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THE GEOLOGY AND MINERALIZATION

OF

THE TRIASSIC BASAL SLATE MEMBER

SLOCAN SEDIMENTS

WHITEWATER DISTRICT

OF

BRITISH COLUMBIA

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INTRODUCTION

The widespread occurrence of silver-lead-zinc mineralization in the Slocan district of B.C. is well-known and well documented. The first discoveries of commercial ore were made in about 1892.

Development of ore bodies and mining in the district progressed from surface cuts and hand selection of supergene ore on exposed outcrops to extensive underground mining and development at such well-known underground mines as Lucky Jim, Cork Province, Whitewater, Ruth-Hope, Mammoth, Standard, Hewitt, Galena Farm, Bosun, and Ottawa.

The writer is attracted to this district as are others by the widespread concentration of economic elements within a relatively confined geographical region.

The abundance of such silver rich minerals as tetrahedrite, freibergite, proustite and native silver in most of the known and depleted ore zones both in secondary as well as primary form, should be emphasized in relation to the economics of large tonnage, surface mine development within the district.

Underground mining in the past has been confined generally to competent rock formations such as quartzite and limestone. Fissure filling systems in competent quartzite have been persistent and well-defined by drift and raise development. Similarly,sphalerite replacement bodies in limestone are readily explored and extracted by underground methods.

Less competent rock strata such as the Basal Slate Member of the Slocan Sediments have not been productive in the past, with the exception of the Whitewater Mine, as known mineralization is not well-defined in terms of a 7' x 8' drift. For this reason fissile members have generally been ignored as a possible host for economic mineral concentration.

At Whitewater Mine, silver-lead-zinc concentration has been sufficiently confined within the sheared and fissile Basal Slate Member to achieve economy of underground extraction in the past. However the higher grade paystreaks of ore mined at this location, represented in most instances only a small portion of the entire mineralized width on any one structure. The writer concludes from research that the incompetent nature of the host rock prevented economic exploitation of a great stratigraphic section of the Slocan sediments in the past, that are in fact not at all deficient in base and precious metals.

On the contrary, this paper will discuss the theory that the black, carbonaceous, fissile Basal Slate Member of the Slocan Sediments may in fact prove to be the original source of economic elements, re-mobilized by hydrothermal activity resulting from the invading Nelson porphyry and re-concentrated within the source rock as well as within more competent rock units stratigraphically higher in the section and located geographically to the south in the Sandon region.

Quoting from "Spencer R. Titley, Introduction, Geology of the Porphyry Copper Deposits,Southwestern North America:"

"One of the most striking characteristics of the porphyry copper deposits seems to be their lack of selectivity for host rock and their capacity to be developed in almost any rock type accessible."

One presumes of course that the original element is present in some natural state and in original anomalous quantities.

Titley further defines porphyry deposits into three types:

(1) "Simple porphyry copper deposits" in which mineralization has developed in the intrusive rocks, that is in the porphyritic host rock.

(2) "Complex porphyry copper deposits" in both the porphyritic rock and the intruded rocks, the intruded rocks include other plutonic rocks, volcanic, metamorphic and sedimentary types.

(3) "Simple porphyry deposits" in which mineralization has developed entirely or almost entirely in the intruded host rock.

By virture of these definitions as outlined by a porphyry specialist, this writer proposes that a porphyry,silver-lead-zinc environment exists in the Slocan district of B.C. and that the economy of open pit mining is enhanced by the widespread distribution of such silver rich minerals as tetrahedrite within quartz veining, as fracture filling and dissemination in host rock and as inclusions within such common minerals as galena, sphalerite and pyrite. The economy of this theory is further advanced by supergene enrichment known to occur in the district to depths in excess of 200 feet. Secondary mineral occurrences are well documented and include native silver, proustite and the silver chloride,cerargyrite.

The writer has approached the Slocan district geology for the purpose of exploring for this type of occurrence rather than for the underground vein systems.

According to Harrison A. Schmitt in his paper "The Porphyry Copper Deposits in their Regional Setting" a pre-requisite to the occurrence of economic concentrations of copper in the U.S. southwest is a complex, triple fault intersection. It would seem logical that such an occurrence in a suitable geological environment might precipitate concentration of economic elements whatever these elements might be,provided anomalous background values are available for mobilization and re-deposition.

Air photo investigation of what the writer considered to be a suitable geological environment disclosed a complex triple fault intersection in the Goat Creek Basin, Slocan District, five miles northeast of the historic mining camp at Sandon, B.C. Further investigation in the field resulted in the discovery of widespread, low grade, silver-lead-zinc mineralization in a quartz stockwork invading the Basal Slate Member of the Slocan Sediments. The mineral zone has been exposed by erosion in the Goat Creek Valley. The occurrence is an obvious continuation of known mineralized structure exposed and mined on Whitewater Creek to the east and on London Ridge to the west. A very old collapsed portal was also observed centered on the creek exposure.

This paper summarizes the known geology and mineral occurrences in the district as interpreted by others from underground workings and outcrops peripheral to the Goat Creek Basin and defines the porphyry potential and fault and fracture patterns underlying the Jim and Dan mineral claims in the Goat Creek Basin.

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June, 1977

A. GEOLOGICAL SUMMARY SLOCAN DISTRICT

The rock types represented in the Slocan district consists of sediments, volcanics and intrusives. The oldest rocks form a series of schists, quartzite and crystalline limestone forming a north-south trending band along the west side of Kootney Lake known as the Kootenay arc of upper Palaeozoic, Mississippian to Permian age.

Overlying unconformably the rocks of the Kootenay arc to the west is the lower Triassic, Kaslo Group of volcanic rocks consisting of meta-andesite flows, tuff and breccia.

Overlying the Kaslo volcanics further to the west is the Slocan Series of upper Triassic, lower Jurassic sediments of Sinemurian time. The contact with the volcanics is unconformable and mineralized on Whitewater Creek. The Slocan sediments contain the great number of silver-lead-zinc deposits of the district and the series consists of quartzite, argillite, slate, and limestone.

The Slocan sediments have been subdivided into four members, that are geographically roughly parallel and are characterized by an abundance of certain rock types. The sediments strike generally northwest and dip southwest. Overlying rocks become progressively younger to the west.

The oldest rock type of the Slocan series and the one that is the subject of consideration in this paper is the basal slate member. This member consists of black fissile slate at least half a mile in thickness, that directly overlies the Kaslo Volcanics.

Overlying the basal slates and adjoining this member to the southwest is a belt of slaty rocks up to four miles wide characterized by a great number of limestone beds varying up to 200 feet or more in thickness.

The basal slate member appears to become progressively limy toward its stratigraphic top and therefore more susceptible to replacement and dissemination of economic elements. A few important past producing properties are located in the upper basal slates and lower limestone member among them are the Cork-Province, Lucky Jim and Whitewater Mines. The ore deposits were characteristically limestone replacement and in the case of Whitewater, fracture filling and replacement in calcareous slates.

The third member of the Slocan Series and the broadest zone overlies the limestone member and is composed chiefly of strong massive rock types including blocky argillites, quartzites and feldspar sandstone, all of which are more or less limy. Some of the largest fissure filling vein deposits of the district occur in this member due to the competent nature of the host rock. Some of the properties which occur in this member are the Standard, Ruth-Hope, Hewitt, Van Roi Mines.

The fourth sedimentary member occupies a wide strip through the central portion of the district and includes the upper most horizon farthest to the southwest. This member is abundantly mineralized and is characterized by a great variety of thinly interbedded rock types including sandy, argillaceous and limy strata and by a great number of porphyritic intrusives, most of which trend with the enclosing formations.

All of the above rocks and ages of rocks are cut by dykes and sills of granite, granodiorite, quartz-diorite and feldspar porphyry. The great section of folded and upturned Slocan sediments was invaded to the south by the Nelson Batholith in the upper Cretaceous, Laramide orogeny and was invaded originally in the north by the older Kuskanax Batholith during the late Jurassic, Nevadian orogeny. The northern contact of the Nelson Batholith apparently plunges at a low angle beneath the rocks of the Slocan Series and its presence at shallow depths beneath the district is inferred from the occurrence of numerous statellitic stocks exposed by erosion.

Intrusive rock type associated with the Nelson Batholith is generally porphyritic biotite-hornblende quartz monzonite. The rock type associated with the Kuskanax Batholith is generally syenite and lineated leucoquartz monzonite.

i - CLASSIFICATION OF ORE DEPOSITS

Ore deposits in the district were classified early in the history of the district into two groups and are still known within the district as "wet" and "dry" ores. The dry ores include those deposits in which the vein matter is composed largely of quartz and includes only a minor portion of lead ane zinc. These deposits commonly have an important content of high grade silver minerals and have in the past been worked from underground primarily for silver. Typical dry ores occur on London ridge west of Goat Creek at the McAllister Mine, Silver Glance Mine and Panama Mine and within the intrusives at the Ottawa and Arlington Mines in the southern part of the district.

Wet ores are characterized by an abundance of galena and sphalerite and silver-bearing minerals are associated. These ores may be classified into sub-types according to the relative abundance of associated gangue minerals. In many deposits quartz is almost the only gangue mineral. In other deposits calcite is relatively abundant and in other deposits siderite is the chief gangue mineral.

Quartz with argentiferous tetrahedrite and some native silver is generally conspicuous in the upper parts of deposits but at depth the quartz is commonly replaced by siderite and at still greater depth quartz gangue again dominates but is generally low grade or barren of ore minerals as contrasted with the upper zone. The upper quartz zone is generally more cellular and vuggy than the quartz at depth. This order is well shown in the Whitewater Mine.

In the same deposits the ore minerals show a transition from galena and higher grade silver minerals in the upper quartz horizon down through galena deposits associated with increasing sphalerite to mostly sphalerite in the siderite zone, with very little ore or no mineralization in the lower quartz zone. In several of the larger composite ore bodies, the mineralization has formed as the result of repeated injections of mineral-bearing solutions, the normal succession with depth,of gangue and ore minerals may be less evident owing to overlap of the materials deposited during the successive stages.

A significant feature connected with these deposits is that at depth in the vicinity of and below the more zincy zone, iron-bearing sulphides, particularly pyrite are conspicuously developed. Chalcopyrite may also be a fairly conspicuous mineral and more rarely pyrrhotite. These sulphides may contain appreciable gold values.

ii - PARAGENESIS

Quartz, pyrite and calcite have a long range through which they are important and as early minerals commenced to form in the order given. At Whitewater, veins of pyrite intersect mases of siderite.

In some deposits siderite and sphalerite are contemporaneous, banded siderite-sphalerite ore in the Whitewater Deep has formed by replacement of successive layers of wallrocks first by one and then by the other mineral. In most cases however the succession from Wallrock to centre or from bottom to top of a deposit is quartz, siderite, sphalerite, galena. Minor chalcopyrite is regarded as being essentially contemporaneous with sphalerite.

Sphalerite is massive, rick brown, lustrous with well-developed cleavage and is found in large bodies of nearly pure ore at Lucky Jim and Whitewater. At Charleston and Wellington the sphalerite is liver brown colour and forms narrow bands and lenses interstratified with other minerals principally pyrite and galena. The sphalerite ore contains appreciable silver values on these properties due to minute blebs and inclusions of argentiferous tetrahedrite.

Siderite is the most common gangue mineral in the larger silver-lead-zinc bodies. It occurs as coarsely crystalline bands and lenses. It may be intimately mixed with or inter-banded with the ore minerals. At depth it is generally replaced by quartz. It varies from light honey colour through various shades of pinkish and reddish brown to dark grey and almost black.

Galena is a common ore mineral within slates as sphalerite is common to limestone replacement. At Whitewater the galena is rarely coarsely crystalline but has been mined underground in masses up to eight feet in thickness and as stringers dispersed through slaty cleavage. It is generally medium to fine-grained. Some varieties known as black lead ore show only minor grain development to the unaided eye.

The silver rich minerals tetrahedrite, freibergite, pyrargyrite, polybasite argentite and native silver in this order of decreasing importance may occur as minute disseminations scattered through galena, sphalerite and quartz.

Magnetite occurs in dense masses closely associated with fine-grained pyrrhotite at Whitewater Deep Mine and is a replacement of lamprophyre.

Pyrite generally increases in quantity with depth. It oxidizes rapidly and has probably been an important factor in the formation of supergene ores which were extensively mined in the early days of the district.

Pyrrhotite is a much less common mineral than pyrite. At Whitewater Deep massive fine-grain pyrrhotite is closely associated with magnetite in the lower levels of the mine.

iii - THEORY OF DEPOSITION

It has been accepted that the source of mineral-bearing solution which produced the deposits of the district had its origin in the intrusive rocks of the Nelson batholith which underly the sedimentary section and that the source of the economic elements is the intrusive itself. This may well be true.

There were obviously two processes of concentration at work:

(1) the filling of fissure and fracture zones;

(2) metasomatic replacement of limestone beds and limy strata.

The economic geologist should seek the answer to several pertinent questions. Under what conditions and as a result of what processes are ores formed in a district? Enquiry into these matters might possibly expand opportunities for exploitation.

What are the factors that led to concentration of the useful elements in a particular environment and not in another? What causes localization of ore? What is the source of economic elements?

Many of the most fundamental problems relating to transportation and deposition of ore materials remain unsettled. Many lead-zinc deposits such as those of Mount Isa, Australia or the Tri-State district in the Mississippi Valley may be hydrothermal deposits or they may be sedimentary beds composed of chemical or mechanical precipitates.

Hydrothermal solutions can be studied near the surface of the earth but here they are contaminated with ground waters and have changed their characteristics through extensive reaction with the wallrocks along their passageways.

This writer is favoured to consider for the Slocan district that the source of hydrothermal solution is in fact the intrusive porphyry; that contamination of these solutions during final migration by reaction with wallrocks resulted in economic elements being taken into solution, for redeposition in economic concentration by fissure filling and metasomatic processes.

According to this hypothesis, the Slocan sediments are themselves the source of economic elements as well as the final host for deposition.

The basal, black shale member of the Slocan Series should be investigated for abnormal concentrations of trace elements, lead and zinc. Large tonnages of low grade ore might in fact occur where ground preparation is significant for redeposition of economic elements mobilized from the host which itself contains high background lead and zinc.

Czeslaw Haranczyk in his paper "Zechstein Lead-Bearing Shales in the Fore-Sudetian Monocline in Poland - Economic Geology Vol. 65, 1970, p.p. 481-495 describes Middle Permian Lower Zechstein lead-bearing shales as a facies equivalent of the copper-bearing shales which occurs northeast of Lubin in the Fore-Sudetian Monocline in the southwest of Poland. Similar to the basal member of the Slocan series, they are a dark, bituminous, laminated rock type consisting of alternating clay and carbonate layers, in this case richly mineralized with disseminated galena. The sediments rich in lead and locally in zinc were deposited in the marginal zone of the Rudna lagoon under evapourite conditions where salinity was high. Small showings of lead are well known and are characteristic of calcium sulphate-bearing carbonate rocks of the Middle and Upper Zechstein of Poland and Germany. The lead showings in saline carbonate rocks is regarded as a general rule. In the Fore-Sudetian monocline area this phenomenon is developed largely under highly specialized conditions with anomalous addition of heavy metals or submarine hydrothermal activity introducing these metals into the early Permian Zechstein Sea. The distribution of sediments seems to be due to the process of sedimentation and fractionation of water in the co-existing lagoon and adjacent parts of the open epicontinental sea under euximic stagnant water conditions.

Wherever there is a source of metal ions and favourable redox conditions for precipitation, ore deposits or at least anomalous concentrations of economic minerals have a chance to form. Such conditions may be met in certain basins of deposition where decaying organic debris or bacterial action generates an exceptional reducing environment. The anomalous metal concentrations possibly represent an absorption of metallic elements from sea water during the slow accumulation of sediments. Much discussion has centered around the source of metals whether (1) a sedimentary syngenetic origin with sulphur coming from a biogenic source or (2) an exhalative sedimentary origin, the metals contributed by submarine volcanic springs and precipitation would take place where stagnant bottom conditions prevail.

Carbonaceous shales and similar marine sediments appear to contain higher percentages of metals than other sedimentary rocks. Some metals are enriched in black, carbonaceous marine shales. Krauskopf (1955) found that several elements are enriched more than a thousand fold in selected organic sediments.

The great number of silver-lead-zinc occurrences localized geographically in the Slocan district and geologically in the Slocan sediments stratigraphically overlying the basal black shale member, draws attention to the sediments themselves as being the original source of economic elements re deposited by more conventional means of fracture filling and replacement. Structural control for deposition no doubt includes the accepted principle of ground preparation by faulting and access to prepared ground by pregnant hydrothermal solutions.

Consideration however should be given to possible large tonnage low grade silver-lead-zinc deposits within the sedimentary strata presently noted for numerous occurrences of narrow high grade vein deposits. The less competent basal black shale member not noted for continuous vein structure may in fact contain areas of widely dispersed low grade mineralization as noted at Whitewater Mine.

B. GEOLOGY OF THE GOAT CREEK BASIN

The area underlying the Goat Creek Basin and covered by mineral claims Dan, Jim, Argento, represents rock types common to the basal slate and limestone member of the Slocan sediments and includes the contact with Kaslo-Volcanics to the northeast. The Triassic sedimentary section has been invaded by stocks, dykes and sills of feldspar porphyry. The southwestern part of the area, stratigraphically higher in the sedimentary sequence include argillaceous rocks including phyllites and quartzite. The regional strike is northwest and the prevalent dip is southwest. The structure plunges west at Murray Creek and the only observed major fold is a synclinal basin west of Zincton and the anticlinal limb outcropping on Goat Creek.

The area of consideration is bounded on the southwest by the Lucky Jim Mine, on the east by the Wellington and Whitewater Mines and on the northwest by the McAllister and Panama Mines.

There are many minor intricate structures in the area as a whole, rock flowage and brecciation testify that much differential movement occurred.

No subdivision of the slates has been made other than the recognition of an assemblage of banded rocks near Zincton termed the Zincton member. This member consists of thinly bedded hard and soft argillaceous strata as well as limy slates and several distinct bands of limestone. The slates are overlain west of Zincton by thickly bedded, non-fissile argillites common to the higher sedimentary sequence.

Dykes and sills are numerous near Zincton and a number can be seen near the mouth of Goat Creek. Porphyritic, mica, lamprophyry dykes younger than feldspar porphyry dykes but pre mineral are exposed near Retallack, west of Murray Creek and follow mineralized faults in the upper Whitewater Mine. All the intrusives are sericitized to a greater or lesser degree.

The stratigraphy of the slates is not well known due to lack of outcrops, intensity of cleavage and intricacy of local structures. Bands of quartzite are rare, even though individual beds of quartzite are common in many sections. There are several limestone bands from 10 to 60 feet in average width as well as bands of calcareous slates which include numerous beds of limestone one inch to several inches thick. Between Zincton and upper Whitewater Creek there are thirteen bands of limestone.

One of the most important is the Lucky Jim limestone band which extends from Zincton to the bridge across Jackson Creek. This band is brecciated in all natural exposures. The second important band is the Whitewater limestone in which are the lower workings of the Whitewater Mine. It is about 50 feet thick. Two bands lie south of and stratigraphically above the Whitewater band. Stratigraphically below the Whitewater limestone to the north, two bands range in apparent width from 30 to 100 feet and outcrop on Whitewater Creek.

i - STRUCTURAL GEOLOGY

The sediments in general strike north-westward and dip south-westward. An important drag fold occurs west of Whitewater Creek and there is much contortion of the beds in the Valley of Kaslo Creek west of Retallack and east of Zincton.

The fault and fracture pattern in the Goat Creek basin has been interpreted by the writer from air photos. All ore deposits in the Slocan district appear to be fracture controlled. Fault and fracture interpretation is therefore considered essential to further investigation.

The area of consideration exhibits a triple complex fault intersection within the basal members of the Slocan series.

These have been termed the Seaton fault complex, the Kaslo fault complex and the Goat fault, trending in order northeast, northwest and northsouth.

ii - MINERALIZATION

Mineralization in the district appears to be related to the Kaslo fault complex at Whitewater and Wellington and appears to be related to the Seaton fault at Lucky Jim.

The Kaslo fault complex has been in part exposed by erosion in Goat Creek 800 meters above the highway and is mineralized at this location over a width of 200 meters where exposed, with quartz veins and veinlets containing pyrite, galena, sphalerite, tetrahedrite. Due to oxidation within the water course, very little primary mineral remains. Quartz veining crosscuts sedimentary strata and also follows the bedding plane.

A continuation of the Kaslo fault complex to the northwest probably accounts for mineralization at the Panama and McAllister Mines on London Ridge.

The occurrences of argentiferous tetrahedrite, galena and sphalerite within the fault system are well known on London Ridge to the west and at Whitewater to the east.

Due to the complexity of the fault intersection in the Goat Creek basin and the wide dispersal of high grade silver mineralization in the district in general, significant opportunity appears to exist for the occurrence of widespread, low grade, concentration of silver and base metals in economic quantities of sufficient value to support open pit mining.

C. GEOLOGY OF THE WHITEWATER MINE

Rocks underlying the Whitewater Mine are fissile slates for the most part. There is a wide variation from argillaceous and graphitic types to calcareous and quartzitic bands. Detailed subdivision is impossible due to little exposure and complexity of structure. There is a tendency for the rocks to be more quartzitic to the west and for limestone to increase to the east. Included in this area is the Whitewater limestone belt. The bands of limestone are distinctive horizon markers, some of the smaller of which contain an admixture of slate. There are five principle bands of limestone, the central about 50 feet thick is referred to as the Whitewater band. It contains the replacement deposit in the Whitewater Mine.

No granitic dykes have been mapped. A lamprophyre dyke occurs in the canyon of Whitewater Creek, another lamprophyre dyke closely follows the Whitewater lode and others occur west of the mouth of Murray Creek.

Whitewater Creek canyon provides a good cross section. To the north the sediments lie nearly vertical, in the central part they are involved in drag folding and in the lower part they dip 50° - 60° southwest. At the mouth of the creek there is a local reversal in dip produced by underfolding. The

Whitewater fold is an asymmetrical drag fold which displays reversals of plunge. It does not cross Whitewater Creek to the east.

To the northwest of the Whitewater Mine, toward Murray and Goat Creeks outcrops are rare much of the ground is covered by dense forest growth and glacial drift derived from the Kaslo Volcanics geographically to the north.

The thrust fault occupied by the Whitewater lode is one of several parallel, northwest trending, mineralized structures that have been exposed by erosion at Whitewater Creek. The Whitewater fault has a displacement on the dip of possibly 400 feet. It is more or less parallel in strike to the general structure and dips at variable angles to the southwest. The dip steepens to the west, to 85 degrees and flattens at lower elevations to 20 degrees. It is a complex zone of breaking and shearing.

A curving flat fault zone follows close to the bottom of the lower part of Whitewater Creek canyon. It is locally mineralized with siderite and sulphides. Rocks exposed by Kaslo Creek below Whitewater Creek are heavily faulted and quartz has been introduced into them.

i - ORE CLASSIFICATION

Four types of ore bodies occur in the Whitewater Mine:

(1) fissure and fracture filling

(2) limestone replacement

(3) dyke replacement

(4) supergene oxide ore

ii - UPPER MINE GEOLOGY

The Whitewater lode in the upper mine is an irregular zone of shearing and fracturing in slates. The structure cut by the lode in the lower levels is complex. The strata is vertical above No. 7 level and strikes parallel to the lode. Above No. 9 level the strata rolls under the lode and dips at low angles to the south. The productive underground ore zone, lies within the area of steeply dipping strata along the hanging wall of the thrust fault. The footwall is poorly defined. Above No. 7 level, the lode appears to have been a relatively simple break up to 20 feet wide in places consisting of mineralization in sheared and shattered slates. Below the level the faulting is branching and not all the branches have been explored. Lateral branching appears to have resulted from northwest and northeast fault intersections as previously discussed. Exposures above the highest adit are scanty and the vein cannot be traced on the ground. The underground productive zone attains a width of 40 feet below the No. 7 level. Splits in the lode west of and below the productive zone have not been entirely explored. It was considered that an intersecting hanging wall branch fault was important in localizing the ore.

iii - MINERALOGY

The ore consists of galena and sphalerite, in about equal amounts with small amounts of tetrahedrite and minor pyrite and chalcopyrite. Silver occurs in the ratio of 2½ oz. to the percent lead. The gangue is chiefly siderite with some quartz. Reports indicate that on the higher levels, five feet of siderite lay on a relatively even footwall above which lay the ore minerals and the remainder of the lode consisted of irregularly mineralized slate. The ore occurs generally as streaks, lenses and irregular pod-like masses attaining a maximum width of nearly 40 feet below No. 7 level. Most of the galena seems to be the normal variety but some steel galena occurs locally termed black lead. The sphalerite varies from brown to an exceedingly dense black variety as well as a very light brown variety.

iv - LOWER MINE GEOLOGY

The lode flattens below No. 13 level from an average dip of 60° to less than 20°. The footwall rocks are slates and the hanging wall rocks are limestone. The angle between the flat and steep parts of the lode is very broken and there are steep splits in the fault system. The sediments dip here northward towards the lode. The locus of flat and steep dips has not been explored. Mineralized fissures in the bed of Whitewater Creek demonstrate the existence of flat feeder zones of the same general atlitude.

v - MINERALOGY

The principle type of ore in the lower mine consists of massive replacement of limestone by sphalerite and siderite. Galena occurs in this ore, disseminated or in local masses in proportion of about 1 to 5 sphalerite. Pyrite and chalcopyrite are rare and the silver content is about 1 oz. to the percent lead.

The replacement ore as a rule follows the bedding of the limestone and plays out up dip away from the lode fault contact. The ore bodies are characterized by siderite in which sphalerite occurs irregularly. The ore bodies are largest next to the fault and wedge out up dip. The ore body occurs continuously for a distance of about 600 feet in this trough with a cross sectional area up to 40 by 40 feet, with the greatest column extending from below the No. 14 level to above the 1472 level.

Dyke replacement ore occurs in the lower mine. It has been referred to as magnetic ore and consists of sphalerite, minor galena in a gangue of magnetite, pyrrhotite,pyrite and some silicate minerals replacing lamprophyre. It occurs in relatively large bodies between No. 14 and 12 levels below the 3600 foot elevation.

The magnetite ore is typically dense and dark in colour and consists of magnetite and pyrrhotite in varying proportions in which brown sphalerite occurs as masses, stringers and scattered grains. Pyrite is locally prominent and minor chalcopyrite is associated with the pyrrhotite. The ore is cut by post ore quartz and epidote stringers. The main magnetic ore body attains a maximum width of 40 feet and a length of 250 feet and plunges to the east between No. 12 and No. 1472 levels.

vi - SUPERGENE ORE

The uppermost levels of the mine were developed in a zone of oxidation and the earliest shipments were carbonate ore. Work began on the property in 1896 and originally paid for itself as high grade silver or was mined from the grassroots without a demand for development money. The vein was traced on surface for 800 feet and several car loads of good ore were shipped from surface stripping in a crushed mass of slate, iron oxide, yellow carbonate copper stained by oxidized tetrahedrite. The ore was scattered irregularly through a broken mass of slate over a width of 20 feet. Enriched silver values were encountered to a depth of 335 feet below the surface. Of the ore shipped in 1896, the silver values ranged from 72 oz. to 298 oz. averaging 114 oz. Ag per ton, 30% lead and 16% zinc.

vii - PRODUCTION

SHIPMENT AND GRADE

	TONS	TOTAL AU	TOTAL AG	AG GRADE	PB	ZN
Upper Mine (Shipping Ore)	23,426	459	1,756,934	75	30%	5.6%
Upper Mine (Milling Ore)	70,587	512	951,881	20	8.5%	10%
Total (Upper Mine)	94,013	971	2,708,815	33.5	13.5%	9%
Lower Mine (Replacement ore)	166,529	386	362,454	2.2	2%	9%

D. GEOLOGY OF THE LUCKY JIM MINE

A division of rock types in this area has been made with the chief purpose of outlining the Zincton member which includes the Lucky Jim limestone. The Zincton member lies stratigraphically about a mile above the Whitewater limestone and geographically a mile to the southwest. The Zincton member consists of argillaceous and calcareous rocks. There are many distinct beds of limestone, impure limestone and limy argillites. The rocks are for the most part thinly bedded and have a distinctive banded appearance.

The Lucky Jim limestone is a dark rock about 30 feet in normal thickness and contains a few discontinuous slaty beds. It is brecciated and locally bleached throughout much of its known extent a distance of about 3½ miles.

Underlying the Zincton member to the north and east are slates of relatively uniform character continuous across strike to the central part of Bear Lake. The slates include at least three distinct bands of limestone up to 25 feet in thickness.

The rocks overlying the Zincton member to the west are soft incompetent, thinly bedded dark slates and slaty argillites.

Light coloured granitic rocks intrude all of these sedimentary members but are most abundant in the slates underlying the Zincton member. The intrusive bodies are mostly sills and range from a few inches to 100 feet thick. Most of these sills are highly altered.

i - STRUCTURAL GEOLOGY

The regional strike of the sediments is to the northwest and the general dip is to the southwest. In detail as at Whitewater the rocks are profoundly deformed. Contorted zones west of the mine represent minor reversals in the general dip. There has been local brecciation of the rocks and discontinuous drag folding. The Lucky Jim limestone has been profoundly shattered throughout most of its extent and locally ground to a fine rubble.

There has been fracturing and faulting of the rocks both parallel to the structure in a northwesterly direction and parallel to Seaton Creek in a northeasterly direction.

Cross fracturing, normal in strike to the Lucky Jim limestone are common in the mine workings and in some instances are mineralized.

There is a system of fracturing through the mine striking northeasterly at right angles to the regional strike of the sediments being northwest. The fractures are a few inches to a few feet apart and locally produce a rude sheeting in the limestone. They are abundant on the No. 5 level and above and a large amount of ore in the upper part of the mine has been localized along them. Not all cross fractures are mineralized, many do contain sulphides in the form of seams, tiny lenses or scattered grains, and single fractures are seen that localize one foot or more of massive sphalerite. Large ore bodies have resulted from merging of ore between nearby fractures producing a width of 40 feet in some cases. The ore formed chimneys on single or multiple fractures and in zones of more intense fracturing swelled into large and irregular bodies.

In the lower part of the mine the influence of cross fracturing is definitely less important. A single cross fracture is followed between No. 8 and 9 levels, scattered mineral extends for tens of feet on either side of it and constitutes a wide replacement zone following a single well defined fault.

The zones of cross-fracturing have not been productive of as much ore as have the zones of more general replacement, but the ore in them has been higher in grade and has contained important amounts of silver and lead as well as zinc. The localization of massive sulphides along fractures prove that they acted as channelways for hydrothermal solutions.

Some limestone in the ore zones is brecciated and some is not. More ore occurs in brecciated limestone than unbrecciated. Dykes and sills within the limestone are pre ore.

Ore deposition is further localized by the presence of slate ribs within the limestone, such ribs may constitute one boundary of a stope.

The distribution of sphalerite and pyrite in some stopes forms locally a pattern of ribs or stripes through the rock evidently governed by pre ore fracturing.

The longer axis of stopes are aligned with the direction of fracturing.

ii - MINERALOGY

The ore consists of sphalerite and pyrite replacing limestone. Concentrates contained less than 1% lead and 1 oz. of silver. There is little or no siderite and quartz. The distribution of mineral within the ore body varies considerably. Bodies localized by cross fractures, the sphalerite may be relatively massive with minor amounts of pyrite.

The margins of ore bodies may be clean cut against unmineralized limestone. In the more general replacement ore, the sphalerite and pyrite occur in streaks and masses and less commonly scattered through the rock. Margins of ore bodies in many cases are poorly defined.

iii - PRODUCTION

	TONS	SILVER OZ.	LEAD LB.	ZINC LB.
1893 to 1945	514,913	303,203	4.37 m.	102.26 m.

Mine grade average = 11.5% Zinc

E. GEOLOGY OF THE WELLINGTON MINE

The rocks underlying the Wellington property are lower members of the Slocan series. Towards the base of the section they are principally slates and thinly laminated argillaceous beds within which are interspersed beds of grey quartzite up to several feet thick and a little impure limestone. These lower members are overlain by a heavier series of argillaceous and carbonaceous beds including considerable limestone. The strata has a general westerly strike which varies to northwest. They are folded into a series of anticlines and synclines in which the predominant dip is to the south and southwest. Locally they are much sheared and crushed. They are penetrated by a few small basic dykes. At least three prominent lodes occur. The Wellington lode outcrops on the Wellington claim. Old mine plans indicate that work has been done on either two lodes or on hanging wall and footwall splits of one. The north lode was intersected on the 140 foot level. It strikes east and dips north at 70°. At the surface it appears as a wide crushed zone and has been traced easterly into the Sunset claim where it continues with the Sunset lode. On the Wellington claim the highest grade ore was obtained from this north lode, as much as five feet of solid galena being found between the 40 and 80 foot levels.

About 1000 feet south of the Wellington lode a strong sheared fissure zone possibly the western extention of the Whitewater lode cuts through the IC and Metis claims. This lode strikes N80°W and dips steeply south.

On the Blutcher claim to the north of the Wellington is another lode regarded as the westerly extention of the Charleston. The lodes are all strongly sheared mineralized fissure zones cutting at a small angle across slaty, argillaceous sediments. The ore shoots that have been discovered all rake to the east and consist of lenses of sphalerite, galena and tetrahedrite, quartz and siderite and crushed slickensided wall rock. The proportion of quartz is generally high. The ore as observed on the Wellington claim carries high silver values in proportion to lead. It assays from 125 oz. to 328 oz. and 10% - 55% lead in carload lots. An average of 400 tons shipped being 175 oz. Ag per ton at 30% lead.

Production from the old workings between 1892 and 1915 amounted to 787 tons containing 117,452 oz. Ag, 475,662 lb. Pb and 100,402 lb. Zn, average grade is 150 oz. Ag.

The Wellington workings adjoin the Whitewater Mine on the west.

F. GEOLOGY OF THE CHARLESTON MINE

The claims are underlain by the basal slate member of the Slocan series, immediately overlying the Kaslo volcanics which lie just north of the property.

The prevailing rocks are fissile, black argillite and slate with occasional narrow beds of quartzite and other massive argillaceous strata. Narrow limestone beds were observed on the Keystone claim. The sediments have a general westerly, northwesterly trend and a southwesterly dip. Contrary dips are common due partly to local folding and faulting.

Three well defined vein lodes have been worked on this property. The general strike is north 60°W and dip is 50° to 65° southwest. The lodes are mineralized fault fissure zones cutting at small angles across sedimentary rocks.

The lodes vary in thickness from a few inches to many feet and contain lenses and more irregular bodies of silver-lead-zinc ore. Sphalerite is the most abundant ore mineral and in places is associated with an unusually large proportion of tetrahedrite. Galena is also an essential ore mineral. Quartz and siderite are the chief gangue minerals. Lode fillings include a large proportion of crushed and broken wall rock.

G. KING AND QUEEN CLAIMS

These claims were located on the old Empress property on the slope north of Bear Lake below the Silver Glance Mine. The workings include several adits about 2000 feet above the road. The rocks underlying the claims are mainly black, carbonaceous slates and thin interbedded quartzites and argillites. They are folded and faulted and have been invaded by numerous dykes and sills of quartz porphyry and a small granitic stock.

The workings explore a zone of fracturing and shearing striking westerly and easterly. In the zone of fracturing are quartz veins and lenses varying from an inch to over a foot in thickness and mostly rather flat lying. They carry tetrahedrite, argentite, pyrite and a little galena and sphalerite, either sparsely disseminated through the quartz or occurring in streaks and bunches providing exceptionally high grade ore. Between 1903 and 1909 117 tons of ore was produced averaging 245 oz. Ag/Ton.

SILVER GLANCE GROUP

This property lies on the southeast side of London ridge. The underlying rocks include a stock of medium-grained granite about 1000 feet in diameter. This stock invades Slocan sediments and is associated by many conspicuous dykes of quartz porphyry.

The sediments comprise interbedded argillaceous and quartzitic strata that strike northwest and dip either northeast or southwest.

The underground workings comprise six or more adits and are extensive but inaccessible. The workings explore two nearly parallel lodes several hundred feet apart. Most of the work has been done on the Silver Glance lode, it is investigated by five or six adits. As developed in these workings the lode cuts across the stock as a sheared and mineralized fissure zone striking N45°E and dipping southeast at 45°. Its average width is about two feet. The lode is composed chiefly of crushed rock but locally carries considerable vein quartz. The quartz occurs as a series of lenses, bands, streaks and irregular masses. It is white, massive, granular or vuggy and contains a little galena and tetrahedrite in nests, streaks and patches. Stephanite (brittle silver) and argentite (silver glance) are also stated to occur and picked specimens have assayed as high as $15,000.00. (1928?)

The "new lode" was discovered in 1928 and is a fairly well defined fissure cutting sediments and quartz porphyry dykes, striking N45°E and dipping 45°NW. It carries lenses and bands of vein quartz varying from a few inches to 3½ feet thick and mineralized principally with disseminated tetrahedrite. The mineralization seemed most pronounced where the lode crosses porphyry dykes.

NIL DESPERANDUM CLAIM

This claim lies south of Fish Lake. On this claim a couple of short adits 150 feet apart vertically have investigated outcrops of vein quartz, occurring as irregular lensy masses in slaty rocks of the Slocan series intersected by dykes and sills of quartz porphyry. The quartz is in places stained with copper carbonates and is sparingly mineralized with pyrite, galena, sphalerite and probably a little tetrahedrite.

H. SUPERGENE ENRICHMENT IN THE SLOCAN DISTRICT

Outcropping bodies of nearly pure galena appear on the whole, to have suffered little oxidation. On the other hand at least one body of sphalerite, the discovery ore body at the Lucky Jim Mine was almost completely oxidized to a depth of about 50 feet. The materials in the oxidized zone being a reddish aggregate of iron oxides, with a little zinc silicate, considerable calcite (aragonite) and fragments of partly replaced wallrock and sphalerite.

The greater oxidation on some properties than others is very largely due to larger proportions of pyrite, the oxidation of which has furnished a strong solvent acid. Pyrite, pyrrhotite and siderite oxidize rapidly, others such as grey copper, chalcopyrite and sphalerite less rapidly but more readily than galena.

Oxidation has reached in many ore bodies to depths of 100 to 200 feet and deeper in a few cases.

Much oxidation has taken place in deposits that were protected from erosion by morainic matter.

Oxidized deposits are distinguished by abundant reddish iron oxide. This oxide may occupy cavities in dominantly quartz ore or galena-rich masses, or soft reddish, porous masses, stained in places by copper carbonates and containing partly decomposed fragments of sphalerite nodular masses of galena, pieces of wallrock, etc. may form the bulk of the vein matter.

Associated with such material is a varying but generally small percentage of secondary minerals such as lead and zinc carbonates and sulphates, manganese oxides and native silver or other high grade secondary, silver-bearing minerals.

Instances of this sort occur at the Queen Bess, Nobel Five, Ruth-Hope, Rambler-Cariboo, Reco and Whitewater.

As a rule the most completely oxidized vein matter occurs near the surface and most of it has long since been mined.

On such properties the iron sulphides, of which pyrite is the most plentiful, have been oxidized to hydrous iron oxides and the siderite to mixtures of hydrous iron and manganese oxides. The sphalerite has been transformed to iron oxide, zinc carbonate and zinc silicate. Copper carbonates are no where abundant. Anglesite (lead sulphide) has developed along fractures and cleavage lines in the galena.

At the Wellington, clusters of white or pale yellow prisms of anglesite are associated with cerussite (lead carbonate).

Tetrahedrite has altered to secondary copper carbonates and sulphates and silver minerals, chiefly native silver.

Oxidation of argentiferous zinc blende and galena also produce secondary relatively stable silver minerals, and carbonate ores so derived generally carry good silver values.

Much or all of the ruby silver and native silver in the oxidized zone is probably secondary. In most cases the resulting carbonate ore occupies much the same space as the original ore and the percentage of silver per unit of volume is much the same as in the primary deposits. In such cases there may be little if any concentration of silver, but merely a loss of lead and zinc.

In other instances as at the Hewitt Mine, where ruby silver and native silver were particularly prominent in the upper parts of the ore deposits, their concentration appears to have resulted from enrichment processes connected, in part at least, with oxidation and the circulation of meteoric waters.

I. ANALYSIS

(1) Faulting and fracturing within the Slocan sediments has localized economic concentrations of silver-lead-zinc mineralization in the Whitewater Zincton district. As the ore bodies are fracture controlled, determining fracture patterns and locating cross fracture intersections will be a key to exploration. Shear zone intersections might contain large volumes of low grade material, that can be profitably mined from surface.

(2) Replacement ore as mined from underground in the past would prove to be marginally economic at today's metal prices if lead content is low.

(3) Direct shipping ore from the supergene zone containing a high lead content could be profitable at today's metal prices utilizing modern earth-moving equipment even on a small scale.

(4) The type of ore shoot represented by the Whitewater lode could probably be expanded to double the original dimension at present metal prices and under today's conditions.

(5) In view of the high metal content in the original Whitewater dumps, it is probable that direct shipping ore was hand sorted from much larger, lower grade ore zones.

(6) The first 1057 tons shipped from the early upper surface workings at Whitewater returned 200 oz. of silver and 50% lead per ton. Exploration in this area will probably encounter high lead-bearing enriched zones near surface that can be mined and shipped direct.

(7) There are few surface workings and outcrop exposures west of Whitewater. Prospecting and plotting fault depression trends, areas of quartz float and vegetation indicators should be initially undertaken.

(8) There is no evidence that the eastern continuation of lode system across Whitewater and Lyle Creeks was ever prospected although the position of the lode is evident. The overburden appears to be fairly deep.

(9) Diamond drilling might not be an effective exploration tool in this area due to extensive faulting and fracturing and the fissile nature of the host slates and recoveries might be poor in the supergene zone. One or two initial

large diameter vertical test holes should be considered if a suitable target can be developed. Percussion drilling will be much more economic and might provide more accurate results.

J. RECOMMENDED EXPLORATION PROCEDURES

GOAT CREEK BASIN

(1) Air photo analysis to determine the fault and fracture pattern has been completed and was the basis on which claims were located in this area following reconnaissance prospecting.

(2) Access roads should be constructed east and west of Goat Creek.

(3) An 800 foot surveyed grid should be established over the entire property.

(4) Mapping fault depressions, quartz float and available outcrops should be undertaken.

(5) Soil samples should be taken over the 800 foot grid and analyzed for lead. It is felt that zinc will be too highly dispersed and too high a background to effectively localize drill targets.

(6) Target areas should be trenched with a backhoe as surface cover is expected to be light, one to three feet.

This information should be compiled and analyzed for drill target detail.

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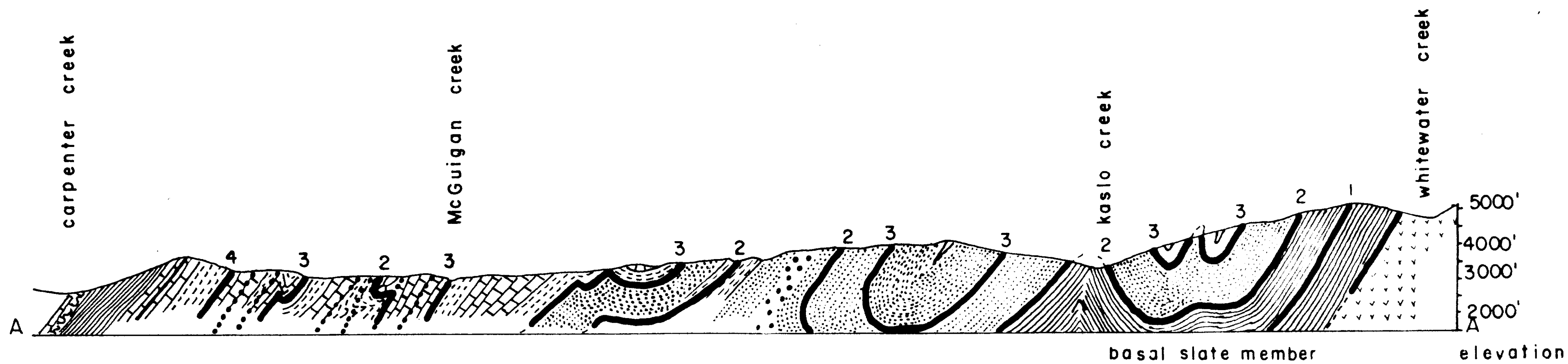

INTRUSIVE	feldspar porphyry	
SLOCAN SEDIMENTS	massive argillaceous and quartzitic strata	
	interbedded fissile and massive strata	
	limestone, marker horizons numbered	
	thinly bedded sandy, argillaceous and limy slates	
	black fissile basal slate member	
KASLO VOLCANICS	meta andesite, flows, tuff, breccia	

SCALE

0 1mi 2mi 3mi

Fig. 2 Section
Slocan Sediments

Drawn by J.C. Snell
from memoir by Cairnes 1932

Fig 5 Fracture Pattern Detail, Whitewater District, Slocan, B.C.

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PHOTO-INTERPRETATION WHITE WATER DISTRICT

Interpretation by	JC Snell P. Eng.
Drawing by	JC Snell
Date	June 1977
Scale	0 450' 900' 1350'

Fig. 4

Regional Fracture Pattern, Whitewater District, Slocan

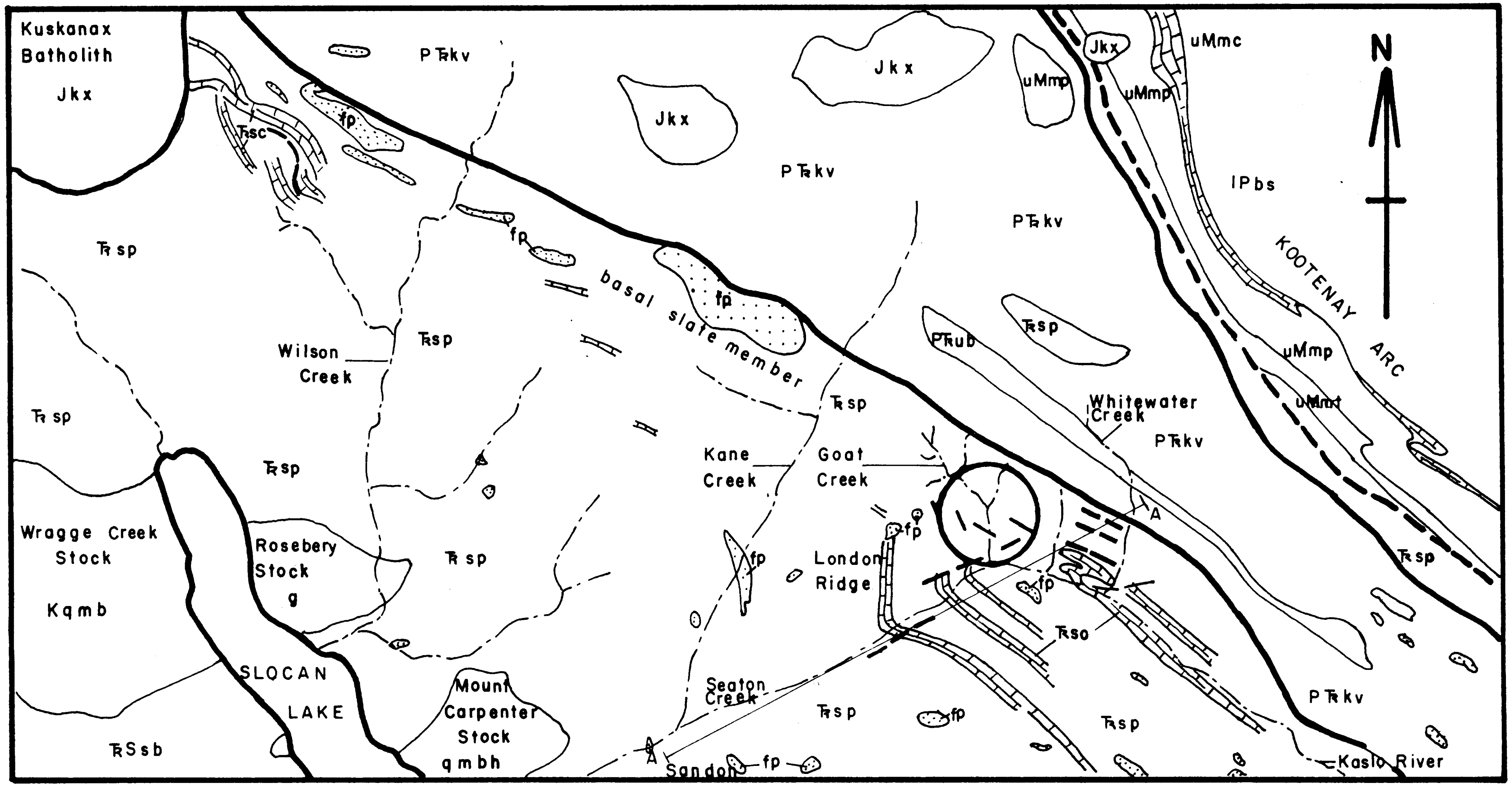
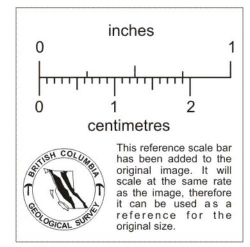


Fig. 1

Geological Location Map



CRETACEOUS	fp	dykes, sills, plugs	feldspar porphyry
	Kqmb	Wragge Creek Stock	hornblend biotite quartz monzonite
	qmbh	Mount Carpenter Stock	biotite hornblend quartz monzonite
	g	Rosebery Stock	granite
JURASSIC	Jkx	Kuskanax Batholith	leuco quartz monzonite
TRIASSIC	T Ssb	Slocan Sediments	grey mica schist
	T sp		grey to black slate, phyllite, argillite
	T sc		grey to black limestone quartzite)
	PTub		serpentine
	PT kv	Kaslo Volcanics	meta andesite flows, tuff, breccia

UPPER MISSISSIPPIAN	uMmt	Milford Group	white chert
	uMmp		grey, brown phyllite and sandstone
	uMmc		grey and white limestone
LOWER DEVONIAN	IPbs	Lardeau Group Broadview	grey and green phyllitic grit and phyllite

Fault — — —

Stream — - — - —

Scale

0 2mi 4mi 6mi

DRAWN BY J C Snell P.Eng.

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PROPERTIES IN WHITEWATER DISTRICT

SLOCAN, B.C.