

LIGHTNING PEAK AREA, OSOYOOS DISTRICT, B.C.

By C. E. Cairnes

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INTRODUCTION

Lightning Peak area is situated at the headwaters of Granby (North fork Kettle) river and Rendell creek (East fork Kettle river), Osoyoos district, British Columbia. As mapped it is an area of some 18 square miles partly surrounding, but mostly lying to the north of, Lightning peak, a prominent mountain from which the area derives its name. The area is accessible from Edgewood on Upper Arrow lake via the Edgewood-Vernon highway and a tractor road which branches to the west from the highway at a distance of 24 miles from Edgewood. The tractor road, built by the provincial government, is about 17 miles long. At the time visited it was being reconditioned for more general traffic and was passable by automobiles for 9 miles from the highway. Its terminus is at the Waterloo mine situated towards the western side of the area.

The latter half of August and the first few days in September were spent by the writer in an investigation of, principally, the economic possibilities of this area. The work included a brief study of general geological conditions with more extended examinations in the vicinity of the more important properties. Traverses were run along most of the trails and also across several less readily accessible sections. Control for these surveys was afforded by a topographic map¹ prepared by the Department of Lands, Victoria.

The work was greatly facilitated by the hearty co-operation of the various property owners and operators, among whom R. L. Clothier and John Morrison of Waterloo Consolidated Mines, Limited, W. A. Calder, and James Graham are specially mentioned. In the field work the writer was ably assisted by Mr. N. D. McKechnie.

Little is known of the early history of Lightning Peak camp. Apparently considerable prospecting during a period of seven or eight years had been done before the camp was first referred to in the annual reports of the provincial government. The principal route into Lightning Peak camp in the early years, and one maintained until quite recently, led from Fire

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Valley Landing on the west side of Lower Arrow lake about 6 miles north of Edgewood, westerly across a low divide for about 4 miles to Fire valley, which is drained by Inonoaklin creek, thence up this valley to near the junction of Sand creek, a western tributary of the Inonoaklin. The trail then

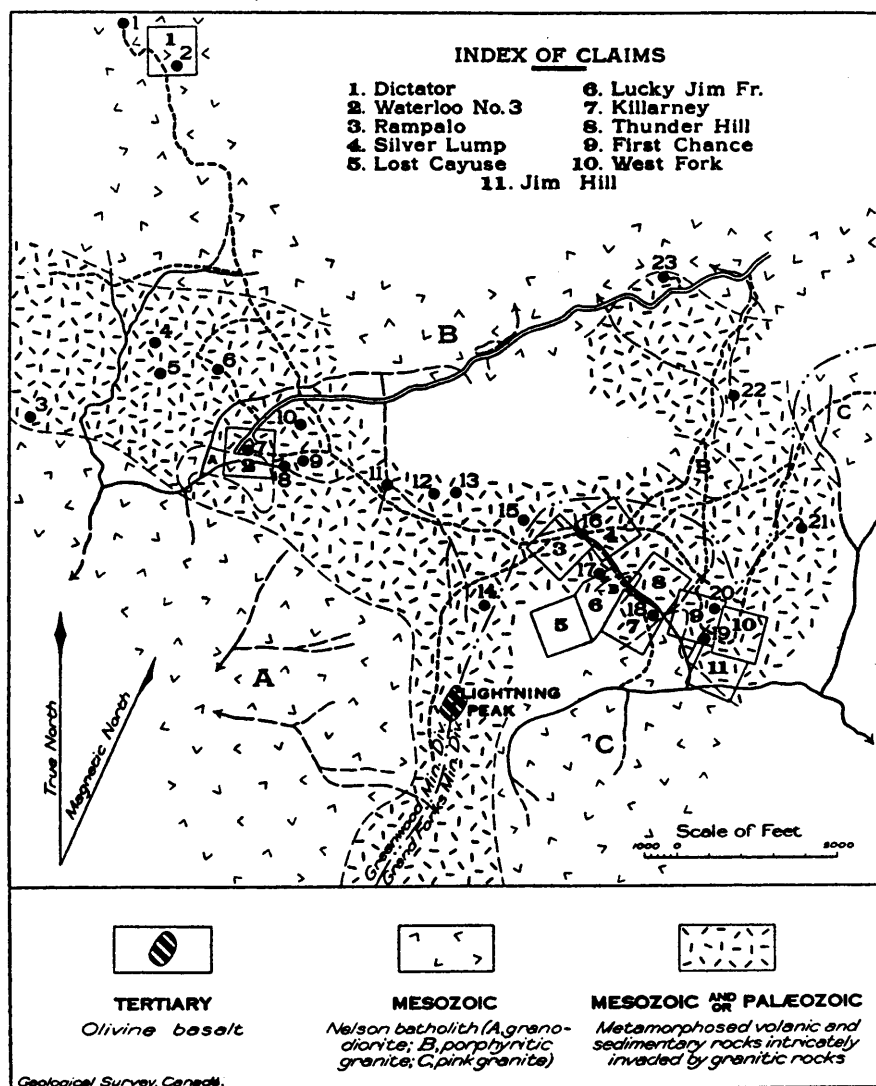


Figure 7. Lightning Peak area, Osoyoos district, British Columbia. Positions of mines, prospects, and other mineral discoveries are indicated by solid circles numbered as in text.

followed up Sand Creek valley and thence westerly via Galloping mountain to Lightning Peak camp, a total distance from Lower Arrow lake of about 26 miles. Another, but less frequented, route led northerly along the divide between the east and west forks of Granby river from Franklin Camp.

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1917—p. 199.

1918—p. 203.

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1919—facing p.

1919—p. 163.

1919—p. 167.

1919—p. 174.

1920—p. 155.

1920—p. 156.

1921—p. 181.

1921—p. 187.

1922—pp. 171.

The Rampalo was the first claim staked in the area and was located in 1897 by Adam and Louis Scaia and Axel Johnson. By 1904¹ three properties had received considerable attention, viz., the Lightning Peak, Waterloo, and Rampalo groups, and small ore shipments had been made from the first two. No further reference is made to the Lightning Peak country until 1917 and the years following. The Waterloo and Lightning Peak groups continue to be centres of principal attraction, but a number of other properties, including the Killarney, Pay Day, Rampalo, Potosi, Dictator, and Lumpy had furnished mineralization of an encouraging nature and still others of lesser interest had received some attention in the way of prospecting.

Developments at this camp have been greatly handicapped by transportation difficulties. Prior to 1917 all supplies had to be carried in and all ore shipments taken out by packhorse over the Galloping Mountain trail. In 1917 and 1918 a snow-trail was constructed, with government assistance, to connect the camp with the Edgewood-Vernon road. This new trail was employed to rawhide ore out on during the winter months and for this purpose was a considerable improvement over the old pack-trail. Even under these conditions, however, the cost of haulage to Edgewood, amounting to about \$30 a ton, was prohibitive for anything but high-grade ore. In 1929, the tractor road previously mentioned was constructed and in 1930 this road was being rapidly widened and surfaced, so that it may be possible in the near future to run an auto over the entire distance from Edgewood to Lightning Peak area.

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¹Ann. Rept., Minister of Mines, B.C., 1904, p. 224.

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GENERAL GEOLOGY

INTRODUCTION

Lightning Peak area is in the heart of the Columbia system of mountains. These are bordered on the east by the great valley of Columbia river and on the west they merge into the Interior Plateau region of British Columbia. The mountain system has been subdivided into a number of mountain groups or ranges, of which that in the vicinity of Lightning peak is commonly referred to as the Monashee mountains.

Relief ranges from about 5,000 feet above sea-level, in the lower valleys, to 7,035 feet at the summit of Lightning peak, the highest point in the area. Save, however, for the principal valleys which are deep and cut steeply below the general surface, this surface has more the characteristics of a plateau region than of an alpine district such as features much of Columbia mountains.

Lightning Peak area is mostly timbered, but, largely as a result of its altitude, not heavily so and in general is readily traversed on foot in almost any direction. Meadow-like expanses are common and at the higher elevations (about 6,000 feet) the hill slopes are bare or but scantily forested. Rock exposures are here best shown, though almost continuous outcrops were also noted at lower elevations along some of the smaller tributary streams. For the greater part, however, the underlying rocks are obscured by accumulations of glacial drift, soil, and vegetation, all of which have proved a handicap to surface prospecting.

The hard-rock formations of the area may be conveniently described under four main subdivisions, namely: Tertiary basalt, minor intrusives, batholithic intrusives, and pre-batholithic rocks. The first is represented only at one locality where it forms the upper 200 feet or so of Lightning peak, the highest point in the area. Minor intrusives are widely distributed within the areas occupied chiefly by pre-batholithic formations and are represented mostly by acidic types. Of these, quartz-porphry dykes are most abundant. Other types include dyke-like bodies of more granitic texture and, still others, mostly small, of a pegmatitic facies. These acidic intrusives are commonly associated with mineralized veins and have been looked upon with considerable favour in mining operations to date. Minor basic intrusions are relatively scarce and economically less interesting than the more acid types. Batholithic intrusions occupy the larger

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part of the area. They vary in composition from granite to diorite, the more acid types constituting the bulk of these intrusives as mapped, whereas the more basic rocks are, in general, intimately associated with the formations they intrude. The pre-batholithic formations occur mostly within a belt, about a mile wide, which stretches in a general east and west direction across the area. They include a variety of both sedimentary and volcanic rock types and have been greatly altered by batholithic intrusions. Most of the mineral deposits of the camp lie within this belt of older rocks.

TERTIARY BASALT

The upper 200 feet or so of Lightning peak is composed of a black or dark bluish grey, massive, fresh-looking lava. The rock varies from dense to slightly granular and carries an abundance of fresh olivine crystals that are in part disseminated through the rock and in part segregated in nests varying in size up to several inches in diameter and composed principally of olivine and pyroxene. Under the microscope a thin section of the lava was observed to contain abundant crystals of olivine and pyroxene (diallage) in a microcrystalline groundmass composed in part of feldspar and carrying small grains of magnetite and other minerals.

The contact of the lava with the underlying older rocks is obscured by talus so that its nature could not be determined. It appeared, however, that the rock was denser towards the base than at the summit, though there was little evidence in that to indicate whether the occurrence represents a heavy flow or succession of flows covering a large area in Tertiary time and since removed by erosion, or whether Lightning peak is the site of an old volcano. No other occurrences of such lava are known anywhere in or near this area in spite of the fact that some nearby summits reach almost to the height of Lightning peak and others not many miles away are considerably higher. The top of Lightning peak has been strongly glaciated and large blocks of the lava observed towards the head of Soda creek over 3,000 feet to the southeast of Lightning peak seemed to indicate the general direction of movement of the ice. Lightning peak is somewhat cone-shaped, a feature that serves to distinguish it from other mountain tops in and near this area. The suggestion is that, although erosion has doubtless played a principal role in developing its contours, the present prominence of this peak is an inherited characteristic, developed, in the first place, from local volcanic eruption.

MINOR INTRUSIVES

Of the minor intrusive rocks those of more acid composition are the more numerous and economically are the most interesting. They may be divided into three principal types: quartz porphyries; granitic porphyries; and pegmatites.

Quartz Porphyries

Rocks classified as quartz porphyry are abundant within areas of the pre-batholithic formations. They form long, dyke-shaped masses mostly only a few feet wide, but traceable in some instances for at least several hundred feet. They are massive and so alike in general appearance that in most cases they can be readily identified even in the smallest exposures.

They are typically light to creamy grey, medium grained, and of uniform texture and acid composition. Hand specimens rarely show appreciable amounts of dark minerals and seem to be very largely composed of quartz and feldspar. Weathered surfaces are commonly speckled or spotted rather than uniformly coloured. Where pyrite is present, the rock may weather a rusty brown. Under the microscope a specimen, typical of a number of dykes observed on the Waterloo property and obtained from the A.U. claim, was found to contain much quartz in more or less granular forms, showing strain and full of minute inclusions. Other essential minerals include microcline and plagioclase (about oligoclase), numerous patches of sericite, and small pyrite cubes. Another specimen obtained from the upper Rampalo adit of the Rampalo property, and more feldspathic in appearance than the specimen just described, was seen, microscopically, to carry abundant quartz, some orthoclase but more microcline, altered plagioclase, and a little altered mafic mineral, probably biotite. The mineral constituents, particularly the quartz, are notably strained and partly granulated.

The quartz porphyry dykes were found intruding the pre-batholithic formations, but were not observed cutting batholithic rocks. They are in many cases closely associated with quartz veins carrying values in gold and other metals. Such quartz veins may occur along either the foot- or hanging-wall of the dykes, or cross the dykes, but are commonly most continuous where developed along the foot-wall. It seems unlikely, however, that the dykes and veins are genetically connected. The dykes in places carry a little pyrite, but in general are notably lacking in ore-minerals. Quartz veins similar to those associated with the dykes also occur quite independently of the dykes. In certain instances, too, as at the Waterloo and Lightning Peak mines, the quartz porphyry dykes were observed to have been faulted and mineralized vein quartz to be distributed along the fault zones. In most instances where the association of dyke and vein-matter was noted it appeared that the relation was structural rather than genetic as if the dykes had provided lines of weakness followed by the vein solutions.

Granitic Dykes

A number of dykes and small intrusive masses of granitic texture, and in mineral composition much resembling the members of the batholithic rocks, were observed within areas underlain by pre-batholithic formations. A number of such bodies, for example, cross Rampalo creek and resemble one or other of the batholithic members in that vicinity, except that, as a rule, they are finer textured. Others were noted at the Lightning Peak mine and are intersected by the main vein at that property. The dykes vary up to 100 feet or more in thickness. The other bodies outcrop over irregular areas which, owing generally to incomplete exposures, are of doubtful size.

Pegmatites

Pegmatites and pegmatitic rocks are abundantly represented in certain parts of the area. A number of occurrences were noted, for example, on the A.U. claim of the Waterloo group and on the West Fork claim of the Lightning Peak group. These pegmatitic intrusives are typically coarse-grained rocks of irregular texture and composed chiefly of quartz and alkali

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feldspar. One occurrence noted on the A.U. claim, 200 feet or more east of the shaft, is composed of large masses of microcline feldspar full of small, irregular cavities whose outlines resemble those of graphic intergrowths of quartz, but, in this case, quartz occurs only as microscopic crystals lining the walls of the cavities.

The pegmatites are apparently more or less dyke-shaped, but are less regular than the quartz-porphry intrusives. These two types are, however, probably closely related in age and though not observed in contact some of the pegmatitic rocks grade into finer grained types much resembling quartz-porphry.

Some vein quartz carrying, in places, pyrite and a little galena, was observed associated with pegmatitic intrusives on the A.U. claim. In general, however, these rocks have provided little mineralization of economic interest.

Minor intrusions of basic composition are scarce as compared with the acid types. Occasional dyke-like bodies a few feet wide, of massive, medium to fine-grained, dark greenish grey rocks, were observed at widely separate localities within the outcrop areas of pre-batholithic rocks. They were not examined microscopically, but appeared to have about the composition of diorite and are probably related to neighbouring batholithic intrusions. Nothing of economic interest was observed in their vicinity.

In addition to the above, one dyke of more basaltic character was noted on the Pilot and Uta claims. It is a dark olive-green, fine-grained rock carrying small, black crystals of hornblende. Under the microscope this rock was observed to carry abundant crystals of brownish amphibole, resembling basaltic hornblende, and numerous clear pyroxene crystals, in a finer grained groundmass composed largely of feldspar. The larger crystals of feldspar are commonly lath-shaped, well-twinned, and fresh in appearance and were determined to have about the composition of labradorite. Accessory minerals include abundant disseminated grains of magnetite, and a little calcite and quartz. It seems possible that this rock may be related to the period of vulcanism with which the basalt rock on the top of Lightning peak is connected.

BATHOLITHIC INTRUSIVES

Batholithic intrusives occupy a large part of the Lightning Peak area and except to the west, in which direction the extent of the pre-batholithic formations is unknown, completely surround it. For convenience in description these batholithic rocks may be subdivided into three members each of which possesses certain distinctive lithological features. These members are referred to as: (1) porphyritic granite, (2) granite-diorite complex, and (3) pink granite.

Porphyritic Granite

This granite occupies much of the northern half of the area and also forms two comparatively small bodies near the centre but towards the eastern side of the area. It is a grey, coarse-grained rock, particularly distinguished in outcrop by conspicuous phenocrysts of potash feldspar

averaging half an inch or so in length. Otherwise the rock is a coarse-grained aggregate of quartz and feldspar with from 5 to 10 per cent of ferromagnesian minerals, chiefly biotite. Under the microscope a specimen from the Dictator claim was found to carry about equal proportions of quartz, orthoclase, and plagioclase with some microcline and biotite. The quartz, in particular, showed evidence of strain and was partly granulated. This granite near its main contacts with pre-batholithic rocks, and where it occurs in small, isolated bodies within these older rocks, is generally less quartzose and takes on more of the composition of a syenodiorite. A specimen of this sort of rock obtained from a small body was studied under the microscope. It carries about equal amounts of orthoclase and plagioclase, but comparatively little quartz. Both green hornblende and brown biotite are present. One large phenocryst of orthoclase contains smaller crystals of hornblende and plagioclase. The plagioclase shows albite, pericline, and Carlsbad twins and seems to be about oligoclase in composition. Vermicular intergrowths of quartz in orthoclase were observed. Both of these minerals show strain.

The porphyritic granite is the principal member of the "Nelson" granite referred to by Brock¹ in earlier explorations west of Columbia river and is correlated with the granite in the vicinity of Nelson and northward into Slocan district, this granite being the most conspicuous and lithologically most easily recognized member of the Nelson batholith complex.

Granite-Diorite Complex

This term has been applied to the large body of granitic rocks occupying the southwestern part of the Lightning Peak area; to a smaller body in the vicinity of the Waterloo No. 3 claim; and to innumerable occurrences intimately associated with the pre-batholithic formations and for the most part either too small, or too incompletely exposed, or too intricately associated with the older rocks to permit of separate mapping.

These rocks are mostly grey to greenish grey, medium to coarse-grained, equigranular, and vary in mineral composition from diorite or quartz diorite to granite. Intermediate types of about the composition of granodiorite are the most abundant and are the chief components of those areas mapped. So far as could be observed contacts between types of varying acidity are quite gradational. The more basic types are in general those associated most intimately with the older rocks and their variation from more normal composition is attributed to contact relations with these pre-batholithic formations. These relations are so intimate that, commonly, single outcrops of the older rocks a few square yards in extent are penetrated by intrusive material to the extent of 50 per cent or more of the volume of the outcrop. Contacts may be sharply defined or may indicate gradations from granitic to older rocks, so that it may be difficult to decide whether the rock at a certain point is intrusive or not. Farther from their contacts with the older rocks, the intrusives are more acid and more uniform in appearance and composition.

Specimens for microscopic examination were obtained from three widely separate localities: one about a mile south of the Waterloo mine; another about a mile southwest of Lightning peak; and the third from the

¹Brock, R. W.: Geol. Surv., Canada, Sum. Rept. 1900, pt. A, p. 71.

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Granite range west of the junction of Waterloo and Rendell creeks. These specimens are much the same in appearance and composition. Each carries abundant quartz which is more or less strained and fractured. In each, feldspar constitutes a somewhat greater proportion of the rock than the quartz and includes both orthoclase and plagioclase, the latter of which is the more plentiful, though not notably so, and is about oligoclase in composition ($Ab_{72} An_{28}$ for the specimen south of the Waterloo mine). Both hornblende and biotite are present, but in minor proportions to the felsic constituents, and are partly altered to chlorite. Accessory minerals include titanite, magnetite, and apatite.

A variety of somewhat different appearance outcrops on a hill $1\frac{1}{2}$ miles about west-southwest from Lightning peak. Below, approximately 250 feet from the summit of this hill on the eastern and northern slopes, the well-exposed rock is a massive, grey to slightly pinkish type carrying abundant dark green, chunky crystals of pyroxene and a smaller but conspicuous amount of fresh-looking biotite. The remaining 60 per cent or so of the rock is chiefly feldspar of grey to slightly pinkish cast. Under the microscope the rock was found to be a quartz diorite composed largely of plagioclase occurring in lath-shaped crystals and about andesine in composition. Otherwise the rock carries scattered, comparatively large crystals of diallage, more abundant flakes of dark brown biotite, a little quartz, probably between 5 and 10 per cent of orthoclase, and accessory apatite.

Pink Granite

The third principal member of the batholithic rocks is widely exposed in the southeastern part of the map-area and also appears to underlie a large area on either side of the Galloping Mountain trail. It seems likely that the intrusives of these two localities are parts of one mass and join east of the map-area.

The pink colour of this granite is due to the large proportion of pink feldspar present. Otherwise the rock carries abundant quartz, commonly somewhat smoky, and a small but variable percentage of dark minerals of which biotite is most conspicuous. In some places almost no dark minerals can be seen. Under the microscope specimens obtained from the main outcrop area southeast of Lightning peak and from Rampalo creek were found to be almost exactly alike and to have the composition of a very acid granite. The rock carries about equal amounts of quartz and feldspar. The former shows some strain. The feldspar is in part orthoclase and in part plagioclase of about the composition of albite-oligoclase. A very little biotite is present and is mostly altered to chlorite. Accessory minerals include quite a lot of titanite and magnetite. The pink granite is distinguished mineralogically from the other batholithic rocks by the more sodic character of its plagioclase feldspar and by the relatively small percentage of mafic minerals present.

This granite is mostly quite massive and as such exhibits but little evidence of deformation. Locally, however, it is quite strongly sheared and fractured and the rock loses the fresh appearance which characterizes it in its more massive outcrops. A belt of sheared granite about 200 yards wide and striking northeasterly was observed in the granite area about

a mile southeast of Lightning peak near the contact with pre-batholithic rocks. What may be a continuation of this same sheared belt is represented by a similar width of the same type of granitic rock crossing Rampalo creek about 2,000 feet from its mouth.

A very similar pinkish granite was observed along the trail to Galloping mountain and also outcrops widely in the vicinity of this prominent hill.

Relations of the Batholithic Rocks

There seems little doubt but that the porphyritic "Nelson" granite and the members of the granite-diorite complex are closely related in origin and that they were intruded at about the same time. Their chief difference is a textural one and though they vary from granite to diorite or quartz diorite in composition this variation appears to be the result of local conditions, the chief of which relates to the intimate association of the more basic types with pre-batholithic formations. Otherwise these rocks have much the same general appearance; are composed of essentially the same minerals; have experienced alteration of a similar character; and are structurally alike. The porphyritic texture so characteristic of the "Nelson" granite is not uncommonly well developed in the granite-diorite member, all gradations being observed in such instances between the more porphyritic and equigranular types. Such porphyritic phases were, for example, noted in a number of the dyke-like bodies and small masses of intrusive associated with the pre-batholithic rocks where they outcrop along the Granite range, and elsewhere in more central parts of the areas, as in the vicinity of the Waterloo and Rampalo properties. The same texture was also noted here and there within the main area of the granite-diorite complex. In most cases, however, this texture was less characteristically developed in the outlying areas than in the main body of porphyritic granite and was most commonly noted where nearest to this main body.

In the case of the "pink granite", however, there is little evidence of direct relationship with the other two types. Its pinkish colour; great abundance of quartz of a slightly smoky appearance; paucity of dark minerals as compared with the other batholithic members; non-porphyritic texture and in general fresh appearance in comparison with the "Nelson" granite; all render it easily separable from the other batholithic rocks. As contrasted with the other batholithic intrusives, it appeared, on the whole, to be notably deficient in sulphides or other metallic minerals. As developed at and in the vicinity of Galloping mountain this pinkish granite is included with the Valhalla granite of the West Kootenay map-sheet¹. In referring to it Brock states² "From near the head of Gloucester creek [north of Franklin mountain] to Fire Valley ridge [i.e. the ridge extending northwest-southeast on either side of Galloping mountain to the southwest of Fire valley] the rock is a pink, quartzose, biotite-granite, seemingly related to the 'Rosslund granites'." Brock also refers to this granite as carrying "inclusions of grey granite" the latter apparently being the "Nelson" granite. In Lightning Peak area no contacts between the pink granite and the other batholithic members were observed.

¹Geol. Surv., Canada, Map 792.

²Brock, R. W.: Geol. Surv., Canada, Sum. Rept. 1900, pt. A, p. 71.

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The features mentioned above seem to support the view that the pink granite is later than the Nelson granite and granite-diorite complex. The difference in age may not, however, be very great. The pink granite is locally strongly sheared and exhibits even greater deformation than was noted in the other batholithic intrusives. At the Lightning Peak mine, on either side of the shaft, is a crushed dyke 100 feet wide of biotite granodiorite porphyry which bears quite a strong lithological resemblance to the more sheared phase of the pink granite. This dyke is intersected by the main vein at this mine and is consequently pre-mineral in age. On the supposition that the dyke is an offshoot from the pink granite the latter would, as in the case of the other batholithic members, be of pre-mineral age.

The age of the batholithic rocks cannot be deduced from their relations within this area. Their correlation, with the possible exception of the pink granite, with the Nelson granite of Kootenay district where this granite has been observed intruding Triassic and older formations, places them as post-Triassic in age and their probable connexion, in time of intrusion, with the Coast Range intrusives of British Columbia, suggests that they are probably of Jurassic or post-Jurassic age. The pink granite is most readily correlated with the Valhalla granite as developed in the vicinity of Galloping mountain. This Valhalla granite, as depicted on the West Kootenay sheet, was regarded as post-Cretaceous.¹ In the Lightning Peak area, however, there are reasons for believing that the pink granite is little if any younger than the Nelson granite which, on the same sheet, is doubtfully referred to post-Jurassic time.

PRE-BATHOLITHIC ROCKS

Pre-batholithic formations occupy a large part of the central part of Lightning Peak area where they occur chiefly within a belt averaging a mile or more in width and extending in a general east and west direction across the map-area.

These formations include a variety of both sedimentary and volcanic rocks, but all have been much altered, chiefly by the numerous intrusions, so that their original characters have been in most places very largely obscured. Some of the rocks, particularly in the western and southwestern parts of the area, are well bedded, but of these only those that are limestone present definite evidence of a sedimentary origin. Most of the bedded formations, as well as those in which such structures are less obvious or wanting, are massive types varying in colour from grey and greenish grey to green. Most of them are fine-grained to dense rocks, the former possessing a microcrystalline, igneous appearance, that is particularly pronounced where the association with granitic intrusives is more intimate and which is attributed to recrystallization and granitization. In many places, however, the rocks from their colour, texture, structure, or mineral composition are regarded as of volcanic origin and as including lavas, tuffaceous rocks, and, possibly, basic intrusives.

Limestone

A great deal of limestone was observed within an elongated elliptical area extending from the vicinity of the Lumpy workings (about 3,000 feet north-northeast of Lightning peak) northwesterly across the Waterloo

¹Geol. Surv., Canada, Map 792.

and Potosi properties to the Granite range. The widest exposures occur in the vicinity of the Waterloo mine, on either side of which a width of about 3,000 feet is about one-third underlain by limestone and the remainder largely by intrusive rocks. The widest single exposure of limestone occurs partly on and partly to the north of the Waterloo No. 3 claim and has a maximum observed width of between 500 and 600 feet. Other conspicuous widths of limestone occur: (1) within the northern two-thirds of the Waterloo claim; (2) at the junction of Silver Spot and Waterloo creeks; (3) on the Potosi group to the northwest of and in line with the limestone exposures on the Waterloo No. 3 claim; (4) on the Silver Spot claim of the Waterloo group to the southeast of and in line with limestone exposures on the Waterloo No. 3 claim; (5) on the Silver Spot No. 3 and No. 4 claims within a mile to the east-southeast of the Waterloo No. 3 claim; and (6) at the Lumpy workings on the Lumpy claim. A little limestone was also observed crossing the Granite range near the northern contact of the southern area of batholithic intrusives.

The limestone is medium to coarsely crystalline. According to the amount and character of impurities it varies from dark grey to nearly white. In general it is quite massive and structureless, but in places is well bedded, bands of nearly pure crystalline limestone a fraction of an inch to several inches wide alternating with, generally, narrower, darker, impure bands. In places the limestone has been altered to massive garnetite composed largely of a reddish garnet associated with some crystalline calcite. One occurrence of bunches of fibrous wollastonite was noted in a limestone outcrop near its contact with diorite intrusives about half a mile south of the Waterloo claim.

The limestone is in contact with other pre-batholithic formations and with intrusive rocks. It forms irregular inclusions in the latter or is sharply cut off by them. Contacts with other pre-batholithic rocks are mostly irregular, but quite sharply defined. Bands of limestone may pinch out abruptly along their strike or may branch to form two or more spurs in the associated rocks. Individual bands several hundred feet wide disappear or narrow to a width of a few feet along their strike within a distance not much greater than their maximum width. Such features may indicate original variations in thickness, or may be due in part to the comparatively high degree of plasticity exhibited by limestone when subjected to deformation.

Other Sedimentary Rocks

Sedimentary rocks other than limestone are difficult to distinguish. Certain, thin, brownish-weathering beds, probably calcareous argillite, occur between heavier limestone beds at the Waterloo mine within or close to the vein zone. Elsewhere on this and other properties are outcrops of massive, dark grey to slightly greenish grey, less commonly brownish, crystalline or finely granular, rocks of quartzitic aspect, but which when examined microscopically resemble tuffs or tuffaceous sediments. A brownish grey, massive, finely granular, rusty weathering rock outcropping 700 feet northeast of the Potosi cabin was found, on microscopic study, to be composed chiefly of a clear, granular mosaic of quartz and feldspar grains

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through which are scattered numerous small blades of light green amphibole, a few small crystals of a pyroxene, probably diopside, and abundant grains or cubes of pyrite. No bedding structures were observed, but the rock is probably a recrystallized feldspathic or, possibly, tuffaceous sandstone.

Volcanic Rocks

A large proportion of the pre-batholithic rocks are probably of volcanic origin. They include three general types: (1) greenish, fine-grained to dense rocks which are either massive or exhibit varying degrees of schistosity; (2) bedded rocks which vary from fine to coarsely fragmental, are commonly greenish or greyish green and, in general, carry conspicuous, dark green crystals of amphibole; and (3) rocks much resembling quartzites, but which have a composition more like volcanic rocks.

The fine-grained to dense, greenish rocks forming the first type are probably lavas. They are the predominant country rocks at Lightning Peak and Killarney workings where they are, in part, strongly sheared and are also, in part, altered by vein solutions. One specimen of a massive, light green, fine-grained rock intersected by tiny veinlets of calcite, obtained about half-way to the face of No. 4 adit at the Lightning Peak mine, was examined in thin section under the microscope and found to consist of a fine-grained, indeterminate groundmass holding numerous, small, lath-shaped feldspars and many pseudomorphs of pyroxene and, possibly, also, olivine, composed of serpentine, chlorite, and calcite. Pyrite is finely disseminated through the rock. Very similar looking rock was observed in the adit on the Pay Day mine and also near workings on the Silver Spot No. 4 claim. Large outcrops of a massive, dark green rock carrying, in places, small, angular fragments, mostly very similar in appearance to the matrix, were observed about a mile south of Lightning peak. This rock appears to be an andesitic flow breccia and shows gradations to rocks of the second type mentioned above.

The second type is represented in part by well-bedded rocks. All are distinguished by the presence of dark green, chunky crystals of amphibole varying mostly from 2 to 3 millimetres in length and, in some of the rocks, closely crowded together. There appear to be gradations from rocks in which such crystals are abundant to others in which they are comparatively few and scattered and as these latter types include members that are distinctly fragmental and in part well-bedded, it seems likely that all are related in origin.

An abundant type is coarse-textured, bedded, and of somewhat conglomeratic appearance. The rock is grey to greenish, and carries numerous fragments that are mostly elongated parallel to the bedding and vary in length up to several inches, though most are much shorter than this. The fragments are fine grained, predominantly either green or light grey, and, probably, at least most of them, are of volcanic origin. They generally have a squeezed appearance and though their edges are in part quite sharp yet the fragments commonly are not sharply defined. The matrix in which the fragments lie composes the greater part of the rock, is of a finer texture, and through it are scattered dark green crystals of amphibole averaging probably about 2 millimetres in diameter. The matrix possesses an irregular texture and somewhat ashy appearance.

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At least two belts of this rock were observed, one about 800 feet east and the other about 1,000 feet west of the summit of Lightning peak. These belts strike nearly north and south and on Lightning peak dip to the east. About half a mile to the north and again less than a mile to the south of the peak, these two belts seem to unite and, therefore, may be supposed to be a single horizon which underlies Lightning peak in a somewhat basin-shaped structure. The thickness of this horizon south of Lightning peak where the best exposures are, is estimated to be between 200 and 300 feet. The horizon on both sides grades into a finer-grained, probably tuffaceous, green rock carrying abundant crystals of amphibole.

The bedded rocks are thought to be waterlain breccias and tuffs. They are in contact with rocks whose mode of origin is more obscure. Among the latter are those previously referred to as holding abundant crystals of green amphibole. Such rocks are apparently most abundant on the hills to the south of Lightning peak and on the upper east and west slopes of this peak. On a ridge at the south edge of the map-area and close to the west edge of the area of pre-batholith strata, a belt striking northerly and about 1,000 feet wide is composed largely of rocks of this type. Doubtless they occur elsewhere, but were not located. Three specimens for microscopic study were taken; one from the northwest slope of Lightning peak about 600 feet below the summit; another about a mile directly south of this peak; and a third from the broad belt referred to above. The first specimen contains many large crystals of green, pleochroic hornblende, possessing, mostly, ragged boundaries fringed by numerous, small, clear crystals of diopside. Other larger crystals of a pyroxene, probably augite, are present and the rock also carries much brownish red biotite. These more prominent minerals lie in a finely crystalline ground of uncertain composition, but seemingly mostly feldspathic. A little calcite was also noted. The rock has a recrystallized appearance. The presence of diopside and a little calcite and the fact that in the outcrop this rock is interbanded with volcanic tuffs and breccias suggest that the rock is probably an altered, limy tuff. The second specimen has about the same appearance under the microscope except that very little pyroxene was observed and considerable titanite is present. The amphibole crystals are crowded with inclusions and commonly show extinction angles up to 40 degrees. Some have ragged edges and others sharply defined crystal boundaries. The third specimen carries: abundant large hornblende crystals, some well twinned; numerous small blades of green amphibole resembling actinolite; considerable diopside in large and small crystals; a little biotite and titanite; and a few crystals of plagioclase feldspar. A fine-grained groundmass constitutes a relatively small proportion of the rock. All three specimens have a distinctly recrystallized appearance. Their composition, and their association with volcanic breccias, tuffs, and, probably, lavas, indicate that they are related products of vulcanism. Their contacts were nowhere observed to be definitely intrusive. In general the belts composed of these rocks appeared to parallel the structures of the adjoining volcanic formations and into which they seem to grade. All this suggests that these rocks are extrusives, in part definitely fragmental and, in part, lavas or flow breccias.

The third type of volcanic rock, those resembling quartzitic sediments, prove on microscopic examination to have much the same mineral composition as members of preceding types. A specimen from the A.U.

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claim about 800 feet north of the shaft has a clear, finely crystalline, feldspathic groundmass in which little or no quartz appeared to be present. Lying in this groundmass are: occasional, large crystals of green, pleochroic amphibole; numerous, small, colourless crystals of pyroxene (probably diopside); some shreds and flakes of reddish brown biotite; and a little epidote and zoisite. Most, at least, of the feldspar of the groundmass is plagioclase, about oligoclase in composition; a little calcite is also present. The rock is thought to be a recrystallized, limy tuff. Another specimen of a somewhat similar rock was obtained on the west slope of Lightning peak about 500 feet below the summit, where the rocks are noticeably saturated with later granitic material. Under the microscope about 50 per cent of rock was found to be composed of amphibole. The amphibole is green, highly pleochroic, has an extinction angle of from 30 to 35 degrees, and occurs in large and small crystals and in shreds. The larger crystals contain numerous, well-formed flakes of biotite. The remaining 50 per cent of the rock is a fine-grained, granular aggregate of fresh-looking plagioclase and a little quartz. This rock is somewhat doubtfully classified as a recrystallized andesite tuff.

Structure and Succession

Locally the structures are complex, but the general structure seems to be that of a syncline plunging westerly or northwesterly. The strata in the vicinity of the edges of the main batholithic bodies tend to strike parallel with the line of contact and to dip away from the granitic bodies. Judging from attitudes of the bedded rocks as obtained here and there across their area and from general differences in the character of the formations, as observed at a great number of points, there are probably two or more principal folds, though the structure as a whole, as already stated, is that of a syncline plunging westerly. Such an interpretation indicates that the massive volcanic types, chiefly lavas, exposed in the more easterly and southeasterly parts of the area, are the oldest, that these are succeeded by coarse and then fine-grained, tuffaceous rocks, including probably, some more normal sedimentary types, and that the youngest members are chiefly limestones.

Age and Correlation

No definite age can be assigned to the pre-batholithic formations. They are older than the Nelson granite which is of Mesozoic, not improbably Cretaceous, age. Because they are mainly volcanic rocks with associated limestone beds, they are tentatively correlated with the rocks occurring at intervals to the northwest of the Lightning Peak country, which were mapped by Dawson¹ with the Cache Creek series. This series is considered to be about Carboniferous in age.

ECONOMIC GEOLOGY

GENERAL STATEMENT

Interest in Lightning Peak camp has been sustained by small shipments of high-grade silver ore carrying, in some cases, important percentages of lead and values in gold and zinc. Attractive mineralization

¹Geol. Surv., Canada, Shuswap Sheet, Map 604.

has been discovered at many places and though, at most of these, it occurs in too small amounts or is too low grade to be profitably mined, yet its presence has encouraged prospecting in the hope of finding better values and more substantial deposits.

A belt of highly altered volcanic and sedimentary rocks, a mile or more wide and extending for several miles in a general east and west direction is flanked by wide areas of batholithic intrusives and is soaked with granitic material and penetrated by many acid dykes of probably related origin. The older rocks are everywhere more or less severely altered, and as a direct indication of mineral possibilities, outcrops commonly carry liberal impregnations of iron sulphide regardless of whether vein matter is present or not. The porphyritic granite member of the batholithic intrusives is correlated with the Nelson granite which in Slocan district is host rock to many valuable ore deposits and is regarded as chiefly responsible for the extensive mineralization occurring elsewhere in that district. In Lightning Peak district this granite also contains significant mineral deposits.

Mineralization at Lightning Peak camp occurs mostly within the belt of pre-batholithic rocks, but a couple of prospects of possible commercial value have been located in the Nelson granite over a mile to the north of this belt. Within the belt, mineralization sufficiently attractive to warrant further exploratory work has been discovered at a dozen or more localities situated at intervals over a distance of about 4 miles. Still others of less prospective value have been located at intermediate points, and doubtless other discoveries would have been made were it not that prospecting is in most places handicapped by an overburden of glacial drift, stream wash, and soil.

The mineral deposits discovered to date occur mostly as veins belonging to one or the other of two principal types. In one type, the vein matter occurs within strongly developed shear zones striking about east and west and dipping, in general, steeply to the north. These shear zones vary from a foot or so to several feet in width and are of unknown length, but in certain instances have been traced by underground and surface workings for at least several hundred feet. They are partly filled with fractured and crushed wall-rock and in part by vein matter. Where, as at the Waterloo mine, the rock involved is mostly limestone, replacement by mineralizing solutions has been a significant factor; elsewhere it is less important. The ratio of vein minerals to associated wall-rock is extremely variable and the proportion of ore to gangue minerals is also variable, so that only locally are the ore minerals sufficiently concentrated to provide ore. Such ore occurs in shoots up to several feet wide, 50 feet or more long, and of yet unproved depth. The ore minerals include galena, sphalerite, pyrite, chalcopyrite, and, generally, important amounts of ruby silver, argentite, native silver, and other high-grade silver minerals. The gangue is chiefly quartz, but some calcite is everywhere present and in limestone rocks may be the more abundant.

Production to date has come entirely from veins of this sort and is mostly credited to the Waterloo and the Lightning Peak mines situated 3 miles apart near the west and east side of the camp, respectively. Owing to transportation costs only the highest grade material has been shipped.

The Waterloo mine has produced about 150 tons, in all, and probably contained, on the average, one hundred tons of ore. The ore is piled on the pier and is shipped by gate shipment. Average value is about \$100 per ton in silver and lead ore, and about \$200 per ton on the Killarney Peak mine.

The other mines are nearly north-south in width and length. In many cases the veins are of narrow width. These veins are at distances of 100 to 200 feet and in such cases sphalerite, or galena, may be recovered amounting to 100 to 200 lbs. to have assayed. The gold value is very low. No free gold has been recorded. The gold value sunk on such veins is less than a foot. An increase in the wall, bands of nearly solid pyrite at the centre of the vein varies from 10 to 20 feet of pyrite at the Waterloo mine. Morning cloud surface workings are mineralized. Pyrite also occurs in widths of 10 to 20 feet. Values are 10 to 20 cents per ton.

The relative values of the east-west type veins are the same as those of the different types. The ore is stibnic and, elsewhere it is too, it may be gold probably.

The Waterloo mine is recorded to have made shipments aggregating over 150 tons, in which silver values varied from 250 to over 700 ounces a ton and probably averaged between 300 and 350 ounces. The shipments also contained, on an average, a small per cent of lead and zinc. Several hundred tons of lower grade material with values in silver, lead, and zinc are piled on the dumps. The Lightning Peak mine is credited with aggregate shipments of 200 tons or more of high-grade silver and silver-lead ore. Average values are not known, but would probably be considerably lower in silver and higher in lead than those of the Waterloo ore. Some silver-lead ore, amounting, possibly, to a few tons, has been shipped from workings on the Killarney property situated half a mile to the east of the Lightning Peak mine.

The other type of vein is represented by numerous quartz veins striking nearly north and south. These vary from a few inches to several feet in width and have been traced for distances up to 1,000 feet or more. In many cases they follow along one or other wall, preferably the foot-wall, of narrow dykes of quartz-porphry, or may even occur in such dykes. These veins carry a sparse dissemination of pyrite. More locally and for distances of a few yards, mineralization may be much more pronounced and in such cases it generally includes other sulphides among which galena, sphalerite, chalcopryite, and grey copper or other high-grade silver minerals may be recognized. Commonly, too, these veins carry low values in gold amounting to a few dollars a ton. In places, selected samples are reported to have assayed \$30 or more in gold and up to 200 or 250 ounces in silver. The gold values are thought to be associated with pyrite and chalcopryite. No free gold has been observed. Quite a little surface or near surface work has been done on a number of these quartz veins, but no production is recorded. On the A.U. claim of the Waterloo group, a shaft has been sunk on such a vein for 35 feet, in which distance it increases from less than a foot to nearly 2 feet in width and shows, in general, progressive increase in mineralization, including towards the bottom and along either wall, bands or long, narrow lenses up to several inches wide composed of nearly solid sulphides. On the Rampalo property, situated towards the centre of the camp, a drift adit 60 feet long follows a quartz vein which varies from several inches to 2 feet thick and carries a conspicuous amount of pyrite and, locally, a little galena and silver-rich sulphides. On the Morning claim, situated in the Nelson granite, a quartz vein exposed by surface workings and varying from a foot to 4 feet thick is conspicuously mineralized with pyrite and, more locally, with galena and sphalerite. Pyrite also abundantly impregnates the adjoining granite wall-rock for widths of from one to several feet, on both sides of the vein. Average values are not known.

The relation between the north-south system of quartz veins and the east-west trending mineralized shear zones is uncertain. Though much the same suite of ore minerals is present in both, the proportions are quite different. Pyrite, rather coarsely crystallized in general, is the characteristic and, commonly, the only visible mineral present in the quartz-veins, whereas it is a very minor constituent of the other system of veins where, too, it mostly occurs in finely crystalline form. For the reason that gold probably accompanies the pyrite, gold values are a significant

feature of the quartz veins and of negligible importance in the east-west veins. High-grade silver minerals are present in both vein systems, but are more abundant in the east-west veins which include conspicuous amounts of ruby and native silver, whereas the north-south veins are more apt to contain grey copper. The inference is that either the two vein systems were formed at different times or under different conditions.

The curious persistence with which so many of the north-south quartz veins follow along a wall or angle across dykes of quartz porphyry suggests either a structural or genetic relationship between the two. That the relation is probably structural is indicated by the facts: that some of the quartz veins occur quite independently of dykes; that others cut across the dykes; that the dykes themselves are rarely mineralized to any appreciable extent; and that in places where the dykes are faulted, mineralized vein quartz may occur along the fault planes.

No intersections of north-south and east-west veins were observed. The "Shaft" vein on the A.U. claim of the Waterloo group is, however, cut off, to the north of the shaft, by a strong east-west shear zone, suggesting that this shear zone as a whole is later than the north-south vein. This shear zone is apparently not mineralized, though even if it were it might be difficult to determine whether mineralization had not occurred in both veins at about the same time and that displacement of the "Shaft" vein was due to post-mineral movement along the east-west shear zone. The matter appears to be worth investigating as there is a possibility that if the two series of veins were formed at or about the same time, some concentration of values might be expected at their intersection. Such a possibility might be readily tested at the intersection of the "Big" vein on the Silver Spot claim of the Waterloo group with a smaller north-south quartz vein.

A mineral deposit of character somewhat different from those above mentioned occurs on the Pay Day group about a mile north of the Lightning Peak mine. There, a zone of heavy sulphide mineralization occurs at and near the contact of granodiorite with altered, greenish, probably volcanic, rocks. As exposed in a short crosscut adit 30 feet below the outcrop this zone is 20 feet wide and carries a varying but high percentage of mixed sulphides occurring in both massive and disseminated form and including chiefly pyrite, sphalerite, chalcopyrite, and magnetite. A sample taken by the Resident Engineer of the district across an aggregate width of 10 feet of the more solid sulphide material assayed: gold, trace; silver, 30 ounces to the ton; copper, 4.2 per cent; lead, nil; zinc, 12 per cent; nickel, nil; arsenic, nil; bismuth, trace.

DESCRIPTION OF PROPERTIES

*Morning Claim (Locality 1)*¹

The Morning claim, held by location, is owned by Nels Melstrom, Edgewood, B.C. It is situated at the extreme north edge of the map-area to the northwest of the Dictator Crown-granted claim and is accessible by trail, half a mile long, from the Dictator cabin.

¹This and other locality numbers appear on Figure 7.

The clastic granite cut well into quartz veins. The 75 degrees v. inated pyrite exceed 2 per cent across width. The wall-rock a width, on hanging-wall granite which the quartz

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The claim lies within an extensive outcrop area of the Nelson porphyritic granite. Workings include two deep pits and one trench, all of which cut well into the underlying rocks. The two pits, 100 feet apart, expose a quartz vein 20 inches wide, striking nearly north and south and dipping 75 degrees west. The vein carries, in order of relative abundance, disseminated pyrite, zinc blende, and galena. In most places, the sulphides do not exceed 2 per cent of the total volume of vein matter, though in places and across widths of several inches the amount probably reaches 10 per cent. The wall-rock on either side of the vein is heavily impregnated with pyrite for a width, on the foot-wall side, of about 3 feet, and for a lesser distance on the hanging-wall. The wall-rock is a medium-grained, highly quartzose, sheared granite which seems to be a phase of the Nelson granite. In the vicinity of the quartz vein this granite has been altered by vein-forming solutions.

The trench lies 55 feet north of the more northerly pit. Here the quartz vein is 4 feet wide and intersects pyritized granite which, 6 feet above the hanging-wall of the main quartz vein, carries a 6-inch vein of heavily mineralized quartz tightly "frozen" to the wall-rock. Where exposed by this trench the main quartz vein is sparsely mineralized.

Mr. Melstrom claims that the main vein does not appear to extend more than a few yards north of the trench, but that in the opposite direction it has been traced for a distance of about 700 feet. Claims have been staked to the north and south of the Morning claim and are owned by Adam Scaia, Edgewood, B.C.

Little is known of the values contained in the main vein or adjoining wall-rock. The prospect warrants further prospecting as well as careful sampling.

Dictator Claim (Locality 2)

The Dictator Crown-granted mineral claim is owned by John Glover, Queens Hotel, Nelson, B.C. The claim is situated at the headwaters of Rendell creek near the northern boundary of the map-area and is accessible by a trail 2½ miles long leading from the main tractor road to the Waterloo mine. A substantial cabin has been erected close to the Dictator workings.

The claim was first staked some thirty years ago by Mr. Glover and was Crown-granted on October 9, 1920. The only reference to it or to development work done on it is contained in the Resident Engineer's (Mr. Freeland) report for 1919¹ from which the following extract is taken:

....."The country-rock surrounding the claims (Dictator and Cloriator) is a medium coarse, grey granite The ore consists of galena, sphalerite, and iron, carrying gold and silver, in a gangue of quartz and broken country rock. The vein has a northerly and southerly strike, dipping 75 degrees to the west. The lead, which outcrops for about 300 feet, is developed by open-cuts and shafts varying from 10 to 30 feet in depth. Owing to the bad state of repair of the deepest shaft it was impossible to visit it, but the owner claims an 18-inch lead in the bottom. The flatness of the surrounding country prohibits any developments by tunnels."

The property lies within the same large area of Nelson porphyritic granite as that which includes the adjacent Morning claim described above, and the quartz vein explored by the several small workings is almost exactly parallel with the Morning vein. The deeper workings are inaccessible and the smaller workings do not show much of the vein in place.

¹Ann. Rept., Minister of Mines, B.C., 1919, p. 167.

Specimens of the vein matter are composed chiefly of massive to, in places, quite vuggy white quartz, mineralized chiefly by pyrite with some galena and zinc blende. A little native sulphur was noted in small cavities in the quartz, formerly occupied by other ore minerals. Both pyrite and galena occur in small, mixed masses or disseminated grains through the quartz. Values are not known.

Granite Range (Locality 3)

Old claim posts were observed on the summit of the Granite range to the northwest of the junction of Rendell and Waterloo creeks. The names of the claims could not be ascertained nor did it appear that any extensive exploratory work had been done. Some crystalline limestone associated with other highly metamorphosed rocks, the whole striking nearly east and west and dipping to the north at about 60 degrees, is in contact to the south with a large body of grey granite and is intersected by minor intrusive masses of similar composition to the main body. These conditions are analagous with those that elsewhere in the area have proved coincident with mineralization.

Potosi Group (Localities 4, 5, and 6)

The Potosi group, consisting of Potosi Nos. 1, 2, 3, and 4 claims held by location, is the property of James Graham, Greenwood, B.C. It is situated northwest of the Waterloo property and is accessible either by a short trail from the Waterloo mine camp or by a trail that branches off the Dictator trail half a mile northwest of the Waterloo tractor road. When visited by the writer a cabin was being constructed on this property by Mr. Graham.

The group lies about in line with the northwesterly continuation of the belt of metamorphic rocks occurring on the Waterloo No. 3 claim and vicinity. Crystalline limestone is abundant in the southwestern half or more of the area occupied by this property. Otherwise the prevailing rocks are metamorphosed types, chiefly volcanic rocks, associated with granitic intrusives and occasional acid dykes.

The property occupies a central position on the broad-topped ridge lying between Waterloo and the West fork of Rendell creek, a ridge referred to locally as the Baby range and having a maximum relief of about 700 feet. On the whole, the underlying rocks are poorly exposed, though locally, as along or near stream bottoms or on the axis of the ridge, outcrops are abundant.

Considerable surface prospecting has been done on the Potosi group, chiefly in the vicinity of localities shown by numbers on Figure 7.

At locality 6, two parallel quartz veins strike a few degrees east of north and lie about 160 feet apart. The westerly vein has been exposed by five open-cuts at intervals over a length of 300 feet. It varies from 2 to 3 feet in width and is mineralized with disseminated pyrite and a little galena. The eastern vein is wider than the other, but, where observed, is not as well mineralized. About 800 feet to the north of locality 6, four or more trenches have explored the continuity of another, or, possibly, one of the same quartz veins, over a distance of about 400 feet. In one pit the vein was 4 feet wide, but carried little or no visible ore minerals.

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A few hundred feet northwest of the Potosi cabin, a series of three or more trenches exposes more vein quartz associated, in places, with calcite and carrying a little pyrite.

At locality 4 a couple of trenches expose a zone of crushed rock several feet wide striking about north and south. The rock involved is principally a light grey, decomposed variety of uncertain origin, probably a dyke. It is brecciated, is stained with iron and manganese oxides, carries some vein quartz, and is mineralized with a little pyrite. Between 400 and 500 feet northeast of these trenches another trench exposes an 18-inch quartz vein in a pegmatitic dyke rock. It is possible that this is the rock involved in the crushed zone at locality 4.

At locality 5 some trenching has been done in a belt of crystalline limestone which, at this locality, is cut by a small, acid dyke and carries a little vein matter represented by calcite and iron sulphide. This limestone belt might be more profitably investigated farther to the southwest in line with the possible continuation of the Waterloo vein zone.

Waterloo Group (Localities 7, 8, 9, 10, 11, 12, and 13)

The Waterloo group comprises the Waterloo No. 3 Crown-granted claim and nineteen other claims held by location. The group is at present being developed, under option to purchase, by Waterloo Consolidated Mines, Limited, of Penticton, B.C. Dr. C. M. Kingston, Grand Forks, B.C., is president of the company and R. L. Clothier, Victoria, B.C., is in charge of operations at the mine. The local address is Edgewood, B.C.

The property is situated at the headwaters of Rendell¹ creek, at the western terminus of the tractor road leading into Lightning Peak area. The claims form three parallel, adjoining rows extending easterly from the mine workings (Locality No. 7) on the Silver King and Waterloo No. 3 claims, the most westerly and second most westerly claim, respectively, of the middle row of the group. Other claims on which considerable work has been done are the A.U. (Locality No. 10), Silver Spot (Localities Nos. 8 and 9), the Silver Spot No. 3 (Locality No. 11), and the Silver Spot No. 4 (Localities Nos. 12 and 13). A little surface work has also been done on the Gold Plate claim situated north of and adjoining the Silver Spot No. 4 claim.

Waterloo Mine (Locality 7)

The Waterloo No. 3 claim was the first location made on this group. It was staked in 1903 by Adam Scaia, owner of the Silver Spot claim. In the same year Scaia sold the Waterloo claim to George McLeod who took out a little high-grade silver ore and later in the same year turned the property over to Dr. C. M. Kingston and G. A. Rendell who held it until the recent arrangements with the present organization. During part of the period of their ownership the property was leased to George S. Boug and Charles Hammarstadt who extracted several tons of high-grade ore. This ore was packed out at a reported cost of \$64 a ton. During the same period it cost \$80 a ton to pack provisions in to the camp.

¹Named after G. A. Rendell, Trail, B.C., a director in the company's organization.

Production to date has come entirely from workings on the main or Waterloo vein as developed on the Waterloo No. 3 claim. The first official reference to production is made in 1904 by Mr. Wm. Thomlinson¹ who states that up to that time "Two small shipments of ore have been made, one of which gave the high returns of 669 ounces silver, \$10.30 gold to the ton, and 45 per cent lead". The next reference is a brief statement in the Annual Report for 1917 to the effect that the vein carries values in both gold and silver. Reports for 1918² state that "Lessees George Boug and Charles Hammarstadt packed on horses 9,381 pounds of high-grade ore to Edgewood to be forwarded from that point to the Trail smelter for treatment. The shipment netted \$3,244.53. The ore contained silver almost entirely, but 375 pounds lead was extracted." Some of this ore is reported to have assayed over 700 ounces in silver. In the following year³ the "development work consisted of driving a tunnel below No. 1. . . . Ore was struck in this tunnel and a shipment of 13 tons made"; 10 tons of this⁴ shipped in March had an average content of 528 ounces silver to the ton and 5 per cent lead, and 3 tons shipped in April carried 293 ounces silver to the ton and 4 per cent lead.

In 1920⁵, 22 tons of high-grade silver-lead ore was packed out on horses. The report for 1927 indicates that the ore shipped in 1920 was of about the same class as that shipped in 1919.

The present writer is informed that since the property was taken over in 1929 by the present organization three shipments have been made. The first, amounting to 31 tons, and obtained from Nos. 1 and 2 adits, was shipped in December, 1929, and averaged 482 ounces silver a ton; the second, 49 tons, and obtained from the same workings, was made in February, 1930, and averaged 250 ounces in silver; and the last, about 30 tons from No. 2 adit, was shipped in March, 1931, and ran 472 ounces silver and \$7 to \$9 gold to the ton⁶.

The workings at Waterloo mine (See Figure 8) include four adits which, in order from east to west and from highest to lowest, are: No. 1, 1,120 feet long; No. 2, 250 feet long and 24 feet below No. 1; No. 3, 40 feet long and 52 feet below No. 2; and No. 4, 10 feet long and 36 feet below No. 3. These adits are driven in on the main Waterloo vein zone which outcrops down the slope below No. 1 adit. This slope is steep, averaging about 25 degrees to No. 4 adit. No. 4 adit is close to the bottom of a narrow, dry ravine on the other side of which the ground rises again to form a low ridge before resuming its downward slope into the main branch of Waterloo creek. The vein zone if continuous to or beyond this creek would, at creek level, gain an additional depth of about 200 feet. In the opposite direction, in line with the strike, the ground rises very slowly above No. 1 adit.

No. 2 adit is connected with No. 1 and with the surface by a raise and stopes. At the surface a number of trenches have explored the easterly continuation of the vein for a distance of 200 feet or so beyond the face of No. 2 adit (the most easterly underground workings).

¹Ann. Rept., Minister of Mines, B.C., 1904, p. 224.

²Ann. Rept., Minister of Mines, B.C., 1918, pp. 204 and 221.

³Ann. Rept., Minister of Mines, B.C., 1919, p. 167.

⁴Idem, p. 174.

⁵Ann. Rept., Minister of Mines, B.C., 1920, p. 156.

⁶It is also reported that this ore carried values in tin to the amount of several dollars a ton.

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Fig. 8

The main vein zone intersects, in a distance of about 4 feet to the north, a zone of brownish granite cuts two or three of granodiorite.

A large proportion of the rock in the vicinity of the workings is crystalline limestone, a feature that distinguishes this locality from the other more important showings in the area. Associated with the limestone are bodies of highly metamorphosed, commonly greenish rocks presumably of volcanic origin. They are locally referred to as "schists", though in general quite massive. The greater part of these "schists" is soaked with material of about the composition of diorite or quartz diorite which has partly replaced and has otherwise been injected into the older rocks. So intimately are the two intermingled that in places outcrops may only doubtfully be referred to as being composed mainly of pre-intrusive or of intrusive material. The trend of the "schists" and limestone is nearly east and west (magnetic) and the prevailing dips appear to be to the north. Limestone contacts are generally sharp, though very irregular in detail. One hundred to two hundred feet south of the workings is the northern edge of a comparatively large area underlain by granodiorite and very like the intrusives elsewhere so intimately associated with the pre-batholithic rocks.

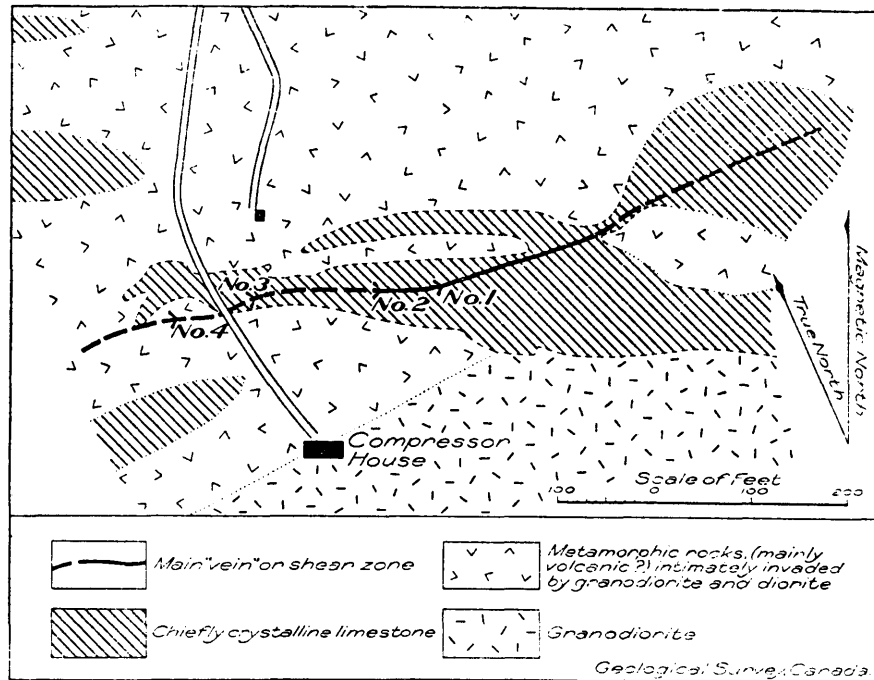


Figure 8. Waterloo mine, Lightning Peak area, British Columbia.

The main Waterloo "vein" is a strong, mineralized, shear zone averaging about 4 feet wide, striking a few degrees south of east, and dipping steeply to the north. This shear zone so far as it has been developed to date intersects, mainly, crystalline limestone, but bands, a few inches thick, of brownish, shaly sediments occur within the shear zone. The zone also cuts two or more acid dykes and, towards the face of No. 2 level, a plug of granodiorite about 25 feet in diameter.

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Movement along the shear zone appears to have been along one principal plane and others of subsidiary importance on either side. These planes are irregular in strike and dip and, in consequence, may merge with, or branch from, those on either side. The hanging- and foot-walls of the shear zone are, therefore, difficult to recognize except by crosscutting. Along the walls of the principal plane of shearing, on Nos. 1 and 2 levels, strong grooves dip about 35 degrees to the east. The relative positions of dislocated parts of dykes on either side of this plane of shearing indicate that the south wall has moved upwards and towards the west with respect to the north wall. The amount of displacement is uncertain, but does not appear to be very great. On No. 2 level a dyke in the north wall of the shear zone is offset in the south wall 35 feet to the west. The plug of granodiorite towards the face of No. 2 level appears to have been offset a few feet in the same direction. On No. 2 level, a fault striking nearly north and south and dipping 30 to 35 degrees west is offset by the main shear zone and the latter intersected by a strong fault striking about 20 degrees west of north and dipping 30 degrees northeast. At about 130 feet from the portal of No. 2 level, a strong fault striking north 40 degrees east and dipping about 20 degrees southeast cuts across the fissure zone and persists to the surface. Ore occurs on either side of this fault and above No. 2 level formed a high-grade shoot which extended to the surface.

The main "vein" or shear zone is mineralized along its entire investigated length, but, as yet, mineralization of economic value has been found only within one relatively restricted section. This section extended from the surface to No. 2 adit level, below which its extent has been only slightly investigated. Within this section, above No. 2 level, the high-grade ore has been mostly stoped out. It occupied a length of about 40 feet at the surface and at the levels of No. 1 and No. 2 adits. Shallow pits in the floor of No. 2 level were filled with water and could not be examined. The high-grade ore at the surface is almost vertically above or slightly to the east of the high-grade ore at No. 2 level. The strong, easterly dipping grooves on the walls of the vein, and the possibility that mineralization may have been guided into the shear zone by the southeasterly dipping fault mentioned above, suggest that if the ore-shoot continues below No. 2 adit it should rake to the east. On the other hand and because most of the high-grade ore extracted from below No. 1 level underlay the southeasterly dipping fault, whereas the high-grade ore above No. 1 level lay above the same fault, it seems likely that this fault may be in part or entirely post-mineral and if so, that it is a normal fault which has displaced the part of the ore-body above No. 1 level to the east with respect to the part below No. 1 level.

Mineralization of medium to low-grade character occurs within the shear zone on either side, but chiefly west of the main ore-shoot. In this direction samples taken by the management for a distance of about 50 feet along No. 2 level indicated that over a width of 3 feet the average values were: silver, 4.0 ounces to the ton; lead, 3.0 per cent; and zinc, 4.2 per cent. On No. 2 level very little ore mineralization was observed beyond 130 feet from the portal until near and at the face where the shear zone is quite heavily mineralized with zinc blende and carries some galena. Values in silver are low, but the extent of mineralization at the face is such as to encourage exploration in this direction.

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The main "vein", or what is presumed to be this vein, is picked up in the lower workings which consist of short adits and open-cuts, but to date no appreciable amount of ore has been found, though some attractive mineralization has been noted. Probably the most interesting discovery was made in an open-cut alongside the road to the Compressor House a few feet southwest of the portal of No. 3 adit. There, a vein of galena 2 inches wide occurs in a narrow, acid dyke. Its proximity to the main shear zone suggests that some work should be done to discover its connexion, if any, with the main "vein".

The ore of the shoot stoped out above No. 2 adit level included a conspicuous amount of native silver, argentite, ruby silver, stephanite, and grey copper associated with argentiferous galena and zinc blende. These minerals, according to report, occurred in lens-like masses and in stringers accompanied by a varying proportion of gangue mineral, chiefly calcite. A couple of specimens of vein matter from this high-grade shoot were examined microscopically under reflected light. One contained a solid chunk of native arsenic about 2 inches in diameter, moulded into a nest of coarsely crystallized calcite. The other specimen had the appearance of an ore-breccia in which angular fragments of ore minerals or groups of minerals were scattered through a gangue of mixed calcite and quartz. The ore minerals included sphalerite and galena associated with two varieties of ruby silver, each of which carried numerous microscopic bodies of native silver. The ruby silvers both appeared to be antimonial types, pyrargyrite and, probably, polyargyrite.

The low-grade mineralization consists of streaks and disseminations of, principally, zinc blende and lesser galena, occurring at intervals along and across the shear zone. The wall-rock is chiefly crystalline limestone. Gangue minerals include a varying proportion of quartz and calcite. At the face of No. 2 level the vein matter shows a brecciated structure in which chunks and bunches of pale yellow or brownish zinc blende, associated with some fine to coarse-cube galena, are moulded in a calcite gangue.

A.U. Claim of the Waterloo Group (Locality 10)

Considerable development work, chiefly in the form of surface trenching, has been done on the A.U. claim within about one-third of a mile northeast of the Waterloo mine workings. This work has uncovered portions of some half a dozen quartz veins. The veins vary from a couple of inches to 2 feet or more in width, strike in a general north and south direction, and dip at high angles either to the east or west. The two that have received most attention are about 30 feet apart. One of them, known as the "Shaft" vein, has been traced for 400 feet, and the other, the more westerly, for 500 feet. About 75 feet west of the south end of the investigated part of the latter vein, a third vein has been picked up and traced northerly for over 100 feet. Vein exposures farther south on the adjoining Silver Spot claim suggest from their position, alinement, and association with an acid dyke that they are continuations of the middle vein mentioned above and, if so, they represent an additional length of 875 feet.

The Shaft vein, as its name implies, has a shaft sunk on it. This is mostly a recent piece of work and at the time visited was down 25 feet

on the vein which averaged 11 inches in width in this distance. Towards and at the bottom of the shaft solid sulphide mineralization up to 3 or 4 inches in width was encountered and consisted chiefly of an intimate mixture of pyrite, galena, zinc blende, and chalcopryrite. Elsewhere the quartz vein carries streaks and disseminations of these minerals, principally pyrite. Surface exposures carried much less mineralization and this largely as pyrite. Chalcopryrite was not observed in the surface workings, but becomes increasingly abundant with depth where, also, films of native copper were observed on fracture surfaces of the quartz. The walls of the vein are sharply defined. The vein matter is in places distinctly banded, quartz carrying abundant pyrite in streaks and bunches lying close to the walls across widths of a couple of inches and succeeded inwards by bands of nearly solid sulphide including abundant galena, pyrite, chalcopryrite, and sooty decomposition products. A specimen of such vein matter was polished and examined microscopically by reflected light. It revealed an intimate association of pyrite, galena, zinc blende, and chalcopryrite; the chalcopryrite being in part minutely disseminated through the sphalerite. The galena carries minute areas of a pale grey mineral which reacts quickly with ferric chloride and may be argentite.

The vein quartz is milky white and where associated with streaks and bands of ore minerals is, in general, quite vuggy. A sample taken by the resident engineer¹ at a depth of 10 feet in the shaft and across the vein where it is 10 inches wide, "assayed 0.12 ounce in gold and 24.5 ounces in silver to the ton, 13 per cent lead, and 4.5 per cent zinc." The writer has been informed by the mining engineer of the company that at the close of 1930 the shaft had been continued to a depth of 36 feet; that at this depth the vein is 22 inches wide; that values in the solid iron sulphide ran from \$20 to \$26 in gold and about 10 ounces silver a ton; that a sample of the solid mixed sulphide ran \$36.80 gold, about 25 ounces silver to the ton, and 35 per cent lead.

The Shaft vein dips to the west at about 50 degrees and appears as though it may eventually intersect the vein to the west whose dip, so far as surface workings indicate, is steeper though in the same direction. The Shaft vein ends about 85 feet north of the shaft, against a strong shear zone striking about east and west.

The vein lying 30 feet west of the Shaft vein occurs along the foot-wall of a narrow, acid dyke which dips steeply to the west. Where exposed by a number of trenches on the A.U. claim this vein would not average over 6 inches in width and is poorly mineralized. Other quartz veins picked up in surface workings on the A.U. claim carry here and there a little pyrite and lesser amounts of galena. A couple of small veins of this sort have been uncovered towards the north end of the claim within 200 feet south of the main tractor road. Another small vein is exposed 400 feet west of the shaft; it underlies an acid dyke dipping steeply to the east and carries some pyrite. Another vein, referred to as the "Red" vein, is exposed 150 feet southwest of the shaft and has been explored in a southerly direction by small trenches. This vein has the appearance of a shear zone impregnated with quartz and carrying some iron sulphide whose oxidation has lent a rusty colour to the outcrop across a width, where noted, of 3 feet.

¹Ann. Rept., Minister of Mines, B.C., 1925, p. 196.

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Silver Spot Claim (Localities 8 and 9)

This claim adjoins the A.U. to the south. Three veins have received particular attention. One (near Locality 9) has already been referred to as the probable continuation of a vein on the A.U. claim. It has been picked up in five trenches over an aggregate distance of 550 feet. This vein is closely associated with an acid dyke and occurs in places along the foot-wall and in other places within the dyke. In a deep pit sunk beside the Discovery post of the Silver Spot claim, the vein is 12 inches wide, and underlies the dyke which is about 10 feet thick and dips 40 degrees west. There and in trenches farther south the vein carries much pyrite and, more locally, some galena and zinc blende. Samples carrying encouraging values in both gold and silver are reported to have been obtained from these workings. One hundred feet east of the Discovery post, a trench exposes an acid dyke with vein quartz on either side and also intersecting it. The quartz carries some pyrite. One hundred and ten feet south of the Discovery post, a wider vein or vein zone is exposed and has been traced westerly for nearly 200 feet, in part of which distance it outcrops on a steep, rocky bluff of granitic and older greenish rocks. This "vein", from what could be seen of it, appears to be a shear zone along which occurs more or less vein quartz carrying a little sulphide mineralization. Its maximum width seems to be about 3 feet.

A third vein, known as the Silver Spot vein, is exposed on the south bank of Silver Spot creek at an elevation of about 5,600 feet. What is presumably the same vein has been traced for about 300 feet by three trenches above the north bank of the creek. About midway of this distance, an adit 65 feet long (Locality 8) intersects the vein at 35 feet from the portal. The vein is of quartz, has a northerly strike, and dips steeply to the west. It has formed along a shear zone in rocks that are chiefly pre-batholithic and, in part, are well banded, dipping about 60 degrees to the northeast. The only mineralization of consequence was observed in exposures at creek bottom where the vein quartz, about 6 inches wide, carries grey copper as well as some pyrite and galena.

Silver Spot No. 3 Claim (Locality 11)

On this claim, at the junction of two tributary creeks, a shear zone about 8 feet wide and striking about east and west carries two bands of mineralized vein matter up to several inches wide, one near the foot-wall of the shear zone and the other about midway between the walls. The chief vein mineral is quartz which, in part, replaces the crushed wall-rock. The latter is mostly a dense, greenish, altered rock associated with some dioritic intrusive. The ore minerals are principally fine-grained galena and zinc blende and occur as narrow streaks in the quartz. Some high-grade silver mineral or minerals may be present, as selected samples are reported to have assayed up to 100 ounces of silver to the ton. The wide shear zone lies rather closely on the projected course of the main vein of the Waterloo mine.

Silver Spot No. 4 (Localities 12 and 13)

On this claim, which adjoins the Silver Spot No. 3 on the east, a great deal of trenching has been done, partly with a view to ascertaining whether the east-west shear zone found on the Silver Spot No. 3 claim continues.

One trench, 3,000 feet long, extends in a westerly to northwesterly direction across the claim and for about 1,200 feet into the adjoining Silver Spot No. 3 claim, where it ends at the shear zone. Another trench, 1,000 feet long, leads westerly from the longer trench. Bedrock is not continuously exposed in these long trenches, but does appear along considerable portions. A few, small, north-south trending quartz veins and a number of narrow, acid dykes were uncovered. It is not certain, however, whether the east-west shear zone was located, as the rocks are not well exposed where it should cross.

Vein matter has been found in two places north of the main trench. The westerly (Locality 12) of these occurrences is exposed by three trenches lying 240 to 315 feet away from the main trench. In the two more southerly trenches limestone occurs across an exposed width of several feet and has been altered to a highly garnetiferous rock in which some vein quartz carrying pyrite was noted. The northernmost trench shows a 6-inch quartz vein, carrying pyrite and galena striking northerly, and intersecting metamorphosed tuffaceous sediments and dioritic intrusives.

The more easterly showing (Locality 13) lies towards the northeast corner of the Silver Spot No. 4 claim. There, a short adit and some surface work have exposed a quartz vein, 1 foot thick, striking north 35 degrees west and dipping 15 degrees northeast. It is well mineralized with pyrite, galena, and zinc blende. The vein is cut by a fault in the adit and at the face it stands nearly on edge and strikes north 35 degrees east. About 150 feet south of the adit, a 6-inch quartz vein is uncovered by a short trench. This vein strikes nearly north, dips 30 degrees east, underlies a quartz porphyry dyke, and is mineralized with pyrite and some galena.

Gold Plate Claim

This claim adjoins the Silver Spot No. 4 on the north. Some surface work has indicated the presence of quartz veins similar to, and possibly in part continuous with, those discovered on the more southerly claim.

Lumpy Claim (Locality 14)

The Lumpy claim, owned by Messrs. George Boug and Robert Lee, Edgewood, B.C., is situated on the northern slope of Lightning peak. The workings lie within about 3,000 feet of, and 600 feet below, the summit and are most readily accessible by trail from the Rampalo property.

The claim was staked by John Prough and Walter A. Johnson in the autumn of 1918. Some high assays were obtained by these men from surface samples. An adit was driven to investigate the character of the mineralization at depth, but as the results of this work did not prove encouraging the property was abandoned and lay open until about 1927 when it was restaked by the present owners.

Mineralization on this property is associated with a belt of limestone that is 100 feet or more wide and strikes north 55 degrees west and dips 60 degrees southwest. This limestone is thought to extend northwest towards the limestone exposures on the Silver Spot No. 3 and No. 4 claims of the Waterloo group.

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On the Lumpy property the limestone is a coarsely crystalline grey rock, in part quite impure. It is associated with granitic intrusives and with some greenish, probably volcanic, rocks. In the vicinity of the workings the limestone is conspicuously jointed along a north 60 degrees east direction and along these joints occur seams of vein matter, a small fraction of an inch wide. The presence of these seams has induced the owners of the claims to explore for deposits of more substantial size, but to date such deposits have not been discovered. Workings include two short adits on the same level and 50 feet apart, one about 70 and the other 30 feet long, and a number of open-cuts and trenches above them. This work has revealed a sparse dissemination of pyrite here and there in the limestone and adjoining rocks, but has not furnished direct clues as to where further work might advantageously be done. The thin seams of vein matter, occurring along joint fractures in the limestone, carry zinc blende, lesser amounts of galena, unidentified silver-sulphides (probably chiefly ruby silver), and traces of native silver and (?) free gold.

Rampalo Group (Localities 15, 16, and 17)

The Rampalo group consists of the Rampalo and Silver Lump Crown-granted claims and the Victoria, Condor Fraction, Southwestern, and Southwestern Fraction claims held by location. One-fourth interest in the Crown-granted claims and one-half interest in the others is owned by Adam Scaia, Edgewood, B.C. The remaining interest in the Crown-granted claims is retained by the estate of the late T. Cortiana. The property is situated about 2½ miles by trail east of the Waterloo mine camp.

The Rampalo was the first claim staked in the district. It was located in 1897 by Scaia Bros. and Axel Johnson. Subsequently it and the adjoining Silver Lump claim were purchased by T. Cortiana who held them until his decease, about 1921. The two claims were Crown-granted in April, 1902.

The rocks on the Rampalo group are chiefly an intimate association of greenish, mostly finely crystalline, metamorphic rocks and abundant granitic intrusives. The intrusives are commonly medium grained, equigranular, dark grey to greenish grey, and of about the composition of biotite-hornblende granodiorite, but in places they are more basic and in other places they grade into coarser-grained porphyritic varieties like the Nelson granite. The rocks invaded by the intrusives show varying degrees of alteration and in places are difficult to distinguish from the invading rocks. They seem to be chiefly of volcanic origin. An occasional quartz porphyry dyke was observed and these have, to some extent, guided development work.

The principal work has been done at locality 16 on either side of the boundary between the Rampalo and Silver Lump claims. There three adits varying in length from 60 to 390 feet have been driven to develop a quartz vein which at the time visited was seen to best advantage at the level of the uppermost or No. 3 adit. This adit is 60 feet long and follows the vein which, in the adit, varies from several inches to over 2 feet in thickness, strikes north 37 degrees east, and dips southeast at about 62 degrees. It lies partly within and partly beneath a 10-foot dyke of light grey quartz porphyry, the courses of the dyke and vein making a small

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angle with one another. Near the portal the vein is offset a few feet by a fault striking nearly north and dipping 45 degrees to the west. The quartz is milky white and in places, particularly near the foot-wall, is banded. It carries disseminated crystals and small bunches of pyrite and, locally, a little galena and silver-rich sulphides. Values are reported to have varied greatly and to have been best near the portal, in the vicinity of the fault, where assays as high as 250 ounces in silver and \$10 in gold are said to have been obtained. Some native silver is stated to have been found in this section of the adit. Elsewhere values are mostly too low to be economically important. The same vein is reported to have been picked up in No. 2 adit about 50 feet below No. 3 adit and commencing about 185 feet northward along the strike of the vein. A third adit (No. 1) was driven by Cortiana to cross this vein at a depth a few feet below that of No. 2 adit and at the same time to investigate the ground to the east of the other adits. This lowermost adit is 390 feet long and at the face encounters a 3-inch quartz vein which appears to be repeated by a series of parallel slips striking nearly north and dipping west at about 40 degrees. Samples from this vein are reported by Adam Scaia to have given 40 ounces silver and \$3 to \$4 gold to the ton. Though this small vein (or veins) is about in the right position to represent the downward continuation of the quartz vein in No. 3 adit, no quartz porphyry dyke occurs in its vicinity and it is possible that the crosscut has not been driven quite far enough to strike the vein seen in the upper adit. The long crosscut intersects greenish, altered rocks interrupted at three points by strong, shear zones striking nearly north and dipping at about 30 degrees to the east. At 18 feet from the portal, a quartz vein, about a foot thick and mineralized with pyrite, cuts across the adit and dips steeply to the east beneath a 10-foot dyke of quartz porphyry. The walls of this vein are strongly sheared. Values in the vein are not known.

On the Victoria claim (Locality 15), surface work has exposed two narrow quartz veins, each about 6 inches wide, in which some mineralization occurs. One vein strikes about north 35 degrees west, dips 60 degrees northeast, and is associated with a small dyke of quartz porphyry. The other vein is exposed about 850 feet west of the first, strikes north 35 degrees east, and dips steeply southeast. Both veins intersect greenish, metamorphic rocks and granitic intrusives.

On the Condor fraction (Locality 17) a little surface work has been done, principally to investigate a shear zone several feet wide striking north 75 degrees west and dipping steeply to the north. This shear zone cuts greenish, altered rocks and associated granitic intrusives and has a rusty, oxidized appearance.

Killarney Group (Locality 18)

The Killarney group, comprising the Killarney, Thunder Hill fraction, and Lucky Jim fraction Crown-granted mineral claims, is the property of Wm. J. Banting, Edgewood, B.C. It is situated in the valley of Rampalo creek and the principal workings are accessible by trail, over half a mile long, from the Rampalo cabin. The Killarney claim was staked about 1918. It and the Thunder Hill fraction were Crown-granted in August, 1925, and the Lucky Jim fraction in October of the following year.

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¹Ann. Rept., Min.

Most of the work on this property has been done on the Killarney claim, on the southwestern slope of the valley of Rampalo creek and within 100 feet of the creek bottom where the valley slope is steep. Two main adits and three shorter adits have been driven and considerable trenching and stripping have been done. Vein matter occurring at a number of points has been investigated by this work.

The rocks in the vicinity of the workings are principally greenish, altered, probably volcanics which for the most part are greatly faulted and sheared. They are associated with greyish green intrusives and are intersected by two or more quartz porphyry dykes varying up to at least 10 feet in width.

Early work on this claim was concerned with the discovery of vein matter, carrying argentiferous galena, in wash and broken ground near the creek. "Two tunnels, 25 and 50 feet respectively", were driven and "a few tons of silver-lead ore taken out of this ground. . . . Samples from the (these) lower workings carried 0.02 ounce in gold, 62 ounces in silver, 60 per cent lead, and 4 per cent zinc."¹ Subsequent operations have been concerned with the discovery of vein matter in place at points higher up the valley slope.

No. 3 adit is the highest and is only a few feet long. At the portal a few inches of vein quartz carrying some galena strikes about north 60 degrees west and dips steeply northwest. A few feet above the adit roof there is a fault, but owing to lack of sufficient exposures here and higher up the hill, it is uncertain what happens to the vein at its junction with the fault. The fault strikes nearly north, dips at a low angle to the west, and has been prospected by a trench for a distance of about 90 feet north from No. 3 adit. At about 50 feet from No. 3 adit the fault as revealed in the trench intersects a narrow quartz porphyry dyke and that part of the dyke east of the fault has, apparently, been offset slightly to the south. The dip of the fault seems to steepen towards the north end of the trench and there an adit or open-cut (No. 3A) has been driven for a few feet in oxidized, broken ground.

The vein visible at the portal of No. 3 adit was apparently picked up in No. 2 adit at a point underground a few feet north of No. 3 adit and 25 feet below it and has been drifted on for 45 feet to the northwest. In this drift the vein dips 50 degrees or so to the northeast, varies in thickness up to a foot or more, and is of quartz carrying a streak of nearly solid sulphide up to several inches wide and composed chiefly of galena with some sphalerite and pyrite. A little stoping has been done above the level mostly near where the adit entered the vein and where the vein is cut off eastward by a strong fault striking nearly north and dipping 35 degrees to the west. Near the face of the drift the vein matter is dislocated and dragged along a fault which may be the one followed by the trench above. At the portal of No. 2 adit, about 40 feet northeast of No. 3 adit and 25 feet below it, a vein several inches wide strikes about north 40 degrees west and dips 60 degrees north. It has afforded a small quantity of silver-lead ore, mostly steely to fine cube galena with some sphalerite and a very little pyrite and chalcocopyrite. Under the microscope the galena was seen to contain small bodies of a grey, probably silver-bearing, mineral. This vein may be the faulted continuation of the vein followed in the drift, 25 feet to the southwest.

¹Ann. Rept., Minister of Mines, B.C., 1922, pp. 171-172.

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The portal of No. 1 adit is 40 feet below and 50 feet east of the portal of No. 2 adit. At about 35 feet from the No. 1 portal, a point underground about 25 feet northeast of the entrance to No. 2 adit, a drift was run northerly for about 40 feet along a slip which dips steeply to the west. Some mineralization is reported to have been found along this slip. Owing, however, to the broken character of the ground no correlation of this mineralization with that encountered on the levels of Nos. 2 and 3 adits, is made. The suggestion advanced by Mr. Freeland¹ that the vein on this property is involved in a series of step-faults which throw it successively farther to the north seems logical in the case of the two upper workings and implies that no long, continuous sections are to be expected within the zone of faulting, whose limits have not yet been defined.

The vein or veins on this property have the general west to northwesterly strike and northerly dip characteristic of the main vein on the adjoining Lightning Peak group to the east and at the Waterloo mine $2\frac{1}{2}$ miles to the west, and it may be that the same zone of shearing and mineralization is present on all three properties. If so, prospecting might be done to advantage towards the west boundary of the Killarney claim or beyond on the adjoining Lucky Jim fraction where it is possible that the east-west vein structures, if present, are less severely affected by faulting. A little surface work has already been done in this direction, but the results are not known.

Lightning Peak Group (Localities 19 and 20)

The Lightning Peak group—including the Thunder Hill, First Chance, West Fork, and Jim Hill Crown-granted claims—is owned by C. F. Deither, St. Paul, Minnesota, and W. A. Calder, Edgewood, B.C. The property lies mostly on the steep, northern slopes of Rampalo and Soda creeks and is accessible either by the Galloping Mountain trail which, farther west, reaches the Waterloo mine via the Rampalo group, or by a more recently constructed trail extending south from the Waterloo tractor road. This latter trail has been modified with the idea of providing a tractor route to the property.

Outcroppings of the main vein on this property were discovered and staked in 1901 or 1902 by Frank Fritz and Chas. Harrigan who, about 1903, turned their holdings over to some St. Paul people. The latter, according to Mr. Calder, gave the name Lightning Peak to the camp, having in mind the Thunder Hill camp in Oregon which at that time was attracting considerable interest. In 1904, a 5-ton general sample of ore from the Lightning Peak property gave smelter returns of 164 ounces silver to the ton and 26 per cent lead². In May of 1905 the four claims of the group were Crown-granted, but shortly afterwards operations ceased. In 1906 the property was leased to W. A. Calder and Walter Bull, the former of whom has been identified with this property during most of its history. These lessees extracted shipping ore to the value of \$3,200 obtained from operations on and from the uppermost or No. 1 adit on the West Fork claim.

¹Ann. Rept., Minister of Mines, B.C., 1927, p. 227.

²Ann. Rept., Minister of Mines, B.C., 1904, p. 224.

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No official records of developments or production between the years 1904 and 1917 are available. From 1917 until 1920 the property is referred to as the Equinox group and during that period was apparently being worked by or under the direction of Mr. Calder. In 1919, 10 tons, and in 1920, 6 tons, of silver-lead ore are reported to have been shipped to Trail¹.

In 1921 and the following three years, the property was worked under lease by William Williams of Edgewood and small shipments are recorded as having been made in 1922, 1923, and 1924. In 1922, No. 3 adit was run and No. 4 adit started; in the following two years development work was chiefly on the lowest level (No. 4 adit).

In 1925 the property was again leased by W. A. Calder who has continued to operate it since that time. Development work during this period has consisted principally in extending No. 4 adit for several hundred feet. Some surface work has also been done on another vein to the north of the cabin (Locality 20) on the First Chance and adjoining Wood Lot claims, the latter being held by location by Mr. Calder. In 1927, 35 tons of ore was rawhided out and shipped to Trail. Altogether, the property is credited with shipments of about 200 tons of silver and silver-lead ore, averaging, on the whole, about 150 ounces in silver to the ton and 35 per cent lead. Mr. Calder reports that in addition about 200 tons of milling ore has been left on the dumps.

The rocks exposed on this property are largely greenish metamorphic rocks, probably of volcanic origin. They are in part quite massive, but in places, as in the vicinity of the main workings, are greatly sheared and fractured. They are intersected by a variety of intrusives and their metamorphism is principally ascribed to intimately associated, irregular bodies of grey to greenish grey, granitic rock of about the composition of granodiorite or quartz diorite. On the First Chance and Jim Hill claims they are in contact with a large body of pink granite. In the vicinity of the main workings and elsewhere, they are intersected by a number of fine-grained, quartz porphyry dykes and by coarser-grained dykes of granodiorite porphyry. A number of small, coarse, pegmatitic dykes were also observed. The quartz porphyry and granodiorite dykes appear to have had some structural control over ore mineralization.

Work has been chiefly concerned with the exploration and development of the main vein or vein zone, a sheared and fissured zone, of uncertain width, which traverses the altered, greenish, volcanic rocks and associated intrusives in a general east and west direction. This zone is intersected by numerous faults having a general north strike and, mostly, a steep dip to the west. In the intervals between the faults, vein matter has been discovered along, in some cases, well-defined, but, in others, poorly marked, fissures or shear zones which terminate abruptly on encountering the north-south faults. The character of the mineralization in the segments between the faults varies from segment to segment, so that although the faults do not appear to be mineralized there nevertheless seems to be some grounds for supposing the faulting to be at least partly pre-mineral in age.

Workings on the main vein zone include a shaft, 95 feet deep, four adits, and considerable surface work and investigate the main vein over a vertical range of about 200 feet and a length of nearly 1,000 feet

¹Ann. Repts., Minister of Mines, B.C., 1917-1920.

on either side of the First Chance and West Fork claim boundaries. Most of the production has come from workings in the vicinity of the main shaft on the West Fork claim. This shaft was sunk on the vein, which dips steeply to the north. From the bottom of the shaft, at 95 feet below the surface, a drift is reported to run to the east for 60 feet. Some good lead ore is stated to have been obtained from the bottom of the shaft, one carload carrying 37 per cent and another 35 per cent lead. At 35 feet, vertically, the shaft meets a drift which runs west for 60 feet to join crosscut adit No. 1 (now caved). Stopes extend to the surface west of the shaft. For 50 feet or so on either side of the shaft the vein lies in a dyke of sheared, medium-grained granodiorite porphyry. East of the shaft the main vein has been traced on the surface for about 250 feet and in this direction is stained with copper carbonates and carries a little galena. West of the shaft the same vein has been traced on the surface for 150 feet and near this point has been picked up by a short crosscut adit (No. 2) and drifted on for 25 feet. A little stoping has been done above the adit level, near the floor of which the vein is cut off by a fault striking about parallel with the vein but dipping to the south. Fifty-five feet west of the shaft a narrow quartz porphyry dyke is cut off at the hanging-wall side of the main vein and reappears on the foot-wall side 93 feet farther west.

Between No. 2 adit and No. 3 adit, 360 feet farther west, the vein encountered in No. 2 adit has been picked up in two open-cuts, in the more easterly of which narrow stringers of vein matter carrying argentite are reported to have been found.

No. 3 adit is 100 feet vertically below the collar of the shaft. This adit runs easterly, is 95 feet long, and follows the main vein. At 64 feet from the portal a winze connects with a raise from the end of a crosscut at No. 4 level. Referring to the drift and winze, Freeland reports that "the ore . . . occurred in lenses in a 4-foot lead. In the vicinity of the shaft (winze) high values in silver and lead were obtained."¹

Work on No. 4 adit level has encountered more difficulties in the way of following vein matter than had been anticipated from work at the surface and in the upper levels. The adit commences 145 feet west of the mouth of No. 3 adit and 60 feet vertically below it. No. 4 adit runs east and is 745 feet long, the face being about 120 feet north of the shaft and 155 feet below the collar of it. In the first 60 feet or so the vein matter was much disturbed, but is stated to have provided between 8 and 9 tons of ore carrying 200 ounces of silver to the ton and about 1 per cent lead and 4 per cent copper. This ore was mostly stoped from about midway of this distance where the wall-rock is partly quartz porphyry, probably representing a spur or spurs from a large dyke which extends northerly up the slope of the hill a few feet to the west of the portal of No. 4 adit.

At 90 feet from the portal another dyke of similar character was encountered. It is about 20 feet thick and is bounded by faults. The fault along the west edge apparently displaced the vein to the south where it was picked up by a crosscut in this direction. The displacement effected by the second fault, on the east side, is not known. Beyond it, no vein

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¹Ann. Rept., Minister of Mines, B.C., 1922, p. 171.

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matter was picked up for about 140 feet along the strike of the vein. The ledge matter where it is again struck in the drift dips steeply to the south and has been followed for about 70 feet to where it is apparently cut off by another north-south fault. In this distance of 70 feet the vein matter corresponds in character with that observed in No. 3 adit and in the two open-cuts mentioned as being situated east of No. 3. The open-cuts lie 40 to 60 feet south of, and 100 feet above, this section of No. 4 adit. West of where No. 4 adit enters the vein for a second time, a crosscut runs south and ends in a raise connecting with a winze from No. 3 adit. In the winze and raise the vein changes its dip with depth, from steep to the north on No. 3 level to steep to the south on No. 4 level. It, presumably, continues east from the foot of the raise through about 50 feet of unproved ground to where No. 4 adit again strikes the vein. On No. 4 adit-level the vein for the next 70 feet east lies along the hanging-wall of a narrow quartz porphyry dyke. At the end of the 70-foot section, the vein is abruptly cut off by a north-south fault. One hundred and thirty feet farther east along the general direction of strike, a quartz vein was struck and followed east for 140 feet to where it enters faulted ground. Fifty feet beyond this, towards the face of the adit, the ground is again extremely broken and sheared. East of a fault marked by a width of several feet of strongly sheared rocks, vein matter occurs and continues 15 feet to the face of the drift. This vein matter may be the faulted continuation of vein matter discovered in a crosscut run a short distance southerly at the east end of the 140-foot vein section. A little ore was discovered in this crosscut.

The vein matter still exposed in the underground workings varies in character and, judging from the values obtained from shipments to date, varied in like manner in different parts of the mine. Mostly this vein matter is represented by from one to several feet of sheared rock within which quartz forms narrow veins and lenses or occurs intimately distributed through, and partly replacing, the wall-rocks. A little calcite is associated with the quartz. The ore minerals are chiefly galena and sphalerite; lesser amounts of pyrite, chalcopyrite, and high-grade silver minerals are present. At the face of No. 4 level, fractures within the ledge matter carry a noticeable amount of native silver. Ruby silver has been reported to occur in the raise between Nos. 3 and 4 levels and argentite is stated to have been found in an open-cut. Doubtless high-grade silver minerals were also encountered in the more easterly workings in the vicinity of the shaft.

The 140-foot length of vein in adit No. 4 is a more regular vein of quartz several inches thick carrying streaks and sparse disseminations of ore minerals, chiefly sphalerite. It lies between strong walls. In these various respects it differs from the ledge matter occurring in this adit both to the east and to the west. It may be, therefore, that the 140-foot section is not a part of the same vein as is drifted on farther west for a length of 70 feet and which eastward terminates at a north-south fault. If the fault is younger than the vein ending against it, it seems likely, both from work done farther east along the level and from the disposition of vein matter in the surface and the near surface workings, that the offset continuation of the 70-foot vein section would lie 20 feet or so south of the adit level. This possibility might be investigated by a crosscut to the south from No. 4 level at some convenient point, or by locating the fault at the surface and finding the vein outcrop on either side of it. If, however, displacement

along this fault occurred mostly or entirely in pre-mineral time, the vein mineralization that occurs on either side of it must be interpreted as representing separate veins which may or may not have any structural connexion with one another.

In addition to workings on the main vein or vein zone, some surface exploration has been done on a quartz vein (Locality 20) occurring along the hanging-wall, east side, of a wide dyke of quartz porphyry. This dyke strikes about north 20 to 25 degrees east, underlies the cabin on this property, and passes a little to the west of the portal of No. 4 adit. The principal showing occurs about 725 feet north of the portal of No. 4 adit or 450 feet north of the cabin. At this point the quartz vein is 2 feet wide, dips steeply east, and is conspicuously mineralized with disseminated pyrite and galena. The quartz has a somewhat banded appearance. The vein has been exposed for only a few yards at this locality and was not observed farther south, but outcrops of vein-quartz noted at intervals farther north on the First Chance and Wood Lot claims may be parts of the same vein. The more northerly showings are narrower and not as well mineralized as the main outcrop.

Pay Day Group (Locality 21)

The Pay Day group, consisting of the Pay Day and nine other claims held by location, is the property of Walter B. Johnstone, A. Williams, *et al.*, of Edgewood, B.C. The principal workings lie about 1,000 feet east of the Galloping Mountain trail and about a mile northeast of the Lightning Peak mine.

The rocks in the vicinity of the workings are in part metamorphosed greenish to greyish green, dense to finely crystalline types, in part of volcanic origin, and in part probably sedimentary. A specimen of a dark grey-green, rather vitreous, crystalline rock, much resembling a quartzite in the hand specimen and obtained from an outcrop 300 feet northwest of the tunnel on this property, was examined microscopically and found to be composed of a mosaic of quartz and feldspar with many large crystals of plagioclase, about oligoclase-andesine (Ab 65: An 35). Scattered through the mosaic are abundant small shreds and crystals of green, strongly pleochroic amphibole, considerable titanite, and small veins and patches of calcite. This rock is probably of tuffaceous or possibly sedimentary origin. It and others like it are associated with more greenish types much resembling rocks observed at the Lightning Peak mine and regarded as being, probably, altered andesitic lavas. The metamorphosed rocks are invaded by others of granitic facies and a body of granodiorite, between 200 and 300 feet wide, lies southwest of the main workings and extends northwesterly across the Galloping Mountain trail for a distance of at least several hundred feet.

Development work on this property includes numerous trenches and an adit 60 feet long. The trenches were for the purpose of tracing a mineralized zone lying within metamorphic rocks close to the northwest edge of the body of granodiorite referred to above. The zone has a general north to northwest strike, and is reported¹ to have been traced at the surface for 600 feet and to vary from 2 to 6 feet in width. In the adit, which is a crosscut at a depth of about 30 feet below the outcrop, the zone is

¹Ann. Rept., Minister of Mines, B.C., 1929, p. 256.

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¹Idem, p. 256.

entered at 40 feet from the portal and continues to the face. It lies mostly if not entirely between two faults striking about north. The fault at the face dips 60 degrees west, the other fault is nearly vertical. A third fault intersects the mineralized zone about 8 feet from the face of the adit.

Underground, the mineralized zone carries a varying but high percentage of sulphides, both massive and banded, and as heavy impregnations in the country rock. The sulphides are associated with quartz and lesser amounts of calcite and ankeritic carbonate. The more abundant sulphides are pyrite, sphalerite, and chalcopyrite. Magnetite is plentiful in places. Other minerals include a little pyrrhotite and galena. A sample taken by the resident engineer, across a width of 10 feet of the more solid sulphide material, assayed: gold, trace; silver, 30 ounces to the ton; copper, 4.2 per cent; lead, nil; zinc, 12 per cent; nickel, nil; arsenic, nil; bismuth, trace¹. The greater width of the mineralized zone at the adit level as compared with its width at the surface may be due to duplication by faulting. At the surface the zone is strongly oxidized.

Big Hill Claim (Locality 22)

A little prospecting has been done on the Big Hill claim situated nearly 2 miles by trail, north of, and accessible from, the Lightning Peak property. It is owned by W. A. Calder, Edgewood, B.C.

There, on the east bank of Big Hill creek, a fault follows the contact of a granitic intrusive with a greenish altered rock. The fault strikes northerly and dips about 60 degrees west. No ore minerals were noted, though the rocks at the contact are stained with iron rust. It is reported that films of argentite have been found coating fractures within the fault zone, which is at least several inches wide.

Pilot and Uta Claims (Locality 23)

The Pilot and Uta are adjoining claims held by location by Messrs. Nels Melstrom and Adam Scaia, respectively, Edgewood, B.C. They are situated north of the Waterloo tractor road about 3 miles east of the Waterloo mine.

The claims lie within an area of highly altered, greenish rocks of uncertain but probably volcanic origin. The metamorphosed rocks are saturated with granitic material and are intersected by quartz porphyry dykes. At one point near the boundary line between the two claims, a dark, olive-green, basaltic dyke several feet wide was observed to strike northeast, and dip 60 degrees southwest.

This dyke is possibly of Tertiary age. On the southwest edge of the dyke a belt several feet wide of sheared and decomposed greenstone carrying a little disseminated pyrite has been investigated by three or more trenches.

The principal work has been done in the vicinity of the Discovery post on the Pilot claim where a trench 80 feet long, and other smaller trenches reveal greenish, highly altered rocks carrying disseminated pyrite and, more locally, chalcopyrite, and, in one place, some molybdenite. The mineralization so far discovered is not of economic value, but is widespread.

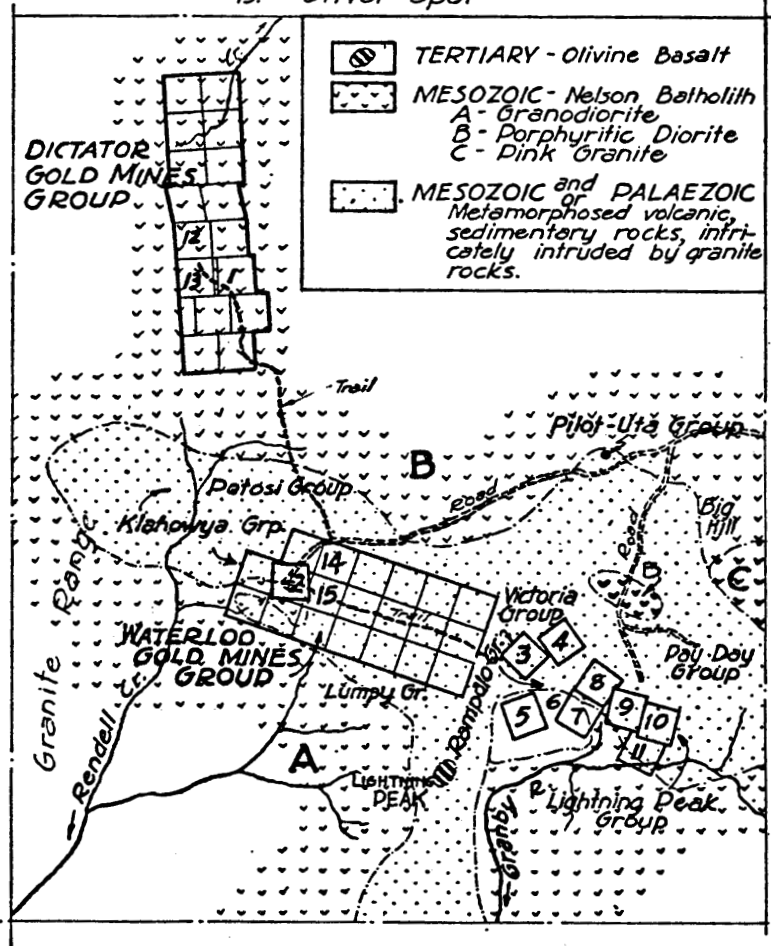
¹Idem, p. 256.

SKETCH MAP SHOWING GEOLOGY & CLAIM GROUPS LIGHTNING PEAK AREA.

SCALE 0 5,000 10,000 20,000 Feet.

LEGEND

- | | |
|--|--|
| <p>1 Dictator, C.G. 2 Waterloo, C.G. 3 Rampalo, C.G. 4 Silver Lump, C.G. 5 Lost Cause, C.G. 6 Lucky Jim Fraction, C.G. 7 Killorney</p> | <p>8 Thunder Hill, C.G. 9 First Chance, C.G. 10 West Fork, C.G. 11 Jim Hill, C.G. 12 Morning 13 Cordova 14 A.U. 15 Silver Spot</p> |
|--|--|



With report by P.B. Freeland, 1933,
Resident Mining Engineer,
Penticton, B.C.

B.C. Department of Mines.

A.M.R.

Valley Landing on the west side of Lower Arrow lake about 6 miles north of Edgewood, westerly across a low divide for about 4 miles to Fire valley, which is drained by Inonoaklin creek, thence up this valley to near the junction of Sand creek, a western tributary of the Inonoaklin. The trail then

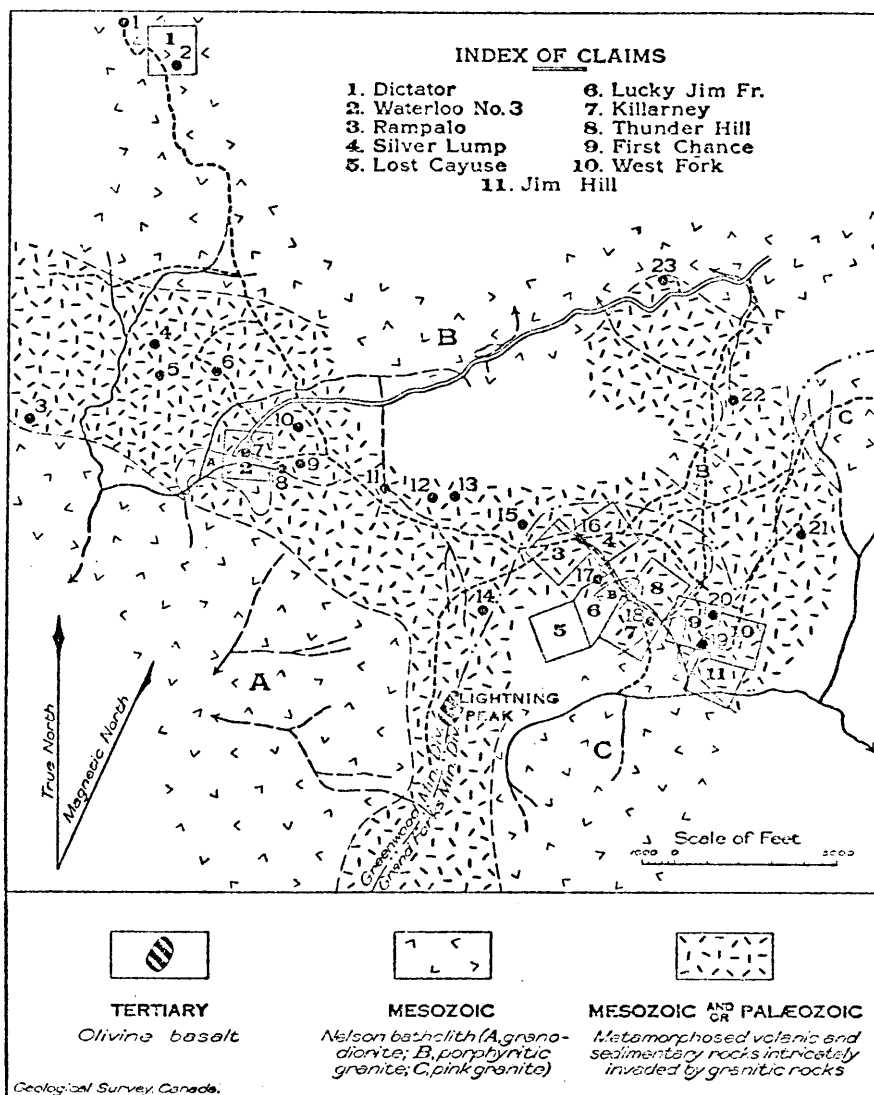


Figure 7. Lightning Peak area, Osoyoos district, British Columbia. Positions of mines, prospects, and other mineral discoveries are indicated by solid circles numbered as in text.

followed up Sand Creek valley and thence westerly via Galloping mountain to Lightning Peak camp, a total distance from Lower Arrow lake of about 26 miles. Another, but less frequented, route led northerly along the divide between the east and west forks of Granby river from Franklin Camp.