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GEOLOGY AND MINERAL EVALUATION OF KOKANEE GLACIER PROVINCIAL PARK, SOUTHEASTERN BRITISH COLUMBIA

(82F/11, 14)

By D. A. Brown and J. M. Logan

KEYWORDS: Economic geology, Kokanee Glacier Park, Kootenay arc, Slocan Group, Rossland Group, Nelson batholith, mesothermal veins, geochemistry, Slocan fault zone.

INTRODUCTION

The Geological Survey Branch is conducting a 2-year program of geological mapping and mineral evaluation of Kokanee Glacier Park. This includes 1:50 000 mapping, examination of mineral occurrences in the park, rock and silt geochemistry, lead isotope analyses of mineralization, and compilation of previous work.

Kokanee Glacier Provincial Park was established in 1922 and named in 1924. From 1940 to 1965 it was a "Class A" park, but in 1965 it was changed to "Class B" to allow mineral exploration on valid claims. In 1973 a moratorium banned any exploration or development in Provincial Parks. New park boundaries were established in the spring of 1987. New additions to the park, together with the 46 existing mineral claims, were designated as "Recreation Areas", where mineral exploration and development are permitted. This study is being conducted to provide mineral resource data to help determine the eventual classification and boundaries of the park. The park, located 35 kilometres northeast of Nelson, is accessible by gravel roads from Highways 3A, 6 and 31A. Logging roads provided access to most of the map area. A helicopter was used to reach more remote areas.

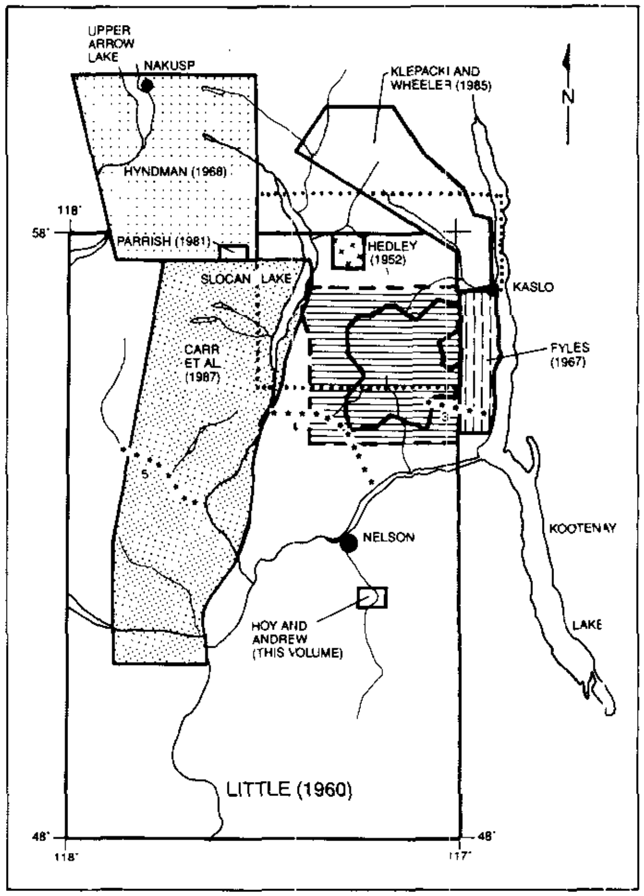

Figure 1-2-1. Location map with areas of previous work, Kokanee Glacier Provincial Park area, British Columbia. Region discussed in this paper is the area of horizontal lines enclosed by dashed lines. The dotted area refers to Cairnes (1934 and 1935). Area outlined for Carr *et al.* (1987) includes older work by Carr (1986), Reesor (1963), Parrish (1987), Parrish (1981) and Parrish *et al.* (1985). *** = Lithoprobe seismic lines (Cook *et al.*, 1987): Line 3 = Coffee Creek, Line 4 = Duhamel and Lemon creeks, and Line 5 = Koch Creek.

PREVIOUS WORK

Areas of previous work are outlined in Figure 1-2-1. The mapping of Cairnes (1934 and 1935) was recompiled by Little (1960) with no significant changes. A map of Slocan Group sedimentary rocks and their structure in the Sandon area was produced by Hedley (1952). Detailed mapping of Paleozoic to Mesozoic stratigraphy and structure was conducted by Fyles (1967) in the Ainsworth area. Klepacki and Wheeler (1985) have documented stratigraphic and structural relationships within the Milford, Kaslo and Slocan groups northwest of Kaslo. The Valhalla complex, which was mapped by Reesor (1963), has been recently reinterpreted, based on geochronology (Parrish, 1984; Carr *et al.*, 1987). Lithoprobe (Cook *et al.*, 1987) detected a reflector, interpreted to be the Slocan Lake fault, that dips gently (about 30 degrees east) beneath the Nelson batholith.

REGIONAL GEOLOGY AND GEOCHRONOLOGY

The park is located on the western edge of the Kootenay arc, in allochthonous rocks of the Quesnel terrane. The region is dominated by the late to post-tectonic I-type Nelson batholith, intruded into Slocan Group sedimentary rocks and Rossland Group sedimentary and volcanic rocks. Paleozoic

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to Upper Mississippian pericratonic rocks are exposed to the east (Fyles, 1967) and the Valhalla complex which includes three Cretaceous to Tertiary gneissic sheets lies to the west (Carr *et al.*, 1987). Easterly directed ductile and brittle fabrics, the Valkyr shear zone and Slocan Lake fault zone, are exposed along Slocan Lake (Carr *et al.*, 1987) and form the western contact of the Nelson batholith. The stratigraphic sequence includes Lower Cambrian Hamill quartzite, exposed on the west shore of Kootenay Lake, to Lower Jurassic Rossland Group, near Slocan Lake (Table 1-2-1; Fyles, 1967).

Numerous geochronometric studies have been published on the region. A Middle Jurassic zircon uranium-lead date was reported for the Kuskanax batholith, an alkaline to peralkaline aegerine augite quartz monzonite (Parrish and Wheeler, 1983; Read, 1973). Uranium-lead and potassium-argon dates bracket the age of Nelson batholith emplacement between 160 and 172 Ma. Middle Jurassic (169 and 165 Ma) zircon uranium-lead dates for the Nelson batholith were reported by Carr *et al.* (1987) and Ghosh (1986). Duncan *et al.* (1979) report a hornblende potassium-argon date of 164 Ma for the Mount Carlyle stock. Younger

TABLE 1-2-1
TABLE OF FORMATIONS AND GEOLOGICAL EVENTS NEAR NELSON BATHOLITH, KOKANEE GLACIER PROVINCIAL PARK AREA

PERIOD	STRATIGRAPHY	METAMORPHISM	DEFORMATION–METAMORPHISM	MINERALIZATION
TERTIARY	not present in map area	Lamprophyre, rhyolite Coryell 51.7±0.5 Ma (2) post-tectonic Ladybird gn. 56.5±1.5 Ma (2) deformed Ladybird gn. 59±1 Ma (2) Airy quartz monzonite, 62±1 Ma (2)	45–54 SLFZ (2) 54–59 VSZ (2) 53 Ma–75 Ma greenschist (4) Paleocene	? Potential ? epithermal ?
CRET.		Mulvey gneiss 100±5 Ma (4) Nelson bath. 169±3 Ma (2) Kuskanax bath. 173±5 Ma (9)	eastward thrusting (1 and 8) Late Cretaceous	? ? Mesothermal quartz-siderite veins
JURASSIC	Rossland Group: Hall Formation (Toarcian; 10) Elise Formation (Pliensbachian; 10) Archibald Formation (Sinemurian; 10)	Feldspar porphyry Quartz latite porphyry 194±3 Ma (5) Hb diorite 195 Ma (7)	Buckling (3) 151–168 greenschist to silm-ksp grade (3) 173 188 Phase I and II folding (3) Quesnellia convergence	Volcanogenic breccia pipe
TRIASSIC	Slocan Group (Late Triassic; 6) unconformity			
PERMIAN	Kaslo Group (Early Permian; 6)			
MISS.-PENN.	Milford Group (Early Pennsylvanian–Early Mississippian; 6) unconformity			
	Lardeau Group (Cambrian-Mississippian; 3)			
	Badshot limestone and Hamill Group (Lower Cambrian; 3)			

LEGEND

Abbreviations:

bath	=	batholith
gn	=	granite
hb	=	hornblende
ksp	=	potassium feldspar
monz	=	monzonite
silli	=	sillimanite
SLFZ	=	Slocan Lake fault zone
VSZ	=	Valkyr shear zone

(1) Archibald *et al.* (1984)
(2) Carr *et al.* (1987)
(3) Fyles (1967)
(4) Mathews (1983)
(5) McMillan (*written communication*, 1987)
(6) Orchard (1985)
(7) Parrish (*personal communication*, 1987)
(8) Parrish (1987)
(9) Parrish and Wheeler (1983)
(10) Tipper (1984)

potassium-argon dates probably reflect partial resetting or overprinting by Cretaceous or Tertiary thermal events (Archibald *et al.*, 1983; Duncan *et al.*, 1979). Hornblende and biotite $^{40}Ar/^{39}Ar$ age spectrum analyses conducted by Harrison (1985) indicate dates for Nelson phases between 153 and 160 Ma. Biotite in the northwest part of the batholith closed with respect to ^{40}Ar by 154 Ma and lost minor ^{40}Ar between 50 and 60 Ma (Harrison, 1985). In contrast, biotites in the south did not close with respect to ^{40}Ar until 50 to 60 Ma (Harrison, 1985). A rubidium-strontium plagioclase date of 137 ± 10 Ma and a hornblende potassium-argon date of 139 ± 5 Ma for potassium-feldspar porphyritic monzonite from Duhamel Creek are reported by Duncan *et al.* (1979), however, it is uncertain whether these results represent a Late Cretaceous phase or partial resetting. Uranium-lead, potassium-argon and rubidium-strontium data from the Valhalla complex and Nelson batholith were discussed by Carr *et al.* (1987).

PARK GEOLOGY

The park is dominated by extensive exposures of Nelson batholith enclosing narrow horizons and tabular blocks of pelitic and psammitic metasedimentary rocks, tentatively correlated with the Late Triassic Slocan Group. Rocks are well exposed above 2000 metres elevation but below this is a cover of glacial-fluvial gravels.

STRATIGRAPHY

SLOCAN GROUP

The Slocan Group underlies the northeastern corner of the map area, in Keen Creek valley, and also occurs as irregular tabular blocks and screens enclosed in the Nelson batholith. It comprises a thick accumulation of variably deformed and metamorphosed shale, argillite, siltstone, quartzite and limestone. Stratigraphic thickness is unknown. Within the batholith, brown-weathering aligned blocks of Slocan Group sediments contrast sharply with the grey-coloured granite. Blocks and screens vary in size up to 100 metres thick, and are mappable along strike for about 8 kilometres. To the north and east, bedding in the sediments is concordant with the main batholith contacts (Figure 1-2-2; Fyles, 1967). Granitic sills, common in the metasedimentary horizons and tabular blocks, have sharp, planar intrusive contacts, subparallel to bedding.

Black shale, grey siltstone and rare limy beds exposed in the Keen Creek valley are crosscut by plagioclase-porphyritic quartz monzodiorite dykes and sills. Biotite hornfels extends less than 10 metres from the dyke and sill contacts. Near the Bismark mine (MINFILE 082FNW-096) pure, recrystallized limestone bands, up to 60 metres thick, lie against the batholith with little calc-silicate formation. The well-bedded and grey-weathering limestone contains minor quartzitic sandstone beds and lenses. The sandstone beds have an unknown provenance.

Siliceous micaeous siltstone and quartzite are common as blocks in the batholith. Siltstone is laminated to finely bedded and locally contains stratabound coarse disseminated pyrite. Rare limy beds have calc-silicate skarn mineral assemblages, including garnet, diopside and wollastonite. Local stratigraphy near Woodbury cabin comprises 20 metres of fine-grained quartzite, overlain by about 25 metres of mauve sandstone and 15 metres of micaeous siltstone. Petrographic studies of these metasediments are in progress.

Another section through four parallel, moderately west-dipping metasedimentary blocks and granite sills, located west of Coffee Creek, begins with interbedded white quartzite and light grey limy quartzite. Wollastonite-bearing marble horizons occur within the quartzite. These are overlain by interbedded, 5 to 10-centimetre-thick, pinkish quartzose sandstone that alternates with 2 to 5-centimetre-thick rusty weathering micaeous silty sandstone. A 5-metre-thick potassium-feldspar porphyritic granite sill separates the lowermost interval from three upper metasedimentary units. The lowest (4 metres thick) and uppermost (3 metres thick) intervals are greenish grey, slightly rusty, thinly bedded siltstone and biotite-bearing quartzite. The middle layer, 3 metres thick, is greenish biotite schist, porphyritic amphibolite and green quartzite. Boudinaged beds parallel metasedimentary horizons. Total stratigraphic thickness is about 120 metres.

The stratigraphy and structure of the Slocan Group remain enigmatic due to its recessive nature, lack of marker horizons and complex structure. Hedley (1952) provided the best attempt at elucidating the Slocan Group near Sandon. If the isolated blocks within the batholith are correlative with Slocan Group, then there appears to be a facies change from shale-argillite to more silicic siltstone-sandstone from Keen Creek to the central part of the park.

Orchard (1985) reports Late Triassic (Carnian and Norian) conodonts from Slocan Group limestone near Retallack, 15 kilometres north of the map area. The Slocan Group unconformably overlies Early Permian Kaslo Group volcanic rocks (Klepacki, 1983; Orchard, 1985) that outcrop east and north of the map area, and are unconformably overlain by Early Jurassic Rossland Group volcanic and sedimentary rocks.

ROSSLAND GROUP

Exposures of Rossland Group are confined to pendants within the Nelson batholith. The largest pendant hosts the Willa gold-copper deposit, in the northwestern corner of the map area (Figures 1-2-2 and 1-2-5). Isolated metavolcanic blocks extent southward, along strike, into the Ymir map area, where Höy and Andrew (this volume) have mapped Rossland stratigraphy in detail.

Tipper (1984) divided the Rossland Group into three formations: (1) Archibald Formation–Sinemurian sedimentary rocks; (2) Elise Formation–lower Sinemurian volcanic rocks; and (3) Hall Formation–Toarcian shallow-water siltstone, greywacke and conglomerate. Based on lithologic and age constraints, volcanic rocks of the Willa area have been tentatively correlated with the Elise Formation.

INTRUSIVE ROCKS

Three intrusive episodes are: (1) Early Jurassic intermediate porphyries, coeval with Rossland volcanics (Table 1-2-1); (2) Middle Jurassic Nelson plutonic suite; and (3) Tertiary dykes. Seven hundred square kilometres (98 per cent) of the

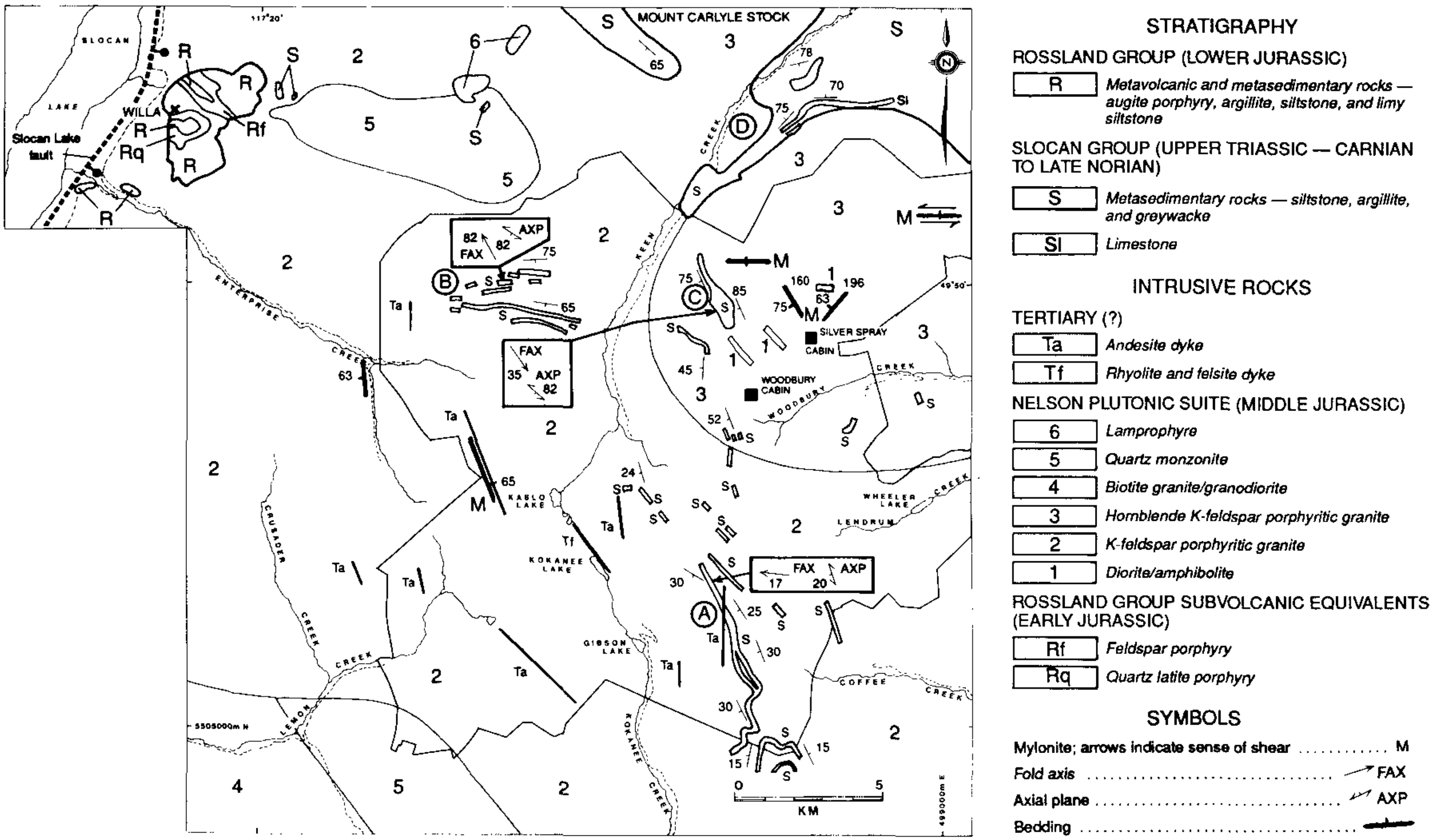

Figure 1-2-2. Geology of Kokanee Glacier Provincial Park area, southeastern British Columbia.

map area is underlain by the composite Nelson batholith. Mineral deposits tend to be spatially associated with the batholith.

Early Jurassic Plutonic Suite

Epizonal intrusive rocks, comagmatic and coeval with Rossland volcanics, intrude Rossland andesitic volcanic rocks. Three varieties of feldspar porphyry and quartz latite porphyry have been mapped at the Willa deposit (Heather, 1985). Pipe-like heterolithic intrusive breccia that hosts the Willa gold-copper-silver mineralization is contained within these intrusions (Heather, 1985).

Zircons extracted from quartz latite porphyry yielded a 194 ± 3 Ma uranium-lead isotopic age (W.J. McMillan, written communication, 1987). Zircons contain a large amount of inherited xenocrystic lead of Proterozoic age (P. van der Heyden, written communication, 1987). Plagioclase porphyry collected by McMillan is currently being processed for zircon uranium-lead dating. Andesitic to basaltic dykes, which crosscut mineralization, were collected for potassium-argon isotopic dating.

Nelson Plutonic Suite (Middle Jurassic)

Within the map area, the Nelson batholith comprises at least six texturally and compositionally distinct phases (inferred oldest to youngest): (1) diorite/amphibolite, (2) potassium-feldspar granite, (3) hornblende potassium-feldspar granite, (4) fine-grained granite, (5) quartz monzonite and (6) lamprophyre. Areas dominated by a particular phase are indicated on Figure 1-2-2. Intrusive contacts are gradational and irregular. Aplite and pegmatite dykes, believed to be comagmatic, occur throughout the area. The suite is subalkaline, calcalkaline and metaluminous (Ghosh, 1986). Sixteen samples for whole-rock chemistry are being analysed.

Diorite/Amphibolite (Unit 1)

The oldest phase is dark grey to black-weathering mesocratic diorite/amphibolite which occurs as angular to rounded xenoliths in younger leucocratic phases. Xenoliths vary in size from centimetre to decimetre scale and are comprised of massive to foliated, fine to medium-grained diorite. Hornblende is fresh and makes up more than 40 per cent of the diorite. Titanite and apatite are associated with hornblende as euhedral crystals up to 2 millimetres long. The xenoliths are ellipsoidal and locally aligned. Surrounding potassium-feldspar megacrysts may be foliated subparallel to the xenolith contacts, crosscut, or contained within the xenolith. During this year's mapping the xenoliths were interpreted to outline phase boundaries within the batholith, but their distribution now seems to be more random. Xenoliths are abundant along the Springer Creek road and near the Enterprise mine (Minfile 082FNW-148).

Potassium-Feldspar Porphyritic Granite (Unit 2 — "Main phase")

The potassium-feldspar megacrystic, medium to coarse-grained hypidiomorphic granite is the dominant Nelson phase. Massive in outcrop, it covers a 550-square-kilometre area. This phase contains up to 50 per cent white to faintly pink, euhedral, equant to prismatic potassium-feldspar megacrysts (Plate 1-2-1). These megacrysts are up to 10 centimetres long and are locally flow aligned. They are microperthitic to perthitic. Megacrysts contain inclusions of biotite, hornblende, plagioclase and quartz. The inclusions are all smaller than corresponding groundmass minerals, suggesting primary potassium-feldspar crystallization, rather than a metasomatic origin. Size and amount of potassium feldspar are extremely variable at outcrop and map scales. Hornblende and biotite phenocrysts are unaltered, black, subhedral and interstitial to potassium feldspar. Plagioclase is unaltered with albite twins. Hornblende and lesser biotite comprise 15 per cent or less of the granite. Visible honey-coloured euhedral titanite, and apatite, magnetite and opaques are accessories. Myrmekitic blebs occur at some plagioclase–potassium-feldspar grain boundaries.

Plate 1-2-1. Potassium-feldspar porphyritic phase of Nelson batholith, lens cap is 5.5 centimetres in diameter.

Hornblende Potassium-Feldspar Porphyritic Granite (Unit 3 — Caribou Ridge Phase)

This phase is differentiated from potassium-feldspar granite by prominent coarse, prismatic, black, euhedral hornblende phenocrysts. The rock is medium to coarse grained. There is much less biotite relative to hornblende and biotite may be absent. Hornblende is euhedral, up to 1.5 centimetres long and interstitial to megacrysts of tartan-twinned microcline. Titanite is ubiquitously associated with hornblende. Very coarse varieties contain 75 per cent potassium-feldspar megacrysts, up to 5 centimetres long, and interstital plagioclase, quartz and euhedral hornblende. Crystal composition and texture are similar to the potassium-feldspar porphyritic phase.

Biotite Granite/Granodiorite (Unit 4 — Lemon Creek Phase)

There are two varieties of biotite granite, mesocratic and leucocratic. The mesocratic biotite granite is a grey, medium to fine-grained rock with few potassium-feldspar megacrysts (< 5 per cent). The rock is massive with 5 to 10 per cent fresh to slightly chlorite-altered biotite. The leucocratic granite is salmon-pink to grey, fine grained and equigranular. Potassium-feldspar megacrysts are uncommon but smaller tartan-twinned microcline is common. Plagioclase is fresh and myrmekitic grains are abundant. Rare biotite phenocrysts are altered to chlorite. Secondary muscovite is anhedral and has locally grown across grain boundaries. It is important to note that muscovite is secondary; this is not a two-mica granite. All grains are anhedral to subhedral, a xenomorphic texture. This phase was also noted by Little (1960).

Quartz Monzonite (Unit 5 — Alpine phase)

The quartz monzonite is pale grey to white, medium grained and massive. Hornblende and biotite are fresh and constitute up to 2 per cent of the rock. Titanite is an accessory. Little (1960) indicated that this phase intruded the Nelson batholith and included it with "Valhalla plutonic rocks". This designation is dropped here; the monzonite is interpreted to be a late phase of the Nelson plutonic suite.

Biotite Lamprophyre/Diorite (Unit 6 — Comstock Phase)

A brown-weathering, biotite-rich, magnetite-bearing body outcrops near the Comstock mine (MINFILE 082FNW-077). It is fine to medium grained, heavy and hard. Biotite blades are up to 2 centimetres long. At the Comstock portals, iron carbonate alteration and limonitic weathering are common.

Tertiary (?) Intrusive Rocks

Inferred Tertiary intrusive rocks occur as narrow rhyolite, felsite, andesite and lamprophyre dykes. The dykes are steeply dipping, north and north-northwest striking, and commonly parallel to airphoto linears.

Andesite dykes are brown-weathering, fine-grained, magnetite-bearing rocks. In the Coffee Pass area, a 3-metre-wide andesite dyke is coarsely vesicular with chilled aphanitic margins. Andesite dykes crosscut rhyolite dykes at the Republic mine, 10 kilometres west of the map area (468039E 5516036N; MINFILE 082FNW-168). Andesite contains resorbed quartz phenocrysts, aligned plagioclase laths and subrounded inclusions of granite, up to 5 centimetres wide.

Rhyolite float was found near the Scranton-Pontiac mine. The rhyolite is quartz phyric, fine grained to aphanitic and cream coloured, with manganese staining along fractures. Quartz phenocrysts are distinctly equant and angular, in an aphanitic felsic groundmass.

STRUCTURE

The structures of the Slocan Group or older metasedimentary rocks in the park are discussed below for four distinct areas (A, B, C and D on Figure 1-2-2). The areas are defined geographically and by structural geometry.

Area A, at the head of Coffee Creek and east of Kokanee Glacier, comprises at least four distinct layers of up to garnet-biotite grade pelitic and psammitic metasediments. They can be traced over 10 kilometres along strike. Beds are gently west to southwest dipping; southern exposures are subhorizontal, hence the irregular outcrop pattern (Figure 1-2-2). Inclined minor folds have shallow west-plunging fold axes and shallow west-dipping axial planes. Folds with similar geometry occur near the Olsen mine (MINFILE 082FNW-187). Locally, minor asymmetric folds are north verging. More competent beds and granitic sills are boudinaged.

Two phases of granite intrusion are evident: an older, deformed granite lacking potassium-feldspar megacrysts, and younger, undeformed potassium-feldspar megacrystic granite sills.

Area B, Bear Grass basin, contains silicic metasedimentary layers and granitic sills along a strike length of about 4 kilometres. Granitic sills are boudinaged in two directions, indicating significant east-west and vertical extension parallel to bedding/sill planes. These centimetre-scale boudins are mimicked by decimetre and larger map-scale metasediment blocks that are pulled apart along an easterly trending axis. Minor folds are tight with angular closures, steeply dipping axial planes and steeply northwest-plunging fold axes.

Area C, northeast of Revenue mine (MINFILE 082FNW-106), is underlain by a band of biotite-grade metasediments about 2.5 kilometres long. Folds are: (1) asymmetrical, suggesting an antiformal closure west of Revenue mine or (2) tight to isoclinal with angular closures, and (3) open warps. Folded granitic sills, with amplitudes of 10 centimetres, indicate pre to syntectonic intrusion. The axial planes have consistently steep southwest dips with fold axes of variable plunge (Plate 1-2-2). Near Silver Spray cabin, psammites are folded into tight to isoclinal folds with rounded to subangular closures at decimetre scale. Boudinaged fine-grained granitic sills, less than 1 metre wide, occur locally. Potassium-feldspar megacrystic granite dykes cut the folded and boudinaged sediments and sills.

Plate 1-2-2. View southeast, down plunge to folded granitic sill and siltstone, indicating early phases of Nelson batholith were syntectonic. Fold axes = 148°/33°; axial plane = 142°/72° SW.

Area D, extending north of the park boundary near Keen Creek, contains poorly exposed, more argillaceous rocks than areas A, B, and C. Folds and fabrics are diverse. Contrasting deformation intensity and metamorphic grade are characteristic. Shale, phyllite and mica schist are repeated, possibly due to faulting. Recrystallized pure limestone horizons and pelitic and psammitic beds parallel the batholith contact. Sandstone layers contained within the limestone are disharmonically folded.

Early minor folds are tight to isoclinal with moderate east-plunging, southeast-inclined axial planes. Open and disharmonic folds are intermediate in age. Younger folds are coarsely crenulated phyllites and mica schist with shallow west-southwest-plunging fold axes and subhorizontal axial planes.

Nelson Batholith Deformation

The oldest fabric in the batholith is primary flow alignment of potassium-feldspar and hornblende crystals; it is coplanar with metasedimetary layers and amphibolite lenses.

Most of the northern Nelson batholith is undeformed and post-tectonic. In contrast, the southern end [(LeClair, 1983) and the eastern margin (Fyles, 1967)] of the batholith are late-synkinematic with deformed margins. Discrete zones of chlorite-grade proto to ultramylonite (less than 50 centimetres wide) occur in the map area. Mylonites are of limited areal extent and their significance is uncertain. Mylonitic granite outcrops 5 kilometres north of Woodbury Creek and 2 kilometres northwest of Kaslo Lake (indicated by an "M" on Figure 1-2-2). Asymmetric potassium-feldspar augen and C-S fabrics (Simpson and Schmid, 1983), north of Woodbury Creek, suggest a left-lateral sense of shear along steep northerly dipping mylonitic foliations. North of Woodbury cabin, steep southwesterly dipping mylonite zones 2 to 5 centimetres wide contain potassium-feldspar megacrysts that display both brittle and ductile deformation textures. The ductile fabric is cut by younger, undeformed granitic dykes of unknown age. The Kaslo Lake mylonites are steep northwesterly dipping.

The most prominent fracture system in the park is a limonitic-weathering brittle fault zone that parallels the Kaslo mylonite. The altered zone is less than 50 metres wide and hosts the Silver Ranch quartz vein mineralization (MINFILE 082FNW-215). The Molly Gibson, Smuggler and Blackburn deposits also lie parallel to a prominent set of linears (Plate 1-2-3). Rocks along these linears are not altered. Jointing within the batholith is well developed. Comparisons of joint measurements, vein attitudes and fault orientations are currently underway.

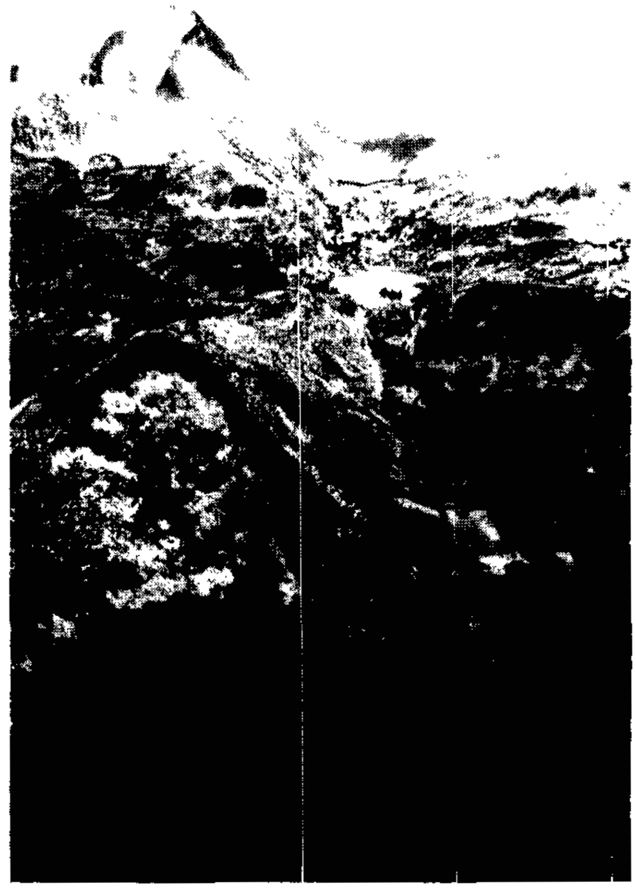

Plate 1-2-3. View southeast to Molly Gibson, Smuggler and Blackburn deposits which occur along prominent northwest-trending linears, Kokanee Provincial Park.

METAMORPHISM

Low-grade regional metamorphism has affected the Slocan Group. Pelitic rocks preserve primary bedding and display phyllitic and schistose foliations. Sedimentary blocks within the batholith are medium-grade garnet-biotite schists. Higher grade, kyanite and sillimanite-bearing rocks occur east of the map area, along the west shore of Kootenay Lake (Fyles, 1967). The metamorphic grade decreases westward toward Slocan Lake (Fyles, 1967). However, at the Revenue mine (Figures 1-2-2, 1-2-3) a foliated metasedimentary pendant contains sillimanite, staurolite and muscovite. The block could have been derived from deeper structural levels, hence correlative with Fyles' (1967) Lardeau Group (Table 1-2-1). Alternatively, Slocan sediments may have reached medium-grade conditions locally, but this has not been documented in the area. Work continues to determine which is more probable.

A contact metamorphic aureole extends 300 to 800 metres from the batholith and is superimposed on the regional metamorphism (Cox, 1979; Childs, 1968; Fyles, 1967). The assemblage includes biotite and andalusite which indicates pressures not greater than bathozone 2, as defined by Carmichael (1978). The contact assemblage reported by Childs (1965) around the Mount Carlyle stock is transitional between bathozones 2 and 3.

MINERALIZATION

Spatial density contours for vein deposits in and near the north end of the Nelson batholith (Goldsmith, 1984) outline the centres of the Slocan, Slocan City and Ainsworth mining camps. Kokanee Park map area occupies a central position between these three historic camps and contains mineralogic, isotopic and geometric characteristics of each. Fifty-three mineral occurrences with greater than 1 tonne recorded pro-

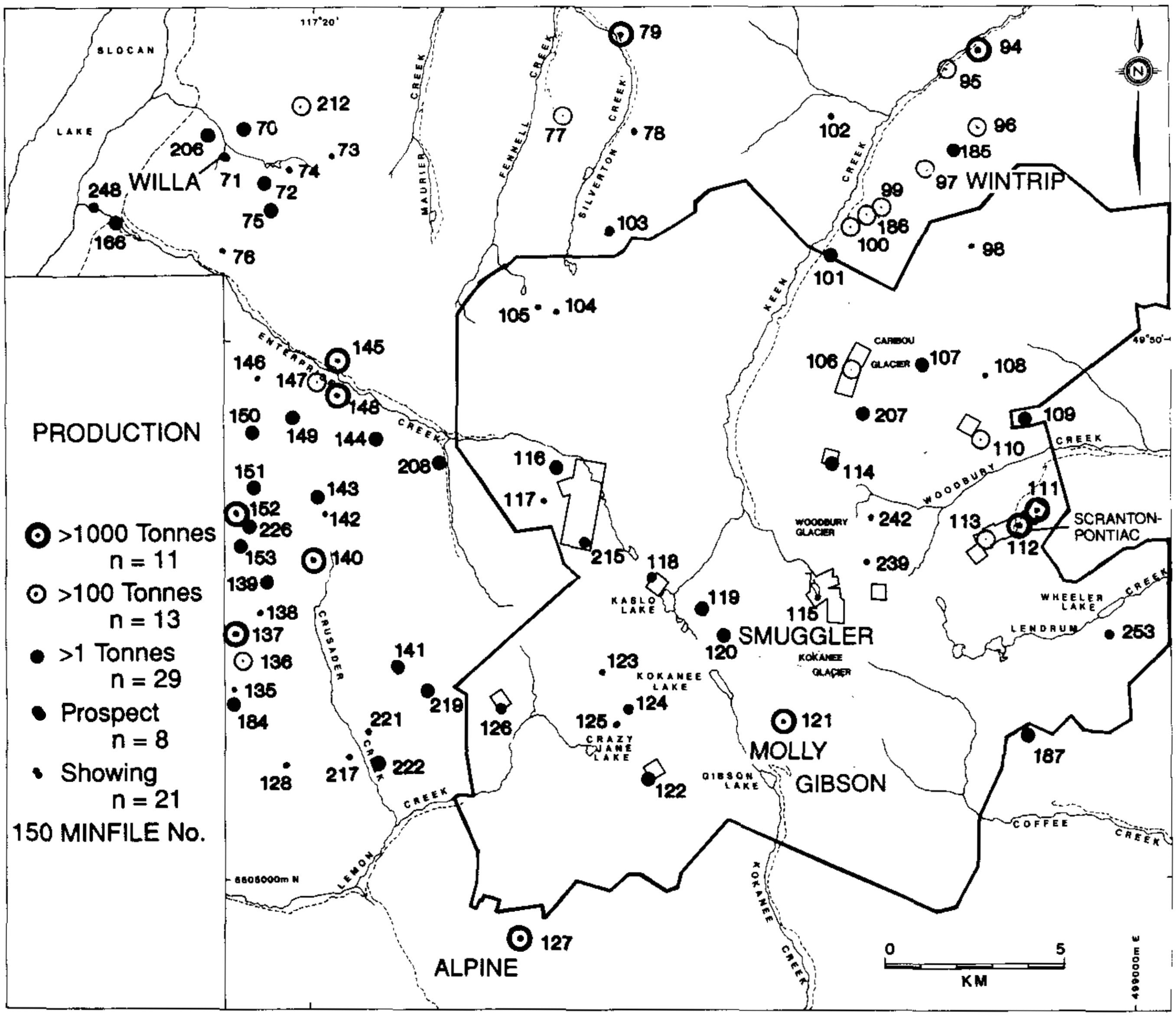

Figure 1-2-3. MINFILE numbers and locations for past producers, prospects and showings near Kokanee Glacier Provincial Park.

duction, 8 prospects and 21 showings are located in the map area (Figure 1-2-3). Vein attitude, host lithology, grades and production data are presented in Tables 1-2-2 and 1-2-3.

Mineral deposits in the Kokanee map area can be divided into three groups based on mineralogy, age and geometry. These are: (1) mesothermal silver-lead-zinc $\pm$ gold-bearing quartz-siderite veins; (2) mesothermal gold-silver-bearing quartz veins; and (3) a gold-copper-silver-bearing volcanic breccia pipe. Brief descriptions of the more productive mineral deposits follow.

MESOTHERMAL QUARTZ-SIDERITE VEINS

Vein mineralization of Group 1 is subdivided into sediment and batholith-hosted, as characterized by deposits in the Slocan and Slocan City camps respectively. The most productive vein attitudes follow a northeasterly striking joint system (Cairnes, 1934).

Sediment-hosted deposits are generally lead and zinc-rich, with a siderite and quartz gangue. In the Slocan Mining Camp, 15 kilometres north of the map area, sediment-hosted deposits average between 10 000 and 100 000 tonnes of ore mined. In the map area, sediment-hosted deposits account for less than 15 per cent of past production. Batholith-hosted veins are generally low in base metal sulphide content and relatively enriched in silver minerals in a quartz gangue. In the Slocan City mining camp, 15 kilometres west of the map area, the deposits are also enriched in gold.

WINTRIP MINE (MINFILE 082FNW-097):

The Wintrip is one of nine sediment-hosted deposits which occupy bedding-parallel, northeast-striking, steeply dipping lode structures in the Keen Creek metasedimentary re-entrant. Mineralization is chiefly wallrock replacement and is better developed where lodes crosscut calcareous horizons.

The Wintrip workings are located east of Keen Creek and north of the park boundary, in a narrow belt of Slocan Group sediments. The first shipment of ore was recorded in 1895 as 13 tonnes averaging 228 grams silver per tonne and 78 per cent lead. Over the life of the mine, a total of 613 tonnes of ore yielded 62 grams gold, 367 388 grams silver, 103 771 kilograms lead and 57 318 kilograms zinc. Most production occurred from 1926 to 1928. The workings have since collapsed and are now inaccessible.

Six or seven adits were driven to explore two parallel structures, the "A" and "B" lodes. A third unexplored lode "C" is reported 75 metres southeast of the "B" lode (Cairnes, 1935). The "A" and "B" lodes are about 100 metres apart, strike 225 degrees and dip 75 degrees northwest, conformable with the enclosing metasediments. The metasediments comprise abundant recrystallized limestone, biotite schist and, in places, thinly bedded argillite and quartzite. The lodes are sheared and brecciated zones, 0.6 to 1.5 metres wide, comprised of cataclasite and fault gouge. Mineralization is composed of disseminated sphalerite, galena and pyrite associated with siderite and minor quartz. Assays on grab samples of dump material from the two portals are presented in Table 1-2-4.

MOLLY GIBSON MINE (MINFILE 082FNW-121)

The Molly Gibson mine was developed on a mineralized fissure hosted by potassium-feldspar porphyritic granite. It was the largest producer in the area and follows a northwest-striking joint set, in contrast to the general northeast strike for most productive veins of the area.

The Molly Gibson property is located at the head of Kokanee Creek, approximately 20 kilometres north from Highway 3A. The Consolidated Mining and Smelting Company of Canada, Limited acquired the claims from La Plata Mines Ltd. in 1910, continued operating until 1950 and held the claims in good standing until 1973, when the claims lapsed. Production between 1899 and 1950 totalled 55 860 tonnes of ore and yielded 372 grams gold, 31.1 million grams silver, 2.3 million kilograms lead and 9242 kilograms zinc. Ninety per cent of the production was completed by 1913.

Underground workings explored two veins, the Florence and Aspen. They strike 145 degrees and dip 75 degrees southwest in potassium-feldspar megacrystic granite. The Florence vein averages 1.5 metres wide while the Aspen vein, located about 15 metres to the southwest, is less than 0.75 metre wide. The veins were developed on five levels, above 2105 metres elevation. The distribution of stopes suggests ore shoots plunge to the southeast at about 45 degrees (McKechnie, 1967).

Dump material contains pervasive propylitic and argillic alteration. Hematite alteration is also present. Vein mineralogy, based on hand specimen examination, comprises galena, sphalerite, arsenopyrite, pyrite and chalcopyrite in a gangue of brecciated buff to pink siderite and quartz. Sulphide petrography is underway to identify silver-bearing minerals. Sulphides occur as irregular open-space fillings parallel to vein walls. Banding and cockade texture are common in these layers and rimming breccia fragments. Coarsely crystalline sphalerite and galena blebs are rimmed by quartz, fine pyrite, coarser euhedral to subhedral arsenopyrite and in places chalcopyrite.

Vein gangue is chiefly manganese-rich siderite that weathers to a bluish black manganese oxide. Chalcedonic to euhedral quartz crystals rim fragments and line fractures, and commonly post-date siderite. Late-stage calcite fills open spaces.

The analytical results for three chip samples from the hangingwall, vein and footwall at 3-level portal (1940-metre elevation), and a single grab sample from the dump below the 1790-metre level crosscut, are given in Table 1-2-5. Grab sample (2-1) metal values are comparable with the vein channel sample (170-2) except for silver.

The Smuggler workings (MINFILE 082FNW-120; Figure 1-2-3) are 2 kilometres northwest and on strike with the Molly Gibson veins. The 1.8-metre-wide Smuggler vein strikes 150 degrees, dips 80 degrees southwest and contains vein mineralogy and morphology indistinguishable from that at Molly Gibson. The ore is galena and lesser sphalerite with arsenopyrite (to 5 per cent) in a manganese-siderite quartz breccia vein healed with chalcedonic quartz. Similar mineralogy, structural continuity and similar lead isotope ratios (Logan *et al.*, this volume) suggest Molly Gibson and Smuggler are part of the same vein system.

TABLE 1-2-2. VEIN CHARACTERISTICS OF OCCURRENCES LISTED IN MINFILE

MINFILE	Property	Production (Tonnes)	Recovered Grade Au (g/t)	Ag (g/T)	Pb (%)	Zn (%)	Host Lithology	Vein Attitude
082FNW-121	Moly Gibson	55860	0.01	556.0	4.05	0.02	K-spar por gn	154/67 SE
082FNW-152	Arlington	19217	0.04	1635.5	4.48	0.62	K-spar por gn	034/67 SE
082FNW-094	Cork Province	19144	0.10	850.3	30.54	47.19	Pel phy/sch/lst	050/65 SE
082FNW-127	Alpine	15551	22.90	14.2	0.32	0.11	Quartz monzonite	270/30 N
082FNW-148	Enterprise	10687	0.19	3057.6	15.67	9.89	K-spar por gn	056/72 SE
082FNW-112	Scranton	8136	14.40	429.9	15.72	14.88	Hb por granite	035/20 SE
082FNW-145	Westmont	3149	0.65	3520.1	6.34	2.09	K-spar por gn	060/75 SE
082FNW-137	Meteor	2645	4.97	1780.3	0.02	0.03	K-spar por gn	285/35 NE
082FNW-140	Slocan Prince	1754	0.00	3481.8	3.45	0.19	K-spar por gn	205/20 NW
082FNW-111	Pontiac	1160	5.34	511.2	6.41	0.38	Hb por granite	025/20 SE
082FNW-079	Fisher Maid	1132	0.03	2048.6	5.21	5.29	K-spar por gn	170/75 W
082FNW-095	Black Fox	886	0.21	60.1	0.66	8.40	Pelitic phy/sch	060/65 SE
082FNW-096	Bismark	868	0.00	2862.1	4.98	0.00	Pel phy/sch/lst	235/70 NW
082FNW-186	Silverbell	644	0.00	3956.3	16.36	1.73	Pelitic phy/sch	east/low
082FNW-097	Wintrip	613	0.10	599.3	16.93	8.37	Pelitic phy/sch	225/75 NW
082FNW-147	Neepawa	461	0.00	4002.4	2.00	0.16	K-spar por gn	—
082FNW-100	Silverbear	459	0.20	1723.5	2.23	1.94	Pelitic phy/sch	040/65 SE
082FNW-077	Comstock	456	0.07	3113.8	37.19	0.00	Qtz monz/lamp	070/40 SW
082FNW-106	Revenue	244	0.89	2605.0	28.21	8.47	Hb por granite	195/80 NW
082FNW-212	LH	196	17.61	9.8	0.00	0.00	Meta sed/vol	270/55 N
082FNW-099	BNA	173	1.14	2748.2	6.64	6.57	Pel phy/sch/lst	200/85 NW
082FNW-136	Howard Fraction	162	5.57	1025.8	0.00	0.00	K-spar por gn	270/12 N
082FNW-113	Sunset	145	16.09	2160.5	39.65	0.00	Hb por granite	030/65 SE
082FNW-110	Ontario #2	143	0.22	11421	10.52	0.05	Hb por granite	255/60 NW
082FNW-143	Hampton	90	0.00	16817	0.00	0.00	K-spar por gn	NE/steep
082FNW-150	Bondholder	63	0.00	7124.6	6.98	0.00	K-spar por gn	065/58 SW
082FNW-109	Baltimore	60	0.52	5867.1	9.35	0.22	Hb por granite	250/80 NE
082FNW-141	Marmion	50	28.00	144.3	0.05	0.03	K-spar por gn	—
082FNW-070	Little Daisy	44	64.80	62.9	0.00	0.00	Feldspar por	—
082FNW-153	Lily B	41	0.76	2748.5	5.63	0.00	K-spar por gn	090/55 S
082FNW-226	Silver Leaf	40	0.00	19.2	14.50	15.67	K-spar por gn	065/84 SW
082FNW-184	Joan	38	0.82	130.8	0.40	0.00	K-spar por gn	—
082FNW-207	Sun	31	0.00	2729.0	39.80	0.00	Hb por granite	—
082FNW-151	Speculator	26	0.00	987.0	22.87	1.59	K-spar por gn	034/67 SE
082FNW-208	Mary/Jumbo	25	6.24	660.6	6.30	6.66	K-spar por gn	—
082FNW-101	Index	20	0.00	1967.3	44.31	9.47	Pelitic phy/sch	125/85 SW
082FNW-222	Gem	19	37.63	1659.9	0.00	0.00	K-spar por gn	—
082FNW-185	Gold Cure	18	0.00	3455.9	50.40	0.00	Pelitic phy/sch	040/80 SE
082FNW-144	Riverside	18	0.00	1534.4	2.52	2.33	K-spar por gn	225/75 NW
082FNW-139	Alice S	15	0.00	2745.3	14.81	0.00	K-spar por gn	070/85 SE
082FNW-166	Kalispell	15	0.00	8229.8	2.15	0.95	Pelitic/psammitic	020/55 SE
082FNW-105	Para*	15	0.68	4064.5	—	4.09	Qtz monzonite	—
082FNW-120	Smuggler	13	0.00	9243.8	63.00	0.00	K-spar por gn	150/80 SW
082FNW-075	Highland LGT	10	0.00	8839.4	0.00	0.00	K-spar por gn	310/75 NE
082FNW-206	Get There Eli	9	13.78	11769.4	0.00	0.00	Meta sed/vol	345/15 NE
082FNW-187	Olsen	8	3.88	3483.5	11.32	13.25	K-spar por gn	260/18 N
082FNW-219	Alexandria 2	6	4.50	3990.0	4.80	0.25	K-spar por gn	—
082FNW-107	Violet	4	0.00	8156.8	12.10	0.00	Hb por granite	040/85 SE
082FNW-114	Silvercup	4	7.75	1104.2	22.27	2.95	Hb por granite	184/84 SW
082FNW-119	Slocan Chief	4	0.00	4478.2	57.58	0.00	K-spar por gn	130/40 SW
082FNW-122	Oro Fino	4	15.50	241.0	1.20	2.80	K-spar por gn	029/63 SE
082FNW-149	Mabou Ohio	4	0.00	1197.5	3.40	4.95	K-spar por gn	055/70 SE
082FNW-116	Boomerang	3	0.00	1493.0	4.03	4.10	K-spar por gn	355/80 E
082FNW-072	Ag Nugget	1	0.00	7060.0	0.00	0.00	Meta sed/vol	063/65 SE

* Grade calculated from one grab sample; Minister of Mines, B.C., Annual Report, 1919.

Only deposits with greater than 1 tonne reported production. Grade calculated by dividing metal recovery by tonnage mined. Lithologic abbreviations are: K-spar por gn = potassium-feldspar porphyritic granite, Pel phy/sch/lst = pelitic phyllite/schist/limestone, Hb por = hornblende porphyritic, Qtz monz/lamp = quartz monzonite/lamprophyre, Meta sed/vol = metasedimentary and metavolcanic rocks, Feldspar por = feldspar porphyry

TABLE 1-2-3. VEIN CHARACTERISTICS OF PROSPECTS AND SHOWINGS LISTED IN MINFILE
(Results are from grab sample assays.)

Minfile	Property	Host[1]	Tonnes[2]	Au (g/T)	Ag (g/T)	Pb (ppm)	Zn (ppm)	Cu (ppm)	Mo (ppm)	Vein Attitude
082FNW-071	Willa*	volc br	D P	7.5	9.6	0.0		1.04		---------
082FNW-118	Blackburn	K-spar	P	0.01	0.38	16.4%	4.8%	188	<10	245/85 NW
				0.13	0.25	3.1%	3.6%	244	70	
				0.15	0.51	1.1%	12.1%	670	<10	
082FNW-126	Barnett	K-spar	P	1.8	0.14	0.34%	288	29	<10	215/25 NW
				6.9	0.11	0.14%	47	8	<10	
				3.3	0.50	0.10%	41	9	<10	
082FNW-215	Silver Ranch	K-spar	P	20	48	0.93%	1.7%	33	<10	30/56 SE
				0.30	5	0.32%	0.26%	12	<10	
				21	135	3.2%	0.89%	91	<10	
				7.1	430	7.8%	7.6%	450	<10	
082FNW-253	Al (Wheeler L.)	K-spar	P	26.0	170	15.9%	3.3%	57	<10	north/steep
				0.35	9	300	80	7	<10	
				1.0	26	3.1%	2.0%	11	<10	
				0.21	2	580	445	6	<10	
				7.9	91	18.3%	8.4%	640	<10	
082FNW-248	Kalappa	Fol. gn	P	<0.02	2.0	180	62	15	10	---------
				0.97	23.0	40	88	72	42	
				0.02	0.5	30	38	62	<10	
082FNW-124	Silver Crest	K-spar	P							---------
082FNW-103	Fairmont	K-spar	P							025/50 SE
082FNW-102	Glue Pot	K-spar	S							235/70 NW
082FNW-104	Christina	K-spar	S	<0.02	5.9	147	1920	25	<10	north/mod.
082FNW-108	Cable	Hb por gn	S	0.05	9	67	99	12	<10	192/80 NW
082FNW-115	Joker	K-spar	S	3.80	42	0.94%	0.44%	57	<10	210/89 NW
082FNW-117	*Gold Galena*	*K-spar*	S							358/19 E
082FNW-123	Hudson Boy	K-spar	S	2.40	490	0.26%	0.30%	45	<10	175/85 W
082FNW-125	Soldier Boy	K-spar	S							---------
082FNW-073	Silver Band	K-spar	S							east/unknown
082FNW-239	Black Eagle	K-spar	S							---------
082FNW-074	Mtn Scenery	K-spar	S							065/unknown
082FNW-098	Nome	Hb por gn	S	0.01	3	11	16	79	<10	194/48 NW
082FNW-076	Daisy	K-spar	S							060/65 SE
082FNW-142	Bond River	K-spar	S	0.90	0.16	4.5%	9.58%	0.13%	<10	265/40 N
082FNW-078	Lou Dillon	K-spar	S							045/65 SE
082FNW-128	Crusader	K-spar	S							---------
082FNW-217	*Gold Reef*	*K-spar*	S							---------
082FNW-242	King Solomon	K-spar	S							---------
082FNW-135	Tailholt	K-spar	S							---------
082FNW-138	Elk	K-spar	S							115/30 SW
082FNW-146	Dalhousie	K-spar	S							---------
082FNW-254	King Solomon	Qtz monz	P							---------

Abbreviations:
[1] 1Fol. gn = foliated granite; Hb por gn = hornblende-potassium feldspar porphyritic granite; K-spar = potassium feldspar porphyritic granite; volc br = volcanic breccia.
[2] D P = developed prospect; P = prospect; and S = showing.
* = grade from reserve data.

TABLE 1-2-4. WINTRIP MINE GRAB SAMPLE ASSAY RESULTS

Sample	Lithology	Easting	Northing	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (%)	Zn (%)	Mo (ppm)
275-1	*Quartz vein*	493215	5524668	*210*	*320*	*251*	0.48	3.44	<10
275-1	Quartz vein	493088	5524667	220	490	1800	19.2	15.8	<10

TABLE 1-2-5. MOLLY GIBSON MINE ASSAY RESULTS

Sample	Easting	Northing	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (%)	Zn (%)	Mo (ppm)
2-1 (5880 level)	489035	5508600	820	940	1200	9.3	4.13	<10
170-1 (3-level)	489300	5509500	<10	29.2	42	0.28	0.1	<10
170-2 (3-level)	489300	5509500	510	2300	2050	9.1	3.93	32
170-3 (3-level)	489300	5509500	50	445	338	1.63	0.65	18

2-1 = Quartz-siderite vein grab sample.
170 = channel sample; 170-1 = hangingwall, 170-2 = vein, 170-3 = footwall.

SCRANTON/PONTIAC/SUNRISE (MINFILE 082FNW-112,111,113)

The Scranton-Pontiac deposit has silver:base metal ratios and a northeast-striking orientation characteristic of Group 1 deposits. However, the gold production is more suggestive of Group 2 mineralization. The claims are located close to the eastern boundary of the park and are accessible from Highway 31, via Woodbury Creek road. Initial production is reported from the Pontiac claim in 1898, Sunset-Sunrise in 1899 and Scranton in 1948. Combined production totals at least 9441 tonnes (incomplete records) which yielded 125 676 grams gold, 4.4 million grams silver, 1313 kilograms copper, 1.4 million kilograms lead, 1.2 million kilograms zinc and 13 875 kilograms cadmium. Scranton accounts for more than 90 per cent of the gold, lead, zinc, copper and cadmium, and 80 per cent of the silver production. Fifty per cent of Scranton production occurred between 1969 and 1979.

The Pontiac, Scranton, Sunset, Grandview and Sunrise workings (from northeast to southwest) follow a southwest-striking vein system of at least 2.1 kilometres strike length. The vein system comprises sheared zones 10 metres or more in width hosting quartz veins and irregular quartz bodies. Country rock is hornblende potassium feldspar granite and potassium feldspar granite. Hornblende diorite outcrops in Sunrise basin. Biotite-grade thinly bedded siltstone, argillite and recrystallized limestone outcrop on the Scranton claims and quartzite was intersected in underground workings (Little, 1960).

The Scranton mine is on the east side of Pontiac Creek, the Sunset mine on the west side. Both are presumed to be on the same vein. The Scranton zone contains at least two veins. Vein attitude ranges from northeast to east striking and dips average 25 degrees southeast at the southwest end of the vein, steepening to 60 degrees southeast toward the northeast. Vein widths vary from 15 to 60 centimetres in the granite but veins commonly pinch out in the sediments. Vein mineralization is predominantly pyrite, up to 35 per cent, with lesser galena and sphalerite stringers and blebs in a fractured quartz gangue.

The lower Pontiac workings, at the 1920-metre elevation, test a quartz vein striking between 25 and 45 degrees northeast. The workings are inaccessible. Vein material from the dump is massive coarse white carbonate mineralized with blebs and stringers of galena and sphalerite (10 per cent combined) and flooded by (2 to 3 per cent) finely disseminated pyrite (sample 291).

Workings in the Sunrise basin include the Sunrise and Grandview, 215 metres to the northeast. The Sunrise was developed on two levels: the lower level (1975-metre elevation) is wet but apparently accessible; the upper level (2030-metre elevation) is completely collapsed. The vein is less than 1.5 metres wide, limonite stained, fractured and sulphide-poor. The footwall granite is fractured and limonitic over 1 metre or less; the hangingwall is sharply defined and locally sericitized (20-centimetre widths). Galena and sphalerite occur intergrown in layers, blebs and patches. Pyrite occurs as coarse aggregates (2 by 1.5 centimetres) and finely crystalline concentrations rimming galena. Lower level vein material (sample 281), upper level stockpiled ore (samples 278 and 279), and altered wallrock (sample 277) have been analysed. Results are given in Table1-2-6.

The Grandview workings are inaccessible. Vein mineralization similar to the Sunrise vein (sample 283) was collected from the lowermost dump (Table 1-2-6).

One hundred fifty metres southwest of the upper Sunrise portal, on the Granite claim, vein mineralization is exposed in a portal at 2090 metres elevation. The vein is 0.5 metre wide and comprised predominantly of pyrite (to 15 per cent), in patches, intergrown with galena and sphalerite. A grab sample (275) was collected at the portal. Indicated reserves were reported at 17 890 tonnes averaging 9.3 grams per tonne gold, 240.1 grams per tonne silver, 8.2 per cent lead and 8.0 per cent zinc (Northern Miner, January 12, 1978, page 24).

MESOTHERMAL QUARTZ VEINS

Mesothermal gold and silver-bearing quartz veins occur along the western edge of the map area in two localities: adjacent to the Willa property in the north, and a larger area straddling Lemon and Crusader creeks in the south (Figure 1-2-3). The majority of quartz veins occur in the porphyritic potassium-feldspar granite phase. The Alpine and Little Daisy veins are exceptions; they are hosted by fine-grained biotite-hornblende quartz monzonite. The LH deposit occupies a silicified shear zone within metasedimentary and metavolcanic pendants.

Most of the veins strike westerly with shallow to moderate northerly dips. Vein widths vary from a few centimetres up to 1.2 metres. The veins have envelopes of argillic and com-

TABLE 1-2-6. SCRANTON/PONTIAC/SUNRISE MINE ASSAY RESULTS

Sample	Easting	Northing	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (%)	Zn (%)	Mo (ppm)
275a	494497	5514090	1.1	420	51	15.4	3.55	<10
277b	494594	5514168	0.15	5	4	0.05	0.07	<10
278 b	494591	5514168	180	165	4	0.98	0.005	<10
279 b	494588	5514171	32	310	62	21.2	13.8	<10
281 c	494717	5514290	7.9	245	23	18.7	10.0	<10
283 d	494875	5514424	3.0	1300	50	20.9	3.88	<10
287 e	495663	5514779	2.1	440	212	12.0	12.0	<10
291 f	496325	5515133	41	220	204	12.3	5.58	<10

Assay results for quartz vein grab samples. Locations: a = Granite dump; b = Sunrise upper portal; c = Sunrise lower portal; d = Grandview dump; e = Scranton lower portal; f = Pontiac lower portal.

monly sericite alteration, which in the Barnett (MINFILE 82FNW-126; Minister of Mines Annual Report, 1922) contains gold and silver mineralization.

ALPINE MINE (MINFILE 082FNW-127)

The Alpine property is located at the head of Sitkum Creek along the divide that marks the southern edge of the park. Initial development of the vein was done in 1896 and 1897. Production commenced with a small shipment of ore in 1915 and continued sporadically until 1948. During this period 15 557 tonnes was mined and yielded 356 162 grams gold, 221 453 grams silver, 49 247 kilograms lead, and 17 085 kilograms zinc. Cove Energy Corporation, with Granges Exploration Ltd. as operator, was drilling the vein in October and November, 1987.

The quartz vein, a discrete shear zone striking 255 degrees and dipping moderately north, is traceable over 400 metres on surface. Contacts with hangingwall and footwall monzonite are sharp and variably sericitized. Vein width averages 1.1 metres. The vein is hosted by fine to medium-grained quartz monzonite (Phase 5; Figure 1-2-2). Pre-mineralization aplite and pegmatite dykes are common; post-mineralization lamprophyre dykes are less abundant. Mineralization comprises electrum, silver minerals, pyrite, and lesser galena and sphalerite. Rare clots of molybdenum were identified in altered potassium-feldspar granite from the mine dump. The vein is limonitic weathering and highly jointed and fractured. Textures are massive crystalline, ribboned, or banded and vuggy. Quartz is variably milky, white, grey and colourless, suggesting episodic deposition. Analytical results are listed in Table 1-2-7.

VOLCANIC BRECCIA PIPE

WILLA (AYLWIN CREEK) DEPOSIT (MINFILE 082FNW-071):

Geology and mineralization of the Willa deposit have been described in detail by Heather (1985) and briefly summarized by Schroeter (1987). Development and exploration continued on the Willa deposit in 1987. Northair Mines Ltd., with its joint venture partners BP Minerals Ltd. and Rio Algom Exploration Inc., has started exploration on the East zone, opened an upper level (1100-metre elevation) into the Main zone and driven a decline under the West zone. There are plans to move a mill onto the site. The deposit occurs in a pendant of Rossland Group rocks within the Nelson batholith.

Mineralization comprises chalcopyrite, pyrrhotite and microscopic gold in the intrusive breccia and adjacent host intrusions. Published reserves for the West zone are 549 700 tonnes grading 7.5 grams gold per tonne, 9.6 grams silver per tonne and 1.04 per cent copper (Northair Mines Ltd., 1987).

AGES OF MINERALIZATION

Ages of mineralization are not well established. However, separate mineralizing events are postulated for each deposit type. Epigenetic vein mineralization (Groups 1 and 2) crosscuts Slocan Group and Nelson plutonic rocks and therefore post-dates intrusion of the batholith. Previous studies have related mineralization to intrusion and assumed a Middle Jurassic age for mineralization. Lead isotope age dating (Logan *et al.*, this volume) suggests a separate mineralizing event in the Tertiary. The mineralized breccia vent at Willa (Group 3) is hosted by and related to Rossland volcanics (Early Jurassic) and pre-dates intrusion of the batholith (Middle Jurassic). Potassium-argon isotopic dating of sericite alteration in the Willa deposit gave a 57±4 Ma age (unpublished data; R.L. Armstrong, The University of British Columbia). This alteration post-dates volcanic breccia mineralization and documents a Tertiary hydrothermal event.

GEOCHEMISTRY

A total of 141 stream sediment samples was collected over an area of 800 square kilometres. Samples were analysed for 30 elements by inductively coupled plasma techniques (ICP); gold was determined by fire assay followed by neutron activation analysis. Sample locations are shown in Figure 1-2-4. Results of the stream sediment sampling are available as Open File 1988-11.

Twelve heavy mineral samples were collected from high-energy stream environments using techniques described by Matysek and Saxby (1987). Three size fractions for each sample were analysed for 30 elements by neutron activation methods. Sample locations are presented in Figure 1-2-4.

A total of 122 grab samples and 121 rock chip samples was collected from mine dumps and across veins and alteration envelopes for assay and geochemical analysis respectively. All the samples have been analysed for gold, silver, copper, lead, zinc and molybdenum, and selected samples for mercury, arsenic and antimony. Analytical results unavailable at the time of writing will be released with stream sediment geochemical data.

TABLE 1-2-7. ALPINE MINE ASSAY RESULTS

Sample	Easting	Northing	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (%)	Zn (ppm)	Mo (ppm)
391 A	481915	5503504	19.2	6	6	0.10	221	<10
394 A	481931	5503399	50	7	<2	0.68	2000	<10
395 A	481782	5503313	19.8	1	<2	0.01	47	176
397 A	481737	5503272	1.6	3	<2	0.07	53	78
404 B	481420	5501625	2.8	8	<2	0.86	60	<10
406 B	481417	5501663	150	55	<2	3.00	11000	<10

Assay results for vein channel and dump grap samples. Locations: A = Alpine and B = King Solomon.

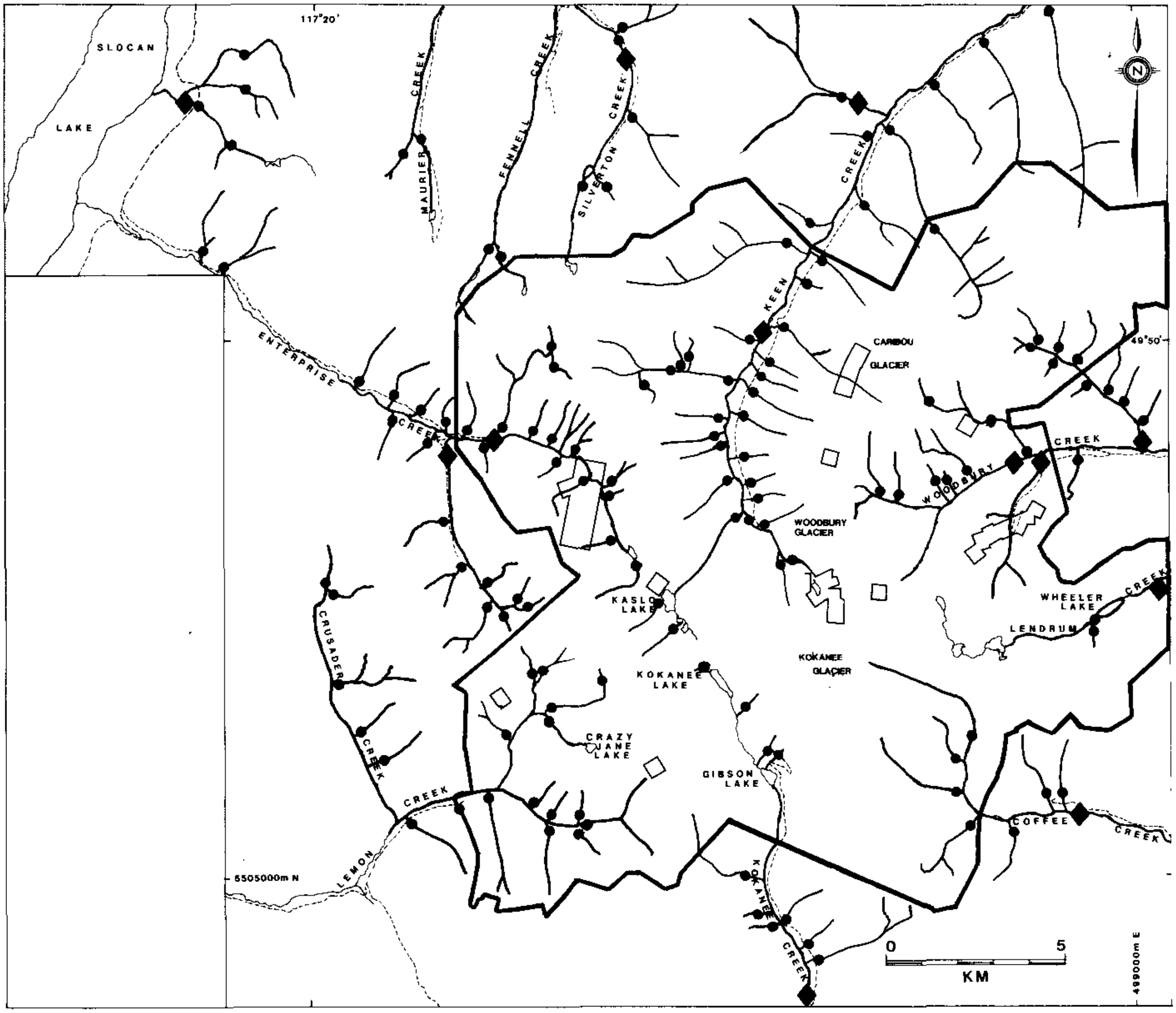

Figure 1-2-4. Stream sediment (solid circles) and heavy mineral sample (solid diamonds) locations, Kokanee Glacier Provincial Park.

Slocan Lake Fault Zone

Rock samples for geochemical analysis were collected from the Slocan Lake fault zone to assess its potential for epithermal gold mineralization. The Slocan Lake fault is a low-angle easterly dipping Eocene normal fault (Parrish, 1984). Lithoprobe seismic reflection profiling shows 30-degree eastward-dipping reflectors interpreted to be the fault (Cook *et al.*, 1987). These reflectors are detected to a depth of at least 15 kilometres below the Nelson batholith and continue eastward under Kootenay Lake.

Carr *et al.* (1987) described the fault zone along the east side of Slocan Lake as closely spaced (about 20 centimetres or less) brittle fractures and faults with lower to middle greenschist grade retrograde alteration. The zone ranges from 100 to 800 metres wide. Nelson granitic rocks in the hangingwall are variably altered to greenschist assemblages, clay-limonite and local quartz stockwork and zones of pyritization. Foliated to mylonitic Cretaceous to Tertiary (Paleocene) granites and older amphibolite to sillimanite-grade metasedimentary rocks in the footwall show little retrograde or hydrothermal alteration.

Limonitic staining is widespread in the hangingwall of the fault zone. Eighteen grab samples were collected along 20 kilometres of the fault zone between Silverton and Slocan (Figure 1-2-5). The majority of samples comprised either chlorite-altered, hematitic or clay-altered limonitic quartz monzonites and porphyritic potassium-feldspar granite. Pyrite occurs as disseminations up to 2 per cent. Four granitic samples comprised quartz stockwork zones with or without sericitic alteration. Five quartz veins, one hosted by footwall Ladybird granite (Carr *et al.*, 1987) were sampled. Tetrahedrite and possible native silver were identified in sample JL-74. Hangingwall fault breccia was sampled at the lookout along Highway 6, 5 kilometres north of Enterprise Creek. The breccia is composed of subangular, matrix-sup-

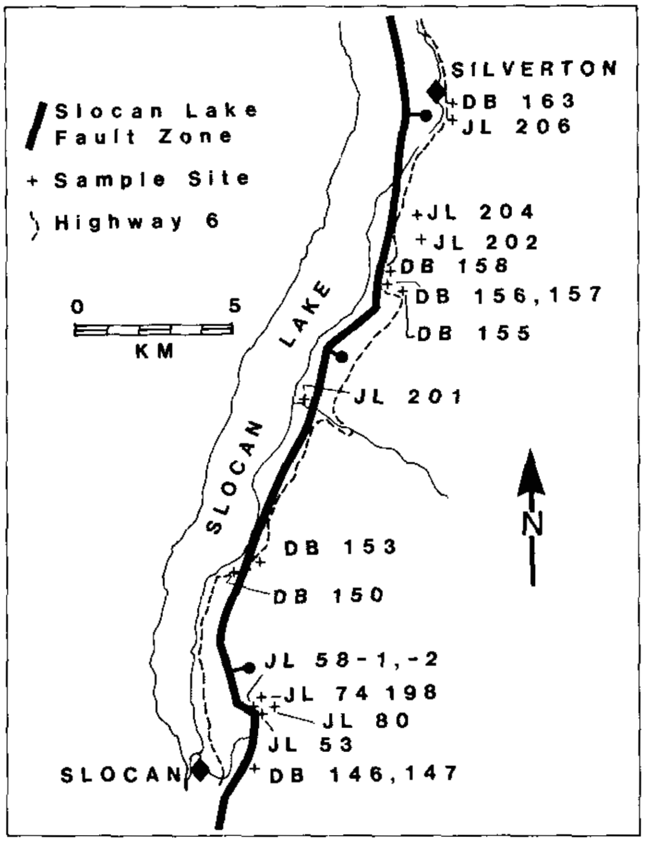

Figure 1-2-5. Slocan Lake fault zone with rock geochemical sample locations. Fault trace compiled from Carr (1986).

ported granitic fragments of variable sizes, less than 10 centimetres in diameter. The matrix has been chloritized and variably silicified. The breccia is more than 10 metres thick and is overlain by argillically altered, bleached and oxidized quartz monzonite. A similar fault breccia outcrops on Springer Creek road (Station JL87-198, Figure 1-2-5). The fault breccia here is overlain by a screen of hornfelsed Slocan Group silty argillite. The sediments are brecciated and healed with euhedral quartz crystals that fill vugs.

A fault breccia is exposed on Red Mountain road directly south of the Ministry of Highways' gravel pit (Station JL87-206, Figure 1-2-5). This southeasterly striking silicified (chalcedonic), pyritized breccia is hosted by hematitic, potassium feldspar megacryst-poor granite.

Geochemical results are given in Table 1-2-8. Gold, silver and molybdenum in most samples are lower than detection limits of 20 ppb, 0.5 ppm and 10 ppm respectively. Gold values of 170 and 150 ppb, with corresponding silver values of 1500 ppm and 8.0 ppm, were obtained from two separate quartz veins (Figure 1-2-5; Table 1-2-8). No enrichment of copper, lead, or zinc is apparent in the fault zone. However, values from quartz vein JL-74 returned 0.26 per cent copper, 3.12 per cent lead and 0.37 per cent zinc. Arsenic concentrations range from less than 1 ppm to 58 ppm. Elevated arsenic values (n = 3) are obtained from quartz veins and a breccia zone. Antimony concentrations range from less than 1 ppm to 17 ppm. Higher values correspond in part with arsenic highs. Mercury values are not yet available.

SUMMARY AND MINERAL POTENTIAL

The rocks underlying Kokanee Park host mesothermal quartz veins. Based on past production, new discoveries are likely to be small, in the order of 10 000 tonnes. The ore

TABLE 1-2-8. SLOCAN LAKE FAULT ZONE GEOCHEMICAL RESULTS

Sample	Description	Au (ppb)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	As (ppm)	Sb (ppm)
JL-53	chl-hem	<20	<0.5	13	28	50	<10	2.5	2.0
JL-58-1	chl-hem	<20	1.0	13	66	32	<10	7.2	2.3
JL-58-2	ser-qtz-py	80	<0.5	22	40	34	<10	6.5	<1.0
JL-74	qtz vein	170	1500	2600	31200	3700	<10	NA	NA
JL-80	sil-flt br	70	<0.5	15	26	40	<10	58.4	11.0
DB-146	ser	<20	<0.5	20	62	60	<10	<1.0	1.2
DB-147	lim arg	<20	<0.5	22	22	29	<10	<1.0	<1.0
DB-150	qtz vein	<20	<0.5	26	70	38	<10	9.8	17.0
DB-153	ser	<20	<0.5	20	36	49	<10	1.9	1.7
DB-155	chl-py	<20	<0.5	17	34	110	<10	3.2	1.2
DB-156	arg-sil-py	<20	<0.5	20	18	15	<10	11.8	1.5
DB-157	chl-flt br	<20	1.5	22	85	180	<10	2.5	1.5
DB-158	sil-arg-lim	<20	0.5	19	20	65	<10	1.2	<1.0
DB-163	qtz vein py	<20	<0.5	22	14	25	<10	NA	NA
JL-198	sil-flt-br	<20	<0.5	16	69	380	<10	22.6	5.8
JL-201	sil-py-flt	25	0.5	62	30	38	<10	NA	NA
JL-202	sil-aplite	<20	<0.5	12	12	25	<10	3.9	<1.0
JL-204	qtz vein	150	8.0	13	26	55	<10	35.4	<1.0
JL-206	sil-flt br	40	<0.5	31	143	60	<10	35.4	6.9

Samples are potassium-feldspar porphyritic granite unless indicated otherwise.
Abbreviations: arg = argillic; br = breccia; chl = chlorite; flt = fault; hem = hematite; lim = limonite; NA = not analysed; py = pyrite; qtz = quartz ser = sericite; sil = silicified.

TABLE 1-2-9. SUMMARY OF EXPLORATION ACTIVITY NEAR KOKANEE GLACIER PARK

Alpine	Cove Energy Corporation (owner) Granges Exploration Ltd (operator)	Surface drilling (over 700 metres), rehabilating lower level, drifting and underground drilling.
Enterprise	Locke Goldsmith (owner)	Drilling (440 metres).
Comstock	Dragoon Resources Inc. (operator)	Refurbishing workings and camp construction.
Bismark	Eric Denny (owner)	Geophysics and geochemistry.
LH	Andaurex Resources Inc. (owner) Noranda Exploration Ltd. (operator)	Drilling.
Silver Ranch	Don Porteous (owner)	Hand trenching and sampling.
Al claims — Wheeler Lake	Dragoon Resources Inc. (operator)	Proposed drilling.
Willa (Aylwin Creek)	Northair Mines Ltd. (operator), B.P. Minerals Ltd., Rio Algom Exploration Ltd.	Decline to test west zone, underground drilling, and relocate Northair's 350 tonne per day mill.

shoots are unpredictable and lode structures discontinuous. This has made the potential of individual occurrences difficult to evaluate.

About 40 per cent of the park is alpine meadow or felsenmeer with almost complete rock exposure. As a result, few if any surface mineral showings have escaped detection by conventional prospecting methods. Batholith-hosted veins are narrow and in the past have been located only in the well-exposed areas above treeline. Subsequent exploration and development have followed these veins to lower elevations that are generally covered by overburden.

The potential of the park area to host deposits other than mesothermal veins is considered low. The setting is appropriate for Tertiary epithermal mineralization, but none has been located.

The composite nature of the batholith, as characterized by distinct phases, felsic dykes and pegmatites, indicates multiple overlapping intrusive events. Neither alteration haloes nor quartz stockworks which might represent a centre of porphyry-type mineralization were recognized, although a magnetic high in the southwest corner of the map area may represent a blind intrusion. Copper and molybdenum abundances are low with the exception of copper at the Willa deposit. Most of the batholith is unaltered.

The potential for skarn mineralization is low due to lack of calcareous horizons. In the Keen Creek sedimentary re-entrant, calc-silicate assemblages developed in response to contact metamorphism, but no sulphide mineralization was identified in the contact aureole. Galena, sphalerite and pyrite-bearing garnet-diopside skarn occurs in hornfelsed Slocan sediments east of the LH deposit. Similar sulphide-bearing skarns are located west of the park, at the Piedmont deposit.

The absence of Rossland volcanic rocks within the park limits the possibility of discovering "Willa-type" mineralization.

Placer gold can be panned from Woodbury Creek, which drains the eastern portion of the park. The gold source may be the Scranton-Pontiac deposit, however, other sources cannot be discounted.

Exploration activity in 1987 is summarized in Table 1-2-9. Most of the work was begun late in the field season. Additional exploration in 1988 is expected in the Recreation Areas, following release of silt and rock geochemistry.

FUTURE WORK

Data compilation and geochemical results will require follow-up during the 1988 field season. More detailed property examinations should utilize low impact evaluation techniques including soil sampling, VLF-electromagnetic and ground magnetometer surveys. Winter laboratory studies will include potassium-argon geochronometry, structural analysis of 1987 field data, fluid inclusion work and sulphide petrography.

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