K. Fraction, and has been reported in small amounts at other prospects. Significantly, only two occurrences of silver are reported at prospects in the Hyder district (Buddington, op. cit., p. 49). Visible silver has been described as both a hypogene and a supergene mineral in these deposits, occurring as discrete blebs intimately associated with massive sulphides or as wire and other delicate growths in cavities. Most of the ore minerals contain silver in variable amounts, suggesting that the silver is present as mineral intergrowths as well as a minor or trace element in the sulphides.

Mercury (Hg) has been found in alloy with electrum in Premier bonanza-type ore and no other occurrence has yet come to light. It appears to be a significant trace element in some of the local rocks, but its abundance and geochemical character are poorly known. The presence of mercury in native silver has been noted as a characteristic of hypogene silver deposits (Boyle, 1968, p. 17).

Sulphides

Galena (PbS) is present in all the known veins in the Hyder district (Buddington, op. cit., p. 49) and has been recognized in all but 6 per cent of the deposits in the Stewart area. These exceptions mainly represent quartz-pyrite and pyrite-chalcopyrite prospects explored primarily for gold or copper. Fine- to medium-grained galena predominates, but coarse material has been noted in random samples. The known amounts of lead (primarily in galena) shipped from the Stewart-Hyder area have been summarized in Tables 2 and 3. Of the largest primary silver or gold-silver producers in the area, the Prosperity-Porter Idaho produced ore with a tenor of 3.8 per cent lead, Dunwell about 1.85 per cent lead, Silbak Premier with 0.67 per cent lead, and Big Missouri with 0.00016 per cent lead. The silver-gold content of galena from the various deposits and oreshoots varies widely as well. At Silbak Premier, for example, total production figures indicate that the silver content in galena averaged less than 1 ounce per ton, but intermediate figures show a variation between oreshoots. White (1939, p. 26) reported an average of 2.5 ounces of silver per ton of galena and selected samples of the clean mineral from various places in the mine have yielded from a trace up to 55 ounces per ton. Minor and trace element analyses of selected clean galena have indicated significant differences in the geochemical nature of galena in the Stewart area which might with further work prove a guide to exploration when used in conjunction with other tools.

Sphalerite (ZnS), like galena, is ubiquitous to the silver and gold-silver deposits in the Stewart district and is found as well in a few of the copper deposits. In the adjacent Hyder section, Buddington (op. cit., p. 50) noted that sphalerite was abundant in veins in the Texas Creek pluton located within 1,000 feet of the contact, but sparse in veins deeper within the pluton. The colour of sphalerite varies from amber to black within deposits as well as areally, but records are too sparse to produce any concepts as to mineral associations or zoning. As indicated by the tables of production statistics (Tables 2 and 6), zinc is locally almost as abundant as lead with the prime exception of the Premier vein system where the lead-zinc ratio was about 3:1. Zinc statistics are generally incomplete for the early years of production from small mines which hand-sorted ore and discarded the worthless sphalerite. Gold-silver values in sphalerites from the area are very erratic and a high content results from admixed agentian tetrahedrite and other silver minerals. Minor and trace elements analysis of selected sphalerites from a number of deposits are discussed on page 120.

Pyrite (FeS_2) has been found as a principal sulphide in every mineral deposit in the area as well as an alteration product within the country rocks, and is the only metallic mineral in some deposits. In most of the deposits, pyrite carries some gold or silver as a microconstituent, and assays indicate a generally erratic gold-siver content varying within oreshoots and from one deposit to another. A miner's rule of thumb at the Premier suggested that gold was more abundant in certain pyrite-rich siliceous zones than in normal ore, but no facts are available for confirmation. Within veins and the replacement mineral deposits, pyrite commonly occurs as simple cubes, whereas in adjacent altered country rock the pyritohedral form predominates. Outside these mineral zones, cubes appear to represent the most abundant habit of pyrite. Buddington (op. cit., p. 89) noted the presence of the two pyrite habits also, but the crystallization factors governing these forms are poorly known.

Pyrrhotite ($Fe_{1-x}S$) occurs sporadically throughout the area and because of its general low content of gold and silver has not attracted exploration interest. In the Hyder section about one-third of the veins contain some pyrrhotite (Buddington, op. cit., p. 99), while in the area as a whole pyrrhotite has been identified in about 13 per cent of the deposits. The distribution of these occurrences suggests that pyrrhotite has been formed in deposits within or adjacent to basic intrusives (for example, Bitter Creek plutons) or mafic-rich portions of the Texas Creek and Hyder plutons.

Chalcopyrite ($CuFeS_2$) has been identified as a minor sulphide in many mineral deposits and comprised the ore mineral at several. The relative abundance of copper, lead, and zinc recovered from the various deposits is shown in Tables 2 and 3, and obviously some copper was contributed by minerals other than chalcopyrite. Early production from the Red Cliff mine yielded ore grading 8.5 per cent copper derived from small lenses of massive pyrite-chalcopyrite-pyrrhotite. The main copper producer in the area has been the Premier system, where chalcopyrite containing minor gold and silver follows pyrite, galena, and sphalerite in order of sulphide abundance.

Molybdenite (MoS_2) remains a rather scarce mineral in the Stewart area in spite of its relative widespread occurrence in the Stewart Complex. The main deposit in the Stewart area is in quartz veins within a small replacement deposit due east of Stewart known as the Molly B. Elsewhere molybdenite has been found erratically in the various granitic plutons as flakes in quartz veinlets or as scattered plates on fracture surfaces. Occurrences of this sort can be seen at the quarries near Hyder, at the Bear River Bridge, and at the Bitter Creek quarry. The relative scarcity of known molybdenite deposits in the area may be a result of the past general lack of interest in porphyry-type mineralization.

Argentite (acanthite-Ag_2S) is an uncommon mineral in the Stewart area noted only in high-grade samples from the Premier and Portland Canal mines. It may be present elsewhere, but the general lack of specimens of sulphides from the properties has restricted the search. Samples collected from the Premier include both massive hypogene argentite admixed in banded sulphide ore and supergene crustifications in small cavities. White's study (op. cit., p. 26) suggests that at the Premier argentite accounted for the bulk of the silver produced from " normal " ore.

Bornite (Cu_5FeS_4) has been identified as an alteration product in a few old mine dumps, but the abundance of the primary mineral has not been determined.

Covellite (CuS) has been reported as a secondary mineral in some of the deposits and can be found in many of the old dumps with other copper or copper-bearing minerals.

Stibnite (Sb_2S_3) is an uncommon mineral in the area and has been noted or reported in typical quartz-sulphide vein mineralization at only five localities. Four lie in the Glacier Creek section and the fifth is near the head of American Creek. All Glacier Creek deposits occur as vein fissure-fillings within augite porphyry which intrudes deformed Bowser siltstones and greywackes, cut also by basic dyke swarms.

Sulphosalts

Tetrahedrite ($[Cu, Fe, Zn, Ag]_{12}[Sb, As]_4S_{13}$), including freibergite, has been identified in roughly one-third of the known mineral deposits in the Stewart area. Buddington (op. cit., pp. 50, 51) noted the occurrence of the tetrahedrite in about half the veins he examined in the Hyder section, and identified freibergite at three properties. This difference between Hyder and the larger Stewart area partly reflects the character of the Hyder veins which lie mostly within Texas Creek granodiorite. Burton (1926, p. 691) suggested that at the Premier tetrahedrite was most abundant in the upper 650 feet and a pronounced quantitative vertical zoning was evident. At a later stage of mine development, White (op. cit., p. 24) indicated that tetrahedrite was not a typical constituent of these ores, which suggests that the apparent vertical zonation noted by Burton was restricted to certain oreshoots within the Premier system. Insufficient evidence is available for other deposits in the area to extend this concept of restricted mineral zoning. With the exception of the Premier mine, tetrahedrite has been the most prominent gold-silver mineral in the district. At most of the small prospects and producers, tetrahedrite-bearing sulphide ore was hand-cobbed and shipped directly to the smelters.

Proustite (Ag_3AsS_3) and *Pyrargyrite* (Ag_3SbS_3), the ruby silvers, are relatively rare minerals in the Stewart deposits. At Premier, pyrargyrite was noted in bonanza shoots and Burton (op. cit., p. 594) mentioned its restriction to sulphide-rich shoots. At the Prosperity-Porter Idaho mine, ruby silver constituted the essential ore mineral and occurs in thin, sulphide veinlets in the various shoots over a total vertical range of 1,300 feet, comparable to the range at Premier. It appears that the ruby silver in these ores was present as discrete microscopic blebs and veinlets mixed with the more abundant tetrahedrite and polybasite and as a result was seldom visible macroscopically.

Polybasite ($[Ag, Cu]_{16}Sb_2S_{11}$), like the ruby silver minerals, is scarce in the vast majority of the Stewart deposits. At Premier, hypogene polybasite has been identified in the massive sulphide ore as well as in late drusy quartz veins cutting the upper bonanza shoots. Burton (op. cit.) suggested that the spectacular polybasite found at Premier in the upper workings seemed to be supergene, but he was able to discriminate hypogene material at depth.

Stephanite (Ag_5SbS_4) was reported by Dolmage (1920, p. 454) occurring in high-grade Premier ore as isolated shoots rich in native silver. However, since that early date none has been identified.

Boulangerite ($Pb_5Sb_4S_{11}$) or *Jamesonite* ($Pb_4FeSb_6S_{14}$) has been reported from several of the small quartz breccia-sulphide veins in the Glacier Creek area. No jamesonite was identified in this study, although a few specimens of boulangerite were identified by X-ray powder photograph. These deposits are comparable to the nearby stibnite-bearing veins, but their host is typically Bowser siltstone rather than intrusive augite porphyry.

Arsenopyrite ($FeAsS_2$) is second to tetrahedrite in relative frequency and has been identified in about 10 per cent of the local mineral deposits. It is rare in the Texas Creek deposits (Buddington, op. cit., p. 51) and in deposits in other plutonic rocks, but occurs almost randomly in most other rock types. It has been found as tiny acicular crystals in both veins and surrounding country rock and rarely as coarse-grained masses within sulphide lenses. Gold-bearing arsenopyrite is common, but the gold values are reported to be erratic. Pyrite and pyrrhotite are common associates along with galena, brownish-black sphalerite, and chalcopyrite as banded masses or streaks in the quartz veins.

Sulphates

Barite ($BaSO_4$) is found in about 12 per cent of the total known metal-bearing deposits and additionally occurs either with quartz and calcite in barren veins or locally as massive pods, vein-like lenses, and stockworks. Barite appears to be present in all the small replacement-type copper deposits in the Stewart area.

Anglesite ($PbSO_4$) was reported by Buddington (op. cit., p. 51) as a common alteration product on galena cleavage surfaces, but has not been found elsewhere in the general area.

Oxides

Quartz (SiO_2) is the dominant gangue mineral in the fissure veins as well as in the known replacement deposits. At least four stages of quartz mineralization are indicated in the Stewart area by cross-cutting relationships with the country rocks, plutons, and dyke swarms. Most of the vein quartz is milky white, and has a massive habit. Apart from its association as host to metalliferous vein and replacement deposits, barren quartz is present along fractures, faults, and shear zones throughout the area and in certain alteration zones constitutes up to 95 per cent of the rocks. Of the more than 5 million tons of ore mined from the district, about 4 million tons was quartz.

Limonite ($2Fe_2O_3xH_20$) appears to be common at most of the deposits in the district in oxidized zones near surface and is present as coatings and thin deposits in the deeper Premier and Prosperity-Porter Idaho workings.

Carbonates

Calcite ($CaCO_3$) is, next to quartz, the most abundant gangue mineral in the Stewart area. It has been identified in about 20 per cent of the mineral deposits forming intergrowths with quartz, and as cross-cutting veinlets. Calcite is distributed widely in alteration zones.

Siderite ($FeCO_3$) is a rare mineral found in several quartz veins in the area associated with pyrite, pyrrhotite, arsenopyrite, and calcite.

Malachite ($[CuOH_2]CO_3$) is fairly common as spotty surface coatings at some of the copper deposits.

Azurite ($Cu[OH_2][CuCO_3]_2$) is scarce in the ores but can be found in most workings at cupriferous deposits as streaky surface coatings. It is especially prominent in tetrahedrite-bearing material.

Tungstate

Scheelite ($CaWO_4$) was produced from the Riverside mine in the Hyder district for a short period, but has not been found in large quantities elsewhere. It has been found in the Premier ores with quartz as veinlets cutting all but the last phase of quartz-sulphide mineralization, and has been noted elsewhere with siderite in quartz veins and occasionally in very rare and small skarn deposits in the Bear River section.

Control of Mineralization

No unique set of controls can be applied to the localization of all mineral deposits in the Stewart area. The occurrence and relative abundance of the deposits suggests that the most favourable country rocks are, in order of importance, Hazelton assemblage, Texas Creek granodiorite, and Bowser sediments. In terms of productivity the mines in Hazelton rocks have far exceeded the tonnage and metal value of all other host rocks combined. Recent studies have shown a number of important relationships to exist between the various host rocks and mineralization, among which are contact relationships between country rocks and intrusives, metasomatic processes and related deformation, local lithology, and structural setting. Consideration of only the most important ore deposits leads to erroneous generalizations about ore controls for the district. The search for ore in this area, which has been largely limited to outcrop prospecting and shallow drilling, has been successful in locating the major deposits, but the hidden deposits yet to be found will require the application of diverse geological techniques.

Spatial relationships show that the majority of mineral deposits lie in or near deformed zones along the various intrusive contact zones. West of Bear River Ridge mineralization has been concentrated in fractures and shears in Texas Creek granodiorite within 2,000 feet of the contact (Buddington, op. cit., p. 54) and in cataclasites, mylonites, and schists of the Hazelton assemblage within 1,000 feet of the contact. The same close tie of mineralization to intrusive contacts appears to hold true also for the smaller plutons and the dykes in either Hazelton or Bowser country rocks. The geological sections (Fig. 4) illustrate depth and suggest that the Bowser-Hazelton contact is another favourable zone for mineralization. Various pieces of evidence point to this contact as a major control along the Cascade Creek section, even though in that locality Bowser rocks have been eroded away. In the Salmon River district, the combination of Texas Creek intrusive, deformed and altered Hazelton epiclastics, the capping of Bowser rocks and local factors controlled the formation of the Premier, Indian, Big Missouri, and the smaller mineral deposits. Within the larger better-known vein systems, such as the Premier and Big Missouri, the oreshoots appear to have been localized by certain rock types in minor structures such as fractures and fold hinges.

Bowser rocks have been almost completely removed by erosion from the important mineralized area near the Texas Creek intrusive contact. Mineral deposits located in this section in Hazelton rocks may have had related extensions in the overlying Bowser assemblage before erosion and a knowledge of the character of such deposits is significant in the search for mineralized zones hidden by Bowser rocks.

On the south slope of Mount Dillworth a few small veins pass through deformed and altered Hazelton into overlying Bowser siltstones. These, as well as the similar Outland Silver Bar veins, lie in deformed dyke zones and are late-phase quartz-sulphide veins. Other vein deposits along Bear River Ridge in Bowser sediments are small lenticular quartz breccia and sulphide masses seemingly scattered without over-all control and with no known depth continuity. Lenses such as those found on the M.C. group consisted of massive galena, tetrahedrite, and minor pyrite in quartz, had high gold-silver values, and outwardly resembled Premier ore. No apparent structural continuity exists.

The majority of deposits localized in Bowser sediments lie east of the Bear River and have fairly obvious spatial relations with the Bitter Creek type of augite porphyry. The lateral continuity of these quartz-breccia veins has been amply exhibited, but none has been traced vertically into underlying Hazelton members. The majority of these veins have been localized along steep northerly trending fissures or shears related to tectonic deformation. Within the known veins the oreshoots have been controlled by conjugate fracture sets which produced " kinks " in the veins and low-pressure depositional sites for the sulphides. Mineralogical comparisons do not indicate significant similarities with the major Cascade Creek zone deposits, but the presence in the area of deformed Hazelton epiclastics cut by an intrusive and capped by Bowser sediments indicates a favourable structural situation.

The role that metasomatic processes played in the control of mineral deposition appears to be fairly significant along the Salmon River-Summit Lake contact zone, but minor or of unknown importance elsewhere. Several types of alteration are recognizable. The intrusive contact zone from Indian Lake to the Alaska boundary is generally diffuse where andesitic epiclastics have been converted in situ by contact metasomatism to hornblende diorite or hornblende granodiorite (*see* p. 73). In the Premier area, similar metasomatic porphyritic rocks were formed which have been locally called the " Premier Porphyry." Metasomatism, which produced the irregular porphyry mass, was followed by mineralizing fluids which injected large amounts of quartz and some adularia into sericitized and chloritized pyritic porphyry and other wallrocks. This latter alteration was followed by at least four phases of intermittent quartz-sulphide and dyke emplacement.

At the Indian mine the partly granitized wallrocks were intensely altered to a fine-grained aggregate consisting essentially of quartz. Later vein emplacement followed with little noticeable alteration. This widespread silicification and pyritization is particularly noticeable in the Noname-Hog Lake section where late quartz veins are abundant.

In the Big Missouri area, chloritic schists derived from deformed volcanic epiclastics have been variably sericitized, silicified, and pyritized. Differential weathering of these schists has produced the brightly coloured zones mentioned in Chapter 2 which are found as well along the Salmon Glacier to the northern limits of the map-area and have been traced regionally over a broad area to the north as far as Treaty Creek.

Propylitic alteration is fairly common but limited to small patches near most of the mineral deposits west of Bear River Ridge in the Hazelton rocks.

Skarn has been noted at a few places in both Hazelton and Bowser rocks in the map-area. Erratic, small, calcite-quartz-epidote-garnet skarns have been observed near various granitic intrusive contacts as well as at dyke contacts. Skarn is fairly rare in the Salmon River district except on the Pictou claim south of the main Premier system where silver-bearing sulphide veins are localized within an irregular garnet-epidote-calcite-quartz envelope developed in cataclastic rocks.

Hornblende as an alteration mineral has developed in a large variety of Hazelton rocks near intrusive contacts and mineralized zones and at other places unrelated to intrusives or mineralization (*see* Fig. 3 and p. 73). At Premier it is a common and well-developed mineral in both the metasomatic porphyry as well as in the less-altered cataclasites, but is not a significant alteration mineral at any other major ore deposit. Scattered hornblende was also identified in wallrocks at the Morris Summit property at Summit Lake.

The role of alteration in terms of ore control has been to prepare specific areas both physically and chemically for mineralization. At the Premier and other deposits the altered country rocks have been subjected to repeated episodes of dyke intrusion and various ages and types of quartz-sulphide vein and replacement mineralization.

The various metasomatic changes effected in the various country rocks in this map-area have produced both mineralological and chemical changes involving simple ionic diffusion and nucleation in closed systems as well as wholesale reconstitution as in the case of the zones of intense silicification.

Silver-Gold Ratios

The idea that a quantitative ratio between chemically related elements could be used as an indicator of origin has been prominent for some decades. A number of dependent factors can be studied, using geochemically related elements, often homologues, which may belong in the same sub-group of the periodic system. By using values such as the Ag/Au ratio in ores, the following points, as well as others, have been considered in this chapter.

(1) Evaluation of the depth, temperature, pH of the ore fluid, and paragenetic relationships.

(2) Evaluation of the mobility of gold and silver as reflected by the Ag/Au values.

(3) Characteristics of mineralized districts.

A group of Ag/Au ratios has been calculated from the published production records for selected ore deposits in the Stewart area.

TABLE 5.—REPRESENTATIVE SILVER-GOLD RATIOS, STEWART AREA

Property	Ag/Au Ratio (Rounded off)	Over All
Silverado	1,300:1	
Dunwell	33:1	
Lucky Seven	42:1	
Prosperity-Porter Idaho	2,750:1	
Big Missouri	0.9:1	
B.C. Silver	40:1	
Premier	25:1	
Premier Border	29:1	22:1
Silbak Premier	17:1	
Silver Tip	221:1	
Morris Summit	1:1	
Riverside	35:1	

A study of Table 2 will show that the above ratios generally cover the over-all noble-metal distribution in the Stewart area, and Table 5 indicates a high Ag/Au ratio of 2,750:1 and a low of 0.9:1, with most at about 30–40:1.

At the Premier, where detailed production figures are available, the silver to gold ratio varies from 112:1 near surface to 6:1 at depth and this spread is more definitive of a deposit than the average value based on total production (*see* Fig. 41). In addition, the Ag/Au ratio of the recently mined bonanza shoot (Leasors Lens, Fig. 50) was found to vary from 27:1 at the top to about 15:1 at the lower end, with an over-all ratio to 21:1.

The Ag/Au ratios for the mines listed above show distinct groups which could, by using additional characteristics, have various genetic/time implications. The high ratios for the Silverado and Prosperity-Porter Idaho veins have been construed to reflect selective mining and also that secondary enrichment has been a more effective process in that area southeast of Stewart than anywhere else in the district. However, the over-all grade of the shoots was about 75 ounces silver per ton and a few samples taken from sub-ore ran about 15 ounces, and recent mineral studies have not disclosed any unusual secondary enrichment.

The Silverado, Prosperity-Porter Idaho, as well as the other high Ag/Au ratio deposits in the area, belong to silver-rich veins in which gold is a minor or trace element. These veins have been shown by field studies to occur in a variety of rock types and structural settings and areally probably represent a late phase of quartz-sulphide mineralization rather than zonal types.

The bulk of the deposits in the Stewart area with Ag/Au ratios of 30 or 40:1 are polymetallic lodes which in the specific case of the Premier system show detailed internal metallic zoning. These are representatives of the early phases of quartz-sulphide emplacement in the Stewart area as indicated by detailed field relationships. The polymetallic Big Missouri and Morris Summit deposits which have 1:1 ratios appear anomalous, but in light of the zoning in the Premier system they may represent remnants of once more-extensive mineralization complicated by faulting and by erosion.

Genesis of the Deposits

It seems important at this time to mention that in the discussion of genesis of any orebody or grouping of deposits that most of the world's greatest and best-known deposits still provide constant topics for discussion. The nature and evolution of geological concepts obviously affects such disputes even though they may be based on the best available field evidence. In the older literature concerning the Stewart area, most of the controversies naturally concerned the genesis of the " complex " Premier ores and the investigators stressed the then current Lindgren view that groups of chemical deposits were introduced into bodies of rock by igneous processes. Later, White (1939, pp. 27–30) emphasized the importance of the structural environment at Premier in localizing the emplacement of the orebodies along fractures in siliceous replacement zones. Current trends in theory stress the concepts of regional metamorphism and granitization as well as syngenetic theories. In synthesizing a genetic concept for the mineral deposits of this area the writer has attempted to relate physical fact with theory, but with the attitude that future theoretical trends and possible new ore discoveries will again force revisions.

The task of ore-genesis explanation is to set out the sequence of major events through which some earlier system has been transformed into a later one. The explanatory premises must then necessarily contain a number of singular statements about the events in the system under inquiry. Obviously not every event in the development of the system will be known or must ever be mentioned. Those chosen for mention are based on assumptions (often tacit) concerning the evolution of the system which may be of an apparent casual nature. In the instance of a unique system such as the Premier, the general assumptions can be vague generalizations, often with a statistical basis, with no reference to the specific features of the parts. As a result, sufficient conditions for the occurrence of the fact have generally been stated in the explicandum, and naturally under the circumstances some have been taken for granted. Like most prima facie explanations of ore genesis, the one developed here is logically probablistic.

The following facts are significant in the present interpretation of the genesis of the mineralized zones in the Stewart area. With rare exceptions the mineral deposits of the Stewart area are fissure veins or transitional fissure-replacement deposits. Spatial relations indicate these deposits have been localized in or along zones of simple deformation and along zones of cataclasis where subsequent alteration of the rocks played a part in determining their competency. The majority of the deposits lie along contact areas within both intrusive and intruded rocks. The over-all character of the various mineralized zones is strikingly similar, with the main variations being size and mineralogy. It is apparent that the physical-chemical environment in the Premier area provided the optimum conditions for ground preparation of the country rock and resulted in the deposition of the largest amounts of mineralizing materials. A crude metal and mineral zoning is apparent which is clearly spatially related to both host and intrusive rocks. The main gold-silver deposits are found in conjunction with hornblende diorite or granodiorite and volcanic epiclastics, and the silver-gold deposits with abundant Sb and As are related to augite diorite-siltstone combinations. Structural and other field information indicates that pervasive deformation of the country rocks preceded actual physical intrusion by the plutons in a manner termed " wedging." Destructional deformation produced cataclasites in certain key lithologic members along more or less continuous zones, and localized folding elsewhere.

Differential rock competency has been a key factor in the preliminary stages of destructive deformation and in the later periods of fracturing. At the Big Missouri, for example, medium-grained green volcanic conglomerates initially were cataclastically deformed in preference to adjacent sandstone and breccia members, and simple cataclasites as well as minor kakirites and mylonites were produced. Subsequent fracturing, alteration, and mineralization affected the cataclasites but left the kakirite and mylonite as residual lenses or horses within the deformed zones. As pointed out in the property report on the Big Missouri (p. 124), gold values are directly proportional to the intensity of quartz-veining which was controlled by fracturing. At later stages in the evolution of ground conditions, the competency of the rocks controlled the general extent of dyke emplacement as well as in detail the trend of individual dykes. The preponderance of dykes along the Cascade Creek cataclasite zone attests to the importance of competence and ground conditioning. The various property reports in which vein and oreshoot controls are described give examples of the significance of these factors.

The apparent importance of chemical controls partly expressed by alteration and mineralization phenomenon has been examined by direct approaches such as petrological studies of the various rock units and by partial analyses of vein and wallrock materials. At the Silbak Premier property it has been shown (pp. 155 to 157) that certain cataclasites have been partially converted by metasomatic processes related to Texas Creek plutonism to rocks physically and chemically similar to granitized border phases of the same intrusive. This initially involved K-silicate alteration and hornblendization of previously deformed volcanic conglomerates. At later stages certain portions of these rocks, conditioned both mechanically and thermally, were mineralized by redistributed oxide-sulphide materials along channelways and trapped to form quartz-sulphide systems. The veins, altered wallrocks, granitized areas, and deformed zones thus constitute significant physical-chemical anomalies within the region.

Silver-gold ratios have assisted, however, in indicating that the early phase deposits were zoned, with gold concentrated in their lower depths and silver in the upper parts, suggesting a changing ore fluid pH from alkaline to more acid, and also a possible temperature gradient decreasing from depth toward the surface. The values also support the field evidence that gold was more abundant in the early phases of mineral deposition than in the late phases. It also appears likely in the light of the mobility of silver that the late phases of mineralization were deposited closer to the surface (lower pressure) than the gold-rich phases. No simple regional metallogenic characteristic is expressed by the Ag/Au ratios because, as shown here, the values are dependent on many variables.

The bulk of the above has been dealt with in the descriptive parts of this report and would normally suffice to outline the genetic concept; but apparently unrelated factors also included may have been significant within the total environment in regard to ore formation. The presence of volcanic breccias, red beds, and rhyolite flows has been noted on the maps and they have been described, but as units seemingly remote from the areas of active metasomatism and metallization they lack spatial significance. If one considers that the active system took place at some as yet undetermined geologic depth over a period of time, seemingly remote parts can then be involved.

The lower Middle Jurassic rhyolite flows at Long and Divide Lakes presently have no apparent feeders, but several small diatreme-like volcanic breccia zones have been noted along the slopes above the Cascade Creek-Salmon Glacier section. Hints of similar rocks have been seen in the Premier system, but alteration has been too pervasive to allow definition. The red beds found along Bear River Ridge obviously blanketed most of the area, but like much of the Bowser cover have been removed by deep erosion. These red rocks usually taken as indicative of arid depositional conditions have no such obvious implications in the Stewart area and indeed may merely represent non-uniform diagenetic alteration.

The foregoing simple approach to the complex relationships has resulted in the following basic hypothesis of genesis of mineral deposits in the Stewart area. Syntectonic deformation which induced destructive deformation along irregular zones now marked by abundant cataclasites was probably accompanied by explosive " acid " volcanism. Later, during the actual penetration of these zones, the plutons partially granitized limited physically-chemically favourable areas of the wallrocks. Petrographic studies have indicated that in these marginal zones the Texas Creek granodiorite has a significantly lower silica content than the main batholith, and this skin of dioritic material thus represents an area of chemical depletion. The mobile constituents, possibly including some of the metals released from the country rocks by the granitizing process during an early stage, permeated through the country rocks and migrated along fissures to depositional sites to produce the initial alteration zones. Meteoric waters enriched with iron-rich complexes from the red beds percolating toward the fractured thermal area mixed with the diffusing mobile materials and in physically favourable sites assisted in the complex physical-chemical processes which led to the deposition of the oxide-sulphide vein systems. Then a later phase(s) of mobilization led to the deposition of the now visible mineral deposits in traps in prepared ground. Later dyke-swarm intrusions in the same altered horizons were themselves mineralized, giving a total of at least four very similar successive episodes. Such apparent repetition would be unusual unless the genetic process involved more or less constant factors determined by the total environment.

The concept outlined above, therefore, rejects that of a classical simple hydrothermal fluid ejected by cooling magma into dilatant voids, which by simple cooling and chemical action, in situ forms complex zoned oxide-carbonate-sulphide masses.

Mineral Exploration in the Stewart Area

Deposits of valuable minerals are present in most rock types in the area throughout a vertical extent of at least 6,000 feet. In terms of production, tonnage from the individual mines has been small, and precious metals are the prime constituent of value. A combination of a changing economic environment, variable manpower supply, unpredictable weather, and difficult topography suggest that the type of mineral deposit that can now be exploited will be limited. Cataclasite zones such as the Cascade Creek offer the choicest immediate exploration potential. The Bear River cataclasite zone has not been easy to assess and others hidden by overlying Bowser rocks or permanent ice and snow are difficult targets in many ways, but these offer significant potential. The fissure deposits of the Bitter Creek-Glacier Creek area have been scanned for surface prospects, and detailed studies of these veins, particularly of vein flexures, could be productive. A number of the old mines, including the Silbak Premier, Indian, Prosperity-Porter Idaho, to name a few, have not yet been subjected to intensive exploration, and valuable high-grade gold deposits are still to be found, such as the bonanza find at the Premier glory hole in 1959 clearly indicates. Detailed geological studies using all the facts available, based on a sound regional background, will continue to be the best exploration approach.

Valuable commodities, including iron, barite, placer gold, hydrocarbons, and lapidary materials have attracted some interest in recent years. Claims have been staked along the crest of Bear River Ridge north of Mount Dolly to cover extensive outcrops of iron-rich red sandstones and conglomerates. These are similar to the more extensive "red bed" units found elsewhere in the Stewart Complex, in the upper Hazelton assemblage, and lowermost Bowser. The Bear River Ridge red beds are thinly laminated, lenticular in nature, and have a variable total iron content which seldom exceeds 20 per cent.

Barite is abundant as a gangue mineral in many of the fissure vein and replacement deposits around Stewart and also occurs as simple veins or stockworks in Bowser siltstones. None of the deposits appears to have any present economic value because of small size or difficult access.

There are no records of the gold recovered by the early placer miners working the river gravels or old high gravels along Bear River, Glacier Creek, and Bitter Creek. Recent prospects on these streams have produced " colours," but nothing of economic consideration. Panning could be used in most of the area to test for heavy minerals such as scheelite, which are known to be associated with the major ore deposits.

The scope of the rockhound is fairly well limited in this area to the ore minerals previously listed. Some good jasper can be found in the streams, especially the upper Bear River, and the glacial moraines are also worth examining, particularly in the Bear River Pass area. Yellow, blue, red, and some green cherts are relatively abundant in the rocks along the west slope of Bear River Ridge, but nothing of outstanding quality was noted.

With regard to hydrocarbons, the Stewart area contributes to the understanding of the geology of the Bowser Basin and may in certain lithological and structural situations have limited exploration potential. Anthraxolite was found by McConnell, with drusy calcite and white quartz in Bear River valley, as reported by Johnston (1915, p. 23). Similar material was collected by the writer from a number of sites on Big Missouri Ridge, Bear River, and Bear River Pass, and analysed. The appearance and composition of this shiny, brittle, black material indicates that it is composed of weakly metamorphosed coaly fragments; otherwise no coal measures have been located in the area and no indications of petroleum or natural gas have been recorded. The search for hydrocarbons in the Bowser Basin will add to the geological knowledge of the Stewart area and will assist mineral exploration.

Geochemical Exploration

In the past, several limited attempts have been made using field geochemical techniques in the Stewart area. Simple soil-sampling for total heavy-metal content has been carried out at the Indian, Premier, Aztec, and R.A.F. properties with generally disappointing or at least negative results. Soil profiles are rarely well developed in the area above the main valleys, and the thin alpine soils consist largely of coarse parent material (talus) with considerable organic matter. At Premier, for example, the " soil " consists of coarse angular talus, mixed with fresh ore fragments blasted from the glory-hole orebodies, considerable organic matter, including hemlock needles and various roots. Soil total heavy-metal profiles across the main glory-hole revealed little that was not apparent to the eye. In the vicinity of the Big Missouri mine a rock mercury survey was carried out by D. H. Brown (1966), using a Lemaire detector. The background in this limited area was found to be 0.2 p.p.m. A plot of the values showed three north-northwest-trending mercury highs, two of which were coincident with " tuffaceous " horizons, and the third with a zone of silicification. The three zones were interpreted as coinciding with the strongest zones of mineralization on the Province claim. At the Premier, the writer sampled several ore zones which contained mercurial high-grade gold-silver ore. The rock samples, analysed by spectrographic methods, contained mercury in the sulphide matrix but no detectable amount in the barren quartz envelope and enclosing wallrocks. The spectrochemical method has well-known mercury-detection limit problems, so rock geochemistry may still prove useful if a more sensitive analytical technique was employed.

In general, the use of geochemistry either involving simple or complex techniques has had minimal application in the Stewart area. The abundance of rock and the generally limited in situ weathering tends to restrict the value of the simple soil-testing methods. Heavy mineral surveys utilizing known mineral associations (*see* Fig. 19) could prove useful as a rapid reconnaissance tool. The whole rock and mineral separate techniques described in the following pages, on the basis of a limited number of samples, appear to present the most useful approach. These methods can be applied without inordinate difficulties at reasonable speed and cost and could prove useful in detecting shallow, hidden deposits. The drawbacks have also been emphasized.

Minor and Trace Element Studies in Hypogene Sulphides.—Some attempts have been made in the past to utilize the minor and trace element content of certain minerals to distinguish or characterize such wide-ranging concepts as metallogenic provinces and ore depth. The concept of metallogenic provinces being defined by the trace or minor element content in hypogene sulphides has been examined in British Columbia by Warren and Thompson (1945), who studied sphalerites. They concluded, in part (p. 334):—

> There appears to be a tendency for each mining camp in Western Canada to exhibit a characteristic assemblage of minor elements. This tendency is reflected in part by the minor elements which appear in sphalerite. There are several instances of one or more mines situated on the same, or intimately related lodes, exhibiting a striking similarity in their minor element content. However, in view of the fact that sufficient collaborative results are not yet available, no final conclusions relative to most of these minor areas may yet be made. Nevertheless, further work may profitably be carried on in this field: there is every indication that detailed studies will show that each important orebody has a characteristic mineral assemblage and, furthermore, a characteristic minor element distribution in those minerals. Variations of the minor element content of sphalerite taken from different depths of one vein or lode have not been studied, and this aspect should also be investigated in the future.

More recently Burnham (1959) has applied the concept, using both chalcopyrite and sphalerite in an attempt to outline belts by the distribution of trace elements.

The mode of occurrence of minor and trace elements in sulphide minerals is covered in most modern physical chemistry and mineralogy texts. The validity of a consistent genetic relationship between chemically similar elements in hypogene sulphides has generally been accepted as a result of Goldschmidt's studies (1954). In making minor and trace element studies of minerals, the main problem is obtaining clean mineral samples and getting reliable analyses.

Pyrite, galena, and sphalerite were chosen for study in the Stewart area because of the frequency of occurrence of these minerals (Fig. 19) and the fact that coarsely crystalline samples could be obtained from a number of the deposits. The study was made in part to test the concept of metallogenic belts and, of more immediate

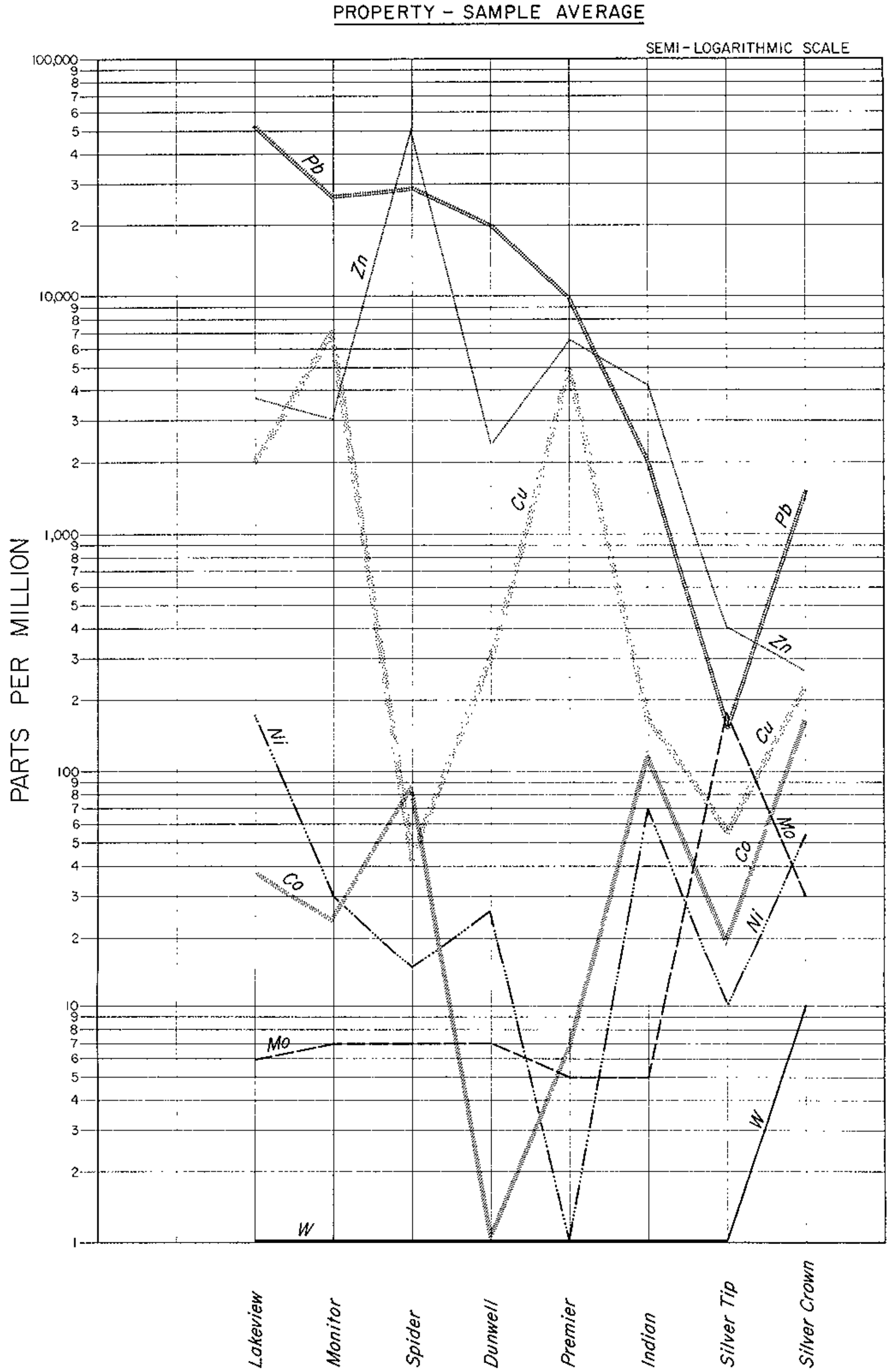


Fig. 20. Trace element distribution in pyrite, Stewart area.

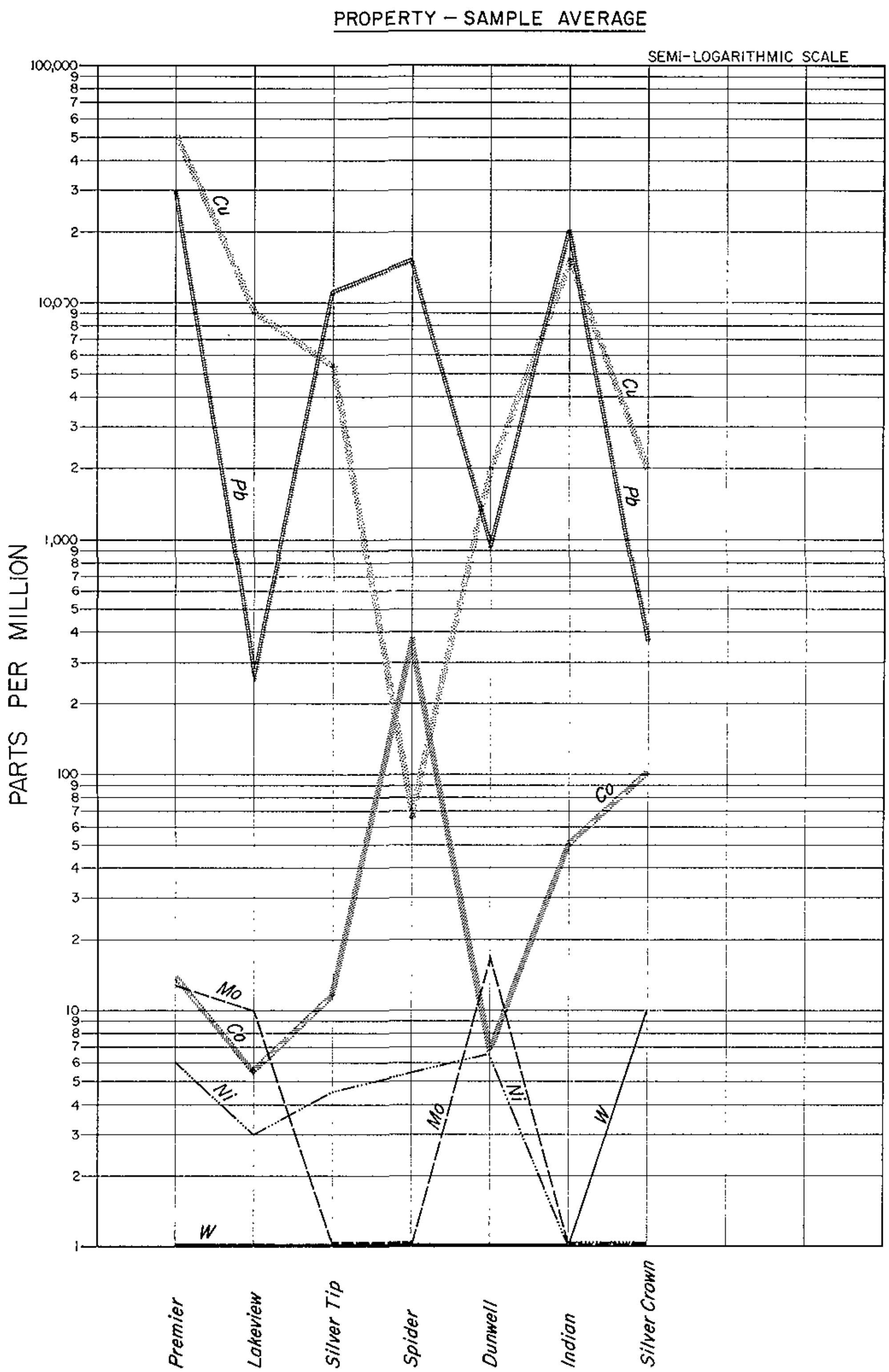


Fig. 21. Trace element distribution in sphalerite, Stewart area.

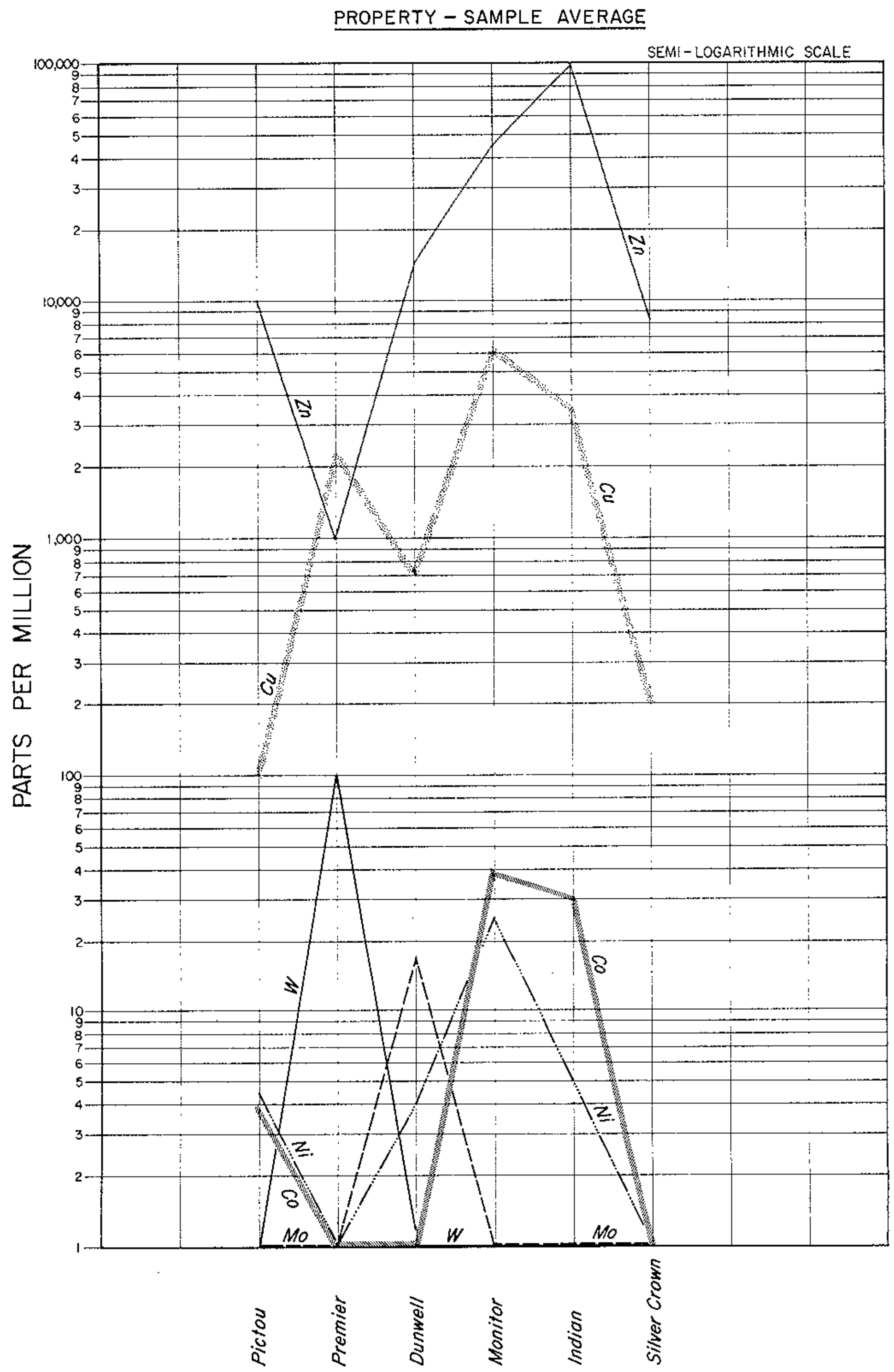


Fig. 22. Trace element distribution in galena, Stewart area.

importance, to determine the distribution of minor and trace elements in hypogene sulphides from the various Stewart deposits. The problem posed was: Would the various deposits be defined by similar trace and minor elements or would they differ? If they showed significant variations, could these be used to study the same minerals in apparently barren or low-grade showings and also to correlate them with better known deposits in the area as geochemical indicators of undeveloped oreshoots?

Studies of the minerals under the microscope showed that most of the clean-looking samples contained more than 5 per cent of other sulphides. As a result, suites of pyrite, galena, and sphalerite were acceptable for only three deposits, the Premier, Dunwell, and Silver Crown. Pyrite proved the most useful mineral, and clean material was prepared from nine deposits. At the time, analyses were restricted to spectrochemical methods, but the inherent problems in the method (high iron) were solved by the departmental analyst, R. J. Hibberson. The element group utilized in the study—copper, lead, zinc, cobalt, nickel, molybdenum, and tungsten—includes both sulfophile and chalcophile elements. Although copper, lead, and zinc are major elements in all the ores, they were retained as indicators when it was found contamination was not a major problem. Also, alternative indicator elements were not detectable at the time with the equipment available.

The results have been grouped for pyrite, galena, and sphalerite in Figures 20, 21, and 22 as graphic representations. With regard to pyrite, the high lead content usually indicates microscopic galena contamination, except for the Silver Tip sample which has negligible lead but anomalous molybdenum. Copper is generally low, except for the Monitor, where copper minerals are rare, and the Premier, which has produced considerable copper from the ores. Comparable relationships are evident for many of the elements and minerals and it is concluded that pyrite alone can be a useful mineral guide to groups of deposits. By combining two or even three minerals the results are more meaningful, such as in the case of the Premier, which has a unique copper-tungsten-cobalt-molybdenum group; the Dunwell, which has a nickel-tungsten-molybdenum group; or the Monitor and Indian, which have significant cobalt and nickel.

Samples from different sites in both the Dunwell and Premier systems (Pictou) show significant element variations in the graphs (Figs. 20, 21, and 22). This may be indicative of elemental variations within the deposits (*see also* Gold-Silver ratios) and suggests that single samples are insufficient to define any one shoot or deposit. The use of any one element to discriminate temperature conditions and ultimately classify any one ore deposit also appears unwarranted.

The utilization of simple trace or minor element distributions on the basis of one or two samples per unit area to define metallogenic provinces has been widespread. The limited study made in the Stewart area (10 properties) shows several trends which can be related to the relative age of the various phases of mineralization and indicates the need for better sampling and more extensive geochemical studies before outlining metallogenic provinces on the basis of trace element distributions.

Whole Rock Geochemistry.—In studying rock alteration in the Premier system, whole rock spectrochemical analyses indicated accumulation of certain major elements which suggested the presence of oreshoots at depth. The results are plotted on Figures 23 and 24, and the general approach has been outlined in the property description, Chapter 6, pp. 160 to 161.

Rock samples taken in barren (pyritic zone) material 60 feet above known high-grade oreshoots showed an apparent enrichment within the zone of calcium, sodium, potassium, and magnesium with respect to non-ore material. In addition, the zone was relatively enriched in barium, with respect to " wallrocks."

This approach may have possibilities elsewhere in the Cascade Creek cataclasite zone, where many showings of apparently barren pyritic quartz with minor hypogene sulphides abound. In the instance of altered, silicified, pyritic country rock, the whole rock method utilizing barium or potassium and a combination of the other minor elements could be attempted where geological conditions suggest a geochemical evaluation.

Within a tri-dimensional mineralized system the whole rock technique suffers the same problem as the mineral separate method. No sense of direction can be indicated, except possibly at the surface, to guide later exploration phases unless other guides are available and implemented.

Geophysical Exploration

To date, use of geophysical exploration in the Stewart area has been startlingly small. A few reports outlining local self-potential ground and airborne electromagnetic and magnetometer surveys available to the writer show that the use of geophysical methods has been limited by the lack of topographic and geological control.

Summary

The traditional exploration methods and attitudes which served to locate almost all the known mineral deposits in the Stewart area have not uncovered a single significant ore deposit since the 1920's. Geological reappraisal of known showings which has been essentially continuous up to the present has been ineffective in the search for hidden deposits. The employment of modern geology, geochemistry, and geophysics is a prime requisite to the further search for significant ore deposits in the Stewart area. These will include the hidden deposits which will require a real focus of effort, as well as others which now appear too small or low-grade but have never been considered systematically.

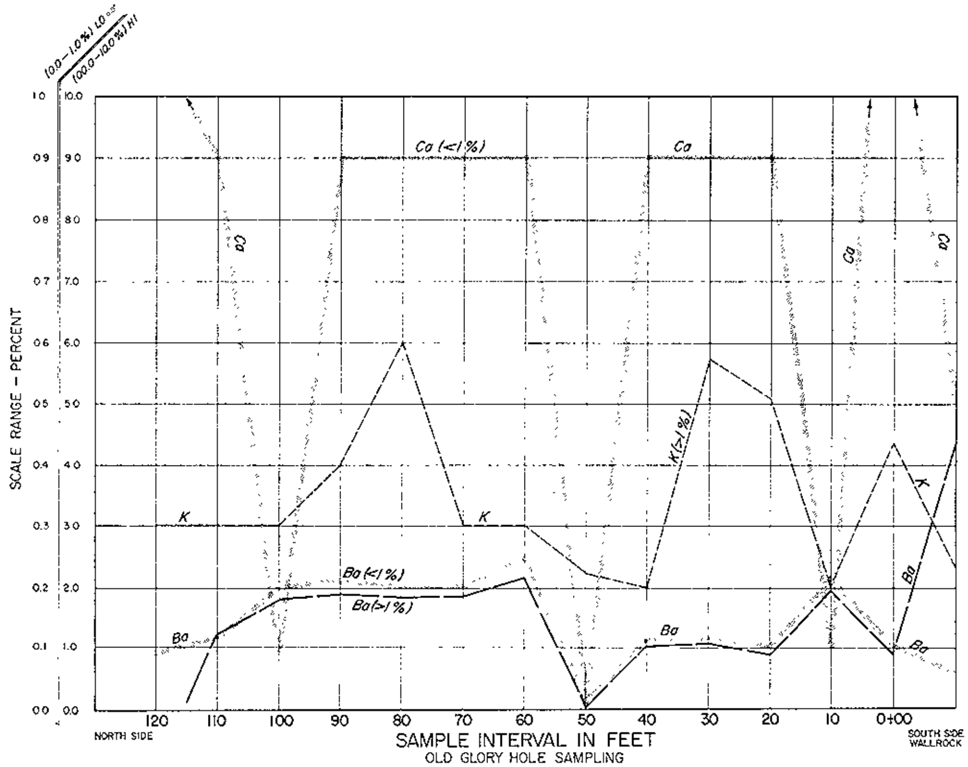


Fig. 23. Major element distribution, Silbak Premier vein system, Ba, Ca, K.

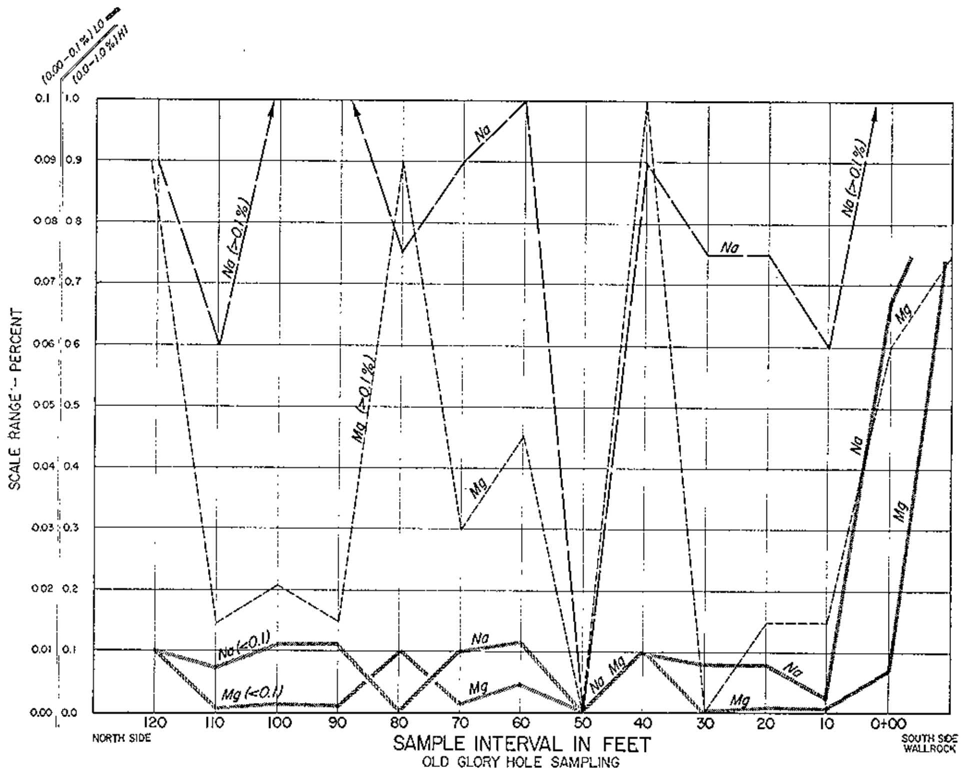


Fig. 24. Major element distribution, Silbak Premier vein system, Na, Mg.

CHAPTER 6

Descriptions of Mines and Prospects

In the following descriptions, the various mineral deposits have been organized alphabetically along with location numbers which correspond with the mineral-deposit distribution-map (Fig. 13). Names of Crown-granted claims (Fig. 15) are used in old reports and are still used, even though some of the claims have reverted to the Crown or have been forfeited. The properties which have had some post-1930 work recorded and which are of special interest have been described in this report, and a list with references to all in the map-area is given as Appendix II. Many of these have been indicated on the distribution-map by their claim-group name. Others not shown on this map can be located with the aid of Figure 15 and the original descriptions. It should be noted that all the references in Appendix II are found in the British Columbia Minister of Mines Annual Reports.

In the property descriptions, pertinent references have been included from the British Columbia Minister of Mines Annual Reports, but additional material can be found for many of the deposits by referring to Hanson (1929 and 1935).

Aztec Group
(Locality 74)

This property, which includes the Crown-granted Tillamook claim, is on the steep slope of Bear River Ridge opposite Bitter Creek on the west side of Bear River and about 8 miles north of Stewart. Like most of the area west of the river and below the ridge-top, it is now fairly inaccessible except by helicopter.

The Aztec is an old property located about 1920. Pits and trenches on the exposed veins extended from about 1,850 to 4,000 feet elevation. The deposits consist of quartz-sulphide breccia filling narrow northwesterly trending shears in fragmental volcanics.

The main vein at 3,975 feet elevation is mineralized across 8 to 9 feet, with coarse-grained galena, sphalerite, and pyrite in a vuggy quartz matrix with country rock inclusions. Uphill the vein narrows and is cut by northwest-trending lamprophyre dykes at 4,100 feet elevation. Below 3,975 feet the vein has been cut off by a normal fault which has produced an apparent displacement of about 1,500 feet to the north. The probable faulted extension of the vein is relatively continuous but has a lower sulphide content than the main vein.

Country rocks in the area consist of green fragmental volcanics and volcanic sandstones generally trending northwest and dipping steeply west. Toward the top of Bear River Ridge these stratified, green volcanic rocks grade into coarse red and purple volcanic breccias, which in turn are overlain unconformably by gently dipping tuffs and sandstones.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1920, 1922, 1965; Assessment Report 759.]

Big Casino
(Big Casino Mining Company Limited)
(Locality 67)

Located in 1908, the property consisted of the Big Casino, Little Casino, Ouray, Jack of Clubs, and Lookout Fraction claims at the head of Lydden Creek on the west side of Bear River adjacent to the Red Cliff mine. In 1910, when the trenching was done on the property, access was fairly easy because of the railroad, bridges, and good trails. It is now difficult to approach the general area without the use of a helicopter.

Mineralization consisting of fissure veins and stringers trending northwest was located in mixed green and red volcanic conglomerates and tuffaceous sandstones of the Hazelton assemblage. The property lies within the wide zone cut by the Portland Canal dyke swarm, which trends northwesterly across Bear River Ridge. In three trenches between elevation 2,700 and 2,900 feet, quartz-barite-jasper-calcite stringers with minor pyrite, sphalerite, and scant galena and chalcopyrite were observed. Discontinuous mineralized zones up to 4 feet wide represent fissure veins and stockworks developed in country rock screens partly deformed between a multitude of large granite and granodiorite dykes of the swarm. Like the Independent and Red Cliff deposits, the erratic nature of the mineralization did not lead to the development of continuous, mineable zones.

[Reference: *Minister of Mines, B.C.*, Ann. Rept., 1910.]

Big Missouri
(Buena Vista Mining Co. Ltd.)
(Locality 20)

The Big Missouri group of claims lies astride Big Missouri Ridge about 5 miles due north of Premier. This claim group, which is the oldest in the Salmon River district, was located in 1904. Prior to 1927 work consisted of the development of visible surface mineralization by open cuts, short adits, and limited diamond drilling. In 1927 the Buena Vista Mining Co. Ltd. assumed control of the group which was being developed by the Big Missouri Mining Co. Ltd., a holding of the Standard Mining Corporation. It was at this time that The Consolidated Mining and Smelting Company of Canada, Limited took control and eventually brought the property into production in 1938 from orebodies on the Providence claim. To facilitate development of the property, a road was built to Premier, a camp and powerhouse erected at Hog Lake, and a small hydro dam constructed at the west side of Long Lake to utilize the Divide Lake-Long Lake storage basin. As part of the mine development scheme, a 750-ton mill was built underground between the 2,100- and 2,300-foot levels, with tailings disposal and surface access on the Salmon Glacier side of the ridge. The present Granduc road now passes over the remains of the surface tramway built to provide transport on the west slope between the 2,300- and 2,800-foot levels. After initiating full production in early 1938 and producing about 850,000 tons of gold-silver ore, the property was permanently abandoned in April, 1942. Since then little interest has been shown in the general mine area. The last geological appraisal of the local mineralization was undertaken in 1966 for Falconbridge Nickel Mines Limited (Assessment Report 912) as a project conceived by Carl C. Wikstrom, of Hyder, Alaska.

Geology

The localization of the Big Missouri group within the generally metamorphosed Hazelton assemblage is illustrated on the main geological map (Fig. 3). It can be readily seen that the area of mineralization lies adjacent to and between a prong of the Texas Creek granodiorite and a series of mylonites on the east which are overlain unconformably by deformed rocks of the Bowser assemblage. The country rocks in the mine area are cut by a great many lamprophyre and hornblende granodiorite dykes, and the Portland Canal dyke swarm passes just to the north.

In more detail the rocks in the mine area include various chlorite and sericite schists and semi-schists, lenticular remnants of cataclasites (kakirites) and mylonites as well as weakly deformed and altered country rocks. These latter are prominent on the west slope above the Granduc road where excellent exposures of medium- to dark-green medium-grained volcanic conglomerates are easily accessible. Below the road on the glacier side, deformed Bowser siltstones are visible.

As many of the mine workings were water-filled and the adits caved when visited by the writer, the underground picture must remain fragmentary. The setting of the claim group, the workings, and the known mineralized zones have been partly compiled from company records.

Structure

The epiclastics trend northwesterly with a steep west dip and the shears trend northwesterly with dips from 35 degrees west through vertical to 50 degrees east, giving a picture of west-dipping country rocks and complexly intersecting shear zones. The main mineralized or silicified zones trend north-northwest parallel to the original rock stratification, but these are intersected by several lesser west-southwesterly trending zones as indicated on Figure 25. A number of flexures in volcanic sandstones and tuffaceous sandstones trend and plunge southwesterly at angles estimated to be from 35 degrees to 60 degrees, with the latter dominant. These correspond to lineations found in the Hazelton assemblage in the general area.

A simplified structural picture for the Big Missouri area shows a complex shear zone between the Texas Creek pluton on the west and competent Hazelton members on the east such as the rocks exposed south of Monitor Lake. These apparently simple shear zones were presumably capped at a slightly higher level by Bowser rocks before erosion.

Faults are significant features along the Big Missouri Ridge, although apparently not as abundant as in the Premier sector. The most obvious fault zone which lies along Silver Creek appears to offset all four silicified zones. Other less significant faults crudely parallel the country rock layering, trending north-northwest, and appear to dip westerly. Fault ore control is difficult to assess, but indications are that a fault mapped in the 2300 and 2860 levels forms the footwall of the ore zone and offsets oreshoots. The present hangingwall of the zone also appears to be a low-angle post-mineral fault against which mineralization terminates abruptly. So far no major fracture or fault systems have been recognized which could conceivably govern ore localization.

Orebodies

The greatest part of the Big Missouri production came from a small part of the main "A" silicified zone. The oreshoots are illustrated on Figures 26 and 27, which show a plan and vertical projection of the bodies, the development layout, and in part the known mineralized zone.

Production statistics indicate that 847,615 tons of ore carrying 58,384 ounces of gold, 52,677 ounces of silver, and 2,712 pounds of lead were mined primarily from the Providence mineral claim section of "A" zone. The stoped areas represent zones of extensive quartz-vein mineralization accompanied by minor free gold, galena, dark-brown sphalerite, chalcopyrite, and relatively rare silver minerals. Gangue also included calcite, country rock fragments, and rarely adularia, which was identified in narrow quartz-sphalerite veinlets.

The "A" zone in which the oreshoots have been localized consists of an area about 200 feet wide trending north-northwest, made up of fractured country rock intricately laced with unevenly spaced quartz-calcite veinlets and stringers with or without sulphides. Gold was associated with the areas of most intense veining and silicification which in turn appear to be best developed in areas where abundant kakirite lenses occur within the schists. Early reports referred to these cataclastic remnants as " porphyry," but the true nature of the rock is easily discerned in thin-sections. The over-all limits of the stockwork-type orebodies were determined by detailed drilling and sampling.

Estimates of ore tonnage and grade made in 1936 as a result of several years of detailed studies indicated a probable ore reserve of 1,842,560 tons, averaging 0.117 ounce gold per ton. The main or 326 orebody included in these estimates had a dip length of 500 feet, with mining widths from 7.5 feet at 0.26 ounce gold to 55 feet at 0.20 ounce gold per ton.

Alteration minerals present in the ore zone include epidote, chlorite, and ubiquitous quartz and calcite. These minerals are widespread in the country rocks in the mine area and their usefulness in delimiting target areas is probably limited.

Adjacent Deposits

The Big Missouri orebodies were the largest known of a number of mineral deposits localized in the immediate area. Many of these showings are still visible in surface workings and compare agreeably in simple mineralogy to the mineral zones exposed on the Province claim. Other claims on which these irregular quartz-calcite-sulphide lenses have been examined are as follows:—

	Lot	
Province	3208	20 showings
Buena Vista	3207	1 zone
Rambler	3208	1 zone
Tip Top		1 zone
Hercules Group	1521, 1522, and 1525	4 showings
Jain	3209	1 showing
Golden Crown		1 zone, 2 showings
Terminus	3221	1 zone
E-Pluribus	3213	2 zones
Laura	3214	1 showing
Day Group	4127, 4129, 4130, 4131, and 4132	2 showings
Unicorn Group	4535 *et al.*	underground workings

In 1966, D. H. Brown's (Report No. 912) assessment of these claims and their mineral potential indicated that there was probably less than 200,000 tons of ore grade mineralization currently available and that the over-all average grade was less than 0.10 ounces gold per ton and less than 1.0 ounces silver per ton.

[References: Assessment Report No. 912; *Minister of Mines, B.C.,* Ann. Repts., 1904–42].

Cassiar Rainbow (Locality 3)

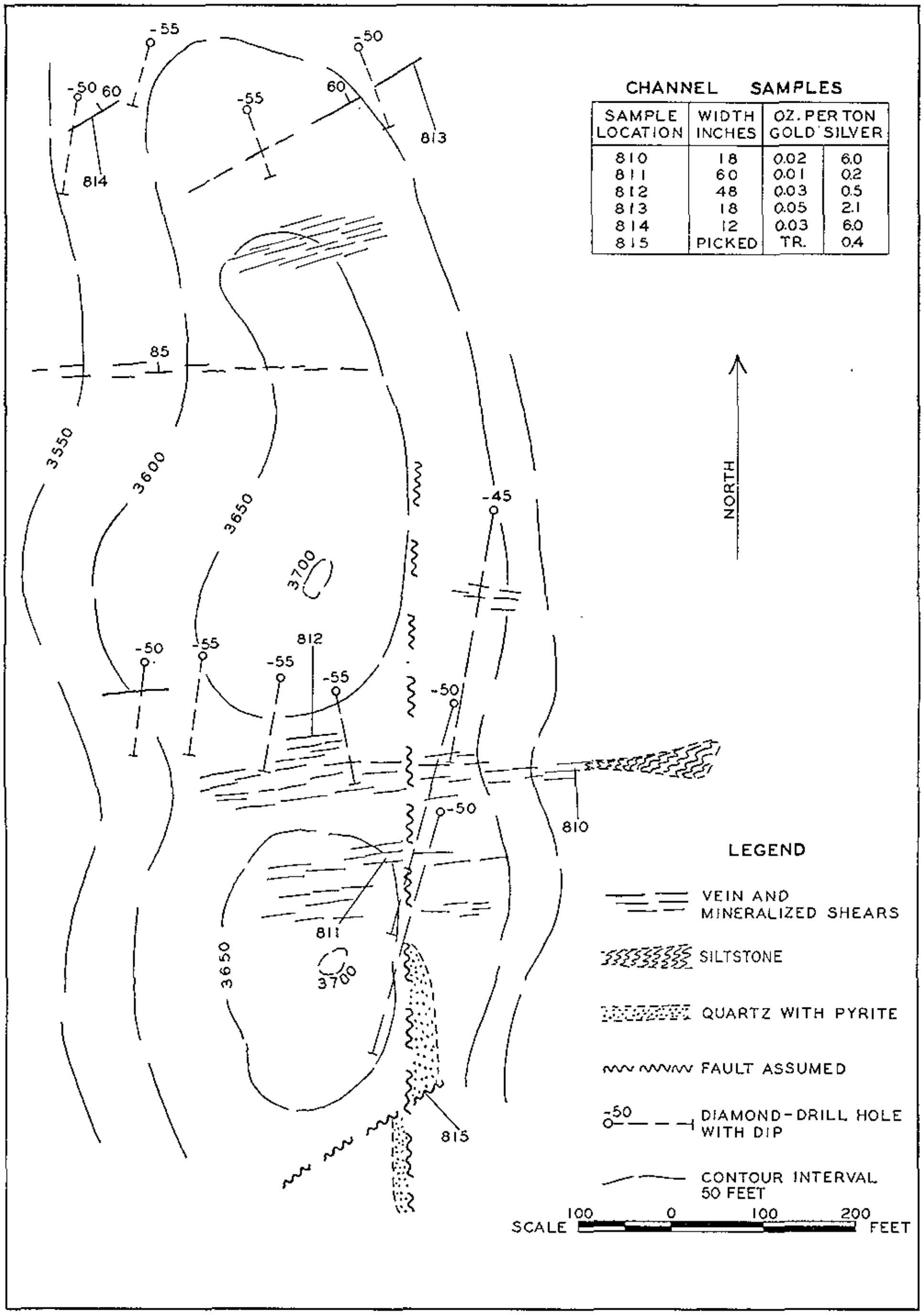
These showings, formerly on the Rainbow and the Rainbow Extension claim groups, in 1947 were controlled by the Cassiar Rainbow Gold Mines, Limited and at that time were located by C. D. E. Barker, of Premier. The showings are on the ridge locally known as the "Trojan Horse," on the east side of Summit Lake. This ground had been previously explored, and a map on page 65 of the British Columbia Minister of Mines Annual Report for 1920 shows the White Moose and War Eagle near this location. Access is now by the Granduc road which skirts the lower slope of the ridge above the lake. A road tunnel through the Trojan Horse, completed in 1968 (drilled and tested in 1967) in order to avoid a serious snowslide situation, passed under the showings without intersecting significant mineralization.

Country rocks consist of intercalated green Hazelton volcanic breccias, conglomerates, and sandstones, and their metamorphic equivalents. These steep-dipping north-trending epiclastics are cut by a series of almost east-west rusty-weathering shears containing quartz, minor pyrite, and other sulphides. The ridge rocks are cut by a number of post shear dykes ranging in thickness from a few inches to 20 feet, which appear to have characteristics of the Premier dyke swarm.

A synopsis of the work performed at the property (1947, p. 86), plus a sketch map (Fig. 28), follows:—

> Trenches and some natural outcrops expose wide zones of shearing that strike westerly and dip steeply northward. This shearing can be followed for 600 feet across the top of the ridge and extends farther down the slopes. Unless trenched, shear zones are poorly exposed, since they have been more susceptible to erosion than the unsheared rocks. One zone, partly exposed on the surface, is seen in the drill-core to be about 160 feet wide, but much of this width is not intensively sheared. Within the shears, pyrite is abundant, silicification is common, and stringers of white quartz and carbonate are numerous. Sphalerite, galena, pyrrhotite, chalcopyrite, and arsenopyrite are found in parts of the shear which is generally restricted to widths of not more than 5 feet. A few veins less than 2 feet wide occur where there is less shearing. The core from the diamond-drill holes resembles material observed in surface exposures, although shearing is more noticeable and sulphides appear to be more abundant. Figure 28, based on a pace and compass traverse, shows the shears, the location of samples, and location of the diamond-drill holes.
>
> Assays of three samples (810, 811, and 812) taken from shear zones and of two (813 and 814) veins gave the following results:—

Sample	Width	Gold	Silver
	Inches	Oz. per Ton	Oz. per Ton
No. 810	18	0.02	6.0
No. 811	60	0.01	0.2
No. 812	48	0.03	0.5
No. 813	18	0.05	2.1
No. 814	12	0.03	6.0



SAMPLE LOCATION	WIDTH INCHES	OZ. PER TON GOLD	SILVER
810	18	0.02	6.0
811	60	0.01	0.2
812	48	0.03	0.5
813	18	0.05	2.1
814	12	0.03	6.0
815	PICKED	TR.	0.4

Fig. 28. Cassiar Rainbow Gold Mines, Limited—plan of surface, showing veins, shears, diamond-drill holes, and assays.

A topographic break, consisting of a northerly trending line of low ground and ponds, and with low bluffs along the west side except where shearing is intensive, may mark a major fault. The rocks on both sides of the break are similar massive, sheared tuffs without markers to indicate displacement. The mineralization is found on both sides of the break, but may be younger than the presumed fault. In the south a zone of quartz and pyrite up to 25 feet wide is found on both sides of the break. A picked sample of quartz-pyrite mineralization (815) assayed: Gold, trace; silver, 0.4 ounce per ton.

[Reference: *Minister of Mines, B.C.,* Ann. Rept., 1947, pp. 86–88.]

Dunwell Mines
(Silver Arrow Explorations Ltd.)
(Locality 80)

The property presently held by Silver Arrow Explorations Ltd. includes 32 Crown-granted claims (Dunwell, Lot 4286; Ben Hur, Lot 870; George E, Lot 872, etc.) on Glacier Creek about 4 miles north of Stewart. Dunwell Mines Ltd. was incorporated in 1922 as a reorganization of Nass River Lands, Limited, which was incorporated in 1913, included the showings originally staked by the Stewart brothers and W. Noble, of Stewart. Early exploration was carried out on these claims by the Stewart Mining and Development Co. Ltd., which was absorbed into the Dunwell Mines Ltd. holdings. The first actual surface exploration in this section was performed by the original placer miners who set up sluiceways on the terrace gravels above the canyon of Glacier Creek. Some of these benches are still visible from the air. In 1926 a 100-ton mill was constructed at the outlet of the canyon and an aerial tram about 1 mile long was built to connect the mill with the main adit at elevation 1,250 feet. The mine and mill operated for part of 1927 and shut down the same year for want of ore reserves.

Since closing, the property has been explored by a variety of groups and leased for hand-mining off and on from 1932 to 1941. The current operators, Silver Arrow Explorations Ltd., have been actively examining the property since 1964.

The mineral deposit has been developed by four adits, all of which are accessible from the old camp area, which is now easily reached by a tote-road which connects to the Bear River road at the British Columbia Department of Highways gravel pit. Some of the camp buildings still stand, but the mill and storage bins have been undercut and caved by the rerouted Glacier Creek.

Dunwell mine production was slightly in excess of 50,000 tons of ore, which contained significant gold, silver, lead, and zinc (*see* Table 2). Almost all of this tonnage came from oreshoots in the " 23 " vein, one of several similar fissure veins found on the property. Surface exposures and trenches indicate that the vein system extends from the George E at Glacier Creek, north through Dunwell to the Sunbeam and Victoria showings. Past and recent efforts to prove the continuity of single veins by trenching and diamond drilling have been inconclusive, partly because of the heavy timber and overburden and partly because of the highly fractured nature of the country rocks.

Fissure veins in this area are found along what has been called the Portland Canal Fissure, a zone of faulting and fracturing apparently confined to graphitic Bowser siltstones, which unconformably overlie Hazelton conglomerates and breccias, and have been intruded by the Bitter Creek augite diorite porphyry, the Portland Canal, and lamprophyre dyke swarms. The rocks in the mine area are predominantly thin-bedded grey to black siltstones, greywackes, and minor intercalated quartzites. The general geologic setting has been illustrated on Figure 3 and the significant mine information on Figure 29. Outcrop in the Dunwell area is largely confined to gullies, a few road or trail cuts, and trenched sections, and the mine workings present the greatest continuous exposures.

Evidence of fold complexity is abundant and the confused nature of the structures is apparent along Glacier Creek. South of the creek a number of exposures of Glacier Creek augite porphyry have been mapped, indicating a probably larger mass at shallow depth plunging north under the Dunwell structures. One tongue of this pluton crudely parallels the fissure zone north of Glacier Creek just east of the mine. Contacts between the porphyry and the siltstones are marked by a narrow, bleached pyritic zone and by post-intrusive shear zones. The massive core of the Portland Canal dyke swarm cuts northwesterly across the country north of the mine, limiting any possible northerly continuation of Dunwell-type veins. A comparison of the distribution maps (Figs. 8 to 13) will show that the Dunwell and other vein deposits in this sector are largely confined to a small area of Bowser rocks isolated by Hazelton members on the west and elsewhere by plutons.

Mineralization on the Dunwell and adjacent George E, Sunbeam, and Victoria properties appears to comprise simple quartz-calcite breccia fissure veins in which isolated pods or lenses of sulphides have been localized. Slightly altered, angular, country rock siltstone fragments form a large part of the vein material, and open vugs are typical. Disseminated or replacement-type mineralization has not been encountered in the Glacier Creek sector so far as known. Sulphide minerals found in the main 23 vein at the Dunwell included galena, dark-brown sphalerite, pyrite, chalcopyrite, as well as minor tetrahedrite, rare argentite, and ruby silver. Native silver and, reportedly, electrum were identified in some high-grade material. Within the veins the sulphides are present as thin, fine-grained streaks and as irregular medium- to coarse-grained masses. The localization of the main ore lenses within the Dunwell 23 vein is shown on Figures 29 and 30.

Oreshoots have been localized within dilatant or wide vein zones, coinciding roughly with vein flexures which appear to mark the loci of intersection of the two main fracture sets. The main oreshoot, apparently localized at structural intersections, has been diagrammatically illustrated on Figure 30. The control of the post-mineral lamprophyre dyke by the same factors is illustrated on Figure 29.

Apart from the Dunwell, other veins in the same environment have been generally unproductive. It is possible that attention to small features such as the vein flexure illustrated here will aid in furthering exploration and development on the Dunwell and other veins in the Glacier Creek section.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1920, 1922–28, 1932–36, 1941, 1954, 1964–67.]

Forty Nine (Locality 7) These claims, which included the Crown-granted Oxidental (Lot 4023), were located in 1917 by Dan and Andy Lindeborg on the west slope of Mount Dillworth. The old workings, mostly pits, are easily accessible from the Granduc road and are marked by a cabin frame. Mineralization consists of mainly northwesterly trending quartz veins and stockworks with some replacement sulphides in schistose Hazelton conglomerate and

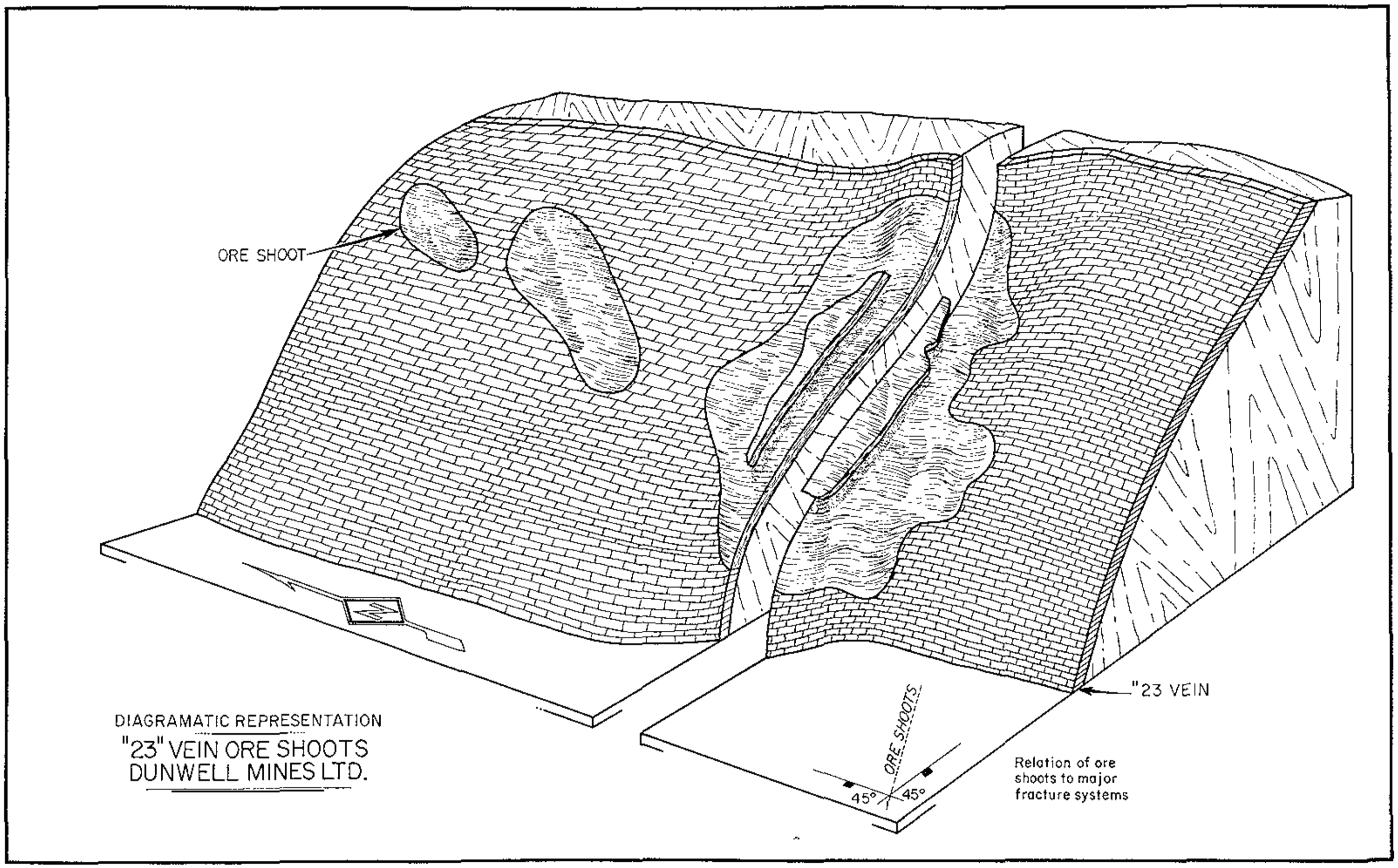


Fig. 30. Diagrammatic representation "23" vein oreshoots, Dunwell Mines, Ltd.

breccia. One vein trending about north 70 degrees east was explored by limited underground workings at an elevation of about 4,100 feet. The property lies within the Portland Canal dyke swarm and the veins have been cut by many dykes. Pyrite is abundant in the wallrocks and veins and is accompanied in lenticular masses and streaks by fine-grained galena, sphalerite, minor tetrahedrite, ruby silver, argentite, native silver, and rare polybasite. The original workings are shown and assays are given in British Columbia Minister of Mines Annual Reports for 1919 (p. 77) and 1920 (p. 62).

[References: *Minister of Mines, B.C.,* Ann. Repts., 1917–20, 1923, 1925.]

Hercules
(Locality 9)

The Hercules group of claims included the Crown-granted Glacier, Martha Ellen, Cornelius, Empire, and Leckie Fraction, which were located north of the Big Missouri property. Surface pits, trenches, and underground workings are readily accessible from the Granduc road which crosses the old property limits. The surface mineralization now visible in the cuts and trenches consists of irregular quartz stockworks and sulphide pods and lenses filling irregular fractures in northwesterly trending shear zones developed in variably schistose green volcanic conglomerates. Pyritized and silicified country rocks on the property contain scattered fine-grained pyrite, galena, and chalcopyrite with erratic gold-silver values.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1910, 1912, 1914, 1917–20, 1923.]

Independent Group
(Independence Gold Mining Co. Ltd.)
(Locality 69)

The original Independent group of six claims was located in 1919 by the Fitzgerald brothers, of Stewart. The property is situated on the steep slope west of Bear River and bounded by Goose, or Fitzgerald, Creek and the ice cap on Bear River Ridge. The Big Casino and Red Cliff properties are adjacent to the north and east boundaries of the Independent. The area is presently accessible only by helicopter.

The country rocks are red and green Hazelton assemblage volcanic conglomerates and breccias which trend northerly and dip steeply west. The main Portland Canal dyke swarm passes through this section and has divided the country rocks into thin panels and wedges. Fitzgerald Creek marks a major normal fault zone where the east side has moved down and north relative to the main ridge.

At least five veins or mineralized zones have been explored by trenches, several adits, and diamond drilling. The old camp is completely demolished and most of the trenches are filled in, the main adit at elevation 2,950 feet on No. 1 vein is still accessible, but the small adits on No. 3 and 4 veins in the gully a few hundred feet to the northeast, which were presumably driven from the old snow level, are completely out of reach at present.

No. 1 vein, trenched at an elevation of 3,250 feet and traced by a drift for 700 feet, consists of a northwest-trending, steep, east-dipping, irregular, quartz-barite-jasper breccia zone containing erratic pyrite, chalcopyrite, sphalerite, minor arsenopyrite, and pyrrhotite, as well as angular fragments of weakly bleached wallrocks.

Silver values reportedly were as high as 10 ounces to the ton and the other metals were negligible. In 1928, in spite of poor diamond-drill results, a second adit at an elevation of 2,760 feet was initiated on the No. 1 vein, but operations ceased at the end of the year. Work has not been recorded on the property since then, but evidence of recent diamond drilling above the main showings at about 3,400 feet elevation was noticed in 1965.

[References: *Minister of Mines, B.C.,* Ann Repts., 1919–23, 1928.]

Indian Mine (Locality 26)

Currently the Indian mine is held by New Indian Mines Ltd., through its subsidiary, Mammoth Indian Mines Limited, which controls 66 claims in the Cascade Creek section of the Salmon River district. The Indian group (original Portland No. 1 and Portland No. 2) claims were located in 1910 to investigate surface mineralization discovered on Indian Ridge between Noname Lake and Indian Lake. Initial development consisted of surface trenching by Indian Mines Ltd. The property was reorganized in 1923 under Indian Mines Corporation, Ltd., which performed the bulk of the underground development between 1923 and December, 1925, when operations ceased. In 1946, Indian Mines (1946), Ltd. acquired the holdings of Indian Mines Corporation, Ltd. and rehabilitated the camp in 1947. The buildings were caved by heavy snow during the 1947/48 winter and some of the buildings were repaired in 1948. Subsequently the Silbak Premier company made a working agreement with the owners and constructed a 2-mile aerial tram-line from the Indian mine to Premier, which was completed in 1951. The bulk of the ore was produced from the Indian in 1952 and concentrated at the Premier mill. In 1953 the operation was closed down nominally because of low lead-zinc prices. In 1962 a geological examination of about 90 claims then controlled by New Indian Mines Ltd. was undertaken by a field crew directed by R. V. Best. In 1963 the company drilled four holes to intersect a narrow northwest-trending zone on the Missing Link and Payroll No. 4 claims and resampled eight pits and trenches. No active exploration has developed since that time, but access to the property which formerly presented severe problems have been completely overcome by the construction of the Granduc road which passes within 2,000 feet of the main adits.

Geology

The property lies astride the irregular contact between the border phase of the Texas Creek granodiorite and altered cataclasites derived from conglomeratic members of the local Hazelton assemblage. In the past the local petrology has been poorly understood because of poor outcrop, fairly heavy undergrowth, difficult access, and, most significantly, because of the use of old Premier mine rock terminology. Both the intrusive and country rocks in which the deposit lies have undergone metamorphism or metasomatism, as well as faulting and dyke intrusions. Lenticular remnants of country rock in the mine area include green volcanic conglomerate and thinly striped tuffs and siltstones, as well as their deformed (cataclastic) equivalents. These country rocks have been largely altered by granitization to produce an irregular pseudoporphyry resembling the Premier Porphyry. These metasomatic rocks are marked by a light- to brownish-green colour, with random coarse orthoclase and disseminated medium-grained, brown hornblende porphyroblasts. The actual igneous contact is fairly clear in the road cuts but becomes somewhat diffuse toward the mine proper, where silicification becomes dominant. The granitized and silicified sections are gradational eastward into the less altered, variably schistose, light-green cataclasites of the Cascade Creek section. In the mine section, evidence of replacement of metasomatic orthoclase by quartz as part of the ground preparation process can be readily seen. This process also involved pyritization, carbonatization, and K-metasomatism, which produced irregular sericitic zones in the pseudoporphyry and cataclasites.

Subsequent to metasomatism, steep northerly fractures developed which served as depositional sites for extensive quartz fissure-vein deposits. These were later cut by members of the Premier dyke swarm and again by lamprophyre dykes. The abundance and localization of these dykes has been illustrated on Figure 11 and the relationship to the irregular main Texas Creek pluton on Figure 3. As at Big Missouri and Premier, a Bowser capping of the deformed Hazelton assemblage can be projected on the basis of existing remnants and their structure (*see* Fig. 4, section E-E′).

Structure

Intrusive igneous contacts with the country rocks include sharp fault features and gradational metasomatic zoning, which together form highly irregular reentrants of the Texas Creek pluton as well as zones of variously metasomatized pendant masses. Linear or foliated features are rare in the pluton but apparent to a prominent degree in the schistose country rocks. The dominant but irregular shear trend appears to be north-northeast and subparallel to the Cascade Creek lineament, truncating the primary rock layering or bedding at an acute angle. This shear zone wanders somewhat irregularly, possibly controlled by local rock competency and degree of fracturing.

Faulting is not an obvious ore control on the property. Faults are found at contacts between non-uniform lithologies and are prominent as minor, late, post-mineral, post-dyke dislocations. Fractures are abundant in the mine section and four distinct sets have been recognized, most of which are unmineralized. These have the following attitudes: 330 degrees/dip 70 degrees west; 0 degrees/dip 80 degrees east; 10 degrees/dip 5 degrees east; and 30 degrees/dip 85 degrees northeast.

Ore Deposit

Production from the Indian mine was largely confined to one oreshoot (22A stope) originally located as a surface prospect. The underground layout has been illustrated in plan and section on Figure 31, but the location of most of the early surface exploration pits and diamond drilling has been lost. The mineral deposit, as known, consists of several lenticular, irregular, fissure-type, sulphide-bearing quartz veins which grade terminally into irregular stockworks. In general the lenses are vertical and trend about 155 degrees. Parallel faults are common in the zone and form distinct vein limits. Fracture steps on the slickenside surfaces suggest vertical movements in the vein zone, but markers which might permit the determination of true slip are not known. Wallrocks include extensively silicified pseudoporphyry and chloritic schistose cataclasites. The veins pinch and swell from 2 feet to 25 feet along a known strike length of about 1,200 feet and a vertical range of at least 400 feet. The sulphide ore occurred as irregular pods or shoots apparently localized at dyke intersections, and appear to have a steep northerly plunge coinciding with expanded or dilatant zones within the country rocks. The sulphide minerals recognized in the predominantly milky quartz and carbonate veins were coarse massive galena, amber to brown sphalerite, and pyrite. Gold and silver values were apparently contained in these minerals. The best exposures are visible at the adit portals, and remnants of the oreshoots can be seen underground.

The veins were explored by open cuts and later by three adits, at elevations 2,034 feet, 2,192 feet, and 2,244 feet, with Nos. 1 and 2 levels interconnected through to the surface by raises. No. 3 level was developed primarily for diamond-drill exploration of the zone, but the portal has caved and the drift is presently filled with water and debris. Snow has lately caved the 2-level portal as well, leaving only the top adit open for easy examination.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1910, 1912, 1913, 1917–20, 1922, 1925, 1948, 1950–53; Assessment Report 448.]

Lakeshore
(Locality 36)

The Crown-granted Lakeshore and located Monitor claims lie on the south end of Monitor Lake on the divide separating Cooper Creek and Long Lake. The claims were included at times in the Bush Consolidated Gold Mines Inc. and Extenuate Gold Mines, Ltd., holdings. Apart from a minor amount of surface trenching on quartz-breccia veins, little exploration was done. In 1963, New Indian Mines Ltd. drilled the main vein on the Lakeshore claim. Five holes totalling about 1,300 feet were drilled and surface sections resampled, but results did not warrant a continuation of the programme.

Two intersecting fissure veins are readily visible on the claims only a few hundred feet south of Monitor Lake. One is localized along a northwest-trending, west-dipping, irregular fissure zone in dark mylonite (pseudoporphyry) and is typical of the quartz-breccia fissure veins of the area. The main sulphide is coarse-grained pyrite, and scattered galena and sphalerite are also visible, but no significant gold-silver values were found. A more extensive vein trends northerly and is along one of a number of subparallel conjugate faults of the Long Lake fault zone which appears to postdate the northwesterly trending vein. Mineralization is likewise spotty, but was traced for about 1,000 feet south along the fault into overburden. A number of smaller quartz veins were located west of Monitor Lake at about 3,600 feet elevation on Slate Mountain, localized as flat, irregular lenses in phyllitic mylonite subparallel to the Bowser siltstone contact (*see* Fig. 3). These small veins have been explored by two short adits and scattered pyrite is the only sulphide. Other quartz veins are present in the phyllitic siltstones on Slate Mountain, but no significant sulphide mineralization was found.

M.C.
(Locality 46)

This group of claims, including the Crown-granted M.C. (Lot 4406) located in 1921, lies astride the crest of Bear River Ridge opposite Bitter Creek. The group is bounded on the west by Silbak Premier holdings. The area was originally reached by a horse trail which connected the Hi-Grade and Prince John groups to Stewart. Access is now limited to helicopter transport.

A small amount of surface work and shallow diamond drilling was performed on vein deposits on the property during the years 1921 to 1924. In 1968 the property was relocated by Erin Explorations Ltd. Work entailed trenching and sampling of the old prospects on the south ridge of Mount Shorty Stevenson at elevation 5,300 feet, and several more veins were located in ground which had previously been snow and ice covered.

The veins are steep easterly trending *en échelon* pods or lenses localized along fissures in red and green volcanic breccias, conglomerates, and sandstones. The largest lens uncovered in the recent work was about 40 feet long, up to 6 feet wide, and possibly 30 feet deep. Mineralization consists primarily of medium-grained galena, brown sphalerite, some pyrite, and a variable fine-grained tetrahedrite groundmass. Picked high-grade samples assayed 0.16 ounce gold, 505 ounces to 550 ounces silver, 1.47 per cent copper, 35.15 per cent lead, and 19.18 per cent zinc. A number of small quartz-carbonate veins worked in the early days were found farther down the ridge toward the old Dalhousie stone cabin. Pyrite, galena, sphalerite, tetrahedrite, with specks of argentite, ruby silver, as well as secondary copper minerals, were identified in these veins. Other small, barren, quartz-carbonate lenses were found in areas just appearing from under the ridgetop ice-cap. They include northerly and northwesterly trending, steeply dipping veins.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1921–24, 1929.]

Mobile
(Locality 92)

The Mobile located claims numbers 1 to 10 are about 4 miles northeast of Stewart between elevations 3,000 feet to 5,000 feet along Big Gulch Creek, a southerly fork of Glacier Creek. With reference to the Crown-grant claim map (Fig. 15b), the claims are bounded on the north by the Billy (Lot 2954) and Kootnay (Lot 1385). The eastern line of Mobile claims includes a narrow strip of the old Chicago group of Crown-granted claims located in 1911. The Mobile claims are presently owned by G. H. Kendrick and were grouped in 1965 and optioned to Anglo United Development Corporation Limited. Old work on known mineralization included five short adits and several trenches on the west side of Big Gulch Creek between elevations 3,700 feet and 3,900 feet. This general area was included within the boundaries of the Mobile No. 5 claim, where geochemical surveys have recently been performed.

Mineralization consists of narrow, erratic, quartz-carbonate-sulphide lenses along steep north-northeast-trending shear zones in deformed graphitic Bowser siltstones. Although reportedly 2,000 feet long, the main zone is not continuous and the visible mineralization seldom has a width of more than a few inches. Minerals identified in the veins include galena, sphalerite, pyrite, minor argentite, tetrahedrite, proustite, and rare native gold. Reported gold-silver and base metal values are erratic and generally low.

Work performed on the property in 1964 and 1966 for Anglo United Development Corporation Limited consisted mainly of geochemical surveys intended to outline mineralization other than that already developed. The results of these surveys were not encouraging and exploration has not been continued.

[References: *Minister of Mines, B.C.,* Ann. Rept., 1929, p. 105; Assessment Reports 745, and 1010.]

Molly B (Locality 99)

The Molly B Crown-granted claim (Lot 4498) is on the east side of the Bear River directly in line with the main street and opposite the airport. It was staked by D. J. Rainey, of Stewart, who first sampled the mineralization in 1915. In 1917 the Molly B group was worked by the owners, J. W. Stewart and associates, who opened several cuts and prepared a tunnel site. The tunnel was continued in 1918 and molybdenite samples were shipped for assay. As part of the group encompassed about a quarter of the Skamakounst Indian Reserve 19, negotiations with the band chief were necessary. In 1937 the area was prospected in conjunction with surface work on the adjoining Oral M group by the Premier Gold Mining Co. Ltd. In 1942, J. Haahti, of Stewart, sent three samples of tungsten-molybdenite mineralization from the main adit vein to the Prince Rupert sampling plant, and in 1946 Stewart Canal Gold Mines Ltd. extended the adit and sampled the mineralization. No further work on the property has been reported, but Haahti is known to have continued driving the adit. A sketch of the main adit on the east bank of the Bear River at elevation 30 feet is shown on Figure 32. The geology and other pertinent sample information which was included in Bulletin 10 (revised), pp. 54–56, as reported by W. H. Mathews, has been quoted in the following:—

> The workings consist of four open-cuts and one short adit on the steep hillside above the Bear River. The lowermost open-cut, at elevation 10 feet, has been driven south-easterly for 10 feet, the adit, at elevation 30 feet and 12 feet easterly from the last open-cut, has been driven south-easterly for 10 feet. An upper open-cut, at elevation 50 feet and 40 feet easterly from the lower open-cut, has been driven easterly 6 feet, another open-cut, at elevation 90 feet and 60 feet easterly from the middle one, has been driven easterly for 6 feet. The uppermost open-cut, at elevation 105 feet and 12 feet easterly from the last, has been driven easterly for 5 feet. They have all been driven on the same mineralized bed.
>
> The scheelite and molybdenite are found in a band of lime-silicate rock formed by high-temperature replacement of a bed of limestone. This bed, which strikes south 60 degrees east and dips from 65 to 75 degrees southwestward, is 8 feet in width in the lowest open-cut, but decreases gradually to a thickness of 2 feet up the hill, then, where next exposed, in the open-cut at elevation 50 feet, it is 4 feet in thickness, and finally, in the uppermost open-cut at elevation 105 feet, it abruptly narrows from 4 feet to less than an inch. The bed can be traced for only a few feet beyond this cut. The rock, originally an impure limestone, has been metamorphosed to a mixture of diopside, garnet, and epidote. Calcite, which may or may not be part of the original limestone, is found in places. This bed, evidently favourable for replacement, has been mineralized with scheelite, molybdenite, and pyrite. The adjacent beds, both above and below the mineralized bed, consist of hard, relatively thin-bedded tuff or impure quartzite, often containing significant amounts of lime-silicate minerals, but no excess calcite, and probably for this reason they were unfavourable for mineralization.
>
> The grade of the molybdenite and scheelite is not high. A 360-pound shipment sent to the Government Sampling Plant at Prince Rupert of hand-sorted material taken from the lowest open-cut assayed: Molybdenum, 4.2 per cent, and tungstic oxide (WO_3), 1.5 per cent. Impurities included:—

	Per Cent		Per Cent
Iron	11.0	Copper	Trace
Sulphur	3.5	Arsenic	Trace
Silica	40.4	Manganese	0.9
Zinc	0.4	Tin	Trace
Phosphorus	0.24	Antimony	*Nil*
Lead	Trace	Bismuth	*Nil*

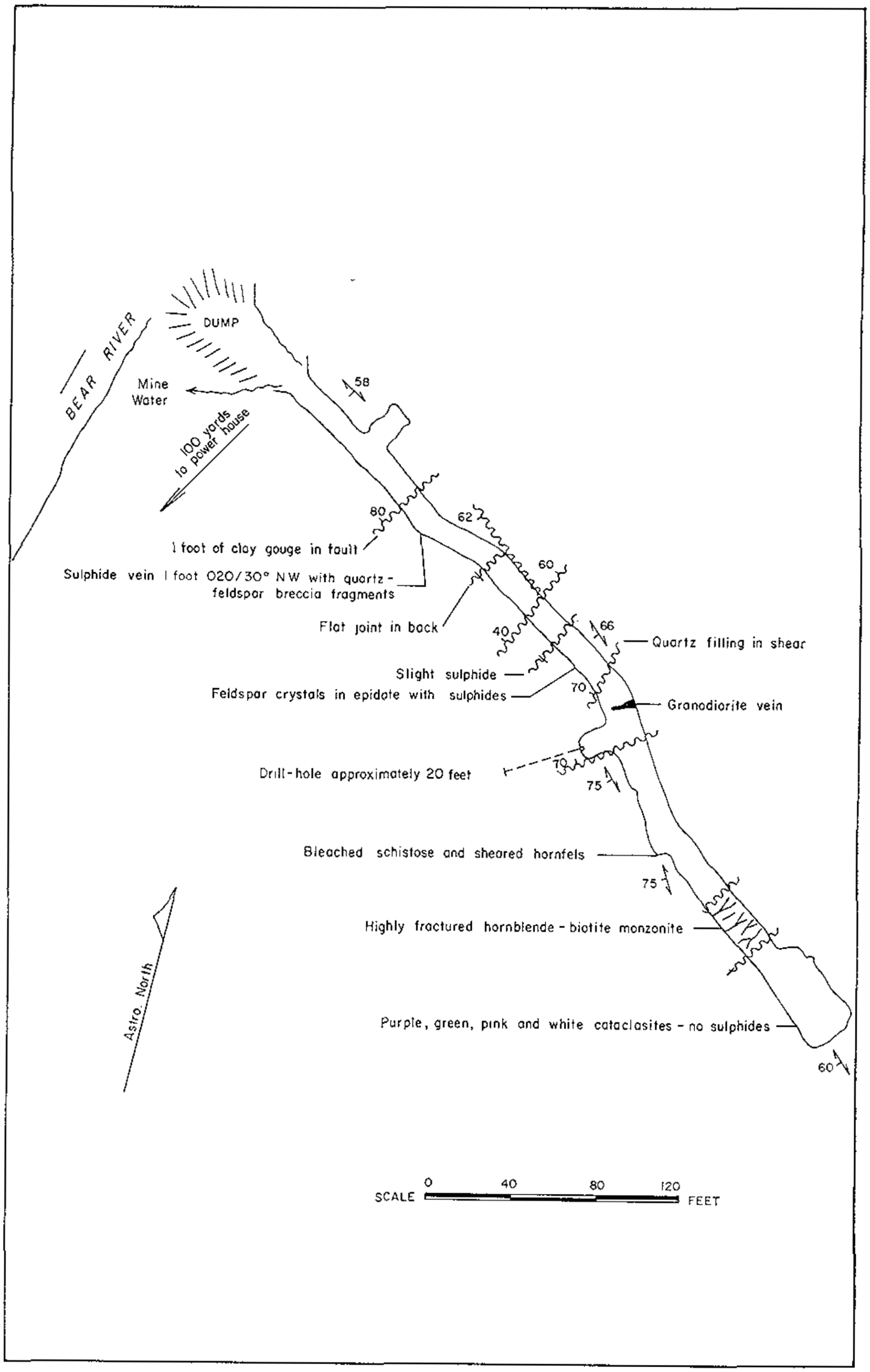


Fig. 32. Geology, Molly B adit.

A channel sample, taken across the face of the adit, a length of 5½ feet, assayed: Tungstic oxide (WO_3), 0.37 per cent; molybdenum (Mo), 0.17 per cent. A second channel, taken across 4 feet on the cut 90 feet above the river level, assayed: Tungstic oxide (WO_3), 0.22 per cent; molybdenum (Mo), 0.02 per cent. A 148-pound sample blasted from the lowest cut and from the face of the adit assayed: Tungstic oxide (WO_3), 0.15 per cent; molybdenum (Mo), 0.2 per cent. Examination with an ultra-violet lamp shows that scheelite is present throughout the exposures, with somewhat lower grade in the constricted parts of the bed than elsewhere. Occasionally high-grade streaks or patches of scheelite-bearing material are found, but these are not sufficiently large to form shipping ore. Elsewhere scheelite is too fine-grained or too uniformly distributed to permit any appreciable concentration by hand-sorting. It is doubtful whether the molybdenite shows the same uniformity of grade throughout the deposit as does the scheelite; in general, it appears to be concentrated in the lower exposures.

The mineralization, consisting of quartz-sulphide vein breccia and scattered tactite, is confined to a narrow, northwesterly trending shear zone shown on Figure 3 opposite Stewart. Sulphides recognized in the narrow lenses include pyrite, pyrrhotite, chalcopyrite, sphalerite, and molybdenite. These are also found as disseminations in cataclastic rocks near joint planes. Scheelite appears to be confined to lenses of tactite which are composed of epidote and garnet and are best exposed in the open cuts.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1915, 1917, 1918, 1930, 1937, 1942, 1946; Bull. 10 (revised), 1943, pp. 54–56.]

Moonlight (Locality 51)

The original Moonlight and Northern claims were located in 1929 by the North-Western Prospectors Syndicate, which was taken over in 1930 by North-Western Aerial Prospectors, Ltd. The Pass, Northern, Moonlight, and Camp located claims explored by the latter group were between 3,300 feet and 5,000 feet elevation along the west side of Kimball Lake, a fluctuating, periodic lake near the head of American Creek and just east of the main spire of Mount Mitre. These claims were immediately west of the Virginia K group of Crown-granted claims located on the east side of American Creek. The area was originally reached by road from Stewart to the American Creek bridge and then by horse trail, a total of about 27 miles from Stewart. The bridge and trail have largely disappeared and the best approach is now by helicopter.

Country rocks in the area are folded Bowser siltstones with intercalated limestones, greywackes, and quartzites which are found as a narrow strip along American Creek and Kimball Lake and overlie green Hazelton volcanic sandstones, breccias, and tuffs. Shearing occurs along the western side of the claims at the eastern edge of the snow and ice. Various small dykes cut all the country rocks.

Mineralization has been explored by trenches and cuts at eight locations, revealing quartz-sulphide veins and replacement sulphide deposits in both the Bowser and Hazelton members. Both northeasterly and northwesterly trending zones occur and the quartz-calcite stringers and veins are generally accompanied by pyrite, galena, sphalerite, minor chalcopyrite, and scattered tetrahedrite. Native gold was identified in the main northeast zone west of the lake along the volcanic siltstone contact. Some high-grade ore was reportedly shipped from the showings in 1935, but there are no records to indicate amounts. In 1937, 61.4 pounds of gold ore from one of the small quartz-calcite veins was shipped to the Trail smelter and assayed 387.8 ounces gold and 164.4 ounces silver per ton. In 1938 the property was taken over by Napco Gold Mines, Ltd., who did a small amount of trenching and drove 50 feet of adit. The property was inactive until 1966 when Frontier Exploration Limited extended the old workings and prospected the area.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1930–32, 1937, 1938, 1966.]

Morris Summit Gold Mines, Ltd.
(Salmon Gold)
(Locality 1)

The property is the Prince, Gold, and Summit Lake Crown-granted claims on the west side of Summit Lake about 1 mile from the north end. Prior to the building of the Granduc road the deposit had difficult access, but it is now easily reached from the road at the north end of Summit Lake. The property was visited several times by the writer, but the two adits comprising the underground workings each time contained " bad air."

The local geological setting at the Morris Summit property is shown on Figure 3. The country rocks are crudely stratified green volcanic conglomerates and breccias with intercalated, thin, volcanic sandstones and tuffaceous bands. Bedding generally dips steeply and trends westerly, but the over-all rock structure has been truncated and obscured by the Summit Lake stock and by the local dyke swarms. Along the contact with the Summit Lake pluton the epiclastics have been variably indurated and hornblendized, apparently in relation to the grain size of the intruded material. Coarse, dark-brown hornblende crystals up to 4 inches long are found in volcanic sandstones and fine-grained conglomerates up to 100 feet from the contact, whereas in the coarse conglomerates and breccias the hornblende was best developed in the fine-grained andesitic rock fragments rather than in the matrix. Alteration along the dyke contacts includes variable induration, pyritization, and epidotization.

In this section the Summit Lake stock is typically a white-weathering, light-grey hornblende granodiorite with irregular quartz-rich (20 per cent to 35 per cent) zones. The dykes have been divided into three local groups on the basis of composition and crosscutting relationships. The oldest are fine grained, dioritic, and resemble the Bear River Pass type (*see* Chapter 3), but at the mine have been called " green dykes." The younger dykes are porphyritic granodiorites which texturally and compositionally resemble the Premier dyke-swarm type. The youngest are typical lamprophyre dykes which cut all rock units.

The faults and shear zones shown on the maps (Figs. 3, 33, and 34) are important in terms of mineralization controls.

The mineralization and apparent structural controls were described at length by White (Ann. Rept., 1946) and Black (Ann. Repts. 1947, 1948) when the property was active and when the underground geology and diamond-drill core was accessible. These reports have been included in part in this report and the surface and underground development maps have been revised and completed and are shown as Figures 33 and 34.

The property, located by Ted Morris and associates of Stewart in 1930, was developed by the Premier Gold Mining Co. Ltd. in 1931. In 1934, The Consolidated Mining and Smelting Company of Canada, Limited, drilled several deep holes, one of which intersected good gold mineralization in the area of the present 3600-level No. 1 zone. In 1936, Salmon Gold Mines Ltd. started the 3600-level adit which was extended 1,500 feet over the following three seasons. In 1945, Morris Summit Gold Mines, Limited, acquired the property and completed 3,724 feet of diamond drilling. In 1946 the 3000 level was started and 2,137 feet of diamond drilling completed.

White's report, based on the 1946 work, included the following description of the mineralization and structural controls:—

> A major fault which strikes north 35 degrees west and dips variably from 40 to 57 degrees southwestward can be traced for nearly a mile. The fault-scarp is well exposed on the north edge of the hanging glacier at an elevation of 3,500 feet. This fault is of economic importance because it cuts off mineralized zones of current interest lying to the west, the continuations of which, east of the fault, have not been found. It is thought that the fault-displacement is very large, possibly measurable in miles. Another fault of lesser importance, having a horizontal displacement of 400 feet, follows the creek-canyon which extends northwesterly from the lakeshore near the camp a distance of 3,500 feet.
>
> Eight hundred feet north of the glacier and immediately east of the major fault is a prominent outcrop 600 feet long in a northwesterly direction and 450 feet wide. This is a huge quartz lode, which strikes north 20 degrees west and dips 60 degrees westward. It is made up of a 50-foot vein of quartz on the west side, a 3-foot vein on the east side, and a central part which is a maze of drusy quartz stringers and irregular zones of quartz-filled breccia. The quartz is only slightly stained and is apparently barren of metallic minerals, except in the central part of the lode where one 2-inch stringer contains massive galena, and some pyrite and tetrahedrite. A sample of this stringer assayed: Gold, trace; silver, 12.4 oz. per ton. The lode has not been traced beyond its outcrop.
>
> Numerous parallel veins from 1 to 8 inches wide, containing quartz, feldspar, calcite, and disseminated pyrite, form a zone in quartz-diorite. The zone is about 100 feet wide, strikes north 60 degrees west and dips 65 degrees northeastward, and can be traced for 1,000 feet.
>
> Elsewhere on the Morris Summit property east of the major fault, several discontinuous rusty shear zones, weakly silicified and containing disseminated pyrite and pyrrhotite, appear to have little economic significance. However, three more important showings occur west of the fault. The outcrops are deeply weathered; consequently, no surface samples were taken. As these showings are similar in structure and mineralogy, only the one of current interest, located near the north edge of the hanging glacier, will be described.
>
> As shown in Figure 33, this showing consists of several shear zones in fragmental volcanic rocks arranged in sub-parallel, branching, and *en échelon* fashion across a width of about 350 feet. The shear zones strike approximately west and, for the most part, dip steeply northward. From the major fault at which they terminate, the shear zones can be traced about 500 feet westward, where they curve slightly northward and merge in an area of disseminated mineralization. The vertical distance between terminal outcrops is about 250 feet.
>
> These shear-zone deposits are siliceous replacements with no defined walls and contain discontinuous lenses of massive sulphides. Pyrrhotite is the principal metallic mineral. Pyrite, arsenopyrite, and chalcopyrite occur in small quantity intimately associated with the pyrrhotite, and occasional grains of galena and sphalerite can be found. Individual sulphide lenses are nowhere more than 24 inches wide and rarely exceed 50 feet in length, but several narrow sulphide stringers

may be distributed in *en échelon* arrangement across widths up to 60 inches. Some sulphide lenses are split longitudinally by one or more veins of drusy quartz and calcite, barren of sulphides. A somewhat different type of mineralization is found in several narrow veins recently exposed by recession of the glacier. These contain pyrite, pyrrhotite, sphalerite, and galena in a quartz-carbonate gangue. They strike west and dip steeply either north or south. An unoxidized sample across one 5-inch vein assayed: Gold, trace; silver, *nil*.

Underground exploration by The Consolidated Mining and Smelting Company disclosed a single mineralized zone in a drift 120 feet north of the main adit and parallel to it. Figure 33 shows this exposure in relation to the surface outcrops in both plan and vertical section. It will be seen that the long crosscuts driven northward beneath the better-looking surface exposures failed to intersect their downward continuations. The zone exposed in the drift is about 240 feet long and averages 30 inches in width. Like the surface exposures, this is a silicified shear zone containing discontinuous streaks and lenses of massive sulphides. Mineralization occurs in the west face of the drift, but pinches out near the east face along an oblique slip. Five channel samples and one specimen were taken in this mineralized zone with the following results. Distances are measured from the crosscut leading to the main adit.

Location of Sample	Description	Width	Assay	
			Gold	Silver
		Inches	Oz. per Ton	Oz. per Ton
West face	Channel sample — silicified rock with quartz stringers and irregular masses of pyrrhotite	24	0.06	0.2
West face	Specimen of massive pyrrhotite with minor amounts of pyrite, arsenopyrite and chalcopyrite	....	0.36	1.0
Crosscut + 15 feet east, S. side	Massive sulphides, mainly pyrrhotite	14	0.03	0.4
Crosscut + 15 feet east, N. side	Siliceous rock with stringers of quartz, pyrrhotite, and pyrite	18	0.03	0.1
Crosscut + 115 feet east	Siliceous rock with several sulphide seams aggregating 12 inches	30	0.03	0.2
Crosscut + 175 feet east	Siliceous rock with abundant masses of pyrrhotite, some pyrite and chalcopyrite	30	0.09	0.4

The 1946 development programme continued into 1947 and the results were reported by J. M. Black (Ann. Rept., 1947) as follows:—

In 1947, underground development was continued, an assay office was built, and, starting from Big Missouri camp-site, 1½ miles of tractor-road was built. About 20 men were employed, and they worked underground 306 days. During the year, 4,791 feet of diamond drilling was done and about 1,500 tons of ore was mined.

The rocks exposed on the 3000 level are fine- to medium-grained, massive, grey and green. Some are probably tuffs, though no bedding is apparent, and some contain coarse fragments. Others are slightly porphyritic intrusives, with small phenocrysts of feldspar, and of a dark-green mineral. Pyrite is abundantly disseminated, and there has been some siliceous and carbonate alteration.

The above igneous complex is cut by many light-coloured carbonate veins up to 2 feet in width and containing a small percentage of quartz. Although most of the veins have a northwesterly strike and a southwesterly dip, a few dip northeastward. Most of them have some gouge along their walls. Some contain pyrite, and in the wallrock of one vein some needles of arsenopyrite were noted.

Many faults which strike from north 40 degrees west to north 40 degrees east are exposed on the 3000 level. For 700 feet from the portal most of these faults dip eastward, but elsewhere most of the dips are westward. On two of these faults, according to the drag and displacement of carbonate stringers, the movement has been only a few feet, with the hangingwall moving down relatively to the footwall. Many other faults, which have a great variety of attitudes, are exposed. All the faults curve, split, and have some gouge, and many of them also contain carbonate stringers.

About 1,900 feet from the portal the 3000 level crosscuts a prominent fault-zone containing about 1 foot of gouge. This zone strikes north 35 degrees west and dips 50 degrees southwestward. It lines up with, has about the same attitude as, and is considered to be the extension of a major fault which is exposed on the surface, where it can be traced for more than a mile. North of the workings the offsetting of a granodiorite-hornfels contact to the right may have resulted from a downward movement of the hangingwall in relation to the footwall; the movement may have had a considerable horizontal component.

For 115 feet east of this fault, quartz and carbonate veins replace the country rock in a much-faulted zone which has the same relationship to the major fault as does a wide quartz lode at the surface. This zone ends at several gouge-filled slips which strike northwesterly and dip 35 degrees southwest. A similar altered zone, with fewer veinlets, extends for 160 feet west of the fault.

The mineral zone exposed in the drift on 3000 level strikes northwesterly and consists of a central white carbonate vein, on both sides of which the wallrock is replaced by white and pink carbonate, light-coloured quartz, massive and disseminated pyrrhotite and pyrite, and small amounts of sphalerite, chalcopyrite, and galena. This mineralized zone is without definite walls, is 22 feet wide at the crosscut, narrows to a few inches at 50 feet along the drift, and widens to about 6 feet within a further distance of 25 feet. The central vein generally dips steeply northeastward, and in a few places southwestward. Three samples (816, 817, and 818) were taken at a point 75 feet along the drift where pyrite predominates, and five samples (819 to 823) were taken at the crosscut where pyrrhotite predominates. The assays are as follows:—

No.	Width	Description	Gold	Silver
			Oz. per Ton	Oz. per Ton
816	40 inches	Small amount of pyrite	*Nil*	*Nil*
817	41 „	Moderate amount of pyrite	Trace	*Nil*
818	Picked	Abundant pyrite	0.05	0.1
819	50 inches	Well mineralized	0.42	0.8
820	51 „	Well mineralized	0.01	1.2
821	44 „	Carbonate vein	0.05	1.1
822	60 „	Very little mineral	0.01	0.1
823	72 „	Small amount of pyrrhotite	0.01	1.1

Five horizontal holes drilled toward the southwest intersected the mineralized zones shown in Figure 34. In Hole 310, some of the massive sulphides are similar to those which occur in the main zone, but toward the east, as indicated by the intersections in Holes 308 and 306, this zone widens into many stringers without massive mineralization. A second zone about 5 feet wide is indicated in Holes 314 and 310, which were drilled to the southwest of the zone explored by the drift. Further exploration will be required in order to correlate these zones with the zones indicated above them by the drill-core intersections. Width of mineralization on this level is greater than that usually found, and may be attributed to the intersection of two zones.

To the east of the major fault no mineralization of economic importance has been found on this property. If the footwall has moved up relative to the hangingwall, and after mineralization took place, most of the mineralization east of the fault may have been eroded. Another possibility is that the wide altered zone (275 feet wide on 3000 level), in which additional quartz and carbonate has been incorporated, may not have reacted, as did the unaltered rocks, to forces which resulted in the formation of westerly striking fractures. The manner in which the mineralized zone appears to widen and to split into many stringers as it approaches the altered zone indicates that, extending as far as the fault, there was no single fracture zone along which mineral-bearing solutions might circulate. If other mineralized zones cannot be followed as far as the fault zone, it will indicate that the mineralization is younger than the altered zone. During 1947, 359 feet of crosscutting, 2,468 feet of drifting, and 4,791 feet of diamond drilling were done, and 1,600 tons of ore was broken in drifting on veins.

The work initiated in 1946 continued into 1948 and was the last major development undertaken at the property. J. M. Black's report for 1948 follows:—

Holes drilled previously from the surface and from the 3600 level indicated mineralized zones, with erratic values in gold, which strike westerly and northwesterly and have steep dips. The exact location of the mineralized intersection is not known because the drill-holes, most of which were over 500 feet in length, were not surveyed, and, therefore, the correlation of the mineralized intersections, which are fairly widely separated, cannot be made with certainty.

The recent development has exposed mineralized zones containing shoots of important gold mineralization below and south of those indicated by the earlier exploration. One of these shoots has been drilled below and above the 3000 level, on which it is exposed. A raise has been driven up in this shoot for a few feet, near its east end. The other shoots have not been developed.

The country rock is massive, grey and green. In part it looks like a fine- to medium-grained gabbroic intrusive and contains rounded inclusions up to several inches across, slightly different in colour from the matrix. Elsewhere the rock is fine grained and in places has what appears to be coarse fragments. No flow boundary or other primary structure was seen. Pyrite is abundantly disseminated, and in the western part of the 3002 West drift some silicification and chloritization is seen.

All the mineralized zones explored are west of a major fault, and the results indicate that the zones split and weaken as they approach the fault.

The mineralized zones consist generally of a central zone, ranging in width from a few inches to several feet, surrounded by a zone in which iron sulphides replace the country rock for a distance up to several feet from the central zone. The central zone consists of a vein or veins of quartz and carbonate, some of which also contain a small proportion of the sulphides chalcopyrite, sphalerite, galena, and arsenopyrite, in massive pyrrhotite and pyrite. The quartz and most of the carbonate are white and grey, but a small proportion of the carbonate is pink. In the outer replacement zone the proportions of the iron sulphides are reversed, and pyrite is much more abundant than pyrrhotite.

The fact that in 3004 East drift the pyrrhotite-pyrite zone is cut by a vein in which chalcopyrite, galena, and sphalerite predominate suggests that the latter sulphides occurring in small amounts near gangue minerals in the central part of the mineralized zone may also be somewhat younger than the pyrrhotite-pyrite mineralization.

The mineralized zones are cut by dark-green lamprophyre dykes, which strike northeasterly and dip steeply. These dykes range in width from a few inches to 5 feet and spall readily where exposed.

As shown on Figure 34, three mineralized zones which curve and branch are exposed on the 3000 level. One drill intersection indicates another zone about 200 feet south of 3004 East drift. A fifth zone splits off the zone exposed in 3002 East drift, about 50 feet above the drift. The general trend of these mineralized zones is westerly to northwesterly, but some veins within the zones diverge slightly from the general trend. Widths up to 20 feet occur, although widths of 2 to 5 feet are most common.

The western part of the mineralized zone exposed in 3002 West drift is in the wall of a fault which contains a few inches of gouge. Some narrow dykes, not shown on the plan (Fig. 34), are displaced a few inches to the right by post-mineralization movement along the fault. Toward the west end of this drift the fault splits and the mineralization is not continuous along the splits; at the west face, quartz predominates and pyrrhotite is absent. This fault may have been the channel for the mineralizing solutions.

The zone exposed in 3004 East drift is also associated with a fault along which, probably, there has been slight post-ore and post-dyke movement; a dyke is sliced by the fault but not displaced.

The position of samples taken is shown on Figure 34. Most of the samples are from three sections—in drifts 3002 West, 3002 East, and 3004 East—that have been found by the management to be of better than average grade. These sections are about 220, 90, and 100 feet in length respectively. The samples are not numerous enough to serve as a dependable base for calculating average values of the indicated shoots, though they do show the range of values that occur. The assays are tabulated below.

Sample No.	Width	Gold	Silver
	Inches	Oz. per Ton	Oz. per Ton
3002 West Drift			
878	34	0.01	0.3
872	30	0.02	0.4
864	20	0.14	2.1
863	72	0.17	0.4
862	56	0.14	0.4
861	46	0.02	0.4
860	44	0.25	0.4
859	48	0.13	0.5
858	17	0.57	0.5
857	36	0.02	0.4
843	52	0.13	0.2
842	34	0.08	0.2
841	56	1.54	0.4
840	39	0.14	0.2
839	33	0.53	0.4
838	32	0.03	0.3
871	6	0.13	0.3
856	19	0.02	0.2
855	47	0.01	*Nil*
816	40	*Nil*	*Nil*
817	41	Trace	*Nil*
818	([1])	0.05	0.1
854	15	0.61	0.4
819	50	0.42	0.8
820	51	0.01	1.2
821	44	0.05	0.1
822	60	0.01	0.1
823	72	0.01	1.1
831	60	0.01	*Nil*
3002 East Drift			
880	15	0.01	0.7
878	15	0.07	0.1
3002 East Drift—Continued			
672	33	4.82	0.88
853	42	2.75	0.6
852	54	0.85	0.6
851[2]	30	1.12	0.8
850[3]	31	0.65	0.5
849[2]	33	0.26	0.7
848[3]	36	0.65	1.0
671	127	0.61	0.9
847	42	3.82	1.8
670	21[4]	2.09	0.9
846	28	0.28	0.7
845	45	0.17	0.1
844	40	0.25	0.2
876	24	0.03	*Nil*
877	48	0.02	*Nil*
875	36	0.02	0.1
874	48	Trace	0.3
3004 East Drift			
870	48	0.07	0.3
865	40	0.14	0.6
866	28	0.02	0.2
867	20	0.20	1.9
868	18	0.19	0.4
873	40	0.78	0.6
869	30	0.86	0.6
669	18	1.38	0.8
668	36	1.00	0.6
667	28	3.83	1.2
666	13	1.35	0.6
665	16	1.18	0.6

[1] Picked.
[2] Hangingwall portion of vein zone.
[3] Footwall portion of vein zone.
[4] Average of two samples.

The gold is erratically distributed and appears to be related to the pyrrhotite, though the amount of gold is not directly proportional to the amount of pyrrhotite. Samples containing much pyrite and little pyrrhotite generally contain less gold than those with a preponderance of pyrrhotite, and those composed only of pyrite are low in gold. No free gold was seen.

On the longitudinal vertical projection EF (Fig. 34) is indicated part of the outline of a shoot containing important gold values exposed in 3002 East drift and part of two other shoots not exposed in the workings. These outlines are based on intersections of mineral zones seen in the core of the holes shown on the plan. For clarity these intersections of the drill-holes with the mineralized zones are omitted from the plan in the vicinity of the vertical projections. The areas outlined on the vertical projection include those parts of three zones in which, judging from an examination of the core, the mineralization is of about the same grade as that exposed on the level; however, additional development is necessary before the areas outlined may be considered to be proven oreshoots. The outlined areas are not extended upward to include intersections obtained in the holes drilled downward from the upper (3600) level. The area outlined below the drift is based on only one intersection (that for Hole 334), about 135 feet below the level. Therefore, the continuity of the shoot between the level and this intersection has not been confirmed, though from the shape of the shoot it seems probable that it does extend downward about as outlined. Outside of the outlined areas the drill-core intersections are narrower or less abundantly mineralized.

The intersections of pyrrhotite-pyrite mineralization of importance in all the holes are shown, except those near the vertical projections. Most of the holes drilled from 3002 West drift did not intersect zones of pyrrhotite-pyrite mineralization.

From the projection EF it appears that the shoots rake steeply northwestward, and from the plan and projections it appears that the parts of the mineralized zones that have the highest values are where the zones curve or split.

The mineralization exposed on the 3000 level is similar to that exposed at the surface and on the 3600 level, indicating that changes in the mineralogy with increasing depth are slight.

In 1949 the work was halted, and apart from appraisals, the property has remained completely inactive since 1961.

[References: *Minister of Mines, B.C.*, Ann Repts., 1930, pp. 114–116; 1946, pp. 62–66; 1947, pp. 83–86; 1948, pp. 66–69; 1949, p. 74.]

Outland Silver Bar
(Locality 6)

The property, which consists of 15 Crown-granted mineral claims including the Lens, Idaho, Vimy No. 1, Mountain Girl, and Bar Silver, is at Outland Point, a northeast spur of Mount Bayard on the west side of the Salmon Glacier. This group of claims is bounded on the west by the old El Dorado group and on the south by the old Munro and Lindburg groups. Access to the showings was originally from the Salmon Glacier. The adits, some of which were driven from the glacier, are now perched hundreds of feet above the surface of the ice. More than a dozen short adits as well as various trenches are shown on Figure 35.

The Outland Silver Bar property lies within the limits of the Portland Canal dyke swarm near its northwestern extremity. The country rocks are banded, dark, quartzitic siltstones and greywackes which have been intruded by members of the Coast Plutonic Complex. On the property the sedimentary rocks are marked by breccia and narrow mylonite zones and by complex, small-scale, isoclinal folding. On Figure 3 these rocks have been represented as part of a fairly extensive siltstone unit probably extending from Big Missouri Ridge under the Salmon Glacier to include Outland Point. The widespread ice and snow cover as well as the complexity of dyke intrusion makes it difficult to determine the structural position of these siltstones, but they probably overlie Hazelton volcanic epiclastics.

At least five generations of dykes forming part of the Portland Canal dyke swarm in this area have been outlined on Figure 35 and are partly visible on Plate XVIIA. Dyke ages are indicated by quartz-vein mineralization which cuts altered porphyritic hornblende diorite and quartz diorite members. The later dykes cut these as well as the veins, but the exact relationship of every type is not known. The latest dykes are probably the dark-green andesitic dykes which are similar to the lamprophyre dykes found at the Morris Summit property and elsewhere.

Johnies vein, a north-northeast trending structure, is the major showing on the Outland Silver Bar property and has been explored by adit No. 1 at elevation 4,041 feet and by adit No. 6 at elevation 3,882 feet. In the adit crosscuts the vein has a width of about 4 feet and has an apparent mineralized section about 100 feet long. The vein lies in brecciated, altered siltstones and has been cut by small, late, dioritic dykes. Other smaller veins are found in the older dykes and generally show little extension into the siltstones. The veins generally consist of quartz with scattered galena, sphalerite, tetrahedrite, and pyrite with minor chalcopyrite. The veins trend north to northeast and dip easterly within minor shear zones in the siltstones and in fractures in the dykes.

Replacement-type mineralization in altered siltstones has been explored in adits Nos. 8, 9, 10, and 13, disclosing a narrow, apparently continuous, steep, low-grade silicified zone trending east-northeast in which pyrite, pyrrhotite, arsenopyrite, scattered chalcopyrite, galena, and sphalerite are visible.

As at many of the properties along the Portland Canal dyke swarm, the best silver-bearing mineralization has been localized as small lenses or pockets within the more competent dyke rocks rather than the country rock siltstones. The high-grade deposits are therefore generally of limited size and relatively difficult to locate and develop.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1921–29; Assessment Report 375.]

Portland Canal
(Locality 87)

The Gypsy, Little Joe, and Lucky Seven Crown-granted claims were located in 1906 along the south slope of Glacier Creek about 4 miles north of Stewart. A 40-foot shaft was sunk on a mineralized quartz vein by the owners Beaton and Didsdale, which reportedly produced assays of $30 to $40 per ton in gold, 20 ounces per ton silver, and 20 per cent lead. Portland Canal Mining Co. Ltd. acquired the original claims as well as nine more in 1908. Two adits were driven and a third, No. 3 tunnel, was projected at elevation 2,400 feet as the main haulageway. After some feasibility studies, a 75-ton concentrator and an aerial tram-line from the Dunwell mill-site were constructed in 1910. A short spur-line from the Portland Canal Short Line Railway was laid to the cencentrator and the wagon-road to Stewart improved. In October, 1911, the mine and mill ceased operations after treating 7,000 tons of gold-silver-lead ore from which about 1,500 tons of concentrates was shipped. The ore apparently averaged 0.12 to 0.3 ounce gold; 5 to 25 ounces silver per ton; 2.5 to 12 per cent lead, and minor variable zinc with an average value of $12 per ton at that date.

Negligible work has been done on the property since 1912, although Portland Canal Terminals Limited drove a tunnel 3,629 feet long eastward from 50 feet in elevation above the Dunwell mill-site to intersect the Portland Canal Fissure and to investigate various known vein systems such as the Portland Canal vein. This tunnel and ancillary development on vein intersections which was completed in 1914 has been mainly used to carry water for the Dunwell mill. In 1954, Cassiar Consolidated cleaned out the tunnel, which was filled with gravel, but since then the adit portal has caved.

In 1968, Granduc Mines, Limited, reopened and mapped the No. 3 Portland Canal tunnel at 2,400 feet elevation for mapping and sampling.

Vein mineralization on the property lies within thin-bedded dark Bowser graphitic siltstones and greywackes which overlie Hazelton volcanic epiclastics. The sedimentary rocks have been intensely folded and deformed and intruded by a number of plutons and dyke swarms. The veins have been injected into extensive fractures localized near the Bowser-Hazelton contact and apparently controlled by underlying intrusions. This fracture system, which included the known vein mineralization, was referred to as the Portland Canal Fissure Zone in old publications.

Two oreshoots averaging 5 feet wide, were mined from the quartz-breccia vein which averaged 8 feet wide and was traced on surface for about 2,000 feet. Both oreshoots were essentially flat-lying pods confined to narrow portions of the main vein. Sulphide mineralization in the quartz breccia consisted primarily of pyrite, with galena and minor sphalerite.

Like other similar veins in this zone, the vein has a sinuous swelling shape and is cut or bounded by later, narrow, hornblende diorite (lamprophyre) dykes.

[References: *Minister of Mines B.C.*, Ann. Repts., 1906, 1909, 1911–13, 1935, 1954, 1968.]

Prosperity and Porter Idaho Mines
(Localities 107 and 109)

Both the Prosperity and Porter Idaho mines are on the southeast slope of Mount Rainey above Kate Ryan Creek, with workings extending from about 4,200 feet to an elevation of about 6,000 feet. The various Crown-granted claims of these two old groups are now included with the Silverado in the extensive holdings of Cassiar Consolidated Mines Limited on Mount Rainey. The Porter Idaho Mining Co. Ltd. was organized in 1925 to take over the Porter Idaho Syndicate formed in 1923 which controlled the claims originally staked by Clay Porter and associates. Underground development of the exposed veins started in 1925 on four mineralized zones, including one easterly and three northeasterly trending vein systems. Ore was shipped first in 1925 from oxidized surface material yielding high silver and lead values. In 1926 the owners of the Prosperity claims traced one of the Porter Idaho veins uphill and initiated trenching in high-grade silver-lead mineralization and shipped some tonnage before snow came. The Premier Gold Mining Co. Ltd. took a 52-per-cent interest in the property in 1926 and in 1928 assumed management of the Porter Idaho. An impressive aerial tram-line was built from the mouth of the Marmot River to the forks where it turned to connect with the mine at 5,000 feet elevation for a total length of 5 miles. With development and exploration expenditures, the Premier company assumed a 76-per-cent interest in the Prosperity mine. By 1930 the mines were in full production, but the declining silver price and the heavy development cost involved in opening up small, isolated oreshoots forced the closure of the two properties on April 11, 1931. In 1938 and 1939, siliceous ore stored at the Marmot dock was shipped to the Tacoma smelter at a small profit. In 1940, Porter Idaho Mining Co. Ltd. was liquidated and Premier's interest in the Prosperity was abandoned to the minority owners, Prosperity Mines Syndicate, Limited, on February 4, 1942.

Big Four Silver Mines Limited assumed control of the Prosperity, Porter Idaho, and Silverado groups in 1946, began limited exploration in 1947, and shipped 28 tons of high grade from Prosperity dumps in 1950. In 1952, Cassiar Consolidated Mines Limited assumed control of Big Four property and consolidated the Prosperity, Porter Idaho, Silverado, and Silver Key groups. They partly rehabilitated the "E," "D," and "I" level adits, mapped part of the workings, and did limited diamond drilling. The Prosperity tunnel was partly rehabilitated in 1963 and since then work has been concentrated on rehabilitating "I" level with the intent of extending it and then diamond drilling to explore the presumed downward extension of the upper ore zones. The main Prosperity and Porter Idaho workings are shown on Figures 36 and 37.

Geology

The vein systems of the Prosperity and Porter Idaho mines lie within layered buff, green, and red Hazelton volcanic epiclastics, crystal tuffs, and intercalated thinly laminated siltstones and greywackes. These are unconformably overlain to the east and southwest by contorted siltstone members of the Bowser assemblage and have been intruded by extensions of the Hyder quartz monzonite. These relations are illustrated on Figure 3. Along the margin of the Hyder pluton in the Kate Ryan Creek area, the country rocks have been mechanically deformed, creating a schist zone which increases in width southeast of the creek and includes both Bowser and Hazelton members. The schists are predominantly sericitic phyllonites near the contact, but grade into chloritic and mixed graphitic zones to the east. In the mines area the country rocks have been cut by members of the northwesterly trending hornblende diorite (lamprophyre) dyke swarm crossing Mount Rainey (*see* Fig. 11).

Structure

Minor sedimentary and volcanic features visible in the general mine area indicate the various country rocks form the steep southerly limb of a truncated syncline which plunges to the northeast under Bowser rocks and the Cambria Snowfield. Zones of dislocation in these units are readily visible at the main intrusive contact and are expressed on the open hillside above Kate Ryan Creek as linear gullies and breaks in the slope. Regular widely spaced west-northwesterly trending fractures extend from Portland Canal across the intrusive mass, and appear to splay out in the volcanic epiclastic rocks forming Mount Rainey, in which relatively closely spaced northwesterly, northerly, northeasterly, and east-northeasterly fracture sets are prominent. In turn, the complexity of the pattern decreases to the south of Kate Ryan Creek where the northwest system predominates. Where mapped underground, the various major fractures are probably spaced at about 20 per hundred feet.

Faulting is a common feature on the mountain. Several ages are indicated by pre- and post-dyke relations, and the ore veins are typically bounded by zones of movement. Extensive crushed zones have been encountered underground and they are now represented by the timbered sections such as along 101 drift north in No. 1 tunnel, 304 drift north, and 305 drift south in No. 3 level (Fig. 36). The "I" tunnel, which has not been timbered, partly follows along one of the major fault zones.

Orebodies

The main surface and underground workings of the Prosperity and Porter Idaho mines shown on Figures 36 and 37 illustrate the vein systems and essentially outline the known oreshoots. Production from the surface showings and stopes was generally confined to irregular swells or bulges found along the veins where sulphide mineralization was concentrated. In general the main shoots trend north to northwest and plunge northerly at 40 to 50 degrees. The apparent confinement of the oreshoots to a zone within 500 feet of surface has generally been interpreted in old reports as an indication that secondary enrichment played a key role in the development of the high-grade shoots. Unfortunately, significant amounts of the ore are not available for study and many of the old stopes are relatively inaccessible.

The stopes shown on the longitudinal projection (Fig. 37) produced slightly less than 30,000 tons of ore containing 2,336,482 ounces of silver, 57,679 pounds of copper, 3,002,997 pounds of lead, 16,495 pounds of zinc, and almost 800 ounces of gold. Estimated grades and potential tonnage figures have not been published recently and there is very little information available on extensions of the orebodies.

The veins, with minor exceptions, are narrow, sinuous quartz fissure veins in shear and breccia zones a few inches to several feet wide. They mainly trend northerly to northwesterly and dip moderately to steeply west. Veins first developed on the Porter Idaho claims were easterly to northeasterly trending, but had little continuity. The primary vein minerals recognized are quartz, galena, sphalerite, tetrahedrite (freibergite), minor polybasite, and native silver. The veins have been irregularly fractured and oxide zones have been encountered erratically within the primary material to the maximum explored depth. The veins and related shears are too narrow to show on Figure 36, but their pattern is indicated by the curving drifts.

Ore controls for the Prosperity and Porter Idaho veins are still largely unknown. In general it appears that the oreshoots are steeply plunging sulphide-rich zones apparently restricted to slight vein flexures.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1925–32, 1947, 1948, 1950, 1952, 1955, 1963–68.]

R.A.F.
(Ruth and Francis Group)
(Locality 85)

The original Ruth and Francis Group of four claims located in 1912 is on the north side near the head of Glacier Creek at about elevation 3,300 feet. Between 1912 and 1927 the main vein in the creek bed was developed by two short adits. The property, which includes the Crown-granted Silver Bow No. 4 and Washington claims, was reorganized by I. McLeod, of Stewart, in 1965 and examined under agreement with Canex Aerial Exploration Ltd.

A three-man crew under G. Bird made detailed geochemical and magnetometer surveys. Three diamond-drill holes totalling 285 feet were drilled, but none exceeded 100 feet in length because of broken ground. Access to the property was by helicopter from Stewart, about 7 miles to the southwest.

The country rocks are contorted, variably banded, Bowser siltstones and greywackes cut by a number of small dykes. A vertical fault zone which trends east-northeast has been traced about a mile along the bottom of a steep-sided gully. Mineralization consists of erratic quartz-sulphide replacements and veins localized along the fault. Sulphide minerals included sphalerite, galena, pyrite, chalcopyrite, boulangerite (possibly some jamesonite), and tetrahedrite.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1912, 1914, 1918, 1922, 1926, 1927, 1965; Assessment Reports 343 and 344.]

Red Cliff
(Red Cliff Mining Co. Ltd.)
(Locality 68)

The Red Cliff group, which included the Crown-granted Mount Lyell, Red Cliff, Montrose, Little Pat Fraction, and Waterloo claims, was staked in 1908 at Lydden Creek near the junction of American Creek and the Bear River, about 12 miles north of Stewart. Oxide zones which mark the area of mineralization are clearly visible from the river and directed prospectors to the location and the subsequent naming of the property.

Much of the development of the property was completed by the Red Cliff Mining Co. Ltd. in the years 1908 to 1912 and during that time 1,249 tons of copper ore was shipped via the Portland Canal Short Line Railway to Stewart and then to the smelter. The mine report of 1912 indicated 5,000 tons of ore was broken and 1,249 tons shipped, 1,500 tons left in stopes, and 2,239 tons put in ore dumps. At the time the mine had indicated it would soon ship 100 tons of ore per day and promised approximately 100,000 tons.

Operations ceased at the mine in 1912 and in 1921 the property was sold to R. W. Wood and associates, who did a minor amount of surface work on the claims. In 1939 the property was optioned by the R. W. Wood and W. R. Wilson estates to H. D. Haywood, who explored a surface showing in the Lydden Creek canyon at 1,900 feet elevation. Small ore shipments were made in 1939, 1940, and 1941, to the Prince Rupert sampling plant. In 1946 the Yale Mining Company, Limited, took an examining option on the group to test gold showings on the Montrose claim. In 1950, Yale Lead & Zinc Mines, Limited completed about 2,000 feet of diamond drilling on mineralized zones in the creek section. In 1959 a small amount of surface work was done by Oro Fino Mines Ltd. under option from Yale Lead & Zinc Mines, Limited. Since then the mineral deposits have undergone scrutiny but little serious attention.

Currently the lower tunnel and workings and the old camp area have largely been buried in thick gravel deposits and the upper areas are mainly worked out with little original mineralization left for study.

The development of the deposits and the description of the known mineralization has been treated extensively in Geological Survey of Canada Memoir 32, 1913, and British Columbia Minister of Mines Annual Reports, 1908 and 1909, and will not be repeated here.

The geologic setting of the isolated lenses of copper ore and gold-quartz veins is similar to that of the nearby Independent and Big Casino properties (*see* p. 132). Red and green volcanic breccias and conglomerates of the Hazelton assemblage have been intruded and variously deformed by members of the Portland Canal swarm of granitic dykes and the mineral deposits are found in diffuse fracture zones and minor shears sub-parallel to the northwest-trending dykes.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1908, 1912, 1921, 1939–41, 1946, 1950, 1959.]

Scottie
(Locality 1)

This group of four claims was staked in 1944 by E. G. Langille, of Stewart, and H. Melville, of Premier. The claims lie in a line along the west shore of Summit Lake north of the Morris Summit holdings and extend one claim-length west of the shore. In 1945 the group was optioned to Leta Explorations, Limited, and this company did 1,250 feet of stripping and open-cutting and 2,730 feet of diamond drilling before dropping the option in the autumn of 1946.

Erratic mineralization on the property is within schistose folded siltstones of the Bowser assemblage. Surface weathering in this zone has produced weak gossan-like areas extending from the lakeshore west toward the intrusive contact. The property is described by White (Ann. Rept., 1946) as follows:—

> The showings are very irregular siliceous replacement bodies containing disconnected streaks and large masses of sulphides. The deposits appear unrelated to any definite structural features, but several unmineralized northwesterly and westerly striking shear zones, having a composite and branching structure into which some of the mineralized zones tend to merge and die out, may have some significance. The sulphide mineralization, similar to that on the Morris Summit property, is characterized by abundant fine-grained pyrrhotite, with smaller amounts of pyrite, arsenopyrite, and chalcopyrite, and occasional grains of sphalerite and galena.
>
> Figure 38 is a plan of the property showing the distribution and shapes of the mineralized zones, the diverse nature of shear planes within the composite shear zones, and the distribution of massive sulphide and siliceous bodies. The results of 19 channel samples and five samples of selected mineralization taken from the deposits are given in tabular form in Figure 38. It will be noted that the gold content is very erratic and apparently is not proportional to the total amount of sulphides. Assays of specimens of fairly pure pyrite and of pyrrhotite do not indicate a preference of gold for either mineral. More study will be necessary to determine the mineral associations of the gold.

[Reference: *Minister of Mines, B.C.*, Ann. Rept., 1946, pp. 66–68.]

Silbak Premier
(Silbak Premier Mines Limited)

The property of Silbak Premier Mines aggregates 86 Crown-granted claims and includes an area of about 5.3 square miles on the west slope of Bear River Ridge immediately north of the Alaska-British Columbia border. It is presently reached from Stewart by the Granduc road, a distance of 14 miles. The property represents the consolidation of the former Premier, B.C. Silver, Sebakwe, and Premier Border claim groups and is currently controlled by the Selukwe Mining Company of London.

The Cascade Falls No. 4 (Lot 3590) and Cascade Falls No. 8 (Lot 3591) claims, now known to cover the principal orebodies, were part of an eight-claim group discovered and staked by William Dillworth and the Bunting brothers in June, 1910. They probably were attracted by an oxidized capping which still forms a bare ridge west of the main glory-hole. Claims Cascade Nos. 4 and 8 along with an adjoining group were taken over by O. B. Bush, who organized the Salmon-Bear River Mining Co. in 1910/1911 to develop them. During the next two seasons, short tunnels (Nos. 1 and 2) and surface cuts were put in on low-grade showings, but nothing was done on adjacent quartz-pyrite-native silver mineralization. In 1914, surface work directed by W. J. Rolfe traced the silver showing 800 feet downhill to the west and discovered good grades in gold and silver along this length. Possibly as a result of the 1914 war, work was discontinued until H. R. Plate, representing a New York syndicate, commenced work on the Nos. 1, 2, and 4 tunnels. In 1918, R. K. Neill, of Spokane, bonded the property from Pat Daly and commenced work on the No. 1 tunnel, where Plate had stopped in apparently barren quartz. Within a few rounds Neill exposed ore which showed native and ruby silver, and high-grade ore was then shipped to Tacoma.

In the fall of 1919 the American Smelting and Refining Company acquired a 52-per-cent interest in the property from Neill and his associates, R. W. Wood, A. B. Trites, and W. R. Wilson, of Fernie, for one million dollars cash. Crude ore shipped during 1919 and 1920 from Premier averaged 4.24 ounces gold and 141 ounces silver per ton, and milling began in 1921 at 200 tons per day. This was increased in 1926 to 400 tons and an average 430 tons per day was actually handled.

B.C. Silver Mines Ltd., which held two claim groups adjoining the Premier, was incorporated in 1919, began exploration in 1922, and after considerable exploration, in 1925 intersected ore 1,500 feet east of the Premier ore zone in the 3 level area. Sebakwe and District Mines Ltd., which gained control of the adjacent Bush property in 1926, started a tunnel from the east fork of Cascade Creek (now Cooper Creek) and intersected the mineralized zone at about 1,050 feet. Independent operation of the various mining companies and syndicates continued on the zone until 1936, when the Premier Gold Mining Co. Ltd., B.C. Silver Mines Ltd., and Sebakwe and District Mines Ltd. were consolidated to form Silbak Premier Mines Limited. The latter two groups were controlled by Selukwe Mining Company of London, which, upon merger, received a substantial interest in Silbak Premier Mines.

After many years of continuous profitable operation, low base-metal prices forced Silbak Premier to close in 1953. Development work was resumed in 1955 under the direction of Henry L. Hill and Associates and in 1956 the property was rehabilitated, but fire destroyed the mill and surface buildings at the No. 4 level portal after only a few months' operation. At this time, underground work was concentrated on the 790, 940, and 1060 levels. Low metal prices in 1957 again forced closure of the property except for geological studies.

In 1959, Silbak Premier granted a one-year lease on the upper levels of the mine to Bermah Mines Ltd. The lessees mined the upper part of a small high-grade ore lens found on the south side of the abandoned glory-hole. This oreshoot was discovered after waste rock had sloughed from the pit wall and exposed silver-gold mineralization. At the termination of the one-year lease, Silbak Premier commenced mining the lower part of the high-grade sulphide lens during parts of 1960, 1961, and 1962. Production from this one lens amounted to roughly 2,736 tons of ore containing 18,595 ounces of gold, 394,933 ounces of silver, 16,258 pounds of copper, 215,999 pounds of lead, and 322,118 pounds of zinc. Stimulated by this plum of bonanza ore, the company reviewed the potential of the property, but work at the mine was severely hampered when in November, 1961, the Salmon River section of the Stewart-Premier road was washed out by overflow of water from Summit Lake. The washed-out section of the road, entirely within Alaska, was largely rebuilt by Silbak Premier.

In 1963 work was initiated on a loading-trestle and ore-bin at the open pit and on the excavation of a mill-site at No. 6 level portal. A new camp was also erected at No. 6 level. Loading facilities at the open pit were completed and a new 75-ton mill and cyanide plant constructed and put into operation in 1964 to handle broken ore from the open pit.

In 1965, Bralorne Pioneer Mines Limited undertook a management agreement with Silbak Premier for the operation of the mine.

During construction, mineralization was exposed along the new Granduc road north of the No. 6 portal, consisting of massive, crudely banded pyrite and sphalerite with interstitial galena and scattered microscopic tetrahedrite. The mineralization, which was not completely outlined, appears to consist of a 10- to 12-foot-wide, north-trending, steeply plunging lens confined to schistose volcanic breccia which lies as a small pendant within intrusive hornblende potash feldspar porphyry.

Bralorne Pioneer Mines Limited continued management of the property until November, 1967, and since then the property has been idle. In December, 1969, a new five-year option was signed with The Granby Mining Company Limited.

Production Record

During the period from 1918 to 1953 when continuous operations ceased, Premier Gold Mining Co. Ltd., B.C. Silver Mines Ltd., and the successor company, Silbak Premier Mines Limited, as well as the Premier Border group purchased in 1958, produced about 4,700,000 tons of ore from the deposit with gross earnings about $30,000,000. Of this, approximately $22,000,000 was paid out in dividends. Since 1953, the Silbak Premier Mines Limited glory-hole has produced another 26,000 tons of good ore. The breakdown of the production statistics has been presented in Table 6 and the position of Silbak Premier Mines Limited as a major British Columbia gold-silver-copper-lead-zinc producer has been illustrated on Figures 16 and 17.

TABLE 6.—RECORDED PRODUCTION OF THE PREMIER VEIN SYSTEM

Mine Section for—	Year	Ore Shipped or Treated	Gold	Silver	Copper	Lead	Cadmium	Zinc
			Oz.	Oz.	Lb.	Lb.	Lb.	Lb.
1. B.C. Silver	1924–27	1,103	2,218	88,058	290	10,787	(?)	(?)
2. Premier	1918–37	2,817,327	1,380,906	33,652,118	2,329,630	22,673,075	(?)	3,194,284
3. *Silbak Premier*	*1936–68*	*1,852,845*	*436,038*	*7,292,860*	*1,967,247+*	*36,236,085*	*177,784*	*13,050,522*
4. Premier Border	1950–53	42,995	3,104	86,695	(?)	3,586,976	19,098	4,344,069
Totals	1918–68	4,714,270	1,822,266	41,119,731	4,297,167+	62,506,923	196,882+	20,588,875+

Ore reserve estimates have not been published by the company since 1961 when the available ore was estimated at about 170,000 tons, including broken ore, measured ore, and indicated ore found below 6 level by diamond drilling (*Minister of Mines, B.C.,* Ann. Rept., 1964, p. 22). Grades are difficult to estimate for the old working places as company records of copper, lead, and zinc values are generally incomplete. Of the 400,000 or more feet of diamond-drill core obtained by the company, virtually none has survived the climate and the old drill logs are of rather limited use. The potential of the property lies in a complete geological reappraisal and a new look at the oreshoots and their apparent controls.

Geology

The Silbak Premier deposit is in a cataclastic zone developed within Hazelton green volcanic conglomerates and stripped tuffs (*see* p. 39) which are unconformably overlain by the Bowser (*see* p. 113) and intruded by the Texas Creek pluton (*see* p. 114). Wedging by the pluton produced incipient cataclasis within certain discrete conglomeratic members and subsequent metasomatism related to the same pluton at a later time and higher level produced irregular granitized zones within the cataclasites and associated mylonites. A metasomatic porphyry was developed which became the site for intense local fracturing and later for the accumulation of extensive deposits of quartz, carbonate, sulphides, and native metals. The same general area has also become laced by dyke swarms and cut by numerous faults. On the main geologic map (Figs. 3B and 3C) the metasomatic porphyry called the " Premier Porphyry " has been indicated by the symbols " PSK " and " h " and the major areas of this unit are outlined.

Part of the Silbak Premier property which was mapped at 1 inch equals 100 feet during 1964 is shown on Figure 40, which encompasses the old and new camp areas, the glory-holes, and part of the dyke swarms. Outcrops, all known surface pits and trenches, surface diamond-drill holes, and the main adits as well as parts of the underground workings have been compiled on this map along with the pertinent geologic information. This map can be used as an overlay on the plan of the underground workings compiled on Figure 41.

Outcrops in the mine area are largely along streams, roadcuts, old workings, and steep ridges. Elsewhere the ground is well blanketed by slide alder, low shrubs, and heavy timber. With the exception of the Premier Porphyry, the nature of the parent country rock has been largely preserved in spite of the incipient dynamic metamorphism and metasomatism. The angular nature of the rock particles, as shown in Plate VIIA, combined with microscopic evidence, shows that the main country rocks were originally volcanic conglomerates and other epiclastics as well as banded tuffs. Other fine-grained rocks in the mine area are green to grey mylonites, some of which, because of their distinctive appearance, have in the past been erroneously lumped with the true porphyry. The pseudoporphyritic nature is illustrated in Plate XVIIIB, a microphotograph of a typical mylonite, and in Plate XXIA, which represents a common cataclasite. The true Premier Porphyry is a much more distinctive rock unit and is best displayed in the main glory-hole area where coarse-grained orthoclase crystals and medium hornblendes are conspicuous in a fine-grained, pyritic, green matrix. Plate XXIB is a photograph of a hornblende feldspar-porphyry which is typical of the true Premier Porphyry. In composition it is comparable to nearby border-alteration phases of the Texas Creek granodiorite. The total extent of this metasomatic porphyry has not been found as it was impossible to map all the underground Premier workings and the old mine descriptions, and drill logs class many pseudoporphyry types as Premier Porphyry. In the main glory-hole area the Premier Porphyry can be viewed best along the north rim, where coarsely twinned, orthoclase porphyroblasts up to 1 inch across form as much as 10 per cent of the rock. Small brownish streaks in the greenish rock represent residual altered metasomatic hornblende which shows a distinct lineation. Fine-grained pyrite cubes are prominent and constitute up to 8 per cent of the rock. In thin-section the orthoclase porphyroblasts are generally clean but have a sericite-carbonate alteration along the cleavage and minute fracture planes. The coarsely twinned crystals have enclosed angular feldspars and rounded fine-grained quartz blebs and partially replaced them. The groundmass of the rock has been almost entirely altered to a mixture of sericite, carbonate, epidote, and minor chlorite with scattered pseudomorphs after hornblende and plagioclase. Small, rounded, quartz blebs remain in the groundmass and make up about 5 to 8 per cent of the rock. Many of the more or less unaltered mylonites or cataclasites typically contain round quartz blebs as wells as angular plagioclase crystals similar to those in the Premier Porphyry, indicating that the porphyry has been derived from cataclasites. Elsewhere, coarse feldspar porphyroblasts have been broken and altered past macroscopic recognition, but rounded quartz grains, attesting to the origin of the rock, as well as residual hornblende and orthoclase metacrysts, can be recognized microscopically. Secondary quartz is present in most of the true porphyry as well as other rocks, but it is uneven, patchy, or has micro-comb textures which differentiate it from the primary quartz grains. Sphene is present in the porphyry as well as in most other rocks. Pyrite is present as cubes which appear to replace the porphyroblasts and presumably is a product of the alteration.

Metasomatic processes have nucleated the hornblende and coarse orthoclase crystals and subsequent alteration has blotted out many of the primary and secondary minerals and the textures. Because of this, boundaries of the Premier Porphyry in the highly altered mineralized area can be adequately defined only by detailed microscopic studies.

As indicated on Figure 40, most of the country rocks, including the Premier Porphyry, have undergone alteration. These rocks are mainly medium green to grey weakly foliated cataclasites and mylonites. The true nature of the rocks can be discerned beyond the mineralized area by their macroscopic and microscopic textures. Within the mineralized area the original mineral and rock particles are replaced by fine-grained, more or less equigranular quartz, sericite, carbonate, minor epidote and pyrite, and spotty magnetite. Extensive alteration has masked the original materials, producing a rather uniform, nondescript material termed " greenstone " in the older publications. Hornblende metacrysts which are present in most of the rocks outside the ore zone have been completely replaced in wallrocks adjacent to the quartz and quartz-sulphide veins, where the rocks consist of about 70 per cent quartz, 15 per cent sericite, and up to 25 per cent pyrite. Rarely, original quartz blebs are preserved in these rocks. Much of the pyrite in the altered wallrocks has a pyritohedral form in contrast to simple cubes found in the Premier Porphyry or the ore.

The terms " purple tuff " and " purple porphyry " are commonly used in old descriptions of the Premier mine and surrounding area. Studies of outcrops of these rocks shown on old company maps and tracing of known purple horizons from outside the mine area have shown that no distinctive purple rock units are present locally. At best, lenses of purple mylonite or kakirite may have existed in the mine, but the colours have been changed by alteration past present recognition. These terms, therefore, have been dropped in this report.

Outcrops northeast of the old B.C. Silver Mines Ltd. camp are relatively scarce, but a few small cuts along the road and the trail leading to Cooper Creek show well-developed mylonite marked by purplish to blood-red streaks. These rocks, shown in Plate IXc, have been locally brecciated and the fractures healed with an iron-rich matrix. In thin-section, rock and mineral fragments as well as the usual rounded quartz grains are enclosed in an oxide-rich matrix with ghosts of broken hornblende metacrysts. The plagioclase clasts are typically $An_{32\pm4}$ and the predominant alteration is to quartz, sericite, and epidote. The rock weathers a grey-white with a distinctive pattern of red fractures, whereas, in the B.C. Silver sector tunnels, the same mylonite is green without the obvious fractures. This contrast emphasizes the differences in the appearance of the rocks developed by weathering and the need for carefully co-ordinated surface-underground mapping.

The numerous dykes which cut across the property have already been described in a previous chapter and are shown on Figures 39 and 40. The two swarms most obvious in the mine area are large, branching, quartz diorite or granodiorite members of the Premier swarm and small hornblende diorite or lamprophyre dykes. The Pemier-type dykes are generally 50 feet to 200 feet wide, but the " Main Dyke " which passes through the northern part of the mine workings has an average width of 400 feet. The porphyritic texture of these dykes is distinctive and readily recognized. The smaller lamprophyre dykes are found throughout most of the mine workings with the exception being in the main glory-hole area where the largest orebodies and the most alteration have been found. Like the granitic dykes, these are mostly steep northwesterly trending bodies, but northerly and easterly trending dykes have also been mapped. In hand specimens the lamprophyres are typically dark brown and medium grained with distinctive lath-like plagioclase and hornblende. Chilled dyke margins are narrow, fine grained, and light coloured, and contrast with the wallrocks.

Structure

The over-all structure in the Cascade Creek area is illustrated on Figures 3, 4, 11, and 12 and described in Chapter 4. Steep west-dipping, northerly trending Hazelton assemblage members overlain by Bowser rocks have been transected at an acute angle by a steep, northerly trending cataclastic zone largely confined to certain green volcanic conglomerates and intruded by the Texas Creek pluton. An elongate steep, west-dipping, northerly trending metasomatic zone containing the Premier Porphyry lies adjacent to the irregular intrusive contact and appears to be the main host of the Premier deposits. The old picture of a shallow, west-dipping volcanic sequence with interlayered " Porphyry " has been completely discarded on the basis of the present data.

Incipient foliation developed in most of the country rocks in the Premier area has erroneously been taken in the past as lithologic layering or bedding. The dominant foliation on the property trends northerly and dips 35 degrees to 45 degrees west. In detail, however, the trends vary from northwest to northeast and dips increase southerly to near vertical. Rather than intersecting shears, the variations appear to represent rolling flexures reflecting an apparent sinuous contact between the Premier Porphyry and the enveloping wallrocks.

In the mine area, joint sets are well developed in most of the rocks. The dominant planes have been plotted on Figure 40 and it appears that the patterns vary from one rock type to another and from dyke to dyke. The Premier Porphyry and ore have a distinctive vertical joint set striking north, whereas the " greenstones " are typified by a set dipping 45 degrees west and striking north. Dykes belonging to the same petrologic group contain distinctive joint sets. Joint patterns appear to be useful in the Premier mine area and the Stewart area in general in defining altered rock groupings.

The major and dominant fracture sets are illustrated by the dyke swarms and are clearly visible on aerial photographs. The northwesterly trend followed by most of the dyke swarms in the general area is prominent on the Premier property as well. A less conspicuous north 70 degree east trend, prominent at Premier, appears to be a major ore control. The intersecting pattern has commonly been attributed to simple regional shear related to " Coast Range " intrusion, but the problem of the origin of the joint pattern is clearly more complex, involving periodic deformation of an inhomogeneous mass of rocks.

Orebodies

With the exception of the high-grade lens mined from 1959 to 1967 in the glory-hole, the writer has seen only sub-ore underground, a few of the remaining ore pillars, and ore samples at the Premier office. Descriptions of the ore at various stages of mine development can be found in old reports, and in the following paragraphs only an over-all treatment is given.

To detail this, the longitudinal projection showing main stope areas and complementary development plan has been compiled on Figure 41. In addition, the major individual oreshoots have been plotted on Figure 39, to show their distribution with regard to the local geology. Mine cross-sections have been included as well on Figures 49, 50, and 51 to complement the long section.

Mineralization in the Premier system consisted of an extensive quartz vein-replacement zone enclosing or partially enclosing a considerable number of sulphide-rich oreshoots from which the main gold-silver production was derived. Quartz represents the main gangue material, which also includes calcite, barite, minor adularia, and country rock. The oreshoots contain on an average 20 per cent sulphides, but in the lenses of bonanza ore this amounted to as much as 80 per cent, with the rest altered wallrock and quartz-calcite veins. Pyrite was the most abundant sulphide and occurs in most of the sub-ore gangue and surrounding wallrock as well. The other major sulphides in order of abundance were sphalerite, galena, chalcopyrite, and pyrrhotite, with small amounts of argentite, tetrahedrite (and freibergite), polybasite, pyrargyrite, stephanite, as well as electrum, native gold, native silver, and rare mercury.

Details of the mineralogy of the individual shoots are relatively unknown. The mineral stephanite was reported by Dolmage (1920) as being confined to a few small veins less than a foot wide in the surface ore first mined in the present glory-hole area. He noted a three-fold division of this ore into

(1) stephanite-native silver ore (approximately 3,000 ounces silver per ton);
(2) " black sulphide ore " (500 to 1,000 ounces silver per ton); and
(3) lower-grade siliceous ore.

Since then no other reports of stephanite have been recorded. Electrum has been noted and identified in high-grade and bonanza oreshoots between the surface and 3 level and rarely below. Native gold apparently has a much more extensive distribution because of its common association with pyrite, but the coarse veinlets found in the bonanza-type shoots had a very limited range. Native silver appears to have been identified in most of the ore, but none was seen in core from below 6 level. Mercury or amalgam was found only in surface bonanza or black sulphide ores. Sphalerite has been found universally in the ores, along with galena, chalcopyrite, and tetrahedrite, from surface to the 8 level area. Within the oreshoots, however, it does display colour variations and also shows an apparent over-all colour change from surface to 8 level. This appears to be from black-brown at the surface or oreshoot top to amber at depth, suggesting a variable iron content within each shoot as well as over the known vertical range of the deposit. Argentite, the most prominent silver mineral at the mine, shows a general decrease in abundance with depth.

An analysis of the available stope production records shows an apparent decrease in silver at depth. To illustrate this change, the gold-silver ratios for various stopes in the main Premier section are plotted in their respective areas on the longitudinal section on Figure 41. The ratios clearly show an apparent planar semicircular zonation with silver content decreasing from a high of 112:1, just north of the 110 sub-level projection, to lower values to the west, east, and to depth, where the value 6:1 (Ag:Au) predominates.

Another indication of the zoning both along strike and in depth is indicated by the following statistical table where ore production from the four main mine zones has been summarized:—

TABLE 7.—SILVER-GOLD RATIOS, PREMIER VEIN SYSTEM

Working Area	Silver/Gold Ratio	Copper	Lead	Zinc
		Per Cent	Per Cent	Per Cent
B.C. Silver	40:1	0.01[1]	0.50[1]	0.01[2]
Premier	24.5:1	0.04	0.41	0.56
Silbak Premier	17:1	0.054	0.98	0.35
Premier Border	28:1	0.01[2]	4.20	5.00

[1] Nearly equal to. [2] Less than.

Various studies of the ore have not revealed any significant or anomalous features and a normal paragenetic sequence was determined by mineralographic methods by Burton (1926) and White (1939). Supergene enrichment was thought by the early workers to have been the main process by which the bonanza and high-grade silver shoots were formed, but studies by White (1939) and in the present work indicate that the bulk of the silver minerals are primary. Secondary argentite, wire silver, and minute gold particles are present in vugs in the " black sulphide " ore as well as in the late vuggy quartz-tetrahedrite-polybasite veins which cut the main sulphide lenses, but they are in minor amounts.

In the few orebodies that can be seen at the mine, the sulphide banding first mentioned by Burton (op. cit., p. 589) is prominent, and is shown in Plate XXA which illustrates pyritic bonanza ore with altered wallrock cut by sulphides and electrum. " Typical " examples of vein electrum found in wallrock and vein gold in argentite from banded ore are shown in Plate XXIIA to illustrate the nature of these minerals which were once presumed to be secondary. In the lower grade zones the sulphides are found as bunches or lenses within quartz gangue and as crude disseminations within alteration zones.

The over-all nature of the ore zone is an elongate, irregular, quartz-carbonate-pyrite vein-replacement network localized along a system of complex intersecting shear fractures. This system has a known length of about 5,500 feet and has its maximum over-all width in the southerly Premier sector, which approaches 600 feet. Figures 42 to 48 are level plans which may be regarded as horizontal sections across the mineral deposit and the shapes of the drifts illustrate the complex intersecting nature of the individual shears involved in the system. Within this complex zone the individual oreshoots are found as isolated or overlapping *en échelon* flattened, pipe-like lenses. These have been illustrated on Figure 39 to show approximate relationships and plunge directions which are uniformly steep to the west. In more detail the individual lenses have a somewhat comb-like appearance, with the " back " of the comb marking the parallel to the azimuth of the plunge length and the teeth forming the width. The comb backs have an azimuth of about 90 degrees with variations up to 130 degrees and the teeth are generally oriented in the 70-degree position, which together mark the two prime fracture directions in the host rocks. This can be readily seen in the " ladder-vein " section which is still easily accessible.

Alteration

In the mine area, variable chloritic alteration and silicification affect most of the country rocks. In the mineral zone the wallrocks — both Premier Porphyry and " greenstone "—have been extensively replaced by quartz, sericite, and pyrite, producing an irregular alteration halo. The massive quartz-pyrite fissure-replacement system enclosing the oreshoots lies within the halo and can be examined both underground and on the surface.

Because many other similar pyritic quartz zones have been localized in similar rocks in the Cascade Creek section (*see* Fig. 39), it was decided to test the minor element content of the barren quartz which enclosed known high-grade shoots at depth. The elements chosen for this were Na, Mg, Ca, Ba, and K, partly because of their geochemical nature and largely because the analyses are relatively simple.

A north-south traverse was made across the wallrocks and barren quartz vein exposed at the old glory-hole where extensive high-grade ore was developed about 60 feet below the sample location. Channel samples weighing 8 to 10 pounds were taken at 10-foot intervals and analysed by the British Columbia Department of Mines and Petroleum Resources Analytical and Assay Branch in Victoria. The results are plotted on Figures 23 and 24. With respect to the wallrock, the quartz vein shows a general lower Na, K, and Mg content and somewhat higher Ba and K. Nodes and troughs on both graphs, especially the Ca and K values, indicate vein zoning which corresponds at depth to two closely spaced sulphide lenses separated from the wallrocks and each other by essentially barren quartz. These results appear to indicate that downdip ore grade material can be detected at a depth of at least 60 feet. The broad Ba anomaly is suggestive, but could not be relied on alone. The Na and Mg are not as predictable, but, combined with Ca and K, produce useful anomalies. The same procedure was followed for various rock, vein, and ore members within the main ore zone with the thought that sub-surface exploration could be aided by simple minor element analyses. Again Ba proved the presence of the vein system but little else, whereas the localization of near-by ore of high grade was indicated by Ca, K, Na, Mg, but the three-dimensional anomalies proved complicated in that the search co-ordinate was not indicated. This study indicates the possibilities of carefully controlled geochemical exploration for this type of deposit.

Ore Search

The location of the " lessee's lens " in 1959 in an area of the mine abandoned in 1936 indicates the opportunity for more ore in the immediate mine system. Such lenses are small, steeply plunging pods which require close-spaced drilling and careful attention to the smallest geological details. The area immediately south of the glory-hole still has a high potential for such shoots and has yet to be covered by detailed exploration.

The larger orebodies have been shown to have certain controls and are localized within the system by distinct structural features. The country rock has not been thoroughly explored south of the main workings except by scattered surface pits and a detailed geological study of that area which has high potential seems pertinent. Apparently barren quartz veins can be useful as geochemical guides to ore and the full potential of the geochemical approach has not been tested. The small oreshoot shown north of Cooper Creek on Figure 39 was located by extensive underground development, but its up-dip barren zone, although well explored by the conventional methods (*see* Fig. 52), did not suggest significant ore at depth. Other such zones have been outlined on Figure 39 and indicate the extensive exploration potential of the Cascade Creek cataclasite zone.

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Silverado
(Cassiar Consolidated Mines Limited)
(Locality 101)

The Silverado property, presently incorporated into a 99-claim group which also includes the Porter Idaho and Prosperity mines, is southeast of Stewart on the slope of Mount Rainey. The original Rainier Fraction (Lot 4511) claim located in 1904 was first part of the Hector Group owned by Chambers, Deaville & Co., who initiated development of the property with several open cuts and some stripping. In 1920 the Silverado group of five claims was relocated on the Hector ground by J. W. Stewart and John Haahti, of Stewart, who traced a vein at 3,500 feet elevation for 300 to 400 feet and sampled pyritic quartz-tetrahedrite mineralization which assayed 360 ounces of silver per ton and $10 gold. The Silverado Mining Company was formed in 1921 and controlled by J. J. Coughlan, of Vancouver. During the year, 5 miles of trail was built from the river to the upper camp at 3,850 feet elevation and a camp and aerial-tram terminal constructed at 1,700 feet elevation. A two-bucket single-cable tramline 1 mile long was built to the upper camp and 7 tons of rich silver ore was transported to the beach. By the end of 1927, several hundreds of feet of drifting and trenching had been completed on the series of flat-lying silver-quartz veins on the Silverado ground without much success, but a new set of steep northwest-trending veins outcropping above 3,500 feet elevation at the toe of Silverado Glacier was then discovered in sub-parallel shears (Fig. 53), which gave some encouragement to the developers. In 1928 the control of the 19 Crown-granted claims was secured by the Premier Gold Mining Company and development of the new vein system was commenced by the newly organized Silverado Consolidated Mines, Ltd. Most of the underground development, which included about 4,000 feet of crosscutting, drifting, and raising on veins, was completed in 1929 and in June, 1930, the Premier Gold Mining Co. Ltd. suspended operations on the property, presumably as a result of the falling price of silver. In 1932, John Haahti, of Stewart, leased the property and mined about 134 tons from the upper tunnel at 3,688 feet and the veins at 3,750 feet just below the glacier toe. This was mainly massive galena with ruby silver and the ore was hand-cobbed at the lower tunnel, sacked, and taken by pack horse to Stewart. The lower workings on the canyon vein at 1,860 feet elevation on the Rainier Fraction were explored in 1939 by John Stewart, but no ore was shipped.

The Big Four Silver Mines Limited took over control of the Silverado, Prosperity, and Porter Idaho properties, which included about 30 Crown-granted and fractional claims and attempted to reopen the Silverado in 1946. A Pioneer-drive tramline 4,000 feet long was erected at 800 feet elevation to connect to the lower mine adit, No. 3 tunnel, at 2,955 feet elevation. A new bunkhouse for 16 men was built and underground Zero-level was advanced 55 feet. In 1947 the company continued Zero-level a few feet, started a raise, and diamond drilled the No. 2 shear. Control of Big Four was taken over by Cassiar Consolidated Mines Limited in 1952 and with the exception of occasional sampling, trail-cutting, and other visits the property has remained inactive.

Production from the Silverado veins is listed at 154 tons from which a few ounces of gold, 31,137 ounces of silver, and some copper, lead, and zinc have been recovered. Most of this was from pits, trenches, and the development headings on vein mineralization, and only one very small stope was attempted (*see* Fig. 53).

Work by the Premier and later companies proceeded on the surmise that the Silverado shear system could be traced southeasterly to join the Prosperity and Porter Idaho systems found on the Marmot River slope of Mount Rainey, a distance of about 1 mile. Unfortunately, most of the intervening ground is covered by ice and perpetual snow and the high elevation leaves only a very short season for work.

Geology

Country rocks in the Silverado area are crudely bedded, green Hazelton volcanic breccias, conglomerates, sandstones, crystal tuffs, and equivalent quartz-chlorite schists, mylonites, and cataclasites. The epiclastic sequence can be readily seen on the open slopes beneath the ice cap and above the dense vegetation of the lower slopes. The rocks form a minor re-entrant along the contact of the Hyder quartz monzonite which at this locality shows a transgressive compositional change from biotite quartz monzonite in the Barney Gulch section southward through biotite granodiorite at Portland Creek to hornblende granodiorite opposite Eagle Point. The hornblende-rich phase is best displayed in the Marmot River section as a border manifestation of the pluton. In the Silverado Creek contact area the dominantly green country rocks have been indurated and have a mottled, purplish cast which is accentuated in irregular, chlorite schist zones. Toward Barney Gulch these thin schist lenses assume a more recognizable mylonitic appearance. Major northwesterly and northerly trending chlorite schist zones, which post-date local cataclasis, are shown on Figure 3.

All the rocks are cut by the northwest-trending hornblende diorite (lamprophyre) dyke swarms as well as other granitic dykes which include feldspar syenite porphyry near the south end of the ridge at 4,000 feet elevation and several feldspar granodiorite porphyry dykes exposed in gullies below the main mine area.

Structure

Layering in the predominantly epiclastic members indicates the country rocks along the west side of Mount Rainey are lensoidal, overlapping units of variable dimensions with inch scale and more widely spaced planes of larger bedding and stratification. Gradation and transition from breccia to conglomerate to sandstone within individual lenses is visible, and thinly laminated crystal tuffs occur throughout the thick section between major units.

The over-all structure on the west slope first suggests a simple, gently east-dipping, northwest-trending homoclinal sequence, but mapping continued around the ridge to the Kate Ryan Creek side shows a major flexure which is essentially synclinal with a steep, southerly limb. To the east at Mount Magee these Hazelton members are unconformably capped by the contorted Bowser rocks.

Apart from the main Silverado Creek fault and minor shear zones, the rocks are well jointed and the rather gently dipping bedding planes predominate. The numerous steep gullies, chimneys, and chutes on the west slope are developed along an easterly fracture set with irregular spacing. The numerous steep cliffs are likewise developed along a northerly fracture system best illustrated on the heights overlooking Stewart.

At the upper mine area shown on Figure 53, the minor faults, lamprophyre dykes, and northwest intersecting shears in which the main vein mineralization occurs have been sketched. These zones appear to tail out under the ice upslope and westerly they are truncated by the main shear zone.

Mineralization

Early development on the Silverado was initiated on the lower slopes at elevation 1,800 feet on the Rainier claim in the Silverado canyon area where at least four high-grade quartz-sulphide veins lie in the bedding and the shears. Minerals found include quartz, pyrite, galena, sphalerite, chalcopyrite, tetrahedrite, and erratic ruby silver, and some native silver. Later work in the nearby canyon at an elevation of 1,750 feet exposed a zone of sub-parallel quartz veins 3 to 6 inches wide in schist which contained small amounts of scheelite.

The main veins developed by the Premier Gold Mining Co. Ltd. and later leasors were quartz fissure veins confined to narrow shears. These narrow quartz lenses contained high-grade silver ore, which constituted the main production. Minerals in these veins included pyrite, massive galena and sphalerite, scattered chalcopyrite, tetrahedrite, pyrargyrite, and native silver. Country rocks in this general area have been variably silicified, weakly pyritized, and epidotized.

In 1968, several of the small, flat-lying, quartz-tetrahedrite veins located south of the main workings were sampled and high silver values reported, but their extent is not known.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1904, 1920–30, 1932, 1939, 1946–48, 1952, 1955, 1964–68; *Dept. of Mines, B.C.* Bull. 10, 1943, p. 56; *Geol. Surv., Canada,* Mem. 175, 1935.]

Silver Coin
(Locality 24)

Eight Crown-granted claims, including the Silver Coin (Lot 2837) held by the E. A. Noble estate, were examined under agreement with Granduc Mines, Limited, in 1967. The claims enclose Noname Lake on Big Missouri Ridge and are reached by the old mine road repaired in 1967 by the British Columbia Department of Highways. Work included reopening of old trenches and resampling scattered sulphide mineralization erratically localized in generally barren north-trending quartz veins which abound in the area.

The country rocks are altered, deformed equivalents of the Hazelton epiclastic rocks, generally conglomerates. These are partially recognizable in in spite of intense silicification, induration, and variable pyritization which has affected rocks in this area.

[Reference: *Minister of Mines, B.C.,* Ann. Rept., 1967.]

Silver Crown
(Locality 30)

The Silver Crown group consists of 19 mineral claims held by record by D. Collison, of Alice Arm. The group lies on the upper west slope of Bear River Ridge between Long and Divide Lakes between elevations 4,500 feet and 5,500 feet. An old claim group called the Silver Cliff, including the Crown-granted Silver Cliff claim, was originally located in this section near the north end of Divide Lake. A road and trail which formerly gave access to this area from Premier has been partially washed out. Work performed during 1965 by the owner consisted of surface work and sampling. In 1968, Mr. Collison put in 33 short trenches on the veins which have an average width of 2 feet and a maximum length of 600 feet.

The country rocks include well-banded siltstones and greywackes as well as minor intercalated limestone and chert pebble conglomerates. Coarse-grained, thick-bedded greywacke probably comprises 50 per cent of the country rock on the property and is part of the predominantly greywacke unit which has been traced northwestward across Bear River Ridge past Divide Lake and along the east slope of Mount Dillworth.

A number of veins from 6 inches up to 7 feet wide found along a 1,500-foot zone trend northerly to northwesterly and fill extensive fractures in Middle Jurassic Bowser siltstones and greywackes. The fractures and veins are concentrated along the axial plane of a northwesterly plunging anticlinal fold. The sediments overlie Hazelton volcanic epiclastics, which locally form the crest of Bear River Ridge. The country rocks and veins have been intruded by northwesterly trending lamprophyre dykes.

The veins are simple quartz breccia and carbonate lenses emplaced along fractures in the folded, layered country rocks. Sulphide minerals recognized include medium- to coarse-grained pyrite, galena, and sphalerite and fine-grained chalcopyrite. Gangue minerals include granular white to pinkish quartz, calcite, and barite. Deformed, slightly graphitic siltstone fragments commonly comprise up to 50 per cent of the veins, whereas the sulphides occur as irregular lenses or pods and appear to form less than 2 per cent of the veins. One selected sample, much better than average, gave the following results: Gold, 0.01 ounce; silver, 6.0 ounces; copper, 0.02 per cent; lead, 13.37 per cent; zinc, 43.9 per cent; and cadmium, 0.59 per cent, over a width of about 3 feet.

Several periods of vein mineralization are visible. The quartz-breccia sulphide material injected along fractures has been cut by at least one younger carbonate sulphide phase, which in turn has been fractured and the cavities coated with crystalline quartz and cubic pyrite.

Because of the clean, coarse habit of the sulphides in these veins, the deposit was selected for mineral trace element analysis. Part of the results are shown on Figures 20, 21, and 22. The nature of the mineralization and the trace element values suggests a similarity between the Silver Crown and the Monitor, which represents late-stage fracture-filling.

[Reference: *Minister of Mines, B.C.,* Ann. Rept., 1965.]

Silver Tip
(Locality 14)

The Silver Tip group of six Crown-granted claims, including the May P.J., Bella Coola, Silver Leaf, Ladybird No. 2, September, and Good Hope, is on the south slope of Mount Dillworth near the head of Silver Creek. The area is alpine and outcrop is fairly good. Vein mineralization was located in 1915 and the first development work consisting of three open cuts and a lower adit was recorded in 1917. The claim group is north of Big Missouri and was surrounded clockwise by the old Silver Crest, F. & M., Unicorn, Montana, and Lion claim groups. Development by the Silver Tip Mining

Development Co. Ltd. included two long adits and several short adits totalling about 1,400 feet and numerous open cuts. After a long period of inactivity, Silver Tip Gold Mines, Limited, initiated work in 1946 on five Crown-granted claims, including the Silver Leaf, Ladybird No. 2, Good Hope, and May P.J. This development consisted of crosscutting northerly from the long adit on Ladybird No. 2 to intersect known surface mineralization. This crosscut was continued in 1947 and at 295 feet from the main drift a 2-foot-wide quartz-sulphide zone was intersected, which seemed to compare with the surface Butte zone. About one-half mile south of this adit in the bottom of Silver Creek another adit was continued to intersect two well-mineralized surface veins. In 1948 the upper adit and crosscut were extended 100 feet and the lower adit showings were explored by more surface trenching. In 1949, sacks of ore from a vein on the May P.J. claim (lower adit) were packed out by horse and shipped to the smelter. In 1950 the May P.J. adit was extended east 190 feet and intersected a cross-vein. A tractor road was built to the camp from Big Missouri and 16 tons of ore was shipped from the veins. In 1952, stoping was started and about 200 tons of ore stored in ore-bins. In the following year, 215 feet of drifting was done on the Blind and May P.J. vein, 139 feet in 1954, and about 100 feet in 1956. The property has been inactive since then and the various adits have caved and are now water-filled. Snow has caved the various camp structures and the road has virtually disappeared.

The above work has been documented here to indicate the amount of development carried out on this type of property which is more or less typical of the complex, erratic, vein mineralization found in the main dyke-swarm environment. Over the 38-year period of somewhat erratic exploration, only 29 tons of ore containing a few ounces of gold, 2,208 ounces silver, and less than 10 tons of combined lead and zinc were produced.

The geology of the area is fairly simple, but fragmented. The country rocks include steep, north-trending Hazelton epiclastics overlain by undulating thin-bedded Bowser siltstones, calcarenites, and greywackes which wedge out southward down the slope of Mount Dillworth, where erosion has removed these rocks. This unconformable sequence has been extensively cut by the hundreds of granitic dykes belonging to the Portland Canal dyke swarm and by later lamprophyre dykes. An indication of the crosscutting relationship of these dykes and the shattering found in the sedimentary country rocks is illustrated in Plate XVIIB.

Mineralization consists of irregular, lenticular, quartz-carbonate sulphide fissure veins of several generations, the earliest of which are cut by granite dykes, and the latest which fill post-lamprophyre faults. The veins are therefore found along several principal directions of which westerly, northeasterly, and northerly trends predominate. Breccia-type fissure veins in which quartz, calcite, or sulphides cement the country rock fragments predominate. Sulphide minerals include pyrite, galena, chalcopyrite, amber to brown sphalerite, and tetrahedrite. Native silver is ubiquitous in the oxidized surface zones and visible in dump specimens. The work done indicates that the oreshoots are erratic within irregular, narrow veins which have limited continuity.

[References: *Minister of Mines, B.C.*, Ann. Repts., *1915, 1917, 1919, 1922,* 1948–54, 1956.]

Spider Group
(Locality 31)

The Spider property, like many in the Stewart area, has changed hands many times and has undergone erratic development. The claims included the Crown-granted Lois and Spider Nos. 1, 2, and 3 at the northeast end of Long Lake in an open alpine area easily reached by aircraft or on foot from the end of the Big Missouri road.

The property was originally located in 1918, optioned to a Belgian syndicate in 1920, and to B.C. Bonanza Mines Ltd., who controlled the group until 1934. Since then it has been owned or leased by a large number of individuals who have attempted to ship high-grade ore from the veins. A good plan of the veins, workings, and general geology can be found in the 1936 Report of the Minister of Mines (B.C.), page B 29. The surface trenches and part of the underground workings on No. 2 vein are still accessible.

Mineralization consists of several sub-parallel quartz-breccia fissure veins emplaced in a small stock of fractured, altered, augite diorite porphyry. The pluton is partly sheathed in Bowser siltstones which have also been cut by the quartz veins. The main veins trend northwesterly and are intersected by other north-northeast quartz veins. Vuggy quartz, calcite, and country rock fragments constitute the gangue, and the main ore minerals include galena, light-brown to amber sphalerite, pyrite, chalcopyrite, and tetrahedrite. Free gold was found in the sulphide lenses encrusting small cavities and Hanson (1935), reported native silver as well.

Ore shipped was hand-cobbed and high grade, as indicated by the production statistics in Table 2.

Although the veins are localized in augite porphyry, the mineralization is not comparable to that associated with veins in the Bitter Creek pluton, which contain prominent antimony minerals.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1919, 1920, 1922, 1923–25, 1927, 1934–36, 1938.]

Troy
(Locality 5)

The property is at the southeast corner of the present Summit Lake and now consists of one located claim held by H. Swan, of Stewart. The Granduc road cuts through the claim and clearly exposes the main mineralization, which comprises a quartz-sulphide fissure vein about 3 feet wide by 70 feet long in red and green lower Bowser sandstones and conglomerates. The veins on the claim are steep and lenticular. They trend northwesterly and enclose erratic silver-bearing galena, sphalerite, tetrahedrite, chalcopyrite, and pyrite. For indications of early mineral values, *see* the British Columbia Minister of Mines Annual Report, 1934, pages 28, 29.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1930, 1934, 1936.]

Virginia K. Group
(Excelsior Prospecting Syndicate, Limited)
(Locality 52)

This property, comprising the Virginia K., Virginia K. Extension, and Star Crown-granted claims and fractions is near the head of American Creek on the ridge east of Kimball Lake. The original Virginia K. claims were located in 1929 and the group of 15 claims and fractions shown on Figure 15c was surveyed in 1940. A number of small vein deposits have been developed on the property between the creek bottom at about 1,600 feet and the ridge at 4,500 feet elevation. Country rocks are mainly folded Bowser sediments which overlie Hazelton volcanic rocks and sediments.

The mineralization primarily consists of quartz-calcite veins and stringers which occur as fissure veins in minor shears and fractures and along bedding fractures. The various veins have been explored by trenches and short adits located on the Star No. 2 Fraction, Virginia K. Fraction, and the Virginia K. No. 5 claims. The continuity of this apparent northeasterly zone has been tested by scattered trenches but not proved. Sulphide minerals in the veins include pyrite, galena, sphalerite, minor chalcopyrite, and tetrahedrite. Native gold and silver, as well as rare electrum, have been reported from the quartz-calcite stringers.

Since 1938 the property has been largely inactive with minor exploration and hand-mining of high-grade sections.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1929–32, 1935, 1938.]

Wolf Group
(St. Eugene)
(Locality 4)

Ten located claims were staked by Granduc Mines, Limited, in May, 1963, across the south end of Summit Lake. No significant mineralization was reported and the claims have been forfeited. The St. Eugene group (Locality 4), which included the St. Eugene and Grey Copper Crown-granted claims on the east slope of August Mountain above Summit Lake, was originally located in 1923. Several erratically mineralized gold-quartz veins in altered Hazelton rocks have been periodically examined and sampled. Properties located adjacent to the St. Eugene were the Sunrise, Vamp, Josephine, and Hollywood, none of which developed significant mineralization.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1923–27.]

Woodbine
(Locality 28)

The Woodbine Gold Mining Co. Ltd. was incorporated in 1930 to acquire and develop a group of seven Crown-granted claims and fractions on the west side of Cascade Creek about 1 mile northwest of the Premier mine. The implication at the time was that a mineralized zone referred to as the "Premier northwest mineral-zone" extended on to the Woodbine claims. A number of erratic areas of quartz-pyrite with scattered gold-silver values have been located in this section, but no obvious extension can be made on geological grounds. The area of silicification and pyritization located on the adjacent Woodbine, Forks, Vancouver No. 1, Woodbine No. 2 Fraction, and Northern Light No. 5 claims had been previously explored and developed by the Premier Extension Gold Mining Co. Ltd., organized in 1923 to pursue the zone-extension concept. The known surface and underground development has been compiled on Figure 54 to facilitate description. The original Premier Extension company grouped 16 claims west of the Premier boundary for exploration purposes. The Premier Gold Mining Co. Ltd. had sampled this property originally and the old records indicate low values. The main adit level at 1,000 feet elevation was developed by the Premier Extension company, with later work on the ground performed by the Woodbine group. Drill-hole records from the latter venture were not reported and the venture collapsed in 1930 nominally because of pumping problems. Tunnel No. 1 was driven by the Premier Extension group in 1929, but the results were apparently disappointing and the operation ceased. The last known activity on the property was in 1936 by the Premier Extension Gold Mining Co. Ltd., but little work was done and the sector has been inactive since that date.

Mineralization is sparse, but scattered small pods of coarse galena and sphalerite are visible in irregular quartz stringers and quartz patches. The country rocks are variably schistose, pyritic, silicified equivalents of the Cascade Creek cataclasite zone which have been irregularly metasomatized and cut by the Premier dyke swarm. In the adit area the light-green country rocks have been shattered irregularly, but one strong northwest set is best developed. The main quartz veins trend north to north-northeast and dip 50 degrees to 60 degrees west. The setting is more comparable to the Indian mine situation than to the Premier vein system.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1927–1930, 1936.]

Yellowstone Group
(Locality 8)

The claims, including the Crown-granted Yellowstone (Lot 4031), were among the first staked in the Salmon Glacier area in 1911 and were located above the Salmon Glacier west of the Forty Nine group. The main showings were later found to be on Forty Nine ground, but another steep, east-northeasterly trending quartz vein was located and drifted on in 1923, disclosing pyrite, galena, and minor ruby silver as lenses in a 20-foot section of vein. Gold-silver values were erratic and low and work was discontinued on the property. The area is now open and easily accessible by the Granduc road which cuts across these properties located along the Portland Canal dyke swarm.

[References: *Minister of Mines, B.C.,* Ann. Repts., 1911, 1914, 1917–20, 1923.]

APPENDIX I

HAZELTON ASSEMBLAGE IN THE SALMON RIVER DISTRICT

LITHOLOGY

The rocks of the Salmon Valley assigned here to the Hazelton assemblage are continuous across the Alaska-British Columbia border. Schofield and Hanson (1922, pp. 11, 12) described these formations 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 andesitic matrix. They vary in size from minute particles to pieces a foot or more across. In thin-section they show phenocrysts of a plagioclase (of intermediate composition), 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.

McConnell's (1913, pp. 14–16) description is:—

> The rocks of the Bear River formation have a wide range and include porphyrites of various kinds, mostly of hyp-abyssal origin, volcanic breccias and agglomerates, tuffs, and occasional argillaceous bands. Small areas in various parts of the district have been silicified and altered into a cherty condition.
>
> A marked feature of the formation is the general absence, except in the case of the argillite bands, not only of sharp, but in most cases even of observable contacts between the massive and fragmental members of the group. The massive porphyrites often show flow structure in thin-sections, but no continuous sheets could be traced out. They appear to occur as a rule in irregular areas and either pass gradually into the fragmentals, or the contacts, if originally sharp, have been obscured by the granitic invasion of the Coast Range batholith and bordering stocks and the subsequent mountain-making movements.
>
> MASSIVE PORPHYRITES PREDOMINATE IN THE SOUTHERN PORTION OF BEAVER RIVER RIDGE. Going north and east the proportion of fragmentals increases and the mountains bordering upper Bear River and extending southward on both sides of the watershed are formed mostly of fragmentals of varying coarseness.
>
> The porphyrites are dark-greyish, medium-grained, comparatively deep-seated rocks. They usually occur in a massive condition, but in places have been sheared into a coarse schist. The porphyritic texture is not prominent as a rule in hand specimens, but in places, especially along the upper slopes of Bear River Ridge, a rock filled with conspicuous white feldspar phenocrysts alternates with the ordinary variety. A red variety due to a development of secondary red oxide of iron is conspicuous in a few areas. . . .
>
> The fragmentals occur as tuffs and volcanic breccis and agglomerates. The tuffs are made up largely of feldspar crystals often broken, quartz grains, and

minute rock fragments lying in a dark, fine-grained mat, and are often difficult to distinguish in the field from the massive porphyrites. The breccias exhibit considerable diversity in character and probably originated in different ways. They consist mainly of angular porphyrite fragments, accompanied in places by slate, limestone, and rarely granite. The fragments vary in size from minute grains up to masses several feet across, but are often very uniform in size over wide areas. The matrix in the specimens examined is altered and difficult to determine, but appears to be massive in some instances, ALTHOUGH MOSTLY CLASTIC, and OCCASIONALLY the rock HAS THE APPEARANCE OF HAVING BEEN CRUSHED IN PLACE. The fragments are usually pressed closely together, but in some areas are widely separated and seem to have been thrown up and fallen back into a still liquid matrix.

. . . The rocks of the Bear River formation usually occur in a massive condition, but in places, especially along American Creek and IN THE SALMON RIVER VALLEY, HAVE YIELDED TO CRUSHING, AND A STRONG SCHISTOSITY approximately paralleling the eastern edge of the Coast Range batholith and dipping toward it, HAS DEVELOPED.

The fragmental varieties consist largely of angular greenstone fragments very similar in composition to the massive porphyrites, enclosed in a massive or pyroclastic matrix. They are seldom distinctly bedded or banded and are often remarkably uniform in composition through sections many hundreds of feet in thickness.

Meanwhile, just south of the border, Westgate (1921, pp. 122–124) described the greenstones 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.

Somewhat later, Buddington (1929, pp. 17–19) summarized his observations:—

The greenstone, tuff, and volcanic breccia of the Alaskan side along the International Boundary east of the Salmon River are continuous with similar rocks of the so-called Bear River formation on the Canadian side. . . .

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.

From these four summaries it could be generally concluded that the Hazelton Group formations present in the Salmon Valley district comprise a sequence of fragmental rocks of volcanic origin, namely, breccias, agglomerates, and tuffs with various intercalated porphyrites and rather uncommon sediments. Their aspect is grey, green, red, or purple and they were variously affected by dynamic metamorphism along the margins of the nearby intrusions. This general picture, which has persisted for almost half a century, has been largely refuted by the present study (*see* Chap. 3).

APPENDIX II

MINERAL DEPOSIT REFERENCES

(Reports of the Minister of Mines, British Columbia)

Salmon River District

Alaska Canadian Consolidated Gold Mines Ltd. (*see* Premier Extension Gold Mines Co., Woodbine)—1925, 100; 1926, 101; 1929, 505; 1930, 442.

American Mining and Milling Co. (formerly Mahood Mines, Ltd.)—1922, 78; 1923, 67, 81; 1924, 58; 1927, 480; 1937, B 21.

Betty group.
Sunrise group.
Daly-Sullivan group.
Lois Edith group.

American Smelting and Refining Co. (*see* Premier)—1919, 75; 1931, 171.

B.C. Bonanza Mines Ltd. (*see* Spider group, Web group)—1925, 110; 1935, B 29; 1936, B 28.

B.C. Silver Mines Ltd. (*see* National Silver Mines, Ltd.)—1927, 58, 98; 1930, 111; 1936, 83; 1937, B 3, 41; 1939, 65; 1941, 54; 1947, 74; 1964, 21.

Bermah Mines Ltd. (*see* Silbak Premier)—1960, A 52, 8; 1964, 21.

Betty group—1922, 83; 1927, 480.

Big Missouri (*see* Pacific Coast Exploration Co., Forty Nine Mining Co.)—1911, 73; 1912, 106; 1913, 89, 94; 1914, 154; 1915, 72; 1916, 86, 520; 1917, 72, 84; 1918, 82; 1919, 79; 1920, 60; 1922, 84; 1923, 84; 1925, 102, 104, 356; 1927, 58, 101; 1928, 114; 1929, 108; 1930, 112; 1931, 46; 1932, 61; 1933, 59; 1934, A 30, B 25; 1935, G 48, B 27, A 31; 1936, B 3, 57; 1937, A 7, 42, B 3, 41; 1938, A 33, 39, B 3, 24; 1939, 35, 42, 65; 1940, 23, 51; 1941, 24, 54; 1942, 26, 53, 76; 1947, 82; Bull. 1, 1932, 39; 1966, 40.

Big Missouri Mining Co. Ltd. (*see* Standard Mining Corporation)—1925, 100; 1926, 98; 1927, 101.

Blue Jay Gold Mining Co., Ltd.—1928, 114.

Border group—1923, 386; 1927, 97; 1928, 113.

Boundary group (*see* Munro Mining Co.)—1910, 73; 1917, 84; 1918, 80; 1919, 74; 1922, 81, 353.

Bralorne Pioneer Mines Limited (*see* Silbak Premier)—1965, 49.

Buena Vista (*see* Buena Vista Mining Co., Ltd., Big Missouri)—1905, 79; 1907, 73; 1908, 57; 1911, 73; 1916, 520; 1917, 72; 1927, 101; 1929, 108; 1936, B 57; 1937, B 41; 1938, A 33, 39, B 24; 1939, 35, 42, 65; 1940, 23, 51; 1941, 24, 54; 1942, 26, 53; Bull. 1, 1932, 39.

Bush—1915, 71.

Bush Cobalt Mines, Ltd. (*see* Cobalt Syndicate, Bush Consolidated Gold Mines, Incorporated)—1927, 97; 1928, 113; 1930, 442; 1936, B 10, B 56.

Bear River District

APPENDIX III

INDEX TO MINERAL DEPOSIT DISTRIBUTION MAP (FIG. 13)

Stewart Area

Map No.	Property	Metals
1.	Scottie	Au, Ag
2.	Morris Summit	Au, Ag
3.	Cassiar-Rainbow	Au, Ag
4.	Wolf Group, St. Eugene Group, Hollywood Mines, Ltd.	Au, Ag, Pb, Zn
5.	Troy	Au, Ag, Pb
6.	Outland Silver Bar Mines Ltd., Eldorado Gold Mines Consolidated Ltd.	Au, Ag
7.	Forty-Nine	Ag, Pb
8.	Yellowstone Group	Ag, Pb
9.	Anaconda Group	Pb, Zn
10.	Silver Basin Group	Ag, Pb, Zn
11.	Hercules Mines Ltd.	Au, Ag, Pb
12.	Lion Group	Ag, Pb, Zn
13.	Silver Crest	Ag, Pb, Zn
14.	Silver Tip	Au, Ag, Cu, Pb, Zn
15.	Last Chance	Pb, Zn
16.	Unicorn Group	Ag, Pb, Zn
17.	Mineral Hill	Ag, Pb, Zn
18.	Day Group	Au, Ag, Pb, Zn
19.	Packer Group	Pb, Zn
20.	Big Missouri, Buena Vista Mining Co.	Au, Ag, Pb, Zn, Cu
21.	Munro	Ag, Pb
22.	Cantu, Last Chance	Au, Ag, Pb, Zn, Cu
23.	Boundary	Ag, Pb, Zn
24.	Silver Coin	Pb, Zn
25.	Pay Roll	Pb, Zn
26.	Indian Mines	Au, Ag, Pb, Zn
27.	Premier Extension	Au, Ag, Pb, Zn
28.	Woodbine	Au, Ag, Pb, Zn
29.	Betty Group	Au, Ag, Pb, Zn, Cu
30.	Silver Cliff, Silver Crown	Au, Ag, Pb, Zn
31.	Spider	Au, Ag, Pb, Zn
32.	Sunrise	Ag, Pb, Zn
33.	Home Ranch	Ag, Pb, Zn
34.	White Heather	Au, Ag, Pb, Zn
35.	Monitor	Pb, Zn
36.	Lakeshore	Pb, Zn
37.	Daly, Sullivan	Ag, Pb, Zn
38.	Peerless	Au, Ag, Pb, Zn
39.	Bush-Cobalt	Ag, Pb, Zn
40.	Sebakwe	Au, Ag, Cu, Pb, Zn, Cd
41.	Northern Light, B.C. Silver	Au, Ag, Cu, Pb, Zn, Cd
42.	Premier, Silbak Premier	Au, Ag, Cu, Pb, Zn, Cd, W
43.	B.C. Silver	Au, Ag, Cu, Pb, Zn
44.	International, High Ore	Au, Ag, Pb, Zn
45.	High-Grade	Au, Ag, Pb, Zn

Map No.	Property	Metals
46.	M.C. Mining Co.	Au, Ag, Cu, Pb, Zn
47.	Prince John	Cu
48.	Chalmers	Pb, Cu
49.	United Empire	Ag, Pb, Zn
50.	Bayview	Au, Pb, Zn
51.	Moonlight	Au, Ag, Pb, Zn
52.	Excelsior, Virginia K.	Au, Ag, Pb, Zn
53.	Mother Lode	Au, Ag, Cu
54.	Blue Jay	Fe
55.	Daly Mines	Ag, Cu
56.	Blue Jay	Ag, Cu
57.	Bandolier	Ag, Cu
58.	Mountain Boy	Ag, Pb, Zn, Cu
59.	Anaconda, Adanac	Pb, Zn
60.	Terminus	Ag, Pb, Zn
61.	Vancouver	Au, Fe
62.	American Girl	Ag, Pb, Zn
63.	Ketchum	Au, Cu, Pb, Zn
64.	Lipton	Zn, Ag, Pb
65.	Morning	Zn
66.	Galena Farm	Pb, Zn
67.	Big Casino	Cu, Pb
68.	Red Cliff	Au, Ag, Cu
69.	Independence	Au, Ag, Pb, Zn
70.	Ruby Silver	Ag, Pb, Zn
71.	Dalhousie	Au, Ag, Cu
72.	International	Pb, Zn
73.	Aztec	Ag, Pb, Zn, Cu
74.	Ore Mountain	Pb
75.	America's Girl Group, Americus Girl	Cu
76.	Silver Ledge	Pb, Zn
77.	Mayflower	Pb, Zn
78.	Victoria	Ag, Pb, Zn
79.	Olympic	Ag, Pb, Zn
80.	Dunwell	Au, Ag, Cu, Pb, Zn
81.	Glacier Creek, George E	Pb, Zn
82.	Lakeview	Ag, Pb, Zn
83.	Nabob	Ag, Pb, Zn
84.	Riverside	Ag, Pb, Zn
85.	Ruth and Francis, R.A.F.	Au, Ag, Pb, Zn, Sb
86.	Phoenix	Ag, Pb, Zn
87.	Portland Canal	Au, Ag, Pb, Zn
88.	Mimico	Ag, Pb, Zn
89.	Albany	Au, Ag, Pb, Zn
90.	Last Chance	Ag, Pb, Zn
91.	L & L Consolidated	Au, Ag, Pb, Zn, Cu, As
92.	Mobile, Chicago, Silver Bar	Ag, Pb, Zn
93.	Red Hill	Ag, Pb, Zn
94.	Ben Bolt	Ag, Pb, Zn
95.	Never Sweat	Ag, Pb, Zn
96.	Black Hill	Ag, Pb, Zn, Cu, Sb
97.	Monroe	Ag, Pb, Zn
98.	Oral M	Au, Ag, Cu
99.	Molly B	Au, Ag, Pb, Zn, Mo, W
100.	Red Reef	Au, Ag, Cu
101.	Silverado	Au, Ag, Pb, Zn, Cu
102.	View	Ag, Pb, Zn

Map No.	Property	Metals
103.	Silver Bell	Pb, Zn
104.	Silver Key	Au, Ag, Pb, Zn
105.	Tacoma	Ag, Pb, Zn
106.	Coast Silver	Pb, Zn, Cu
107.	Prosperity	Au, Ag, Pb, Zn, Cu
108.	Melvin	Ag, Pb
109.	Porter Idaho	Au, Ag, Pb, Zn, Cu
110.	Aberdeen	Pb, Zn
111.	Wire Gold	Au
112.	Marmot Consolidated	Pb, Zn
113.	Fraser	Cu, As
114.	Dominion	Cu, Pb, Zn
115.	Midas	Au, Cu
116.	Minto	Au, Cu
117.	Bi-Metallic	Au, Ag, Pb, Zn, Cu
118.	Patricia, Oversight	Au, Cu, Pb, Zn
119.	Glacier Girl	Fe, Ag
120.	Marmot Metals	Au, Ag, Pb, Zn

HYDER AREA*

1.	Mountain View	Au, Ag, Pb
2.	Lucky Boy Extension	Pb, Zn, Cu
3.	Bishop	Fe, Cu
4.	Victoria	Fe
5.	Fish Creek, lower workings	Au, Ag, Pb, Cu
6.	Fish Creek, upper workings	Au, Ag, Pb, Cu
7.	Hyder Skookum	Fe, Cu, As
8.	Titan	Au, Ag, Pb, Zn
9.	Monarch	Ag, Pb, Zn, Cu, W
10.	Last Shot	Pb, Zn, Cu
11.	Howard	Pb, Zn
12.	Sixmile	Au, Pb
13.	Riverside	Au, Ag, Pb, Zn, Cu, W
14.	Butte	Au, Ag, Pb
15.	Crest	Au, Pb, Cu
16.	Cripple Creek	Ag, Pb, Zn
17.	Portland	Pb, Zn, Cu
18.	Hobo	Au, Ag, Pb, Zn, Cu, As
19.	Alaska-Premier	Au, Pb, Zn, Cu
20.	Daly Alaska, upper workings	Au, Ag, Pb, Zn, Cu, As
21.	Daly Alaska, lower workings	Pb, Zn, Cu, Ag
22.	Stoner-Clegg-O'Rourke	Au, Ag, Pb, Zn, Cu
23.	Stoner	Ag, Pb, Zn, Cu
24.	Virginia	Ag, Pb, Zn
25.	Border	Pb, Zn, Cu
26.	Gold Cliff Premier	Au, Ag, Pb, Zn, Cu
27.	Cantu	Au, Ag, Pb, Zn, Cu
28.	Barthof	Cu, Pb
29.	96 Group	Ag, Pb, Zn, Cu
30.	Silver Bar	Cu, Pb

* *See* U.S.G.S., Bull. 807, 1929.

APPENDIX IV

INDEX TO CROWN-GRANTED CLAIMS, STEWART MAP AREA*

Geographic Distribution	Claim Name	Lot No.
American Creek (Big Gulch-Mountain Boy Creeks)	American Girl	444
"	Bandolier	3199
"	Belle Fr.	5390
"	Blackhorse	5389
"	Blue Jay	3225
"	Boe Fr.	4958
"	Canary No. 2	6086
"	Canary No. 3	6087
"	Canary No. 4	6088
"	Chris	4965
"	Cotton Top	4964
"	Eagle	6085
"	Evening	4953
"	Fox	4963
"	Hard Money	447
"	Lake Fr.	4956
"	Last Chance No. 1	5724
"	Last Chance No. 2	5725
"	Last Chance No. 3	5726
"	Little Left Fr.	4957
"	Louise	1555
"	Lucky Jim No. 1	5718
"	Lucky Jim No. 2	5719
"	Lucky Jim No. 3	5720
"	Lucky Jim No. 4	5721
"	Lucky Jim No. 5	5722
"	Lucky Jim No. 6	5723
"	Maybee	3226
"	Mountain Boy	445
"	Mountain Boy Extension	4961
"	Mountain Boy Extension No. 1	4962
"	Mountain Boy Fr.	4967
"	Northern Belle	446
"	Rangoon	3200
"	Ruby	887
"	Sigrid	4959
"	Sigrid No. 1	4960
"	Silver Mask	4966
"	Silver Mask Fr.	5388
"	Star No. 1	4954
"	Star No. 2	4955
American Creek (Champion-Basin Creek)	Ayrshire	3232
"	Cobalt Fr.	3236
"	Diamond	4825
"	Dix	4911
"	Edith M	3235

* To accompany *Figures 15a, 15b, 15c.*

Geographic Distribution	Claim Name	Lot No.
American Creek (Champion-Basin Creek)	Ena	3528
"	Evans	3231
"	Glenora	3234
"	Granby	3239
"	Hope No. 1 Fr.	4900
"	Hope No. 2 Fr.	4901
"	Hope No. 5	4899
"	Hope No. 6 Fr.	4902
"	Ketchum	1075
"	Mother Lode	3238
"	Noonday Fr.	4910
"	Noonday No. 2	4909
"	Noonday No. 3	4908
"	Noonday No. 4	4906
"	Noonday No. 5	4905
"	Noonday No. 6 Fr.	4904
"	Noonday No. 7	4903
"	Noonday No. 8	4912
"	Oneda	3233
"	Quige	4826
"	Railroad	3237
"	Silver Dollar	4822
"	Snow	4824
"	Stop and Rest	1076
"	Sunshine	1077
"	Valley	4823
"	Vancouver Fr.	4907
American Creek (Kimball Lake)	Star No. 2 Fr.	5814
"	Star No. 3 Fr.	5811
"	Virginia K. Extension No. 1	5822
"	Virginia K. Extension No. 2	5823
"	Virginia K. Extension No. 3	5820
"	Virginia K. Extension No. 4	5819
"	Virginia K. Extension No. 5	5815
"	Virginia K. Extension No. 6	5813
"	Virginia K. Fr. No. 3	5817
"	Virginia K. No. 1	5810
"	Virginia K. No. 2	5812
"	Virginia K. No. 3	5816
"	Virginia K. No. 4	5818
"	Virginia K. No. 5	5821
Bear River (Mount Johnson)	Elf	4879
"	Elf & Fairy	4873
"	Elf & Fairy No. 1	4874
"	Elf No. 1	4880
"	Elf No. 2	4881
"	Elf No. 3	4952
"	Elf No. 4	4882
"	Elf No. 5	4883
"	Elf No. 6	4884
Bitter Creek	Alberta No. 3	(†)
"	Alberta No. 5	5875
"	Alberta No. 6	5876
"	Betsy Fr.	3524
"	Betty No. 3	3464
"	Betty No. 4	3466
"	Betty No. 5	3468

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Bitter Creek	Black Bear	4809
„	Compass	3438
„	Florence No. 1	3459
„	Florence No. 2	3460
„	Florence No. 3	3465
„	Gold Hill No. 1	4812
„	Hill Fr.	4819
„	Lakeshore	4808
„	Lead Coil	4811
„	Lead Coil No. 2	4813
„	Mauritania	4564
„	Mauritania Fr.	4566
„	Mauritania No. 1	4565
„	Mauritania No. 4	4568
„	Mauritania No. 5	4569
„	Mauritania No. 6	3439
„	May No. 4	5634
„	May No. 5	5635
„	Morgan	5881
„	Morgan "A" Fr.	5878
„	Morgan " B " Fr.	5886
„	Morgan No. 1	5882
„	Morgan No. 3	5883
„	Morgan No. 4	5860
„	Morgan No. 6	5862
„	M.X.	5884
„	M.X.X.	5885
„	Ophir Fr.	5880
„	Ophir No. 2	5871
„	Ophir No. 3	5872
„	Ore Fr.	4814
„	Ore Hill	4815
„	Ore Hill No. 2	4816
„	Ore Hill No. 3	4817
„	Ore Hill No. 4	4818
„	Ore Hill No. 6	4821
„	Ore Mountain No. 5	4820
„	S.D.	4560
„	S.D. No. 1	4561
„	S.D. No. 2	4562
„	S.D. No. 3	4563
„	Silver Band	4810
„	Star Fr.	5639
„	Star No. 1	5637
„	Star No. 2	5638
„	Sunnyside	(†)
Dalhousie Creek	Algonquin	1490
„	Alpine	4927
„	Alpine Fr.	5374
„	Ben Lomond	1487
„	Dalhousie	4924
„	Dalhousie Fr.	4972
„	Deep Fr.	4930
„	Dundee	1491
„	Erie	1489
„	Mammoth	1488
„	O.K.	4928

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Dalhousie Creek	O.K. Fr.	4929
,,	Orient	4925
,,	Penetang	1494
,,	Rock of Ages Fr.	4940
,,	Rock of Ages No. 1	4939
,,	Rock of Ages No. 2	4933
,,	Rock of Ages No. 3	4935
,,	Rock of Ages No. 4	4934
,,	Rock of Ages No. 5	4936
,,	Rock of Ages No. 6	4938
,,	Rock of Ages No. 7	4937
,,	Talisman Fr.	4932
,,	Talisman No. 1	4931
,,	Tecumseh	1492
,,	Tillamook	4926
,,	Wentworth	1493
Divide Lake	Bess Fr.	3456
,,	Betty Fr.	3454
,,	Betty No. 1	3447
,,	Betty No. 2	3448
,,	Betty No. 3	3449
,,	Betty No. 4	3450
,,	Betty No. 5	3451
,,	Betty No. 6	3452
,,	Betty No. 7	3453
,,	Divide	(†)
,,	Divide Fr.	3455
,,	Silver Cliff	4921
,,	Silver Cliff No. 2	4922
,,	Silver Cliff No. 3	4923
,,	Silver Cliff No. 4	4920
Glacier Creek	Ajax	770
,,	Albany	1820
,,	Albany Fr.	1825
,,	Albany No. 2	1821
,,	Albany No. 3 Fr.	1823
,,	Albert	(†)
,,	Alice Fr.	5254
,,	Alice No. 1	5252
,,	Alice No. 1 Fr.	5257
,,	Alice No. 2	5253
,,	Alice No. 2 Fr.	5260
,,	Alice No. 3 Fr.	5264
,,	Alice No. 4	5255
,,	Alice No. 5	5256
,,	Auto	771
,,	Barney	421
,,	Barney Fr.	409
,,	Ben Ali	4283
,,	Ben Ali No. 2	4470
,,	Ben Bolt	775
,,	Ben Bolt Fr.	2325
,,	Ben Hur	870
,,	Ben Hur Fr.	871
,,	Big Four	(†)
,,	Big Four No. 3	5259
,,	Billy	2954

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Glacier Creek	Black Bear	1553
,,	Black Hill No. 1	5240
,,	Black Hill No. 2	5241
,,	Black Hill No. 3	5242
,,	Black Hill No. 4	5243
,,	Black Hill No. 5	5261
,,	Bull Fr.	2323
,,	Bulldog	4596
,,	Bulldog No. 1	4597
,,	Bulldog No. 2	4598
,,	Bulldog No. 3	4599
,,	Charles	4418
,,	Charles No. 3 Fr.	4419
,,	Chicago Fr.	2319
,,	Chicago No. 1	2317
,,	Chicago No. 2	2318
,,	Columbia	411
,,	Dandy No. 1	(†)
,,	Dandy No. 2	(†)
,,	Donald	4548
,,	Dunedin Fr.	4291
,,	Dunwell	4286
,,	Dunwell Fr.	4290
,,	Dunwell No. 2	4287
,,	Dunwell No. 2 Fr.	4294
,,	Dunwell No. 3	4288
,,	Dunwell No. 3 Fr.	4295
,,	Dunwell No. 4	4289
,,	Dunwell No. 4 Fr.	4475
,,	Eclipse	430
,,	Evening Sun	1517
,,	Extension	418
,,	Faith	4586
,,	Faith No. 1	4583
,,	Faith No. 2	4584
,,	Faith No. 3	4585
,,	Francis	(†)
,,	Galena	4544
,,	George E	872
,,	George E No. 2	4284
,,	George E No. 3 Fr.	4471
,,	Gloria	4474
,,	Go Between Fr.	2959
,,	Gypsy	416
,,	Hazel Fr.	(†)
,,	Helen	2956
,,	Herbert	417
,,	Jane	2955
,,	Jennie	2958
,,	John	(†)
,,	Jumbo	774
,,	June No. 1	(†)
,,	June No. 2	(†)
,,	Kootnay	1385
,,	L & L Fr.	4528
,,	L & L No. 1	4526
,,	L & L No. 2	4527

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Glacier Creek	Lakeview No. 1	3598
"	Lakeview No. 2	3599
"	Lakeview No. 3	3600
"	Last Chance	403
"	Little Joe	873
"	Little Joe Fr.	438
"	Little Pearl Fr.	1384
"	Lucky Boy	402
"	Lucky Boy Fr.	1822
"	Lucky Seven	874
"	Lulu	926
"	M & D Fr.	4285
"	M & D No. 2	4472
"	Mabel	2957
"	Maid of Erin	773
"	May No. 1	5246
"	May No. 2	5247
"	Mayflower	419
"	Mayflower	4468
"	Melba	437
"	Mimico	(†)
"	Mink No. 3	(†)
"	Minnie	772
"	Morning Star	(†)
"	Mosquito	428
"	Mountain Lake	4481
"	Mountain Meadow Fr.	4482
"	Myra	4473
"	Nabob	4547
"	Nabob Fr.	4551
"	Nabob No. 2	4548
"	Nabob No. 4	4550
"	Nelley W No. 4	5245
"	Nelley W No. 1 Fr.	5244
"	Nellie V	404
"	Never Sweat	2321
"	North Line	4496
"	November Fr.	5258
"	O.K. Fr.	2960
"	Olga	436
"	Olympic Fr.	4483
"	Raven	1824
"	Rex	769
"	Richard II	429
"	Riverside	405
"	Rivetter	(†)
"	Rosalie	3201
"	Sadie	420
"	Sadie Fr.	408
"	Saxonia	4484
"	Sentinel	(†)
"	Silver Bar Fr.	1828
"	Silver Bar No. 1	1826
"	Silver Bar No. 2 Fr.	1827
"	Silver Bell Fr.	3601
"	Silver Bow No. 1	456
"	Silver Bow No. 2	457

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Glacier Creek	Silver Bow No. 3	458
”	Silver Bow No. 4	459
”	*Silver King*	1388
”	Silver Lake Fr.	4293
”	Smiling Morn	4478
”	South Line	4497
”	Spring Fr.	5262
”	Standwell	4480
”	Star No. 1	(†)
”	Star No. 2	(†)
”	Summer Breeze	4479
”	Sunbeam	869
”	Sunbeam Fr.	4469
”	Sundown Fr.	4292
”	Sunshine	4499
”	Sunshine Fr.	4506
”	Sunshine No. 1	4500
”	Sunshine No. 2	4504
”	Sunshine No. 4	4505
”	Thelma	1552
”	Tiger	1554
”	Tyee	4467
”	Victory	4476
”	Viking	4545
”	Virginia Fr.	4420
”	Washington	868
”	*Washington No. 1*	867
”	White Fr.	5248
”	White Hill	(†)
”	White Silver	5249
”	Wolverine Fr.	2961
Le Sueur Creek	Pershing	4762
”	Pershing No. 1	4763
”	Ruby	4764
”	Ruby No. 1	(†)
”	Star	4765
”	Stirling	4766
Lydden Creek	Big Casino	4529
”	Bisbee	5371
”	Bisbee No. 1	5372
”	Dot Fr.	87
”	Jack of Clubs	4530
”	Jerome Fr.	5368
”	Jerome No. 1	5367
”	Jerome No. 2	5369
”	Jerome No. 3	5370
”	Last Chance	88
”	Lipton No. 1	1977
”	Lipton No. 2	1978
”	Lipton No. 3	1550
”	Lipton No. 4	1551
”	Little Casino	4532
”	Little Pat Fr.	78
”	Lookout Fr.	4531
”	Lydden Fr.	5373
”	Mac Fr.	86
”	Merry Widow	3202

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Lydden Creek	Mount Lyell	77
"	Mount-Rose	76
"	Ouray Fr.	4533
"	Red Cliff	75
"	Waterloo	79
Marmot Bay	McFadden	4600
"	Spokane	4436
Marmot River (South Fork)	Bess	4976
"	Fountain	4750
"	Glacier	4984
"	Grey Rock	4983
"	Hope	5231
"	Horseshoe	4975
"	Maud	4980
"	May	4981
"	May Fr.	4982
"	Montana	4974
"	Peach Fr.	4979
"	Peach No. 1	4977
"	Peach No. 2	4978
"	Point Fr.	4985
"	Silver Spring	4973
"	Sunlight	4749
"	Victor	(†)
Mount Dillworth	A.G. Fr.	4171
"	Anaconda	4618
"	Anaconda No. 1	4619
"	Argentite	4153
"	Bella Coola	4036
"	Boston	4026
"	Buena Vista	3207
"	Butte	4033
"	Cerargyrite	4160
"	Chicago	4027
"	Cornelius	1523
"	Darwin	4028
"	Dickens	4030
"	Dumas	4029
"	Empire	1524
"	Forty Nine	4024
"	Galena	4615
"	Galena Fr.	4617
"	Galena No. 1	4616
"	Glacier	1522
"	Good Hope	4037
"	Good Hope	4538
"	H. & W. Fr.	4541
"	Hessite	4159
"	High Grade	4605
"	High Grade No. 1	4604
"	High Grade No. 2	4603
"	Ladybird No. 2	4040
"	Leckie Fr.	1525
"	Lion Fr.	4169
"	Lion No. 1	4166
"	Lion No. 2	4167
"	Lion No. 3	4168

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Mount Dillworth	Martha Ellen	1521
”	May P.J.	4038
”	Milan Dollar Fr.	4034
”	Montana	5092
”	Montana No. 1	5093
”	Montana No. 1 Fr.	4178
”	Montana No. 2	5094
”	Montana No. 2 Fr.	4179
”	Montana No. 3	5095
”	Native	4158
”	Occidental Fr.	4035
”	Old Timer	4032
”	Oxedental	4023
”	Polybacite	4154
”	Polybacite Fr.	4177
”	Proustite	4156
”	Pyrargyrite	4155
”	Rambler	3206
”	September Fr.	4163
”	Silver Creek Fr.	4540
”	Silvercrest Fr.	4162
”	Silver Leaf	4039
”	Snow King	4539
”	Stephanite	4157
”	Stromeryrite	4161
”	Tiger	4152
”	Tiger Fr.	4170
”	Tip Top	3205
”	Tip Top Fr.	4180
”	Unicorn	4534
”	Unicorn No. 2	4535
”	Unicorn No. 3	4536
”	Unity	4537
”	Unity Fr.	4542
”	Whizz Bang	4164
”	Yellowstone	4031
”	Yellowstone Fr.	4025
Mount Dolly	Alpine	1816
”	Barney	4994
”	Bayview No. 1	4182
”	Bayview No. 2	4181
”	Beth	4186
”	Cliff Fr.	3266
”	Clyde	1813
”	Era	1815
”	First Fr.	5088
”	Forrest	4398
”	Forrest No. 2	4399
”	Forrest Wedge Fr.	4404
”	Gold Cliff No. 1	4989
”	Gold Cliff No. 1 Fr.	4997
”	Gold Cliff No. 2	4987
”	Gold Cliff No. 2 Fr.	4990
”	Gold Cliff No. 3 Fr.	3265
”	Gold Cliff No. 4	4988
”	Gold Cliff No. 5	4992
”	Gold Cliff No. 6	3268

Geographic Distribution	Claim Name	Lot No.
Mount Dolly	Gold Fr.	4996
"	Gordon	(†)
"	Hemlock	1817
"	Jerry Dog	4986
"	Jim	5085
"	Jim Fr.	4403
"	K.P. No. 1	4183
"	Kent	4192
"	Lucille No. 1	4185
"	Margaret	3267
"	Mars	1812
"	Mary Fr.	5087
"	Maybloom	(†)
"	N.M. Fr.	5898
"	N.M. No. 1	5894
"	N.M. No. 2	5895
"	N.M. No. 3	5896
"	N.M. No. 4	5897
"	N.M. No. 5 Fr.	5899
"	N.M. No. 6 Fr.	5900
"	N.M. No. 7 Fr.	5901
"	Prince	1818
"	Prince No. 2	1819
"	Prince John No. 1	4387
"	Prince John No. 2	4388
"	Prince John No. 3	4389
"	Prince John No. 4	4390
"	Prince John No. 5	4391
"	Prince John No. 6	4392
"	Prince John No. 7	4393
"	Prince John No. 8	4394
"	Prince John No. 9	4395
"	Prince John No. 10	4400
"	Prince John No. 10 Fr.	4405
"	Rand	(†)
"	Red Bluff	4396
"	Red Bluff No. 2	4397
"	Red Bluff No. 3	4401
"	Tacoma	4184
"	Tenas Fr.	4402
"	Thames	1814
"	Tom	4993
"	Tom Fr.	5101
"	Zeal	5086
Mount McLeod (Marmot River)	Alameda	5124
"	Canadian	5541
"	Canadian No. 1	5542
"	Canadian No. 2	5543
"	Canadian No. 3	5546
"	Canadian No. 4	5547
"	Canadian No. 5	5548
"	Canadian No. 6	5544
"	Canadian No. 7	5545
"	Canadian No. 8	5549
"	Cardena	5128
"	Lucky Strike	5123
"	Moonshine	5126

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Mount McLeod (Marmot River)	Star	5127
"	Star Fr.	5130
"	Vel Fr.	5129
"	Velvet	5125
Mount Rainey	Ariel	4513
"	Boise	5109
"	Cambria	5119
"	Canyon	4520
"	Canyon	4524
"	Chinook	5108
"	Climax	4509
"	Contact Fr.	4525
"	Copper King	1864
"	Copper Queen	1865
"	Eureka	4732
"	Fortune	4512
"	Gargoyle	1866
"	Gem of the Mountains	4735
"	Gem of the Mountains Fr.	4736
"	Glacier Fr.	4515
"	Glenearn	4510
"	Good Ore	1861
"	Good Ore No. 2	1862
"	Grand Ridge	5110
"	Groundhog	(†)
"	Guard	5120
"	Honest John	1860
"	Iron Hill	4508
"	Key Fr.	5113
"	Lucille	4729
"	Melvin	1867
"	Melvin No. 1 Fr.	1868
"	Melvin No. 2 Fr.	1869
"	Melvin No. 3 Fr.	4727
"	Melvin No. 4 Fr.	1870
"	Millie	5111
"	Molly B	4498
"	Munro	5382
"	Munro No. 2	5383
"	Nettie L.	4730
"	Never Sweat	4733
"	Never Sweat Fr.	4738
"	Night Fr.	5205
"	P.C. No. 1 Fr.	5105
"	P.G. No. 2 Fr.	5106
"	Prickly Heat	4734
"	Prickly Heat Fr.	4737
"	Prosperity	1858
"	Prosperity Fr.	1859
"	Rainier Fr.	4511
"	Red Reef Fr.	1390
"	Red Reef No. 1	1405
"	Red Reef No. 2	1406
"	Red Reef No. 3	1407
"	Red Reef No. 4	1408
"	Renown	4507
"	Republic No. 1	1863

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Mount Rainey	S.B. Fr.	4771
"	S.N. Fr.	4770
"	Safe Key Fr.	4776
"	Safe Key No. 2 Fr.	4772
"	Shamrock No. 2	(†)
"	Silverado Fr.	4522
"	Silverado No. 4 Fr.	4523
"	Silverado No. 3	4520
"	Silverado No. 4	4521
"	Silver Bank Fr.	4746
"	Silver Bank No. 1	4742
"	Silver Bank No. 2	4743
"	Silver Bank No. 3	4745
"	Silver Bank No. 4	4744
"	Silver Bell No. 1	4773
"	Silver Bell No. 2	4774
"	Silver Bell No. 3	4775
"	Silver Bell No. 4 Fr.	4517
"	Silver Bow No. 1	4518
"	Silver Bow No. 2	4516
"	Silver Bow No. 3 Fr.	4514
"	Silver Fr.	4748
"	Silver Key Fr.	5103
"	Silver Key No. 1	5104
"	Silver Key No. 2	5122
"	Silver Key No. 3	5114
"	Silver Key No. 4	5115
"	Silver Key No. 5	5116
"	Silver Key No. 6	5117
"	Silver Key No. 7	5118
"	Silver Night	4768
"	Silver Night No. 2	4769
"	Slide	4728
"	Snoqualmie	5112
"	Stand Pat	5384
"	Star No. 4	(†)
"	Sunday	4731
"	Tacoma	5107
"	Teapot Dome	1857
"	Tram Fr.	4519
"	Triangle Fr.	4424
"	Triumph	4739
"	Victoria	4740
"	Victoria Fr.	4741
"	View No. 1	(†)
"	Warden	5121
Salmon Glacier (August Mountain)		1838
"	Copperhead	1832
"	Copperhead Fr.	1837
"	Good Luck No. 1	(†)
"	Good Luck No. 2	(†)
"	Good Luck No. 3	(†)
"	Gray Copper	4503
"	Gray Copper Fr.	(†)
"	Hollywood No. 1	4485
"	Hollywood No. 2	4486
"	Hollywood No. 3	4487

† Surveyed but not Crown-granted.

Geographic Distribution	*Claim* Name	Lot No.
,,	Hollywood No. 4	4488
,,	Hollywood No. 5	4489
,,	Hollywood No. 6	4490
,,	Hollywood No. 7	4491
,,	Hollywood No. 8	4492
,,	Hollywood No. 9	4493
,,	Hollywood No. 10	4494
,,	Hollywood No. 11	4495
,,	Josephine	1833
,,	St. Eugene	(†)
,,	St. Eugene Extension	(†)
,,	St. Eugene Fr.	(†)
,,	St. Eugene No. 2	(†)
,,	St. Eugene No. 3	4502
,,	Shough	1829
,,	Shough Fr.	1839
,,	Shough No. 2	1830
,,	*Silver Belt*	1835
,,	Silver View	1831
,,	Silver View Fr.	1836
,,	Sunrise	1840
,,	Sunrise No. 1	(†)
,,	Sunrise No. 2	(†)
,,	Vamp	1834
,,	Vamp Fr.	(†)
Salmon Glacier (Mount Bayard)	Almo	2847
,,	Almo Fr.	4445
,,	Amy A.	5430
,,	Arrow	5422
,,	Arrow Fr.	5423
,,	Banana Fr.	4601
,,	Bar Cross	5428
,,	Bar Silver	4193
,,	Big Chief No. 1	5413
,,	Big Chief No. 2	5414
,,	Big Chief No. 3	5415
,,	Boundary	5421
,,	Eldorado	2846
,,	Eldorado No. 2	4444
,,	Eldorado No. 3	4443
,,	Hibbard C	5429
,,	Idaho	4602
,,	Kidd	5424
,,	Kidd No. 1	5425
,,	Lens	3624
,,	Long Fr.	5427
,,	Mineral Zone	4189
,,	Mons	3625
,,	Mount Girl	4190
,,	Munro	5412
,,	Munro No. 1	5411
,,	Munro No. 2	5416
,,	Munro No. 3	5417
,,	*Munro No. 4*	5419
,,	Munro No. 5	5420
,,	Native Silver	5527
,,	Ruby Silver Fr.	5528

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Salmon Glacier (Mount Bayard)	Silver Bars	4193
,,	Silver Dollar	5418
,,	Silver Dollar Fr.	5426
,,	Silver Thought Fr.	2848
,,	Silver Thought No. 2 Fr.	2849
,,	Vimy No. 1	3623
Summit Lake (Goat Creek)	Beach	(†)
,,	Butte	(†)
,,	Gold No. 11	6270
,,	L.X.	(†)
,,	Prince No. 1	6407
,,	Prince No. 2	6408
,,	Prince No. 4	6409
,,	Prince No. 5	6410
,,	Prince No. 6	6411
,,	Prince Fr.	6412
,,	Reward	
,,	Summit Lake No. 1	6296
,,	Summit Lake No. 2	6297
,,	Summit Lake No. 3	6298
,,	Summit Lake No. 4	6299
,,	Summit Lake No. 5	6300
,,	Summit Lake No. 6	6301
,,	Summit Lake No. 7 Fr.	6405
,,	Summit Lake No. 8	6406
,,	Terry	(†)
,,	Troy	(†)
,,	Troy No. 2	(†)
,,	Welcome	(†)
Cascade Creek (Bear River Ridge)	A.C. Fr.	5251
,,	A.C.C. Fr.	4423
,,	A.C.C. No. 1 Fr.	4422
,,	A.M. Fr.	4440
,,	AX Fr.	3852
,,	Anniversary	4410
,,	Bean Fr.	5522
,,	Bell	3842
,,	Bell No. 2	3849
,,	Big Dick	1981
,,	Big Missouri	3217
,,	Bill	1841
,,	Bill Fr.	1854
,,	Blue Bird	4277
,,	Blue Jay Fr.	4426
,,	Bluox	4140
,,	Bonanza	4411
,,	Border	4165
,,	Boston Fr.	5521
,,	Boston No. 2 Fr.	5523
,,	Boundary	3926
,,	Boundary No. 1	2314
,,	Boundary No. 2	2315
,,	Boundary No. 4	2313
,,	Briton	4414
,,	Briton No. 1	1804
,,	Brookland	511
,,	Buena Vista	3207

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Cascade Creek (Bear River Ridge)	Bush Fr.	4147
”	Bush No. 1	5196
”	Bush No. 2	5197
”	Bush No. 3	5198
”	Bush No. 4	5199
”	B.X. 1	4427
”	B.X. 2	4428
”	B.X. 3	4429
”	B.X. 4 Fr.	4430
”	B.X. 5	4431
”	B.X. 6 Fr.	4432
”	B.X. 7 Fr.	4433
”	B.X. 8 Fr.	4434
”	Cabin	3922
”	Cascade Falls No. 4	3590
”	Cascade Falls No. 5	1272
”	Cascade Falls No. 8	3591
”	Cascade Forks No. 1	3603
”	Cascade Forks No. 2	3604
”	Cascade Forks No. 3	3605
”	Cascade Forks No. 4	3606
”	Cascade Forks No. 5	3607
”	Cascade Forks No. 6	3608
”	Climax	3841
”	Club Fr.	4278
”	Cobalt	4053
”	Cobalt No. 2	4054
”	Daisy	4594
”	Daisy No. 2	4595
”	Daley	3929
”	Dally	3595
”	Daly	3685
”	Dan Fr.	5091
”	Dauntlas	3219
”	Day Fr.	4132
”	Day No. 1	4127
”	Day No. 2	4129
”	Day No. 3	4130
”	Day No. 4	4131
”	Dixie	4135
”	Double 0 No. 6	4046
”	Double 00 Fr.	2844
”	E. Pluribus	3213
”	Eagle	4197
”	Edith	3686
”	Essington	3593
”	Exchange Fr.	1848
”	Exchange No. 1	1843
”	Exchange No. 2	1844
”	Exchange No. 3	1845
”	Exchange No. 4	1846
”	Exchange No. 5	1847
”	Extension Fr.	3692
”	Extra	5193
”	Fair	839
”	Falls View	3223
”	Fillier	1842

Geographic Distribution	Claim Name	Lot No.
Cascade Creek (Bear River Ridge)	Five Fr.	5192
"	Forks	3610
"	Forty-five	512
"	Four Fr.	5191
"	Fritz	1982
"	G.T. Fr.	3222
"	Glacier	1849
"	Glacier End Fr.	1856
"	Glacier No. 1	1850
"	Glacier No. 2	1851
"	Glacier No. 4	1852
"	Glacier No. 7	4421
"	Gold Cup Fr.	5234
"	Golden Crown	3210
"	Golden Fr.	4118
"	Grandview	4142
"	Group	3927
"	Grub	3924
"	Grubstake	3928
"	Gun Fr.	4016
"	H.E. Fr.	1853
"	Halton	4146
"	High Ore Fr.	4613
"	High Ore No. 1	4608
"	High Ore No. 1 Fr.	4612
"	High Ore No. 2	4609
"	High Ore No. 3	4610
"	High Ore No. 4	4611
"	Hooligan	4019
"	Humbolt Fr.	4137
"	Humbolt No. 2 Fr.	4136
"	Idaho	2836
"	Idaho Fr.	2841
"	International	3923
"	International	3930
"	Iron Cap	5228
"	Irwin	3612
"	J.P. Fr.	3211
"	Jain	3209
"	Jean	4196
"	Jean Fr.	5526
"	Joe Fr.	4139
"	Kansas	3218
"	Kitchener	4046
"	Knob Hill	3220
"	Lakeshore	4176
"	Laura	3214
"	Lesley	3839
"	Lesley Fr.	3848
"	Lesley M.	3838
"	Lesley No. 2	3843
"	Lesley No. 3	3845
"	Lesley No. 4	3844
"	Lesley No. 5	3846
"	Lesley No. 6	3847
"	Limit	3840
"	Little Joker	3904

Geographic Distribution	Claim Name	Lot No.
Cascade Creek (Bear River Ridge)	Lois	3687
”	Longview No. 1	5194
”	Look Out	3905
”	Loser	4056
”	Lucky	3925
”	Lucky Fr.	4281
”	Lucky Jim	4408
”	Lucky No. 1 Fr.	4280
”	M.C.	4406
”	M.C. Fr.	4417
”	M.C. No. 1	4407
”	M.C. No. 1 Fr.	4409
”	M.L.	4452
”	Mack Fr.	1807
”	Mack No. 1	1808
”	Mack No. 2 Fr.	1809
”	Mack No. 3 Fr.	1810
”	Mack No. 4 Fr.	1811
”	Maggie Jiggs Fr.	4442
”	Mahood	3850
”	Maple Leaf No. 1	4451
”	Maple Leaf No. 2	4450
”	Maple Leaf No. 3	4449
”	Maple Leaf No. 4	4448
”	Maple Leaf No. 5	4447
”	Meteor	5218
”	Midas	3901
”	Midas Lake Fr.	3900
”	Mineral Basin	4059
”	Mineral Basin Fr.	4062
”	Mineral Basin No. 1	4060
”	Mineral Basin No. 2	4061
”	Mineral Hill	3902
”	Missing Link Fr.	2316
”	Mist Fr.	4151
”	Mist No. 1	4149
”	Mist No. 2	4150
”	Money	4043
”	Morn	4064
”	Mountain	4141
”	Mystery	3903
”	N.H. Fr.	4416
”	Neill Fr.	4148
”	Nellie Fr.	4614
”	Nine of Hearts	4412
”	Nine of Hearts No. 1	4413
”	Nine Spot Fr.	4415
”	Northern Light Fr.	4057
”	Northern Light No. 1	4058
”	Northern Light No. 1 Fr.	4048
”	Northern Light No. 2	4047
”	Northern Light No. 3	4049
”	Northern Light No. 4	4050
”	Northern Light No. 5	4051
”	Northern Light No. 6	4052
”	Northern Light No. 7	4055
”	Northern Light No. 8	4063

Geographic Distribution	Claim Name	Lot No.
Cascade Creek (Bear River Ridge)	Northern Light No. 9 Fr.	4454
”	O.B.	5214
”	O.B. Fr.	5219
”	O.B. No. 1	5215
”	O.B. No. 1 Fr.	5220
”	O.B. No. 2	5216
”	O.B. No. 2 Fr.	5223
”	O.B. No. 4	5217
”	Oakville Fr.	4021
”	Oakville No. 2 Fr.	4022
”	Oakwood	4020
”	O'Brien Fr.	4441
”	One Fr.	5190
”	Outlook No. 8	(†)
”	P.T. Fr.	5140
”	P.X. Fr.	4425
”	Packers Fr.	5540
”	Pass Fr.	3906
”	Pat Fr.	3594
”	Paul	4138
”	Pay Roll No. 3	5524
”	Pay Roll No. 4	5525
”	Peace	4195
”	Peer Fr.	4593
”	Peerless Fr.	4592
”	Peerless No. 2	4587
”	Peerless No. 3	4588
”	Peerless No. 4	4589
”	Peerless No. 5	4590
”	Peerless No. 6	4591
”	Petite Fr.	2842
”	Pictou	3596
”	Pit Fr.	4767
”	Pittsmont Fr.	5139
”	Pittsmont No. 2	5136
”	Pittsmont No. 3	5137
”	Pittsmont No. 4	5138
”	Portland No. 1	1980
”	Portland No. 2	1979
”	Premier Extension No. 1	3688
”	Premier Extension No. 2	3689
”	Premier Extension No. 3	3690
”	Premier Extension No. 4	3691
”	Premier Fr.	4279
”	Premier Fr. No. 2	2855
”	Province	3208
”	Red Rock	1855
”	Rincon	4143
”	Ruby Silver	4123
”	Ruby Silver No. 1	4119
”	Ruby Silver No. 2	4120
”	Rupert	3597
”	Shorty Fr.	5213
”	Shure	4041
”	Silver Coin	2837
”	Silver Coin Fr.	2840
”	Silver Creek Fr.	4540

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Cascade Creek (Bear River Ridge)	Silver Lake Fr.	5221
"	Silver Lake No. 1	5200
"	Silver Lake No. 1 Fr.	5250
"	Silver Lake No. 2	5201
"	Silver Lake No. 3	5202
"	Silver Lake No. 4	5203
"	Silver Lake No. 5	5204
"	Simcoe	4145
"	Simpson	3592
"	Single O Fr.	2843
"	Spider No. 1	4172
"	Spider No. 2	4173
"	Spider No. 3	4174
"	Star Extension	5211
"	Star Extension No. 1	5212
"	Start Fr.	5222
"	Start No. 2	5206
"	Start No. 3	5207
"	Start No. 5	5209
"	Start No. 6 Fr.	5210
"	Storm	2838
"	Storm Fr.	5090
"	Sullivan	3684
"	Sunshine	4194
"	Sure Money	4017
"	Sure Money No. 1	4018
"	Ten Fr.	3861
"	Terminus	3221
"	Texada	4133
"	Texada Fr.	4134
"	Three	5188
"	Three Fr.	5189
"	Triple 000 Fr.	2845
"	Trites	3611
"	True Blue	3693
"	U and I	4144
"	Union Fr.	3215
"	Unum Fr.	3216
"	Valley Fr.	6204
"	Vancouver	4121
"	Vancouver No. 1	4122
"	Vancouver No. 2	4124
"	Vancouver No. 3	4125
"	Vandal Fr.	3785
"	View	1806
"	View Fr.	1805
"	White Heather No. 1	(†)
"	White Heather No. 2	(†)
"	Win Fr.	3224
"	Winer	3212
"	Winner	4116
"	Wood Fr.	3609
"	Wood Fr.	3931
"	Woodbine	4045
"	Woodbine Fr.	4126
"	X Fr.	4117
"	XIOU8	5180

† Surveyed but not Crown-granted.

Geographic Distribution	Claim Name	Lot No.
Cascade Creek (Bear River Ridge)	XIOU8 Fr.	5195
"	XIOU8 No. 2	5181
"	XIOU8 No. 3	5182
"	XIOU8 No. 4	5183
"	XIOU8 No. 5	5184
"	XIOU8 No. 6	5185
"	XX Fr.	4128
"	Young Fr.	4276

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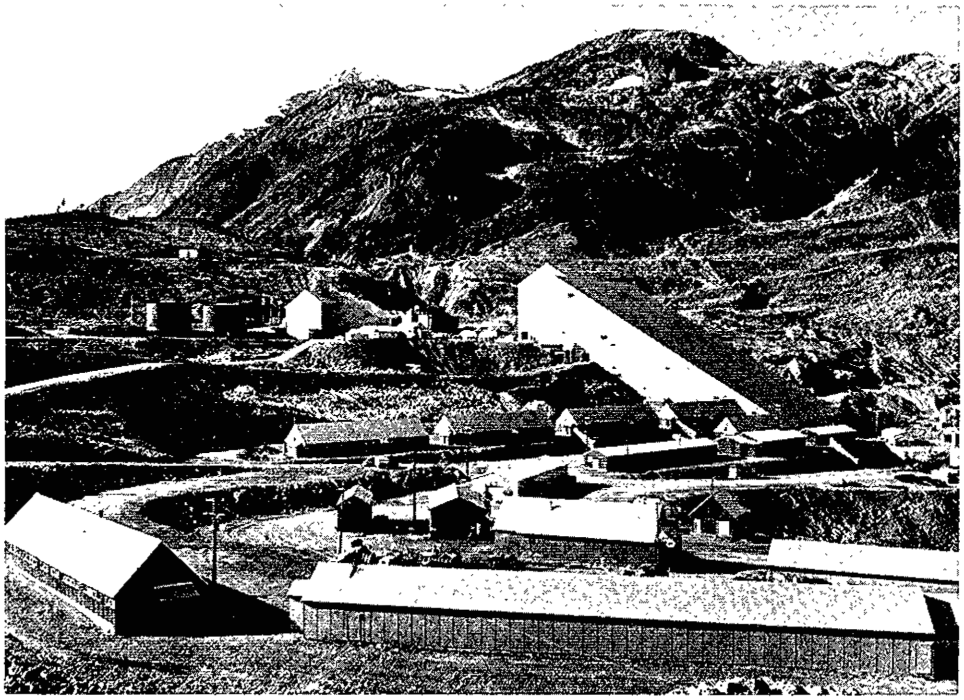
1971

3,000-870-6627



IA. Granduc concentrator, Tide Camp (1969).

Plate IB. Silbak Premier concentrator and 6 Level Camp (1969).

Plate IIA. Summit Lake, looking north, June, 1966, after the 1965 "jokulkaup." Note the stranded icebergs and the high moraine.

Plate IIB. Summit Lake, looking south, September 2, 1967. The lake drained on September 17th.

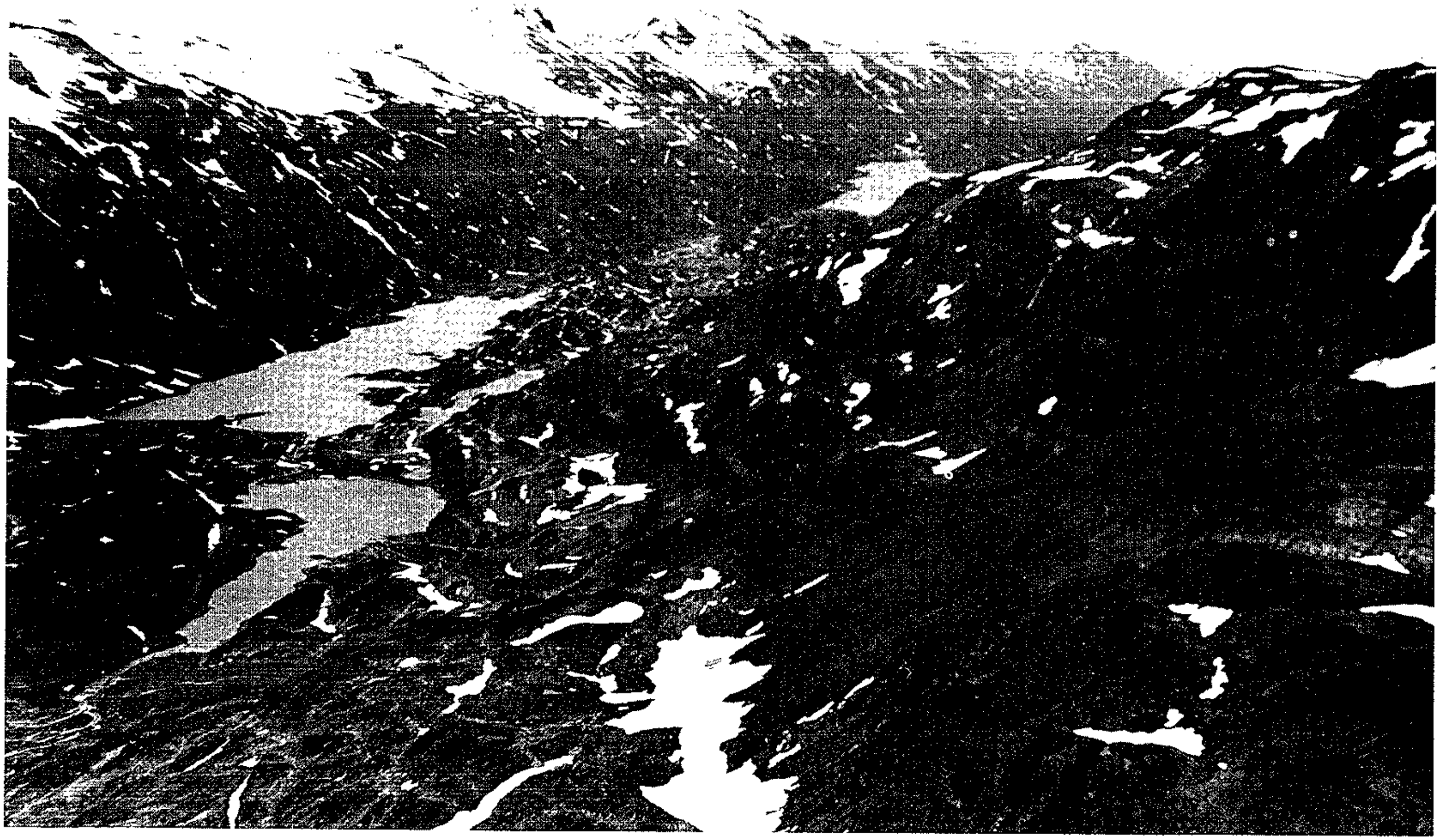


Plate III. Divide-Long Lake valley, looking south. Bear River Ridge in background, Mount Dillworth at right.

Plate IVA. Salmon Glacier, looking south, August, 1965. Note "Daisy Lake" area in left foreground, flow pattern in medial moraines, crevassed edge at edge of lake.

IVB. Salmon Glacier, looking south, September, 1969. Note the extensive broken area, and the retreat since 1965 (*see* plate above).

Plate VA. Salmon Glacier, looking west. Medial moraine, with supraglacial debris along old "cat" road.

Plate VB. Ice worms, *Mesenchytræus solifugus*.

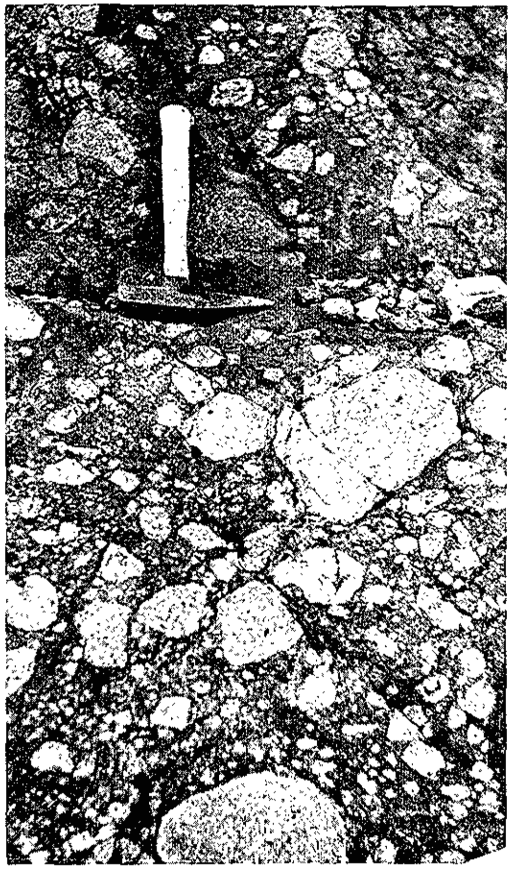


Plate VIa. Volcanic breccia, Mount Dillworth, purple fragments in red matrix.

Plate VIb. Volcanic breccia, Mount Dillworth, red and green fragments in schistose green matrix.

Plate VIc. Volcanic breccia, Premier area, green fragments in green matrix.

Plate VIIA. Weakly deformed green volcanic conglomerate, Premier area, showing fragments, crude foliation, and pencil lineation.

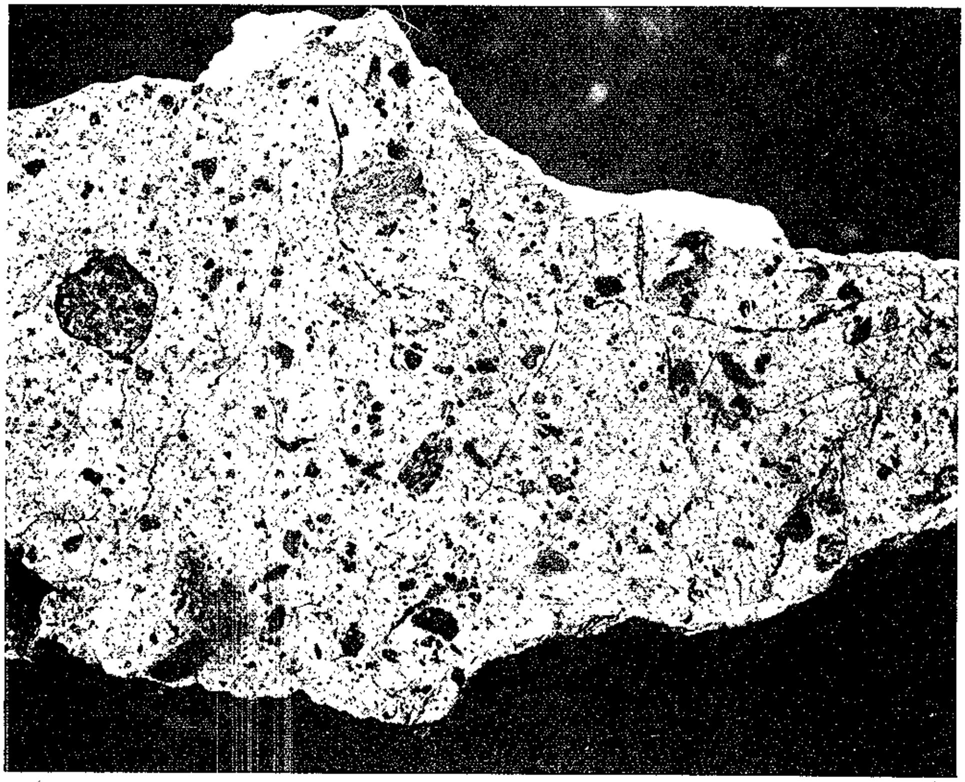


Plate VIIB. Cross-sectional view of specimen in Plate VIIA.

Plate VIIIA. Red and green volcanic conglomerate and sandstone. Betty Creek section. Tops up to right.

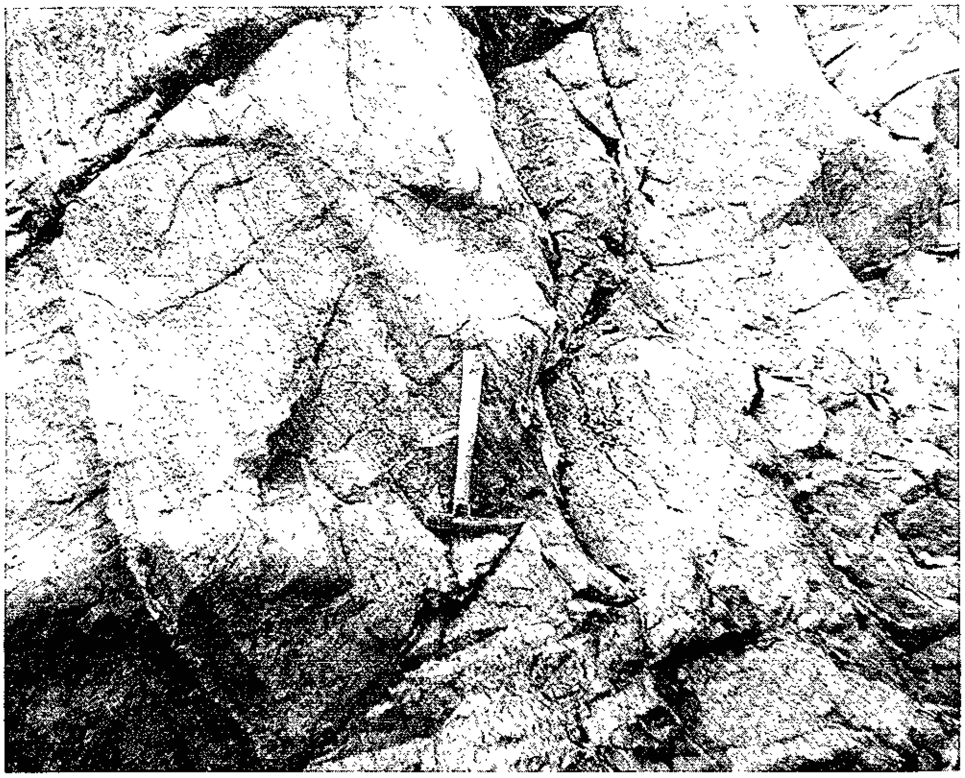


Plate VIIIB. Close-up of Plate VIIIA showing laminations and cross-bedding.

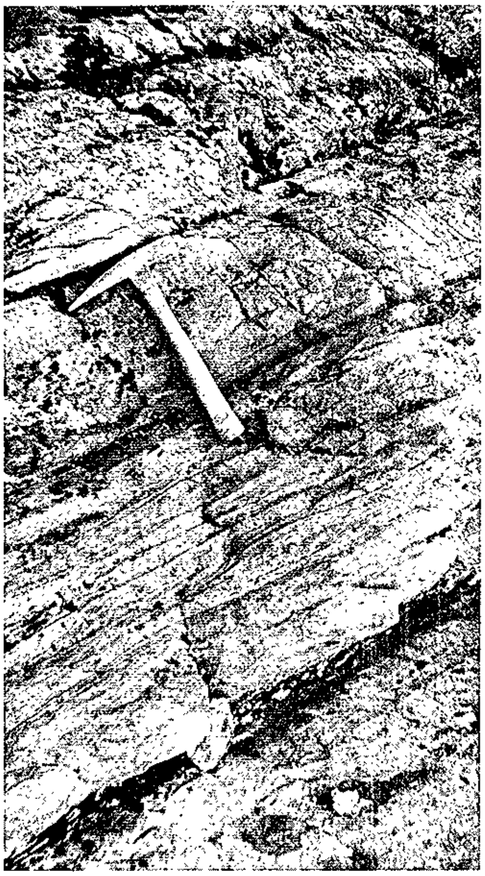


Plate IXA. Green volcanic sandstone with thin-bedded intercalated lithic tuff.

Plate IXB. Cross-bedded, green volcanic sandstone.

Plate IXC. Green mylonite breccia, B.C. Silver section. Note "red" fracture filling.

Plate XA. Contact area volcanic epiclastics (foreground) and overlying Bowser sediments, Troy Ridge section.

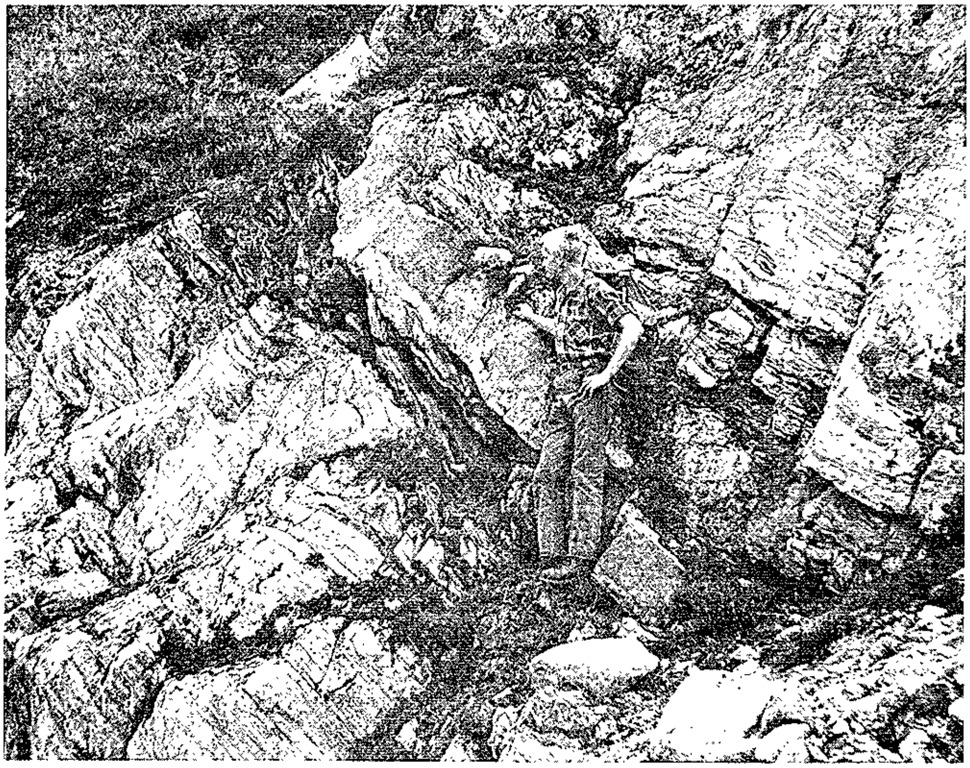


Plate XB. Transition zone, Troy Ridge. Volcanic sandstone, lithic tuff, dolomite, greywacke, siltstone. Tops up.

Plate XI. Bowser siltstone (black) and intercalated greywacke (grey), Troy Ridge looking west. Note curvilinear folds (*see* p. 84).

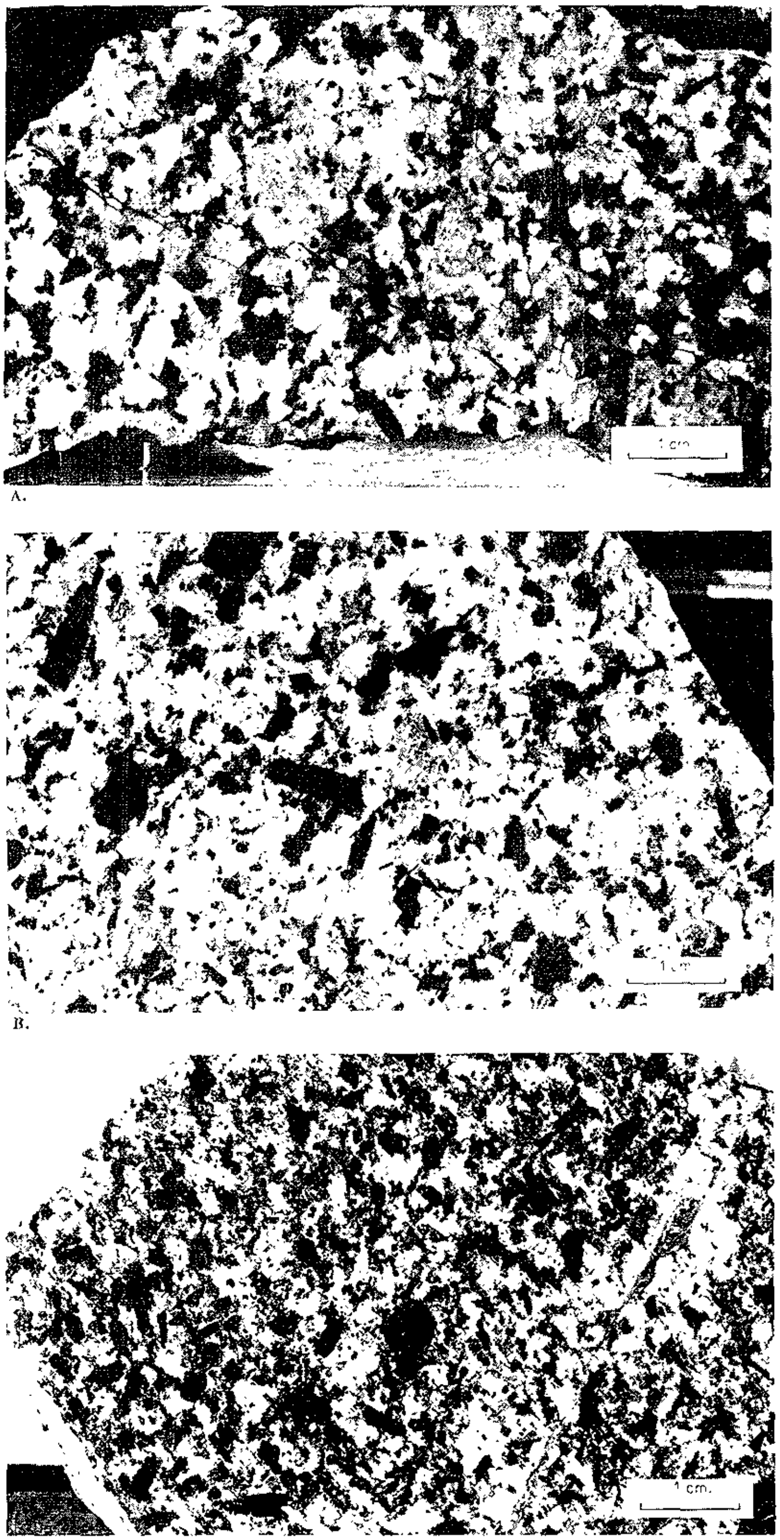
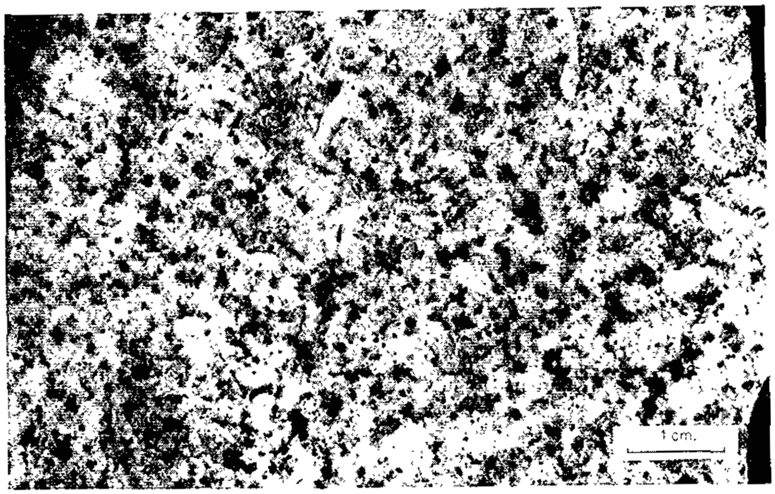
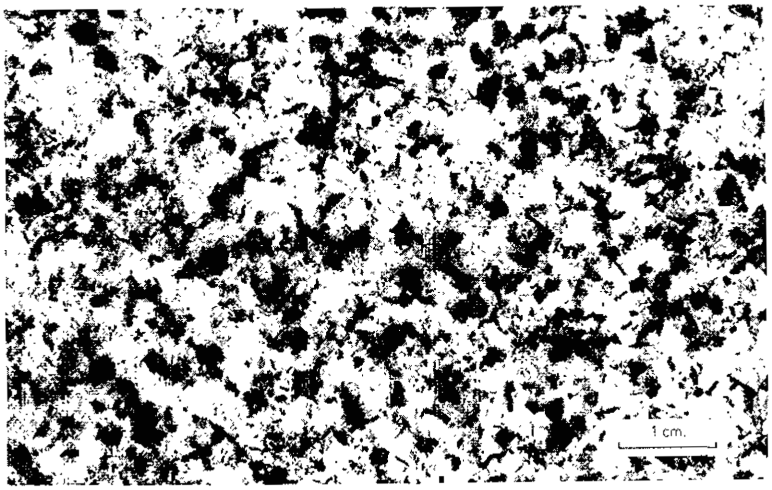


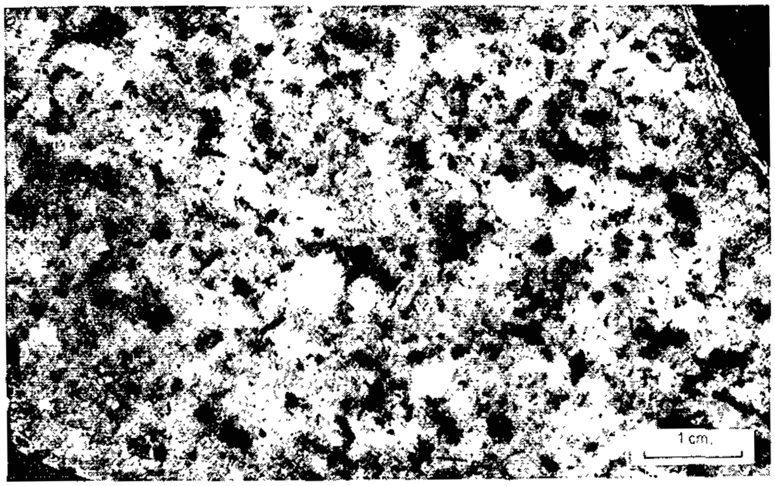
Plate XII. Hand specimens of the Texas Creek granodiorite pluton.
A. Ninemile area. B. Riverside area. C. Fish Creek area.



A.



B.



C.

Plate XIII. Hand specimens of the Hyder quartz-monzonite pluton.
A. Hyder quarry. B. Barney Gulch. C. Bear River bridge quarry.

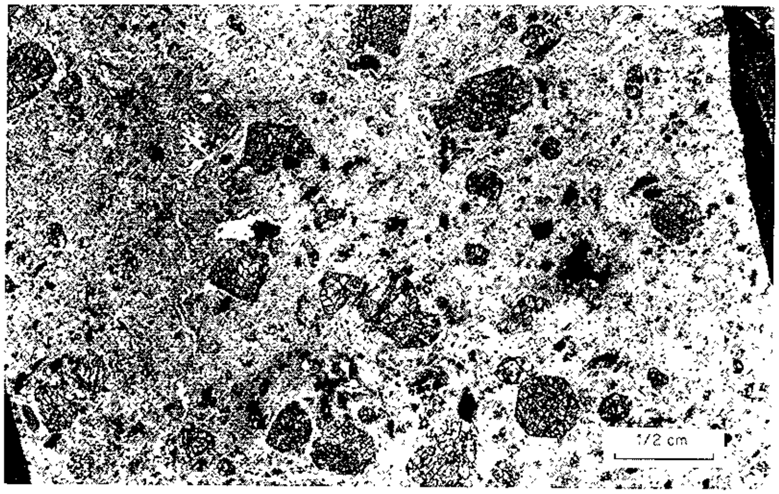


Plate XIVA. Hand specimen of the Glacier Creek diorite plutons, Long Lake stock.

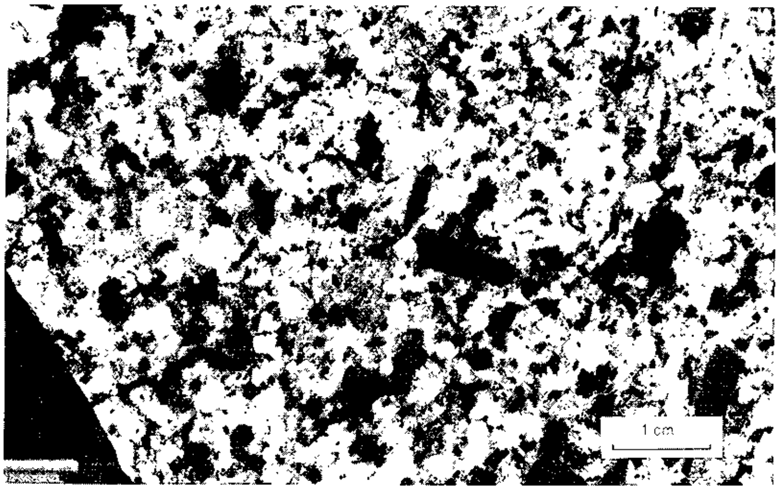


Plate XIVB. Hand specimen, Summit Lake granodiorite stock.

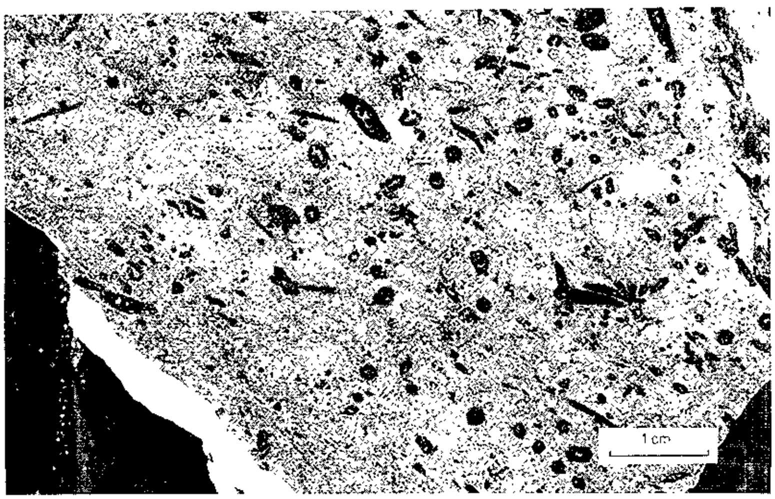


Plate XIVC. Hand specimen, altered green volcanic conglomerate showing coarse-grained incipient hornblende.

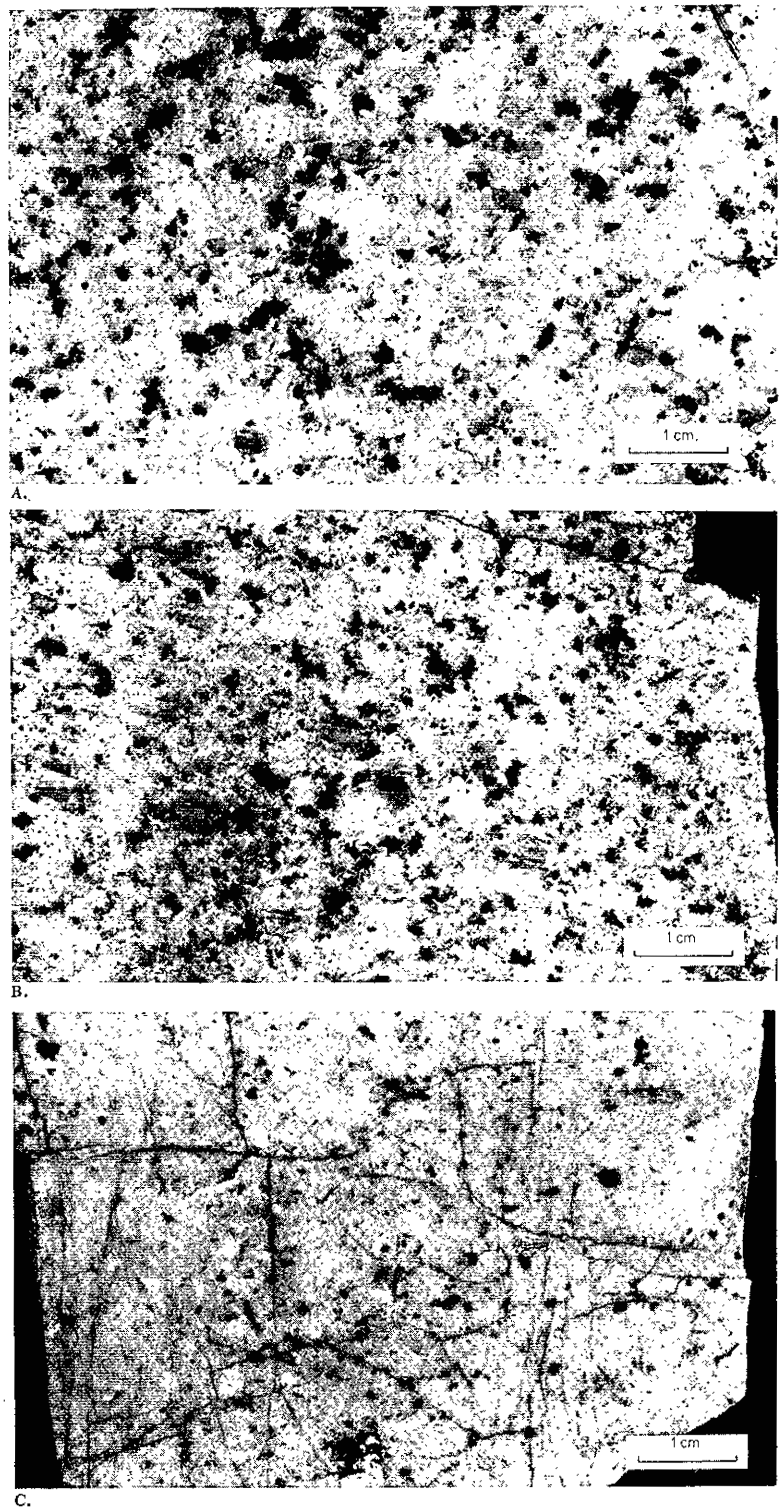
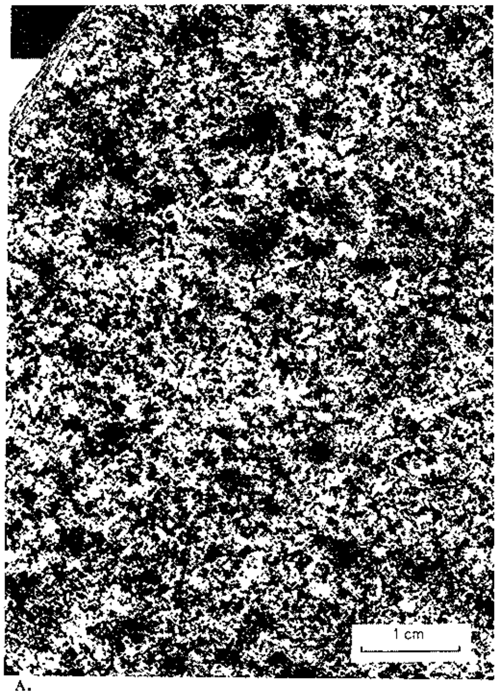
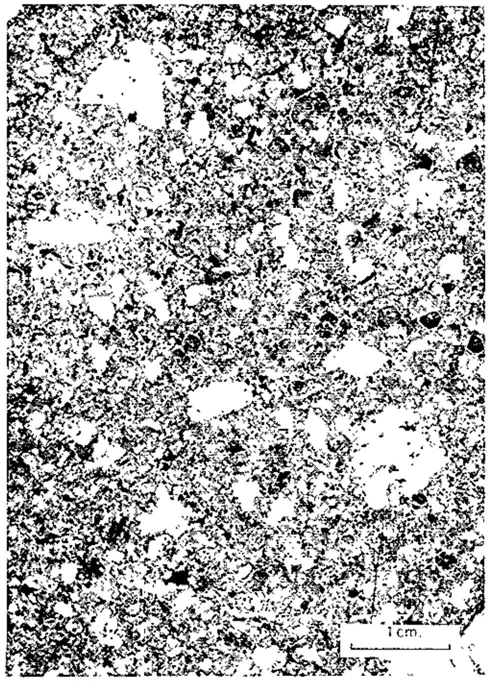


Plate XV. Hand specimens, Bitter Creek quartz-monzonite pluton. A. Uniform coarse-grained phase, Bitter Creek quarry. B. Porphyritic phase, Bitter Creek section. C. Quartz porphyry phase, Bear River section.

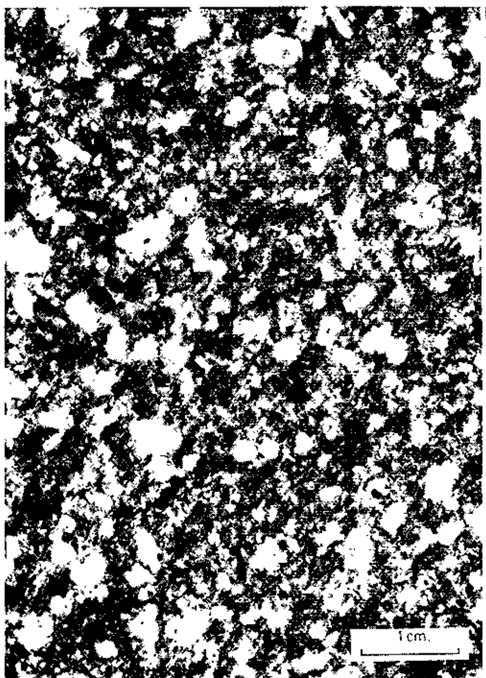


A.

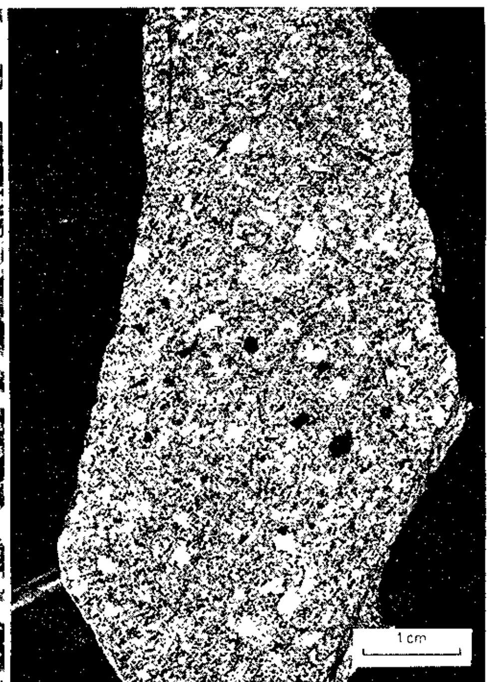


B.

Plate XVI. Hand specimens of dyke rocks. A. Bear River Pass type, uniform diorite. B. Portland Canal type, porphyritic granodiorite. C. Premier type, uniform porphyritic granodiorite. D. Lamprophyre, spessartite variety.



C.



D.

Plate XVIIA. Portland Canal dyke swarm, looking west to Outland Point.

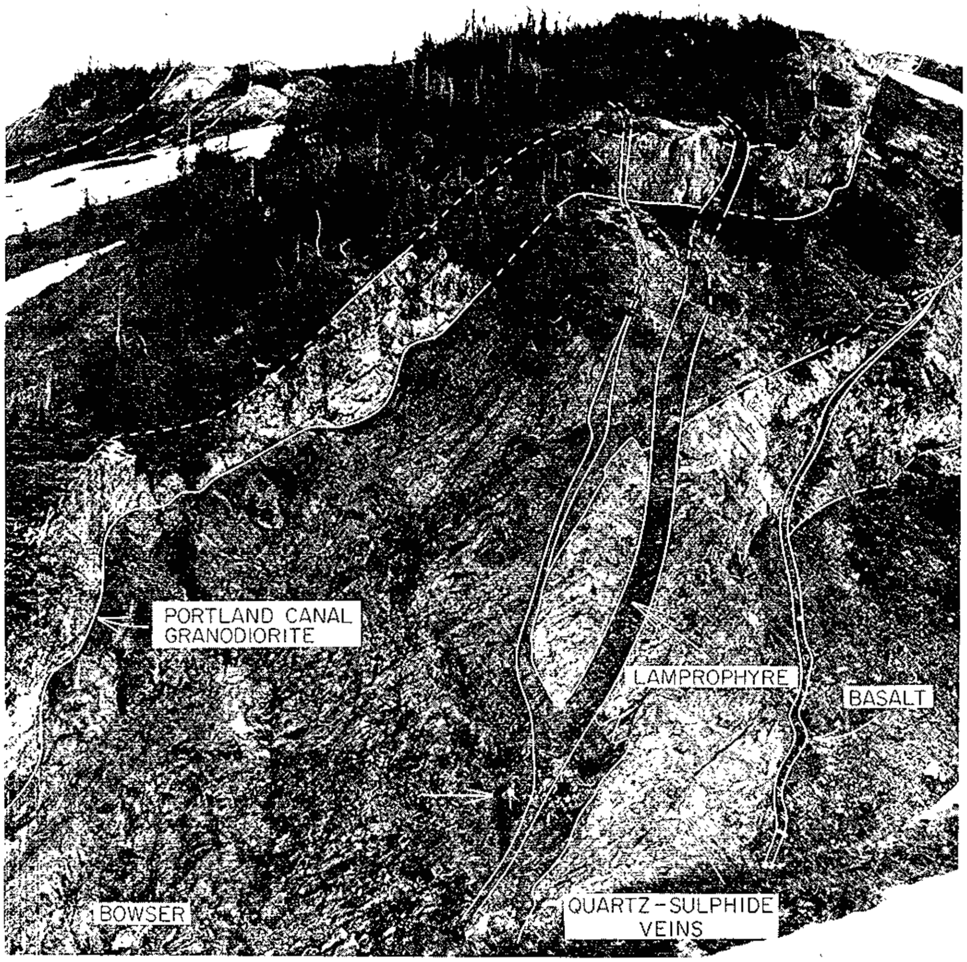


Plate XVIIB. Portland Canal dyke swarm, Mount Dillworth area, showing lamprophyre dykes cutting Portland Canal-type dykes. Portland Canal dykes intrude Bowser sediments.

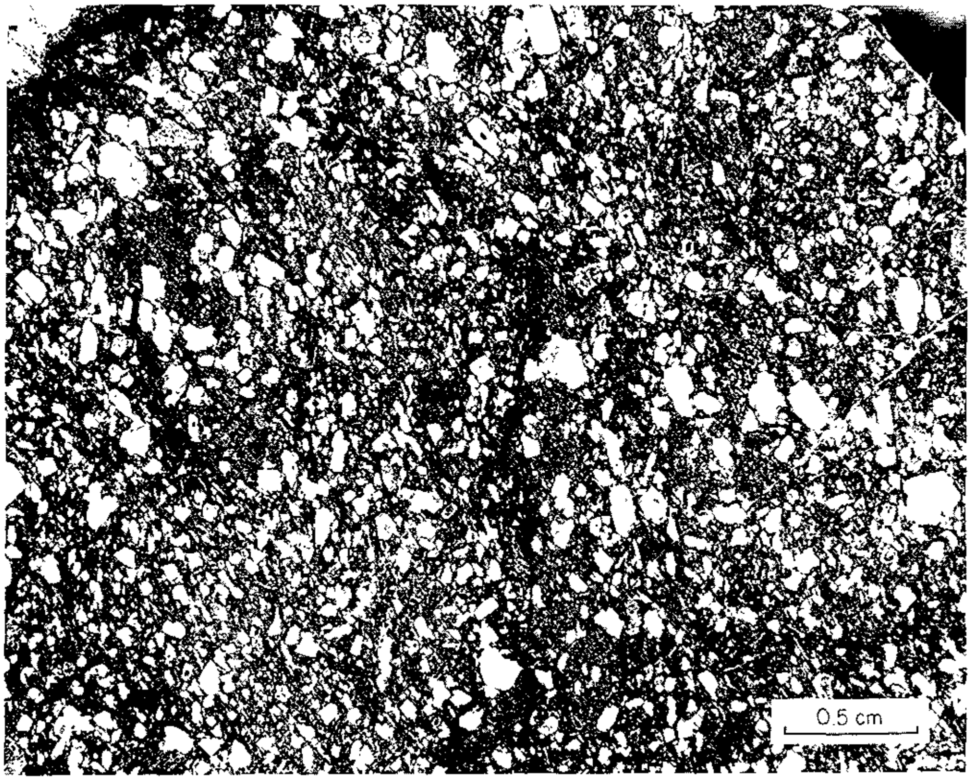


Plate XVIIIA. Hand specimen, black mylonite, Cobalt Creek section.

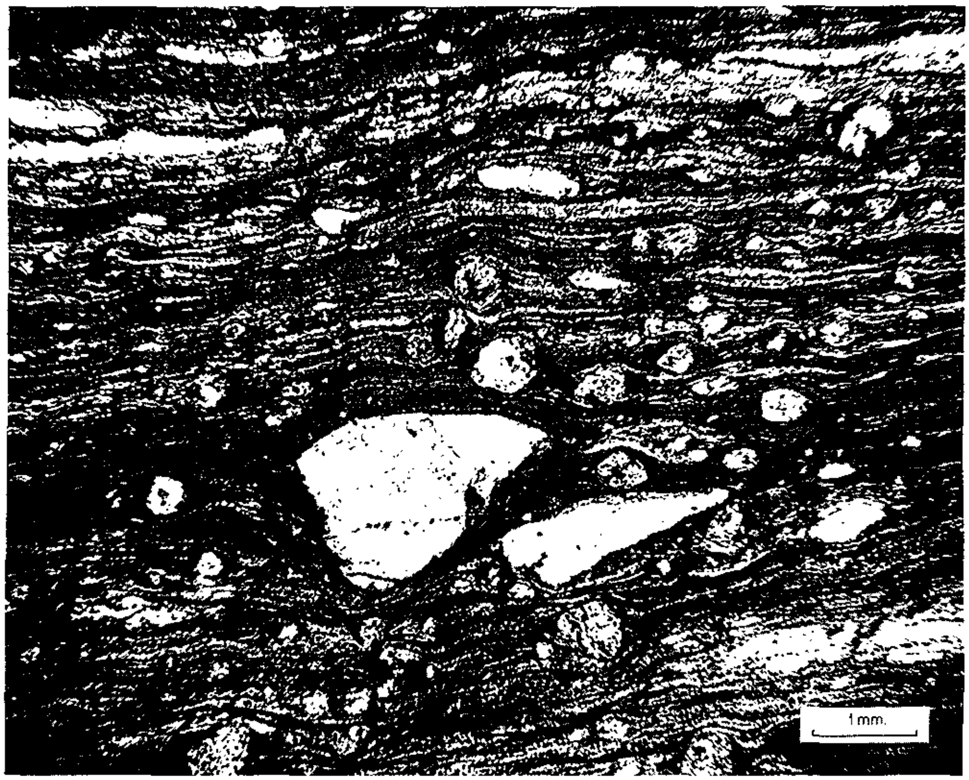


Plate XVIIIB. Negative projection of a thin-section of black mylonite showing feldspar clasts and banding.

Plate XXIVA. Big Missouri camp, Hog Lake, 1939. Only a few remnant foundations survive today.

Plate XXIVB. View from the United Empire across Bear River valley to the Dunwell mine, 1935.

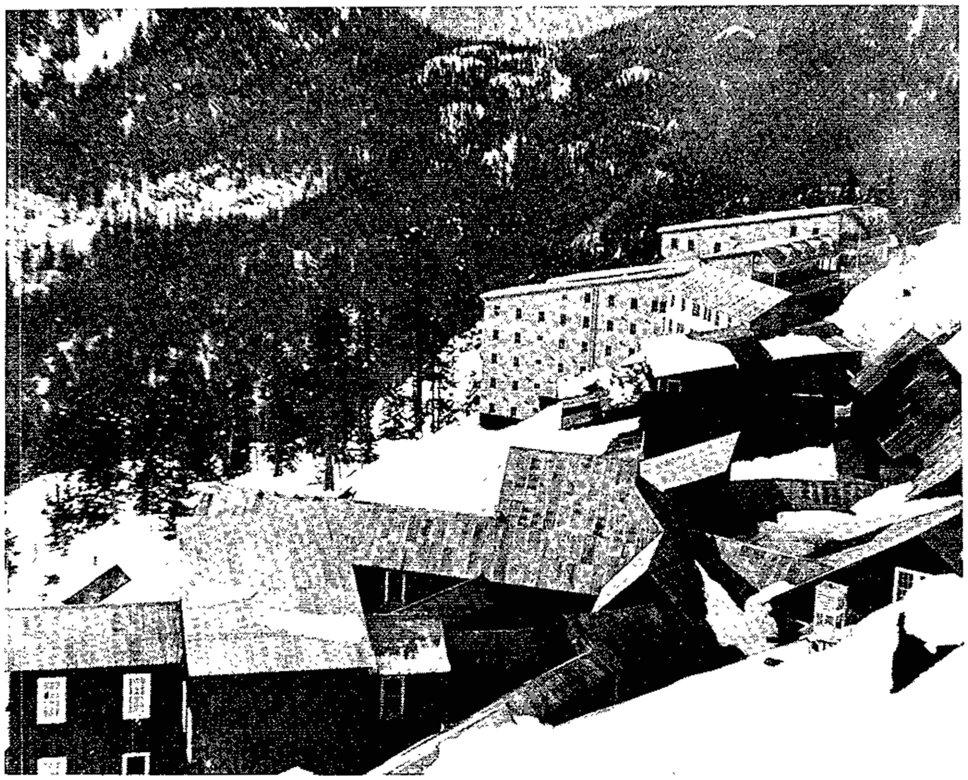


Plate XXIIIA. Premier, British Columbia, main camp Premier mine, 4 level area, 1928. Only the office and bunkhouse (background) now remain.

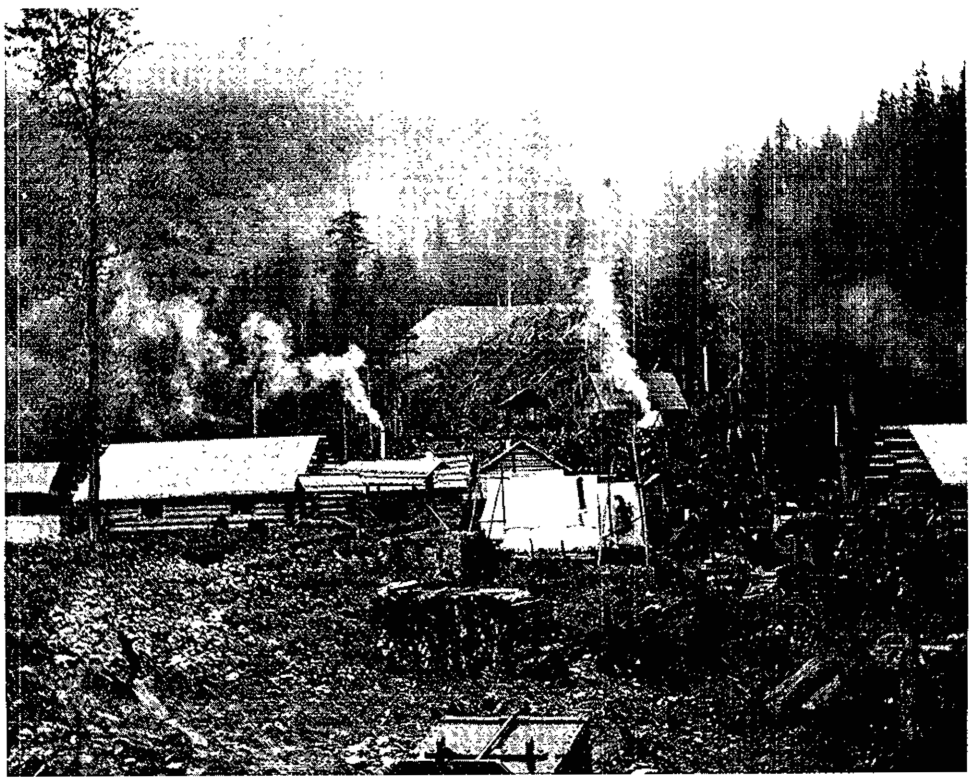


Plate XXIIIB. Red Cliff mine, main camp, 1910.

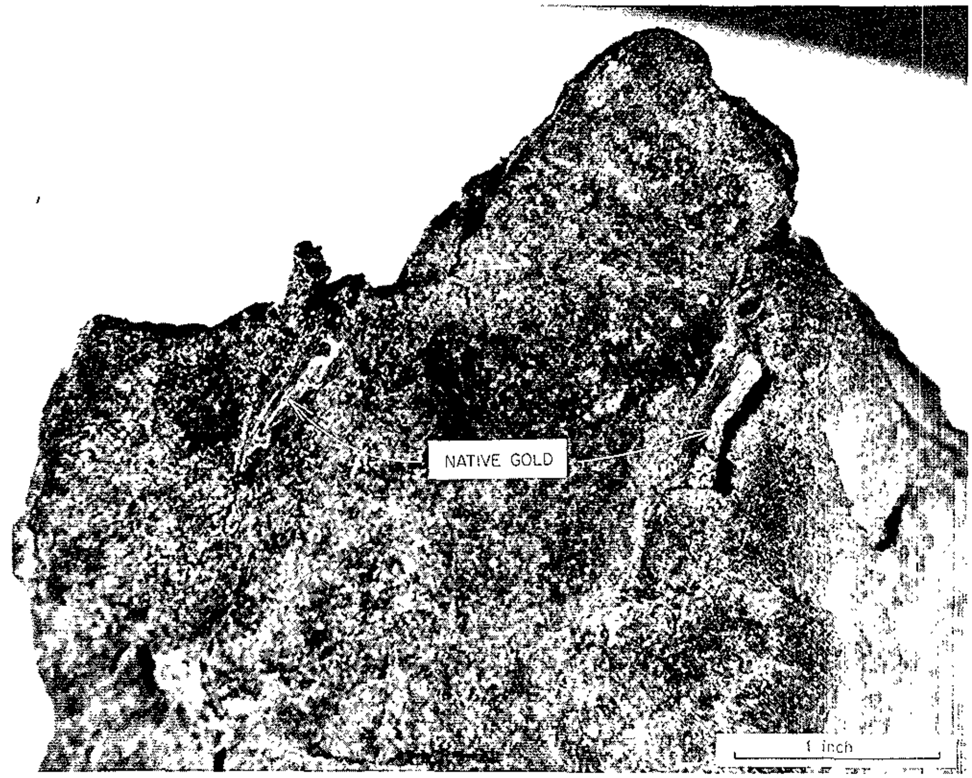


Plate XXIIA. Hand specimen, massive argentite, showing native gold as veinlets, Silbak Premier mine.

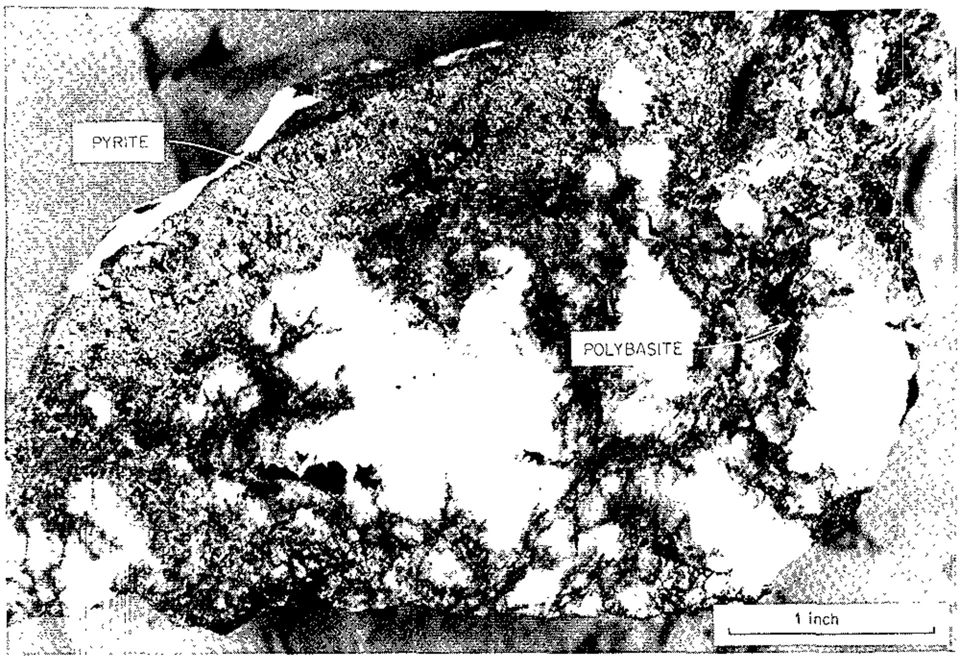


Plate XXIIB. Hand specimen, late stage quartz vein, showing polybasite, tetrahedrite, and native silver (in vugs), Silbak Premier mine.

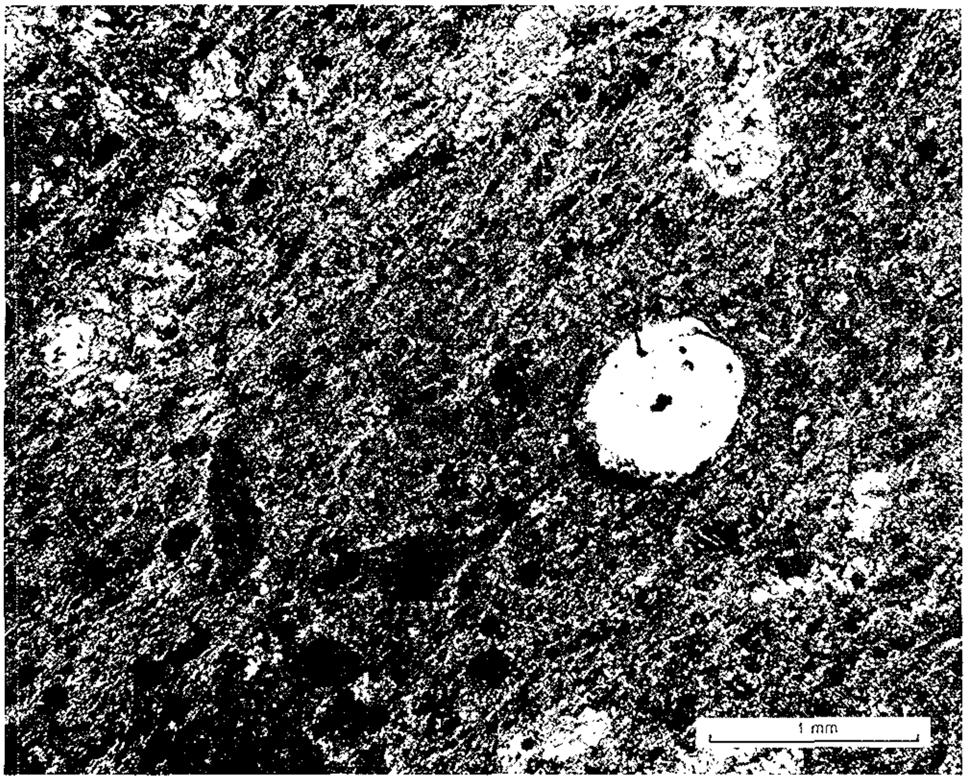


Plate XXIA. Photomicrograph of green cataclasite, Cascade Creek section, showing angular plagioclase clasts, rock fragments, and rounded quartz particles.

Plate XXIB. Hand specimen, Premier porphyry.

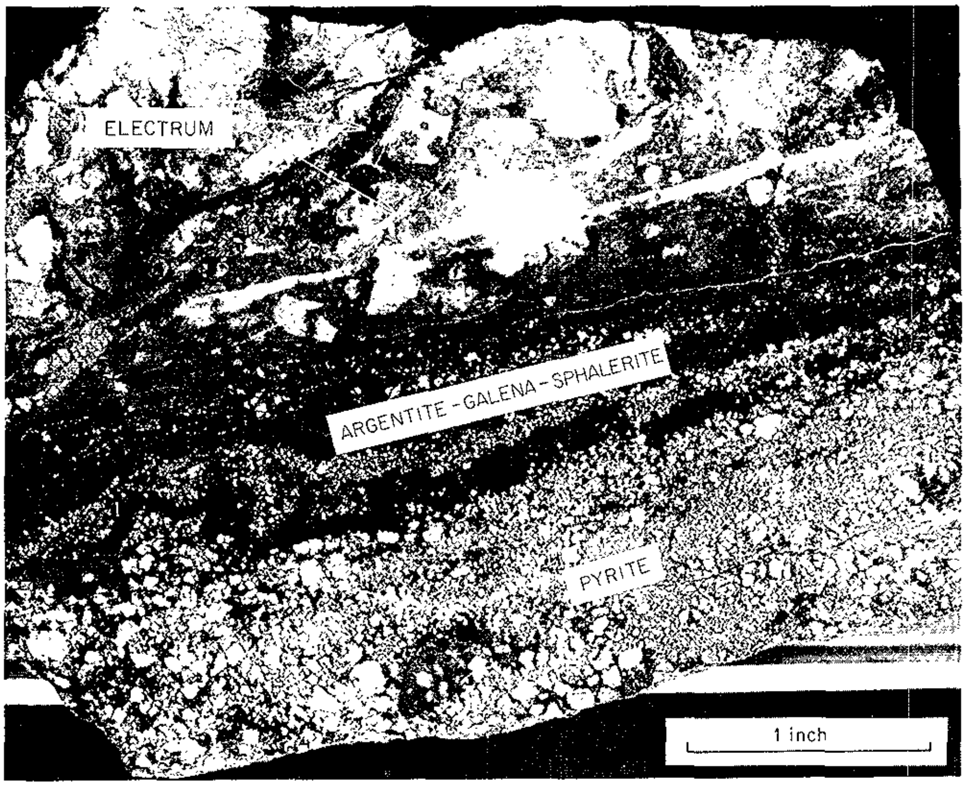


Plate XXA. Polished hand specimen, Bonanza-type ore, Silbak Premier mine, showing mineral banding, electrum veinlets along fractures, and altered country rocks.

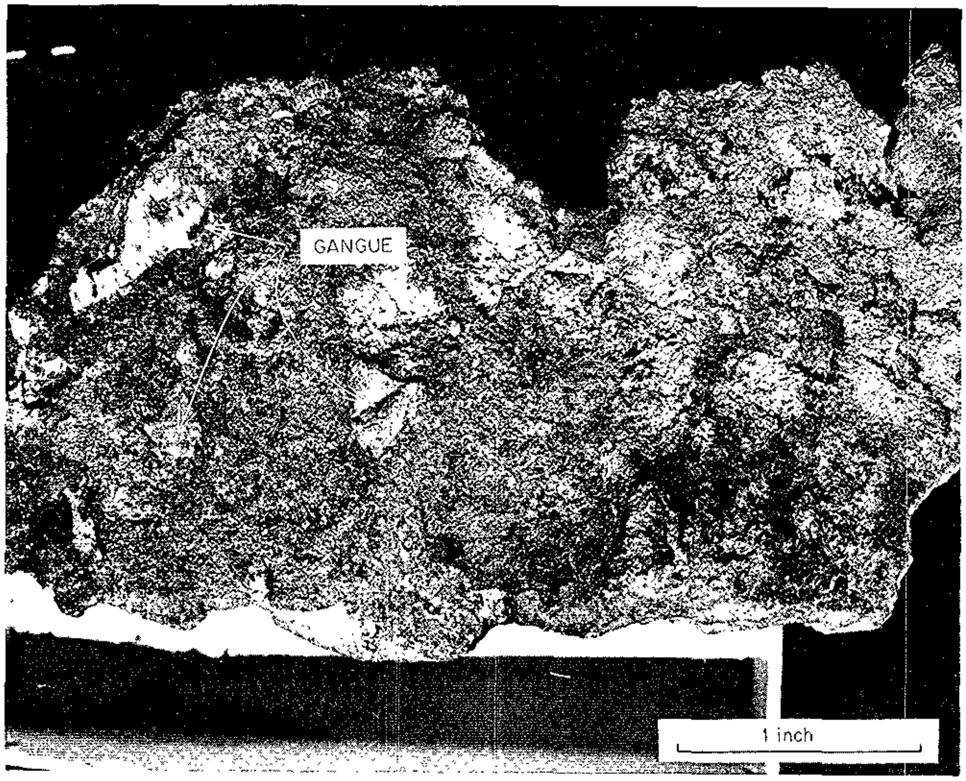


Plate XXB. Hand specimen, electrum vein, Silbak Premier mine.

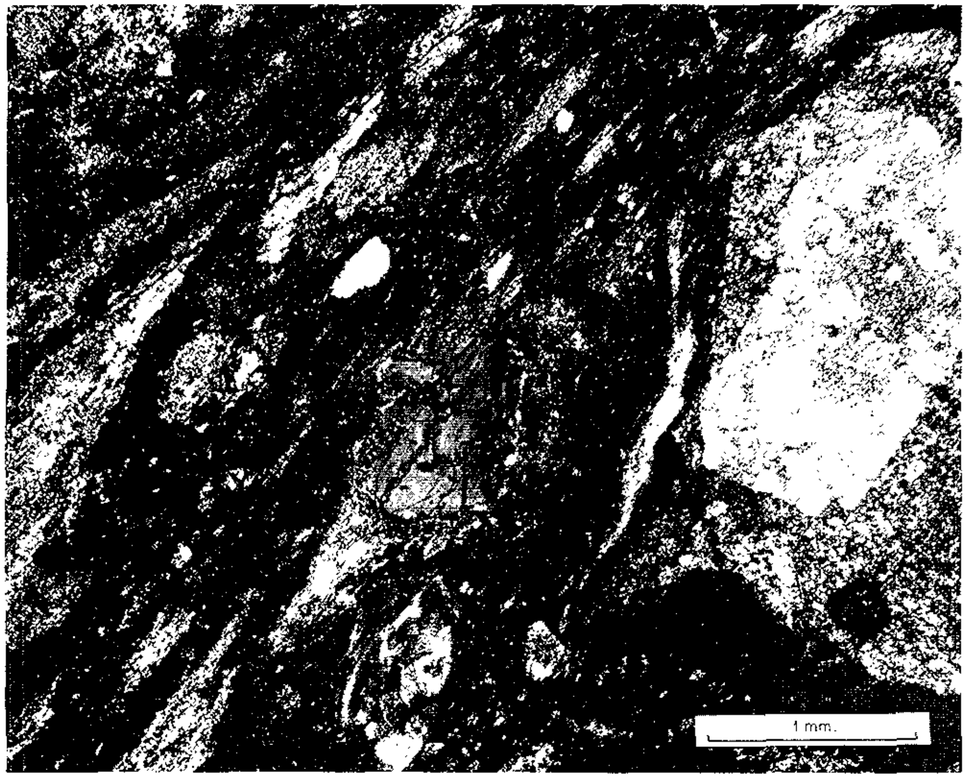
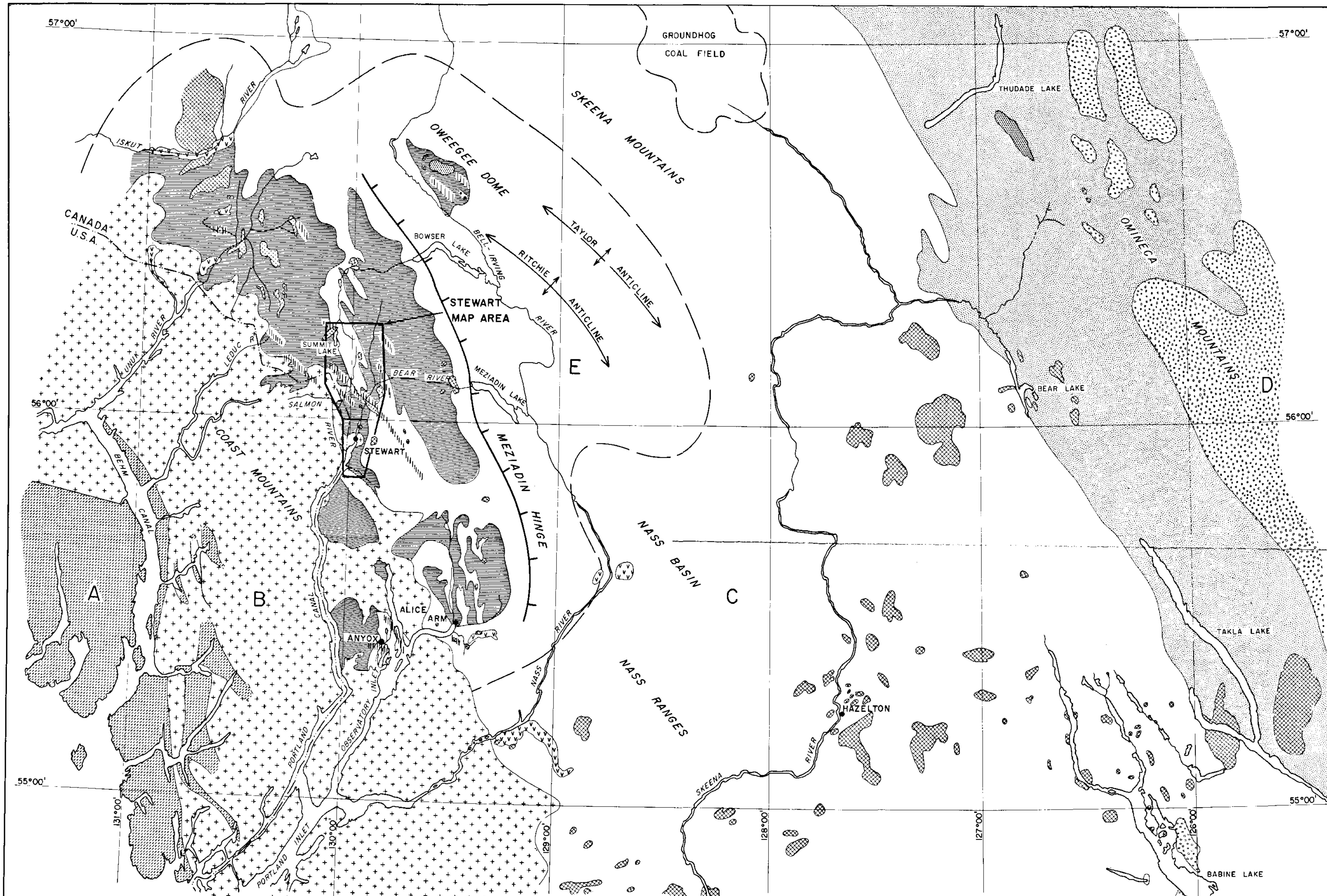


Plate XIXA. Photomicrograph of green volcanic conglomerate-crossed nicols.

Plate XIXB. Negative projection of a thin-section of green kakirite.



SEDIMENTS - VOLCANICS

- Stewart Complex - Triassic and Jurassic (undivided)
- Sustut Assemblage - Cretaceous and Tertiary (undivided)
- Palaeozoic
- Tertiary and Recent Volcanics
- Bowser Assemblage - Middle Jurassic to Upper Jurassic (undivided)

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure I

GEOLOGICAL FEATURES

in a portion of

Northwestern B.C. — Southeastern Alaska

SCALE 0 8 16 24 32 MILES

INTRUSIVES

- Coast - undivided
- Omineca - Topley - undivided
- Skeena - undivided
- Dyke swarms - undivided

MAJOR FEATURES

- A Wrangell - Revillagigedo Belt
- B Coast Crystalline Belt
- C Bowser Basin
- D Omineca Crystalline Belt
- E Bear River Uplift
- Wrangell - Revillagigedo Metamorphics

#58 ①

Figure I

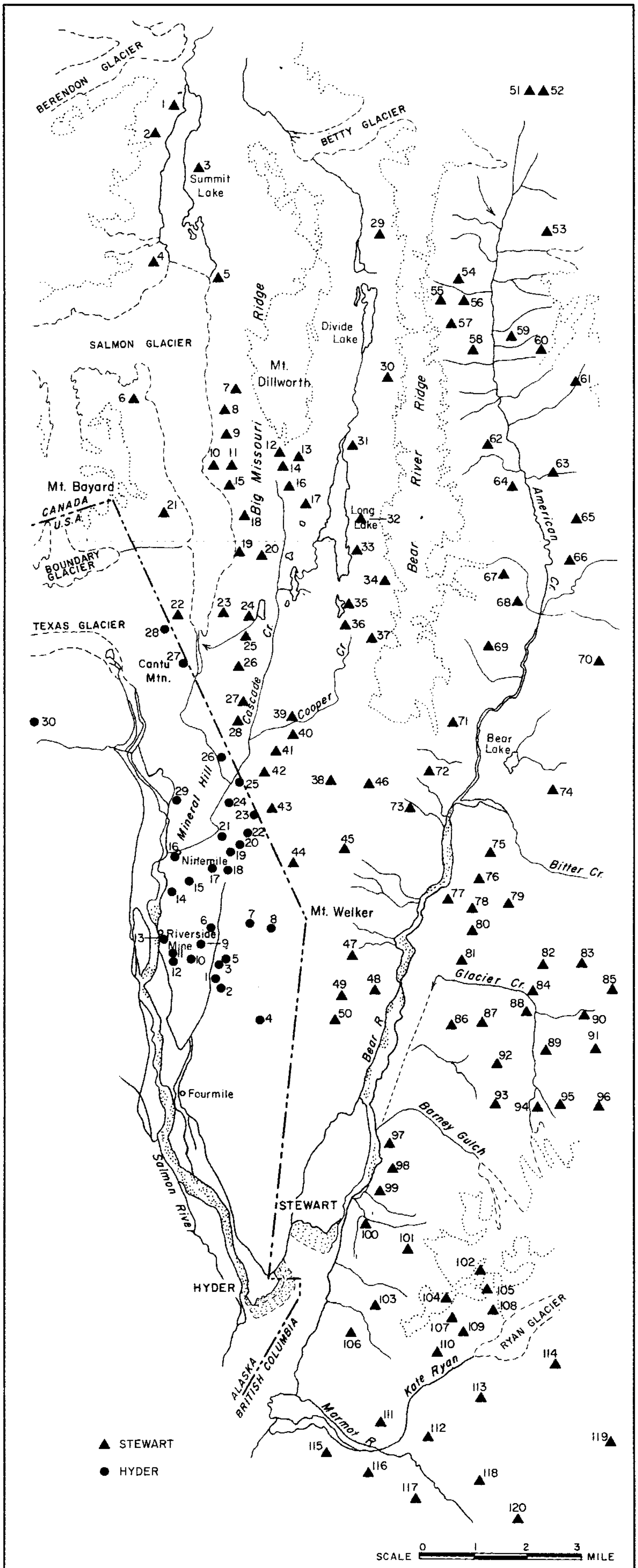
Figure 2

SKETCH MAP OF SUMMIT LAKE AREA SHOWING RECENT GLACIAL RECESSION

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources 1970

#58 (2)

Figure 2



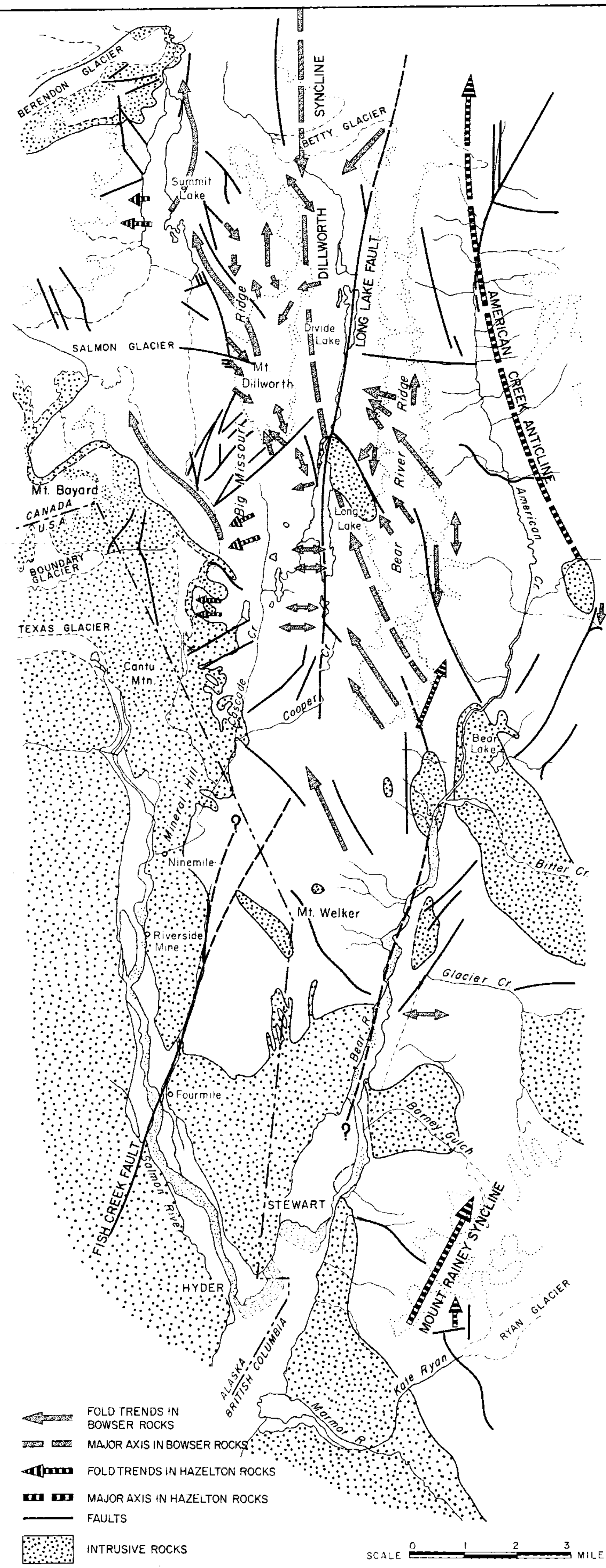
MINES AND PROSPECTS IN THE STEWART AND HYDER AREAS

DISTRIBUTION MAP No. 1

Figure 8

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources, 1970

Figure 8



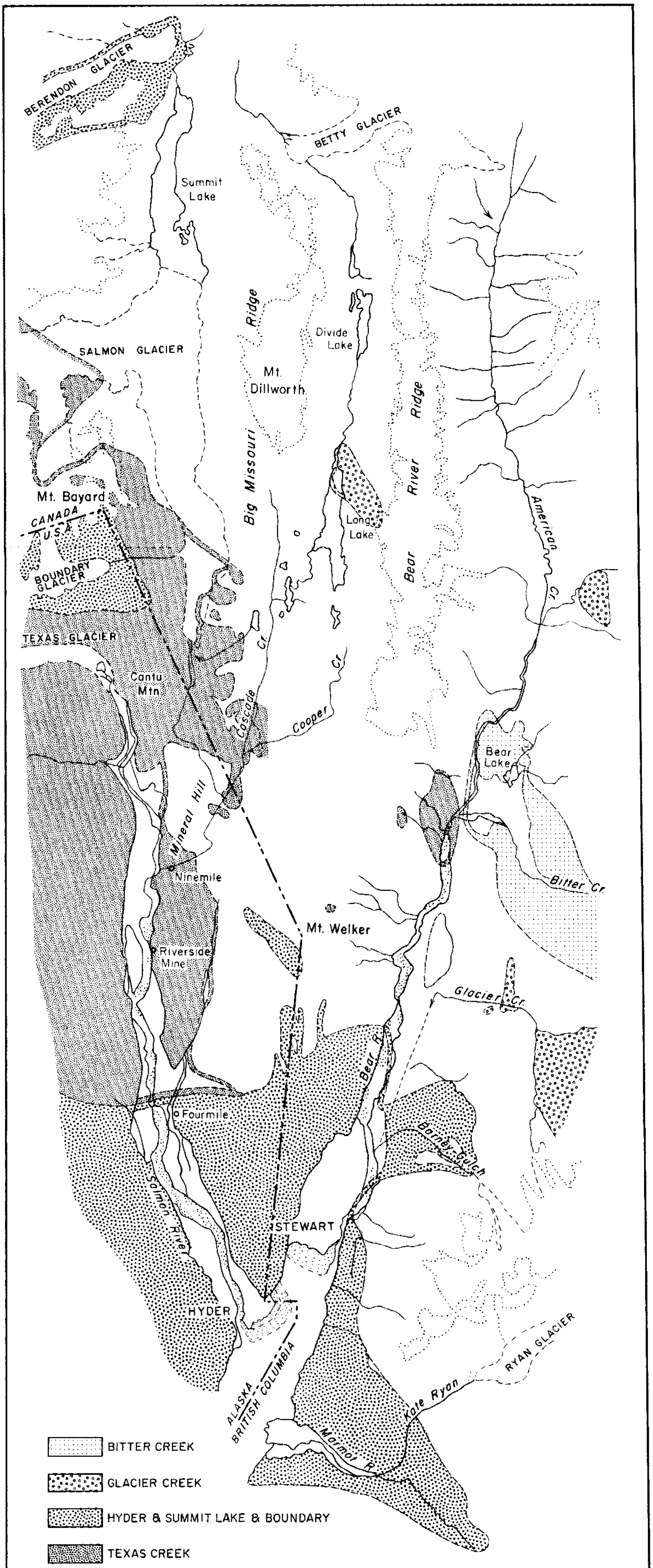
DISTRIBUTION MAP SHOWING STRUCTURAL TRENDS

DISTRIBUTION MAP No. 2

Figure 9

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources, 1970

Figure 9

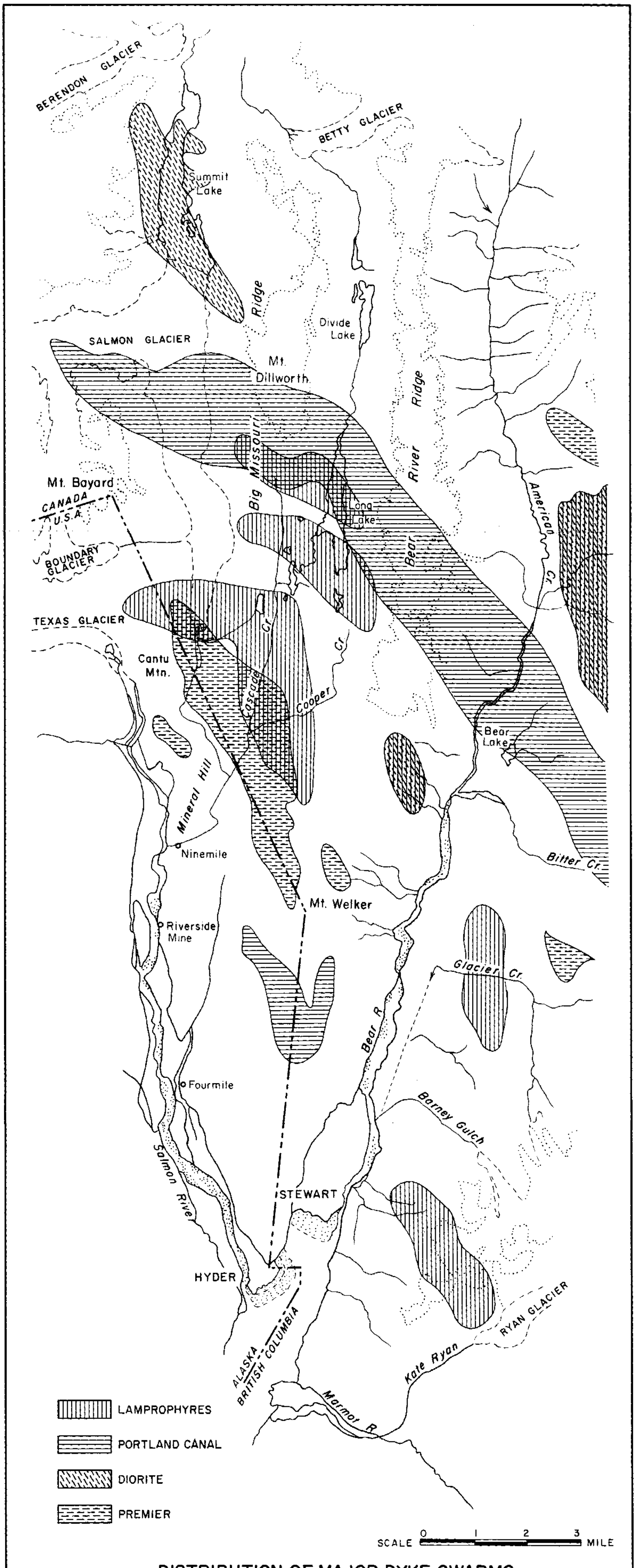


DISTRIBUTION OF MAJOR PLUTONIC ROCK TYPES
DISTRIBUTION MAP No. 3

Figure 10

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 10

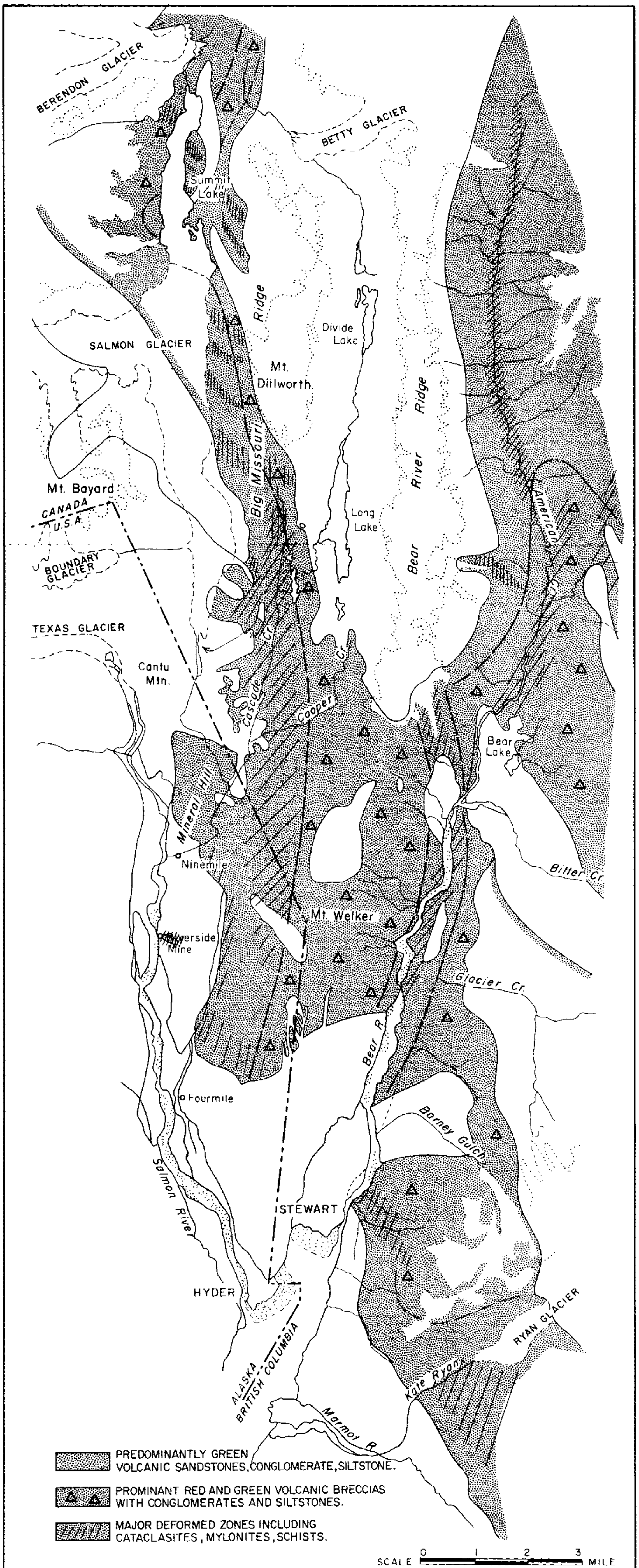


DISTRIBUTION OF MAJOR DYKE SWARMS

DISTRIBUTION MAP No. 4

Figure 11

To Accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources, 1970



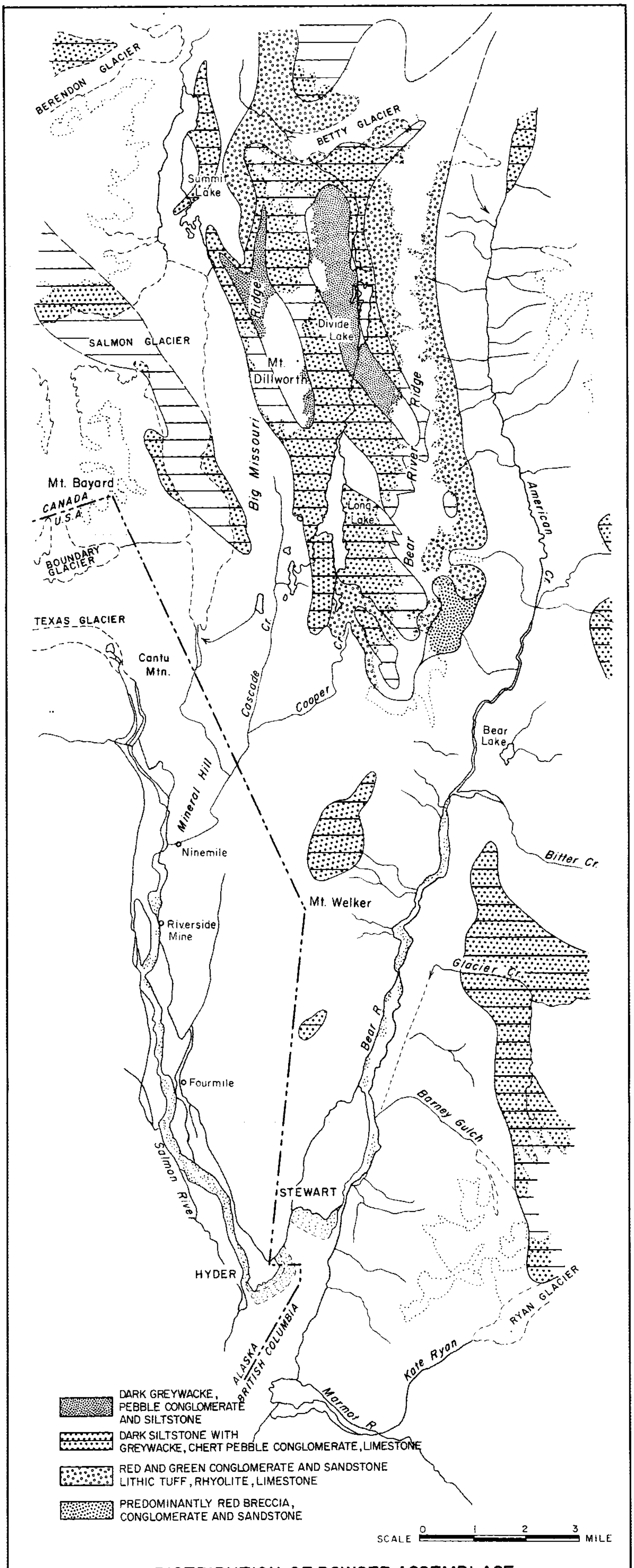
DISTRIBUTION OF HAZELTON ASSEMBLAGE

DISTRIBUTION MAP No. 5

Figure 12.

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 12



DISTRIBUTION OF BOWSER ASSEMBLAGE

DISTRIBUTION MAP No. 6

Figure 13

To Accompany Builletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 13

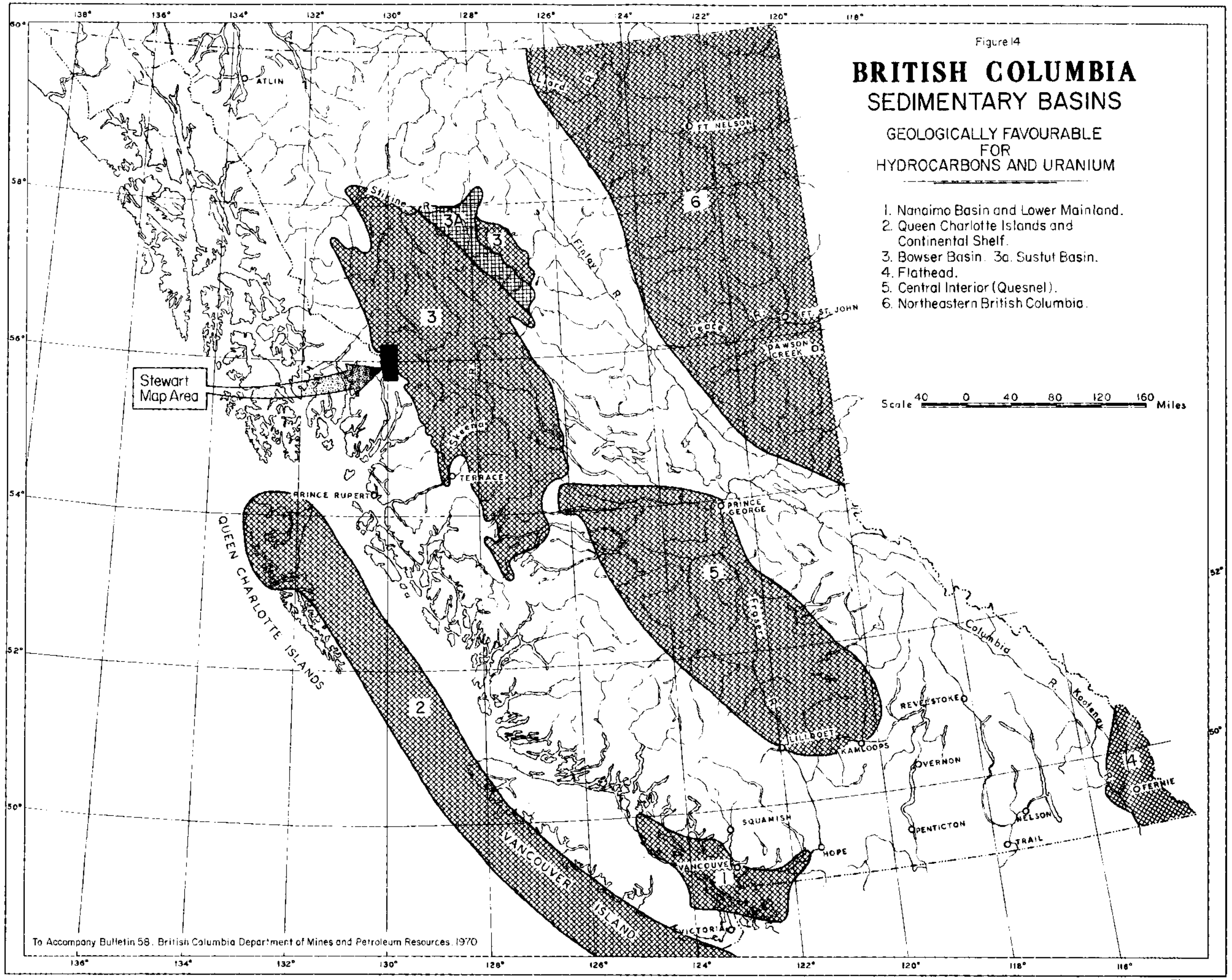
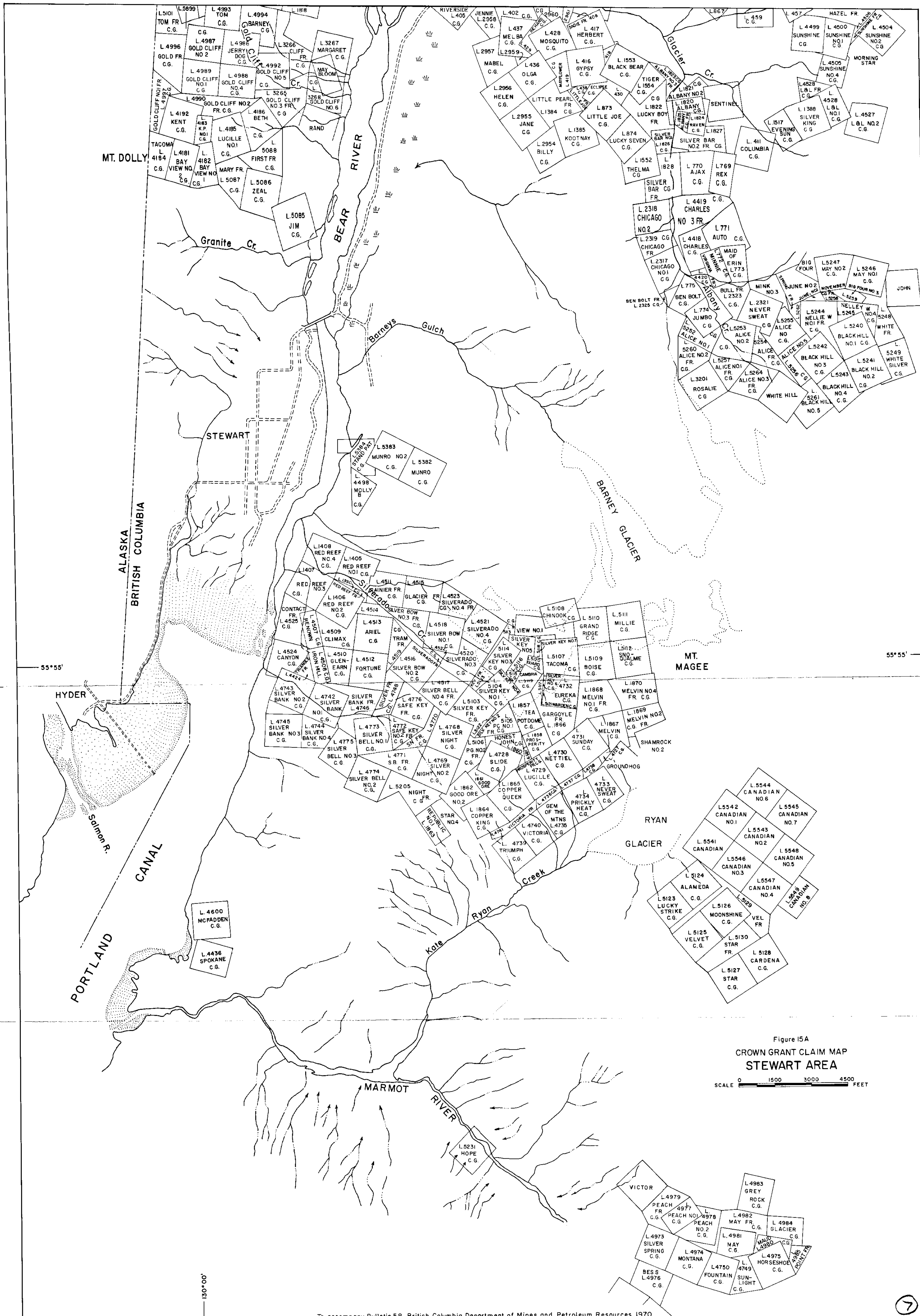


Figure 14
BRITISH COLUMBIA
SEDIMENTARY BASINS
GEOLOGICALLY FAVOURABLE
FOR
HYDROCARBONS AND URANIUM
1. Nanaimo Basin and Lower Mainland.
2. Queen Charlotte Islands and Continental Shelf.
3. Bowser Basin. 3a. Sustut Basin.
4. Flathead.
5. Central Interior (Quesnel).
6. Northeastern British Columbia.
Scale 40 0 40 80 120 160 Miles
Stewart Map Area
ATLIN
FT. NELSON
FT. ST. JOHN
DAWSON CREEK
TERRACE
PRINCE RUPERT
PRINCE GEORGE
QUEEN CHARLOTTE ISLANDS
VANCOUVER ISLAND
REVELSTOKE
LILLOOET
KAMLOOPS
VERNON
PENTICTON
NELSON
TRAIL
FERNIE
SQUAMISH
HOPE
VANCOUVER
VICTORIA
Stikine R.
Finlay R.
Peace R.
Fraser
Columbia R.
Kootenay
To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 14



MT. DOLLY
BEAR RIVER
Granite Cr.
Barneys Gulch
STEWART
ALASKA
BRITISH COLUMBIA
HYDER
Salmon R.
PORTLAND CANAL
BARNEY GLACIER
MT. MAGEE
RYAN GLACIER
Kate Ryan Creek
MARMOT RIVER
Glacier Cr.
Albany Cr.
Silverado Cr.
55°55'
130°00'
L.4996 GOLD FR. C.G.
L.4987 GOLD CLIFF NO.2
L.4989 GOLD CLIFF NO.1 C.G.
L.4988 GOLD CLIFF NO.4 C.G.
L.4992 GOLD CLIFF NO.5
L.3267 MARGARET C.G.
L.4192 KENT C.G.
L.4185 LUCILLE NO.1
L.5088 FIRST FR C.G.
L.5087
L.5086 ZEAL C.G.
L.5085 JIM C.G.
L.4181 BAY VIEW NO.2 C.G.
L.2957 MABEL C.G.
L.2956 HELEN C.G.
L.2955 JANE C.G.
L.2954 BILLY C.G.
L.437 MELBA C.G.
L.428 MOSQUITO C.G.
L.417 HERBERT C.G.
L.436 OLGA C.G.
L.416 GYPSY C.G.
L.1553 BLACK BEAR C.G.
L.1554 TIGER C.G.
L.1822 LUCKY BOY FR.
L.873 LITTLE JOE C.G.
L.874 LUCKY SEVEN C.G.
L.1385 KOOTNAY C.G.
L.1552 THELMA C.G.
L.770 AJAX C.G.
L.769 REX C.G.
L.411 COLUMBIA C.G.
L.4419 CHARLES NO 3 FR.
L.2318 CHICAGO NO.2
L.771 AUTO C.G.
L.4418 CHARLES C.G.
L.2317 CHICAGO NO.1 C.G.
L.4499 SUNSHINE C.G.
L.4500 SUNSHINE NO.1 C.G.
L.4504 SUNSHINE NO.2 C.G.
L.1388 SILVER KING C.G.
L.4527 L & L NO.2 C.G.
L.5247 MAY NO.2 C.G.
L.5246 MAY NO.1 C.G.
JOHN
L.2321 NEVER SWEAT C.G.
L.5242 BLACK HILL NO.3 C.G.
L.5241 BLACK HILL NO.2 C.G.
L.3201 ROSALIE C.G.
WHITE HILL
L.5383 MUNRO NO.2 C.G.
L.5382 MUNRO C.G.
L.4498 MOLLY B C.G.
L.1408 RED REEF NO.4 C.G.
L.1405 RED REEF NO.1 C.G.
L.1406 RED REEF NO.2 C.G.
L.4513 ARIEL C.G.
L.4512 FORTUNE C.G.
L.4524 CANYON C.G.
L.4521 SILVERADO NO.4 C.G.
L.5108 CHINOOK
L.5110 GRAND RIDGE C.G.
L.5111 MILLIE C.G.
L.5107 TACOMA C.G.
L.5109 BOISE C.G.
L.5112 SNOQUALMIE C.G.
L.1868 MELVIN NO.1 FR. C.G.
L.1870 MELVIN NO.4 FR. C.G.
L.4745 SILVER BANK NO.3 C.G.
L.4774 SILVER BELL NO.2 C.G.
L.5205 NIGHT FR. C.G.
L.1864 COPPER KING C.G.
L.4739 TRIUMPH C.G.
L.5544 CANADIAN NO.6
L.5545 CANADIAN NO.7
L.5542 CANADIAN NO.1
L.5543 CANADIAN NO.2
L.5541 CANADIAN
L.5546 CANADIAN NO.3
L.5548 CANADIAN NO.5
L.5547 CANADIAN NO.4
L.5124 ALAMEDA C.G.
L.5123 LUCKY STRIKE C.G.
L.5126 MOONSHINE C.G.
L.5125 VELVET C.G.
L.5130 STAR FR.
L.5128 CARDENA C.G.
L.5127 STAR C.G.
L.4600 McFADDEN C.G.
L.4436 SPOKANE C.G.
L.5231 HOPE C.G.
VICTOR
L.4983 GREY ROCK C.G.
L.4979 PEACH FR C.G.
L.4982 MAY FR. C.G.
L.4984 GLACIER C.G.
L.4973 SILVER SPRING C.G.
L.4974 MONTANA C.G.
L.4981 MAY C.G.
L.4750 FOUNTAIN C.G.
L.4975 HORSESHOE C.G.
BESS L.4976 C.G.
Figure 15A
CROWN GRANT CLAIM MAP
STEWART AREA
SCALE 0 1500 3000 4500 FEET
To accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 15A

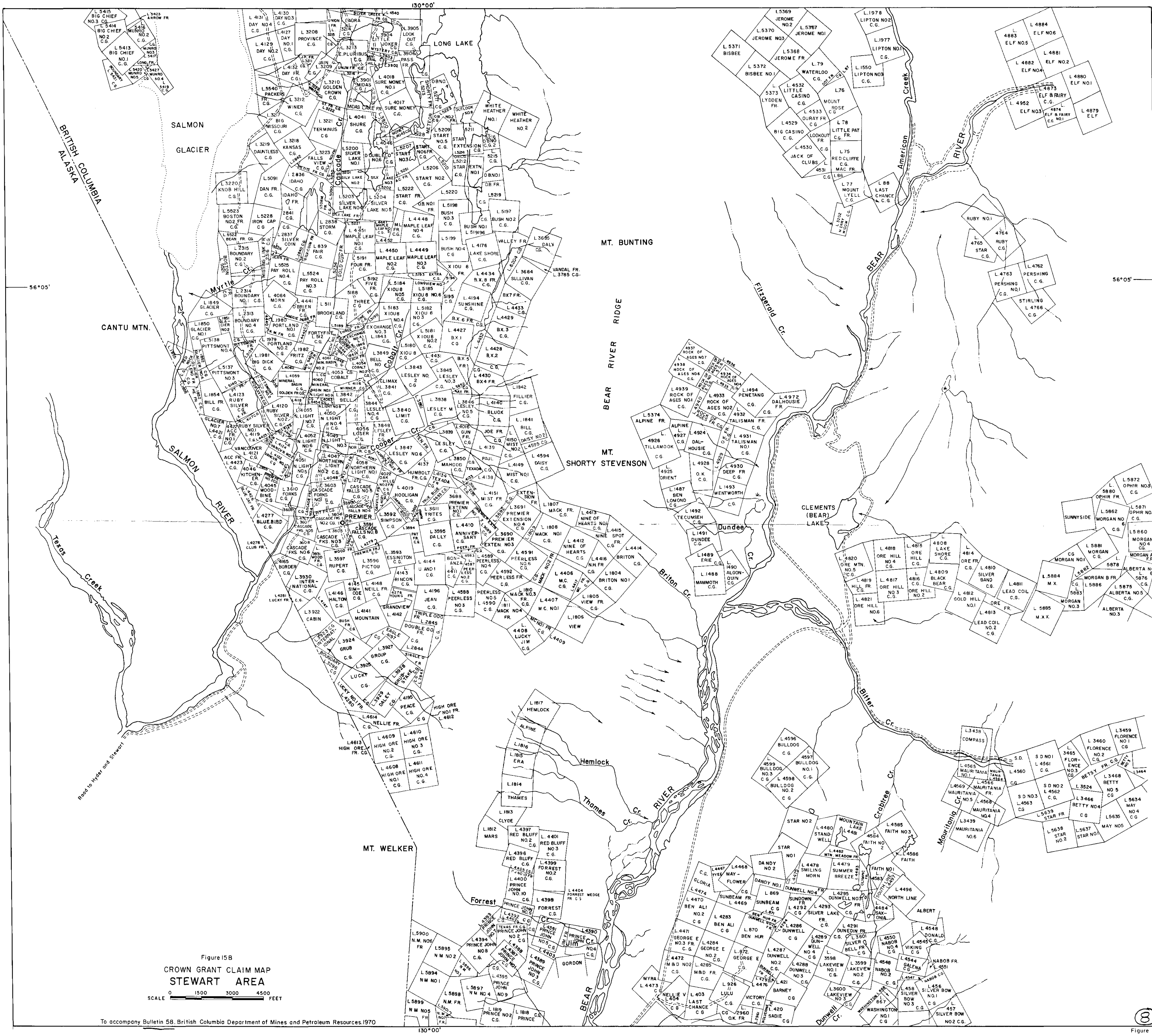


Figure 15B
CROWN GRANT CLAIM MAP
STEWART AREA

To accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources. 1970

Figure 15B

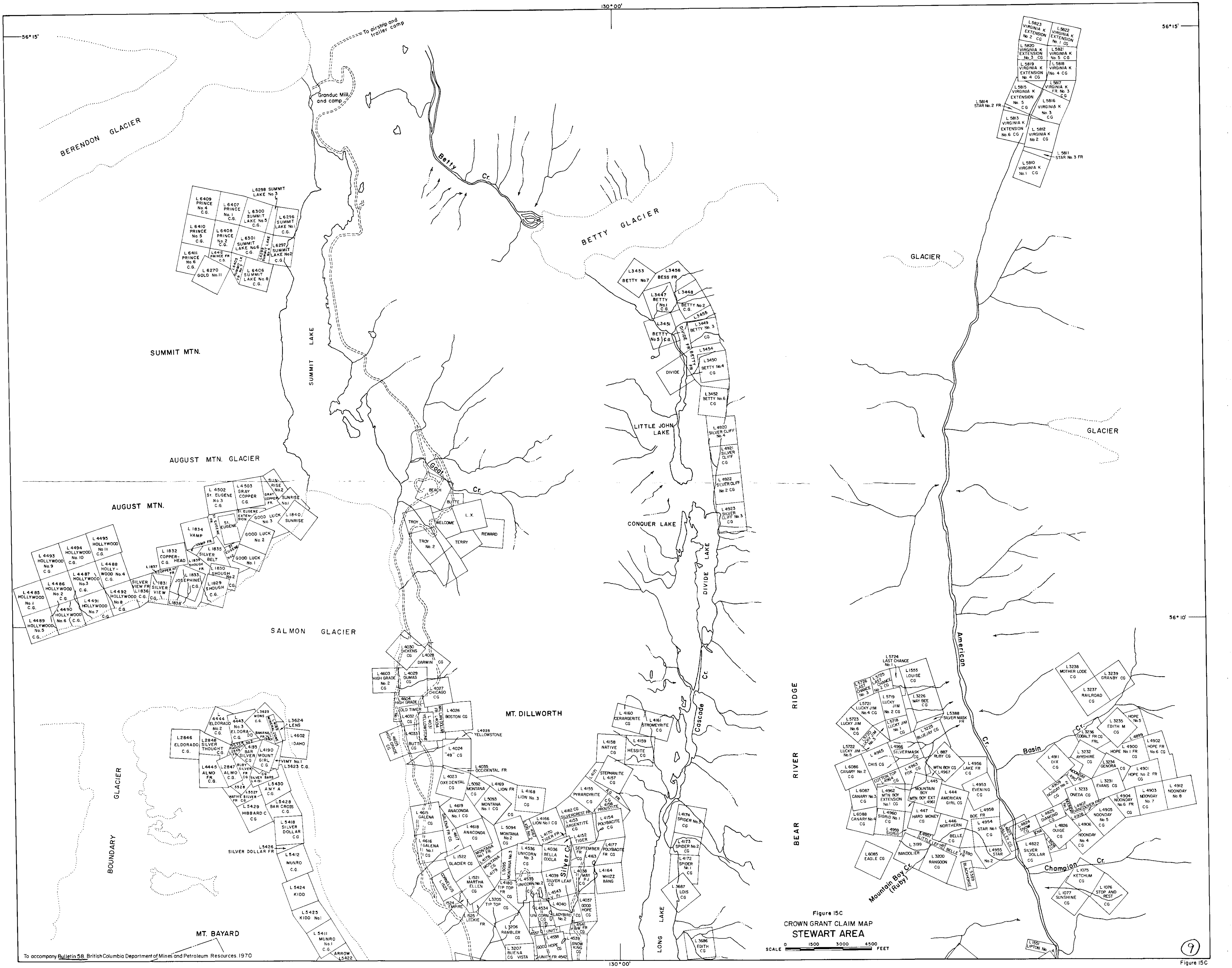


Figure 15C
CROWN GRANT CLAIM MAP
STEWART AREA

To accompany Bulletin 58 British Columbia Department of Mines and Petroleum Resources 1970

Figure 15C

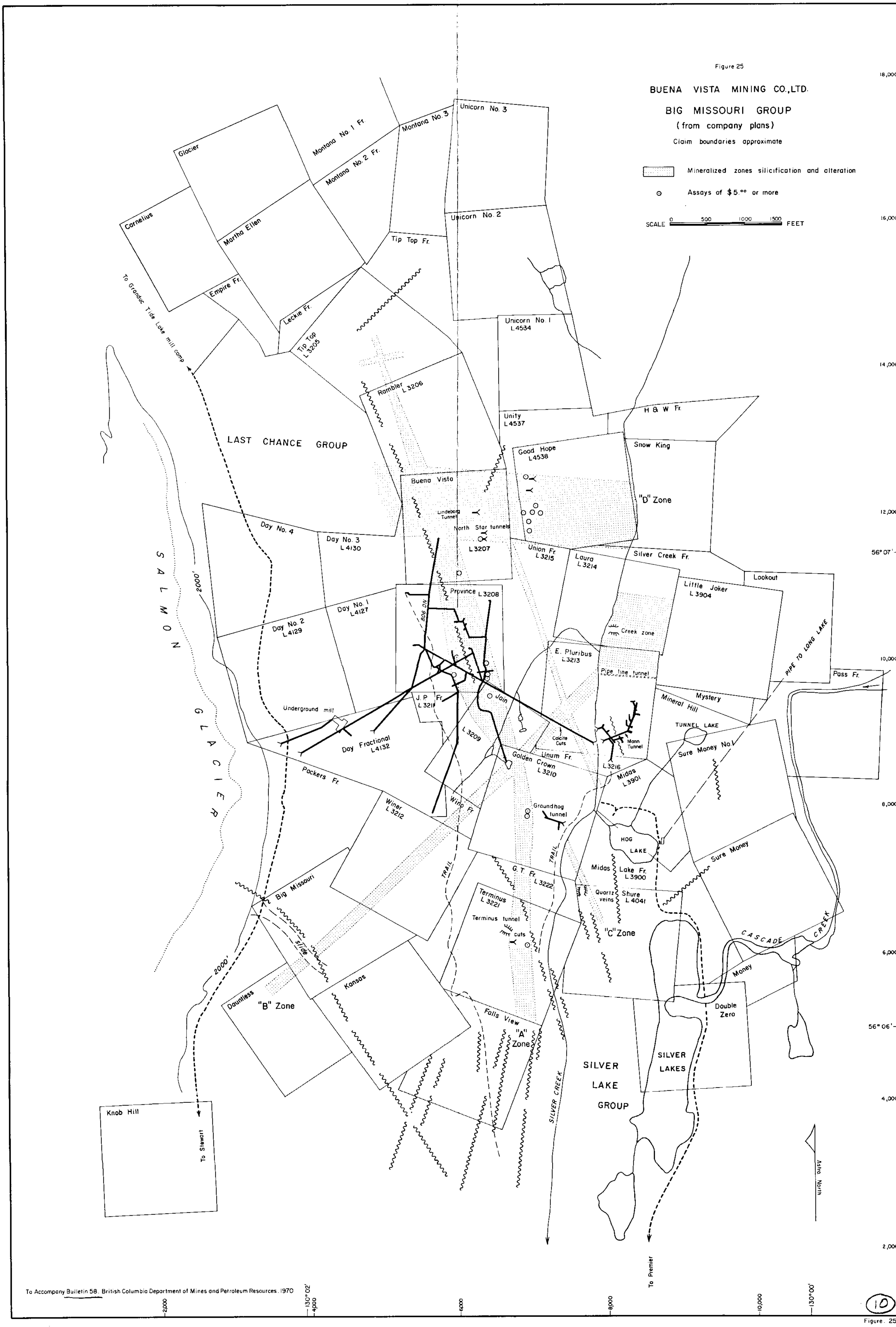


Figure 25
BUENA VISTA MINING CO., LTD.
BIG MISSOURI GROUP
(from company plans)
Claim boundaries approximate
Mineralized zones silicification and alteration
Assays of $5.00 or more
SCALE 0 500 1000 1500 FEET
LAST CHANCE GROUP
SALMON GLACIER
SILVER LAKE GROUP
SILVER LAKES
CASCADE CREEK
SILVER CREEK
PIPE TO LONG LAKE
TUNNEL LAKE
HOG LAKE
"A" Zone
"B" Zone
"C" Zone
"D" Zone
Creek zone
To Grandue Tide Lake mill camp
To Stewart
To Premier
Underground mill
Lindeborg Tunnel
North Star tunnels
Pipe line tunnel
Mann Tunnel
Groundhog tunnel
Terminus tunnel
Calcite Cuts
Quartz veins
806 ON
TRAIL
slide
Astro North
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
56° 07'
56° 06'
130° 02'
130° 00'
To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970
Figure 25

Figure 26

BUENA VISTA MINING Co., LTD.

PLAN OF BIG MISSOURI MINE

(Adapted from mine drawings)

To Accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources, 1970

Figure 26

(11)

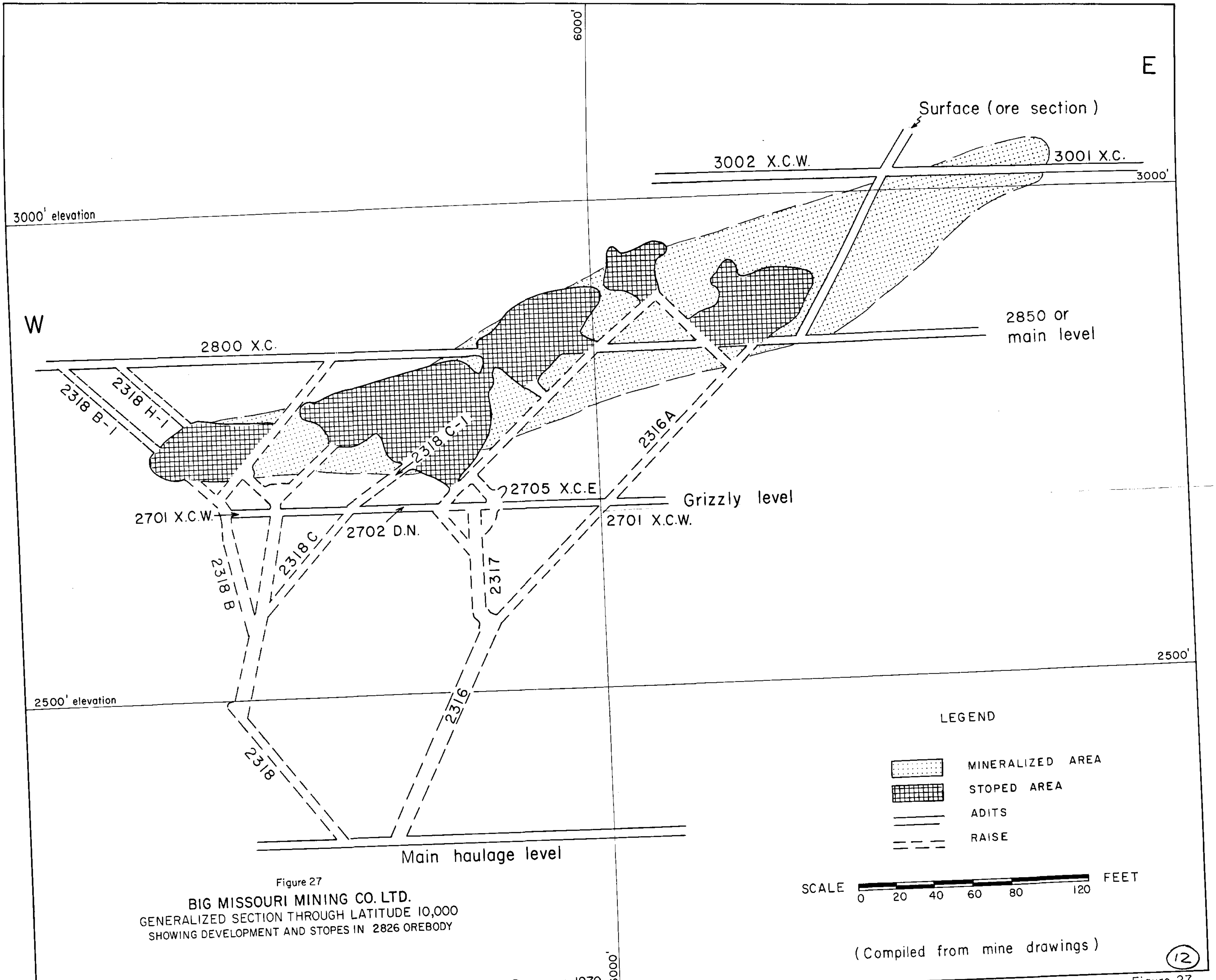
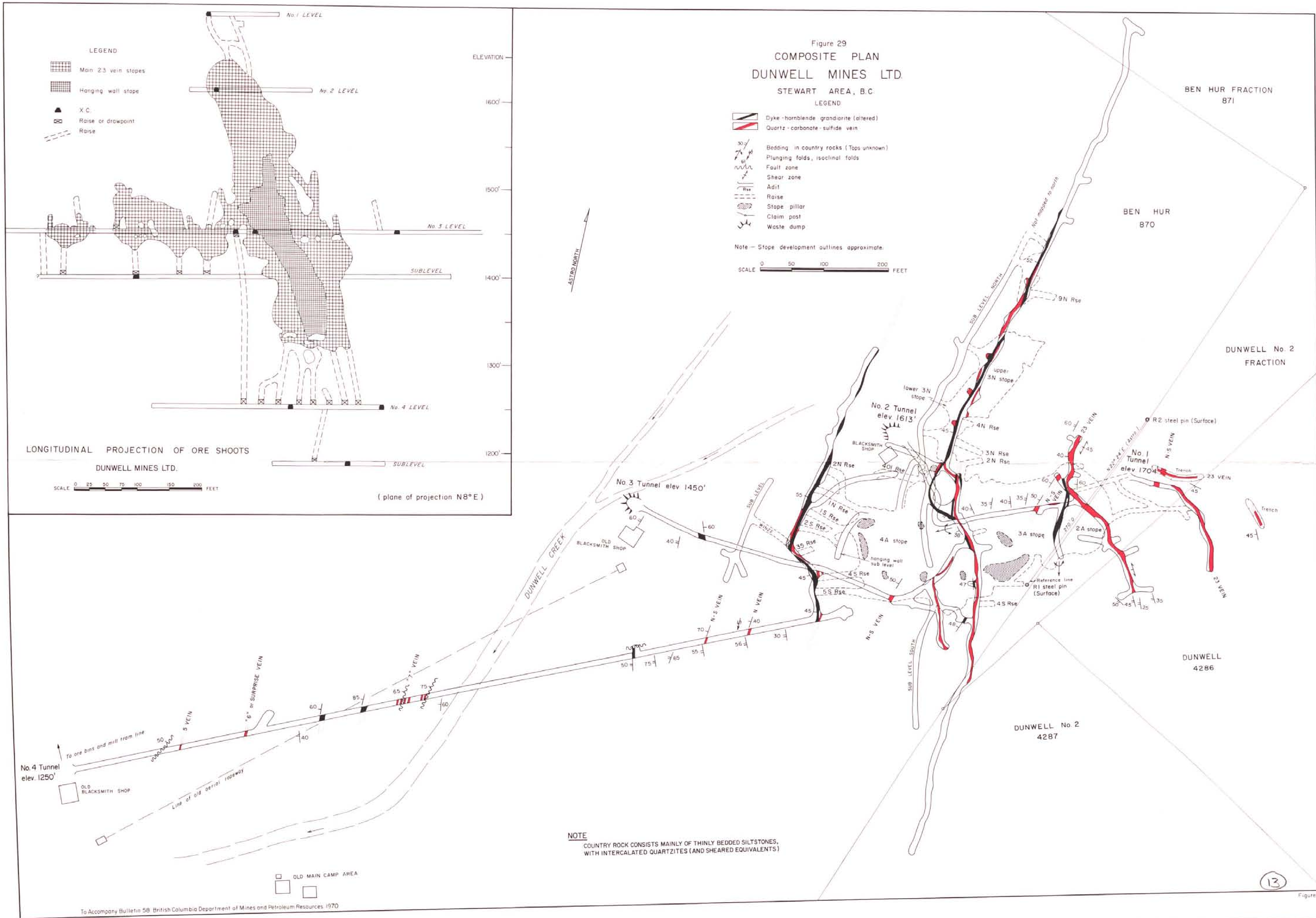


Figure 27
BIG MISSOURI MINING CO. LTD.
GENERALIZED SECTION THROUGH LATITUDE 10,000
SHOWING DEVELOPMENT AND STOPES IN 2826 OREBODY

(12)

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 27



LONGITUDINAL PROJECTION OF ORE SHOOTS
DUNWELL MINES LTD.
(plane of projection N8°E)
LEGEND
Main 23 vein stopes
Hanging wall stope
X.C.
Raise or drawpoint
Raise
No. 1 LEVEL
No. 2 LEVEL
No. 3 LEVEL
SUBLEVEL
No. 4 LEVEL
SUBLEVEL
ELEVATION
1600'
1500'
1400'
1300'
1200'
SCALE 0 25 50 75 100 150 200 FEET
Figure 29
COMPOSITE PLAN
DUNWELL MINES LTD.
STEWART AREA, B.C.
LEGEND
Dyke - hornblende grandiorite (altered)
Quartz - carbonate - sulfide vein
Bedding in country rocks (Tops unknown)
Plunging folds, isoclinal folds
Fault zone
Shear zone
Adit
Raise
Stope pillar
Claim post
Waste dump
Note — Stope development outlines approximate.
SCALE 0 50 100 200 FEET
ASTRO NORTH
BEN HUR FRACTION 871
BEN HUR 870
DUNWELL No. 2 FRACTION
DUNWELL 4286
DUNWELL No. 2 4287
No. 2 Tunnel elev. 1613'
No. 3 Tunnel elev 1450'
No. 1 Tunnel elev. 1704'
No. 4 Tunnel elev. 1250'
BLACKSMITH SHOP
OLD BLACKSMITH SHOP
OLD BLACKSMITH SHOP
DUNWELL CREEK
SUB LEVEL NORTH
SUB LEVEL SOUTH
Not mapped to north
9N Rse
upper 3N stope
lower 3N stope
4N Rse
3N Rse
2N Rse
2N Rse
401 Rse
1N Rse
1S Rse
2S Rse
3S Rse
4S Rse
5S Rse
4S Rse
4A stope
3A stope
2A stope
hanging wall sub level
23 VEIN
N-S VEIN
N VEIN
5 VEIN
"6" or SURPRISE VEIN
"7" VEIN
Trench
R2 steel pin (Surface)
Reference line
R1 steel pin (Surface)
To ore bins and mill tram line
Line of old aerial ropeway
OLD MAIN CAMP AREA
NOTE
COUNTRY ROCK CONSISTS MAINLY OF THINLY BEDDED SILTSTONES, WITH INTERCALATED QUARTZITES (AND SHEARED EQUIVALENTS)
To Accompany Bulletin 58 British Columbia Department of Mines and Petroleum Resources 1970
Figure 29

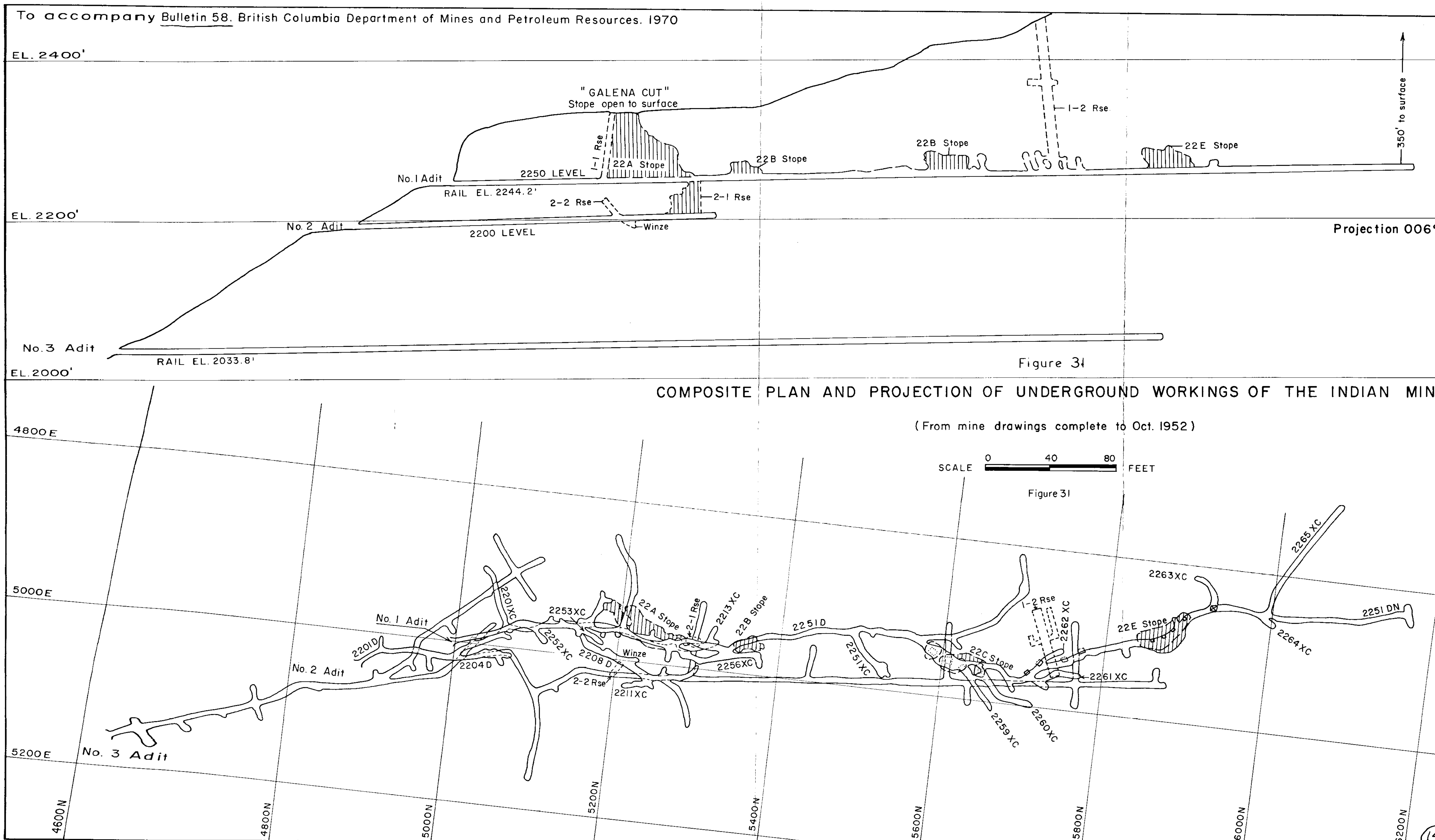

To accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970
EL. 2400'
EL. 2200'
EL. 2000'
"GALENA CUT"
Stope open to surface
1-1 Rse
22A Stope
22B Stope
22B Stope
1-2 Rse
22E Stope
350' to surface
No. 1 Adit
2250 LEVEL
RAIL EL. 2244.2'
2-2 Rse
2-1 Rse
No. 2 Adit
2200 LEVEL
Winze
Projection 006°
No. 3 Adit
RAIL EL. 2033.8'
Figure 31
COMPOSITE PLAN AND PROJECTION OF UNDERGROUND WORKINGS OF THE INDIAN MINE
(From mine drawings complete to Oct. 1952)
SCALE 0 40 80 FEET
Figure 31
4800E
5000E
5200E
No. 1 Adit
No. 2 Adit
No. 3 Adit
2201D
2201XC
2204D
2253XC
2252XC
2208D
Winze
2-2 Rse
2211XC
22A Stope
2-1 Rse
2213XC
22B Stope
2256XC
2251D
2251XC
22C Stope
2259XC
2260XC
1-2 Rse
2262XC
2261XC
22E Stope
2263XC
2265XC
2264XC
2251DN
4600N
4800N
5000N
5200N
5400N
5600N
5800N
6000N
6200N
14

Figure 31

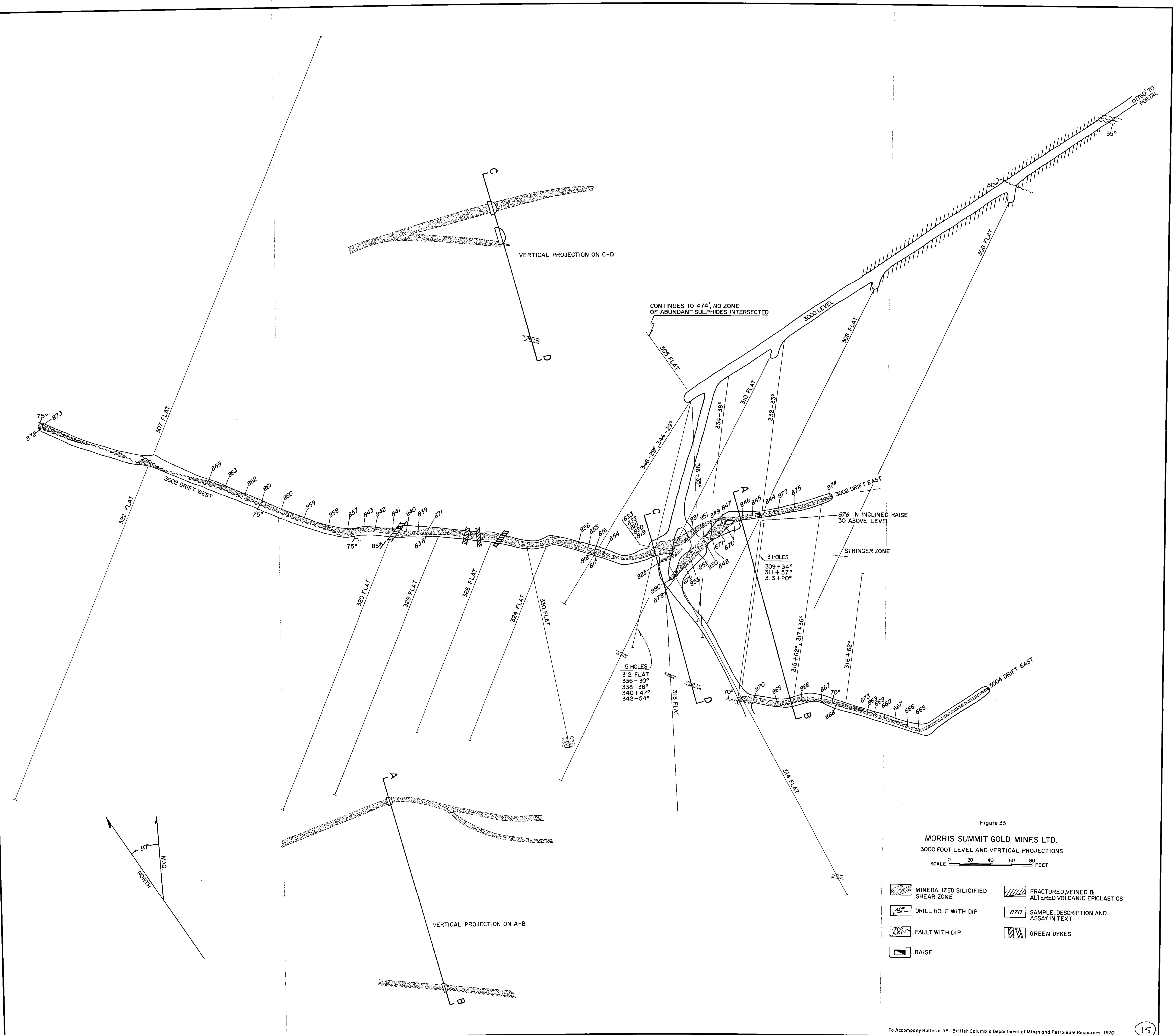


Figure 33

MORRIS SUMMIT GOLD MINES LTD.

3000 FOOT LEVEL AND VERTICAL PROJECTIONS

SCALE 0 20 40 60 80 FEET

MINERALIZED SILICIFIED SHEAR ZONE

DRILL HOLE WITH DIP

FAULT WITH DIP

RAISE

FRACTURED, VEINED & ALTERED VOLCANIC EPICLASTICS

SAMPLE, DESCRIPTION AND ASSAY IN TEXT

GREEN DYKES

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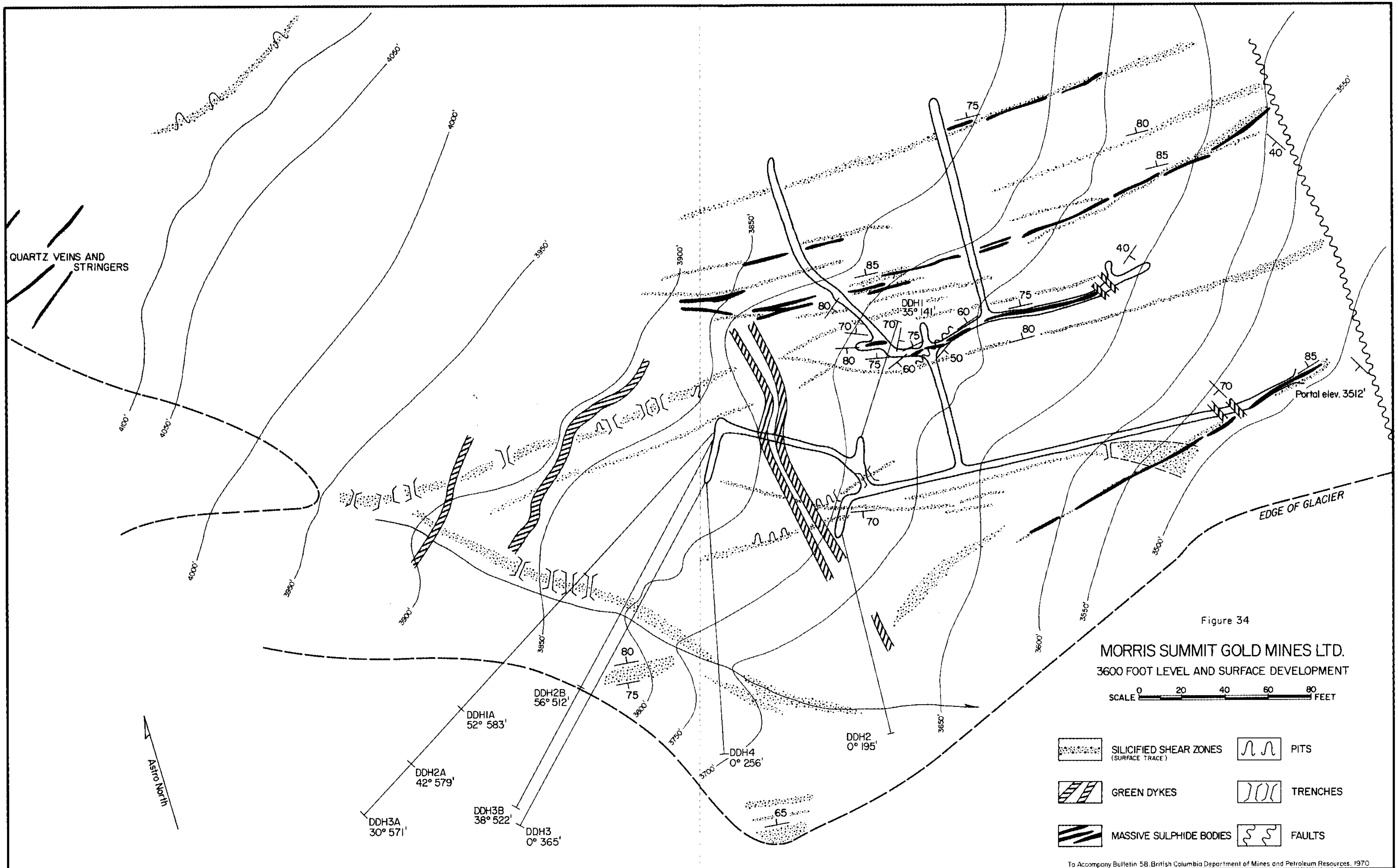
(15)

Figure 33



To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 34

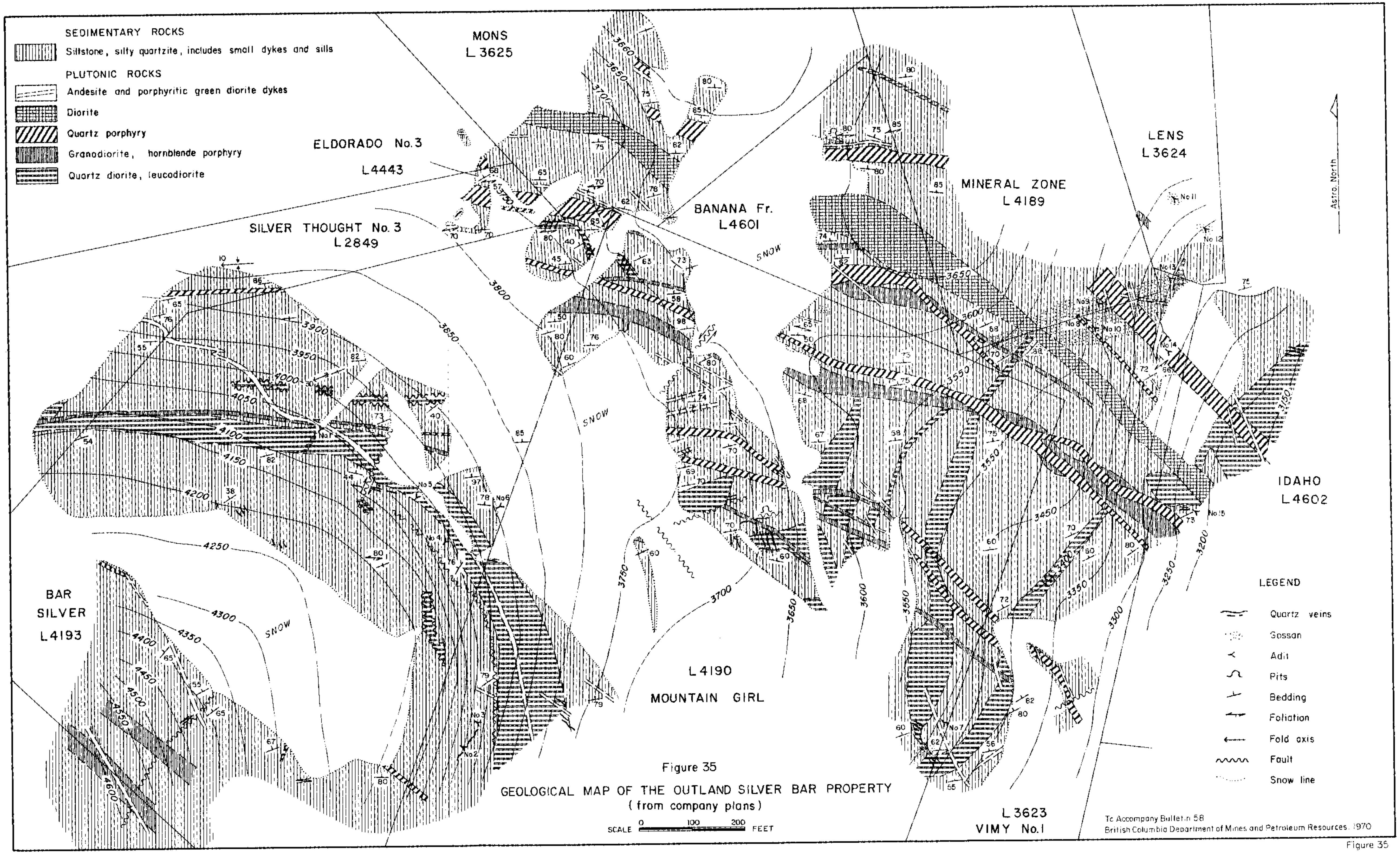


Figure 35
GEOLOGICAL MAP OF THE OUTLAND SILVER BAR PROPERTY
(from company plans)

Figure 35

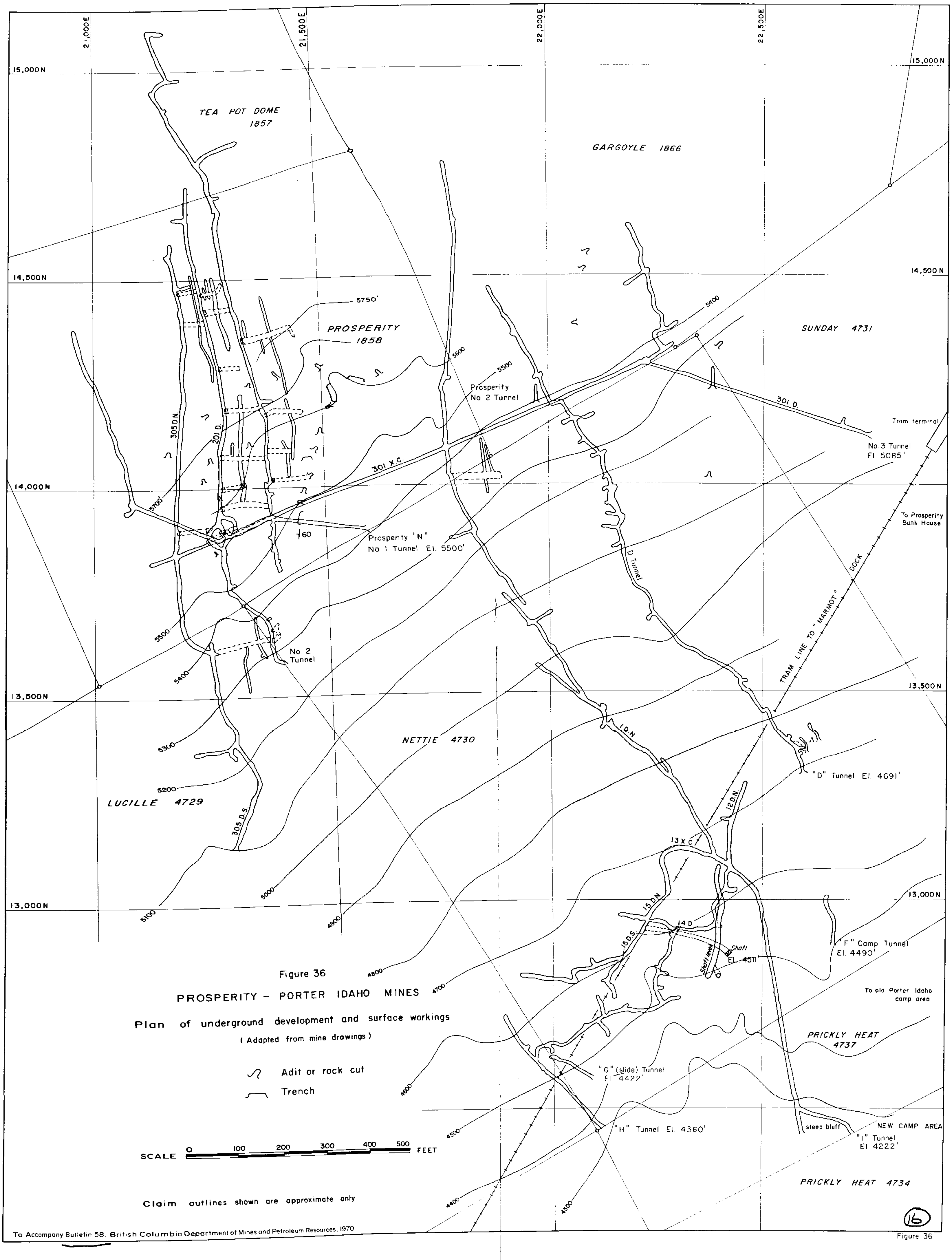


Figure 36

PROSPERITY - PORTER IDAHO MINES

Plan of underground development and surface workings

(Adapted from mine drawings)

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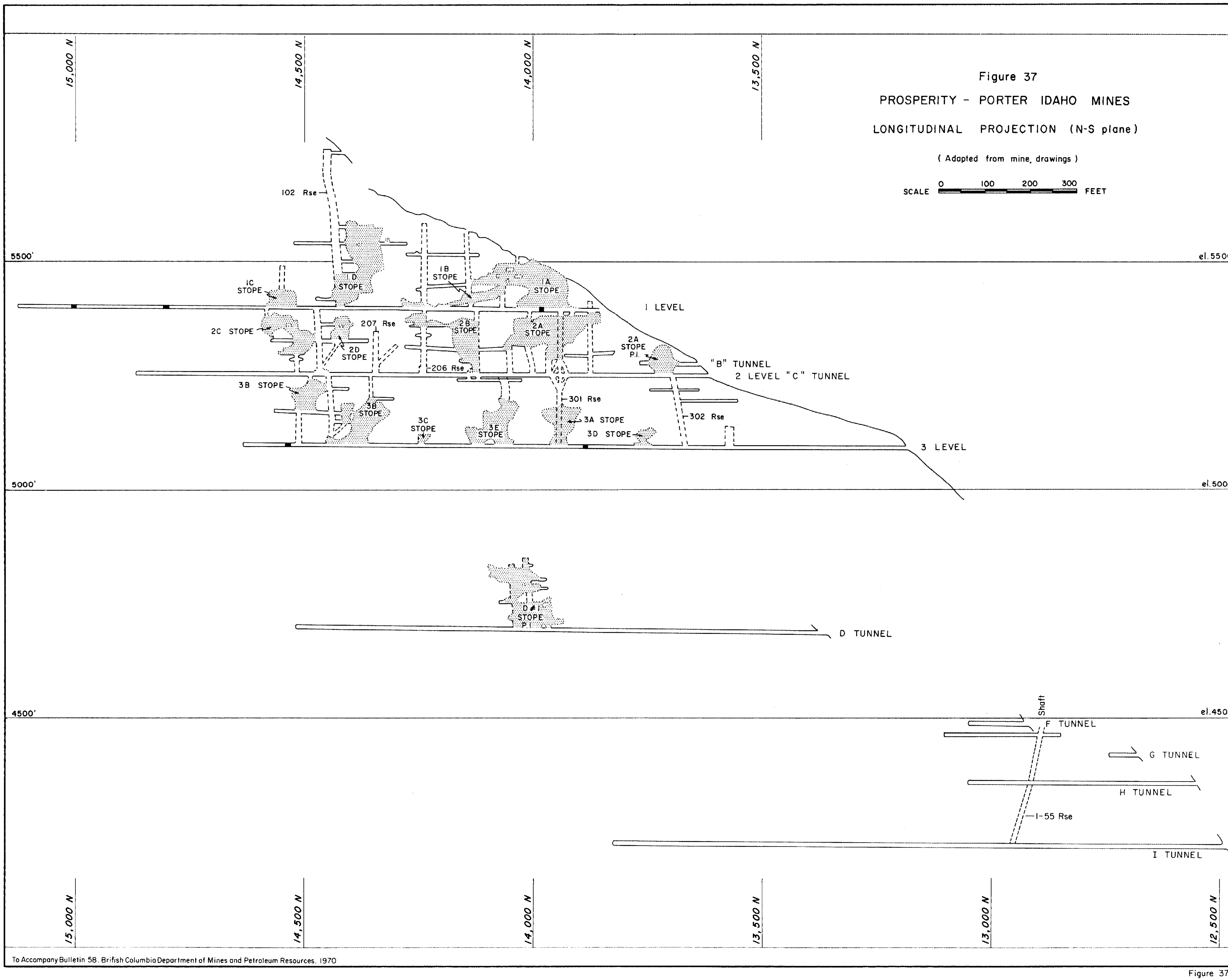
Figure 37
PROSPERITY - PORTER IDAHO MINES
LONGITUDINAL PROJECTION (N-S plane)
(Adapted from mine drawings)
SCALE 0 100 200 300 FEET
15,000 N
14,500 N
14,000 N
13,500 N
13,000 N
12,500 N
5500'
el.5500'
5000'
el.5000'
4500'
el.4500'
102 Rse
1C STOPE
1D STOPE
1B STOPE
1A STOPE
1 LEVEL
2C STOPE
207 Rse
2D STOPE
2B STOPE
2A STOPE
2A STOPE P.I.
206 Rse
"B" TUNNEL
2 LEVEL "C" TUNNEL
3B STOPE
3B STOPE
3C STOPE
3E STOPE
301 Rse
3A STOPE
3D STOPE
302 Rse
3 LEVEL
D-1 STOPE P.I.
D TUNNEL
Shaft
F TUNNEL
G TUNNEL
H TUNNEL
1-55 Rse
I TUNNEL
To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 37

CHANNEL SAMPLES

Sample Location	Width inches	Ounces per ton Gold	Ounces per ton Silver
1	4	1·00	1·5
2	23	0·14	1·7
3	60	0·26	0·6
4	32	Tr.	1·3
5A	40 (S.side)	0·98	1·7
5B	37 (N.side)	0·44	0·4
6A	37 (W.side)	1·49	1·7
6B	60 (E.side)	0·24	1·0
7	8	0·09	5·8
8A	20 (W.side)	1·20	1·4
8B	34 (E.side)	0·54	1·2
9A	11 (S.W.side)	3·37	1·7
9B	28 (N.E.side)	0·22	Nil
10	17	Tr.	1·8
11	20	Nil	Tr.
12	28	Nil	Nil
13A	54 (W.side)	Nil	1·3
13B	54 (E.side)	Tr.	0·6
14	62	Nil	1·0
15	35	0·47	0·3
16	8	0·06	0·7
17	24	1·19	3·1
18	28	Tr.	0·5

NOTE: All widths given are normal to the attitude of the deposit.
The direction of the arrows pointing to the sample locations are parallel to the directions in which the samples were cut.

SPECIMEN SAMPLES

Sample Location	Description	Ounces per ton Gold	Ounces per ton Silver
8A	Mixed sulphides in calcite	0·06	1·8
8B	Massive Pyrrhotite some Chalcopyrite	0·11	Nil
14	Massive Pyrrhotite	Tr	0·3
16	Massive Pyrite	3·59	2·2
16	Massive Pyrrhotite some Chalcopyrite	3·52	3·4

LEGEND

- Shear zones
- Silicified zones with scattered sulphides
- Massive sulphide bodies
- Open cuts

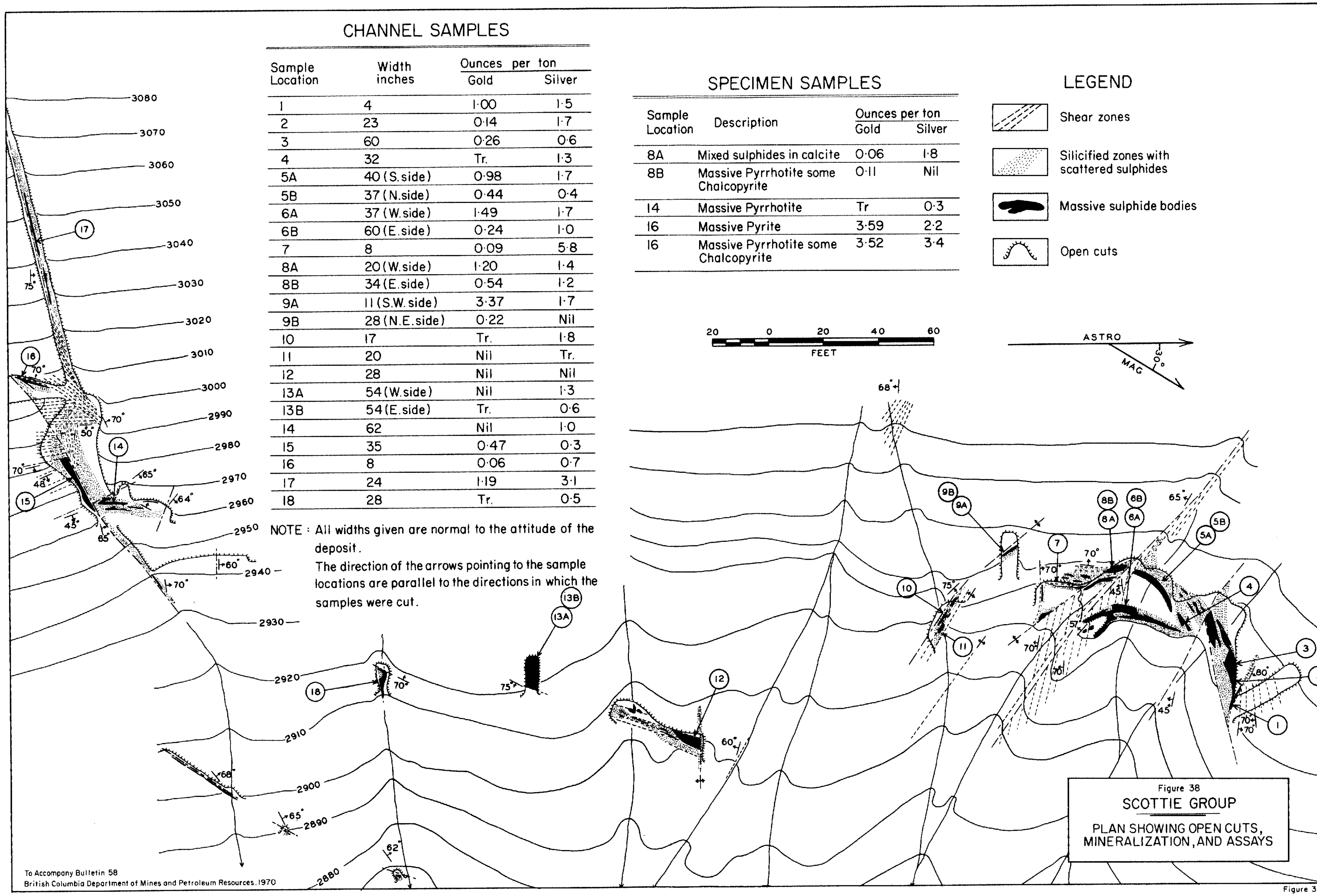

Figure 38
SCOTTIE GROUP
PLAN SHOWING OPEN CUTS, MINERALIZATION, AND ASSAYS

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British Columbia Department of Mines and Petroleum Resources, 1970

Figure 38

Figure 39
GENERAL GEOLOGY OF THE SILBAK PREMIER MINES LTD. AREA SHOWING ORE SHOOT PROJECTIONS

Figure 39

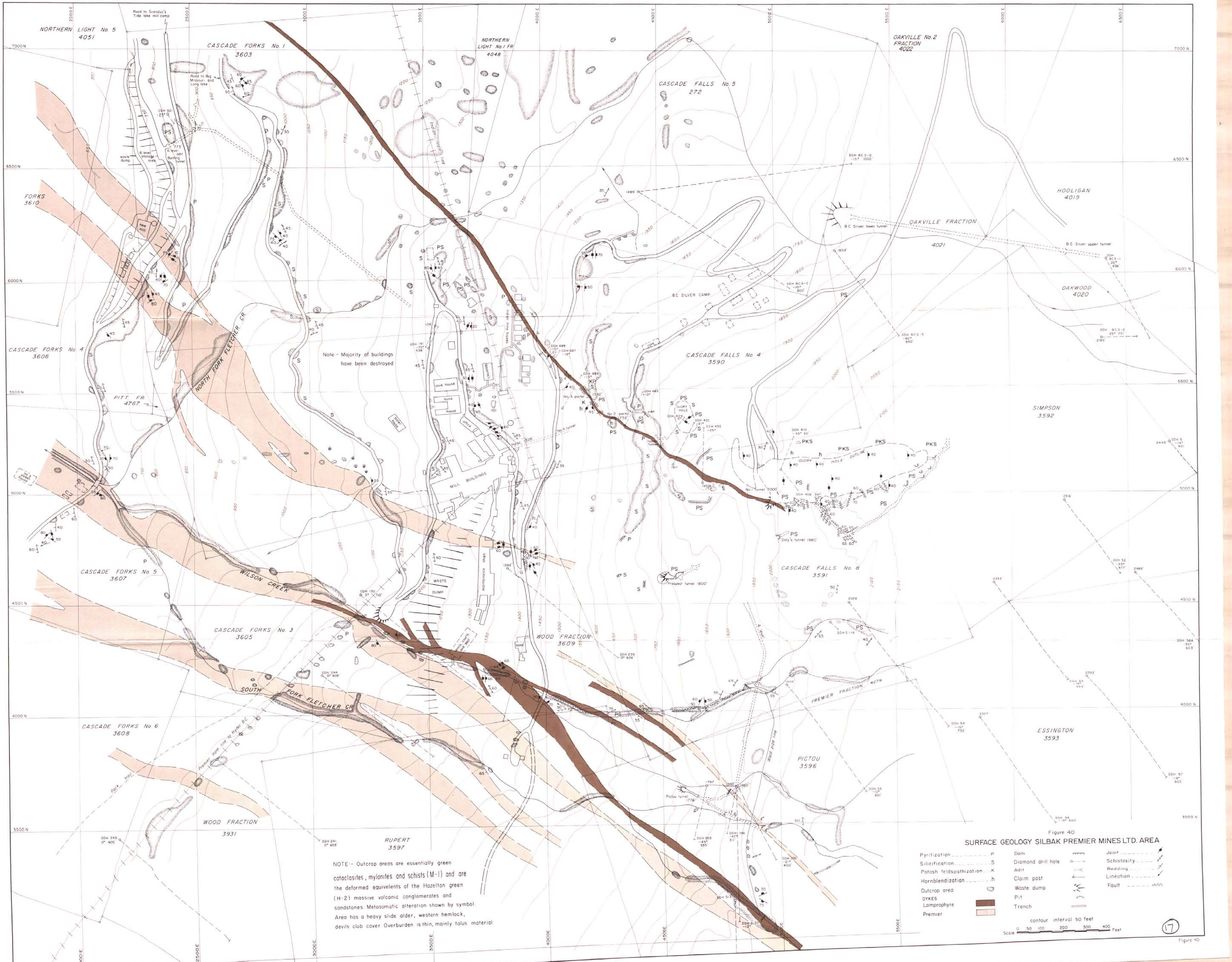

Figure 40
SURFACE GEOLOGY SILBAK PREMIER MINES LTD. AREA

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Figure 40


Figure 41
SILBAK PREMIER MINES
LONGITUDINAL PROJECTION ON N 40° E
1·10 — Au·Ag RATIO FROM STOPE PRODUCTION STATISTICS
LEGEND
Rse = Raise , Dr = Drift , X.C. = Cross cut
Raise , Raise - Sublevel
Stoped areas
2500 FOOT ELEVATION
2000 FOOT ELEVATION
1500 FOOT ELEVATION
1000 FOOT ELEVATION
500 FOOT ELEVATION
MAIN DYKE
2080 LEVEL
1620 LEVEL
1670 LEVEL
1525 LEVEL
1350 LEVEL
1070 LEVEL
940 LEVEL
790 LEVEL
660 SUBLEVEL
560 SUBLEVEL
110 SUBLEVEL
1450 SUBLEVEL
1240 SUBLEVEL
1230 SUBLEVEL
1220 SUBLEVEL
SEBAKWE SHAFT
B.C.S. No 2 SHAFT
B.C.S. No 1 SHAFT
602 SHAFT
7 LEVEL
8 LEVEL
Pictou Tunnel Elev. 1750'
C.F.#8 No 1 Tunnel
No 2 Tunnel Portal Elev. 1752'
No. 3 Tunnel Portal Elev. 1582'
No. 4 Tunnel Portal Elev. 1328'
No. 6 Tunnel Portal Elev. 773'
Slide Tunnel 2064
Bush 2070 tunnel
Bush 2160 & 2190 Tunnels
To Accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources. 1970
890 feet to portal
665 feet to portal
NORTHERN LIGHT TUNNEL
PREMIER BORDER SECTOR
SEBAKWE SECTOR
PREMIER SECTOR
(See Figure 40)
Section A
Section B
Section C
B.C. SILVER LOWER TUNNEL
PICTOU TUNNEL
C.F.#8 No I TUNNEL
SEBAKWE RAISE
See figure
BUSH 2070 TUNNEL
SLIDE TUNNEL
BUSH 2160 TUNNEL
BUSH 2190 TUNNEL
Figure 41
SILBAK PREMIER MINES LTD.
COMPOSITE PLAN OF WORKINGS
0 200 400 600 800 1000
SCALE — FEET
Figure 41

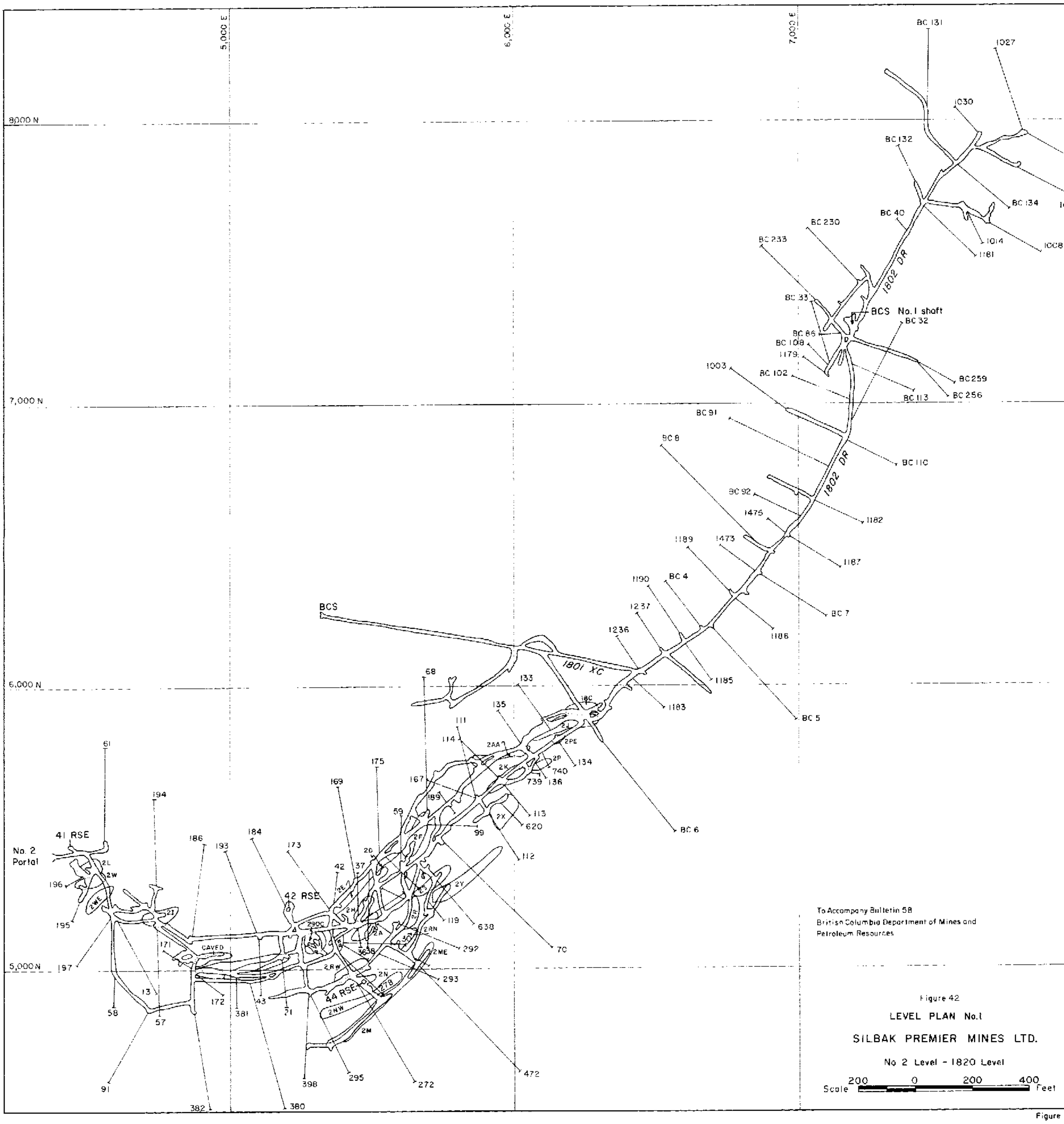


Figure 42

LEVEL PLAN No. 1

SILBAK PREMIER MINES LTD.

No 2 Level - 1820 Level

Scale 200 0 200 400 Feet

Figure

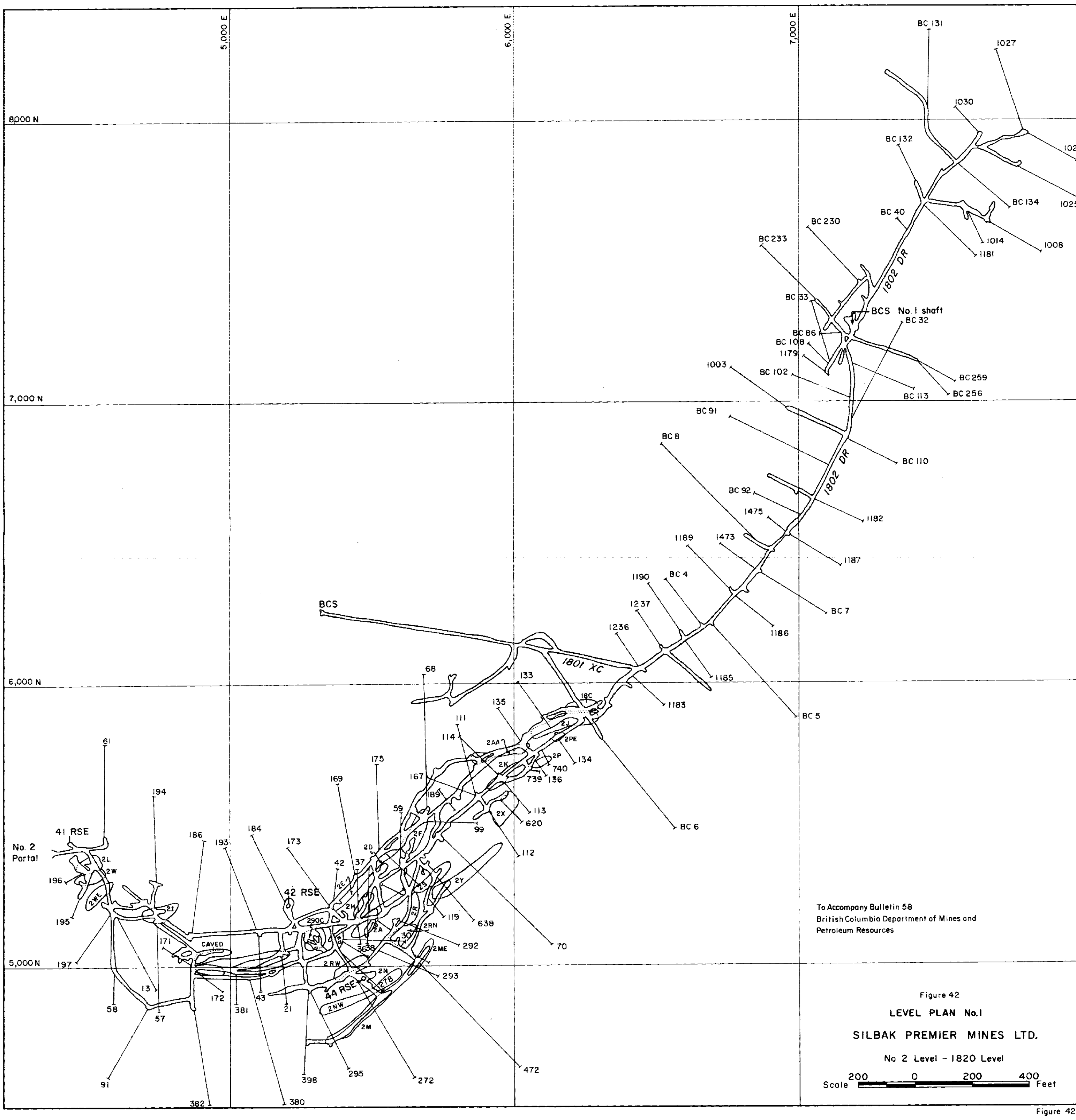


Figure 42

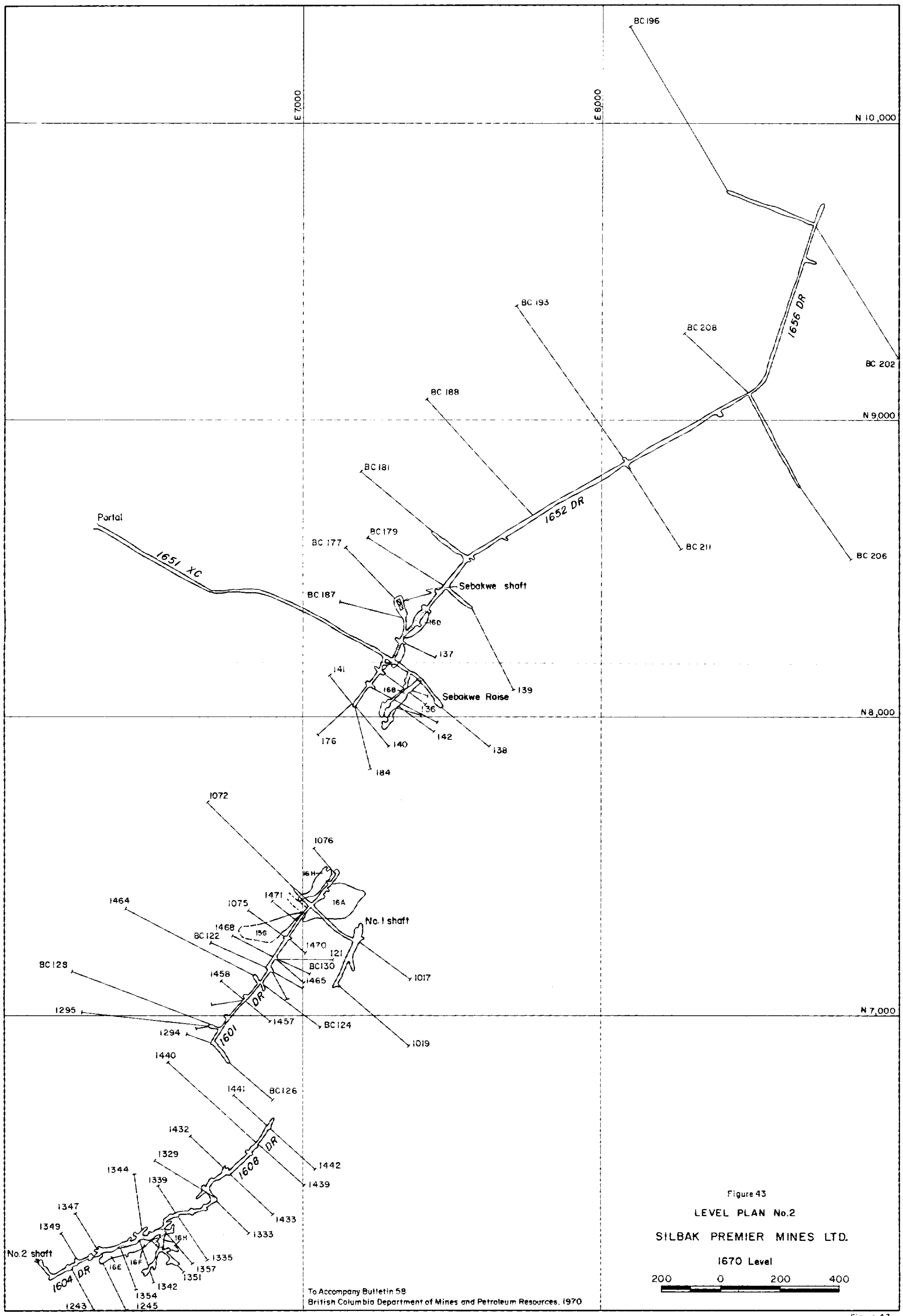
LEVEL PLAN No. 1

SILBAK PREMIER MINES LTD.

No 2 Level - 1820 Level

Scale 200 0 200 400 Feet

Figure 42


E 7,000
E 8,000
N 10,000
N 9,000
N 8,000
N 7,000
Portal
1651 XC
1652 DR
1656 DR
Sebakwe shaft
Sebakwe Raise
No. 1 shaft
No. 2 shaft
1601 DR
1608 DR
1604 DR
Figure 43
LEVEL PLAN No. 2
SILBAK PREMIER MINES LTD.
1670 Level
200 0 200 400
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British Columbia Department of Mines and Petroleum Resources, 1970

Figure 43

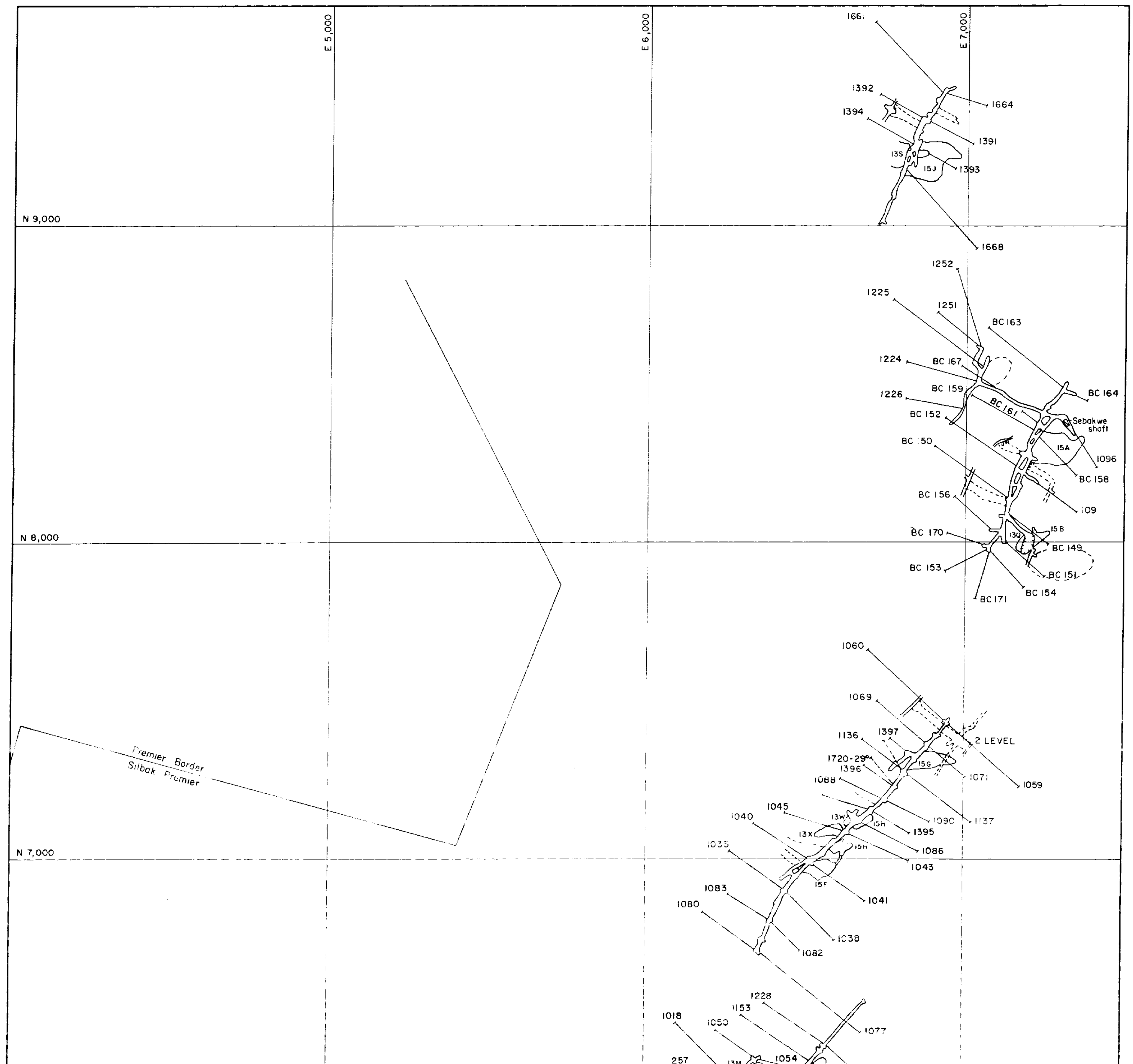

Figure 44

LEVEL PLAN No. 3

SILBAK PREMIER MINES LTD.

No 3 Level - 1525 Level

Scale 200 0 200 400 Feet

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Figure 44

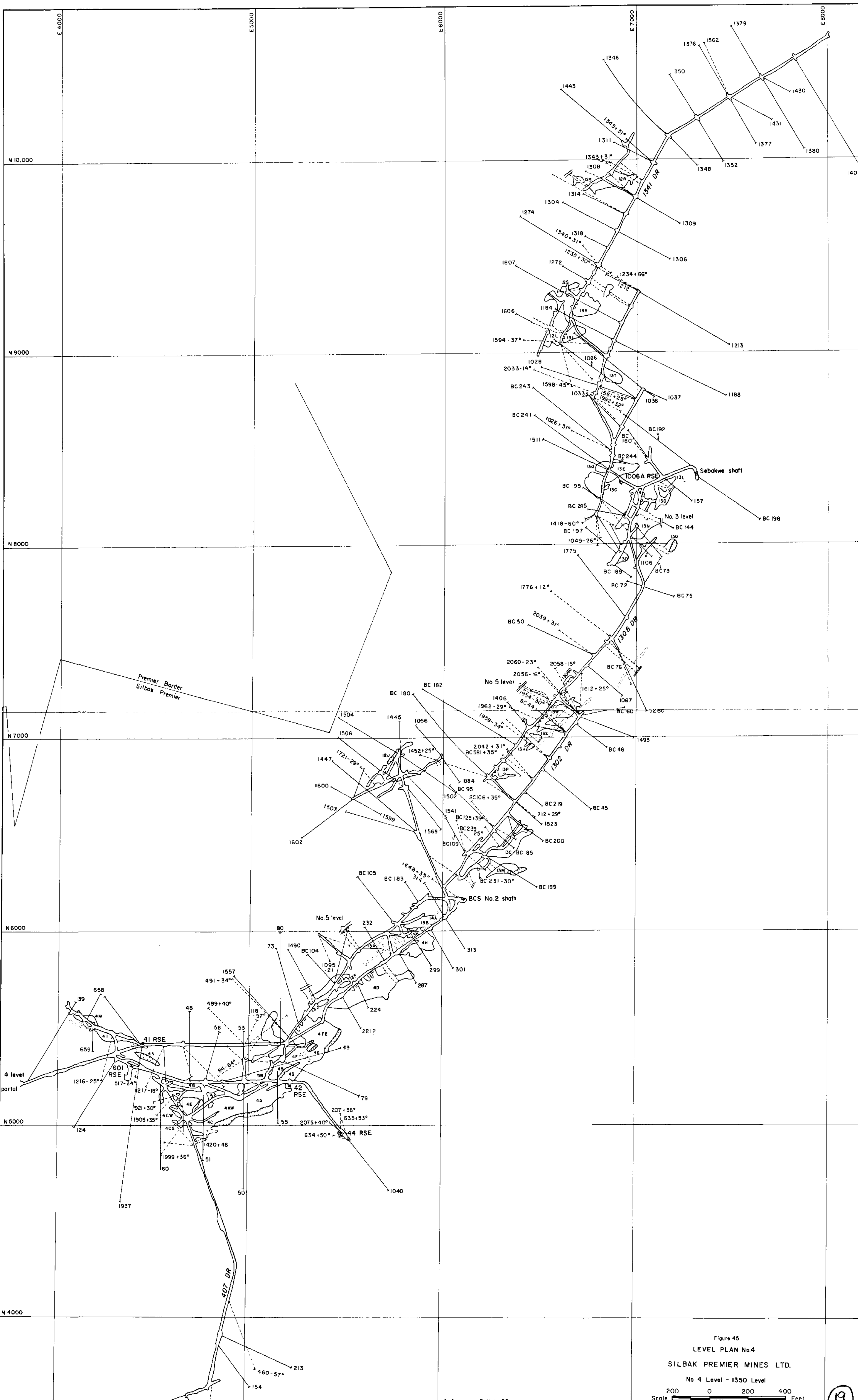


Figure 45
LEVEL PLAN No.4
SILBAK PREMIER MINES LTD.
No 4 Level - 1350 Level
Scale 200 0 200 400 Feet

19

Figure 45

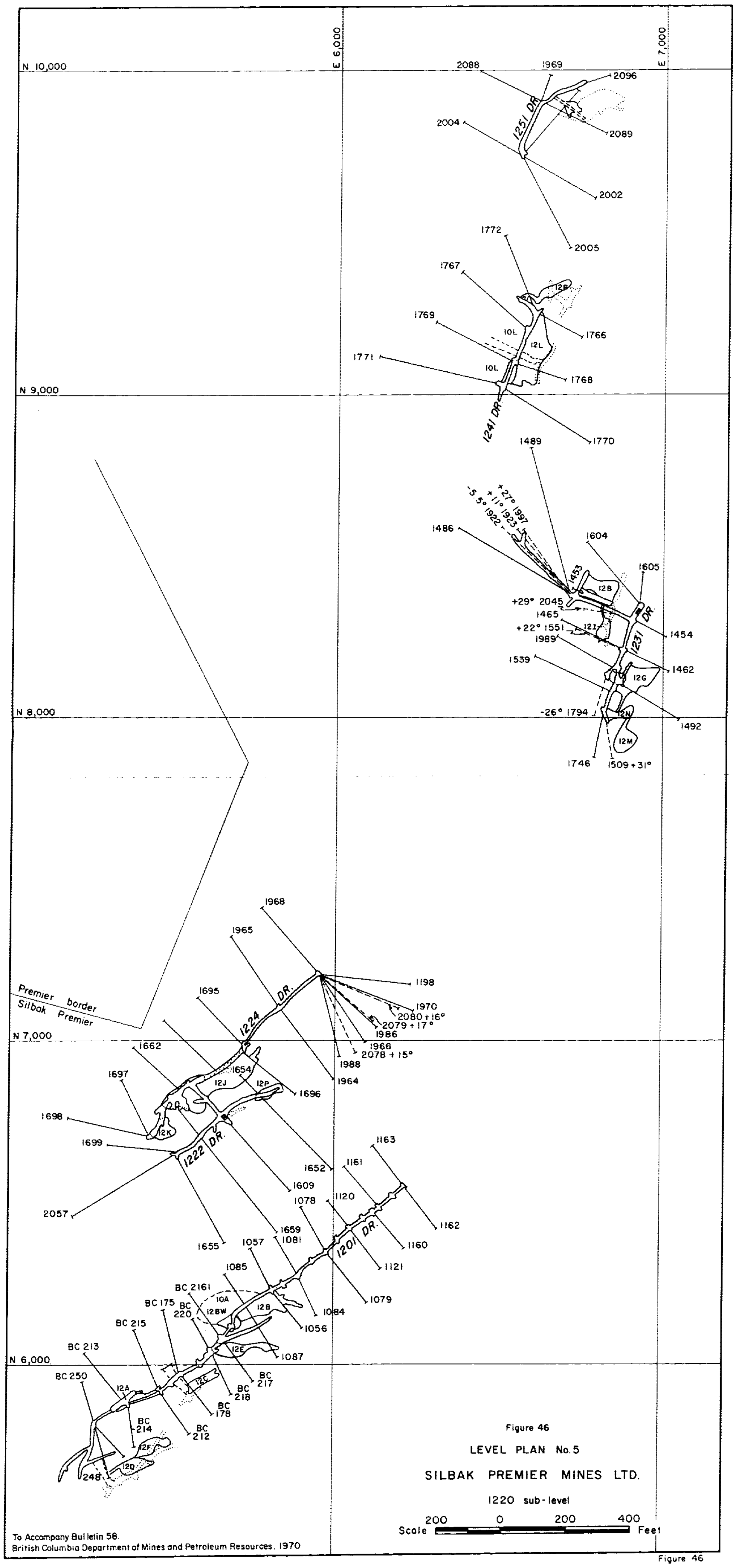

N 10,000
N 9,000
N 8,000
N 7,000
N 6,000
E 6,000
E 7,000
1251 DR.
1241 DR.
1231 DR.
1224 DR.
1222 DR.
1201 DR.
Premier border
Silbak Premier
Figure 46
LEVEL PLAN No. 5
SILBAK PREMIER MINES LTD.
1220 sub-level
Scale
Feet
To Accompany Bulletin 58.
British Columbia Department of Mines and Petroleum Resources, 1970

Figure 46

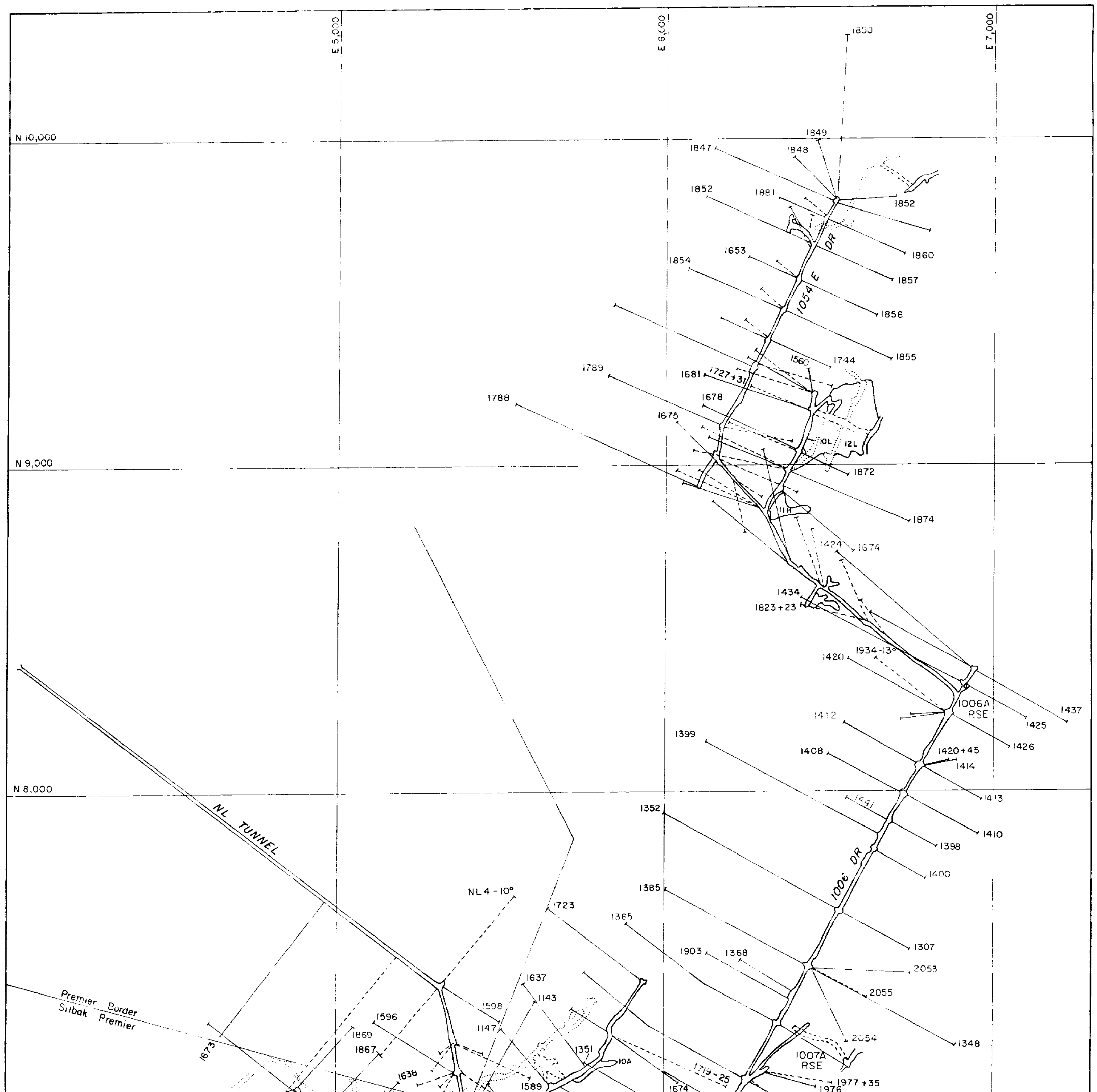
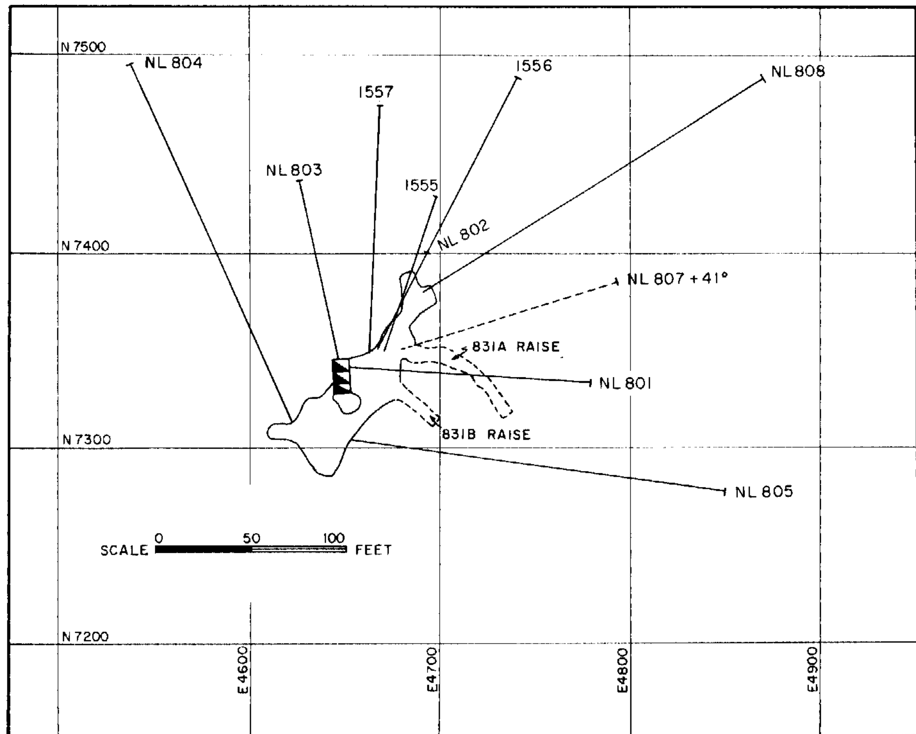


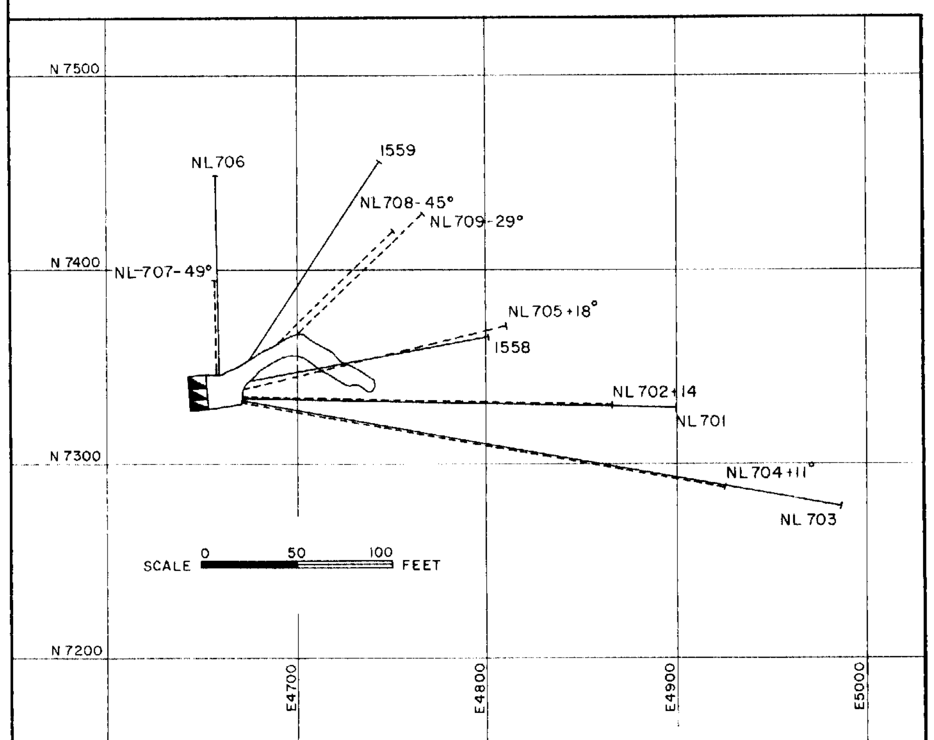
Figure 47
LEVEL PLAN No.6
SILBAK PREMIER MINES LTD.
No 5 Level - 1070 Level
Scale 200 0 200 400 Feet
To Accompany Bulletin 58
British Columbia Department of Mines and Petroleum Resources 1970
E 5,000
E 6,000
E 7,000
N 10,000
N 9,000
N 8,000
N 7,000
N 6,000
NL TUNNEL
Premier Border
Silbak Premier
NL 4 - 10°
1054 E DR
1006 DR
1001 DR
1006A RSE
1007A RSE
1008A RSE
601 RSE
av. dip 75°

Figure 47



No. 8 LEVEL

SILBAK PREMIER MINES LTD



No. 7 LEVEL

SILBAK PREMIER MINES LTD

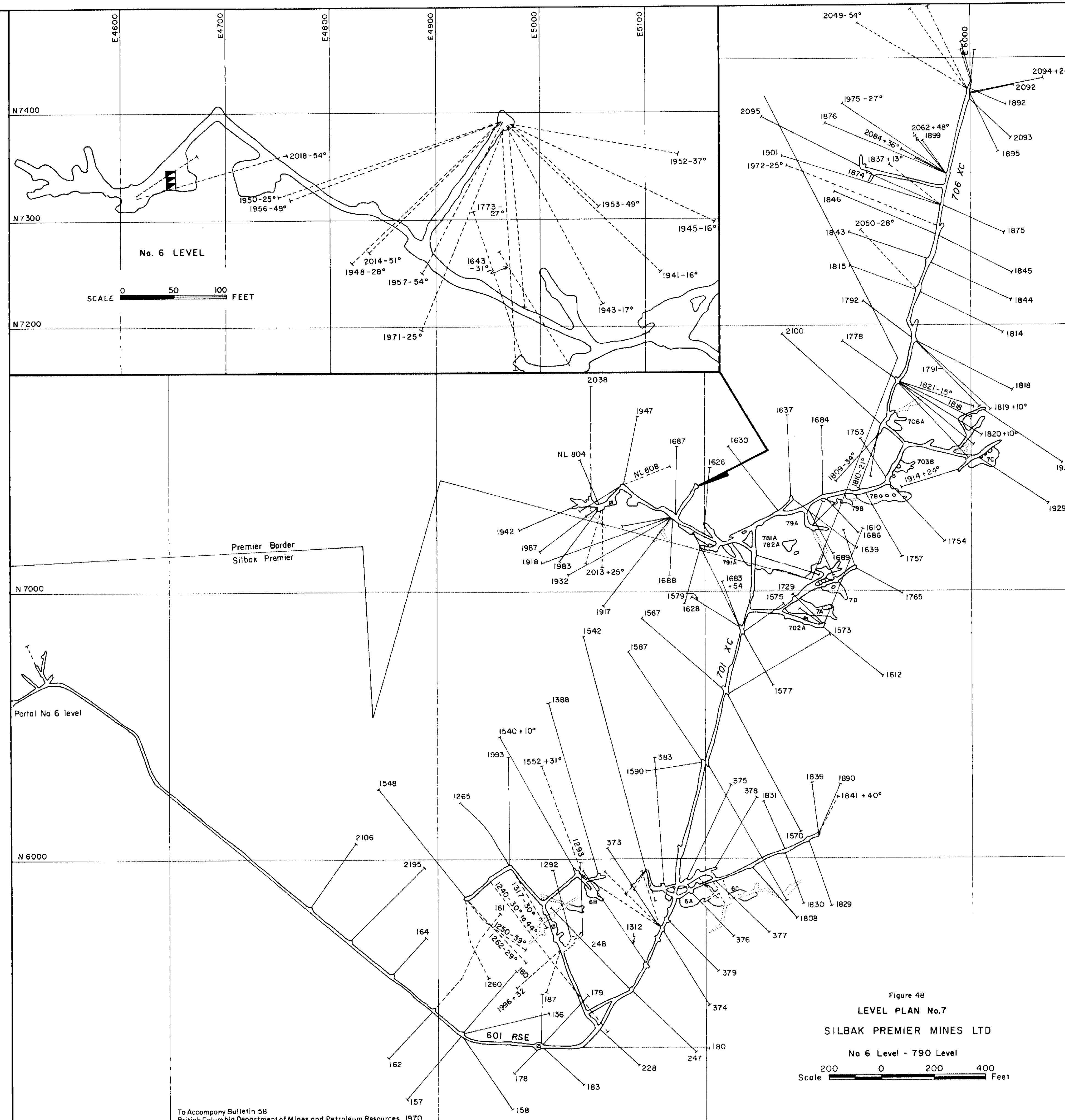


Figure 48

LEVEL PLAN No.7

SILBAK PREMIER MINES LTD

No 6 Level - 790 Level

Scale 200 0 200 400 Feet

Figure 48

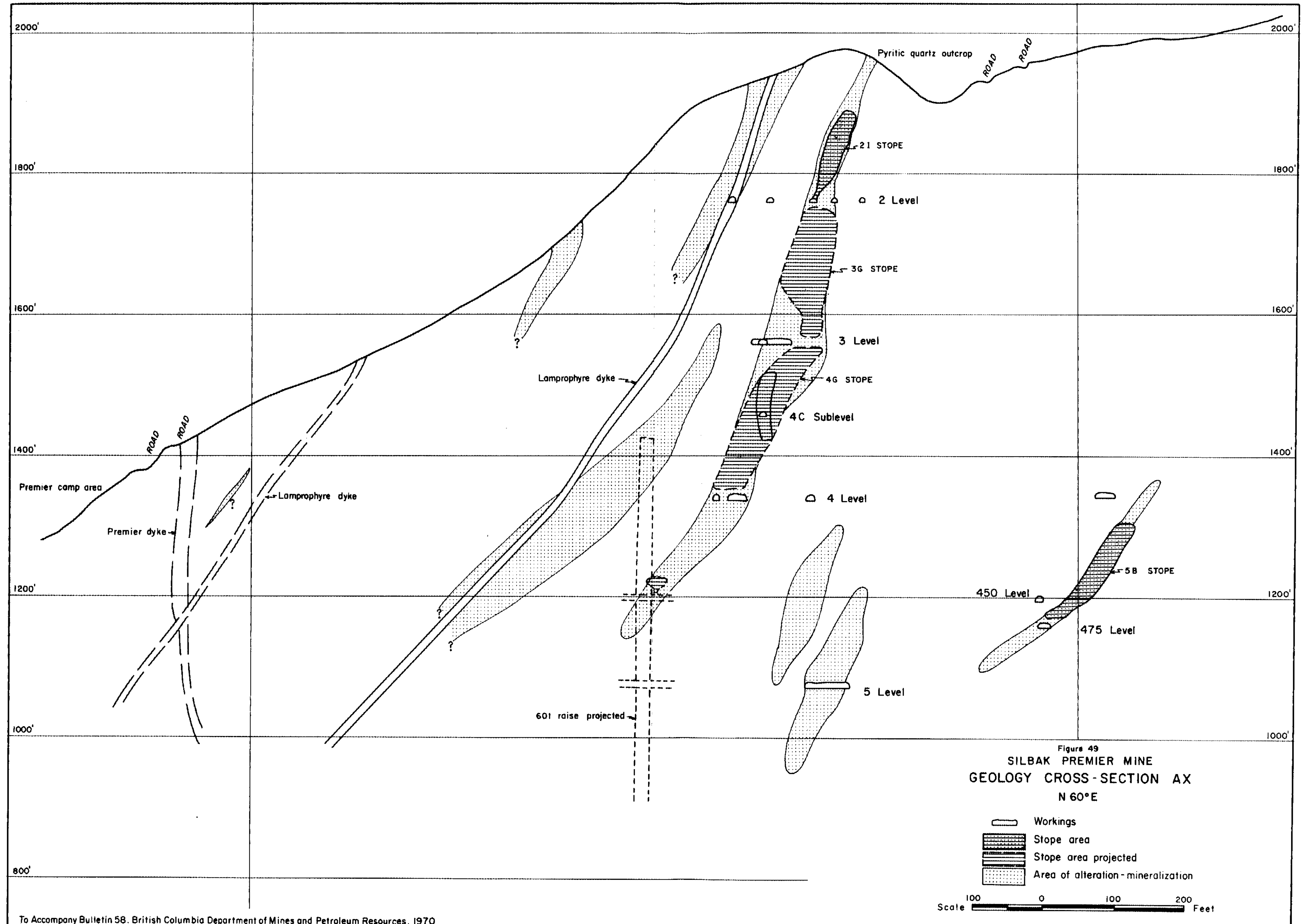

2000'
1800'
1600'
1400'
1200'
1000'
800'
Pyritic quartz outcrop
ROAD
ROAD
21 STOPE
2 Level
3G STOPE
3 Level
4G STOPE
4C Sublevel
4 Level
Lamprophyre dyke
Premier camp area
Premier dyke
Lamprophyre dyke
5B STOPE
450 Level
475 Level
5 Level
601 raise projected
Figure 49
SILBAK PREMIER MINE
GEOLOGY CROSS-SECTION AX
N 60°E
Workings
Stope area
Stope area projected
Area of alteration - mineralization
Scale 100 0 100 200 Feet
To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 49

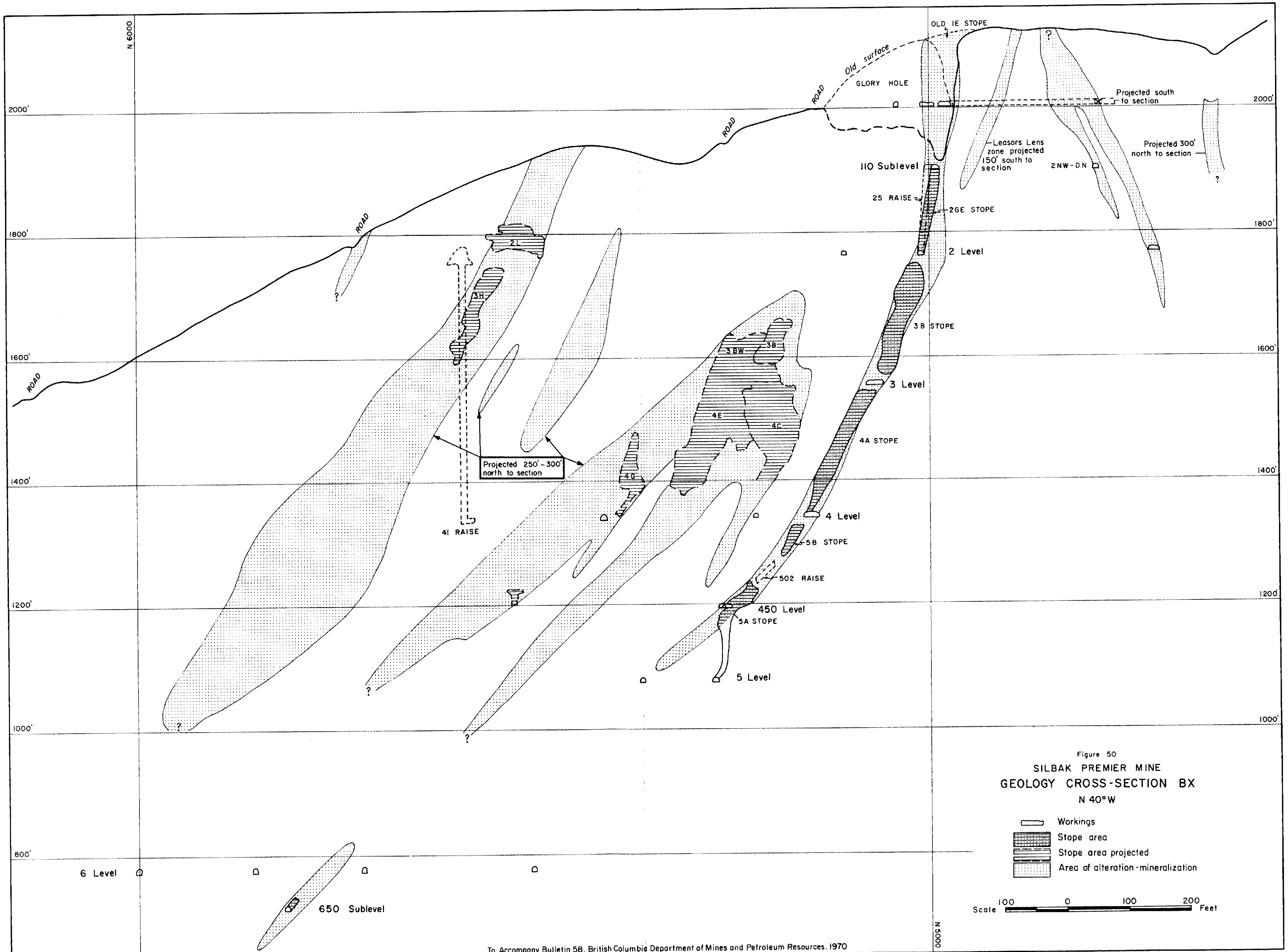

N 6000
2000'
1800'
1600'
1400'
1200'
1000'
800'
ROAD
Old surface
GLORY HOLE
OLD IE STOPE
Projected south to section
Leasors Lens zone projected 150' south to section
Projected 300' north to section
2NW-DN
110 Sublevel
25 RAISE
2GE STOPE
2L
3H
2 Level
3B STOPE
3BW
3B
3 Level
4E
4C
4A STOPE
4G
Projected 250'-300' north to section
41 RAISE
4 Level
5B STOPE
502 RAISE
450 Level
5A STOPE
5 Level
6 Level
650 Sublevel
N 5000
Figure 50
SILBAK PREMIER MINE
GEOLOGY CROSS-SECTION BX
N 40° W
Workings
Stope area
Stope area projected
Area of alteration-mineralization
Scale 100 0 100 200 Feet
To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 50

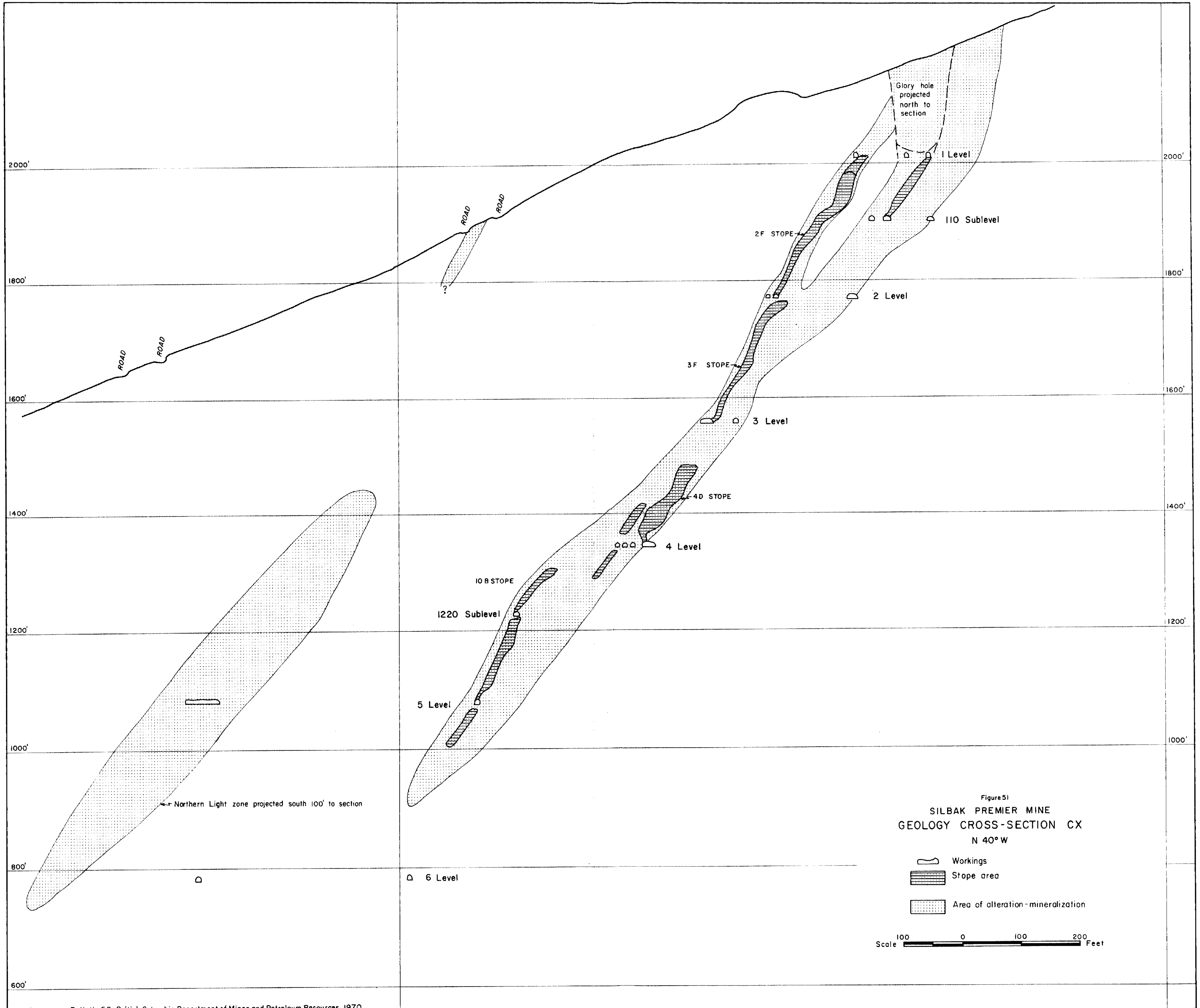


Figure 51
SILBAK PREMIER MINE
GEOLOGY CROSS-SECTION CX
N 40° W

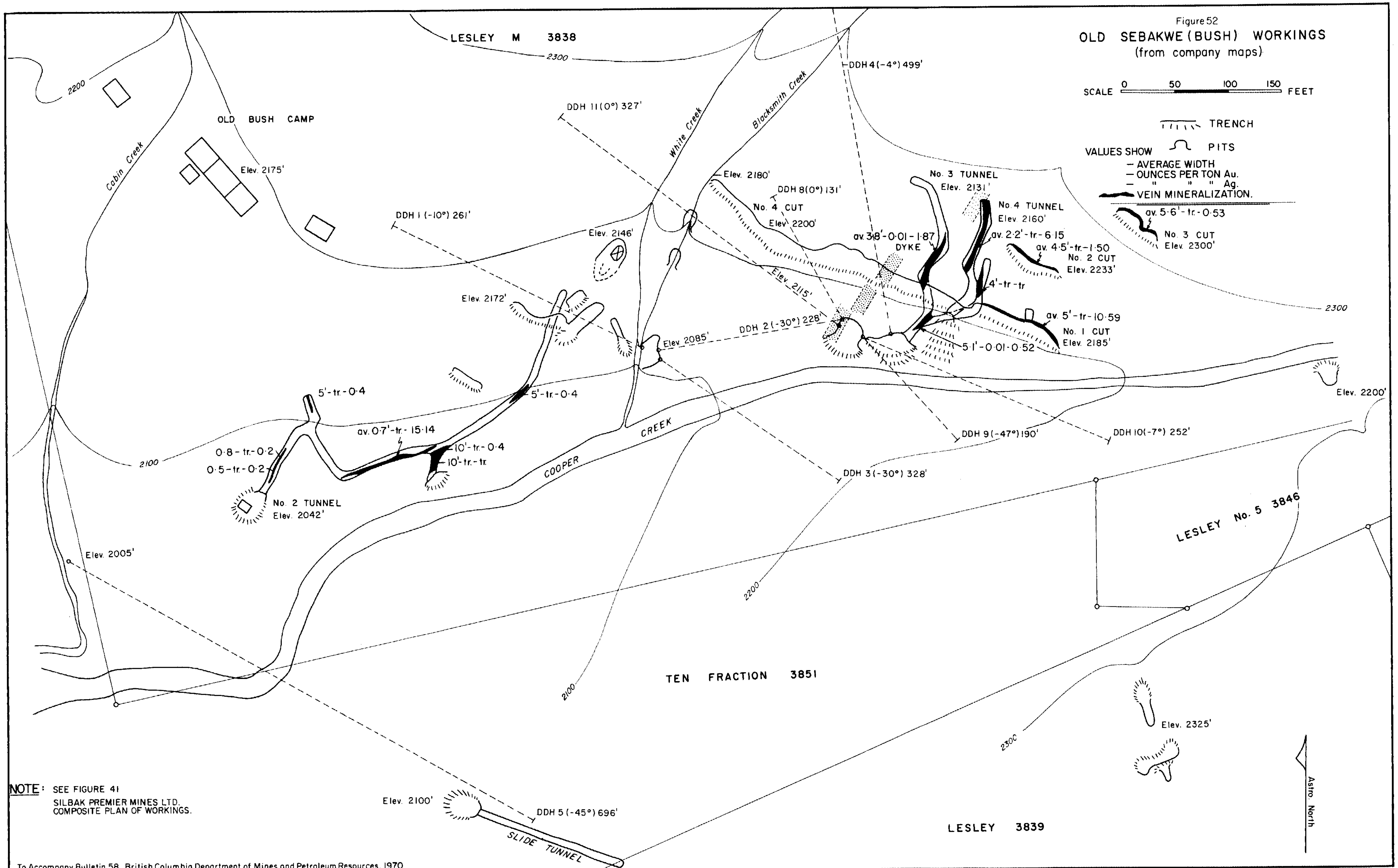


Figure 52
OLD SEBAKWE (BUSH) WORKINGS
(from company maps)

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

Figure 52

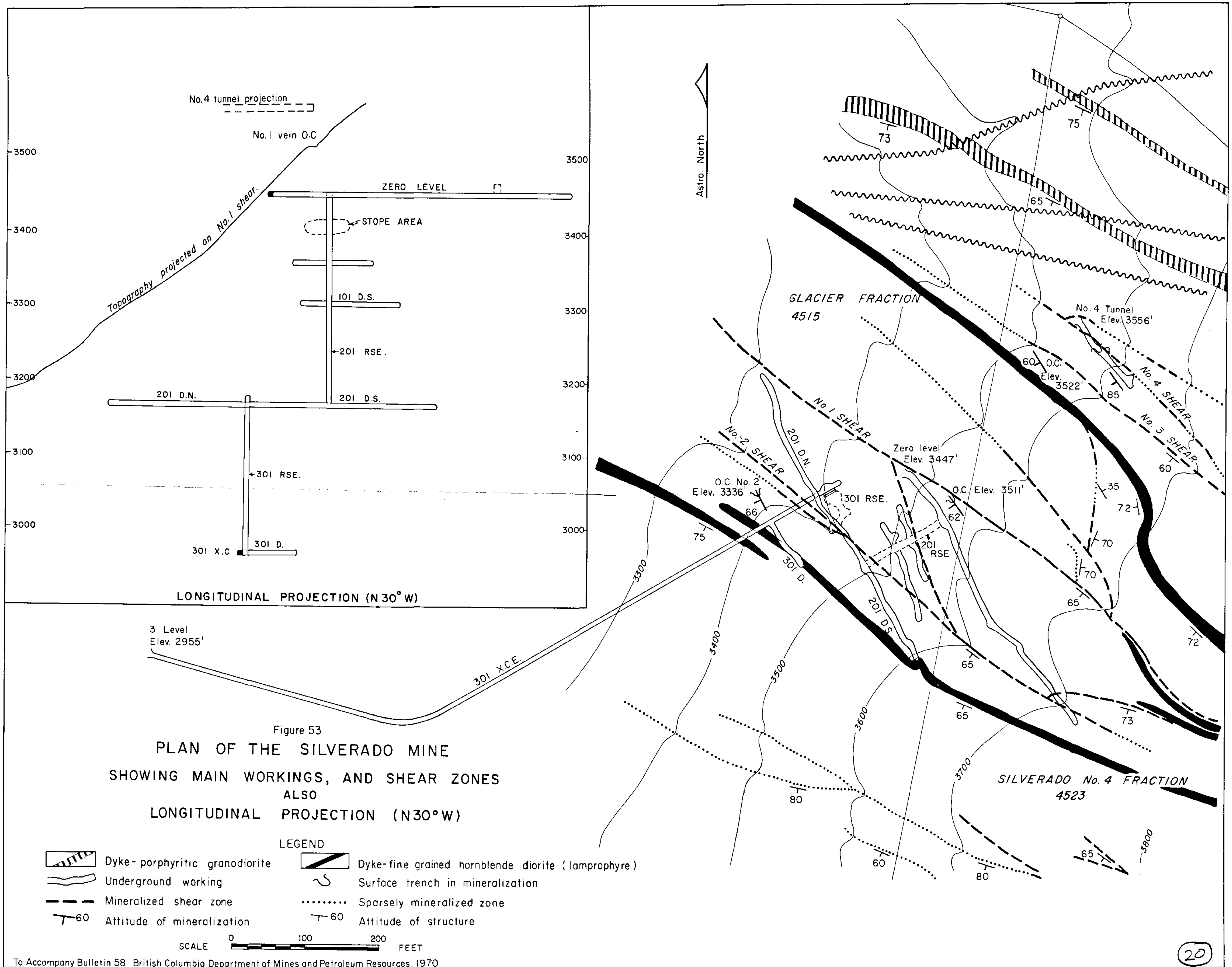


Figure 53

PLAN OF THE SILVERADO MINE

SHOWING MAIN WORKINGS, AND SHEAR ZONES

ALSO

LONGITUDINAL PROJECTION (N30°W)

To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources. 1970

(20)

Figure 53

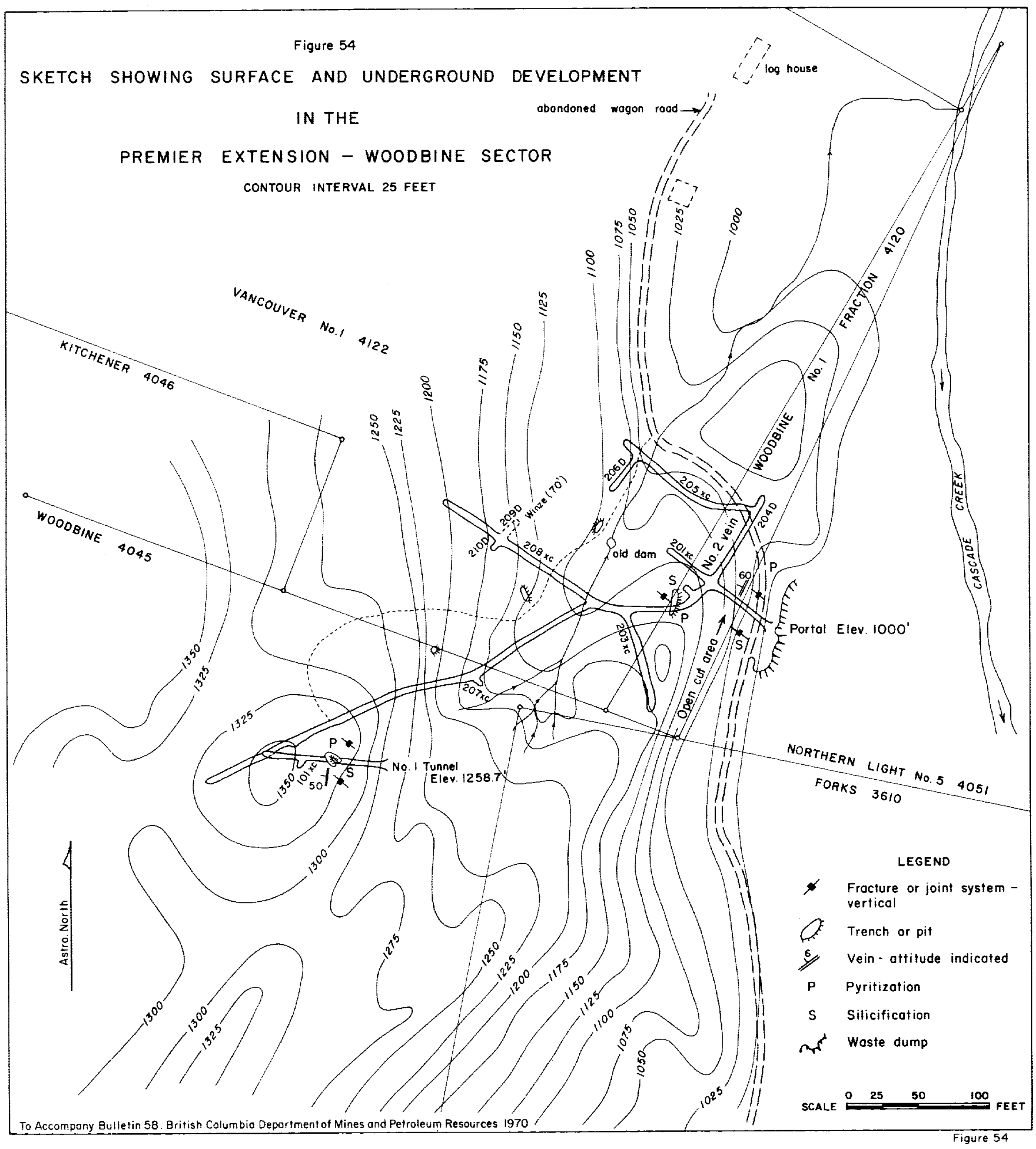


Figure 54
SKETCH SHOWING SURFACE AND UNDERGROUND DEVELOPMENT
IN THE
PREMIER EXTENSION – WOODBINE SECTOR
CONTOUR INTERVAL 25 FEET
log house
abandoned wagon road
VANCOUVER No. 1 4122
KITCHENER 4046
WOODBINE 4045
WOODBINE No. 1 FRACTION 4120
NORTHERN LIGHT No. 5 4051
FORKS 3610
CASCADE CREEK
No. 2 vein
Winze (70')
old dam
Open cut area
Portal Elev. 1000'
No. 1 Tunnel
Elev. 1258.7'
Astro North
LEGEND
Fracture or joint system – vertical
Trench or pit
Vein – attitude indicated
P Pyritization
S Silicification
Waste dump
SCALE 0 25 50 100 FEET
To Accompany Bulletin 58. British Columbia Department of Mines and Petroleum Resources 1970
Figure 54

LEGEND

SEDIMENTARY AND VOLCANIC ROCKS

CENOZOIC

PLEISTOCENE AND RECENT

- (pale yellow) Unconsolidated deposits. River flood plain; estuarine deposits, river channel and stream-cut terraces; alluvial fans, deltas and beaches; outwash, glacial lake sediments

MESOZOIC

MIDDLE TO UPPER JURASSIC

Bowser assemblage

- B1 Siltstones, greywacke, argillite, minor chert pebble conglomerate, minor limestone (including equivalent phyllites)
- B2 Lithic wacke, feldspathic wacke, siltstone, pebble conglomerate (including equivalent phyllites)
- B3 Rhyolite, Rhyolite breccia
- B4 Green, red, and buff volcanic sandstone, conglomerate, minor breccia
- B5 Red and black volcanic sandstones, conglomerates minor breccia
- B6 Red, green, and black volcanic breccia (with purple phases)

LOWER TO MIDDLE JURASSIC

Hazelton assemblage

- H1 Red and green volcanic conglomerates and sandstones, crystal and lithic tuffs
- H2 Green massive volcanic conglomerates, sandstones, minor breccia with minor intercalated siltstones
- H3 Red and purple massive volcanic conglomerate, breccia, and sandstone with minor intercalated siltstones
- H4 Green volcanic breccia, with sandstone and conglomerate

PLUTONIC ROCKS

Coast Crystalline Belt

CENOZOIC

TERTIARY

- bcm Bitter Creek quartz monzonite, granodiorite
- gcd Glacier Creek augite diorite (and equivalent)
- sld Summit Lake diorite
- bgd Boundary granodiorite
- hqm Hyder quartz monzonite (and equivalent)

MESOZOIC

MIDDLE JURASSIC?

- tcg Texas Creek granodiorite (and equivalent)

- H Hornblende is the predominant mafic mineral
- B Biotite is the predominant mafic mineral
- Inclusions of country rocks
- h Metasomatic hornblende
- po Porphyry phase

METAMORPHIC ROCKS

JURASSIC-CRETACEOUS?

Hazelton equivalents

- M1 Green cataclasites, mylonites, schists
- M2 Black (bl), purple (pu), red (r), and green (gn), mylonite (predominant colour)
- M3 Buff and green schists (including phyllonite)

ALTERATION

- P Pyritization
- S Silicification
- K Feldspathization
- h Metasomatic hornblende prominent

DYKE ROCKS

CENOZOIC

TERTIARY

- Hornblende diorite, quartz diorite (lamprophyre everywhere)
- Diorite, hornblende diorite (mainly Bear Pass area)
- Quartz monzonite, granodiorite and quartz diorite commonly porphyritic (belt of dykes) (mainly Portland Canal dyke swarm)
- Granodiorite porphyry (in Premier area) (includes Premier dyke swarm)

- Geologic contact (defined, approximate, assumed)
- Bedding (horizontal, inclined, vertical, contorted)
- Flow layers (volcanics) (inclined, vertical)
- Schistosity (horizontal, inclined, vertical)
- Joint system (inclined, vertical)
- Fault (defined, approximate, assumed)
- Fault movement (apparent)
- Lineament (air photograph feature)
- Anticline (normal, overturned)
- Syncline
- Fold axes, mineral lineation (horizontal, inclined)
- Fossil locality
- Mining property
- Adit
- Tunnel
- Quarry
- Dyke swarms (one line represents 10 to 15 dykes)
- Dyke swarm limit
- Bore hole — BH
- Road, all weather (other)
- Trails
- Tram line
- Bridge
- Building
- Boundary monument
- Glacier
- Debris-covered ice
- Gravel, sand or mud
- Moraine
- Marsh
- Lake
- Intermittent stream
- Lake or stream, indefinite
- Contours (interval 500 feet) — 2000
- Height in feet above mean sea level — 6548
- International boundary
- War memorial
- Ice boundary location (year) — 1957
- Horizontal control point
- Mine waste dump
- Mine glory hole

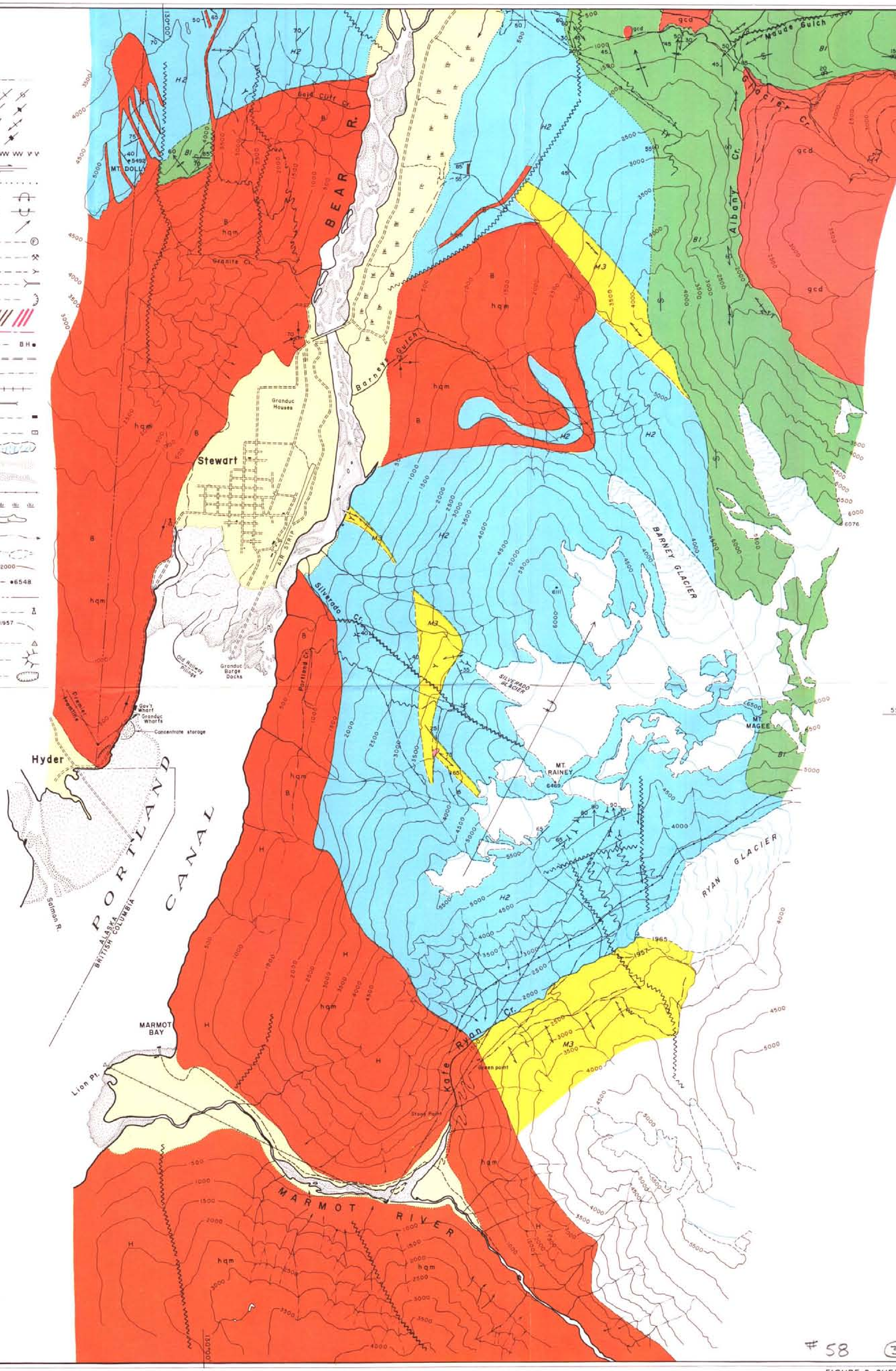


Figure 3

GEOLOGICAL MAP OF THE STEWART AREA

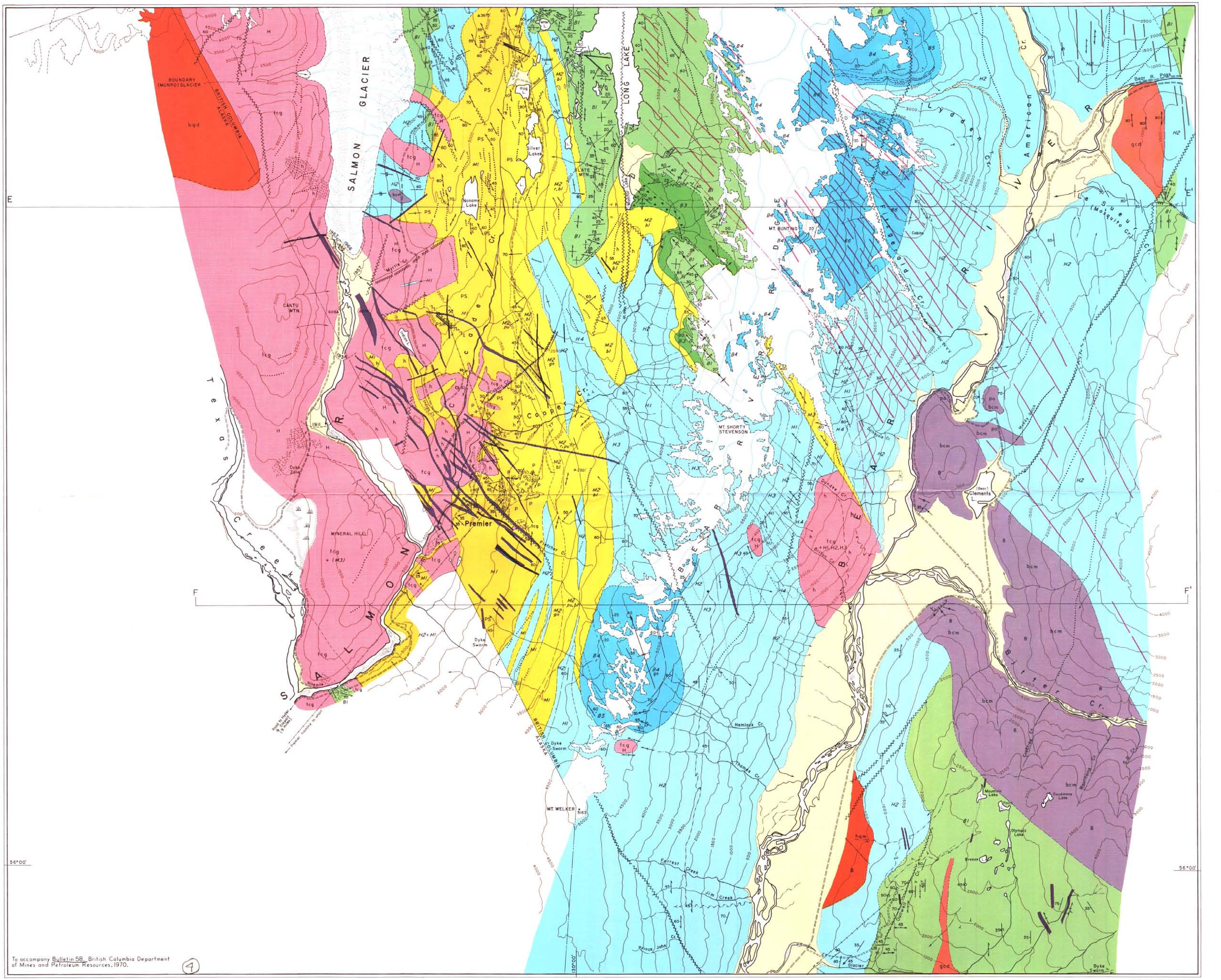
Geology by E.W. Grove, 1964-1965

Scale 0 — 1 Mile

Contour interval 500 feet

To accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources, 1970.

FIGURE 3. SHEET A



To accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources, 1970.

FIGURE 3 SHEET B
FOR LEGEND SEE SHEET A

To accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources, 1970.

(5)

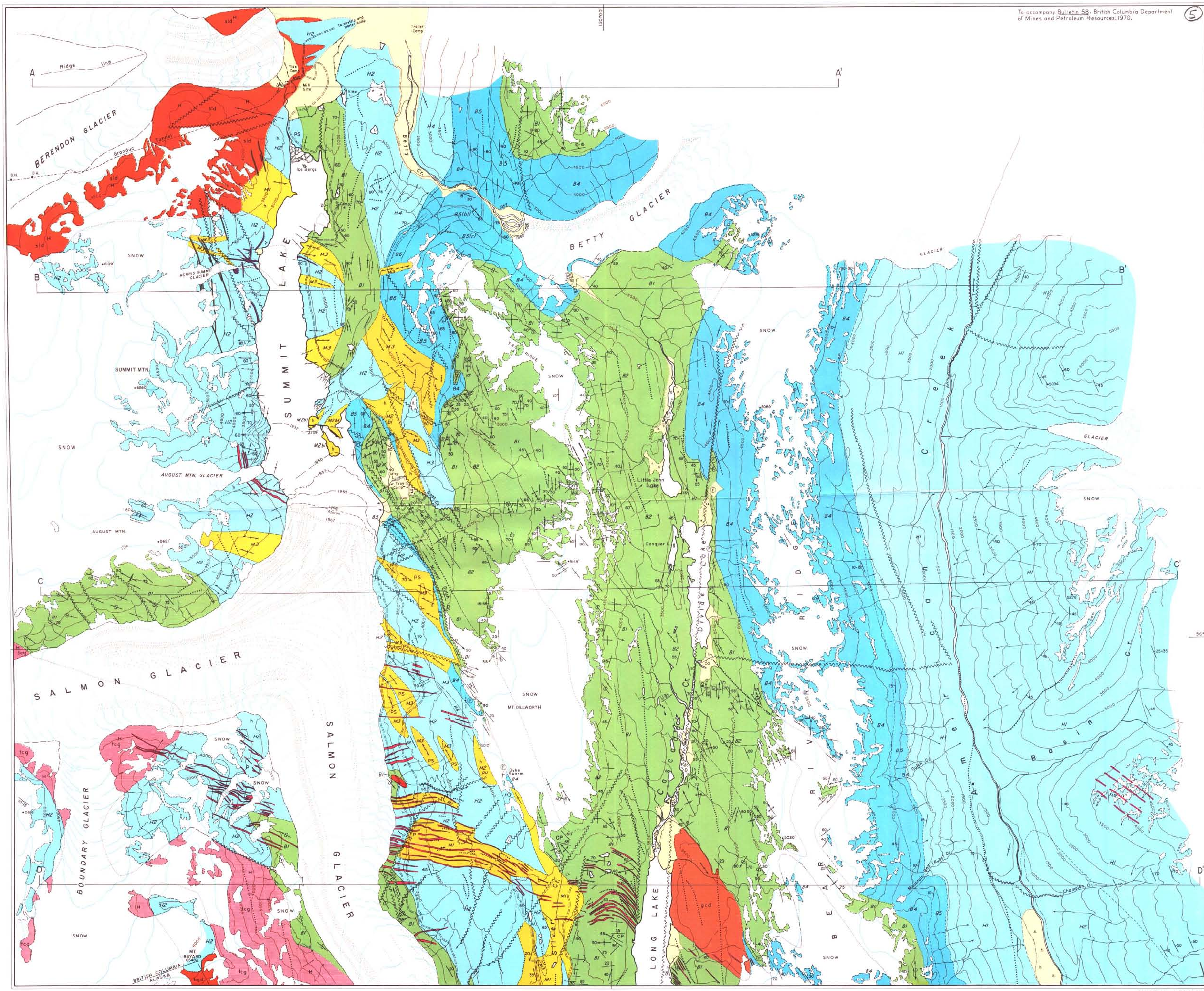


FIGURE 3. SHEET C
FOR LEGEND SEE SHEET A

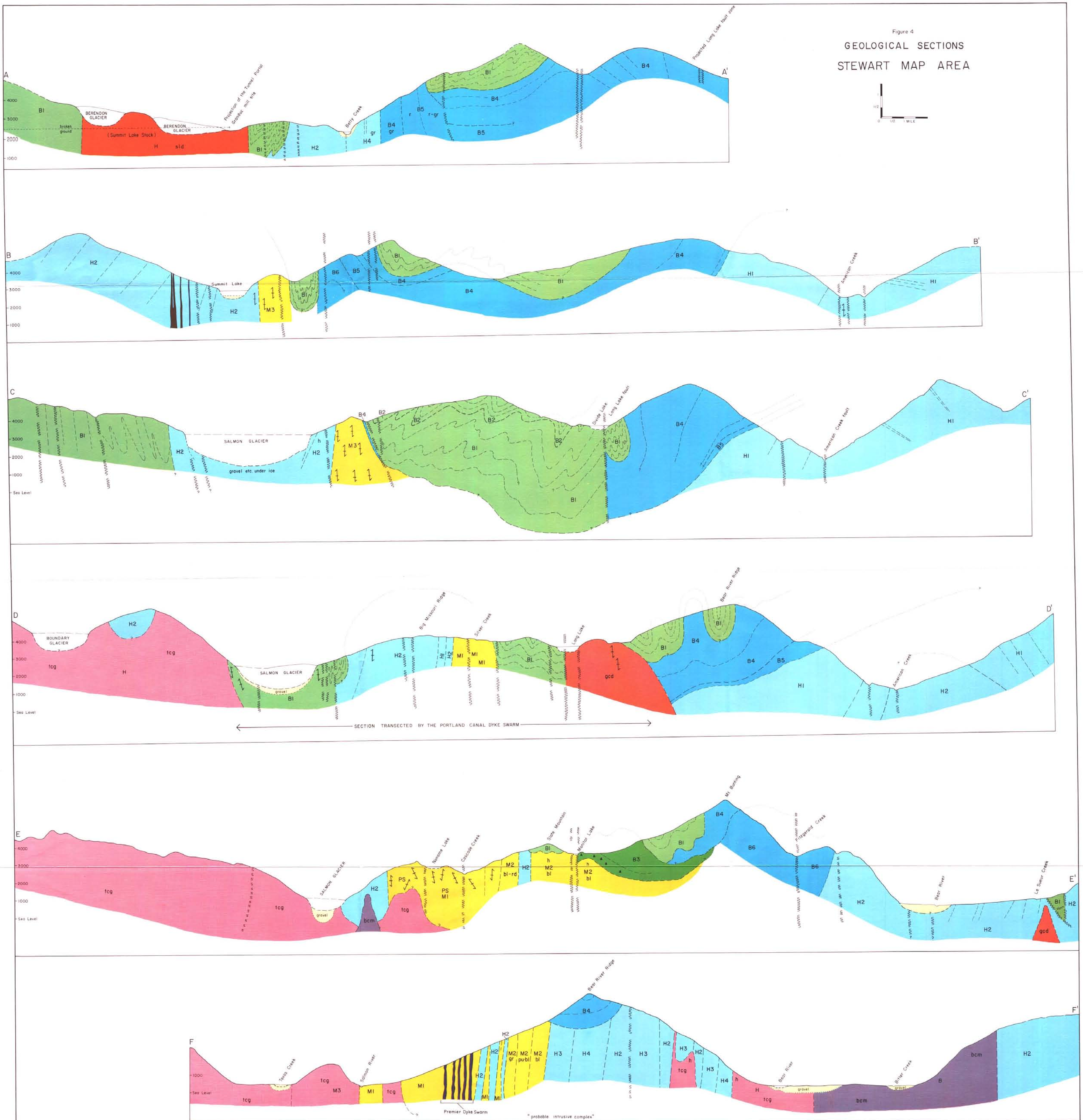


Figure 4
GEOLOGICAL SECTIONS
STEWART MAP AREA

To accompany Bulletin 58, British Columbia Department of Mines and Petroleum Resources, 1970.

FIGURE 4