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Petroleum Resources
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Mineral Resources Division
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APPLIED GEOCHEM

# GEOLOGY AND MINERAL EVALUATION OF KOKANEE GLACIER PROVINCIAL PARK SOUTHEASTERN BRITISH COLUMBIA (82F/11, 14)

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# PREFACE

Kokanee Glacier Park was established in 1922 over an area that had already undergone more than two decades of mineral exploration and mine development. Several exploration and mining operations existed in the Park prior to its establishment and then intermittently from 1922 until the general moratorium on exploration in parks was enacted in 1973. From 1940 to 1965 it was designated a "Class A" park, but in 1965 the designation was changed to "Class B" to allow mineral exploration on valid claims. One small underground mine was permitted to operate after the moratorium.

Government's desire to resolve the conflict between recreational and mineral values led to this area being included in the 1985-86 Wilderness Advisory committee study. This Committee recommended that the rectangular boundaries of the Park be rationalized, based on an adequate assessment of park and resource values. In 1987, as an interim measure, the existing mineral titles within the park were reclassified as Recreation Area in recognition of the pre-existing rights of the title owners to explore their properties.

In 1987/88 in accordance with the Wilderness Advisory Committee's recommendations the Ministry of Energy, Mines and Petroleum Resources undertook a mineral potential study of the Park and recreation area additions that were located outside the original square core area. This study was directed at identifying the types and sizes of mineral deposits in the area and determining where the greatest potential lay for locating new deposits. Both office compilation of data and field surveying to confirm old reports and acquire new information were included in the study.

The results of this study documented the mineral potential data necessary to outline zones of high mineral potential. After this study was completed, the Minister of Parks and the Ministry of Energy, Mines and Petroleum Resources announced in December 1988 that mining will not be allowed in Provincial Parks. For Kokanee Park the Government intends to acquire title to claims in the area within the old Park boundaries while allowing mineral exploration in the new Recreation Areas added under Section 19 of the **Mineral Tenure Act**. This report is being published to provide valuable data and interpretations to assist exploration in the new Recreation Area additions and other adjacent areas as part of government's roll in mineral resource management.

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# SUMMARY

Kokanee Glacier Park covers about 305 square kilometres within the Selkirk Mountains of southeastern British Columbia. The park is centred 35 kilometres northeast of Nelson, between Slocan and Kootenay lakes. Topography is rugged with glacier-covered mountain peaks over 2750 metres high. Keen Creek valley is the lowest area in the park at 1200 metres elevation.

Most of Kokanee Glacier Park is underlain by rocks of the Nelson batholith, that were emplaced about 170 million years ago, during Middle Jurassic time. The composite batholith can be divided into six phases (Brown and Logan, 1988). The main phase is potassium-feldspar megacrystic granite. Other less important phases are: hornblende potassium-feldspar porphyritic granite, biotite granite/granodiorite, diorite/amphibolite and biotite lamprophyre. The Nelson plutonic suite is subalkaline and metaluminous with Cordilleran I-type affinities.

The northern end of the batholith intrudes the Upper Triassic Slocan Group which consists of argillite, siltstone and minor amounts of limestone. The eastern edge intrudes a sequence of Lower Cambrian to Upper Triassic metasedimentary and metavolcanic rocks (Brown and Logan, 1988; Fyles, 1967) that dip westward at a moderate angle. The western boundary is the Slocan Lake fault zone and Cretaceous to Tertiary gneissic intrusions of the Vahalla complex (Carr *et al.*, 1987).

There are fifteen past producers and fourteen mineral prospects in Kokanee Glacier Park. Total production from the park was 82 209 tonnes that yielded 126 461 grams gold, 38 439 kilograms silver, 3 821 758 kilograms lead, 1 246 306 kilograms zinc, 1 473 kilograms copper and 13 875 kilograms cadmium. The value of past production is about 17 million dollars (February, 1988). All producers are low tonnage (<56 000 tonnes) and occur within the batholith. No mines are currently operating in the park.

Metallogenic studies, combined with detailed geological mapping, indicate that Kokanee Glacier Park holds potential for discovery of new, low tonnage mesothermal vein-type deposits. Based on past production, new discoveries will probably be less than 50 000 tonnes in size but rich; carrying silver, lead, and zinc. Gold-bearing veins are possible but less likely. Assessment of the resource potential of the vein deposits is difficult because the veins are narrow and discontinuous, have very thin alteration haloes and are apparently not related to obvious linear structures.

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. In the 60 per cent of the park below treeline, rock exposure is limited.

Historically, the park has been known for silver-lead-zinc veins, however, several veins carry gold. Perhaps low gold prices and the microscopic nature of the gold prevented previous prospectors from recognizing these veins and their potential. The potential of the park area to host deposits other than mesothermal veins is considered low. Although the setting is appropriate for Tertiary epithermal mineralization, none has been located. Neither alteration of the types normally associated with porphyry copper deposits nor quartz stockworks were found. However, 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 outside of the park. Rocks composing the bulk of the batholith are relatively fresh.

Calcareous horizons are rare so the potential for skarn mineralization is low. 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. The absence of Rossland volcanic rocks within the park limits the possibility of discovering "Willa-type" mineralization. Detailed examination of each pendant in the park indicated no similarities with Willa deposit host lithologies. Placer gold has reportedly been panned by individuals from Enterprise Creek (Little, 1960) and Woodbury Creek, which drain the western and eastern portions of the park, respectively. The gold source may be the Scranton-Pontiac deposit, however, it could be from other as yet undiscovered sources.

# INTRODUCTION

## LOCATION, ACCESS AND TOPOGRAPHY

Kokanee Glacier Park covers about 305 square kilometres within the Selkirk Mountains of south-eastern British Columbia. The park is centred thirty-five kilometres northeast of Nelson, between Slocan and Kootenay Lakes. Topography is rugged with glacier-covered mountain peaks over 2750 metres high. Keen Creek valley is the lowest area in the park at 1200 metres elevation. The park 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.

## PREVIOUS GEOLOGICAL WORK

Areas of previous work are outlined in Figure 1.

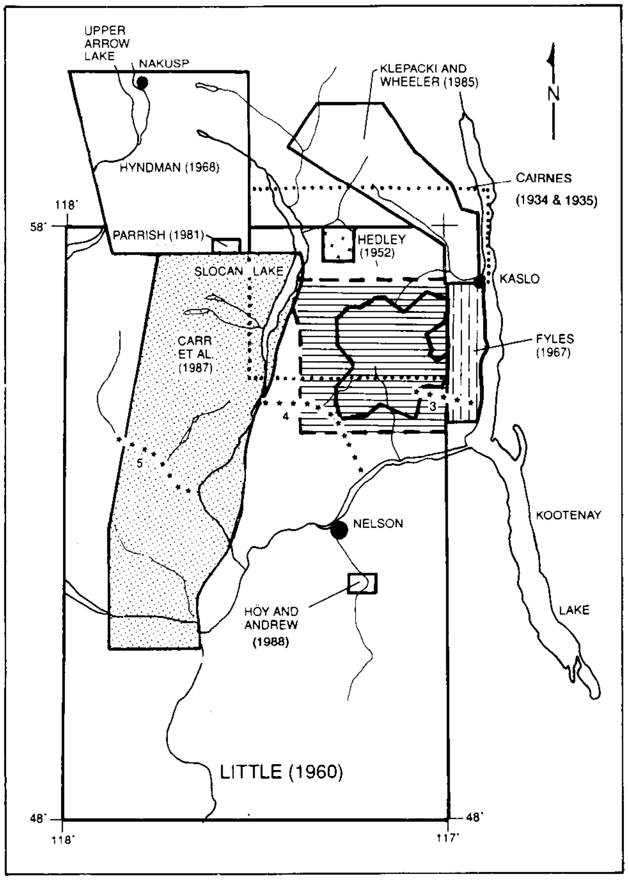



Figure 1. Location map showing areas of previous work. Region discussed in this report is the area of horizontal lines enclosed by dashed lines. The area bounded by Carr *et al.* (1987) includes older work by Carr (1986), Reesor (1963), Parrish (1987), Parrish (1981) and Parrish *et al.* (1985). *** = Lithoprobe seismic lines (Cook *et al.*, 1987).

The mapping of Cairnes (1934 and 1935) defined the regional geological setting of 22 mineral occurrences. He meticuously plotted locations of 12 mines and 10 prospects, and distinguished two phases of the "Mesozoic" Nelson batholith in the Kokanee Glacier Park; porphyritic granite and granite/granodiorite. His Slocan Sheet (Map 272A; 1:63 360 scale) shows seven areas of possible Slocan-equivalent schists, quartzite, argillite, limestone and altered volcanics intruded by the Nelson batholith, east and west of Keen Creek. Cairnes also suggested the Rockland mine (Willa deposit) was hosted by the Slocan Group. Little's (1960) 1:250 000 scale Nelson West Half map (Map 1090A) was a simplified compilation of Cairnes work. Little identified the metasedimentary pendants from Cairnes' Map 272A as "paragneiss" and suggested the Nelson batholith was Early Cretaceous in age. The Willa area was indicated to be largely volcanic Slocan Group intruded by porphyritic syenite and quartz diorite. The most recent geological mapping for Kokanee Glacier Park was published in 1960.

Published studies outside the park comprise the following. In the Sandon area, Hedley (1952) produced a map of Slocan Group sedimentary rocks and structure. 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 previously mapped by Reesor (1963), has been recently reinterpreted, largely based on geochronology and kinematic indicators (Parrish,1984; Carr *et al.*, 1987). Lithoprobe (Cook *et al.*, 1987) detected a reflector, interpreted to be the Slocan Lake fault, that dips about 30 degrees eastward beneath the Nelson batholith from Slocan Lake. The reflector is projected to be about 10-15 kilometres below surface at Kokanee Lake with in the park.

## PRESENT STUDY

The Geological Survey Branch conducted a geological mapping and mineral potential evaluation program in Kokanee Glacier Park during the 1987/88 field season. This study was undertaken to provide the required database for mineral assessment of the park. Office research and 90 days fieldwork included 1:50 000 scale mapping, examination of mineral occurrences, rock and stream sediment geochemistry, lead isotope analyses of mineralization, and compilation of previous work. The area mapped (1330 square kilometres) extended beyond the park to establish the regional geology and setting of mineralization. This report concentrates on relevant features of Kokanee Glacier Park. Traverses were sufficiently spaced in the park to define all exposed roof pendants and altered zones. Most negotiable ridges were mapped. This report amalgamates information from two Geological Fieldwork papers (Brown and Logan, 1988 and Logan *et al.*, 1988) and incorporates Open File 1988-11.

## ACKNOWLEDGMENTS

The authors gratefully acknowledge discussions with Eric Denny, an authority on mineral deposits in the park and an astute prospector. Special thanks are extended to the staff of the Kootenay District Parks Branch for their cooperation and logistical support. Support for lead isotope research from the British Columbia Science Council in a grant to Dr. C.I. Godwin is gratefully acknowledged. Discussions with Dr. R.L. Armstrong and a review of the lead isotope section of the manuscript improved the text.

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

| PERIOD | STRATIGRAPHY | INTRUSIVE EVENTS | DEFORMATION–METAMORPHISM | MINERALIZATION |
|---|---|---|---|---|
| TERTIARY | not present in map area | Lamprophyre, rhyolite<br>Coryell 51.7±0.5 Ma (2)<br>post-tectonic Ladybird gn. 56.5±1.5 Ma (2)<br>deformed Ladybird gn. 59±1 Ma (2)<br>Airy quartz monzonite, 62±1 Ma (2) | 45–54 SLFZ (2)<br>54–59 VSZ (2)<br>53 Ma – 75 Ma greenschist (4)<br>Paleocene | ? Potential<br>? epithermal<br>?<br>? |
| CRET. | | Mulvey gneiss 100±5 Ma (4) | eastward thrusting (1 and 8)<br>Late Cretaceous | ?<br>Mesothermal quartz-siderite veins |
| JURASSIC | | Nelson bath. 169±3 Ma (2)<br>Kuskanax bath. 173±5 Ma (9) | 151–168 greenschist to silli-ksp grade (3)<br>Buckling (3) 173 | |
| JURASSIC | Rossland Group: Hall Formation (Toarcian; 10)<br>Elise Formation (Pliensbachian; 10)<br>Archibald Formation (Sinemurian; 10) | Feldspar porphyry<br>Quartz latite porphyry 194±3 Ma (5)<br>Hb diorite 195 Ma (7) | 188 Phase I and II folding (3)<br>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)

# REGIONAL GEOLOGY AND GEOCHRONOLOGY

Kokanee Glacier 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 to Upper Mississippian pericratonic rocks are exposed to the east (Fyles, 1967) and the Valhalla complex comprised of 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, and Fyles, 1967).

Numerous geochronometric studies have been published on the region. A Middle Jurassic zircon uranium-lead date was reported from the Kuskanax batholith, which is an alkaline to peralkaline aegerine augite quartz monzonite (Parrish and Wheeler, 1983, and 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 potassium-argon dates probably reflect partial resetting or overprinting by Cretaceous or Tertiary thermal events (Archibald *et al.,* 1983; Duncan *et al.,* 1979). A review of the potassium-argon thermal history by Mathews (1983) states that although the Kokanee Creek area was uplifted in the Tertiary it was not reset, whereas the southwest corner of the map area shows resetting of biotite. Hornblende and biotite $^{40}Ar/^{39}Ar$ age spectrum analyses conducted by Harrison (1985) indicate dates for Nelson phases between 153 to 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 to 60 Ma. In contrast, biotites in the south did not close with respect to $^{40}Ar$ until 50 to 60 Ma. 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). Presumably these results represent 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 screens and tabular blocks of pelitic and psammitic metasedimentary rocks, tentatively correlated with the Late Triassic Slocan roup. 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 park in Keen Creek valley, but 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 minor limestone. Stratigraphic thickness is unknown. Within the batholith, aligned, brown-weathering blocks of Slocan Group sediments stand out sharply against the grey-coloured granite. Blocks and screens vary in size up to 100 metres thick, and are mappable along strike for as much as 8 kilometres. To the north and east, bedding in the sediments is concordant to the main batholith contacts (Figure 2 and Map 1; 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 dikes and sills. Biotite hornfels extends less than 10 metres from the dike and sill contacts. Near the Bismark mine (MINFILE 82FNW096) pure, recrystallized limestone bands, up to 60 metres thick, lie against the batholith with no 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 micaceous siltstone and quartzite are common as blocks in the batholith. Siltstone is laminated to finely bedded and locally beds are rich in stratabound coarse disseminated pyrite. Rare limy beds have calc-silicate skarn mineral assemblages, including garnet, diopside and wollastonite. Near Woodbury cabin the blocks contain a sequence with 20 metres of fine-grained quartzite, overlain by about 25 metres of mauve sandstone and 15 metres of micaceous siltstone.

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 micaceous 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; it is recessive, lacks marker horizons and is structurally complex. 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. Three samples collected by the authors 4 kilometres northeast of Silverton on Idaho Peak also give Norian and Late Norian ages (Orchard, written communication, May, 1989). The Slocan Group unconformably overlies Early Permian Kaslo Group volcanic rocks (Klepcki, 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 rocks are confined to pendants within the Nelson batholith. The largest pendant hosts the Willa gold-copper deposit, 8 kilometres northwest of the park boundary (Figure 2 and Map 1). Isolated metavolcanic blocks extend southward, along strike, into the Ymir map area, where Höy and Andrew (1988) have mapped Rossland stratigraphy in detail.

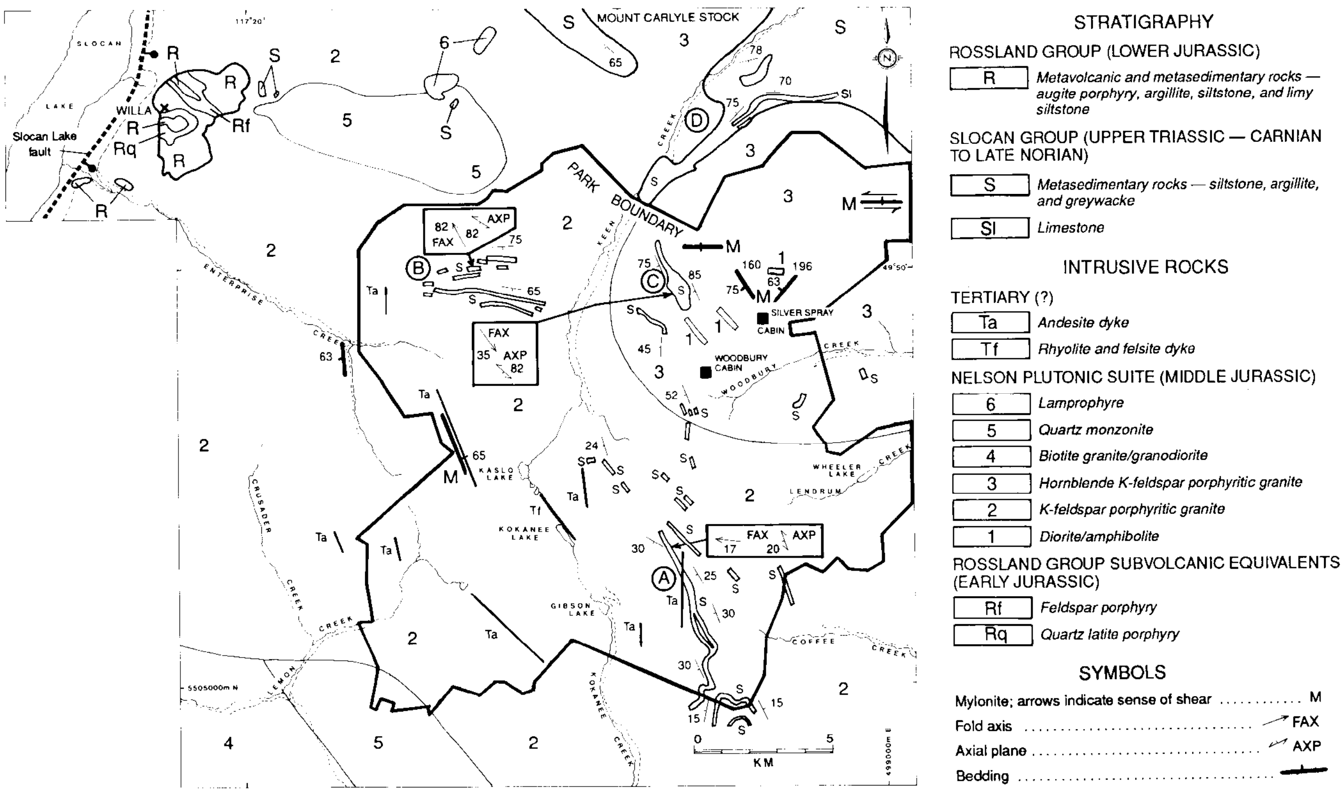



**Figure 2.** Simplified geology and structural areas (A, B, C and D) of Kokanee Glacier Park area, southeastern British Columbia.

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, greywackes 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) Middle Jurassic Nelson plutonic suite; and (3) Tertiary compositionally bimodal dikes. Most of the park (about 95 per cent) 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. Pipe-like heterolithic intrusive breccia that hosts the Willa gold-copper-silver mineralization is contained within these intrusions (Heather, 1985). Mapping during the 1987 field season indicates this plutonic suite is absent from the park, and restricted to the Willa area only.

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. A basaltic dike, which crosscuts mineralization, is being analyzed 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 2 and Map 1. Intrusive contacts are gradational and irregular. Aplite and pegmatite dikes, believed to be comagmatic, occur throughout the area. The suite is subalkaline, calcalkaline and metaluminous (this paper and Ghosh, 1986).

#### 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 fieldwork xenoliths were interpreted to outline phase boundaries within the batholith, but their distribution now seems to be random. Xenoliths are abundant along the Springer Creek road and near the Enterprise mine (Minfile 82FNW148).

#### POTASSIUM-FELDSPAR PORPHYRITIC GRANITE (UNIT 2 - "MAIN PHASE")

Potassium-feldspar megacrystic, medium to coarse-grained hypidomorphic 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). 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.

## TABLE 2
## WHOLE-ROCK CHEMISTRY RESULTS

| Sample | Rock | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ | S | $CO_2$ | LOI | sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JL-229 | Granite | 71.08 | 0.31 | 15.26 | 0.54 | 1.32 | 0.04 | 0.54 | 1.69 | 3.54 | 4.19 | 0.08 | 0.01 | 0.07 | 0.80 | 99.47 |
| JL-265 | Granite | 62.22 | 0.65 | 16.43 | 1.53 | 3.55 | 0.12 | 1.82 | 4.04 | 3.55 | 3.59 | 0.24 | 0.01 | 0.07 | 0.74 | 98.56 |
| JL-271 | Diorite | 53.97 | 0.83 | 11.60 | 0.81 | 6.20 | 0.13 | 11.74 | 6.27 | 2.24 | 3.42 | 0.33 | 0.02 | 0.14 | 0.29 | 97.99 |
| JL-273 | Grano | 67.11 | 0.32 | 16.50 | 1.22 | 1.27 | 0.07 | 0.58 | 2.63 | 4.55 | 4.36 | 0.09 | 0.19 | 0.07 | 0.30 | 99.26 |
| JL-289 | Grano | 67.89 | 0.25 | 16.76 | 0.44 | 1.07 | 0.03 | 0.39 | 2.03 | 4.92 | 3.66 | 0.06 | 0.01 | 0.07 | 0.79 | 98.37 |
| JL-293 | Granite | 65.98 | 0.42 | 16.60 | 1.65 | 1.60 | 0.08 | 0.71 | 3.09 | 4.67 | 4.27 | 0.10 | 0.03 | 0.07 | 0.32 | 99.59 |
| JL-306 | Lamp | 62.80 | 0.73 | 13.85 | 1.44 | 3.38 | 0.10 | 2.04 | 3.74 | 2.78 | 3.66 | 0.17 | 0.01 | 3.06 | 4.72 | 102.48 |
| JL-369 | Diorite | 49.88 | 1.23 | 12.52 | 2.86 | 7.21 | 0.18 | 8.73 | 9.97 | 2.34 | 1.39 | 0.16 | 0.16 | 1.18 | 2.22 | 100.03 |
| JL-375 | Granite | 65.55 | 0.55 | 16.14 | 2.00 | 2.34 | 0.09 | 1.23 | 3.48 | 3.62 | 3.32 | 0.19 | 0.02 | 0.28 | 0.76 | 99.57 |
| JL-407 | Granite | 74.53 | 0.14 | 14.41 | 0.47 | 0.57 | 0.03 | 0.14 | 1.05 | 3.45 | 4.91 | 0.02 | 0.01 | 0.14 | 0.46 | 100.33 |
| DB-145 | Lamp | 45.47 | 1.27 | 11.91 | 3.06 | 4.62 | 0.14 | 8.46 | 7.84 | 1.90 | 6.04 | 1.28 | 0.40 | 2.77 | 5.00 | 100.16 |
| DB-148 | Fol gn | 70.56 | 0.26 | 15.47 | 0.22 | 1.68 | 0.03 | 0.38 | 1.60 | 3.47 | 4.46 | 0.12 | 0.02 | 0.48 | 0.58 | 99.33 |
| DB-149 | Alt. gn | 74.98 | 0.06 | 14.22 | 0.39 | 0.23 | 0.01 | 0.02 | 0.64 | 3.73 | 4.40 | 0.03 | 0.01 | 0.69 | 0.63 | 100.04 |
| DB-152 | Ksp gn | 70.03 | 0.21 | 14.28 | 0.89 | 0.97 | 0.05 | 0.52 | 1.73 | 2.80 | 3.14 | 0.07 | 0.05 | 2.00 | 3.46 | 100.20 |
| DB-250 | plag por | 66.48 | 0.41 | 16.50 | 1.10 | 2.09 | 0.07 | 0.98 | 3.35 | 4.03 | 3.44 | 0.13 | 0.01 | 0.07 | 0.46 | 99.12 |
| DB-274 | Granite | 67.98 | 0.35 | 16.09 | 1.30 | 1.34 | 0.05 | 0.47 | 3.09 | 5.09 | 2.32 | 0.08 | 0.01 | 0.07 | 0.32 | 98.56 |
| DB-294 | Rhy | 76.81 | 0.04 | 12.97 | 0.39 | 0.63 | 0.08 | 0.03 | 0.22 | 2.71 | 4.34 | 0.00 | 0.01 | 0.07 | 1.25 | 99.55 |
| DB-319 | Basalt | 48.37 | 1.63 | 15.76 | 3.27 | 5.30 | 0.15 | 5.32 | 7.83 | 3.02 | 2.67 | 0.53 | 0.04 | 2.00 | 4.17 | 100.06 |
| DB-322 | Granite | 73.44 | 0.17 | 14.27 | 0.66 | 0.87 | 0.03 | 0.30 | 1.24 | 3.11 | 4.52 | 0.05 | 0.01 | 0.90 | 0.65 | 100.22 |
| DB-324 | Granite | 68.09 | 0.49 | 15.20 | 0.89 | 2.07 | 0.08 | 1.21 | 2.56 | 3.33 | 4.11 | 0.18 | 0.01 | 0.07 | 0.87 | 99.16 |
| DB-338 | Diorite | 50.69 | 1.10 | 15.28 | 1.96 | 7.42 | 0.19 | 5.97 | 7.31 | 2.97 | 2.68 | 0.30 | 0.02 | 0.28 | 1.34 | 97.51 |
| DB-350 | Granite | 69.76 | 0.37 | 15.35 | 1.12 | 1.57 | 0.07 | 0.81 | 2.73 | 3.55 | 3.66 | 0.12 | 0.02 | 0.28 | 0.58 | 99.99 |
| DB-400 | Diorite | 50.98 | 0.76 | 11.14 | 0.99 | 5.85 | 0.13 | 9.82 | 6.16 | 2.33 | 3.04 | 0.29 | 0.02 | 0.14 | 6.67 | 98.32 |
| DB-418 | Rhy | 75.90 | 0.04 | 13.16 | 0.78 | 0.54 | 0.05 | 0.11 | 1.26 | 0.10 | 5.10 | 0.00 | 0.02 | 0.55 | 3.09 | 100.70 |
| DB-419 | Basalt | 53.67 | 1.04 | 15.44 | 1.85 | 4.93 | 0.18 | 3.22 | 6.81 | 2.58 | 3.03 | 0.31 | 0.01 | 3.75 | 5.22 | 102.04 |
| MA-264 | Slst | 63.23 | 0.63 | 13.22 | 0.23 | 4.80 | 0.04 | 2.64 | 5.99 | 1.72 | 1.65 | 0.19 | 1.69 | 5.40 | 3.00 | 104.43 |
| MA-269 | Lamp | 50.37 | 0.85 | 14.03 | 1.76 | 8.27 | 0.16 | 7.96 | 8.02 | 3.21 | 1.78 | 0.21 | 0.56 | 0.14 | 1.20 | 98.52 |
| MA-272 | Qtze | 65.71 | 0.35 | 4.77 | 0.18 | 1.35 | 0.07 | 4.90 | 18.64 | 1.23 | 0.13 | 0.27 | 0.01 | 2.77 | 2.85 | 102.87 |
| MA-354 | Granite | 59.24 | 0.82 | 17.48 | 2.03 | 4.05 | 0.13 | 2.15 | 4.82 | 3.93 | 3.34 | 0.33 | 0.04 | 0.14 | 0.85 | 99.35 |
| MA-362 | Qzte | 77.56 | 0.46 | 8.61 | 0.58 | 1.62 | 0.05 | 1.94 | 3.51 | 1.72 | 2.02 | 0.16 | 0.01 | 0.07 | 0.37 | 98.68 |
| MA-370 | Granite | 70.22 | 0.30 | 15.22 | 0.57 | 1.71 | 0.06 | 0.61 | 2.44 | 3.16 | 4.05 | 0.09 | 0.01 | 0.07 | 0.53 | 99.04 |
| MA-389 | Monz | 71.20 | 0.27 | 15.94 | 0.39 | 1.20 | 0.02 | 0.60 | 1.81 | 4.04 | 3.52 | 0.07 | 0.01 | 0.07 | 0.65 | 99.79 |
| MS-36 | Andesite | 40.96 | 1.45 | 10.31 | 3.80 | 5.02 | 0.17 | 8.98 | 12.33 | 1.60 | 3.93 | 1.43 | 0.19 | 4.71 | 7.02 | 101.90 |

Abbreviations: Lamp = lamprophyre, Qtze = quartzite, Slst = siltstone, Grano = granodiorite, Fol gn = foliated granite, Alt. gn = altered granite ("Ladybird granite"), Ksp gn = potassium feldspar granite, plag por = plagioclase porphyry, Rhy = rhyolite, Monz = monzonite.

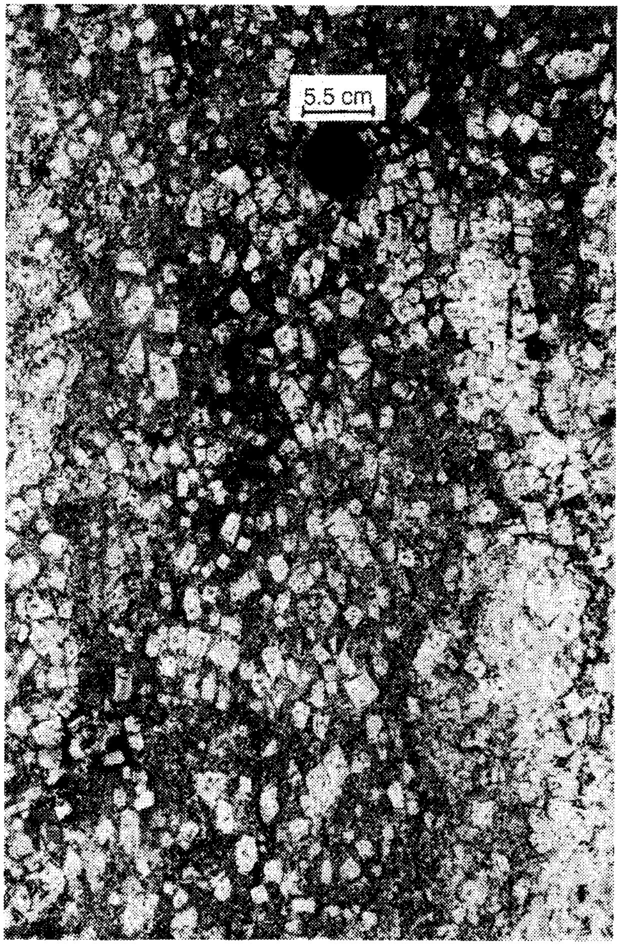



Plate 1. Potassium-feldspar porphyritic phase of Nelson batholith.

**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 biotite 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 82FNW077). It is fine to medium grained, heavy and hard. Biotite blades are up to 2 centimetres long. At Comstock portals, iron carbonate alteration and limonitic weathering are common.

**WHOLE-ROCK GEOCHEMISTRY SUMMARY FOR NELSON PLUTONIC SUITE**

Thirty-three samples, seventeen Nelson batholith and sixteen miscellaneous rocks, collected for major element analysis. Rock type and chemistry are given in Table 2. Conclusions drawn from these analytical results indicate that granitic rocks of the Nelson batholith are: subalkaline (total alkalies versus $SiO_2$ plot) to calc-alkaline (AFM diagram); dominantly metaluminous but locally peraluminous with the Shand (1951) index less than 1.1; and correspond to the Cordilleran I-type classification of granites.

Criteria used to define the Nelson batholith as Cordilleran I-type include the following:

* Field evidence

- Compositional spectrum from diorite to granodiorite.

- Complex, polyphase plutons comprise the batholith.
- Dioritic xenoliths.

However, uncharacteristically, there are no coeval associated volcanic rocks.

* Petrographic evidence

- Hornblende > > biotite (and no muscovite)
- Abundant titanite and lesser magnetite.

* Geochemical evidence

- $SiO_2$ < 70 weight per cent
- Molar $Al_2O_3/(CaO + Na_2O + K_2O) < 1.1$; metaluminous.
- Clinopyroxene normative.

A departure from typical I-type rocks is that $Na_2O$ is only slightly less than $K_2O$, $TiO_2$ content is moderate and the granite is "reduced" with FeO > $Fe_2O_3$.

### Tertiary (?) Intrusive Rocks

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

Andesite dikes are brown-weathering, fine-grained, magnetite-bearing rocks. In the Coffee Pass area, a 3-metre-wide andesite dike is coarsely vesicular with chilled aphanitic margins. Andesite dikes crosscut rhyolite dikes at the Republic mine, 12 kilometres west of the Park boundary (MINFILE 82FNW168). 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 2 and Map 1). 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 siliceous, pelitic and psammitic metasediments. They can be traced over 10 kilometres along strike. Beds dip gently west to southwest; southern exposures are subhorizontal, hence the irregular outcrop pattern (Figure 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 82FNW187). Locally, minor asymmetric folds verge northwards. More competent beds and granitic sills are boudinaged.

Two phases of granite intrusion are evident: an older, deformed granite lacking potassium feldspar megacrysts and 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 82FNW106), 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 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 dikes cut the folded and boudinaged sediments and sills.

Area D, extending north of the park boundary, 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. Pure recrystallized limestone horizons, pelitic and psammitic beds parallel the batholith contact. Sandstone layers contained within the limestone are tightly and 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.


Plate 2. View southeast, down plunge of a folded Nelson granitic sill and siltstone unit, indicating early phases of Nelson batholith were syntectonic.

## Nelson Batholith Deformation

The oldest fabric in the Nelson 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 eastern margin (Fyles, 1967) of the batholith are late-synkinematic with deformed margins. Discrete zones of chlorite-grade proto to ultramylonite occur (less than 50 centimetres wide) in the park. Mylonites are of limited areal extent and their significance is uncertain. Mylonitic granite occurs 5 kilometres north of Woodbury Creek and 2 kilometres northwest of Kaslo Lake (indicated by an "M" on Figure 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 dikes of unknown age. The mylonites near Kaslo Lake dip steeply northwest.

The most prominent fracture system in the Park is a limonitic-weathering brittle fault zone that parallels the mylonite northwest of Kaslo Lake. The altered zone is less than 50 metres wide and hosts the Silver Ranch quartz vein mineralization (MINFILE 82FNW215). The Smuggler and Blackburn deposits also lie parallel to a prominent set of linears (Plate 3). Rocks along these linears are not altered.

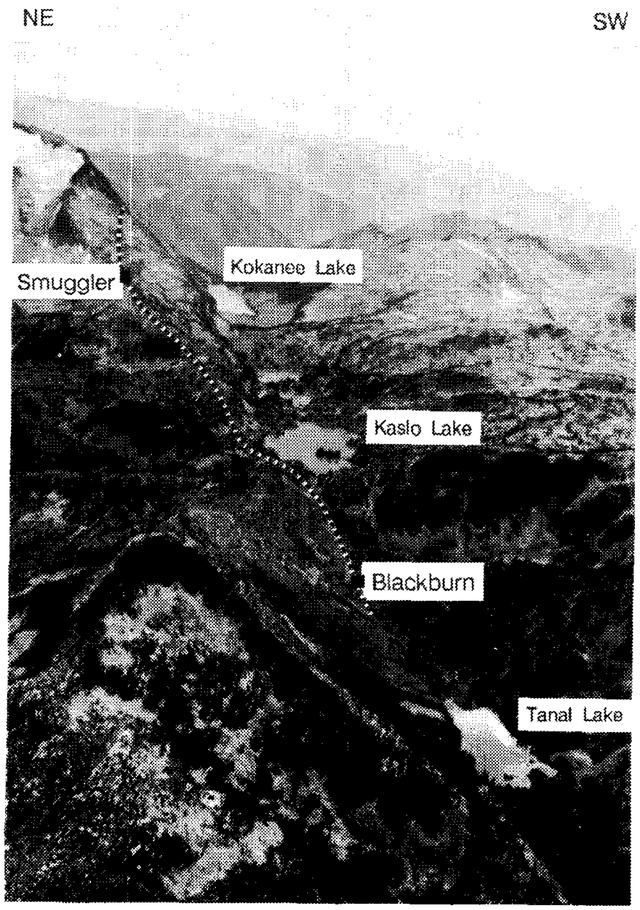



Plate 3. View southeast to the Blackburn and Smuggler deposits which occur northeast of prominent northwest-trending linears. The dashed line indicates the approximate surface trace of the structure that hosts the vein mineralization, the Molly Gibson lies farther northeast than the Smuggler.

## 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

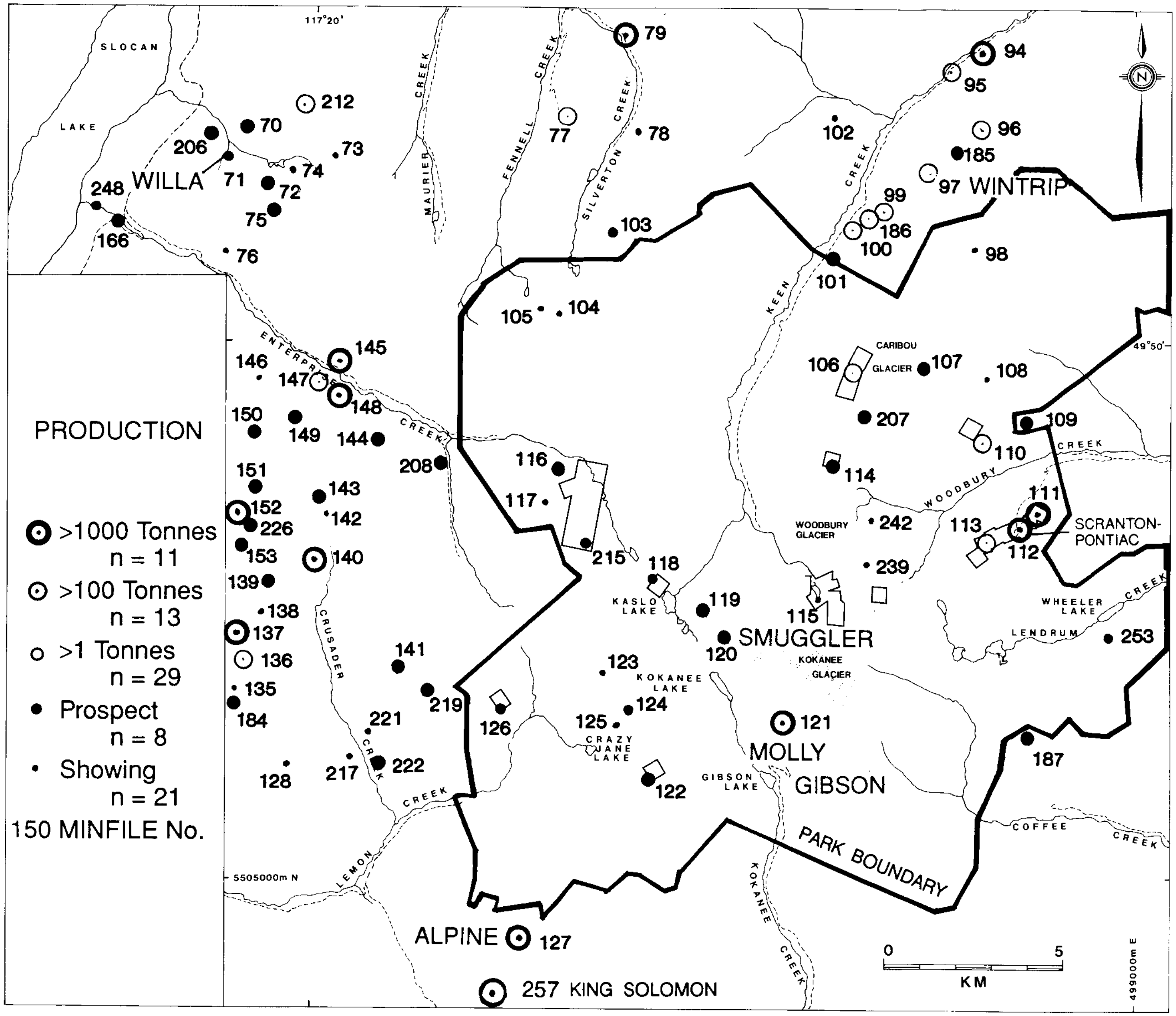



Figure 3. MINFILE numbers and locations for past producers, prospects and showings near Kokanee Glacier Park.

kyanite and sillimanite-bearing rocks occur east of the park, 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 2, 3 and Map 1 a foliated metasedimentary pendant contains sillimanite, staurolite and muscovite. The block may have been derived from deeper structural levels, hence correlative with Fyles' (1967) Lardeau Group (Table 1). Alternatively, Slocan sediments may have reached medium-grade conditions locally, but this has not been documented in the area.

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 around the Mount Carlyle stock is transitional between bathozone 2 and 3.

**TABLE 3**
**DOLLAR VALUE OF PAST PRODUCTION FOR AREAS OF HIGH MINERAL POTENTIAL (SOME DATA IS UNAVAILABLE; FEBRUARY, 1988)**

| METAL | Tonnes | Au | Ag | Pb | Zn | Cu | Cd |
|---|---|---|---|---|---|---|---|
| **METAL PRICE** | | **$550/oz** | **$7.80/oz** | **$0.42/lb** | **$0.56/lb** | **$1.25/lb** | **$3.50/lb** |
| **AREA 1 - SCRANTON/PONTIAC/SUNSET** | | | | | | | |
| **TOTAL = $6,083,549** | | | | | | | |
| Pontiac | 1,160 | 109,450 | 148,699 | 55,765 | 5,419 | | |
| Scranton | 24,597 | 1,959,650 | 842,478 | 1,183,311 | 1,495,237 | 3,611 | 106,880 |
| Sunset | 145 | 41,250 | 78,562 | 53,237 | | | |
| **TOTAL =** | **25,902** | **2,110,350** | **1,069,739** | **1,292,313** | **1,500,656** | **3,611** | **106,880** |
| **AREA 2 - ALPINE** | | | | | | | |
| **TOTAL = $6,420,271** | | | | | | | |
| Alpine | 15,551 | 6,298,050 | 55,528 | 45,600 | 21,093 | | |
| **AREA 3 - MOLLY GIBSON** | | | | | | | |
| **TOTAL = $9,907,465** | | | | | | | |
| Molly Gibson | 55,680 | 6,600 | 7,750,283 | 2,096,455 | 11,411 | | |
| Smuggler | | 13 | 30,139 | 7,644 | | | |
| Slocan Chief | 4 | | 4,493 | 440 | | | |
| **TOTAL =** | **55,877** | **6,600** | **7,784,915** | **2,104,539** | **11,411** | | |
| **AREA 10 - REVENUE** | | | | | | | |
| **TOTAL = $252,517** | | | | | | | |
| Revenue | 244 | 3,850 | 159,401 | 63,737 | 25,529 | | |
| **AREA 11 - ONTARIO/BALTIMORE** | | | | | | | |
| **TOTAL = $515,271** | | | | | | | |
| Ontario | 156 | 550 | 406,942 | 13,754 | | | |
| Baltimore | 60 | 550 | 88,280 | 5,195 | | | |
| **TOTAL =** | **216** | **1100** | **495,222** | **18,949** | | | |

**+ Sun, Para, Silvercup (4 tonnes), Violet (4 tonnes), Oro Fino (4 tonnes), and Boomerang (3 tonnes) = $60,973**

**GRAND PARK TOTAL = $17 million (excluding Alpine)**
**82,254 tonnes**

Metal prices for February, 1988; $1.00 Can. = $0.80 U.S.

# MINERAL OCCURRENCES

Regionally Kokanee Glacier Park lies between three distinct and historic mining camps. Deposits in the park contain mineralogic, isotopic and geometric characteristics of each. Vein attitude, host lithology, grades and production data are presented in Tables 4 and 5. There are more deposits around the perimeter of the park than within it, as indicated by the regional distribution of mineral occurrences (Figure 3).

The Sandon camp, about 15 kilometres north of the park, is characterized by mesothermal vein deposits hosted by Slocan Group sediments. Sediment-hosted deposits are generally lead and zinc-rich, with a siderite and quartz gangue. They average between 10 000 and 100 000 tonnes of ore mined. Production exceeds 3.5 million tonnes from 172 producers that yielded 1814 tonnes of silver and 217 464 tonnes of lead. Zinc records are incomplete. The Dickenson mine is the only mine that remains in operation today.

The Ainsworth camp, 10 kilometres east of the park, comprises a number of stratabound replacement bodies hosted in Paleozoic to Mesozoic metasedimentary and metavolcanic rocks (Fyles, 1967). Production of approximately 700 000 tonnes from 75 producers yielded 177 tonnes of silver and 55 123 tonnes of lead. Smelter penalties for zinc resulted in inaccurate records. All mines are now abandoned.

The Slocan City mining camp, 15 kilometres west of the park, contains mostly mesothermal veins enriched in gold and hosted in various phases of the Nelson batholith. A few sedimentary pendants occur which contain skarn and/or vein mineralization. Batholith-hosted veins are generally low in base metal sulphide content and relatively enriched in silver minerals in a quartz gangue. Production exceeds 78 000 tonnes from 72 producers, that yielded 154 tonnes of silver and 3531 tonnes of lead.

The Willa gold-copper deposit, west of the park, is in a breccia pipe in Rossland volcanic rocks in a roof pendant in the Nelson batholith. It is economically significant and is currently being developed for production. South of the park, near Nelson and the West Arm of Kootenay Lake, the area is devoid of mineral occurrences.

## MINERAL DEPOSITS IN KOKANEE GLACIER PARK

There are fifteen past producers within Kokanee Glacier Park; all are plotted on Map 3 and 4. Each deposit, in order of importance, is described below from 1987 field observations, MINFILE records and data in Little (1960). They are all batholith-hosted mesothermal quartz veins. The total dollar value of all mining in the park over the last century is about 17 million Canadian dollars (based on February, 1988 metal prices; Table 3). Vein characteristics are listed in Tables 4 and 5.

### MOLLY GIBSON MINE (MINFILE 82FNW121)/ SMUGGLER (MINFILE 82FNW120)/ SLOCAN CHIEF (MINFILE 82FNW119)/ BLACKBURN (MINFILE 82FNW118)

The Molly Gibson mine was developed on a mineralized fissure hosted by potassium-feldspar porphyritic granite. It was the largest producer in the park (Table 3) and follows a northwest-striking joint set, in contrast to the general northeast strike of most productive veins of the region. The northwest-striking vein system is over 6 kilometres long, hosting the Molly Gibson, Smuggler, Slocan Chief and Blackburn deposits.

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 property 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 of silver, 2300 tonnes of lead and 9 tonnes of zinc. Ninety per cent of the production was completed by 1913.

Underground workings explored two veins, the Florence and Aspen, striking 145 degrees and dipping 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. 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

## TABLE 4
## VEIN CHARACTERISTICS OF MINES WITH MORE THAN ONE TONNE PRODUCTION

| MINFILE 82FNW- | Property | Production (Tonnes) | Recovered grade Au (g/t) | Ag (g/t) | Pb (%) | Zn (%) | Host lithology | Vein attitude |
|---|---|---|---|---|---|---|---|---|
| 94 | Cork Province | 191441 | 0.10 | 850 | 30.54 | 47.19 | Pelitic phy/sch | 050/65 SE |
| **121** | **Molly Gibson** | **55860** | **<0.01** | **556** | **4.05** | **0.02** | **K-spar por gn** | **154/67 SE** |
| 152 | Arlington | 19217 | 0.04 | 1635 | 4.48 | 0.62 | K-spar por gn | 034/67 SE |
| 127 | Alpine | 15551 | 22.90 | 14 | 0.32 | 0.11 | Quartz monz | 270/30 N |
| 148 | Enterprise | 10687 | 0.02 | 3058 | 15.67 | 9.89 | K-spar por gn | 056/72 SE |
| **112** | **Scranton** | **24587** | **14.40** | **430** | **15.72** | **14.88** | **Hb por gn** | **035/20 SE** |
| 145 | Westmont | 3149 | 0.65 | 3520 | 6.34 | 2.09 | K-spar por gn | 060/75 SE |
| 137 | Meteor | 2645 | 4.97 | 1780 | 0.02 | 0.03 | K-spar por gn | 285/35 NE |
| 140 | Slocan Prince | 1754 | 0.00 | 3482 | 3.45 | 0.19 | K-spar por gn | 205/20 NW |
| **111** | **Pontiac** | **1160** | **5.34** | **511** | **6.41** | **0.38** | **Hb por gn** | **025/20 SE** |
| 79 | Fisher Maiden | 1132 | 0.03 | 2049 | 5.21 | 5.29 | K-spar por gn | 170/75 W |
| 95 | Black Fox | 886 | 0.21 | 60 | 0.66 | 8.40 | Pelitic phy/sch | 060/65 SE |
| 96 | Bismark | 868 | 0.00 | 2862 | 4.98 | 0.00 | Pelitic phy/sch | 235/70 NW |
| 186 | Silverbell | 644 | 0.00 | 3956 | 16.36 | 1.73 | Pelitic phy/sch | east/low |
| 97 | Wintrip | 613 | 0.10 | 599 | 16.93 | 8.37 | Pelitic phy/sch | 225/75 NW |
| 147 | Neepawa | 461 | 0.00 | 4002 | 2.00 | 0.16 | K-spar por gn | -- |
| 100 | Silverbear | 459 | 0.20 | 1723 | 2.23 | 1.94 | Pelitic phy/sch | 040/65 SE |
| 77 | Comstock | 456 | 0.07 | 3114 | 37.19 | 0.00 | Qtz monz/lamp | 070/40 SW |
| **106** | **Revenue** | **244** | **0.89** | **2605** | **28.21** | **8.47** | **Hb por gn** | **195/80 NW** |
| 212 | LH | 196 | 17.61 | 10 | 0.00 | 0.00 | Meta sed/vol | 270/55 N |
| 99 | BNA | 173 | 1.14 | 2748 | 6.64 | 6.57 | Pelitic phy/sch | 200/85 NW |
| 136 | Howard Fraction | 162 | 5.57 | 1026 | 0.00 | 0.00 | K-spar por gn | 270/12 N |
| **113** | **Sunset** | **145** | **16.09** | **2160** | **39.65** | **0.00** | **Hb por gn** | **030/65 SE** |
| **110** | **Ontario #2** | **143** | **0.22** | **11421** | **10.52** | **0.05** | **Hb por gn** | **255/60 N** |
| 143 | Hampton | 90 | 0.00 | 16817 | 0.00 | 0.00 | K-spar por gn | NE/steep |
| 150 | Bondholder | 63 | 0.00 | 7124 | 6.98 | 0.00 | K-spar por gn | 065/58 SW |
| **109** | **Baltimore** | **60** | **0.52** | **5867** | **9.35** | **0.22** | **Hb por gn** | **250/80 NE** |
| 141 | Marmion | 50 | 28.00 | 144 | 0.05 | 0.03 | K-spar por gn | -- |
| 70 | Little Daisy | 44 | 64.80 | 62 | 0.00 | 0.00 | Feld por | |
| 153 | Lily B | 41 | 0.76 | 2748 | 5.63 | 0.00 | K-spar por gn | 090/55 S |
| 226 | Silver Leaf | 40 | 0.00 | 19 | 14.50 | 15.67 | K-spar por gn | 065/84 SW |
| 184 | Joan | 38 | 0.82 | 130 | 0.40 | 0.00 | K-spar por gn | -- |
| **207** | **Sun** | **31** | **0.00** | **2729** | **39.80** | **0.00** | **Hb por gn** | **--** |
| 151 | Speculator | 26 | 0.00 | 986 | 22.87 | 1.59 | K-spar por gn | 034/67 SE |
| 208 | Mary/Jumbo | 25 | 6.24 | 660 | 6.30 | 6.66 | K-spar por gn | -- |
| 101 | Index | 20 | 0.00 | 1967 | 44.31 | 9.47 | Pelitic phy/sch | 125/85 SW |
| 222 | Gem | 19 | 37.63 | 1660 | 0.00 | 0.00 | K-spar por gn | -- |
| 185 | Gold Cure | 18 | 0.00 | 3456 | 50.40 | 0.00 | Pelitic phy/sch | 040/80 SE |
| 144 | Riverside | 18 | 0.00 | 1534 | 2.52 | 2.33 | K-spar por gn | 225/75 NW |
| 139 | Alice S | 15 | 0.00 | 2745 | 14.81 | 0.00 | K-spar por gn | 070/85 SE |
| 166 | Kalispell | 15 | 0.00 | 8230 | 2.15 | 0.95 | Peltie/psammite | 020/55 SE |
| **105** | **Para** | **15** | **0.68** | **4064** | | **4.09** | **Qtz monzonite** | |
| **120** | **Smuggler** | **13** | **0.00** | **9244** | **63.00** | **0.00** | **K-spar por gn** | **150/80 SW** |
| 75 | Highland LGT | 10 | 0.00 | 8839 | 0.00 | 0.00 | K-spar por gn | 310/75 NE |
| 206 | Get Th Eli | 9 | 13.78 | 11769 | 0.00 | 0.00 | Meta sed/vol | 345/15 NE |
| 187 | Olsen | 8 | 3.88 | 3483 | 11.32 | 13.25 | K-spar por gn | 260/18 N |
| 219 | Alexandria 2 | 6 | 4.50 | 3990 | 4.80 | 0.25 | K-spar por gn | -- |
| **107** | **Violet** | **4** | **0.00** | **8157** | **12.10** | **0.00** | **Hb por gn** | **040/85 SE** |
| **114** | **Silvercup** | **4** | **7.75** | **1104** | **22.27** | **2.95** | **Hb por gn** | **184/84 SW** |
| **119** | **Slocan Chief** | **4** | **0.00** | **4478** | **57.58** | **0.00** | **K-spar por gn** | **130/40 SW** |
| **122** | **Oro Fino** | **4** | **15.50** | **241** | **1.20** | **2.80** | **K-spar por gn** | **029/63 SE** |
| 149 | Mabou Ohio | 4 | 0.00 | 1197 | 3.40 | 4.95 | K-spar por gn | 055/70 SE |
| **116** | **Boomerang** | **3** | **0.00** | **1493** | **4.03** | **4.10** | **K-spar por gn** | **355/80 E** |
| 72 | Ag nugget | 1 | 0.00 | 7060 | 0.00 | 0.00 | Meta sed/vol | 063/65 SW |

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 and schist and limestone, Hb por = hornblende porphyritic, Qtz monz/lamp = quartz and lamprophyre, Meta sed/vol = metasedimentary and metavolcanic rocks, Feldspar por = feldspar porphyry. Names in **BOLD** are properties located in Kokanee Glacier Park.

**TABLE 5**
**VEIN CHARACTERISTICS OF PROSPECTS AND SHOWINGS LISTED IN MINFILE**
**(RESULTS ARE FROM GRAB SAMPLE ANALYSES)**

| MINFILE 82FNW- | Property | Host | Au (g/t) | Ag (g/t) | Pb (%) | Zn (%) | Cu (ppm) | Mo (ppm) |
|---|---|---|---|---|---|---|---|---|
| **118** | **Blackburn** | **K-spar** | **0.01** | **0.38** | **16.4** | **4.8** | **188** | **<10** |
| | | | **0.13** | **0.25** | **3.1** | **3.6** | **244** | **70** |
| | | | **0.15** | **0.51** | **1.1** | **12.1** | **670** | **<10** |
| **126** | **Barnett** | **K-spar** | **1.8** | **0.14** | **0.34** | **0.03** | **29** | **<10** |
| | | | **6.9** | **0.11** | **0.14** | **tr** | **8** | **<10** |
| | | | **3.3** | **0.50** | **0.10** | **tr** | **9** | **<10** |
| **215** | **Silver ranch** | **K-spar** | **20** | **48** | **0.93** | **1.7** | **33** | **<10** |
| | | | **0.30** | **5** | **0.32** | **0.26** | **12** | **<10** |
| | | | **21** | **135** | **3.2** | **0.89** | **91** | **<10** |
| **253** | **Al** | **K-spar** | **26.0** | **170** | **15.9** | **3.3** | **57** | **<10** |
| | | | **0.35** | **9** | **0.03** | **0.01** | **7** | **<10** |
| | | | **1.0** | **26** | **3.1** | **2.0** | **11** | **<10** |
| | | | **0.21** | **2** | **0.06** | **0.04** | **6** | **<10** |
| | | | **7.9** | **91** | **18.3** | **8.4** | **640** | **<10** |
| 248 | Kalappa | Fol. gn | <0.02 | 2.0 | 0.02 | tr | 15 | 10 |
| | | | 0.97 | 23.0 | tr | 0.01 | 72 | 42 |
| | | | 0.02 | 0.5 | tr | tr | 62 | <10 |
| **124** | **Silver Crest** | **K-spar** | | | | | | |
| 103 | Fairmont | K-spar | | | | | | |
| 102 | Glue Pot | K-spar | | | | | | |
| **104** | **Christina** | **K-spar** | **<0.02** | **5.9** | **0.01** | **0.19** | **25** | **<10** |
| **108** | **Cable** | **Hb por gn** | **0.05** | **9** | **tr** | **0.01** | **12** | **<10** |
| **115** | **Joker** | **K-spar** | **3.80** | **42** | **0.94** | **0.44** | **57** | **<10** |
| **117** | **Gold Galena** | **K-spar** | | | | | | |
| **123** | **Hudson Bay** | **K-spar** | **2.40** | **490** | **0.26** | **0.30** | **45** | **<10** |
| **125** | **Soldier Boy** | **K-spar** | | | | | | |
| 073 | Silver Band | K-spar | | | | | | |
| **239** | **Black Eagle** | **K-spar** | | | | | | |
| 074 | Mtn Scenery | K-spar | | | | | | |
| **098** | **Nome** | **Hb-por gn** | **0.01** | **3** | **tr** | **tr** | **79** | **<10** |
| 076 | Daisy | K-spar | | | | | | |
| 142 | Bond River | K-spar | 0.90 | 0.16 | 4.5 | 9.58 | 1300 | <10 |
| 078 | Lou Dillion | K-spar | | | | | | |
| 128 | Crusader | K-spar | | | | | | |
| 217 | Gold Reef | K-spar | | | | | | |
| **242** | **King Solomon** | **K-spar** | | | | | | |
| 135 | Tailholt | K-spar | | | | | | |
| 138 | Elk | K-spar | | | | | | |
| 146 | Dalhousie | K-spar | | | | | | |
| 257 | King Solomon | Qtz monz | | | | | | |

Abbreviations:
Fol. gn = foliated granite; Hb por gn = hornblende-potassium feldspar porphyritic granite; K-spar = potassium feldspar porphyritic granite; tr = trace; volc br = volcanic breccia; - = no analysis. Names in **bold** are in Kokanee Glacier Park.

pyrite, coarser euhedral to subhedral arsenopyrite and in places chalcopyrite.

Vein gangue is chiefly manganese-rich siderite that weathers to a bluish black, and 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 grab samples from the hangingwall, vein and footwall at 3-level portal (1940 metre elevation) and from the dump below the 1790-metre level crosscut are given in Table 6.

TABLE 6
MOLLY GIBSON MINE ANALYTICAL RESULTS

| Sample | Au (ppb) | Ag (ppm) | Cu (ppm) | Pb (%) | Zn (%) | Mo (ppm) |
|---|---|---|---|---|---|---|
| 2-1 (5880 level) | 820 | 940 | 1200 | 9.3 | 4.1 | <10 |
| 170-1 (3-level) | <10 | 29.2 | 42 | 0.3 | 0.1 | <10 |
| 170-2 (3-level) | 510 | 2300 | 2050 | 9.1 | 3.9 | 32 |
| 170-3 (3-level) | 50 | 445 | 338 | 1.6 | 0.6 | 18 |

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

The Smuggler workings, 2 kilometres northwest and on strike with the Molly Gibson veins produced 13 tonnes of ore. 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. The Slocan Chief, located 1 kilometre northwest of Smuggler, produced 4 tonnes of ore. The Blackburn occurrence, with no recorded production, lies about 2 kilometres northwest of Slocan Chief. Similar mineralogy, structural continuity and similar lead isotope ratios (Logan *et al.*, 1988) suggest Molly Gibson, Smuggler, Slocan Chief and Blackburn are part of the same vein system.

## SCRANTON, PONTIAC, SUNRISE AND SUNSET (MINFILE 82FNW-112,111,113)

The Scranton, Pontiac, Sunrise and Sunset deposits 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 25 900 tonnes which yielded 125 676 grams gold, 4.4 million grams silver, 1313 kilograms copper, 1400 tonnes lead, 1200 tonnes zinc and 14 tonnes cadmium (Table 3). 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. Minor amounts of biotite-grade thinly bedded metasiltstone, meta-argillite and recrystallized limestone outcrop on the Scranton claims and quartzite was intersected in underground workings.

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 striking northeast to east; 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. Mineralization is predominantly pyrite, up to 35 per cent, with lesser galena and sphalerite stringers and blebs in a fractured quartz gangue. The inaccessible lower Pontiac workings, at the 1920-metre elevation, follow a quartz vein striking between 025 and 045 degrees. 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 (2-3 per cent) finely disseminated pyrite (Table 7, 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. Erratic, high grade gold values suggest free gold occurs in the veins (Table 7).

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. 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).

TABLE 7
SCRANTON/PONTIAC/SUNSET MINE ANALYTICAL RESULTS

| Sample | Au (g/t) | Ag (g/t) | Cu (ppm) | Pb (%) | Zn (%) | Mo (ppm) |
|---|---|---|---|---|---|---|
| 275 a | 1.1 | 420 | 51 | 15.4 | 3.5 | <10 |
| 277 b | 0.15 | 5 | 4 | 0.1 | 0.1 | <10 |
| 278 b | 180.0 | 165 | 4 | 1.0 | tr | <10 |
| 279 b | 32.0 | 310 | 62 | 21.2 | 13.8 | <10 |
| 281 c | 7.9 | 245 | 23 | 18.7 | 10.0 | <10 |
| 283 d | 3.0 | 1300 | 50 | 20.9 | 3.9 | <10 |
| 287 e | 2.1 | 440 | 212 | 12.0 | 12.0 | <10 |
| 291 f | 41.0 | 220 | 204 | 12.3 | 5.6 | <10 |

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

## REVENUE (MINFILE 82FNW106)

The Revenue mine is on the north side of Sturgis Creek, a tributary of Keen Creek. It is accessible via an overgrown trail from Keen Creek road. Sporadic production between 1913 and 1941 yielded 244 tonnes of ore containing 217 grams gold, 635 620 grams silver, 68.8 tonnes lead and 20.7 tonnes zinc. Workings consist of four collapsed adits and a few surface trenches. Cairnes (1935) reported over 200 metres of tunnelling had been completed by June, 1927.

The quartz veins are hosted in unaltered hornblende potassium-feldspar porphyritic granite with hornblende diorite xenoliths. The veins are less than 150 centimetres wide and strike about 020 degrees and dip steeply southeast. Mineralization consists of sphalerite-rich layers and pods in quartz veins with patches of galena. Disseminated and massive pyrite is also present in the veins. Limonitic fractures parallel the vein, across a zone less than 3 metres wide.

## ONTARIO NO. 2 (MINFILE 82FNW110)/ BALTIMORE (MINFILE 82FNW109)

The Ontario No. 2 and Baltimore workings are located north of Woodbury Creek on the west and east sides of Silver Spray Creek respectively. Both workings apparently explored the same east-northeast-trending lode structure. The Ontario workings lie within the park adjacent to Crown Granted Claim (lot number 3182). The Baltimore claims, 1 kilometre to the east are outside the eastern boundary of the park.

Production from the Ontario between 1907 and 1921 totalled 156 tonnes of ore and yielded 31 grams gold, 1792 kilograms silver and 15 600 kilograms lead. Production from the Baltimore from 1902 to 1907 and 1954 totalled 60 tonnes of ore and yielded 31 grams gold, 352 025 grams silver, 5.6 tonnes lead and 131 kilograms zinc.

The lode structure is strongly sheared, strikes 255 degrees, dips 75 degrees north and is hosted by hornblende potassium-feldspar porphyritic granite. Narrow blocks of muscovite-biotite schist and psammite occupy sections of the hangingwall and footwall in the Baltimore workings. Mineralization occupies quartz breccia veins and comprises galena, pyrite, sphalerite and silver minerals as massive and irregular disseminations.

The Baltimore workings are mainly shallow surface trenching. Cairnes (1935), reports a 33 metre shaft connected to an adit (now caved) which explores the vein for 75 metres of strike length. On surface the vein can be traced for well over 100 metres. The Ontario workings now inaccessible, include two adits 30 metres apart vertically and comprise about 500 metres of development work. Considerable stoping is reported to have been completed above the lower level.

## SUN (MINFILE 82FNW207)

The Sun is located 1 kilometre south of the Revenue mine. It produced 31 tonnes of ore, 84.6 kilograms silver and 12.3 tonnes lead. The workings were not visited during the 1987 field season.

## PARA (MINFILE 82FNW105)/ CHRISTINA (MINFILE 82FNW104)

The Para and Christina workings are situated on the west and east flanks of Paupo Mountain, in the northwest corner of the park. Production from the Para totalled 15 tonnes of ore, no grade is recorded.

Both explore narrow (up to 50 centimetre) north-striking steeply dipping vein cutting coarse grained potassium-feldspar porphyritic granite. Mineralization comprises pyrite, sphalerite and galena in a banded quartz gangue containing finely disseminated sulphides. Tetrahedrite, chalcopyrite and pyrargyrite have been reported (Cairnes, 1935). A grab sample of stockpiled massive sphalerite ore at the Para assayed 1.0 gram per tonne gold, 1750 grams per tonne silver, 2.16% lead and 36.5% zinc.

## VIOLET (MINFILE 82FNW107)

The Violet workings occupy the divide between Mount McQuarrie and Sunset Mountain at 2562 metres elevation and are accessible by the Silver Spray trail from Woodbury Creek. Production in 1921 totalled 4 tonnes which yielded 29 561 grams silver and 471 kilograms lead.

Underground workings include two adits connected by a 20-metre raise, crosscuts and stopes which total less than 75 m, all presently inaccessible. The workings follow a shear zone 2 to 5 metres wide striking 040 degrees and dipping 85 degrees southeast in coarse grained hornblende potassium feldspar porphyritic granite.

Mineralization occurs in quartz stringers and veins within the argillic-altered lode and comprises galena, pyrite, lesser sphalerite with freibergite and silver sulphides.

### Silver Cup (Minfile 82FNW114)

The Silver Cup is located 1.5 kilometres southwest of the Sun workings. Silver Cup produced 4 tonnes of ore in 1940 that yielded 31 grams gold, 4417 grams silver, 891 kilograms lead and 118 kilograms zinc.

Mineralized quartz and carbonate veins are hosted in a limonitic fracture zone that is less than 7 metres wide. Veins on surface are less than 5 centimetres wide. Brecciated clay-altered wallrock, hornblende potassium-feldspar porphyritic granite, occurs within veins. Mineralization comprises coarse sphalerite and galena in a gangue of coarse pink and white carbonate.

### Oro Fino (Minfile 82FNW122)

The Oro Fino workings occupy a 25 hectare claim located at the headwaters of Nilsik Creek, south of Sunset and Outlook Mountains. Production in 1940 totalled 4 tonnes and yielded 62 grams gold, 964 grams silver, 48 kilograms lead and 112 kilograms zinc.

Development work includes two adits at the 2086-metre and 2118-metre elevations and surface trenching at 2196 metres elevation outlining a strike length of approximately 100 metres. The quartz vein occupies a tight fracture in potassium feldspar-porphyritic granite which strikes 030 degrees and dips 65 degrees southeast. Vein mineralogy comprises pyrite, sphalerite and galena: stronger mineralization is associated with smoky quartz. Wallrock is oxidized and altered to sericite and argillite assemblages up to 10cm on either side of the vein.

A grab sample of mineralized vein material stockpiled at the upper portal returned 24 grams per tonne gold, 380 grams per tonne silver, 2.8% lead and 3.8% zinc. Altered wallrock sampled from directly inside the lower portal returned 0.11 gram per tonne gold, 8 grams per tonne silver, trace lead and 0.01% zinc. Assay sample results from the surface trenching are given in Table A.

### Boomerang (Minfile 82FNW116)

The Boomerang is situated on Enterprise Creek, 3 kilometres west of the park boundary. It produced 3 tonnes of ore in 1956 that yielded 4479 grams silver, 121 kilograms lead and 123 kilograms zinc. The vein was explored by two adits, about 30 metres vertically apart (Cairnes, 1935).

The narrow mineralized quartz vein is hosted by potassium-feldspar porphyritic granite. Zones of argillic alteration, limonitic weathering and locally silicification occur adjacent to the main fault that hosts the quartz vein. Mineralization is sparse but includes galena, light coloured sphalerite, pyrite and reportedly native silver and argentite. The vein strikes north and dips about 80 degrees east.

## MINERAL DEPOSITS OUTSIDE KOKANEE GLACIER PARK

Five other deposits, Cork Province, Wintrip, Alpine, Enterprise, and Westmont, are included in this discussion because they occur within 5 kilometres of the park boundary (Map 4) and they had significant production (Table 4).

### Cork Province Mine (Minfile 82FNW094), Wintrip (Minfile 82FNW097)

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

The Cork Province workings are located south of Keen Creek and north of the park boundary. The first shipment of ore was recorded in 1900. Over the life of the mine, a total of 191,411 tonnes of ore yielded 1896 grams gold, 16 278 kilograms silver, 5846 tonnes lead, 9034 tonnes zinc and 69 900 kilograms cadmium. Most production occurred in two periods, from 1915 to 1929 and 1949 to 1965. The workings have since collapsed and are now inaccessible.

The Slocan Group metasediments comprise recrystallized limestone, biotite and andalusite schists and, in places, carbonaceous and thinly bedded argillite and quartzite. The Nelson batholith contact lies approximately 500 metres to the north of the workings. The fissure-filled lodes are sheared and brecciated zones, about 0.5 to 2 metres wide with some disseminated sulphides in the wallrocks. Mineralization is composed of disseminated sphalerite, galena, pyrite and minor chalcopyrite. The gangue consists dominantly of carbonate, minor quartz and wallrock fragments.

The Wintrip workings are located 4 kilometres southwest of the Cork Province mine within the sedimentary re-entrant. The first shipment of hand-sorted 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 kilograms silver, 104 tonnes lead and 57 tonnes zinc. Most production occurred from 1926 to 1928. The workings have since collapsed and are 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.

## Alpine Mine (Minfile 82FNW127), King Solomon (Minfile 82FNW257)

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 15 551 tonnes was mined and yielded 356 162 grams gold, 221 453 grams silver, 49 tonnes lead, and 17 tonnes zinc. Granges Exploration Ltd. drilled the vein in October and November, 1987.

The quartz vein strikes 255 degrees and dips moderately north, is traceable over 400 metres on surface and projects into the park. 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 2). Pre-mineralization aplite and pegmatite dikes are common; post-mineralization lamprophyre dikes 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. Vein 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 8. The Alpine and King Solomon contain anomalous gold values with coincident zinc.

TABLE 8
ALPINE MINE ANALYTICAL RESULTS

| Sample | Au (g/t) | Ag (g/t) | Cu (ppm) | Pb (%) | Zn (ppm) | Mo (ppm) |
|---|---|---|---|---|---|---|
| 391A | 19.2 | 6 | 6 | 0.10 | 221 | <10 |
| 394A | 50.0 | 7 | <2 | 0.68 | 2000 | <10 |
| 395A | 19.8 | 1 | <2 | 0.01 | 47 | 176 |
| 397A | 1.6 | 3 | <2 | 0.07 | 53 | 78 |
| 404B | 2.8 | 8 | <2 | 0.86 | 60 | <10 |
| 406B | 150.0 | 55 | <2 | 3.00 | 11000 | <10 |

Analytical results for grab samples. Locations: A = Alpine and B = King Solomon.

The King Solomon is situated 2 kilometres southwest of the Alpine. Published references to this property are unknown and it was Eric Denny (prospector from Nelson, B.C.) who identified the workings to the authors. The quartz vein occupies a shear zone 0.15 metre wide cutting quartz monzonite. The vein has sharply defined hangingwall and footwall contacts and strikes east with a shallow north dip. Vein mineralogy is similar to the Alpine vein with slightly more galena and sphalerite.

## Enterprise (Minfile 82FNW148), Westmont (Minfile 82FNW145)

The Enterprise property is located 4 kilometres west of the park, on the south side of Enterprise Creek; the Westmont/Eastmont property is on the north side of the creek. Enterprise production occurred over 81 years, the first shipments were made in 1896. From 10 687 tonnes of ore mined, 217 grams gold, 32 676 kilograms silver, 1675 tonnes lead and 1057 tonnes zinc were recovered. At the Westmont 3149 tonnes of ore was produced which yielded 2 046 grams gold, 11 084 kilograms silver, 200 tonnes lead and 66 tonnes zinc. Arctex Engineering Ltd. has carried out continuous exploration on the Enterprise property since 1983. Diamond-drilling programs were completed in 1986 and 1987.

Two parallel veins outcrop on the Enterprise property. The western vein has received recent drilling exploration, the main vein 115 metres to the east is historically more important having produced the bulk of past production. It is continuous over 680 metres horizontal distance and developed over a vertical distance of 300 metres. Country rock is potassium-feldspar megacrystic granite commonly with xenoliths of diorite, in places comprising up to 40 per cent. The vein strikes about 055 degrees, dips 70 degrees southeast and varies in width up to 0.6 metre, averaging 0.3 metre.

The distribution of sulphide and gangue minerals indicates a vertical zoning pattern within the vein system. Quartz decreases downward into a more carbonate-rich siderite and calcite mineralogy. Sulphide assemblages also change from galena and tetrahedrite-rich upper sections to more sphalerite-rich at depth.

At the Westmont property the main lode strikes 060 degrees, dips 75 degrees southeast, averages 1.2 metres in width and comprises a zone of brecciated and silicified country rock. Sulphide mineralogy includes galena, sphalerite, pyrite, tetrahedrite and silver sulphosalts.

## PROSPECTS AND SHOWINGS IN KOKANEE GLACIER PARK

Mineral occurrences in the park are described below and plotted on Map 4. Of the 14 mineral occurrences, Al and Silver Ranch contain elevated gold values in grab sample assays.

The Al (82FNW253) showing is located approximately 1 kilometre south of Wheeler Lake in potassium-feldspar porphyritic granite. This is a relatively recent discovery which has received only cursory trenching and soil sampling. Elevated gold values have been obtained from grab sampling in sloughed trenches. The quartz veins are less than 5 centimetres thick, base metal-rich and occupy a northerly trending argillic-altered zone 15 centimeters wide. Vein mineralogy comprises galena, sphalerite and pyrite. Grab sample analyses are listed in Table 5.

The Silver Ranch vein (82FNW215) occupies a sheared and faulted northwest-trending joint set located on the east flank of Boomerang Mountain. Mineralization is covered by crown grants, over which a hand trenching and sampling program was completed in 1987. The quartz vein is up to 1 metre thick and occupies a 5-metre-wide clay and limonite-altered zone in potassium feldspar porphyritic granite. Mineralization comprises coarse-grained pyrite, intergrown galena and sphalerite and silver minerals, grab sample analyses are listed in Table 5.

Four additional mineral occurrences are distributed along regional structures parallel to the Silver Ranch vein system. These include the Hudson Bay (82FNW123), Silver Crest (82FNW124), Soldier Boy (82FNW125) and Gold Galena (82FNW177). Mineralization comprises galena, sphalerite, pyrite and various silver minerals, in quartz veins (generally <15 centimeters wide) and flanked by limonitic and argillic-altered wallrocks.

The Joker (82FNW115) is located on the east side of Joker Lake at the head of Keen Creek. The crown grants cover workings begun before 1900 and include four or more adits (now caved) which tested quartz veins containing base and precious metals. A lower vein at the southeast end of the lowest Joker Lake strikes 055 degrees, dips 85 degrees southeast and carries traces of disseminated galena and tetrahedrite. At the uppermost lake another vein striking 015 degrees, dips 60 degrees southeast contains disseminated pyrite, galena, sphalerite and chalcopyrite. The veins are narrow (less than 10 centimetres wide) hosted by potassium-feldspar porphyritic granite.

The Barnett (82FNW126) crown grant is situated 1 kilometre north of McGuire Creek on the east side of Mount Ruppel. The vein has been tested by three short exploratory adits and over 450 metres of surface stripping. The quartz vein follows a flat sheared and altered joint plane in potassium-feldspar porphyritic granite. Vein mineralogy comprises pyrite, galena and tetrahedrite in massive, banded and drusy varieties of quartz. A 75-centimetre argillic and sericitic alteration envelope contains sparse disseminated sulphides that reportedly carry gold values (Minister of Mines Annual Report, 1922).

The Black Eagle (82FNW239) and King Solomon (a second occurrence of the same name; 082FNW242) prospects are situated at the head of Woodbury Creek. Neither could be located during 1987 fieldwork. The King Solomon is reported to have produced 32 tonnes of ore which yielded 1698 kilograms lead and 514 kilograms zinc (Minister of Mines Annual Report, 1947).

### GALENA LEAD ISOTOPE CHARACTERISTICS OF MINERALIZATION

The following discussion of new galena lead isotope data from 22 mineral deposits located in and around Kokanee Glacier Provincial Park is condensed from Logan *et al.* (1988). The study was undertaken to determine lead isotope characteristics of a variety of mineral occurrences. Deposits were selected on the basis of past production, mineralogy and vein orientation, to ensure all types were represented. Lead isotope ratios cluster in three separate groups. The groupings suggest three separate lead sources; two show mixing with Nelson batholith leads. The majority of the deposits have lead signatures close to Nelson batholith potassium-feldspar leads and a few have old nonradiogenic leads. Lead isotope ratios, when

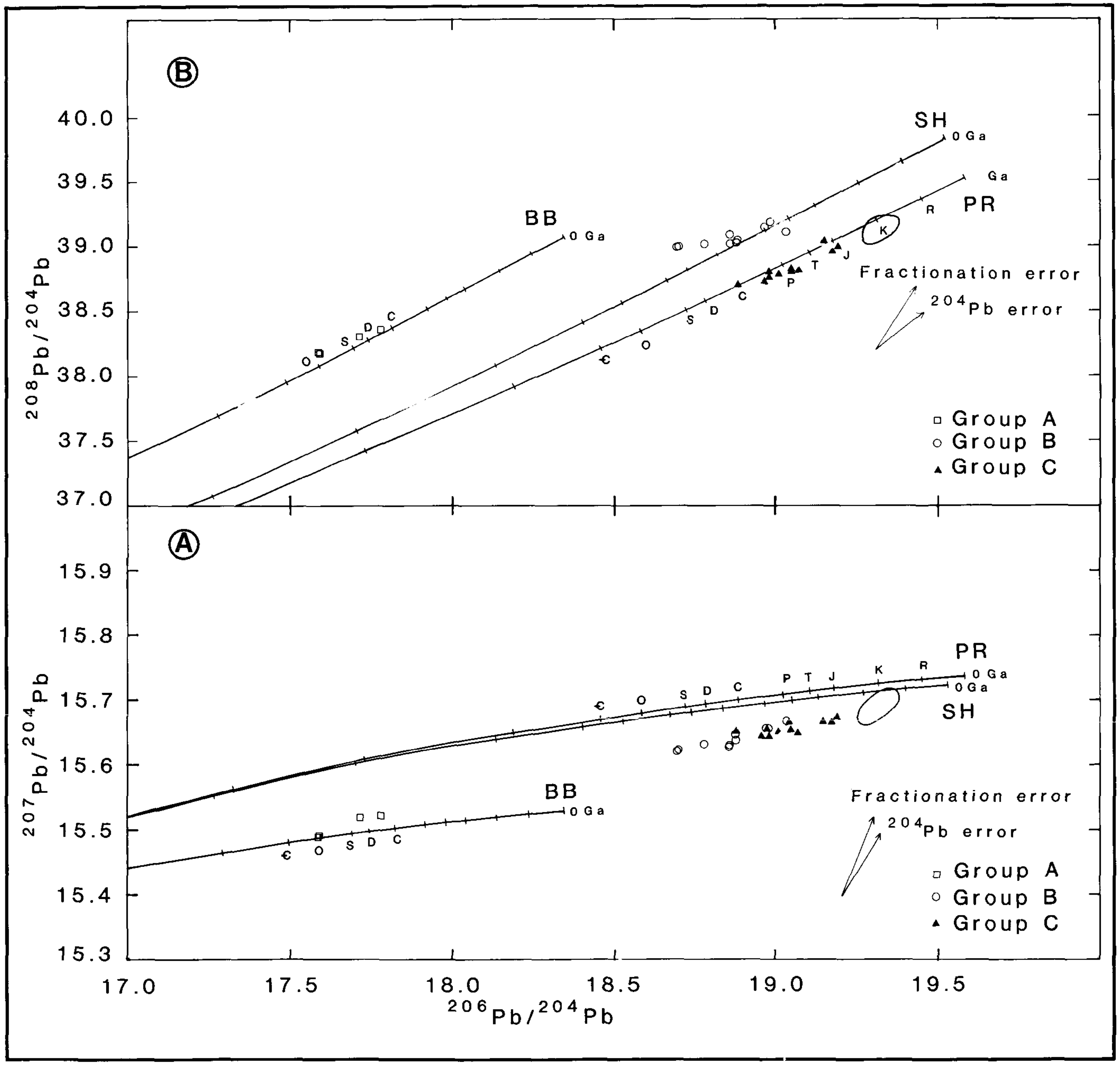



Figure 4. Galena lead isotope ratio diagram for mesothermal quartz veins in Kokanee Glacier Park. Model growth curves are: PR = pericratonic (Goutier, 1986), SH = shale (Godwin *et al.*, 1982), and BB = Bluebell (Andrew *et al.*, 1984). Time intervals are marked with standard abbreviations.

interpreted with a geological database, provide a framework within which to evaluate mineral potential, in particular, its potential to host gold-bearing deposits.

The lead isotope database for the map-area is extensive. However, comparison with previous studies is complicated by inaccurately located samples and old data of poorer quality. Therefore, only new analyses from the Kokanee Glacier Park mineral evaluation are discussed (Table 9).

Galena lead isotope ratios from new analyses are plotted on $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ (Figure 4A), $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ (Figure 4B) and $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ (Figure 5) diagrams, and compared to the shale curve of Godwin and Sinclair (1982), the pericratonic curve of Goutier (1986) and the Bluebell curve of Andrew *et al.* (1984). The deposit name, location, host lithology, MINFILE number and deposit type are documented in Table 10. Property descriptions and bibliography for each sample location are available in MINFILE records.

## FRAMEWORK FOR INTERPRETATION

Different sources of lead within the earth (mantle, lower crust, upper crust, orogene) have different characteristic lead isotope signatures (Doe and Zartman, 1979). These signatures are dependant on the relative amounts of uranium and thorium in the source, and the length of time of isolation from other sources. Thus galena lead isotopic analyses cannot be used to date mineralization absolutely. Lead growth model curves however, provide a reference framework within which lead isotope data can be interpreted. The three growth curves used in this paper have been derived empirically from lead data from mineral deposits in the Canadian Cordillera.

The data for the curve of Godwin and Sinclair was mainly from shale-hosted sedimentary exhalative deposits in the Canadian Cordillera (Carne and Cathro, 1984). The shale curve reflects an upper crustal environment of lead evolution (Zartman and Doe,

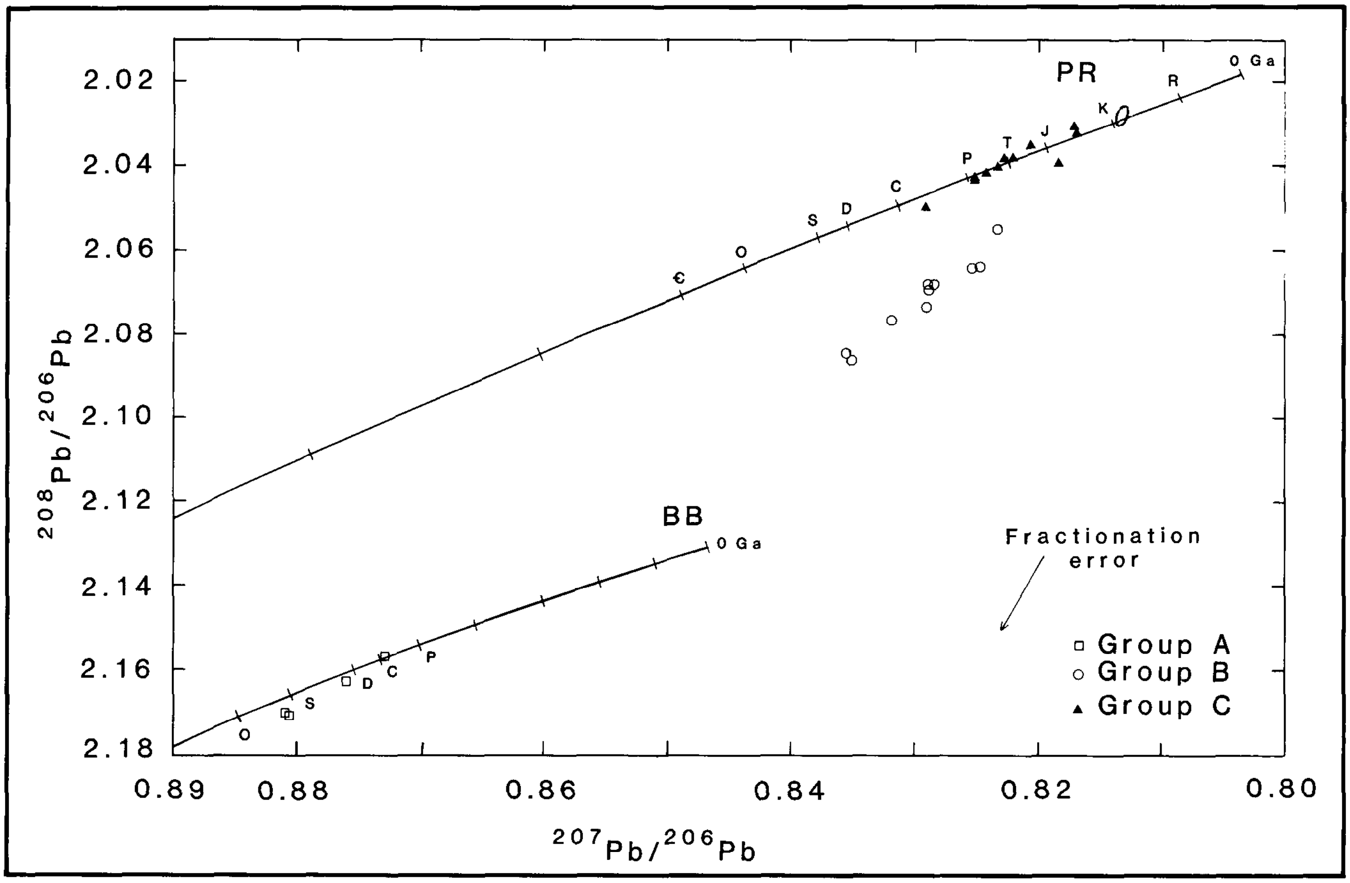



Figure 5. Galena lead isotope ratio diagram for mesothermal quartz veins in Kokanee Glacier Park. Model growth curves are: PR = pericratonic (Goutier, 1986), SH = shale (Godwin *et al.*, 1982), and BB = Bluebell (Andrew *et al.*, 1984). Time intervals are marked with standard abbreviations.

## TABLE 9
## GALENA LEAD ISOTOPE DATA FOR MESOTHERMAL VEINS, KOKANEE PARK, SOUTHEASTERN BRITISH COLUMBIA

| Leadfile No. | Minfile No. | Deposit Name | Run No. | Run Quality | $^{206}Pb/^{204}Pb$ | % error | $^{207}Pb/^{204}Pb$ | % error | $^{208}Pb/^{204}Pb$ | % error | $^{207}Pb/^{206}Pb$ | $^{208}Pb/^{206}Pb$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GROUP A** | | | | | | | | | | | | |
| 30033-001 | 082/F/NW-120 | Smuggler | 1 | good | 17.590 | 0.00 | 15.492 | 0.01 | 38.187 | 0.00 | 0.88074 | 2.17102 |
| 30037-001 | 082/F/NW-119 | Slocan Chief | 1 | fair | 17.783 | 0.00 | 15.522 | 0.02 | 38.354 | 0.00 | 0.87289 | 2.15673 |
| 30040-001 | 082/F/NW-118 | Blackburn | 1 | good | 17.719 | 0.00 | 15.520 | 0.01 | 38.317 | 0.00 | 0.87590 | 2.16252 |
| 30053-001 | 082/F/NW-121 | Molly Gibson | 1 | good | 17.587 | 0.00 | 15.489 | 0.01 | 38.177 | 0.00 | 0.88072 | 2.17078 |
| 30053-002 | 082/F/NW-121 | Molly Gibson | 1 | good | 17.599 | 0.00 | 15.494 | 0.00 | 38.191 | 0.00 | 0.88035 | 2.17002 |
| 30053-AVG | 082/F/NW-121 | Molly Gibson | 1 | good | 17.593 | 0.00 | 15.492 | 0.01 | 38.184 | 0.02 | 0.88053 | 2.17045 |
| **GROUP B** | | | | | | | | | | | | |
| 30029-001 | 082/F/NW-106 | Revenue | 1 | good | 18.968 | 0.00 | 15.657 | 0.00 | 39.158 | 0.00 | 0.82545 | 2.06444 |
| 30030-001 | 082/F/NW-099 | BNA | 1 | good | 18.873 | 0.00 | 15.647 | 0.00 | 39.033 | 0.00 | 0.82904 | 2.06812 |
| 30031-001 | 082/F/NW-109 | Baltimore | 2 | good | 18.891 | 0.00 | 15.655 | 0.01 | 39.177 | 0.00 | 0.82481 | 2.06406 |
| 30032-001 | 082/F/NW-141 | Marmion/Maryland | 1 | good | 18.859 | 0.00 | 15.631 | 0.01 | 39.026 | 0.00 | 0.82884 | 2.06934 |
| 30036-001 | 082/F/Nw-114 | Silver Cup | 1 | fair | 19.031 | 0.00 | 15.668 | 0.02 | 39.111 | 0.00 | 0.82334 | 2.05515 |
| 30046-001 | 082/F/NW-077 | Comstock | 1 | fair | 18.693 | 0.00 | 15.618 | 0.01 | 38.961 | 0.00 | 0.83552 | 2.08426 |
| 30046-001R | 082/F/NW-077 | Comstock | 2 | good | 18.704 | 0.00 | 15.628 | 0.01 | 38.998 | 0.00 | 0.83556 | 2.08499 |
| 30046-001A | 082/F/NW-077 | Comstock | | good | 18.698 | 0.01 | 15.623 | 0.02 | 38.980 | 0.01 | 0.83554 | 2.08463 |
| 30625-001 | 082/F/NW-152 | Arlington | 1 | good | 18.853 | 0.00 | 15.629 | 0.00 | 39.091 | 0.00 | 0.82901 | 2.07346 |
| **GROUP C** | | | | | | | | | | | | |
| 30025-001 | 082/F/NW-127 | Alpine | 1 | good | 19.171 | 0.00 | 15.666 | 0.00 | 38.937 | 0.00 | 0.81718 | 2.03102 |
| 30026-001 | 082/F/NW-111 | Pontiac | 1 | good | 18.974 | 0.00 | 15.655 | 0.01 | 38.770 | 0.00 | 0.82507 | 2.04329 |
| 30027-001 | 082/F/NW-113 | Sunrise | 1 | good | 18.881 | 0.00 | 15.653 | 0.02 | 38.702 | 0.00 | 0.82905 | 2.04981 |
| 30038-001 | 082/F/NW-122 | Oro Fino | 1 | fair | 19.130 | 0.00 | 15.654 | 0.02 | 38.446 | 0.01 | 0.81834 | 2.00971 |
| 30038-001R | 082/F/Nw-122 | Oro Fino | 2 | good | 19.144 | 0.00 | 15.667 | 0.02 | 39.047 | 0.00 | 0.81837 | 2.03961 |
| 30039-001 | 082/F/NW-105 | Para | 1 | good | 19.007 | 0.00 | 15.653 | 0.00 | 38.789 | 0.00 | 0.82353 | 2.04074 |
| 30039-002 | 082/F/NW-105 | Para | 1 | good | 19.011 | 0.00 | 15.647 | 0.00 | 38.768 | 0.00 | 0.82306 | 2.03928 |
| 30039-AVG | 082/F/NW-105 | Para | 1 | good | 19.009 | 0.00 | 15.650 | 0.00 | 38.779 | 0.00 | 0.82330 | 2.04001 |
| 30042-001 | 082/F/NW-215 | Silver Ranch | 1 | good | 19.044 | 0.00 | 15.654 | 0.02 | 38.822 | 0.00 | 0.82201 | 2.03856 |
| 30043-001 | 082/F/NW-253 | Al | 1 | good | 18.980 | 0.00 | 15.644 | 0.01 | 38.762 | 0.00 | 0.82422 | 2.04219 |
| 30044-001 | 082/F/NW-257 | King Solomon | 1 | good | 19.185 | 0.00 | 15.674 | 0.02 | 38.995 | 0.00 | 0.81697 | 2.03256 |
| 30045-001 | 082/F/NW-208 | Jumbo/Mary | 1 | good | 19.069 | 0.00 | 15.650 | 0.01 | 38.810 | 0.00 | 0.82071 | 2.03520 |
| 30048-001 | 082/F/NW-212 | East of LH | 1 | good | 19.041 | 0.00 | 15.666 | 0.01 | 38.809 | 0.00 | 0.82275 | 2.03816 |
| 30059-001 | 082/F/NW-113 | Granite/Sunrise | 1 | good | 18.9959 | 0.01 | 15.644 | 0.03 | 38.739 | 0.01 | 0.82513 | 2.04331 |

Analyses by J.E. Gabites.

Analyses normalized to Broken Hill lead standard values of Richards *et al.* (1981); $^{206}Pb/^{204}Pb$ = 16.604, $^{207}Pb/^{204}Pb$ = 15.390, $^{208}Pb/^{204}Pb$ = 35.561.

Suffixes on Leadfile numbers are: 00x = sample number,! = poor analysis, not used in average.

R = rerun analyses. A = arithmetic average of rerun analyses, plotted on figures. AVG = arithmetic average of analysis from the same deposit, plotted on figures.

1981). Goutier's curve was modified from the shale curve to more accurately fit data from deposits in the Eagle Bay assemblage, Adams Plateau. The deposits that Goutier analyzed are volcanogenic but have an upper crustal signature. The Adams Plateau area is in the pericratonic terrane (Wheeler *et al.,* 1987), as is the Nelson batholith. Thus Goutier's model is used here because it is more appropriate. In the rest of this paper Goutier's curve is referred to as the pericratonic curve. The Bluebell curve of Andrew *et al.*, approximates the evolution of nonradiogenic, probably mantle and/or lower crust-derived lead, for deposits in the Canadian Cordillera. This curve was modelled by assigning the Bluebell deposit an assumed age at the base of the Cambrian.

Previous lead isotope studies of the Nelson batholith (Sinclair 1964, 1966; Reynolds and Sinclair, 1971), Slocan Group (Logan, 1986; Ghosh, 1986) and vein deposits (LeCouteur, 1973; Andrew *et al.,* 1984) led to interpretation of the anomalous nature of the Slocan leads by various models which involve mixing of components from two separate lead reservoirs. In these models the batholith, which is of uranium-depleted upper mantle/lower crustal derivation, supplied the nonradiogenic component, which mixed during emplacement with upper crustal leads to produce the observed Slocan data array (Reynolds and Sinclair, 1971; Andrew *et al.,* 1984). By approximating a lower crustal growth curve, Andrew *et al.,* show Slocan lead isotope data to lie along a mixing isochron that corresponds to the age of mineralization and presumably to the time mixing occurred.

## INTERPRETATION

The lead isotope ratios from epigenetic vein deposits in Kokanee Glacier Park fall into three groups designated A, B, and C. The grouping is most apparent on the $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot (Figure 4B). The groupings are assigned distinct symbols, that have been used in Figure 6 to show the distribution of deposits. Group A deposits lie along a northwest linear whereas Groups B and C are distributed randomly throughout the map area.

Group A data are relatively nonradiogenic and lie on the Bluebell curve on the $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot. The model age implied by this curve is Cambrian to Ordovician. Two points are just above the Bluebell curve. These points come from four batholith-hosted deposits, the Blackburn, Molly Gibson, Slocan Chief, and Smuggler. The Molly Gibson was the largest past producer (Table 10). The deposits lie along

**TABLE 10**
**LOCATION AND HOST LITHOLOGY FOR MESOTHERMAL VEINS, KOKANEE PARK, SOUTHEASTERN BRITISH COLUMBIA**

| Minfile No. | Deposit Name | UTM Location Easting | UTM Location Northing | Host Lithology | Deposit Type | Production (tonnes) |
|---|---|---|---|---|---|---|
| **GROUP A** | | | | | | |
| 82F/NW-118 | Blackburn | 485563 | 5513364 | K-spar | vein | 0 |
| 82F/NW-119 | Slocan Chief | 486953 | 5512505 | K-spar | vein | 4 |
| 82F/NW-120 | Smuggler | 487559 | 5511750 | K-spar | vein | 13 |
| 82F/NW-121 | Molly Gibson | 489035 | 5508600 | K-spar | vein | 55 860 |
| **GROUP B** | | | | | | |
| 82F/NW-077 | Comstock | 483296 | 5526295 | Qtz. mon/lamp | vein | 456 |
| 82F/NW-099 | BNA | 492000 | 5523600 | Pel/psa/lst | vein | 173 |
| 82F/NW-106 | Revenue | 491131 | 5519134 | Hb por gn | vein | 244 |
| 82F/NW-109 | Baltimore | 495950 | 5517754 | Hb por gn | vein | 60 |
| 82F/NW-114 | Silver Cup | 487625 | 5511666 | Hb por gn | vein | 4 |
| 82F/NW-141 | Marmion/Maryland | 476241 | 5514056 | Hb por gn | vein | 50 |
| 82F/NW-152 | Arlington | 473981 | 5515135 | K-spar | vein | 19 217 |
| **GROUP C** | | | | | | |
| 82F/NW-105 | Para | 482390 | 5520617 | K-spar | vein | 15 |
| 82F/NW-111 | Pontiac | 496325 | 5515133 | Hb por gn | vein | 1160 |
| 82F/NW-113 | Granite/Sunrise | 495114 | 5523532 | Hb por gn | vein | 145 |
| 82F/NW-113 | Sunrise | 494714 | 5514283 | Hb por gn | vein | 145 |
| 82F/NW-122 | Oro Fino | 485356 | 5507733 | K-spar | vein | 4 |
| 82F/NW-127 | Alpine | 481934 | 5503399 | Qtz monzonite | vein | 15 551 |
| 82F/NW-208 | Jumbo/Mary | 479651 | 5516615 | K-spar | vein | 25 |
| 82F/NW-212 | East of LH | 477354 | 5526027 | Metavol/skarn | vein | 0 |
| 82F/NW-215 | Silver Ranch | 483690 | 5514368 | K-spar | vein | 0 |
| 82F/NW-253 | Al | 498281 | 5511798 | K-spar | vein | 0 |
| 82F/NW-257 | King Solomon | 481420 | 5501622 | Qtz. monzonite | vein | 0 |

Abbreviations are: K-spar = potassium-feldspar porphyritic granite, Qtz mon/lamp = quartz monzonite and lamprophyre, Pel/psa/lst = pelite, psammite and limestone, Hb por gn = hornblende-porphyritic granite, Qtz mon = quartz monzonite, Metavol/skarn = metavolcanic rocks and skarn.

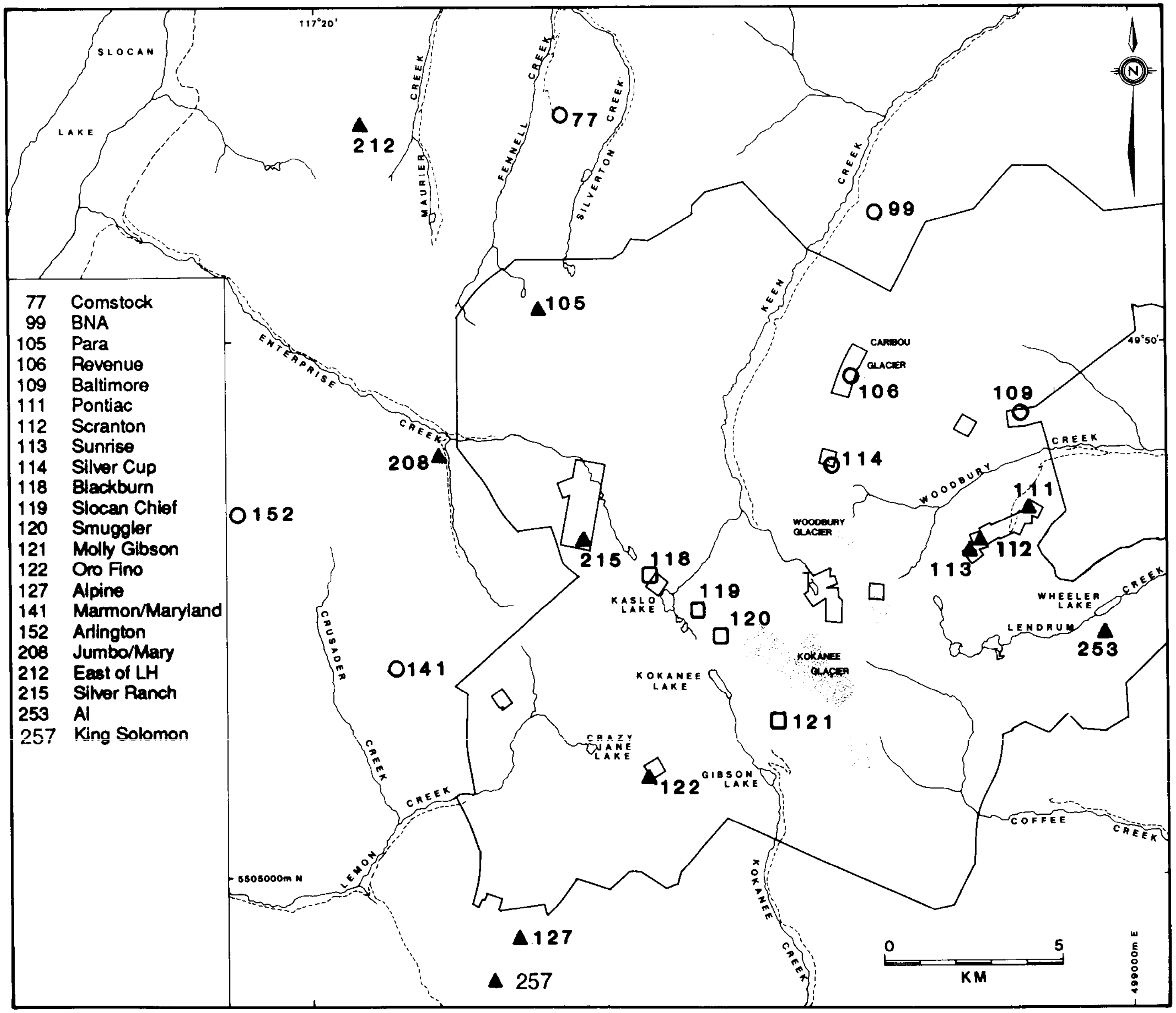



Figure 6. Vein deposit locations and MINFILE numbers for those galena lead isotope samples analysed. Symbols distinguish three groups: squares = Group A, circles = Broup B, solid triangles = Group C.

a northwesterly striking joint set west of Kokanee Glacier. Vein mineralogy of the four deposits comprises galena, sphalerite, arsenopyrite, pyrite and minor chalcopyrite in a gangue of brecciated buff to pink siderite. Manganese-rich siderite gangue, coated with black manganese oxide, is unique to the batholith-hosted deposits which are typically quartz-rich. Arsenopyrite is only reported from one other deposit in the Slocan camp, the LH. These characteristics emphasize the unusual nature of these four deposits. The presence of this anomalous lead, with a Cambro-Ordivican Bluebell curve model age, from veins that crosscut the Middle Jurassic batholith is enigmatic.

A possible interpretation for Group A lead is that it represents a hydrothermal event during the Jurassic to Tertiary, involving fluids derived from either the lower crust/upper mantle, or from Precambrian basement. This requires that the Bluebell deposit be epigenetic and of the same age (Sinclair, 1964; LeCouteur, 1973). Deposits near Ainsworth, 15 kilometres to the east, have been interpreted to be either epigenetic or syngenetic stratiform veins (Höy *et al.,* 1981). These deposits have similar lead isotope ratios (LeCouteur, 1973) to Group A.

An alternative explanation is that Group A is directly derived from a Bluebell-type Cambrian or older deposit. Incorporation by the batholith of a large mineralized inclusion of miogeocline, Lardeau Group or older rocks is implied. Mineralization in the Lardeau Group near Ainsworth contains lead with similar isotope ratios. The siderite gangue of Group A is typical of sediment-hosted deposits in the Slocan camp, 15 kilometres to the north, and suggests a sediment-derived component to the mineralizing fluids. However, there is no surface expression of sedimentary inclusions near Group A deposits. Remobilization of lead from the supposed "inclusion" by fluids during the Jurassic-Tertiary could produce the observed shift from Cambrian age, assigned to the Bluebell deposit. Although, mixing of lead with the younger mineralizing fluids would be expected to produce a more significant shift in lead ratios, generating ratios transitional between Groups A and B.

Groups B and C data overlap on the $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot (Figure 4A), between the pericratonic and Bluebell curves. However, plots of $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$, and $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ clearly distinguish Groups B and C (Figures 4B, 5). Group B is more thorogenic (208Pb) and less radiogenic ($^{207}Pb$ and $^{206}Pb$) than Group C and forms a linear array between the Bluebell and pericratonic curves. Mineralogically, these deposits are mesothermal silver-lead-zinc-bearing quartz veins. The exception, Marmion/Maryland, recorded appreciable gold recovery, more typical of Group C. On the $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ plots, the spread of data may reflect mixing in the batholith between pericratonic and Bluebell-type leads in the Jurassic. Thus, the spread of data is representative of the mixed source for the plutonic rocks and associated mineralizing fluids that has been described from other isotope systematics (LeCouteur, 1973; Andrew *et al.,* 1984; Ghosh, 1986).

Group C data are more uranogenic and less thorogenic than Group B data. They form a linear array along the pericratonic curve in Figures 4B and 5. These data suggest a source distinct from Group B. On the $^{206}Pb/^{204}Pb$ diagram, Group C data plot with younger model ages than Group B. Mineralogically Group C deposits cannot be distinguished from Group B, gold has been recovered from the majority and is the only economic mineralization in some deposits. Lead isotope analysis of feldspar concentrates from the Nelson batholith (Ghosh, 1986) cluster at the radiogenic end of Groups B and C on Figure 4A. On Figures 4B and 5 the batholith leads plot on the pericratonic curve coincident with the projected intersection of the Group B and C linear clusters. Mixing in the batholith is inferred from both linear arrays and suggests an equivalent age for Groups A and B. Three deposits in Group C plot at the more radiogenic end of the linear arrays in Figures 4A and 5. They are characterized by high-grade gold mineralization. They are located in the southwest corner of the map area, where Tertiary potassium-argon dates from biotite have been obtained (Parrish, personal communication, 1987). It is not known whether these dates reflect either a Tertiary thermal resetting of a Jurassic monzonite, or Tertiary intrusion. The low thorium content suggests that the bulk of the lead source is not the batholith.

## CONCLUSIONS

Lead isotope ratios in the mineral occurrences in Kokanee Glacier Park fall into three groups. All deposits analyzed are epigenetic veins in and near the Middle Jurassic Nelson batholith. Three separate lead sources are necessary to produce the data arrays. These are a lower crustal/upper mantle Bluebell-type, pericratonic type and an unknown source. Mixing of these three reservoirs occurred in the batholith during the Middle Jurassic. Group A deposits are surrounded by deposits of Group B and C near the centre of the batholith. A subset of Group C represents occurrences in the southwest corner of the map area with more radiogenic lead and a gold-enriched mineralogy and may correlate with a Tertiary intrusive event.

# GEOCHEMISTRY

Stream sediment, heavy mineral and rock samples were collected to assess precious and base metal values in drainage basins within the park. Results from each medium are discussed below.

## STREAM SEDIMENTS

The 1977 Regional Stream Sediment (R.G.S.) and Water Geochemical Reconnaissance study for N.T.S. sheet 82F includes 50 samples from the park and its environs. Anomalous metal values were delineated from six localities (threshold values were established statistically from the 1987 data; see below). Only sample 7209 (tributary of Kokanee Creek) which contains anomalous lead and mercury represents an area where no known mineralization occurs. Sample 1191 (Aylwin Creek) contains anomalous copper and sample 1226 (tributary of Enterprise Creek) contains anomalous molybdenum and copper. They reflect copper-gold-silver mineralization in the Willa deposit (082FNW071). These results actually spurred prospectors back into the area and lead to the discovery of the Willa deposit. Sample 1252 (Silverton Creek) contains anomalous zinc, lead, and mercury which represents dispersion from the Lou Dillon occurrence (082FNW078). Sample 7291 (Desmond Creek) contains anomalous zinc, lead, silver, copper, and mercury and was collected below the Index workings (82FNW101). Sample 7206 (northwest of Gibson Lake) contains anomalous lead and molybdenum which may reflect Molly Gibson (082FNW121) mineralization.

A total of 141 stream sediment samples were collected in the 1987 field season over an area of 800 square kilometres Map 2. Samples were analyzed for 30 elements by inductively coupled plasma techniques (ICP); gold was determined by fire assay followed by neutron activation analysis.

The geochemical data have been treated statistically. Histograms and probability plots were computer generated using PROBPLOT (Stanley, 1988) and show multiple log-normal distribution for all elements. Analytical results, means, standard deviations and threshold values for the partitioned populations are tabulated in Table A.

Anomalous metal values (i.e. values greater than threshold) occur within the Park and indicate downstream dispersion from: (1) past producers and mineral occurrences (i.e. mine dumps and trenches); (2) areas on strike extensions of known mineralization and (3) areas containing no known mineralization. Determination of the anomaly source is an important step in evaluating follow-up procedures and locating new ore zones. Geochemical sampling successfully identified known mineralization. Orientation sampling carried out at the Willa deposit (volcanic breccia pipe), along the Slocan Lake fault zone (detachment fault) and at Molly Gibson (silver-lead-zinc) and Alpine (gold-silver,(with lesser lead, zinc)) veins has defined element associations and pathfinder elements particular to specific deposit types. Therefore, new extensions and new discoveries could be detected geochemically. The stream sediment geochemical signatures and respective deposit types are listed in Table 11.

TABLE 11
STREAM SEDIMENT GEOCHEMICAL SIGNATURES

| COMMODITY | TYPE | DEPOSIT/AREA | GEOCHEMICAL SIGNATURE Zn | Pb | Ag | Cu | Mo | Au | Hg | As | Sb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cu, Au** | Breccia | Willa | | | | X | X | X | | X | / |
| **Ag, Pb, Zn (Au)** | Vein | Sylvana | X | X | / | / | | | / | X | |
| Ag, Pb, Zn (Au) | Vein | Molly Gibson | X | X | X | | X | / | / | X | X |
| **Au, Ag (Pb, Zn)** | Vein | Alpine | | | | | | X | | X | X |
| **Pb, Zn** | Skarn | Piedmont | X | X | | | | | | | |
| **Potential Au, Ag** | Detachment | S.L.F.Z. | | | | | | / | | X | X |

Abbreviations/symbols: S.L.F.Z. = Slocan Lake fault zone; X = consistently anomalous; / = frequently anomalous.

The majority of anomalous stream sediment samples are concentrated in three areas: between the Alpine deposit and Barnett vein; along the northwest striking "Enterprise Creek - Gibson Lake" linear and around the Willa deposit (Map 2).

Stream sediment samples 01, 107 and 108 from Nilsik Creek and tributaries within the southwest corner of the park contain anomalous gold, molybdenum and mercury values. Mineralization is not known from these areas. The geochemical signature is characteristic of the Alpine gold-silver vein.

Seven anomalous sediment samples are distributed along a northwest linear extending from the headwaters of Kokanee Creek at Gibson Lake to the upper section of Enterprise Creek. Samples 23, 24, and 25 contain anomalous values of lead, zinc, molybdenum, arsenic, antimony, and silver. Sample 24 also contains anomalous gold. These anomalies and sample 26 are interpreted to reflect contamination from workings at the Molly Gibson. Anomalous values in sample 26, on the southwest side of Tanal Lake, may reflect glacial dispersion from Blackburn or it could represent an extension of the vein system. Samples 26, 27, 71 and 08 contain anomalous zinc and lead values. In addition, samples 71 and 08 have anomalous values of silver, mercury and arsenic and sample 26 has anomalous molybdenum. Samples 27, 28 and 71 probably represent metal dispersion from the Silver Ranch, Blackburn and

Boomerang mineral occurrences. The anomalous values of sample 08 may represent downstream dispersion from the strike extension of the Silver Ranch mineralized fault zone.

Near Aylwin Peak, samples 81, 82, 83, 84, 86 and 87 contain anomalous values of one or more of copper, gold, molybdenum, mercury and antimony. Copper, silver, and molybdenum are diagnostic for the Willa deposit. No similar element association was detected within the park.

Sample 130 contains anomalous lead, zinc, and mercury and may reflect a broad dispersion from the Al occurrence.

A pair of anomalous mercury values (samples 133 and 134) occur at the headwaters of Nelles Creek. These anomalies may indicate the upper level of an epithermal system. Mineral occurrences are not known from this area, though elevated gold values are present in heavy mineral sample HM-08. Glacial dispersion down Woodbury Creek from known gold showings, cannot be ruled out, but alternatively, the gold may be derived from the headwaters of Nelles Creek and coincide with the mercury anomalies.

## HEAVY MINERAL STREAM SEDIMENTS

Twelve heavy mineral samples were collected from high-energy stream environments using techniques described by Matysek and Saxby (1987). The samples were wet-seived to produce -60+100, -100+200 and 200 size fractions. Magnetic separation techniques partitioned each size fraction further into magnetic, paramagnetic (slightly) and nonmagnetic proportions. The para and nonmagnetic fractions were analyzed for 30 elements by neutron activation methods. Sample locations are shown in Map 2, results are listed in the Appendix.

Heavy mineral data cannot be directly compared without first relating element concentration to the volume of each size fraction and original sample size. Gold values have been recalculated to provide meaningful numbers for comparing samples (Appendix). General conclusions include: the proportion of fine gold to coarse gold is high; gold occurs in the nonmagnetic fraction suggestive of free gold (i.e. not locked in sulphide grains); and relatively high concentrations of uranium and some rare earth elements are present. Background and threshold values cannot be established for this small data set. The Willa deposit clearly displays a heavy mineral signature in sample 87-04 with 8.51 and 2.97 parts per billion gold from size fractions -100+200 and -200. An elevated gold value (2.44 parts per billion) in sample 87-08 from the -60+100 size fraction indicates gold mineralization may occur within the drainage basin of Nelles Creek. No evidence of the Scranton/Pontiac deposits is apparent from sample 87-06 (Pontiac Creek).

## ROCK SAMPLES

A total of 122 grab samples for assay and 121 rock chip samples for analysis was collected from mine dumps and across veins and alteration envelopes. All the samples have been analyzed for gold, silver, copper, lead, zinc, molybdenum, and selected samples for mercury, arsenic and antimony (locations on Map 2 and results in Table A). Applicable results have been presented in the "Mineral Occurrences" section of this paper.

# METALLOGENIC MODELS AND MINERAL POTENTIAL

Assessment of mineral potential requires application of metallogenic models to the study area, in this case Kokanee Glacier Park. Based on past production, regional geology and industry interest, models for the following deposit types are worthy of consideration: * mesothermal veins, Willa-type volcanic breccia pipes, epithermal gold veins, skarns, porphyry coppers and detachment gold deposits. Each will be reviewed and its relevance to the park discussed below.

The evaluation of mineral potential is subjective and based on field observations, past production statistics and geochemical surveys. Only after extensive drill exploration and detailed mapping can actual deposit sizes, grades and dollar values be quantified. We identified eleven domains of "high mineral potential" within the park following criteria listed below (the domains are shown on Map 4):

* Past production records.
* Favourable geology.
* Known veins, continuous structures and intense alteration.
* Stream sediment geochemical anomalies.

The "high mineral potential" is a relative term applied within the park area only. It does not imply that new deposits will be greater than 50 000 tonnes.

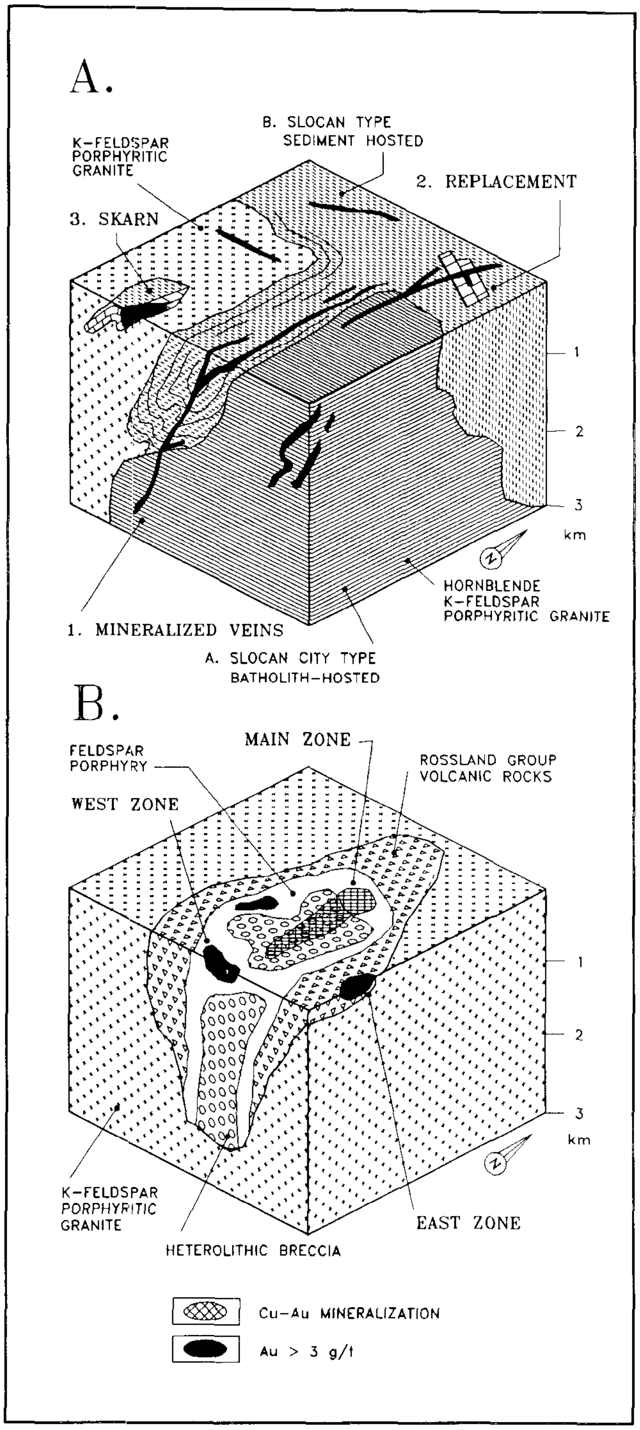



Figure 7. Metallogenic models for Nelson batholith, illustrating potential areas for vein, skarn and replacement mineralization. A = vein model, B = breccia pipe model.

## MESOTHERMAL VEINS

Vein mineralization is divided into batholith and sediment-hosted, as characterized by deposits in Slocan City and Slocan camps respectively. These are illustrated diagramatically in Figure 7.

## BATHOLITH-HOSTED VEINS

Batholith-hosted quartz veins are the most promising target for new discoveries and provided all past production from the park. The veins can be subdivided into: gold-bearing and silver-bearing types, both with appreciable base metal content. Areas of high potential for quartz veins include domains 1 to 10 (Map 4).

### DOMAIN 1 - SCRANTON/PONTIAC/SUNRISE/SUNSET

The Scranton/Pontiac/Sunrise/ Sunset vein system supported the second largest producing mine in the park (25 902 tonnes but records are incomplete). It is

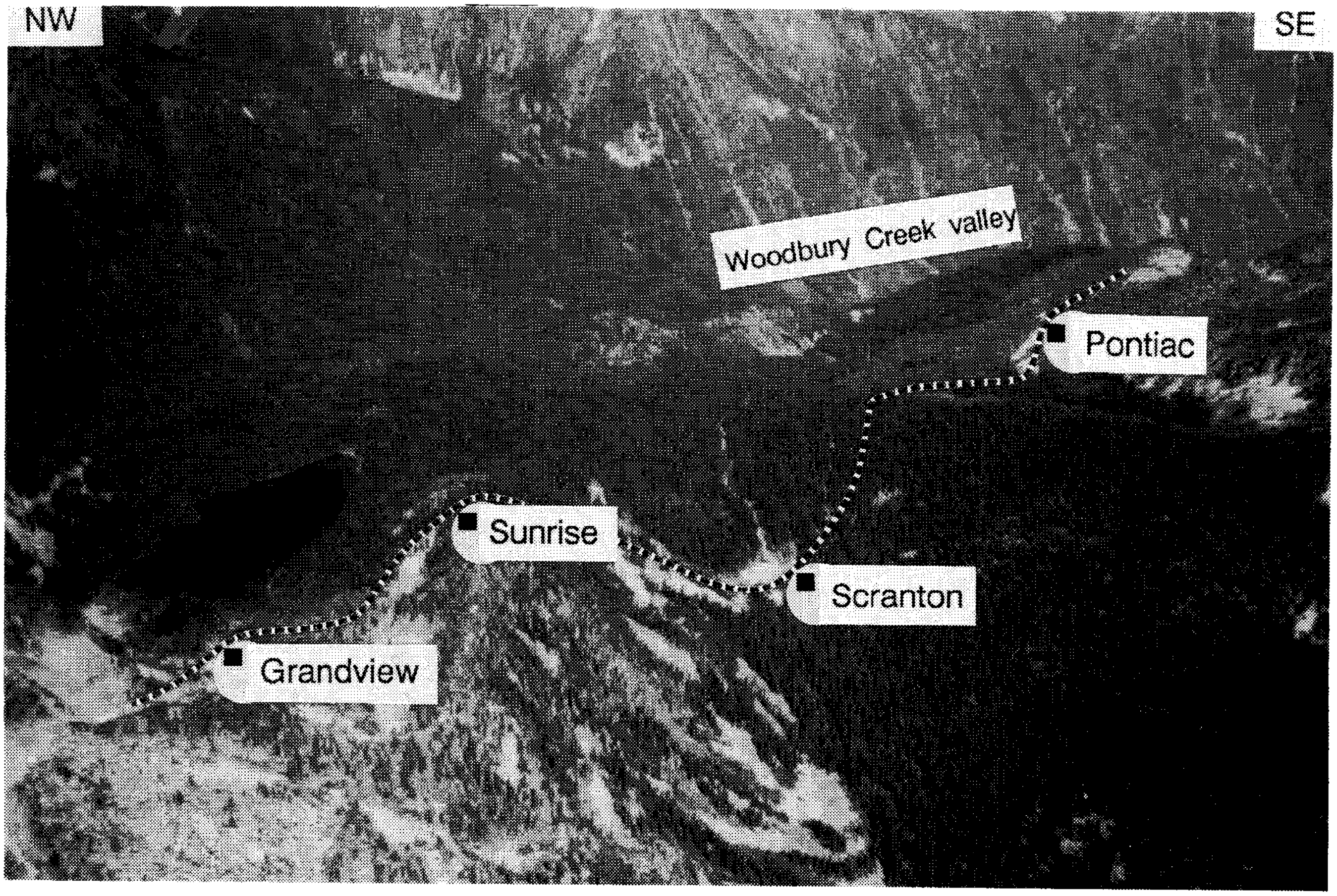



Plate 4. View looking northeast to Grandview, Sunrise, Scranton and Pontiac vein system. Sunset Lake is shown northwest of the Sunrise workings. The surface trace of the vein is indicated by the dashed line.

the most attractive exploration target because of its past gold production record, high gold values, well-defined structure and vein continuity (Table 4). Published reserves are 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).

The vein trace was followed on surface by old trenches, vein outcrops and workings, for about 2.5 kilometres (Plate 4). The workings have explored only about 10 per cent of the structure.

**DOMAIN 2 - ALPINE**

The Alpine and King Solomon gold-silver-lead-zinc vein deposits are situated 500 to 1500 metres south of the park boundary (Plate 5). However, the down-dip extension of the vein projects into the park. The Alpine produced 3561 kilograms gold and 2214 kilograms silver from 15 557 tonnes of ore making it the largest gold producer in the vicinity of the park. Surface drilling, rehabilitation of underground workings and underground drilling were carried out by Granges Exploration Ltd. late in 1987.

The quartz vein, up to 1 metre thick, is well defined over 400 metres on surface (Plate 6). The vein strikes 255 degrees and dips moderately north. It is limonitic and weathers rusty brown, in sharp contrast with the country rock of unaltered grey Nelson quartz monzonite.

The gold and molybdenum geochemical signature present in streams draining the north side of Mount Cornfield (1.5 kilometres northwest of the deposit) suggests similar mineralization in the area, possibly an en echelon and/or eastward extension of the Alpine vein. The Alpine vein is known to project north across the park boundary.

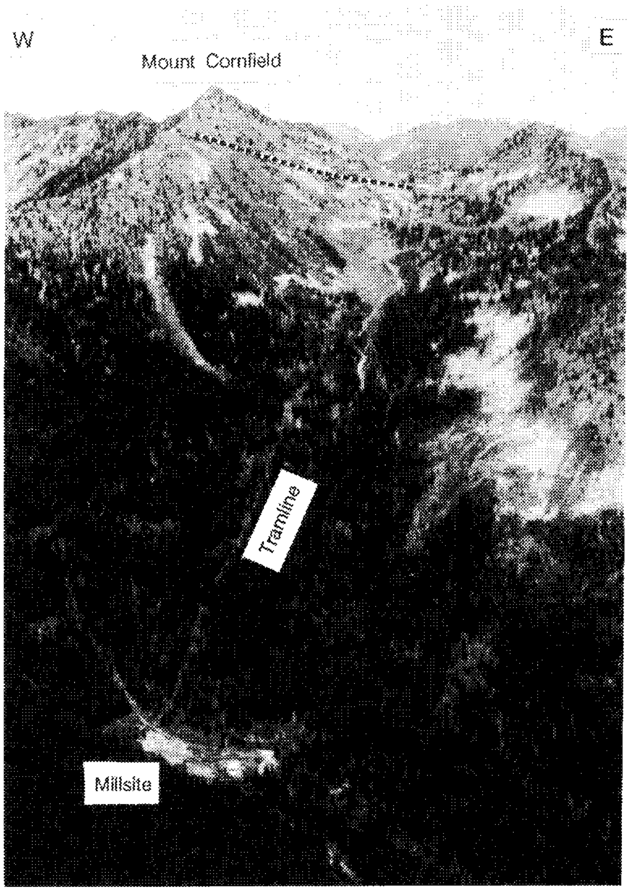



Plate 5. Aerial fiew looking north to the Alpine millsite, tramline and waste dumps on the south slope of Mount Cornfield. The park boundary runs along the topographic divide, on the north side of the Crown Grants. The dashed line represents the surface trace of the vein.

**DOMAIN 3 - MOLLY GIBSON/BLACKBURN**

The Molly Gibson mine was the largest producer in the park (55 850 tonnes; Tables 3 and 4). The base metal mineralization occurs along a northwest-striking structure that can be traced over 5 kilometres on surface. Three past producers along the structure are the Molly Gibson (Plate 7), Smuggler and Slocan Chief mines (Table 3). This domain is ranked third, principally due to past production tonnage but also because of the structural continuity of the vein system.

The mineralized structure is untested along most of its strike length (about 90 per cent; Map 1 and Plate 3) and may be source of an anomalous stream sediment gold value of 26 ppb. Development on the Smuggler, Slocan Chief and Blackburn occurrences was limited.

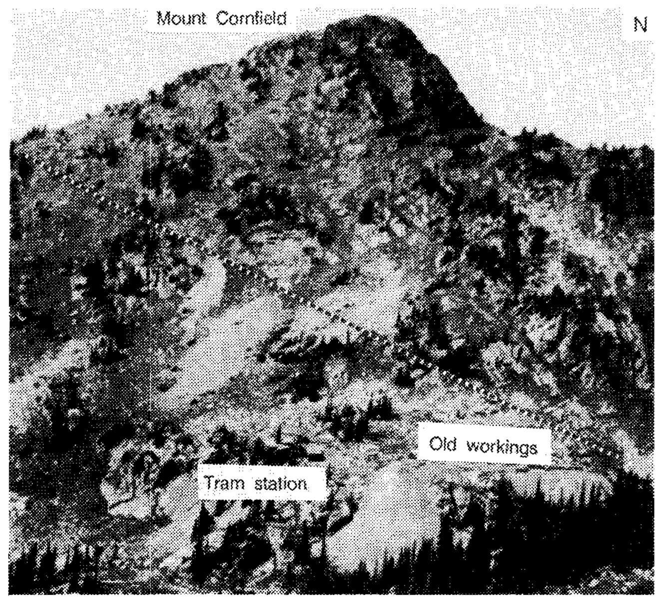



Plate 6. View west towards Alpine mine dumps, surface vein trace and aerial tramway station.

**DOMAIN 4 - ORO FINO**

The Oro Fino has recorded production of 4 tonnes of relatively gold enriched silver-lead-zinc ore. The vein on surface is less than 30 centimetres wide, strikes about 030 degrees and dips 65 degrees southeast. East-striking crossfaults truncate the vein at its southern end. Mineralization includes pyrite, sphalerite and galena. The high gold values, prominent vein and associated fault with precious metal-bearing argillic alteration zone make this area an attractive exploration target.

**DOMAIN 5 - SILVER RANCH/BOOMERANG**

The Silver Ranch domain consists of narrow, irregular gold-silver-lead-zinc-bearing quartz veins in a north to northwest-trending zone of sheared porphyritic granite (Plate 8). The intensity of argillic alteration and amount of sheared granite are the basis for allocating this domain as having mineral potential. The Boomerang showing could be the northern extension of Silver Ranch deposit.

Three trenches and two adit dumps were resampled. The upper adit is about 25 metres long and the lower adit about 45 metres long. The vein is narrow (less than 5 centimetres wide) and discontinuous on surface.

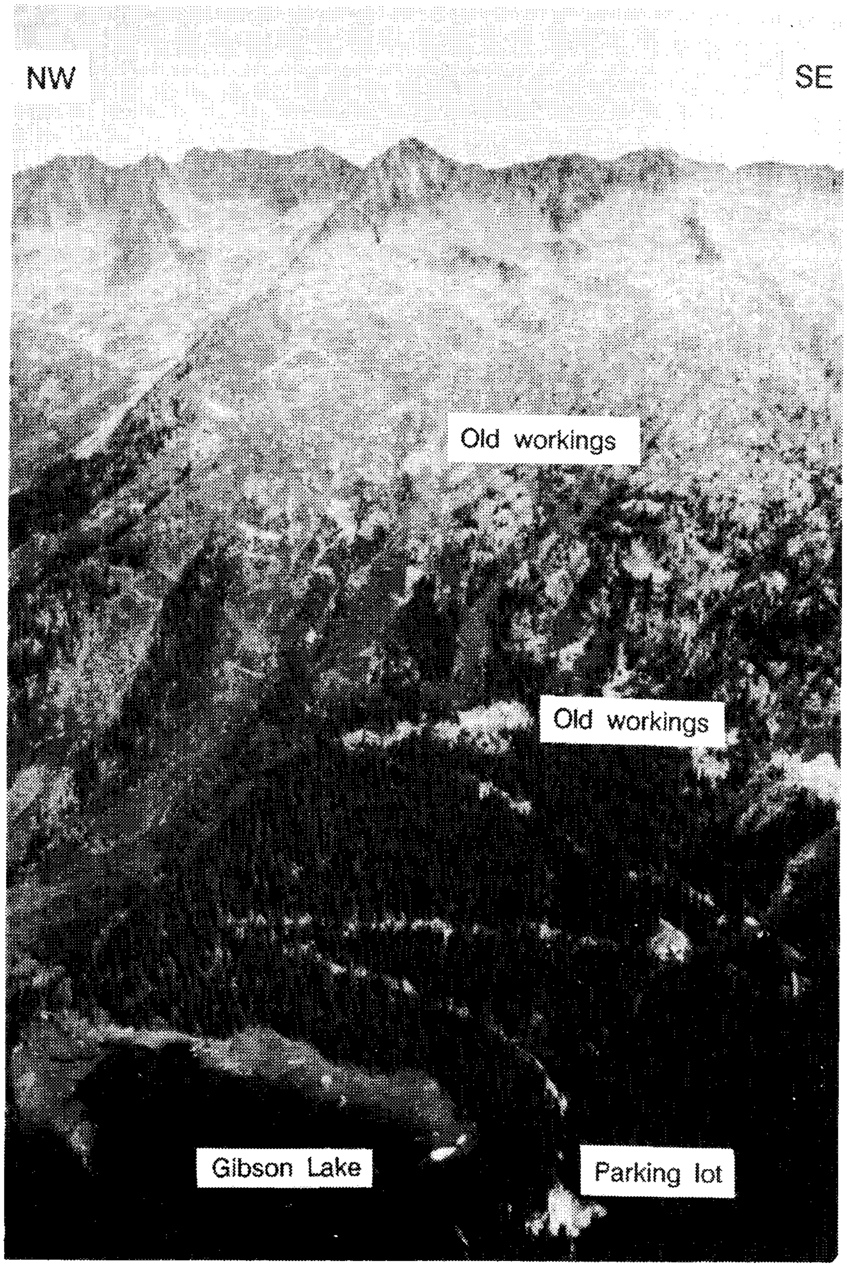



Plate 7. Molly Gibson workings above Gibson Lake.

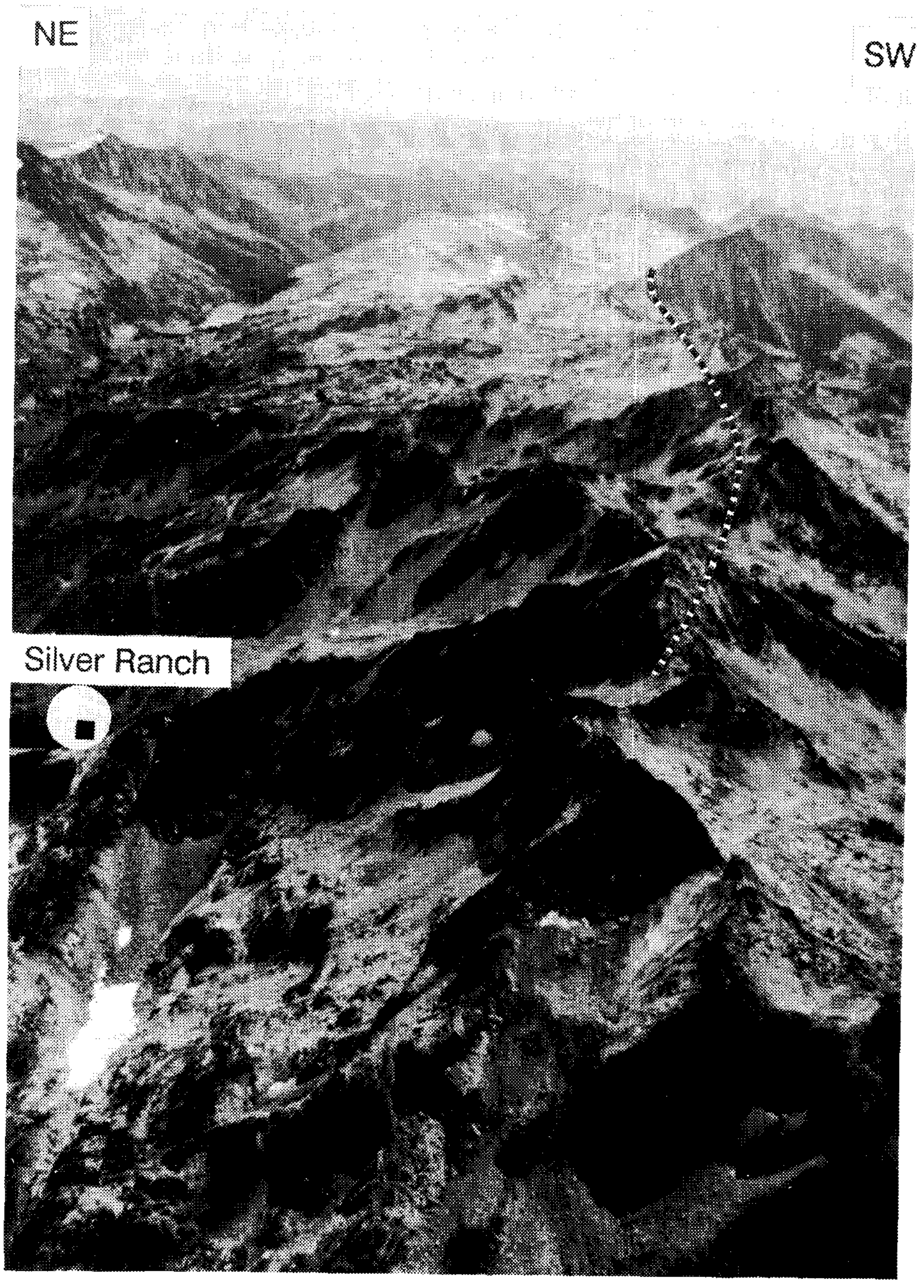



Plate 8. View southeast along the northwest-trending linear that hosts the Silver Ranch mineralization. "Area 6 - Northwest-linear" -- (Map 4) is faintly visible to southwest (dashed line).

#### DOMAIN 6 - NORTHWEST LINEAR

A northwest-trending linear zone of argillic and limonitic alteration extends 4 kilometres between Nansen and Sunset Mountains. Silicified stockworks and veins containing base metal values and gold occur within this domain (Hudson Bay and Soldier Boy; Map 3). These criteria were used to define this area of mineral potential. The Silver Crest showing 1 kilometre east of the main structure may be a splay fault and hence is included in this domain (Plate 8).

Early exploration work on the Hudson Bay showing developed a narrow irregular sulphide-bearing quartz vein.

#### DOMAIN 7 - BARNETT

The Barnett claim contains a northeast-striking shallow-dipping quartz vein that is exposed for approximately 500 metres, by trenching and three short crosscuts. The quartz vein, less than 30 centimetres wide, is sparsely mineralized with pyrite and galena. Argillic and sericitic alteration extends up to 10 centimetres into footwall and hangingwall granite.

Three grab samples of vein material returned low but consistent gold values and high silver values (Table 5). The anomalous stream sediment in McGuire Creek contained 76 parts per billion gold.

#### DOMAIN 8 - AL (WHEELER LAKE)

Mineral assessment of claims in the Wheeler Lake area is hindered by lack of exposure. Scarcity of outcrops led workers to propose a soil survey of the area in 1983. It is unknown whether this was undertaken. Seven trenches and a short adit expose narrow gold and silver-bearing quartz veins. Vein dimensions, orientation and continuity are unknown, but based on limited surface observations, the width is narrow (less than 5 centimetres).

#### DOMAINS 9 AND 10 - REVENUE AND ONTARIO/BALTIMORE

These two domains are suggested to have mineral potential based on past mineral production (Tables 3 and 4).

### SEDIMENT-HOSTED VEINS

Potential for sediment-hosted veins is extremely low in the park. Only 5 per cent of the park is underlain by meta-sedimentary rocks and their character is silicic; most known deposits outside the park are in argillaceous sediments. Only the Keen Creek re-entrant, that consists of argillaceous metasedimentary rocks, is a favourable domain (for example Cork Province, Wintrip and five other deposits). The most productive veins follow a northeasterly striking joint system in the Slocan camp (Cairnes, 1934).

#### DOMAIN 11 - KEEN CREEK RE-ENTRANT

Seven silver-lead-zinc deposits occur within the Keen Creek re-entrant, most of which are north of the park. Based on past production and favourable geology additional silver-lead-zinc ore could be found in this area. However, gold values are negligible. Limited drilling, soil and silt geochemistry and geophysical survey activity by industry is ongoing in this domain. The deposits are located in a northeast-striking structure that parallels the average bedding attitude. The Slocan Group re-entrant does not extend south into the park's new boundaries.

## WILLA-TYPE VOLCANIC BRECCIA PIPE

### WILLA (AYLWIN CREEK) DEPOSIT (MINFILE 82FNW071)

Geology and mineralization at the Willa deposit, located 6 kilometres northwest of the park, has been described in detail by Heather (1985). A simplified breccia pipe model for Willa is illustrated in Figure 7-B. 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. 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).

During the 1987 mapping we found no pendants with meta-volcanic rocks correlative with the Rossland Group. Hence potential for Willa-type deposits is very low. All pendants in the Nelson batholith within the park, are correlative with Slocan Group or older meta-sedimentary rocks.

## EPITHERMAL GOLD

Characteristics of epithermal gold deposits are: shallow depth (less than 1.5 kilometres) and low temperature 50-350°C of formation, textures indicating open-space filling and extensive, structurally controlled alteration.

The hydrothermal alteration assemblages in Kokanee Glacier Park are predominantly associated with mesothermal quartz veins. No low-temperature epithermal alteration assemblages (adularia-albite or alunite-silica) were identified. Phyllic and argillic alteration is restricted to narrow vein envelopes. Therefore, the park holds little potential for epithermal gold deposits.

## SKARN

The Rossland Group in general and Elise Formation in particular are prime units for hosting gold-bearing skarn deposits (Ray and Spence, 1986). The Tillicum Mountain gold-copper skarn, 35 kilometres northwest of Kokanee Glacier Park, is a good example. Tillicum yielded 52 890 grams gold, 54 837 grams silver, 2314 kilograms lead, 4188 kilograms zinc from 226 tonnes of production during 1981 and 1985. The gold-bearing calc-silicate skarn alteration is stratabound and hosted in andesitic tuff and tuffaceous sediments.

Within the park, only five per cent of the rock is metasedimentary and little of this is calcareous, therefore the skarn potential is negligible.

## PORPHYRY COPPER

Porphyry copper deposits display concentric alteration zones (potassic-phyllic-propylitic), disseminated pyrite-chalcopyrite-molybdenite±bornite and clear structural control. Hydrothermal alteration is widespread, pervasive and complex.

The Nelson batholith in Kokanee Glacier Park does not exhibit any of the characteristics of porphyry copper environments and is not a likely area for porphyry copper exploration.

## DETACHMENT GOLD

The Slocan Lake fault zone is a major low-angle easterly dipping décollement mapped on surface and detected by Lithoprobe (Cook *et al.*, 1987) to a depth of at least 15 kilometres below the Nelson batholith. Carr *et al.* (1987) described the fault zone along the east side of Slocan Lake as consisting of closely spaced (about 20 centimetres or less) brittle fractures and faults in a zone of lower to middle greenschist grade retrograde alteration. The zone ranges from 100 to 800 metres in width. Nelson granitic rocks in the hangingwall are variably altered to greenschist assemblages, clay-limonite and local quartz stockworks and zones of pyritization. Foliated to mylonitic Cretaceous to Tertiary (Paleocene) granitic gneisses and older metasedimentary rocks of amphibolite to sillimanite grade in the footwall show little retrograde alteration.

Recent interest has been directed toward these major, low-angle detachment faults as potential zones of hydrothermal activity, alteration and possible mineralization. Extrapolation of the Slocan Lake fault zone beneath Kokanee Glacier Park indicates it is over 10 kilometres deep and hence too deep to be the source of mineralization in the park. However, the fault zone's surface trace remains a viable exploration target, 12 kilometres west of the park.

## AGES OF MINERALIZATION

Ages of mineralization are not well established. However, separate mineralizing events are postulated for each deposit type. Epigenetic vein mineralization crosscuts the Slocan Group and Nelson plutonic rocks and therefore postdates intrusion of the batholith. Previous studies have related mineralization to the intrusive event and assumed a Middle Jurassic age for mineralization. Lead isotope analyses (Logan *et al.*, 1988) suggest a separate mineralizing event of Tertiary age. The mineralized breccia at Willa is hosted by and genetically related to Rossland volcanics (Early Jurassic) and predates intrusion of the batholith (Middle Jurassic). Potassium-argon isotopic dating of sericite alteration in the Willa deposit gave a 57±2 Ma age (unpublished data; R.L. Armstrong, The University of British Columbia). This alteration postdates volcanic breccia mineralization and documents a separate Tertiary hydrothermal event.

## CONCLUSIONS

Mineral potential within the Kokanee Glacier Park is limited to vein targets. All past production came from small underground mines. Two vein groups are evident: mesothermal silver-lead-zinc-bearing quartz and carbonate veins and mesothermal gold-silver-bearing quartz veins. Such veins are viable exploration targets with potential for mine development at recent metal prices (February, 1988).

Rock samples collected from the park indicate that known silver-lead-zinc veins are gold-bearing. Past production records indicate newly discovered deposits would likely be in the 50 000-tonne range or less, however, the potential exists for discovery of larger tonnage deposits. The value of past production (82 287 tonnes), based on recent metal prices, is about 17 million dollars (Table 3). Considering that production took place over a 90-year time span and the small tonnage mined, Kokanee Glacier Park deposits are of most interest to small-scale operators (Table 12).

**TABLE 12**
**SUMMARY OF 1987 EXPLORATION ACTIVITY NEAR KOKANEE GLACIER PARK**

| | | |
|---|---|---|
| Alpine | Cove Energy Corp. (owner)<br>Granges Exploration Ltd.(operator) | Surface drilling (over 700 metres), rehabilating lower level, drifting and underground drilling |
| Enterprise | Locke Goldsmith (owner)<br>Arctex Engineering Ltd. (operator) | 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)<br>Noranda Exploration Inc. (operator) | Proposed drilling |
| Silver Ranch | Don Porteous (owner) | Hand trenching and sampling |
| Al | Dragoon Resources Inc. (operator) | Proposed drilling |
| Willa | Northair Mines Ltd. (operator)<br>B.P. Minerals Ltd. and<br>Rio Algom Exploration Ltd. (owners) | Decline to test west zone, underground drilling |

# REFERENCES


Andrew, A., Godwin, C.I. and Sinclair, A.J. (1984): Mixing Line Isochrons: a New Interpretation of Galena Lead Isotope Data From Southeastern British Columbia, *Economic Geology*, Volume 79, pages 919-932.

Archibald, D.A., Glover, J.K., Price, R.A. Farrar, E. and Carmichael, D.M. (1983): Geochronology and Tectonic Implications of Magmatism and Metamorphism, Southern Kootenay Arc and Neighbouring Regions, Southeastern British Columbia, Part I, Jurassic to Mid-Cretaceous, *Canadian Journal of Earth Sciences*, Volume 20, pages 1891-1913.

Brown, D.A. and Logan, J.M. (1988): Geology and Mineral Evaluation of Kokanee Glacier Provincial Park, Southeastern British Columbia (82F/11, 14); *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork, 1987, Paper 1988-1, pages 31-48.

Cairnes, C.E. (1934): Slocan Mining Camp, British Columbia, *Geological Survey of Canada*, Memoir 173, 137 pages.

Cairnes, C.E. (1935): Descriptions of Properties, Slocan Mining Camp, British Columbia, *Geological Survey of Canada*, Memoir 184, 274 pages.

Carmichael, D. (1978): Metamorphic Bathozones and Bathograds: a Measure of the Depth of Post-metamorphic Uplift and Erosion on the Regional Scale, *American Journal of Science*, Volume 278, pages 769-797.

Carne, R.C. and Cathro, R.J. (1982): Sedimentary Exhalative (SEDEX) Zinc-lead-silver Deposits, Northern Canadian Cordillera; *Canadian Institute of Mining and Metallurgy*, Bulletin, Volume 75, No. 840, pages 66-78.

Carr, S.D. (1986): The Valkyr Shear Zone and the Slocan Fault Zone: Eocene Structures That Bound the Valhalla Gneiss Complex, Southeastern British Columbia, Unpublished M.Sc. thesis, *Carleton University*, 106 pages.

Carr, S.D., Parrish, R.R. and Brown, R.L. (1987): Eocene Structural Development of the Valhalla Complex, Southeastern British Columbia, *Tectonics*, Volume 6, Number 2, pages 175-196.

Childs, J.F. (1968): Contact Relationships of Mount Carlyle Stock, Slocan, British Columbia, Unpublished M.Sc. thesis, *The University of British Columbia*, 76 pages.

Cook, F.A., Simony, P.S., Coflin, K.C., Green, A.G., Milkereit, B., Price, R.A., Parrish, R., Patenaude, C., Gordy, P.L., and Brown, R.L. (1987): Lithoprobe Southern Canadian Cordilleran Transect: Rocky Mountain Thrust Belt to Valhalla Gneiss Complex, *Geophysical Journal of the Royal Astronomical Society*, Volume 89, pages 91-98.

Cox, John (1979): The Geology of the Northwest Margin of the Nelson Batholith, British Columbia, Unpublished M.Sc. thesis, *University of Alberta*, 95 pages.

Doe, B.R. and Zartman, R.E. (1979): Chapter 2. Plumbotectonics I, The Phanerozoic, *in* Geochemistry of Hydrothermal Ore Deposits, 2nd Edition, H.L. Barnes, Editor, *Wiley Interscience*, New York, pages 22-70.

Duncan, I.J., Parrish, R.R. and Armstrong, R.L. (1979): Rb/Sr Geochronology of Post-tectonic Intrusive Events in the Omineca Crystalline Belt, Southeastern British Columbia, *Geological Association of Canada*, Cordilleran Section, Programs with Abstracts, page 15.

Fyles, J.T. (1967): Geology of the Ainsworth-Kaslo Area, British Columbia, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 53, 125 pages.

Ghosh, D.K. (1986): Geochemistry of the Nelson-Rossland Area, Southeastern British Columbia, Unpublished Ph.D. thesis, *University of Alberta*, 310 pages.

Godwin, C.I. and Sinclair, A.J. (1982): Average Lead Isotope Growth Curves For Shale-hosted Zinc-lead Deposits, Canadian Cordillera, *Economic Geology*, Volume 7, pages 675-690.

Goutier, F.M. (1986): Galena Lead Isotope Study of Mineral Deposits in the Eagle Bay Formation, Southeastern British Columbia, Unpublished M.Sc. thesis, *The University of British Columbia*, 153 pages.

Harrison, T.M. (1985): Thermal History of the Nelson Batholith, British Columbia, *Geological Society of America*, Abstracts with Programs, page 260.

Heather, K.B. (1985): The Aylwin Creek Gold-copper-silver Deposit, Southeastern British Columbia, Unpublished M.Sc. thesis, *Queen's University*, 253 pages.

Hedley, M.S. (1952): Geology and Ore Deposits of the Sandon Area, Slocan Mining Camp, British

Columbia, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 29, 130 pages.

Höy, T. and Andrew, K.P.E. (1988): Preliminary Geology and Geochemistry of the Elise Formation, Rossland Group, between Nelson and Ymir, Southeastern British Columbia (82F/06); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1.

Höy, T., Edmunds, F.R., Hamilton, J.M., Hauser, R.L., Muararo, T.W. and Ransom, P.W. (1981): Lead-zinc and Copper-zinc Deposits in Southeastern British Columbia, Field Guides to Geology and Mineral Deposits, Calgary 1981; *Geological Association of Canada*, Mineralogical Association of Canada and Canadian Geophysical Union, pages 41-67.

Hyndman, D.W. (1968): Petrology and Structure of Nakusp Map-area, British Columbia, *Geological Survey of Canada*, Bulletin 161, 95 pages.

Klepacki, D.W. (1983): Stratigraphic and Structural Relations of the Milford, Kaslo, and Slocan Groups, Roseberry Quadrangle, Lardeau Map Area, British Columbia, in Current Research, Part A, *Geological Survey of Canada*, Paper 83-1A, pages 229-233.

Klepacki, D.W. and Wheeler, J.O. (1985): Stratigraphic and Structural Relations of the Milford, Kaslo and Slocan Groups, Goat Range, Lardeau and Nelson Map Areas, British Columbia, *in* Current Research, Part A, *Geological Survey of Canada*, Paper 85-1A, pages 277-286.

LeClair, A.D. (1983): Stratigraphy and Structural Implications of Central Kootenay Arc Rocks, Southeastern British Columbia, *Geological Survey of Canada*, Paper 83-1A, pages 235-240.

LeCouteur, P.C. (1973): A Study of Lead Isotopes From Mineral Deposits in Southeastern British Columbia and in the Anvil Range, Yukon Territiory, Unpublished Ph.D. thesis, *The University of British Columbia*, 142 pages.

Little, H.W. (1960): Nelson Map-Area, West Half, British Columbia (82F W1/2), *Geological Survey of Canada*, Memoir 308, 205 pages.

Logan, J.M. (1986): Geochemical Constraints on the Genesis of Ag-Pb and Zn Deposits, Sandon, British Columbia, Unpublished M.Sc. thesis, *The University of British Columbia*, 178 pages.

Logan, J.M., Gabites, J.E. and Brown, D.A. (1988): Galena Lead Isotope Characteristics of Mineralization in Kokanee Glacier Provincial Park, Southeastern British Columbia (82F/11,14), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 535-541.

Mathews, W.H. (1983): Early Tertiary Resetting of Potassium-argon Dates in the Kootenay Arc, Southeastern British Columbia, *Canadian Journal of Earth Sciences*, Volume 20, pages 867-872.

Matysek, P.F. and Saxby, D.W. (1987): Comparative Study of Reconnaissance Stream Sediment Sampling Techniques For Gold: Fieldwork (93L), *B.C.Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 395-400.

McKechnie, (1967): Molly Gibson, *Minister of Mines, B.C.,* Annual Report, 1966, pages 208-209.

Northair Mines Ltd. (1987): Exploration and Development Review, Willa, Annual Report 1987; *Northair Mines Ltd.,* pages 3-7.

Orchard, M.J. (1985): Carboniferous, Permian and Triassic Conodonts From the Central Kootenay Arc, British Columbia: Constraints on the Age of the Milford, Kaslo and Slocan Groups, *in* Current Research, Part A, *Geological Survey of Canada*, Paper 85-1A, pages 287-300.

Parrish, R.R. (1981): Geology of the Nemo Lakes Belt, Northern Valhalla Range, Southeast British Columbia, *Canadian Journal of Earth Sciences*, Volume 18, pages 944-958.

Parrish, R.R. (1984): Slocan Lake Fault: A Low Angle Fault Zone Bounding the Valhalla Gneiss Complex, Nelson Map Area, Southern British Columbia, *in* Current Research, Part A, *Geological Survey of Canada*, Paper 84-1A, pages 323-330.

_______ (1987): Comprehensive Geochronology of the Valhalla Complex (VC), An Extensional Core Complex of Southeastern B.C., *Geological Association of Canada-Mineralogical Association of Canada*, Saskatoon, page 78.

Parrish, R.R., Carr, S.D. and Brown, R.L. (1985): Valhalla Gneiss Complex, Southeast British Columbia, *Geological Survey of Canada*, Paper 85-1A, pages 81-87.

Parrish, R.R. and Wheeler, J.O. (1983): Uranium-lead Zircon Age of the Kuskanax Batholith, Southeastern British Columbia, *Canadian Journal of Earth Sciences*, Volume 20, pages 1751-1756.

Ray, G.E. and Spence, A. (1986): The Potassium-rich Volcanic Rocks at Tillicum Mountain -- Their Geochemistry, Origin and Significance (82F/13, 82K/4); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1987-1, pages 45-49.

Read, P.B. (1973): Petrology and Structure of Poplar Creek Map-Area, British Columbia, *Geological Survey of Canada*, Bulletin 193, 144 pages.

Reesor, J.E. (1963): Structural Evolution and Plutonism in Valhalla Gneiss Complex, British Columbia, *Geological Survey of Canada*, Bulletin 129, 128 pages.

Reynolds, P.H. and Sinclair, A.J. (1971): Rock and Ore-lead Isotopes from the Nelson Batholith and Kootenay Arc, British Columbia, Canada, *Economic Geology*, Volume 66, pages 259-266.

Richards, J.R., Fletcher, I.R. and Blockley, J.G. (1981): Pilbara Galenas: Precise Isotopic Assay of the Oldest Australian Leads; Model Ages and Growth Curve Implications, *Mineralia Deposita*, Volume 16, pages 7-30.

Simpson, C. and Schmid, S.M. (1983): An Evaluation of Criteria to Deduce the Sense of Movement in Sheared Rocks, *Geological Society of America*, Bulletin, Volume 94, pages 1281-1288.

Sinclair, A.J. (1964): A Lead Isotope Study of Mineral Deposits in the Kootenay Arc, Unpublished Ph.D. thesis, *The University of British Columbia*, 257 pages.

_______ (1966): Anomalous Leads from the Kootenay Arc, British Columbia, in Tectonic History and Mineral Deposits of the Western Cordillera, H. Gunning and W.H. White, Editors, Canadian *Institute of Mining and Metallurgy*, Special Volume 8, pages 249-262.

Stanley, C.R. (1988): PROBPLOT, An Interactive Computer Program to Fit Mixtures of Normal (or Log-normal) Distributions with Maximum Likelihood Optimization Procedures, *Association of Exploration Geochemists,* Special Volume 14.

Tipper, H.W. (1984): The Age of the Jurassic Rossland Group of Southeastern British Columbia, *in* Current Research, Part A, *Geological Survey of Canada*, Paper 84-1A, pages 631-632.

Zartman, R.E. and Doe, B.R. (1981): Plumbotectonics - - The Model, in R.E. Zartman and S.R Taylor, Editors, Evolution of the Upper Mantle, *Tectonophysics*, Volume 75, pages 135-162.

**APPENDIX**
**HEAVY MINERAL SAMPLING RESULTS AND CALCULATED GOLD CONCENTRATIONS FOR NONMAGNETIC SIZE FRACTION**

| SAMPLE | SIZE | Wt g | | Au ppb/wt | | W ppm/wt | | U ppm/wt | | TOTAL | Au ppb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | FRACTION | NM | PM | NM | PM | NM | PM | NM | PM | Wt kg | NM |
| 87-01 | -60 +100 | 2 | 10 | - | - | - | - | - | - | 10.7 | - |
| | -100 +200 | <1 | 4 | - | - | - | - | - | - | | - |
| | -200 | <1 | 4 | - | - | - | - | - | - | | - |
| 87-02 | -60 +100 | 106 | 79 | <9 | - | 140 | - | 9 | - | 9.1 | 0.10 |
| | -100 +200 | 50 | 43 | 170 | <6 | 110 | <4 | 8.1 | 2.1 | | 0.93 |
| | -200 | <1 | 9 | - | <7 | - | 5 | - | 5.8 | | - |
| 87-03 | -60 +100 | 8 | 54 | 76 | - | 76 | - | 154 | | 11.9 | 0.05 |
| | -100 +200 | 3 | 17 | 380 | 20 | 61 | <4 | 151 | 6.8 | | 0.10 |
| | -200 | <1 | 1 | - | <24 | - | <6 | - | 4.8 | | - |
| 87-04 | -60 +100 | 52 | 51 | 64 | - | 370 | - | 4.6 | - | 11.1 | 0.30 |
| | -100 +200 | 63 | 45 | 1500 | 82 | 280 | 5 | 3.2 | 1.2 | | 8.51 |
| | -200 | 15 | 12 | 2200 | 150 | 120 | <4 | 5.3 | 2.0 | | 2.97 |
| 87-05 | -60 +100 | 12 | 29 | <5 | - | 67 | - | 187 | - | 9.2 | <0.01 |
| | -100 +200 | 4 | 8 | <87 | <5 | 700 | <18 | 179 | 25.3 | | <0.04 |
| | -200 | 2 | <1 | 2700 | - | 130 | - | 135 | - | | 0.59 |
| 87-06 | -60 +100 | 55 | 13 | 28 | - | 9 | - | 21.4 | - | 10.5 | 0.15 |
| | -100 +200 | 12 | 27 | 400 | <11 | 12 | <4 | 69.2 | 3.9 | | 0.46 |
| | -200 | 8 | 5 | 250 | <26 | 6 | <7 | 25.4 | 4.8 | | 0.19 |
| 87-07 | -60 +100 | 7 | 28 | <33 | - | 140 | - | 172 | - | 9.7 | <0.02 |
| | -100 +200 | 7 | 16 | <25 | <5 | 180 | 8 | 150 | 7.9 | | <0.02 |
| | -200 | 3 | 3 | 26 | <5 | 47 | 7 | 68.4 | 11.9 | | <0.01 |
| 87-08 | -60 +100 | 6 | 41 | 4200 | - | 11 | - | 62 | - | 10.3 | 2.44 |
| | -100 +200 | 10 | 21 | <15 | <5 | 6 | <4 | 49.1 | 8.3 | | <0.01 |
| | -200 | 8 | 3 | 180 | <5 | <4 | <5 | 26.9 | 5.7 | | 0.14 |
| 87-09 | -60 +100 | 9 | 65 | <5 | - | 44 | - | 102 | - | 9.3 | <0.01 |
| | -100 +200 | 7 | 30 | <5 | <12 | 65 | <4 | 112 | 4.6 | | <0.01 |
| | -200 | 13 | 2 | <5 | <5 | 38 | <4 | 32.5 | 4.1 | | <0.01 |
| 87-10 | -60 +100 | 8 | 81 | 64 | - | <8 | - | 78.7 | - | 10.6 | 0.05 |
| | -100 +200 | 6 | 38 | 47 | <9 | 14 | <4 | 62.2 | 3.2 | | 0.03 |
| | -200 | 1 | 9 | <25 | <15 | <5 | <4 | 30.8 | 12.1 | | <0.01 |
| 87-11 | -60 +100 | 12 | 26 | 42 | - | 25 | - | 44.9 | - | 10.5 | 0.05 |
| | -100 +200 | 9 | 12 | <19 | <28 | 20 | <7 | 38.9 | 10.9 | | 0.02 |
| | -200 | 2 | 4 | <5 | <22 | 10 | <5 | 17.9 | 11.3 | | <0.01 |
| 87-12 | -60 +100 | 12 | 47 | <41 | - | 270 | - | 112 | - | 10.5 | <0.05 |
| | -100 +200 | 4 | 11 | 99 | <27 | 160 | <9 | 153 | 9.3 | | 0.04 |
| | -200 | 2 | 1 | 1100 | 97 | 20 | <15 | 78.9 | <6.9 | | 0.21 |

NM = Nonmagnetic fraction; PM = Paramagnetic fraction; - = no data available.

## LEGEND

### STRATIFIED ROCKS

LOWER JURASSIC
**ROSSLAND GROUP**

- **R** Undifferentiated metavolcanic and metasedimentary rocks
- **Rv** Metavolcanic rocks – augite porphyry, greenstone, argillite. Probable **ELISE FORMATION** (Sinemurian-Pleinsbachian)

UPPER TRIASSIC (CARNIAN TO NORIAN)
**SLOCAN GROUP**

- **S** Metasedimentary rocks – undifferentiated (S), quartzitic siltstone (Ss), argillite and greywacke (Sa), pebbly sandstone (Sc)
- **Sl** Limestone

PERMIAN AND/OR TRIASSIC
**KASLO GROUP**

- **Kv** Metavolcanic rocks – andesite flows, tuff and breccia

PALEOZOIC AND TRIASSIC
**NEMO LAKES BELT**

- **P-Tms** Pelite, schist, amphibolite and ultramafic rocks

PRE-MIDDLE JURASSIC

- **ms** Metasedimentary rocks intruded by orthogneiss and pegmatite sills and dykes

### INTRUSIVE ROCKS

TERTIARY (?)

- **Ta** Andesite and basalt dykes
- **Tr** Rhyolite/felsite dykes

TERTIARY (PALEOCENE TO EOCENE)
**LADYBIRD GRANITE**

- **PEg** Leucocratic biotite quartz monzonite to granite with smoky quartz ± garnet. Muscovite fish in Slocan Lake fault zone

LATE CRETACEOUS
**MULVEY GNEISS**

- **IKgn** Melanocratic biotite-hornblende augen granodioritic gneiss with leucocratic veins

MIDDLE JURASSIC
**NELSON PLUTONIC SUITE**

- **N7** Feldspar porphyry dykes
- **N6** Lamprophyre
- **N5** Quartz monzonite
- **N4** Biotite granite to granodiorite
- **N3** Hornblende potassium feldspar porphyritic granite
- **N2** Potassium feldspar porphyritic granite
- **N1** Diorite/amphibolite

EARLY JURASSIC
**ROSSLAND GROUP SUBVOLCANIC EQUIVALENTS**

- **Rf** Feldspar porphyry
- **Rq** Quartz latite porphyry

### SYMBOLS

- Contacts: defined, approximate, assumed
- Fault: defined and approximate, dot on down-dip side
- Mylonite; arrows indicate sense of shear
- Slocan Lake fault zone; solid dot on hangingwall
- Valkyr shear zone; half circle on upper plate
- Bedding – undetermined facing direction
- Foliation
- Axial plane
- Dyke attitude
- Quartz vein attitude
- Vein surface trace
- Mineral lineation (Bi = biotite; M = mineral)
- Fold axis
- Crenulation fold axis
- Isotopic age determination sample location
- Area of outcrop
- Ice
- Park boundary

Abbreviations: and = andalusite, gt = garnet, sil = sillimanite


**REFERENCES**

Archibald, D.A., Krogh, T.E., Armstrong, R.L. and Farrar, E. (1984). Geochronology and Tectonic Implications of Magmatism and Metamorphism, Southern Kootenay Arc and Neighbouring Regions, Southeastern British Columbia, Part II, Mid-Cretaceous to Eocene, *Canadian Journal of Earth Sciences*, Volume 21, pages 567-583.

Cairnes, C.E. (1934): Slocan Mining Camp, British Columbia, *Geological Survey of Canada*, Memoir 173, 137 pages.

Cairnes, C.E. (1935). Descriptions of Properties, Slocan Mining Camp, British Columbia, *Geological Survey of Canada*, Memoir 184, 274 pages.

Carr, S.D. (1986): The Valkyr Shear Zone and the Slocan Fault Zone: Eocene Structures That Bound the Valhalla Gneiss Complex, Southeastern British Columbia, Unpublished M.Sc. Thesis, *Carleton University*, 106 pages.

Childs, J.F. (1968). Contact Relationships of Mount Carlyle Stock, Slocan, British Columbia, Unpublished M. Sc. Thesis, *The University of British Columbia*, 76 pages.

Cook, F.A., Simony, P.S., Coflin, K.C., Green, A.G., Milkereit, B., Price, R.A., Parrish, R., Patenaude, C., Gordy, P.L., and Brown, R.L. (1987): Lithoprobe Southern Canadian Cordilleran Transect: Rocky Mountain Thrust Belt to Valhalla Gneiss Complex, *Geophysical Journal of the Royal Astronomical Society*, Volume 89, pages 91-98.

Cox, John (1979): The Geology of the Northwest Margin of the Nelson Batholith, British Columbia, Unpublished M.Sc Thesis, *University of Alberta*, 95 pages.

Duncan, I.J., Parrish, R.R., and Armstrong, R.L. (1979): Rb-Sr Geochronology of Post-tectonic Intrusive Events in the Omineca Crystalline Belt, Southeastern British Columbia; Cordilleran Section, *Geological Association of Canada, Programs and Abstracts*, 1979 meeting, Vancouver, B.C., p. 15.

Duncan, I.J. and Parrish, R.R. (1979): Geochronology and Sr Isotope Geochemistry of the Nelson Batholith: A Post-tectonic Intrusive Complex in Southeast British Columbia; *Geological Society of America Abstracts with Programs*, V. 11, p. 76.

Fyles, J.T. (1967): Geology of the Ainsworth-Kaslo Area, British Columbia, *B.C.Ministry of Energy, Mines and Petroleum Resources*, Bulletin 53, 125 pages.

Harrison, T.M. (1985): Thermal History of the Nelson Batholith, British Columbia, *Geological Society of America*, Abstracts with Programs, page 260.

Heather, K.B. (1985): The Aylwin Creek Gold-Copper-Silver Deposit, Southeastern British Columbia, Unpublished M.Sc. Thesis, *Queen's University*, 253 pages.

Hedley, M.S. (1952): Geology and Ore Deposits of the Sandon Area, Slocan Mining Camp, British Columbia; *B.C.Ministry of Energy, Mines and Petroleum Resources*, Bulletin 29, 130 pages.

Höy, T. and Andrew, K.P.E. (1988): Preliminary Geology and Geochemistry of the Elise Formation, Rossland Group, Between Nelson and Ymir, Southeastern British Columbia (82F/06); *B.C.Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1.

Hyndman, D.W. (1968): Petrology and Structure of Nakusp Map-area, British Columbia, *Geological Survey of Canada*, Bulletin 161, 95 pages.

Klepacki, D.W. (1983): Stratigraphic and Structural Relations of the Milford, Kaslo, and Slocan Groups, Roseberry Quadrangle, Lardeau Map Area, British Columbia, Current Research, Part A, *Geological Survey of Canada*, Paper 83-1A, pages 229-233.

Klepacki, D.W. and Wheeler, J.O. (1985): Stratigraphic and Structural Relations of the Milford, Kaslo and Slocan Groups, Goat Range, Lardeau and Nelson Map Areas, British Columbia, *Geological Survey of Canada*, Paper 85-1A, pages 277-286.

Little, H.W. (1960). Nelson Map-Area, West Half, British Columbia (82F W1/2), *Geological Survey of Canada*, Memoir 308, 205 pages.

Logan, J.M., Gabites, J.E. and Brown, D.A. (1988): Galena Lead Isotope Characteristics of Mineralization in Kokanee Glacier Provincial Park, Southeastern British Columbia (82F/11,14), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1.

Mathews, W.H. (1983): Early Tertiary Resetting of Potassium-Argon Dates in the Kootenay Arc, Southeastern British Columbia, *Canadian Journal of Earth Sciences*, Volume 20, pages 867-872.

Orchard, M.J. (1985): Carboniferous, Permian and Triassic Conodonts From the Central Kootenay Arc, British Columbia: Constraints on the Age of the Milford, Kaslo and Slocan Groups, *Geological Survey of Canada*, Paper 85-1A, pages 287-300.

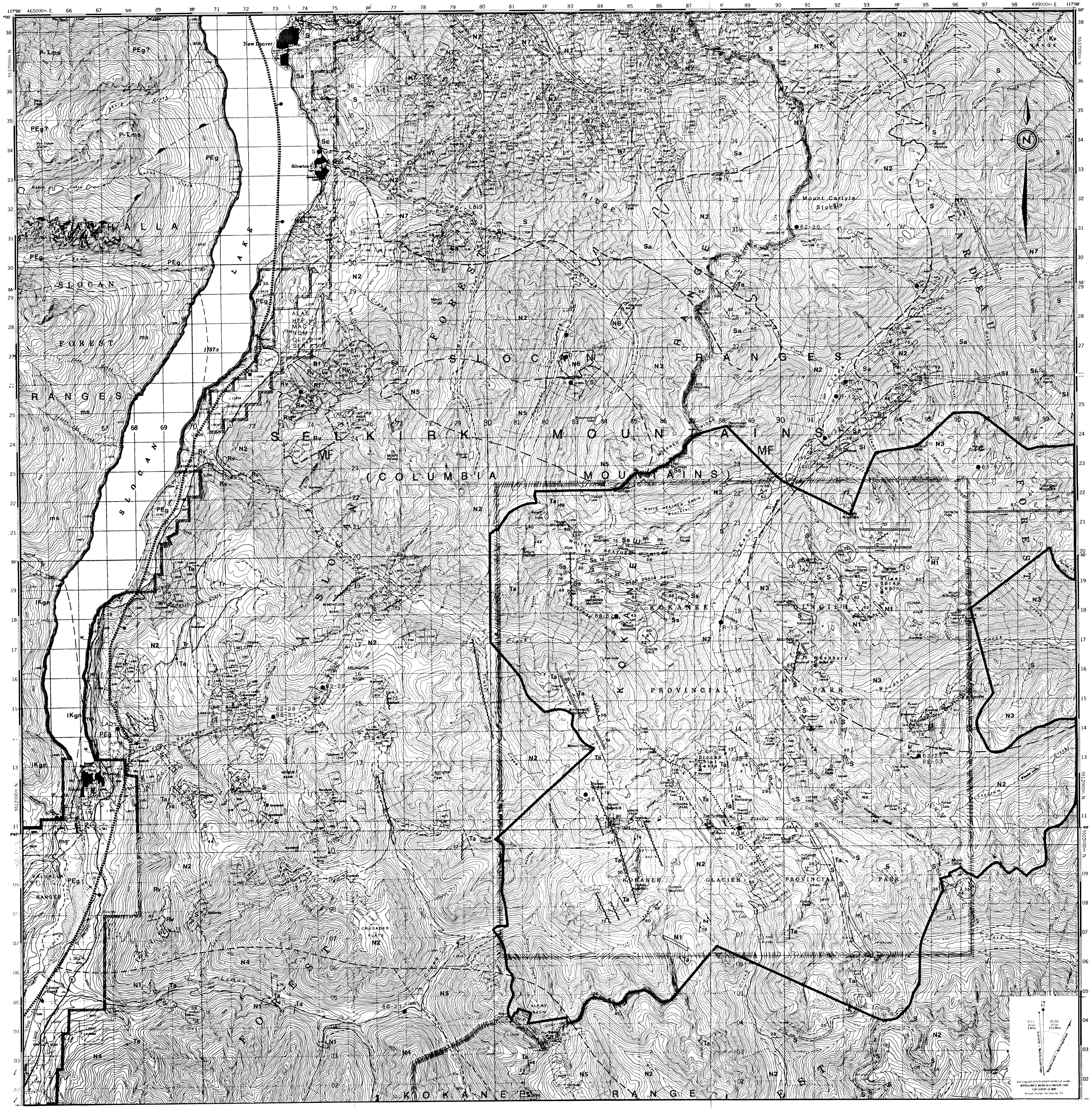
Parrish, R (1984): Slocan Lake Fault: A Low Angle Fault Zone Bounding the Valhalla Gneiss Complex, Nelson Map Area, Southern British Columbia, Current Research, Part A, *Geological Survey of Canada*, Paper 84-1A, pages 323-330.

......... (1987): Comprehensive Geochronology of the Valhalla Complex (VC), An Extensional Core Complex of Southeastern B.C., *Geological Association of Canada-Mineralogical Association of Canada*, Saskatoon, page 78.

Parrish, R., Carr, S.D. and Brown, R.L. (1985). Valhalla Gneiss Complex, Southeast British Columbia, *Geological Survey of Canada*, Paper 85-1A, pages 81-87.

Parrish, R.R. and Wheeler, J.O. (1983): Uranium-lead Zircon Age of the Kuskanax Batholith, Southeastern British Columbia, *Canadian Journal of Earth Sciences*, Volume 20, pages 1751-1756.

Reesor, J.E. (1963): Structural Evolution and Plutonism in Valhalla Gneiss Complex, British Columbia, *Geological Survey of Canada*, Bulletin 129, 128 pages.



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PAPER 1989-5


# MAP 1
# GEOLOGY OF KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA
## NTS 82F/11, 14


Geology by D.A. Brown, J.M. Logan, M.M. Andrews and M.J. Schenck
Compilation by D.A. Brown from Cairnes (1934, 1935), Carr (1986), Heather (1985), Hedley (1952) and Little (1960)


SCALE 1: 50 000
KILOMETRES 0 1 2 3 4 KILOMETRES

**TABLE OF FORMATIONS AND GEOLOGICAL EVENTS NEAR NELSON BATHOLITH, KOKANEE GLACIER PROVINCIAL PARK AREA**

| PERIOD | STRATIGRAPHY | INTRUSIVE EVENTS | 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) | SLFZ (2); VSZ (2); Paleocene – greenschist (4); – eastward thrusting (1 and 8) | ? Potential ? epithermal |
| CRET. | | Mulvey gneiss 100±5 Ma (4); Nelson bath. 169±3 Ma (2); Kuskanax bath. 173±5 Ma (9) | 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); greenschist to sill-ksp grade (3); Phase I and II folding (3); Quesnellia convergence | Volcanogenic breccia pipe |
| TRIASSIC | Slocan Group (Late Triassic; 6) | | | |
| | unconformity | | | |
| PERMIAN | Kaslo Group (Early Permian; 6) | | | |
| PENN. | Milford Group (Early Pennsylvanian–Early Mississippian; 6) | | | |
| MISS. | 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; sill = 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)

**ISOTOPIC AGE DETERMINATIONS COMPILED FROM PREVIOUS WORKERS FOR KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA (82F/11,14)**

| Sample | Location | Easting | Northing | Map Unit | Lithology | Material analysed | Date±1 σ error | Reference |
|---|---|---|---|---|---|---|---|---|
| U-Pb DATES | | | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| K-Ar DATES | | | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| LADY | Slocan | 467250 | 5514250 | Ladybird Gn. | Fol. granite | Mu "fish" | ~47 | Parrish, pers. comm., 1988. |

**Rb-Sr DATES**

| Sample | Location | Easting | Northing | Map Unit | Lithology | Material analysed | Date±1 σ error | Initial ratio | Reference |
|---|---|---|---|---|---|---|---|---|---|
| NOM | Aylwin Creek | 473650 | 5525650 | Nelson bath. | Qtz monzonite | W. Rx.,hb,bi | 148 ± 3 | 0.7065 | UBC. |
| ALAS | Aylwin Creek | 473650 | 5525650 | Nelson suite ? | Alaskite | W.Rx. | 149 ± 6 | 0.7050 | UBC. |
| LADY | Slocan | 467250 | 5514250 | Ladybird Gn. | Foliated granite | Mu "fish" | 54.5 ± 1 | — | Carr et al., 1987. |
| NB2-1-5,3p | Kootenay L. | 484800 | 5492200 | Nelson bath. | por granodiorite | W.Rx. | 140 ± 10 | 0.70655 | UBC. |
| NBI-1,5 | Kootenay L. | 484800 | 5492200 | Nelson bath. | por granodiorite | F.-W.Rx. | 167 ± 17 | 0.7068 | UBC. |
| NBI-4L,4Peg | Kootenay L. | 484800 | 5492200 | Nelson bath. | por granodiorite | W.Rx. | 162 ± 40 | — | UBC. |
| NBI-5 | Kootenay L. | 484800 | 5492200 | Nelson bath. | por granodiorite | Bi-W.Rx. | 62 ± 1.5 | 0.7071 | UBC. |
| ------ | Nemo Lakes | ------ | -------- | Slocan Group | metasediments | W.Rx. | 228 ± 21 | 0.7063 | Parrish, 1981. |

All K-Ar dates are recalculated with $^{40}K$ decay constants: $\lambda\varepsilon = 0.581 \times 10^{-10}$ year$^{-1}$; $\lambda\beta = 4.96 \times 10^{-10}$ year$^{-1}$;
Abundance ratio $^{40}K/K = 1.167 \times 10^{-4}$ atom per cent.

**ABBREVIATIONS**

Bath. = batholith, Bi = biotite, Ck. = creek, F. = feldspars, Gp. = Group, Hb = hornblende, Hwy = highway, L. = Lake, Mt. = Mount, Mtn. = mountain, Mu = muscovite, N.R.A. = not a reliable analysis (radiogenic argon was not measured), por = porphyritic, Qtz = quartz, W.Rx. = whole rock.


**REFERENCES**

Archibald, D.A., Glover, J.K., Price, R.A. and Farrar, E. and Carmichael, D.M. (1983): Geochronology and Tectonic Implications of Magmatism and Metamorphism, Southern Kootenay Arc and Neighbouring Regions, Southeastern British Columbia, Part I, Jurassic to Mid-Cretaceous, *Canadian Journal of Earth Sciences*, Volume 20, pages 1891-1913.

Carr, S.D., Parrish, R.R. and Brown, R.L. (1987). Eocene Structural Development of the Valhalla Complex, Southeastern British Columbia, *Tectonics*, Volume 6, Number 2, pages 175-196.

Ghosh, D.K. (1986): Geochemistry of the Nelson-Rossland Area, Southeastern British Columbia, Unpublished Ph. D. Thesis, *University of Alberta*, 310 pages.

Leech, G.B., Lowdon, J.A., Stockwell, C.H. and Wanless, R.K. (1963): Age Determinations and Geological Studies (Indicating isotopic ages: Report 4); *Geological Survey of Canada*, Paper 63-17, 140 pages.

Lowdon, J.A. (1961): Age Determinations by the Geological Survey of Canada; *Geological Survey of Canada*, Paper 61-17, 127 pages.

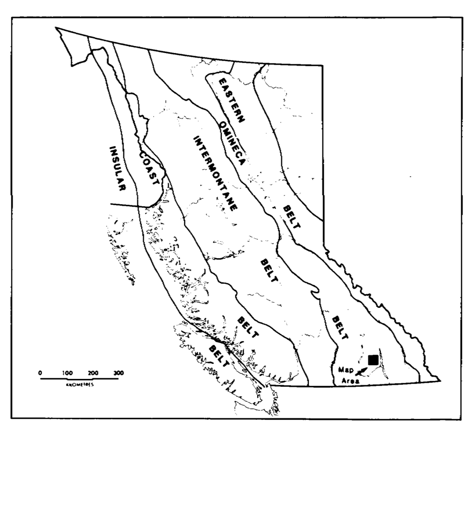
Lowdon, J.A., Stockwell, C.H., Tipper, H.W. and Wanless, R.K. (1963): Age Determinations and Geological Studies; *Geological Survey of Canada*, Paper 62-17, 140 pages.

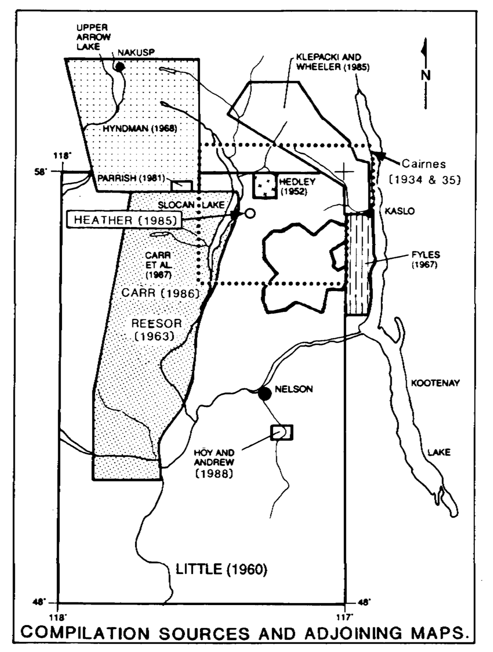
Nguyen, K.K., Sinclair, A.J. and Libby, W.G. (1968). Age of the Northern Part of the Nelson Batholith; *Canadian Journal of Earth Sciences*, V. 5, p. 955-957.

Parrish, R.R. (1981): Geology of the Nemo Lakes Belt, Northern Valhalla Range, Southeast British Columbia, *Canadian Journal of Earth Sciences*, Volume 18, pages 944-958.

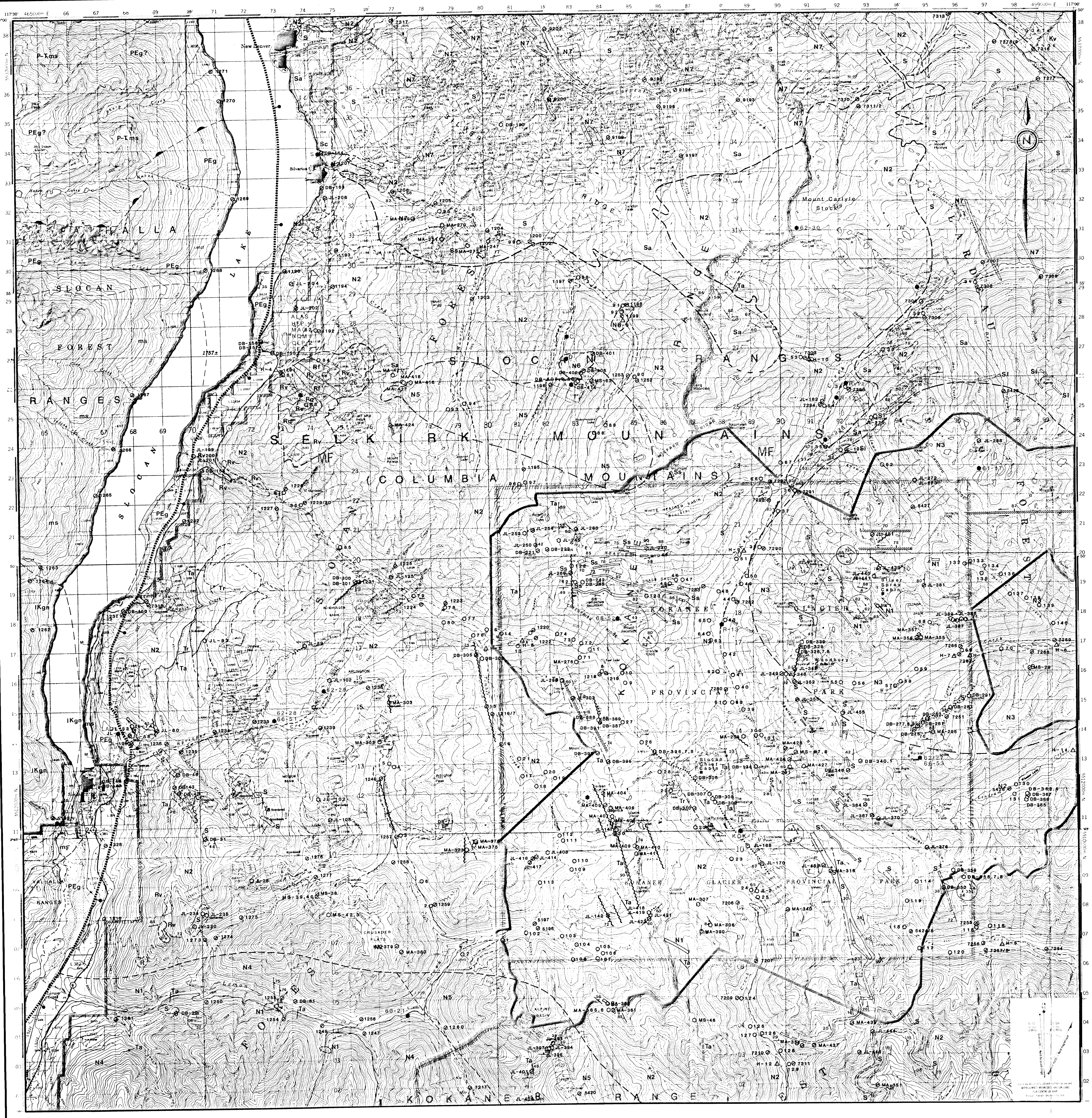
UBC = University of British Columbia geochronology laboratory, Dr. R.L. Armstrong files.

Wanless, R.K., Stevens, R.D., Lachance, G.R. and Edmonds, C.M. (1968): Age Determinations and Geological Studies, K-Ar Isotopic Ages, Report 8; *Geological Survey of Canada*, Paper 67-2A, pages 1-53.




COMPILATION SOURCES AND ADJOINING MAPS.

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MAP 2

# GEOCHEMICAL SAMPLE LOCATIONS FOR KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA

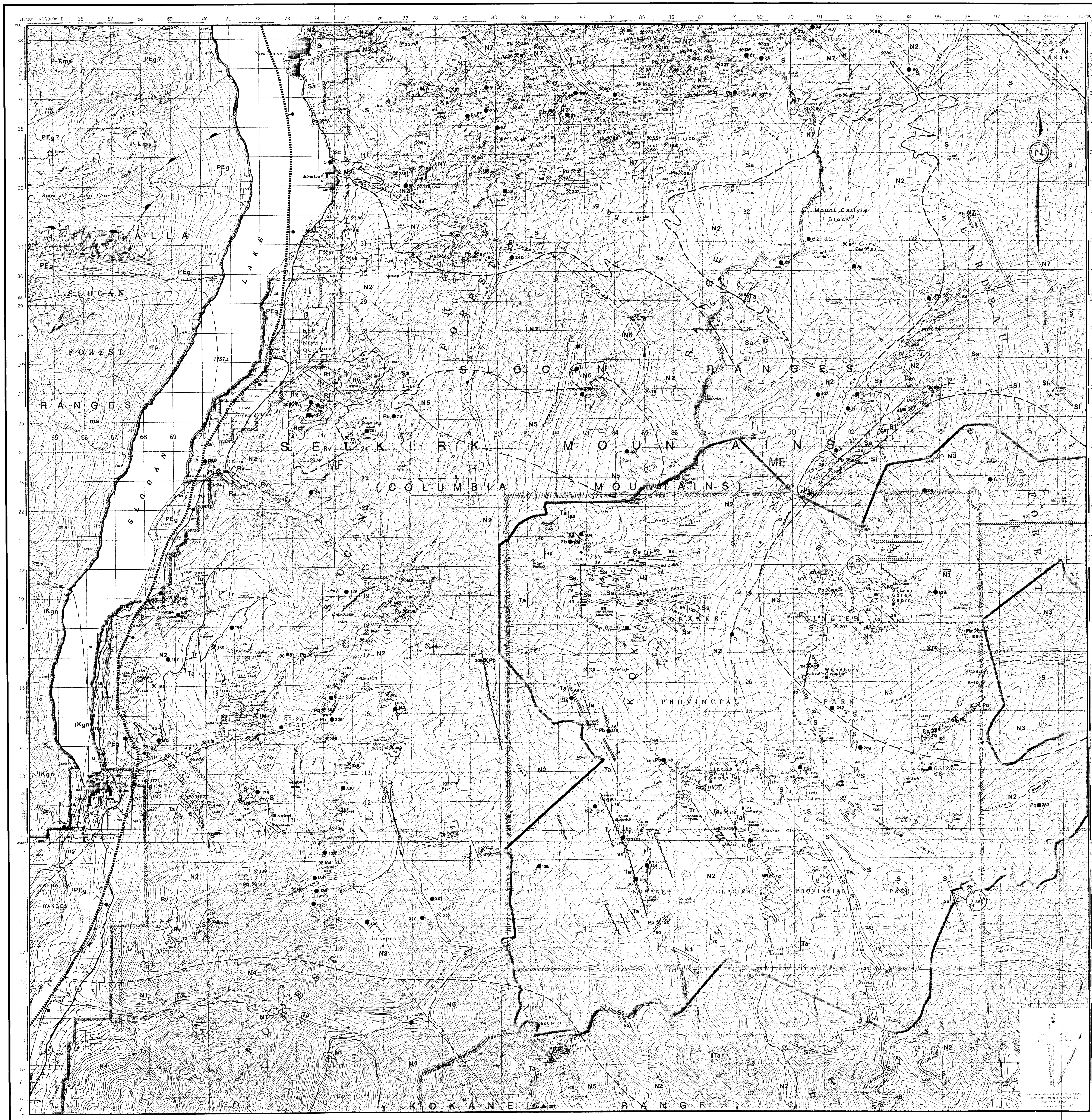
## NTS 82F/11, 14

Compilation by D.A. Brown and J.M. Logan
Results tabulated on Paper 1989-5, Table A

SCALE: 1: 50 000
KILOMETRES 0 1 2 3 4 KILOMETRES

### SYMBOLS

Regional geochemical survey (RGS-1977) stream sediment sample location ........ ⊘
Heavy mineral sample location (collected in 1987) ........ △
Stream sediment sample location (collected in 1987) ........ ○
Rock assay sample location ........ ⬡
Rock geochemistry sample location ........ ⊘

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MAP 3

# MINERAL OCCURRENCES AND LEAD ISOTOPE DATA FOR KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA

NTS 82F/11, 14

Compiled by J.M. Logan

SCALE: 1: 50 000

KILOMETRES 0 1 2 3 4 KILOMETRES

## SYMBOLS

MINERAL OCCURRENCES

Producer ............ ⊗
Past Producer ............ ⚒
Developed Prospect ............ ■
Prospect ............ ▲
Showing ............ ●

LEAD ISOTOPE SAMPLE LOCATIONS

Mineral Occurrence, other ............ Pb, ⊙

**MINERAL OCCURRENCES FOR KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA.**

| NUMBER 82F/NW- | PROPERTY NAME | PRODUCTION TONNES | PRODUCTS |
|---|---|---|---|
| 1 | APEX | 153 | Ag, Pb, Zn |
| 2 | MOWITCH | 83 | Ag, Au, Pb, Zn |
| 3 | BOSUN | 63 222 | Ag, Pb, Zn, Au, Cd |
| 4 | HARTNEY | 255 | Pb, Ag, Zn |
| 5 | CALIFORNIA, CLIPPER | 308 | Pb, Ag |
| 6 | SANDOW, SILVER BELL | 314 | Pb, Ag |
| 7 | IDAHO | 26 856 | Ag, Pb, Zn |
| 8 | ALAMO | 357 | Ag, Pb, Zn |
| 9 | CONDUCTOR | - | Pb, Ag, Zn |
| 10 | QUEEN BESS | 16 561 | Pb, Ag, Zn |
| 11 | SILVERITE, BLACK COLT | 48 | Pb, Zn, Ag, Au |
| 12 | PALMITA | 2 531 | Pb, Ag, Au, Zn |
| 13 | HINKLEY | 106 | Pb, Ag, Zn, Cd |
| 14 | CINDERELLA | 227 | Pb, Ag, Zn |
| 15 | ALTOONA | 7 488 | Zn, Pb, Ag |
| 16 | MERCURY | 179 | Ag, Pb, Zn |
| 17 | MAJESTIC, UNEXPECTED | 221 | Pb, Ag |
| 18 | SAPPHIRE, MINNEAPOLIS | 37 | Pb, Ag |
| 19 | AJAX | 27 | Ag, Pb |
| 20 | LAST CHANCE | 8 448 | Ag, Pb, Zn |
| 21 | SURPRISE 2 | 44 746 | Ag, Pb, Zn, Au |
| 22 | FOUTH OF JULY | 6 | Pb, Ag, Zn, Au |
| 23 | BOADICEA | 8 | Pb, Ag |
| 24 | CARBONET 2 | - | Ag, Pb |
| 25 | LUCKY BOY | - | Ag, Pb |
| 26 | US | - | Zn |
| 27 | ALMEDA | - | Ag, Pb |
| 28 | BELL, SUNSET | 4 146 | Pb, Ag, Zn, Au |
| 30 | GREENHORN | 14 | Ag, Pb |
| 31 | ORO | 7 | Ag, Pb, Zn |
| 32 | CHAMBERS, SHADY | 48 | Pb, Ag, Zn |
| 33 | GREY COPPER | 69 | Ag, Pb, Au, Zn |
| 34 | BLUEBIRD | 807 | Ag, Pb, Zn |
| 35 | RECO | 6 697 | Ag, Pb, Zn |
| 36 | SLOCAN SOVEREIGN | 4 539 | Pb, Ag, Zn, Au |
| 37 | NOBLE FIVE | 39 816 | Pb, Ag, Zn, Cd, Au |
| 38 | MADISON | - | Ag, Pb |
| 39 | ARGO | - | Pb, Zn |
| 40 | VICTORIA | 3 | Ag, Pb, Zn |
| 41 | DANIEL | 16 | Zn, Ag |
| 42 | ELKHORN, NEW SPRINGFIELD | 3 071 | Pb, Zn, Ag, Au |
| 43 | WONDERFUL | 28 406 | Pb, Ag, Zn, Au |
| 44 | OREGAN, JAN | - | Pb |
| 45 | CORINTH | 111 | Pb, Ag, Zn, Au |
| 46 | SUNSHINE | 464 | Pb, Ag, Au |
| 47 | MINNESOTA, DIXIE HAMMER | - | Pb |
| 48 | CARNATION | 529 | Pb, Ag, Zn, Au |
| 49 | EVENING, JENNIE | 4 | Ag, Pb |
| 50 | SILVANA, SILMONAC | 288 974 | Ag, Pb, Zn, Cd |
| 51 | DORTHOY | - | Ag, Pb |
| 52 | RUTH, HOPE | 59 753 | Pb, Ag, Zn, Au |
| 53 | SILVERSMITH, SLOCAN STAR | 355 072 | Pb, Ag, Zn, Cd, Au |
| 54 | RICHMOND, EUREKA | 36 651 | Ag, Pb, Zn, Cu, Au |
| 55 | FREDDIE LEE | 742 | Pb, Ag, Au, Zn |
| 56 | NOONDAY | 357 | Ag, Pb, Zn, Au |
| 57 | IVANHOE, ELGIN | 40 294 | Pb, Ag, Zn, Au |
| 58 | OAKLAND | - | Ag, Pb, Zn |
| 59 | WAKEFIELD | 8 942 | Pb, Ag, Zn |
| 60 | MAMMOTH, MONARCH | 20 919 | Zn, Pb, Ag, Cd, Au |
| 61 | ECHO, GRAPHIC | 740 | Ag, Pb, Zn |
| 62 | JOHNSBY | - | Zn, Ag, Pb |
| 63 | LUCKY THOUGHT (AU) | 8 951 | Ag, Pb, Zn |
| 64 | VAN ROI | 284 707 | Ag, Pb, Zn, Cd, Au |
| 65 | HEWITT | 111 720 | Ag, Pb, Zn |
| 66 | MATALLIC (MIDNIGHT) | 235 | Ag, Pb, Zn, Cu, Au |
| 67 | GALENA FARM | 83 723 | Zn, Pb, Ag, Au, Cd |
| 68 | NOONDAY, CURLEY | 577 | Pb, Ag, Zn, Cd, Au |
| 69 | COLONIAL | 301 | Ag, Pb |
| 70 | LITTLE DAISY | 44 | Au, Ag |
| 71 | WILLA, ROCKLAND | - | Cu, Au, Ag |
| 72 | SILVER NUGGET | 1 | Ag |
| 73 | SILVER BAND | - | Pb, Zn, Ag |
| 74 | MTN. SCENERY, MTN. CHIEF | - | Pb, Zn, Ag |
| 75 | HIGHLAND LIGHT, VICTOR | 10 | Ag, Ba |
| 76 | DAISY | - | Pb, Zn, Ag, Cu |
| 77 | COMSTOCK | 456 | Ag, Pb, Au |
| 78 | LOU DILLON | - | Ag, Au |
| 79 | FISHER MAIDEN | 1 132 | Ag, Pb, Zn, Au, Ba |
| 80 | COMSTOCK, VIRGINIA | 5 | Ag, Pb |
| 81 | MOUNTAIN CON | 448 | Ag, Pb, Au, Zn |
| 82 | GRANITE KING | - | Ag, Pb |
| 83 | FLINT | 171 | Pb, Ag, Zn, Au |
| 84 | MARTIN | 54 | Pb, Ag, Zn |
| 85 | MOHAWK | 6 | Pb, Ag |
| 86 | UTICA | 28 609 | Ag, Pb, Zn, Cd, Au |
| 87 | RAINBOW | 6 | Pb, Ag, Au |
| 88 | HELEN | 6 | Ag, Pb |
| 89 | KENO | 3 | Pb, Ag |
| 90 | BIG BEN | - | Pb, Ag |
| 91 | MONTEZUMA | 3 843 | Ag, Pb, Zn |
| 92 | BLACK BEAR | 5 | Pb, Ag |
| 93 | LIBERTY | 6 | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 121 | MOLLY GIBSON | 55 860 | Ag, Pb, Zn, Au |
| 122 | ORO-FINO | 4 | Au, Ag, Zn, Pb |
| 123 | HUDSON BAY | - | Ag, Pb |
| 124 | SILVER CREST, WHITE HEATHER | - | Au, Ag, Pb |
| 125 | SOLDIER BOY | - | Ag, Au |
| 126 | BARNETT | - | Ag, Au |
| 127 | ALPINE | 15 551 | Au, Ag, Pb, Zn |
| 128 | CRUSADER | - | Ag, Au |
| 129 | PIEDMONT (HOPE 2) | 479 | Zn, Pb, Ag |
| 130 | CHAPLEAU | 297 | Au, Ag |
| 131 | KILO | 2 120 | Au, Ag, Pb, Zn |
| 132 | HOLLINGER | - | Au, Ag |
| 133 | ROSE | - | Au, Ag, Pb |
| 134 | GOLDSTREAM, BEARPAW | - | Au, Ag |
| 135 | TAILHOLT | - | Au |
| 136 | KING JACK, HOWARD FR | 162 | Ag, Au |
| 137 | METEOR | 2 643 | Ag, Au, Zn, Pb, W |
| 138 | ELK | - | Au, Ag |
| 139 | ALICE S | 15 | Ag, Pb |
| 140 | SLOCAN PRINCE | 1 754 | Ag, Pb, Zn |
| 141 | MARMION, MARYLAND | 50 | Au, Ag |
| 142 | B AND R | - | Pb, Ag |
| 143 | HAMPTON | 90 | Ag, Pb, Zn |
| 144 | RIVERSIDE | 18 | Ag, Pb, Zn |
| 145 | WESTMONT, EASTMONT | 3 149 | Ag, Pb, Zn |
| 146 | DALHOUSIE | - | Zn, Pb |
| 147 | NEEPAWA (PEG LEG) | 461 | Ag, Pb, Zn |
| 148 | ENTERPRISE | 10 687 | Ag, Pb, Zn |
| 149 | MABOU, OHIO | 4 | Ag, Zn, Pb |
| 150 | BOND HOLDER | 63 | Ag, Pb |
| 151 | SPECULATOR | 26 | Pb, Ag, Zn, Ba |
| 152 | ARLINGTON | 19 217 | Ag, Pb, Cu, Zn, Au |
| 153 | LILY B | 41 | Ag, Pb, Au |
| 154 | ANNA | 177 | Ag, Pb, Cu, Zn, Ba |
| 155 | OTTAWA | 23 246 | Ag, Ba |
| 156 | TAMARACK | 83 | Ag, Pb, Ba |
| 157 | LITTLE TIM (LT) | 500 | Ag, Pb, Zn, Ba |
| 158 | MOLY | 8 | Ag, Pb, Zn |
| 159 | ALMA (MYRTLE) | 60 | Ag, Zn, Pb, Ba |
| 160 | RADIO | - | Ag, Pb, Zn |
| 161 | COLORADO, SLOCAN BELLE | 67 | Ag, Pb, Zn |
| 162 | CORONATION | - | Ag, Pb |
| 163 | HAPPY MEDIUM | 12 | Ag, Pb |
| 164 | HAMILTON, BACHELOR, VM | 46 | Ag, Au, Pb |
| 165 | WHITEHOPE (PAYSTREAK) | 81 | Pb, Zn, Ag, Au |
| 166 | KALISPELL | 15 | Ag |
| 167 | NORTHERN LIGHT | - | Ag, Pb, Zn |
| 168 | REPUBLIC 2 | 294 | Ag, Au, Pb, Zn |
| 169 | CLUB | - | Ag |
| 170 | RUBY (MARBLE) | - | Ag, Au |
| 171 | PORT HOPE | 14 | Ag, Au |
| 172 | LAKEVIEW | 161 | Au, Ag, Pb, Zn |
| 173 | DAYTON | 17 | Ag, Pb, Au |
| 174 | EXCHANGE | 17 | Ag, Au |
| 175 | EVENING STAR | 42 | Ag, Au |
| 176 | CALUMET, HECLA | - | Ag, Pb, Ba |
| 177 | MOUNTAIN CHIEF | 2 989 | Zn, Ag, Pb, Cu |
| 178 | MARION | 47 | Pb, Ag, Zn |
| 179 | CLIFF | 22 | Zn, Ag, Pb |
| 180 | STANDARD | 743 415 | Zn, Pb, Ag, Cd, Au |
| 181 | AMERICAN BOY | 5 948 | Ag, Pb, Zn |
| 182 | BUFFALO | 103 | Ag, Pb, Zn |
| 183 | JENNIE LIND | 27 | Ag, Pb |
| 184 | JOAN | 38 | Ag, Pb |
| 185 | GOLD CURE | 18 | Pb, Ag |
| 186 | SILVER BELL | 644 | Ag, Pb |
| 187 | OLSEN | 8 | Ag, Zn, Pb, Au |
| 188 | BUSTER | 2 | Ag, Zn, Pb, Au |
| 189 | SKYLARK, RANGER | 3 | Ag, Au |
| 190 | CHAMPION, SAPPHIRE | - | Ag, Au |
| 191 | HAMILTON | 33 | Ag, Pb, Au |
| 193 | GOLD VIKING | 15 | Au, Ag |
| 194 | CHICAGO | 3 | Pb, Ag, Zn |
| 195 | ARGENTA | 41 | Ag, Pb |
| 196 | SLOCAN KING | 10 | Pb, Ag, Zn, Mn |
| 197 | CANADIAN | 855 | Pb, Ag, Zn, Au |
| 198 | ADAMS | - | Pb, Ag, Zn, Au |
| 199 | REDRESS FR. | 4 | Ag, Pb |
| 200 | SHADY FR. (GEM) | 2 | Pb, Ag, Zn |
| 201 | VULTURE | - | PB, Ag, Zn |
| 202 | R E LEE | 243 | Ag, Pb, Zn |
| 203 | NUMBER ONE | 553 | Pb, Ag, Zn, Au |
| 204 | VICTOR (VIOLAMAC) | 49 402 | Ag, Pb, Zn, Cd, Au |
| 205 | SILVER RIDGE | 55 | Pb, Ag, Zn, Au |
| 206 | GET THERE ELI | 9 | Ag, Au |
| 207 | SUN | 31 | Pb, Ag |
| 208 | JUMBO (MARY) | 25 | Ag, Au, Pb, Zn |
| 209 | FREDDY | 228 | Ag, Pb, Zn |
| 212 | LH | 196 | Au, Ag |
| 213 | HOMESTAKE | 330 | Ag, Au, Zn, Pb |
| 214 | JOYCE | 87 | Ag, Au, |
| [illegible] | [illegible] | [illegible] | [illegible] |

**LEAD-ISOTOPE ANALYSES COMPILATION FOR KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA (82F/11,14)**

| DEPOSIT AND/OR SAMPLE NUMBER | NAME | EASTING | NORTHING | HOST LITHOLOGY | DEPOSIT TYPE MATERIAL | | | | | | | REFERENCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 082F/NW-120 | SMUGGLER + | 487559 | 5511750 | K-SPAR | VEIN | 17.590 | 0.00 | 15.492 | 0.01 | 38.187 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-119 | SLOCAN CHIEF + | 486953 | 5512505 | K-SPAR | VEIN | 17.783 | 0.00 | 15.522 | 0.02 | 38.354 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-118 | BLACKBURN + | 485563 | 5513364 | K-SPAR | VEIN | 17.719 | 0.00 | 15.520 | 0.01 | 38.317 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-121 | MOLLY GIBSON + | 489035 | 5508600 | K-SPAR | VEIN | 17.587 | 0.00 | 15.489 | 0.01 | 38.177 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-121 | MOLLY GIBSON + | 489035 | 5508600 | K-SPAR | VEIN | 17.599 | 0.00 | 15.494 | 0.00 | 38.191 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-121 | MOLLY GIBSON + | 489035 | 5508600 | K-SPAR | VEIN | 17.593 | 0.00 | 15.492 | 0.01 | 38.184 | 0.02 | LOGAN et al., 1988 |
| 082F/NW-165 | WHITE HOPE + | 467825 | 5518350 | K-SPAR | VEIN | 18.878 | 0.00 | 15.639 | 0.01 | 39.042 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-106 | REVENUE + | 491131 | 5519134 | HB POR GN | VEIN | 18.968 | 0.00 | 15.657 | 0.00 | 39.158 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-099 | BNA + | 492000 | 5523600 | PEL/PSA/LST | VEIN | 18.873 | 0.00 | 15.647 | 0.00 | 39.033 | 0.0 | LOGAN et al., 1988 |
| 082F/NW-109 | BALTIMORE + | 495950 | 5517754 | HB POR GN | VEIN | 18.981 | 0.00 | 15.655 | 0.01 | 39.177 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-141 | MARMION/MARYLAND + | 476241 | 5514056 | HB POR GN | VEIN | 18.859 | 0.00 | 15.631 | 0.01 | 39.026 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-114 | SILVER CUP + | 487625 | 5511666 | HB POR GN | VEIN | 19.031 | 0.00 | 15.668 | 0.02 | 39.111 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-077 | COMSTOCK + | 483296 | 5526295 | QTZ MONZ/LAMP | VEIN | 18.693 | 0.00 | 15.618 | 0.01 | 38.961 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-077 | COMSTOCK + | 483296 | 5526295 | QTZ MON/LAMP | VEIN | 18.704 | 0.00 | 15.628 | 0.01 | 38.998 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-077 | COMSTOCK + | 483296 | 5526295 | QTZ MONZ/LAMP | VEIN | 18.698 | 0.01 | 15.623 | 0.02 | 38.980 | 0.01 | LOGAN et al., 1988 |
| 082F/NW-048 | CARNATION + | 480650 | 5534500 | ARG/QTZT | VEIN | 18.790 | 0.01 | 15.632 | 0.03 | 39.024 | 0.01 | LOGAN et al., 1988 |
| 082F/NW-152 | ARLINGTON + | 473981 | 5515135 | K-SPAR | VEIN | 18.853 | 0.00 | 15.629 | 0.00 | 39.091 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-152 | ARLINGTON * | 473981 | 5515135 | K-SPAR | VEIN | 18.847 | 0.00 | 15.640 | 0.00 | 39.020 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-105 | PARA + | 482390 | 5520617 | K-SPAR | VEIN | 19.007 | 0.00 | 15.653 | 0.00 | 38.789 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-105 | PARA + | 482390 | 5520617 | K-SPAR | VEIN | 19.011 | 0.00 | 15.647 | 0.00 | 38.768 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-105 | PARA + | 482390 | 5520617 | K-SPAR | VEIN | 19.009 | 0.00 | 15.650 | 0.00 | 38.779 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-111 | PONTIAC + | 496325 | 5515133 | HB POR GN | VEIN | 18.974 | 0.00 | 15.655 | 0.01 | 38.770 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-113 | GRANITE/SUNRISE + | 494497 | 5514090 | HB POR GR | VEIN | 18.959 | 0.01 | 15.644 | 0.03 | 38.739 | 0.01 | LOGAN et al., 1988 |
| 082F/NW-113 | SUNRISE + | 494717 | 5514290 | HB POR GN | VEIN | 18.881 | 0.00 | 15.653 | 0.02 | 38.702 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-122 | ORO FINO + | 485356 | 5507733 | K-SPAR | VEIN | 19.130 | 0.00 | 15.654 | 0.02 | 38.446 | 0.01 | LOGAN et al., 1988 |
| 082F/NW-122 | ORO FINO + | 485356 | 5507733 | K-SPAR | VEIN | 19.144 | 0.00 | 15.667 | 0.02 | 39.047 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-127 | ALPINE + | 481934 | 5503399 | QTZ MON | VEIN | 19.171 | 0.00 | 15.666 | 0.00 | 38.937 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-208 | JUMBO/MARY + | 479651 | 5516615 | K-SPAR | VEIN | 19.069 | 0.00 | 15.650 | 0.01 | 38.810 | 0.00 | LOGAN et al., 1988 |
| E-LH | EAST OF LH + | 477354 | 5526027 | METAVOL/SKARN | SKARN | 19.041 | 0.00 | 15.666 | 0.01 | 38.809 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-215 | SILVER RANCH + | 483690 | 5514368 | K-SPAR | VEIN | 19.044 | 0.00 | 15.654 | 0.02 | 38.822 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-253 | AU/WHEELER + | 498281 | 5511798 | K-SPAR | VEIN | 18.980 | 0.00 | 15.644 | 0.01 | 38.762 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-257 | KING SOLOMON | 481420 | 5501622 | QTZ MONZ | VEIN | 19.185 | 0.00 | 15.674 | 0.02 | 38.995 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-112 | SCRANTON * | 495663 | 5514779 | HB POR GN | VEIN | 18.989 | 0.08 | 15.634 | 0.13 | 38.890 | 0.14 | ANDREW et al., 1984 |
| 082F/NW-112 | SCRANTON * | 495663 | 5514779 | HB POR GN | VEIN | 18.868 | 0.00 | 15.643 | 0.00 | 38.638 | 0.00 | REYNOLDS & SINCLAIR, 1971 |
| 082F/NW-112 | SCRANTON * | 495663 | 5514779 | HB POR GN | VEIN | 18.776 | 0.00 | 15.619 | 0.00 | 38.769 | 0.00 | SINCLAIR, 1964 |
| 082F/NW-112 | SCRANTON * | 495663 | 5514779 | HB POR GN | VEIN | 18.997 | 0.06 | 15.685 | 0.01 | 38.889 | 0.05 | COX, 1979 |
| 082F/NW-112 | SCRANTON * | 495663 | 5514779 | HN POR GN | VEIN | 18.885 | 0.00 | 15.654 | 0.00 | 38.689 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-086 | UTICA * | 490760 | 5535655 | SCST PEL/PSAM | VEIN | 18.786 | 0.00 | 15.633 | 0.00 | 38.984 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-086 | UTICA * | 490760 | 5535655 | SCST PEL/PSAM | VEIN | 18.781 | 0.00 | 15.625 | 0.00 | 38.965 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-086 | UTICA * | 490760 | 5535655 | SCST PEL/PSAM | VEIN | 18.986 | 0.04 | 15.565 | 0.11 | 38.554 | 0.12 | ANDREW et al., 1984 |
| 082F/NW-065 | HEWITT SILVERTON + | 478090 | 5530709 | PSAM/QTZT K-SPAR | VEIN | 18.694 | 0.00 | 15.610 | 0.02 | 38.997 | 0.00 | LOGAN et al., 1988 |
| 082F/NW-065 | HEWITT SILVERTON * | 478090 | 5530709 | PSAM/QTZT K-SPAR | VEIN | 18.681 | 0.08 | 15.578 | 0.17 | 38.883 | 0.11 | ANDREW et al., 1984 |
| 082F/NW-065 | HEWITT SILVERTON * | 478090 | 5530709 | PSAM/QTZT K-SPAR | VEIN | 18.702 | 0.05 | 15.608 | 0.05 | 39.020 | 0.02 | COX, 1979 |
| 082F/NW-155 | OTTAWA * | 471250 | 5515100 | K-SPAR | VEIN | 18.874 | 0.00 | 15.635 | 0.00 | 39.046 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-155 | OTTAWA * | 471250 | 5515100 | K-SPAR | VEIN | 18.841 | 0.04 | 15.656 | 0.10 | 39.093 | 0.10 | ANDREW et al., 1984 |
| 082F/NW-050 | SYLVANNA SILMONAC * | 481950 | 5535425 | PEL/PSAM/LST | VEIN | 18.713 | 0.02 | 15.622 | 0.03 | 38.985 | 0.03 | ANDREW et al., 1984 |
| 082F/NW-091 | MONTEZUMA * | 496000 | 5532000 | PEL/LST/ SCST | VN/REPL | 17.580 | 0.00 | 15.500 | 0.00 | 38.218 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-003 | BOSUN * | 474100 | 5535379 | PEL/QTZT/TUFF | VEIN | 18.737 | 0.00 | 15.626 | 0.00 | 39.013 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-130 | CHAPLEAU * | 471699 | 5509297 | K-SPAR | VEIN | 19.137 | 0.00 | 15.672 | 0.00 | 38.901 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-087 | RAINBOW * | 491820 | 5536050 | SCST/QTZT | VEIN | 19.277 | 0.00 | 15.749 | 0.00 | 39.507 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-005 | CALIFORNIA * | 477100 | 5536625 | PEL/PSAM | VEIN | 18.620 | 0.00 | 15.611 | 0.00 | 39.029 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-094 | CORK PROVINCE * | 494700 | 5528050 | SCST/LST | VEIN | 18.790 | 0.00 | 15.628 | 0.00 | 39.015 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-162 | CORONATION * | 469050 | 5518605 | K-SPAR | VEIN | 18.965 | 0.00 | 15.650 | 0.00 | 38.939 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-148 | ENTERPRISE * | 476800 | 5518475 | K-SPAR | VEIN | 18.717 | 0.00 | 15.628 | 0.00 | 38.944 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-079 | FISHER MAIDEN * | 484609 | 5528550 | K-SPAR | VEIN | 18.739 | 0.00 | 15.627 | 0.00 | 38.948 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-101 | INDEX * | 490650 | 5522490 | K-SPAR/PEL/PSAM | VEIN | 18.758 | 0.00 | 15.642 | 0.00 | 38.933 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-057 | IVANHOE * | 482655 | 5533550 | PEL/PSAM | VEIN | 18.743 | 0.00 | 15.637 | 0.00 | 38.995 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-166 | KALISPELL * | 470403 | 5523218 | K-SPAR/PSAM/PEL | VEIN | 18.701 | 0.00 | 15.625 | 0.00 | 38.945 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-157 | LITTLE TIM * | 473724 | 5517112 | K-SPAR | VEIN | 18.811 | 0.00 | 15.634 | 0.00 | 39.129 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-037 | NOBLE FIVE * | 485655 | 5537255 | ARG/QTZT | VEIN | 18.894 | 0.00 | 15.657 | 0.00 | 39.019 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-035 | RECO * | 487000 | 5537500 | ARG/QTZT | VEIN | 18.859 | 0.00 | 15.756 | 0.00 | 39.272 | 0.00 | RUSSELL & FARQUHAR, 1960 |
| 082F/NW-052 | RUTH HOPE * | 483500 | 5535250 | ARG/QTZT | VEIN | 18.699 | 0.00 | 15.624 | 0.00 | 38.992 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-180 | STANDARD * | 477500 | 5533650 | ARG/QTZT/LST | VEIN | 18.664 | 0.00 | 15.628 | 0.00 | 39.000 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-204 | VICTOR * | 481000 | 5537850 | ARG/QTZT | VEIN | 18.715 | 0.00 | 15.617 | 0.00 | 38.969 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-204 | VICTOR * | 481000 | 5537850 | ARG/QTZT | VEIN | 18.955 | 0.00 | 15.884 | 0.00 | 38.922 | 0.00 | SINCLAIR, 1964 |
| 082F/NW-226 | SILVER LEAF * | 476500 | 5525200 | K-SPAR | VEIN | 18.627 | 0.00 | 15.607 | 0.00 | 38.906 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-201 | VULTURE * | 488200 | 5536100 | PEL/PSAM/LST | VEIN | 18.704 | 0.00 | 15.621 | 0.00 | 39.006 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-053 | SILVERSMITH * | 483850 | 5534650 | ARG/SLSN | VEIN | 18.721 | 0.00 | 15.642 | 0.00 | 39.045 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-064 | VAN ROI * | 479392 | 5530647 | QTZT/PEL | VEIN | 18.708 | 0.00 | 15.640 | 0.00 | 39.027 | 0.00 | LECOUTEUR, 1973 |
| 082F/NW-083 | FLINT * | 492500 | 5530255 | K-SPAR | VEIN | 18.725 | 0.03 | 15.642 | 0.06 | 38.985 | 0.05 | COX, 1979 |
| 082F/NW-056 | NOONDAY * | 486325 | 5533350 | ARG/SLT | VEIN | 18.691 | 0.05 | 15.631 | 0.08 | 39.127 | 0.01 | COX, 1979 |
| CD-1 | SLOCAN SEDIMENTS * | 487000 | 5533450 | ARG/SLT | DIAG PY | 18.875 | 0.02 | 15.644 | 0.03 | 38.658 | 0.03 | LOGAN, 1986 |
| CD-1 | SLOCAN SEDIMENTS * | 487000 | 5533450 | ARG/SLT | DIAG PY | 18.878 | 0.02 | 15.631 | 0.03 | 38.627 | 0.03 | LOGAN, 1986 |
| CD-1 | SLOCAN SEDIMENTS * | 487000 | 5533450 | ARG/SLT | DIAG PY | 18.972 | 0.02 | 15.656 | 0.03 | 38.741 | 0.03 | LOGAN, 1986 |
| CD-1 | SLOCAN SEDIMENTS * | 487000 | 5533450 | ARG/SLT | DIAG PY | 18.897 | 0.02 | 15.646 | 0.03 | 38.630 | 0.03 | LOGAN, 1986 |
| CD-1 | SLOCAN SEDIMENTS * | 487000 | 5533450 | ARG/SLT | DIAG PY | 18.874 | 0.02 | 15.641 | 0.03 | 38.608 | 0.03 | LOGAN, 1986 |
| PA-606 | SLOCAN SEDIMENTS * | 485550 | 5538050 | PEL/PSAM | DIAG PY | 19.121 | 0.02 | 15.659 | 0.03 | 38.731 | 0.03 | LOGAN, 1986 |
| PA-606 | SLOCAN SEDIMENTS * | 485550 | 5538050 | PEL/PSAM | DIAG PY | 18.980 | 0.02 | 15.642 | 0.00 | 38.676 | 0.03 | LOGAN, 1986 |
| PA-606 | SLOCAN SEDIMENTS * | 485550 | 5538050 | PEL/PSAM | DIAG PY | 18.947 | 0.02 | 15.637 | 0.03 | 38.643 | 0.03 | LOGAN, 1986 |
| PA-606 | SLOCAN SEDIMENTS * | 485550 | 5538050 | PEL/PSAM | SYNG PY | 17.816 | 0.02 | 15.581 | 0.03 | 38.522 | 0.03 | LOGAN, 1986 |
| PA-606 | SLOCAN SEDIMENTS * | 485550 | 5538050 | PEL/PSAM | SYNG PY | 18.502 | 0.03 | 15.617 | 0.03 | 38.496 | 0.03 | LOGAN, 1986 |
| PA-606 | SLOCAN SEDIMENTS * | 485550 | 5538050 | PEL/PSAM | SYNG PY | 18.655 | 0.02 | 15.629 | 0.03 | 38.407 | 0.03 | LOGAN, 1986 |
| R-10 | NELSON BATHOLITH FELDSPARS * | 496550 | 5516050 | K-SPAR | K-SPAR | 19.153 | 0.00 | 15.660 | 0.00 | 39.029 | 0.00 | REYNOLDS & SINCLAIR, 1971 |
| R-14 | NELSON BATHOLITH FELDSPARS * | 470850 | 5523950 | K-SPAR | K-SPAR | 19.331 | 0.00 | 15.657 | 0.00 | 38.893 | 0.00 | REYNOLDS & SINCLAIR, 1971 |
| SB-29.7 | INITIAL NEL BATH @ 164 Ma * | 496720 | 5516400 | HB POR GN | W RX | 19.415 | 0.01 | 15.684 | 0.01 | 39.111 | 0.05 | GHOSH, 1986 |
| 8035A | INITIAL SLOC SED @ 164 Ma * | 0 | 0 | ARG/SLT | W RX | 18.700 | 0.01 | 15.661 | 0.01 | 38.907 | 0.05 | GHOSH, 1986 |
| 8035C | INITIAL SLOC SED @ 164 Ma * | 0 | 0 | ARG/SLT | W RX | 18.745 | 0.01 | 15.653 | 0.01 | 38.706 | 0.05 | GHOSH, 1986 |
| 8035D | INITIAL SLOC SED @ 164 Ma * | 0 | 0 | SCST/QTZT | W RX | 18.733 | 0.01 | 15.652 | 0.01 | 38.774 | 0.05 | GHOSH, 1986 |
| 8035F | INITIAL SLOC SED @ 164 Ma * | 0 | 0 | SCST/QTZT | W RX | 18.735 | 0.01 | 15.665 | 0.01 | 38.646 | 0.05 | GHOSH, 1986 |
| 8035G | INITIAL SLOC SED @ 164 Ma * | 0 | 0 | LST | W RX | 18.786 | 0.01 | 15.678 | 0.01 | 38.265 | 0.05 | GHOSH, 1986 |
| 8035B | INITIAL SLOC SED @ 164 Ma * | 0 | 0 | ARG/SLT | W RX | 18.779 | 0.01 | 15.630 | 0.01 | 38.374 | 0.05 | GHOSH, 1986 |
| 8004 | NELSON BATHOLITH FELDSPARS * | 490200 | 5494575 | K-SPAR | k-spar | 19.309 | 0.01 | 15.692 | 0.01 | 39.139 | 0.05 | GHOSH, 1986 |
| 8004 | NELSON BATHOLITH FELDSPARS * | 490200 | 5494575 | K-SPAR | k-spar | 19.313 | 0.01 | 15.710 | 0.01 | 39.180 | 0.05 | GHOSH, 1986 |
| 8059A | NELSON BATHOLITH FELDSPARS * | 490200 | 5494575 | K-SPAR | k-spar | 19.273 | 0.01 | 15.690 | 0.01 | 39.080 | 0.05 | GHOSH, 1986 |
| 8059B | NELSON BATHOLITH FELDSPARS * | 490200 | 5494575 | K-SPAR | k-spar | 19.275 | 0.01 | 15.667 | 0.01 | 39.059 | 0.05 | GHOSH, 1986 |
| 8059C | NELSON BATHOLITH FELDSPARS * | 490200 | 5494575 | K-SPAR | k-spar | 19.213 | 0.01 | 15.636 | 0.01 | 38.737 | 0.05 | GHOSH, 1986 |
| 8059D | NELSON BATHOLITH FELDSPARS * | 490200 | 5494755 | K-SPAR | k-spar | 19.307 | 0.01 | 15.695 | 0.01 | 39.150 | 0.05 | GHOSH, 1986 |

**NOTES**

+ = Analysis normalized to Broken Hill lead Standard values of Richards et al. (1981).
* = Analysis normalized to Richards et al. (1981), converted using intercomparison factors of Godwin et al. (In preparation).

**ABBREVIATIONS**

ARG = argillite, BATH = batholith, DIAG PY = diagenetic pyrite, GN = granite, HB POR GN = hornblende porphyritic granite, K-SPAR = potassium feldspar porphyritic granite, k-spar = potassium feldspar, LAMP = lamprophyre, LST = limestone, METAVOL = metavolcanic, NEL = NELSON, PEL = pelite, PSAM = psammite, QTZ MONZ = quartz monzonite, QTZT = quartzite, SCST = schist, SED = sediments, SLSN = siltstone, SLOC = Slocan, SLT = slate, W.RX = whole rock, SYNG PY = syngenetic pyrite, VN/REPL = vein/replacement mineralization.

**REFERENCES**

Andrew, A., Godwin, C.I. and Sinclair, A.J. (1984): Mixing Line Isochrons. A New Interpretation of Galena Lead Isotope Data from Southeastern British Columbia, *Economic Geology*, Volume 79, pages 919-932.

Cox, John (1979): The Geology of the Northwest Margin of the Nelson Batholith, British Columbia, Unpublished M.Sc Thesis, *University of Alberta*, 95 pages.

Ghosh, D.K. (1986): Geochemistry of the Nelson-Rossland Area, Southeastern British Columbia, Unpublished Ph. D. Thesis, *University of Alberta*, 310 pages.

Godwin, C.I., Gabites, J.E. and Andrew, A. (In preparation): A Galena Lead Isotope Data Base for the Canadian Cordillera, with Notes for Explorationists, *B.C. Ministry Energy, Mines and Petroleum Resources*, Open File.

LeCouteur, P.C. (1973): A Study of Lead Isotopes from Mineral Deposits in Southeastern British Columbia and in the Anvil Range, Yukon Territory, Unpublished Ph. D. thesis, *University of British Columbia*, 142 pages.

Logan, J.M., Gabites, J.E. and Brown, D.A. (1988): Galena Lead Isotope Characteristics of Mineralization in Kokanee Glacier Provincial Park, Southeastern British Columbia (82F/11,14), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1.

Logan, J.M. (1986): Geochemical Constraints on the Genesis of Ag-Pb and Zn Deposits, Sandon, British Columbia, Unpublished M. Sc. Thesis, *University of British Columbia*, 178 pages.

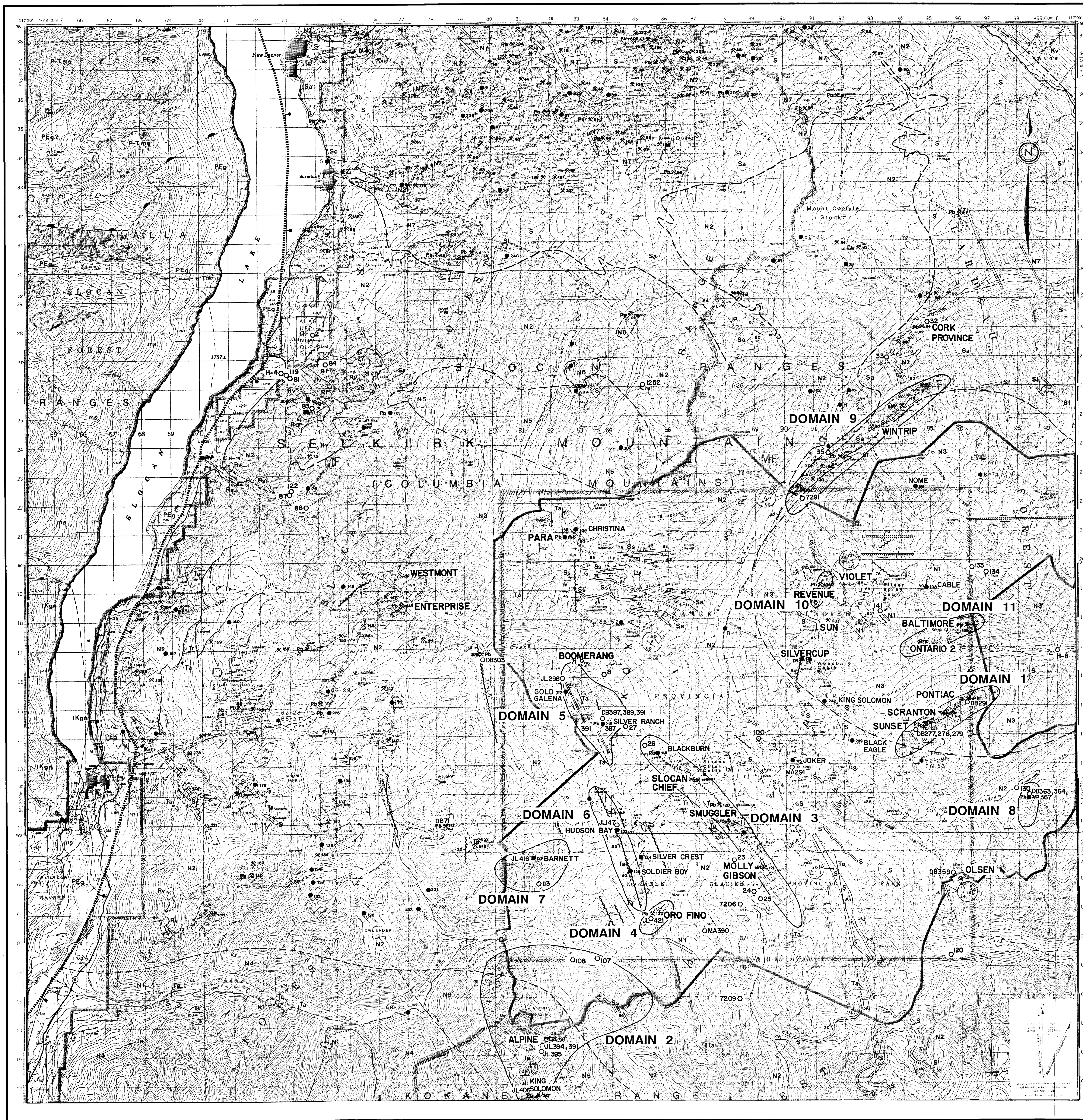
Reynolds, P.H. and Sinclair, A.J. (1971). Rock and Ore-lead Isotopes from the Nelson Batholith and Kootenay Arc, British Columbia, Canada, *Economic Geology*, Volume 66, pages 259-266.

Richards, R.D. Fletcher, I.R. and Blockley, J.G. (1981): Pilbara Galenas— Precise Isotopic Assay of the Oldest Australian Leads, *Mineralium Deposita*, Volume 16, pages 7-30.

Russell, R.D. and Farquhar, R.M. (1960): Lead Isotopes in Geology, *Intersciences Publishes*, New York, 243 pages.

Sinclair, A.J. (1964): A Lead Isotope Study of Mineral Deposits in the Kootenay Arc, Unpublished Ph. D. Thesis, *University of British Columbia*, 257 pages.

MAP 3
TO ACCOMPANY PAPER 1989-5




Ministry of Energy, Mines and Petroleum Resources

BRITISH COLUMBIA GEOLOGICAL SURVEY

PAPER 1989-5

MAP 4

# DOMAINS OF HIGH MINERAL POTENTIAL IN KOKANEE GLACIER PROVINCIAL PARK

NTS 82F/11, 14

by D.A. Brown

SCALE: 1: 50 000

KILOMETRES 0 1 2 3 4 KILOMETRES

SYMBOLS

MINERAL OCCURRENCES

Producer ........ ⊗

Past Producer ........ ⚒

Developed Prospect ........ ■

Prospect ........ ▲

Showing ........ ●

LEAD ISOTOPE SAMPLE LOCATIONS

Mineral Occurrence, other ........ Pb, ⊙

MAP 4
TO ACCOMPANY PAPER 1989-5

## ROCK GEOCHEMICAL RESULTS - 1987.

| STATION | EASTING | NORTHING | ROCK | Au ppb | Ag ppm | Cu ppm | Pb ppm | Zn ppm | Mo ppm | As ppm | Sb ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JL-2 | 489035 | 5508600 | MRLZ | 820 | 940 | 1200 | 9.30 % | 4.13 % | <10 | | |
| JL-28 | 471699 | 5509297 | VEIN | 2.1 ppm | 36 | 24 | 0.10 % | 0.15 % | <10 | | |
| JL-52 | 473981 | 5515135 | MRLZ | 30 | 1280 | 215 | 5.70 % | 11.47 % | <10 | | |
| JL-53 | 467792 | 5514540 | GRNT | <20 | <0.5 | 13 | 28 | 50 | <10 | 2.5 | 2.0 |
| JL-58 | 467658 | 5514363 | ALRZ | <20 | 1 | 13 | 66 | 32 | <10 | 7.2 | 2.3 |
| JL-58 | 467658 | 5514363 | ALRZ | 80 | <0.5 | 22 | 40 | 34 | <10 | 6.5 | <1.0 |
| JL-74 | 467731 | 5514503 | VEIN | 170 | 1500 | 2600 | 3.12 % | 0.37 % | <10 | | |
| JL-80 | 468602 | 5514346 | ALRZ | 70 | <0.5 | 15 | 26 | 40 | <10 | 58.4 | 11.0 |
| JL-83 | 470276 | 5517407 | VEIN | <20 | 179 | 308 | 1.53 % | 4.80 % | 12 | | |
| JL-89 | 473724 | 5517112 | MRLZ | 510 | 4200 | 2050 | 3.62 % | 0.98 % | <10 | | |
| JL-89 | 473724 | 5517112 | MRLZ | 180 | 4400 | 5800 | 11.30 % | 4.34 % | <10 | | |
| JL-102 | 474040 | 5515400 | VEIN | 4.3 ppm | 2300 | 317 | 1350 | 830 | <10 | | |
| JL-102 | 474500 | 5515950 | VEIN | 50 | 119 | 34 | 1.55 % | 0.46 % | <10 | | |
| JL-108 | 474469 | 5511153 | VEIN | 1.9 ppm | 66 | 11 | 250 | 20 | <10 | 18.9 | 1.5 |
| JL-125 | 476778 | 5519382 | MRLZ | 974 | 2300 | 2470 | 7.80 % | 12.97 % | 18 | | |
| JL-142 | 483850 | 5507800 | ALRZ | <20 | <0.5 | 21 | 22 | 45 | <10 | 1.0 | 2.0 |
| JL-147 | 484180 | 5510750 | VEIN | 2.4 ppm | 490 | 45 | 0.26 % | 0.30 % | <10 | | |
| JL-168 | 488750 | 5510200 | VEIN | 420 | 280 | 112 | 3.90 % | 1.56 % | <10 | | |
| JL-170 | 489300 | 5509500 | ALRZ | <10 | 29.2 | 42 | 0.28 % | 0.10 % | <10 | | |
| JL-170 | 489300 | 5509500 | VEIN | 510 | 2300 | 2050 | 9.10 % | 3.93 % | 32 | | |
| JL-170 | 489300 | 5509500 | ALRZ | 50 | 445 | 338 | 1.63 % | 0.65 % | 18 | | |
| JL-182 | 491320 | 5525200 | GOUG | 60 | 60 | 117 | 520 | 310 | <10 | 68.3 | 7.2 |
| JL-191 | 492000 | 5523600 | VEIN | 100 | 410 | 1250 | 8.10 % | 9.49 % | 15 | | |
| JL-198 | 467717 | 5513843 | SLSN | <20 | <0.5 | 16 | 69 | 380 | <10 | 22.6 | 5.8 |
| [illegible] | | | | | | | | | | | |

ANALYTICAL METHODS

Gold (Au) and silver (Ag) by standard fire assay and atomic absorption spectroscopy.
Copper (Cu), lead (Pb), zinc (Zn), molybdenum (Mo), arsenic (As), and antimony (Sb) by atomic absorption.

## STREAM SEDIMENT SAMPLE LOCATION AND RESULTS - 1987.

| Sample number | Easting | Northing | Rock type | Zn ppm | Pb ppm | Ag ppm | Cu ppm | Mo ppm | Au ppb | Hg ppb | As ppm | Sb ppm | Ni ppm | Co ppm | Mn ppm | Fe % | U ppm | Th ppm | Sr ppm | V ppm | Bi ppm | Se ppm | LOI wt. % | Sample wt grams |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Detection limits | | | | 1 | 2 | 0.1 | 1 | 1 | 1 | 5 | 0.1 | 0.1 | 1 | 1 | 5 | 0.01 | 5 | 2 | 1 | 2 | 0.1 | 0.2 | | |
| 001 | 480200 | 5507000 | GRDR | 145 | 31 | 0.1 | 12 | 2 | 147 | 50 | 3.7 | 1.3 | 13 | 7 | 755 | 2.77 | 31 | 7 | 92 | 36 | 0.2 | 1.1 | 15.4 | 11.08 |
| 002 | 477800 | 5508200 | GRDR | 99 | 21 | 0.2 | 9 | 1 | 9 | 5 | 2.9 | 0.6 | 8 | 6 | 526 | 2.61 | 17 | 22 | 63 | 28 | 0.2 | 0.4 | 6.4 | 9.10 |
| 003 | 476750 | 5510600 | GRDR | 86 | 15 | 0.2 | 7 | 1 | 4 | 5 | 2.7 | 0.6 | 5 | 4 | 390 | 2.09 | 5 | 29 | 47 | 23 | 0.1 | 0.2 | 2.5 | 24.45 |
| 004 | 476550 | 5513000 | GRDR | 116 | 23 | 0.1 | 8 | 2 | 1 | 5 | 3.3 | 0.5 | 10 | 6 | 554 | 2.97 | 5 | 18 | 54 | 35 | 0.2 | 0.3 | 4.9 | 2.35 |
| 005 | 476450 | 5513100 | GRDR | 107 | 19 | 0.1 | 3 | 1 | 1 | 5 | 3.8 | 0.2 | 5 | 6 | 494 | 2.86 | 5 | 21 | 29 | 27 | 0.4 | 0.2 | 3.5 | 2.24 |
| 006 | 477450 | 5509100 | GRDR | 106 | 19 | 0.1 | 10 | 1 | 1 | 5 | 1.7 | 0.2 | 22 | 7 | 651 | 3.08 | 9 | 27 | 140 | 33 | 0.1 | 0.2 | 4.2 | 26.24 |
| 007 | 478750 | 5506500 | GRDR | 78 | 13 | 0.1 | 7 | 1 | 3 | 10 | 1.1 | 0.4 | 9 | 4 | 394 | 1.92 | 19 | 15 | 53 | 24 | 0.3 | 0.2 | 4.9 | 10.97 |
| 008 | 483700 | 5516000 | GRDR | 390 | 160 | 11.2 | 13 | 3 | 10 | 90 | 26.5 | 1.0 | 10 | 7 | 690 | 3.62 | 6 | 9 | 55 | 17 | 0.2 | 0.4 | 9.3 | 6.64 |
| 009 | 484550 | 5515650 | GRDR | 96 | 19 | 0.1 | 8 | 2 | 2 | 10 | 3.8 | 0.4 | 4 | 7 | 687 | 2.87 | 11 | 13 | 48 | 44 | 0.2 | 0.2 | 6.1 | 29.61 |
| 010 | 484400 | 5515950 | GRDR | 115 | 26 | 0.1 | 5 | 3 | 1 | 20 | 3.1 | 0.4 | 6 | 7 | 673 | 3.28 | 9 | 14 | 45 | 43 | 0.2 | 0.2 | 5.7 | 8.60 |
| 011 | 483350 | 5516800 | GRDR | 94 | 10 | 0.1 | 8 | 1 | 1 | 10 | 1.7 | 0.2 | 3 | 7 | 579 | 3.14 | 5 | 12 | 39 | 43 | 0.1 | 0.2 | 3.9 | 14.86 |
| 012 | 481300 | 5517450 | GRDR | 104 | 21 | 0.1 | 10 | 2 | 5 | 20 | 11.0 | 0.5 | 5 | 6 | 480 | 2.88 | 5 | 8 | 51 | 47 | 0.1 | 0.5 | 4.8 | 10.69 |
| 013 | 480850 | 5517050 | GRDR | 125 | 16 | 0.2 | 7 | 2 | 1 | 10 | 2.7 | 0.2 | 3 | 6 | 592 | 2.99 | 5 | 17 | 85 | 37 | 0.1 | 0.3 | 5.0 | 0.75 |
| 014 | 480250 | 5517350 | GRDR | 158 | 29 | 0.2 | 7 | 2 | 1 | 30 | 6.1 | 0.6 | 4 | 5 | 686 | 2.81 | 27 | 14 | 57 | 35 | 0.3 | 0.7 | 12.8 | 4.70 |
| 015 | 479821 | 5514980 | GRDR | 111 | 23 | 0.2 | 10 | 2 | 1 | 20 | 5.3 | 0.3 | 8 | 6 | 645 | 3.05 | 9 | 10 | 69 | 39 | 0.2 | 0.4 | 8.3 | 6.33 |
| 016 | 480322 | 5513710 | GRDR | 130 | 27 | 0.1 | 9 | 3 | 1 | 20 | 2.9 | 0.2 | 10 | 6 | 669 | 3.01 | 5 | 13 | 78 | 29 | 0.1 | 0.2 | 6.7 | 12.31 |
| 017 | 481009 | 5512527 | GRDR | 106 | 20 | 0.1 | 5 | 2 | 1 | 10 | 1.7 | 0.3 | 9 | 4 | 499 | 2.33 | 5 | 14 | 41 | 23 | 0.2 | 0.2 | 4.8 | 10.99 |
| 018 | 481475 | 5512238 | GRDR | 104 | 23 | 0.4 | 9 | 3 | 1 | 20 | 2.7 | 0.3 | 8 | 4 | 774 | 2.09 | 75 | 8 | 51 | 29 | 0.4 | 0.5 | 10.1 | 4.90 |
| 019 | 482109 | 5512457 | GRDR | 161 | 42 | 0.1 | 8 | 2 | 1 | 50 | 5.8 | 0.5 | 4 | 4 | 892 | 2.02 | 48 | 3 | 64 | 24 | 0.3 | 1.5 | 18.2 | 2.39 |
| 020 | 481781 | 5512634 | GRDR | 115 | 15 | 0.1 | 4 | 2 | 1 | 5 | 1.9 | 0.2 | 6 | 4 | 516 | 2.22 | 6 | 16 | 38 | 25 | 0.1 | 0.2 | 4.3 | 2.37 |
| 021 | 480834 | 5513103 | GRDR | 89 | 13 | 0.1 | 5 | 2 | 1 | 10 | 1.4 | 0.2 | 4 | 5 | 490 | 2.20 | 5 | 10 | 33 | 25 | 0.1 | 0.2 | 6.2 | 16.45 |
| [illegible] | | | | | | | | | | | | | | | | | | | | | | | | |
| 103 | 482140 | 5507128 | GRNT | 88 | 19 | 0.1 | 11 | 2 | 4 | 20 | 2.0 | 0.2 | 15 | 6 | 478 | 2.40 | 10 | 12 | 60 | 35 | 0.2 | 0.4 | 8.8 | 8.20 |
| 104 | 482643 | 5506803 | GRNT | 141 | 34 | 0.1 | 12 | 1 | 2 | 30 | 2.4 | 0.4 | 18 | 6 | 702 | 2.65 | 34 | 6 | 120 | 32 | 0.3 | 0.3 | 23.5 | 6.98 |
| 105 | 483337 | 5506554 | GRNT | 86 | 8 | 0.1 | 10 | 1 | 5 | 10 | 1.6 | 0.2 | 6 | 5 | 481 | 2.26 | 5 | 17 | 35 | 23 | 0.1 | 0.2 | 4.4 | 13.62 |
| 106 | 483407 | 5506465 | GRNT | 82 | 9 | 0.1 | 5 | 3 | 1 | 5 | 1.7 | 0.2 | 5 | 4 | 496 | 2.26 | 11 | 11 | 45 | 26 | 0.1 | 0.2 | 6.0 | 4.14 |
| 107 | 483350 | 5506351 | GRNT | 96 | 18 | 0.1 | 10 | 3 | 46 | 10 | 2.3 | 0.2 | 11 | 5 | 530 | 2.16 | 10 | 5 | 71 | 30 | 0.1 | 0.5 | 7.4 | 6.15 |
| 108 | 482490 | 5506414 | GRNT | 169 | 32 | 0.2 | 17 | 6 | 1 | 30 | 4.5 | 1.1 | 19 | 8 | 1094 | 2.99 | 35 | 4 | 91 | 40 | 0.5 | 0.8 | 14.2 | 3.73 |
| 109 | 482458 | 5509465 | GRNT | 116 | 28 | 0.2 | 12 | 2 | 1 | 10 | 2.9 | 0.5 | 27 | 9 | 925 | 3.16 | 5 | 13 | 104 | 41 | 0.5 | 0.4 | 7.5 | 18.10 |
| 110 | 482503 | 5509695 | GRNT | 135 | 30 | 0.6 | 12 | 2 | 1 | 10 | 4.2 | 0.5 | 15 | 8 | 872 | 3.69 | 5 | 13 | 96 | 33 | 0.1 | 0.3 | 5.7 | 11.34 |
| 111 | 482146 | 5510478 | GRNT | 141 | 21 | 0.2 | 8 | 1 | 1 | 10 | 2.1 | 0.6 | 12 | 7 | 773 | 3.22 | 18 | 19 | 81 | 35 | 0.1 | 0.6 | 9.7 | 3.43 |
| 112 | 482082 | 5510573 | GRNT | 177 | 30 | 0.1 | 10 | 1 | 1 | 20 | 2.1 | 1.1 | 10 | 7 | 781 | 3.26 | 8 | 14 | 88 | 35 | 0.5 | 0.5 | 11.1 | 3.26 |
| 113 | 481394 | 5508905 | GRNT | 168 | 49 | 0.3 | 13 | 3 | 76 | 40 | 1.9 | 1.0 | 27 | 10 | 1281 | 3.86 | 32 | 11 | 116 | 46 | 0.4 | 0.7 | 16.0 | 6.36 |
| 114 | 494503 | 5508984 | GRNT | 39 | 9 | 0.1 | 5 | 1 | 1 | 5 | 1.5 | 0.2 | 2 | 2 | 226 | 1.25 | 5 | 10 | 17 | 16 | 0.2 | 0.2 | 1.7 | 12.86 |
| 115 | 496495 | 5507392 | GRNT | 128 | 17 | 0.1 | 10 | 1 | 1 | 20 | 7.4 | 0.2 | 6 | 6 | 770 | 3.30 | 5 | 11 | 41 | 41 | 0.4 | 0.2 | 6.8 | 26.00 |
| 116 | 496966 | 5507426 | GRNT | 97 | 19 | 0.1 | 11 | 1 | 1 | 5 | 6.5 | 0.3 | 7 | 7 | 592 | 4.56 | 5 | 14 | 58 | 61 | 0.3 | 0.4 | 5.1 | 13.26 |
| 117 | 494617 | 5506668 | GRNT | 193 | 36 | 0.1 | 10 | 2 | 1 | 40 | 6.4 | 0.6 | 5 | 6 | 972 | 3.03 | 5 | 5 | 51 | 39 | 0.2 | 0.8 | 10.9 | 4.23 |
| 118 | 494158 | 5507360 | GRNT | 110 | 29 | 0.1 | 11 | 2 | 1 | 10 | 6.1 | 0.5 | 5 | 6 | 743 | 2.76 | 5 | 5 | 38 | 34 | 0.2 | 0.7 | 7.0 | 18.02 |
| 119 | 494179 | 5508278 | GRNT | 32 | 7 | 0.1 | 10 | 1 | 2 | 5 | 1.1 | 0.2 | 1 | 3 | 205 | 1.32 | 5 | 11 | 18 | 17 | 0.1 | 0.2 | 1.4 | 59.73 |
| 120 | 495569 | 5506540 | GRNT | 127 | 30 | 0.5 | 15 | 2 | 11 | 60 | 10.2 | 0.9 | 7 | 6 | 1220 | 2.40 | 5 | 1 | 67 | 33 | 0.4 | 1.9 | 25.9 | 4.18 |
| 121 | 482968 | 5519163 | GRNT | 154 | 31 | 0.1 | 22 | 2 | 1 | 20 | 2.9 | 0.6 | 12 | 9 | 783 | 4.15 | 5 | 12 | 68 | 64 | 0.2 | 0.8 | 5.5 | 37.46 |
| 122 | 482793 | 5519680 | GRNT | 172 | 24 | 1.0 | 27 | 5 | 1 | 5 | 8.0 | 0.8 | 17 | 8 | 695 | 3.66 | 5 | 8 | 70 | 59 | 0.1 | 1.9 | 5.7 | 24.84 |
| 123 | 485333 | 5518648 | GRNT | 103 | 11 | 0.2 | 17 | 2 | 1 | 5 | 3.0 | 0.9 | 15 | 7 | 542 | 2.68 | 5 | 10 | 135 | 49 | 0.1 | 0.8 | 4.6 | 44.04 |
| 124 | 488556 | 5504936 | GRNT | 106 | 21 | 0.1 | 7 | 2 | 1 | 5 | 2.1 | 0.5 | 8 | 5 | 582 | 2.28 | 5 | 8 | 55 | 29 | 0.1 | 0.2 | 4.5 | 7.34 |
| 125 | 488822 | 5503983 | GRNT | 145 | 39 | 0.1 | 9 | 3 | 1 | 30 | 5.0 | 0.8 | 14 | 8 | 860 | 3.23 | 5 | 7 | 103 | 43 | 0.3 | 0.5 | 10.7 | 7.52 |
| 126 | 489129 | 5503688 | GRNT | 61 | 9 | 0.1 | 3 | 1 | 1 | 5 | 1.4 | 0.2 | 2 | 3 | 360 | 1.55 | 5 | 5 | 14 | 20 | 0.1 | 0.2 | 3.8 | 57.56 |
| 127 | 488932 | 5503678 | GRNT | 132 | 56 | 0.1 | 9 | 1 | 1 | 20 | 3.3 | 0.9 | 9 | 6 | 759 | 2.94 | 5 | 10 | 62 | 34 | 0.4 | 0.3 | 11.6 | 14.29 |
| 128 | 489748 | 5503098 | GRNT | 256 | 35 | 0.6 | 11 | 1 | 1 | 30 | 5.1 | 0.8 | 5 | 9 | 1057 | 3.74 | 5 | 7 | 44 | 49 | 0.2 | 0.3 | 6.9 | 26.88 |
| 129 | 490015 | 5502683 | GRNT | 125 | 23 | 0.3 | 11 | 1 | 19 | 20 | 5.2 | 0.4 | 3 | 6 | 579 | 2.82 | 5 | 7 | 40 | 36 | 0.6 | 0.9 | 6.7 | 12.18 |
| 130 | 497907 | 5512170 | GRNT | 248 | 218 | 1.1 | 10 | 2 | 6 | 50 | 15.3 | 0.6 | 5 | 7 | 999 | 3.86 | 5 | 5 | 90 | 37 | 0.6 | 0.7 | 13.7 | 8.84 |
| 131 | 497844 | 5511961 | GRNT | 110 | 16 | 0.1 | 6 | 2 | 1 | 30 | 12.3 | 0.8 | 4 | 4 | 437 | 2.83 | 5 | 7 | 39 | 29 | 0.3 | 0.5 | 8.6 | 25.97 |
| 132 | 496381 | 5519717 | GRNT | 71 | 13 | 0.1 | 4 | 1 | 1 | 20 | 1.7 | 0.4 | 6 | 3 | 616 | 1.89 | 5 | 1 | 64 | 30 | 0.3 | 0.6 | 11.5 | 12.86 |
| 133 | 496134 | 5519704 | GRNT | 149 | 24 | 0.2 | 9 | 1 | 1 | 50 | 22.3 | 0.6 | 9 | 4 | 853 | 1.78 | 13 | 1 | 114 | 26 | 0.4 | 2.2 | 16.9 | 7.42 |
| 134 | 496863 | 5519545 | GRNT | 101 | 23 | 0.4 | 13 | 1 | 4 | 60 | 5.1 | 0.7 | 6 | 3 | 728 | 1.78 | 12 | 1 | 106 | 27 | 0.6 | 2.3 | 20.9 | 23.62 |
| 135 | 496825 | 5519386 | GRNT | 120 | 12 | 0.2 | 10 | 4 | 1 | 30 | 6.1 | 0.6 | 8 | 4 | 1011 | 2.52 | 16 | 1 | 74 | 41 | 0.4 | 1.3 | 17.6 | 4.54 |
| 136 | 497383 | 5519284 | GRNT | 104 | 22 | 0.1 | 8 | 1 | 1 | 40 | 3.1 | 0.4 | 7 | 4 | 663 | 2.31 | 22 | 1 | 84 | 39 | 0.5 | 2.2 | 16.5 | 8.22 |
| 137 | 497750 | 5518687 | GRNT | 65 | 12 | 0.1 | 9 | 1 | 1 | 20 | 1.1 | 0.7 | 7 | 3 | 556 | 2.42 | 60 | 1 | 128 | 46 | 0.3 | 2.6 | 15.2 | 10.31 |
| 138 | 498239 | 5518471 | GRNT | 135 | 29 | 0.1 | 10 | 1 | 1 | 30 | 22.1 | 0.5 | 6 | 4 | 1606 | 2.06 | 15 | 1 | 114 | 46 | 0.5 | 2.7 | 18.1 | 8.50 |
| 139 | 498727 | 5518235 | GRNT | 57 | 13 | 0.1 | 5 | 1 | 1 | 20 | 11.2 | 0.3 | 8 | 2 | 424 | 1.42 | 16 | 1 | 84 | 34 | 0.4 | 1.5 | 11.3 | 15.36 |
| 140 | 499221 | 5517657 | GRNT | 72 | 13 | 0.5 | 10 | 1 | 1 | 10 | 13.3 | 0.4 | 21 | 5 | 401 | 1.94 | 7 | 3 | 74 | 48 | 0.3 | 1.8 | 13.6 | 5.30 |
| 141 | 493238 | 5518230 | AMPH | 126 | 50 | 0.2 | 21 | 1 | 1 | 40 | 7.4 | 1.5 | 31 | 7 | 911 | 2.06 | 14 | 5 | 213 | 35 | 0.4 | 0.5 | 8.2 | 29.68 |

**ABBREVIATIONS** ALRZ = alteration, AMPH = amphibolite, ANDS = andesite, GNSS = gneiss, GOUG = gouge, GRDR = granodiorite, GRNT = granite, HRFL = hornfels, LAMP = lamprophyre, MRLZ = mineralization, MVCC = metavolcanic, PEGM = pegmatite, SCKK = stockwork, SLSN = siltstone, SLTE = slate, SKRN = skarn, TILL = till, VCBC = volcanic breccia, VEIN = vein.

**ANALYTICAL PROCEDURES**
Analyses performed by ACME Analytical Laboratories Ltd., 852 E. Hastings St., Vancouver, B.C., V6A 1R6.

1. Elements **Zn, Pb, Ag, Cu, Mo, Ni, Co, Mn, Fe, U, Th, Sr and V**
Inductively Coupled Plasma Emission Spectroscopy (ICPES). A 0.500 gram sample was digested with 3ml 3-1-2 $HCl-HNO_3-H_2O$ at 95 $^0$ C for one hour and was diluted to 10 ml with water. This leach was almost total for base metals, but partial for Fe and Mn.

2. Gold (**Au**)
Graphite Furnace Atomic Absorption. A 10 gram sample (or the sample material remaining after Analytical procedure 1 (above) was completed, which, due to sampling difficulties, may have totalled less than 10 grams) was ignited at 600 $^0$ C, digested with hot aqua regia, extracted with MIBK, and analysed by graphite furnace atomic absorption.

3. Mercury (**Hg**)
Same digestion as in Analytical Procedure 1 above. An aliquot of the extract was added to a $SnCl_2-HCl$ solution. The reduced Hg was measured by cold vapour AA.

4. Elements **As, Sb, Bi** and **Se**
Hydride Generation of volatile elements and determination by ICPES. Digestion as in Analytical Procedure 1 above.

5. Loss on Ignition (**LOI**)
A 0.5gram sample was placed in a furnace and heated to 500 $^0$ C over 2 to 3 hours and held at this temperature for an additional 4 hours. After cooling to room temperature the sample was reweighed.

## MEANS, STANDARD DEVIATIONS AND THRESHOLDS DETERMINED GRAPHICALLY[I] FOR PARTITIONED 1987 STREAM SEDIMENT SAMPLE DATA.

| ELEMENT (UNITS) | POPULATION (%) | b[II] | b + s[III] | b - s[IV] | THRESHOLDS |
|---|---|---|---|---|---|
| Zn (ppm) | A (84) | 103 | 136 | 78 | 181 |
| | B (16) | 275 | 489 | 155 | |
| Pb (ppm) | A (90) | 19 | 30 | 12 | 48 |
| | B (10) | 175 | 430 | 71 | |
| Ag (ppm) | A (97) | 0.07 | 0.42 | 0.01 | 2.8 |
| | B (03) | 12.6 | 17.7 | 8.9 | |
| Cu (ppm) | A (96) | 10 | 16 | 5 | 27 |
| | B (04) | 79 | 182 | 35 | |
| Mo (ppm) | A (95) | 1.5 | 2.5 | 1.0 | 5 |
| | B (05) | 8 | 10 | 6 | |
| Au (ppb) | A (95) | 0.3 | 1.7 | 0.04 | 21 |
| | B (05) | 77 | 147 | 40 | |
| Hg* (ppb) | A (97.5) | 19 | 34 | 4 | 49 |
| | B (02.5) | 85 | 133 | 37 | |
| As (ppm) | A (5) | 4 | 8 | 2 | 15 |
| | B (8) | 19 | 24 | 15 | 29 |
| | C (7) | 100 | 241 | 41 | |
| Sb (ppm) | A (0) | 0.4 | 0.6 | 0.2 | 1.1 |
| | B (6) | 1.0 | 1.2 | 0.9 | 1.5 |
| | C (4) | 2.7 | 6.0 | 1.3 | |
| Ni (ppm) | A (90) | 7 | 14 | 4 | 28 |
| | B (10) | 51 | 88 | 29 | |
| Co* (ppm) | A (95) | 6 | 7.5 | 4 | 10 |
| | B (05) | 12 | 19.5 | 6 | |
| Mn (ppm) | A (10) | 297 | 376 | 235 | 476 |
| | B (77) | 580 | 730 | 460 | 917 |
| | C (13) | 1162 | 1570 | 894 | |
| Fe* (%) | A (94.5) | 2.6 | 3.3 | 2 | 3.8 |
| | B (05.5) | 4.3 | 4.5 | 4.0 | |

I. Stanley, C.R. (1987): PROBPLOT: An Interactive Computer Program to Fit Mixtures of Normal (or Log-normal) Distributions Using Maximum Likelihood Optimization Procedures, in *The Association of Exploration Geochemists*, Special Volume 14.

II. Antilog of mean of population.

III. Antilog of mean plus 1 standard deviation of population.

IV. Antilog of mean minus 1 standard deviation of population.

* Arithmetic population.

## 1977 STREAM SEDIMENT SAMPLE LOCATIONS AND RESULTS - REGIONAL GEOCHEMICAL SURVEY.

| Sample number | Easting | Northing | Rock type | Zn ppm | Pb ppm | Ag ppm | Cu ppm | Mo ppm | Hg ppb | Ni ppm | Co ppm | Mn ppm | Fe % | U ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1190 | 473312 | 5529893 | GRNT | 104 | 14 | 0.6 | 24 | 1 | 10 | 24 | 7 | 615 | 1.45 | 8.0 |
| 1191 | 473087 | 5526355 | GNSS | 96 | 8 | 0.2 | 245 | 6 | 5 | 30 | 20 | 425 | 3.75 | 2.4 |
| 1192 | 474306 | 5527782 | GRNT | 80 | 11 | 0.1 | 12 | 1 | 20 | 6 | 5 | 495 | 1.90 | 12.9 |
| 1193 | 475048 | 5530103 | GRNT | 230 | 62 | 0.8 | 12 | 1 | 5 | 16 | 6 | 405 | 1.75 | 8.9 |
| 1194 | 474844 | 5529119 | GRNT | 114 | 10 | 0.2 | 16 | 2 | 10 | 10 | 6 | 410 | 2.00 | 10.1 |
| 1195 | 481307 | 5523753 | GRNT | 470 | 85 | 1.0 | 6 | 1 | 50 | 6 | 5 | 415 | 1.90 | 83.7 |
| 1196 | 482222 | 5526187 | GRNT | 114 | 18 | 0.1 | 18 | 1 | 10 | 126 | 17 | 385 | 2.30 | 6.6 |
| 1197 | 482970 | 5529142 | GRNT | 280 | 180 | 1.2 | 18 | 1 | 30 | 90 | 15 | 815 | 2.40 | 14.4 |
| 1198 | 484807 | 5528468 | GRNT | 295 | 82 | 2.4 | 16 | 1 | 10 | 20 | 7 | 675 | 2.10 | 13.4 |
| 1199 | 484734 | 5528170 | GRNT | 66 | 7 | 0.2 | 20 | 1 | 10 | 130 | 16 | 320 | 2.10 | 5.8 |
| 1200 | 481536 | 5530983 | SLTE | 154 | 39 | 0.6 | 30 | 2 | 10 | 60 | 12 | 640 | 2.10 | 3.6 |
| 1202 | 481647 | 5530588 | SLTE | 178 | 41 | 1.4 | 18 | 1 | 5 | 88 | 13 | 450 | 2.05 | 8.4 |
| 1203 | 479620 | 5528938 | GRNT | 92 | 15 | 0.4 | 12 | 1 | 20 | 26 | 7 | 665 | 1.95 | 22.7 |
| 1204 | 480166 | 5531380 | SLTE | 108 | 19 | 0.1 | 28 | 1 | 10 | 26 | 9 | 800 | 2.15 | 3.1 |
| 1205 | 478350 | 5532220 | SLTE | 1640 | 390 | 2.6 | 46 | 3 | 20 | 26 | 11 | 1100 | 2.75 | 3.2 |
| 1206 | 476841 | 5532644 | SLTE | 295 | 45 | 1.8 | 44 | 3 | 10 | 22 | 10 | 550 | 2.80 | 2.8 |
| 1207 | 475082 | 5533591 | SLTE | 355 | 46 | 0.9 | 42 | 3 | 20 | 26 | 11 | 865 | 3.10 | 2.8 |
| 1216 | 479901 | 5514595 | GRNT | 88 | 14 | 0.3 | 4 | 1 | 10 | 6 | 5 | 510 | 2.05 | 14.1 |
| 1217 | 479901 | 5514595 | GRNT | 86 | 18 | 0.2 | 6 | 1 | 20 | 4 | 5 | 525 | 2.20 | 18.6 |
| 1218 | 483731 | 5516098 | GRNT | 104 | 41 | 0.1 | 10 | 3 | 30 | 14 | 7 | 710 | 2.55 | 27.2 |
| 1219 | 484162 | 5515949 | GRNT | 82 | 36 | 0.2 | 6 | 3 | 40 | 6 | 5 | 410 | 2.20 | 31.4 |
| 1220 | 481423 | 5517513 | GRNT | 124 | 46 | 0.3 | 10 | 1 | 30 | 4 | 8 | 650 | 2.60 | 21.0 |
| 1222 | 481713 | 5517282 | GRNT | 72 | 11 | 0.1 | 6 | 1 | 10 | 2 | 6 | 590 | 2.15 | 24.6 |
| 1223 | 478343 | 5518559 | GRNT | 94 | 19 | 0.4 | 4 | 1 | 20 | 2 | 7 | 755 | 2.35 | 18.6 |
| 1224 | 477587 | 5518443 | GRNT | 64 | 7 | 0.1 | 4 | 2 | 10 | 2 | 4 | 230 | 1.55 | 10.6 |
| [illegible] | | | | | | | | | | | | | | |

## HEAVY MINERAL SEPARATE SAMPLE LOCATIONS.

| Sample | Easting | Northing | Location |
|---|---|---|---|
| H-1 | 479829 | 5516798 | Timber Creek |
| H-2 | 481081 | 5517170 | Enterprise Creek |
| H-3 | 484621 | 5528182 | Silverton Creek |
| H-4 | 472996 | 5526478 | Aylwin Creek |
| H-5 | 497325 | 5506685 | Coffee Creek |
| H-6 | 496277 | 5516677 | Pontiac Creek |
| H-7 | 496385 | 5516666 | Woodbury |
| H-8 | 499245 | 5517010 | Nelles Creek |
| H-9 | 488699 | 5520189 | Keen Creek |
| H-10 | 490781 | 5526688 | Long Creek |
| H-11 | 502950 | 5513300 | Lendrum Creek |
| H-12 | 489800 | 5502725 | Kokanee Creek |

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TABLE A

# 1987 GEOCHEMICAL RESULTS FOR KOKANEE GLACIER PROVINCIAL PARK AND SURROUNDING AREA

### NTS 82F/11, 14

Includes results of 1977 Regional Geochemical Survey

Compiled by D.A. Brown and J.M. Logan