Geology in British Columbia

1977 — 1981

Province of British Columbia
Ministry of
Energy, Mines and
Petroleum Resources

British Columbia Cataloguing in Publication Data
Main entry under title:
Geology in British Columbia. -- 1975-1977/81.

Irregular.
With: Exploration in British Columbia; and, Mining in British Columbia, ISSN 0823-1265, continues: Geology, exploration and mining in British Columbia, ISSN 0085-1027.
1976 published in 1983.
1977/81 published as a 1 volume cummulation.
Issuing body varies: 1975, Ministry of Mines and Petroleum Resources; 1976-1977/81, Ministry of Energy, Mines and Petroleum Resources.
ISSN 0823-1257 = Geology in British Columbia

1. Geology - British Columbia - Periodicals. 2. Geology, Economic - British Columbia - Periodicals. 3. Mines and mineral resources - British Columbia - Periodicals. I. British Columbia. Ministry of Mines and Petroleum Resources. II. British Columbia. Ministry of Energy, Mines and Petroleum Resources.

QE187.G46 557.1105

TABLE OF CONTENTS

ILLUSTRATIONS

FIGURES

PHOTOGRAPHS

PLATES

PREFACE

In 1969, the Annual Report of the Ministry grew to such a size that it was decided to divide it and initiate a new publication entitled *Geology, Exploration and Mining in British Columbia*. The new volume was concerned with publishing geological and technical reports and recording exploration activity in the Province. The first edition, Geology, Exploration and Mining in British Columbia, 1969, was 466 pages, by 1970 it was 561 pages.

Exploration activity continued to bloom but our staff did not expand. In the mid-1970's re-organizations within the Ministry shifted priorities and put severe pressure on publications production section. Staff turnover was rapid, the section did not grow to match new workload, backlogs began and built rapidly. We are making a concentrated effort to attempt to eliminate the backlogs and get back on schedule.

This volume represents such an attempt. It contains contributions that span four years. The publication, *Geology in British Columbia,* is supposed to be released annually; we apologize that production difficulties have forced us to combine several issues in order to catch up. Also because of production difficulties, the volume is small, since little material was submitted after 1977. Ministry geologists switched their efforts and published more preliminary maps, reports in Geological Fieldwork and the Paper series, and in external publications.

SOUTHEAST BRITISH COLUMBIA
(NTS DIVISION 82)

1977—GEOLOGY OF THE SKOMAC MINE AND BOUNDARY FALLS AREA (82E/2)

By B. N. Church

INTRODUCTION: The Skomac mine is a recently revived small gold and silver operation in the Boundary Falls area located 5.5 kilometres southwest of Greenwood. The workings consist of several adits on a quartz vein system traceable on three Crown-granted claims, the Nonsuch, Republic, and Last Chance.

The first mine development began in the period 1894 to 1896 when adits Nos. 1 and 2 were driven on the Nonsuch claim, and an inclined shaft was sunk on the Last Chance claim. The only noted production from this era, amounting to a few carloads of crude ore, was recorded by Republic Gold Mines Ltd. in 1904. Although the mine appears to have been thoroughly examined and sampled in 1922, no additional work was undertaken in the area for the next 40 years. The property was then acquired by Skomac Mines Ltd. who re-opened the old workings on the Last Chance claim. From 1962 to 1964 a total of 670 tonnes of ore was mined from adits Nos. 4 and 5 and shipped to the Trail smelter. Except for a small production by lessees in 1969, the mine remained closed for 10 years.

The current period of mining activity began in 1974 when Robert Mines Ltd. gained control of the property. Adit No. 6 on the Nonsuch claim was opened at this time. Operations during the spring and summer months of 1975 yielded a total of 434 tonnes of ore and an additional 548 tonnes in 1976. In October 1976, No. 7 adit was started to investigate the downward extension of the vein system and by December excavations had advanced about 110 metres to a point almost under the previous workings. The only work undertaken in 1977 was a program of diamond drilling from No. 7 adit to test parallel vein structures. A small mill was also transported to the site at this time.

PHYSIOGRAPHY: The Skomac mine, together with a few other small workings overlooking Boundary Creek south of Greenwood, are part of what was once referred to as Smith's Camp.

The mine site is situated at the base of a diorite face (Plate I) where the slopes rising gently from Boundary Falls (elevation 2,250 feet) steepen abruptly through about 700 metres of relief to a series of wooded summits on the north and west. General rounding of ridges and peaks in the area resulted from Pleistocene glaciers moving southwest at about 210 degrees. In the valley of Boundary Creek a broad apron of sand and gravel was deposited and then eroded by meltwaters from the last glacial period.

GENERAL GEOLOGY: The area is underlain by a wide ranging section of Tertiary, Mesozoic, Upper Paleozoic, and older basement rocks (Fig. 1). These formations have undergone several episodes of deformation and are intruded by granite, diorite, serpentine, and a variety of dykes.

The relative stratigraphic position and age of the formations is assessed by degree of metamorphism and intrusive relationships. Fossil evidence provides some specific control.

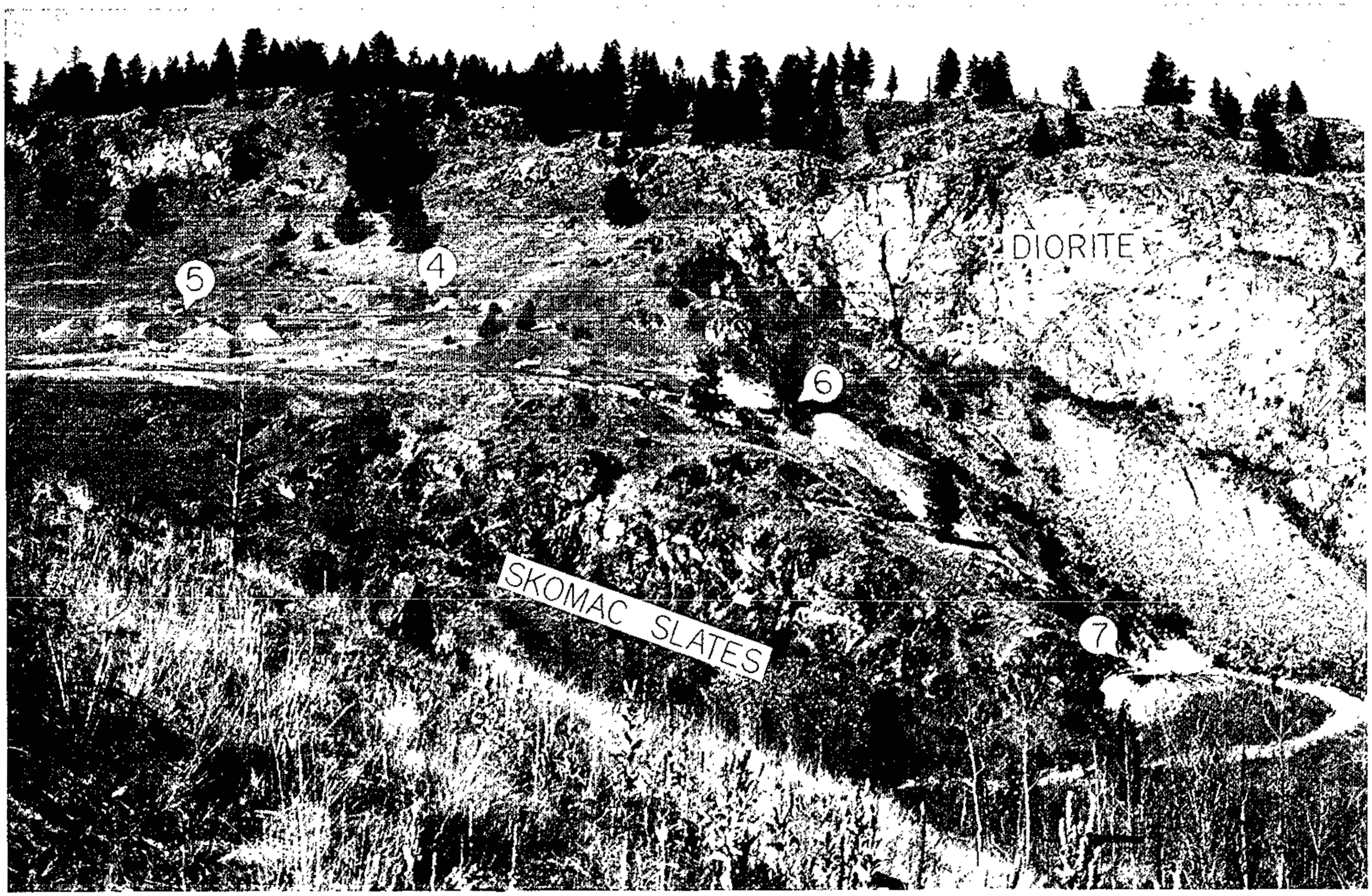


Plate I. Panorama of the Skomac minesite, looking northerly at the main portals

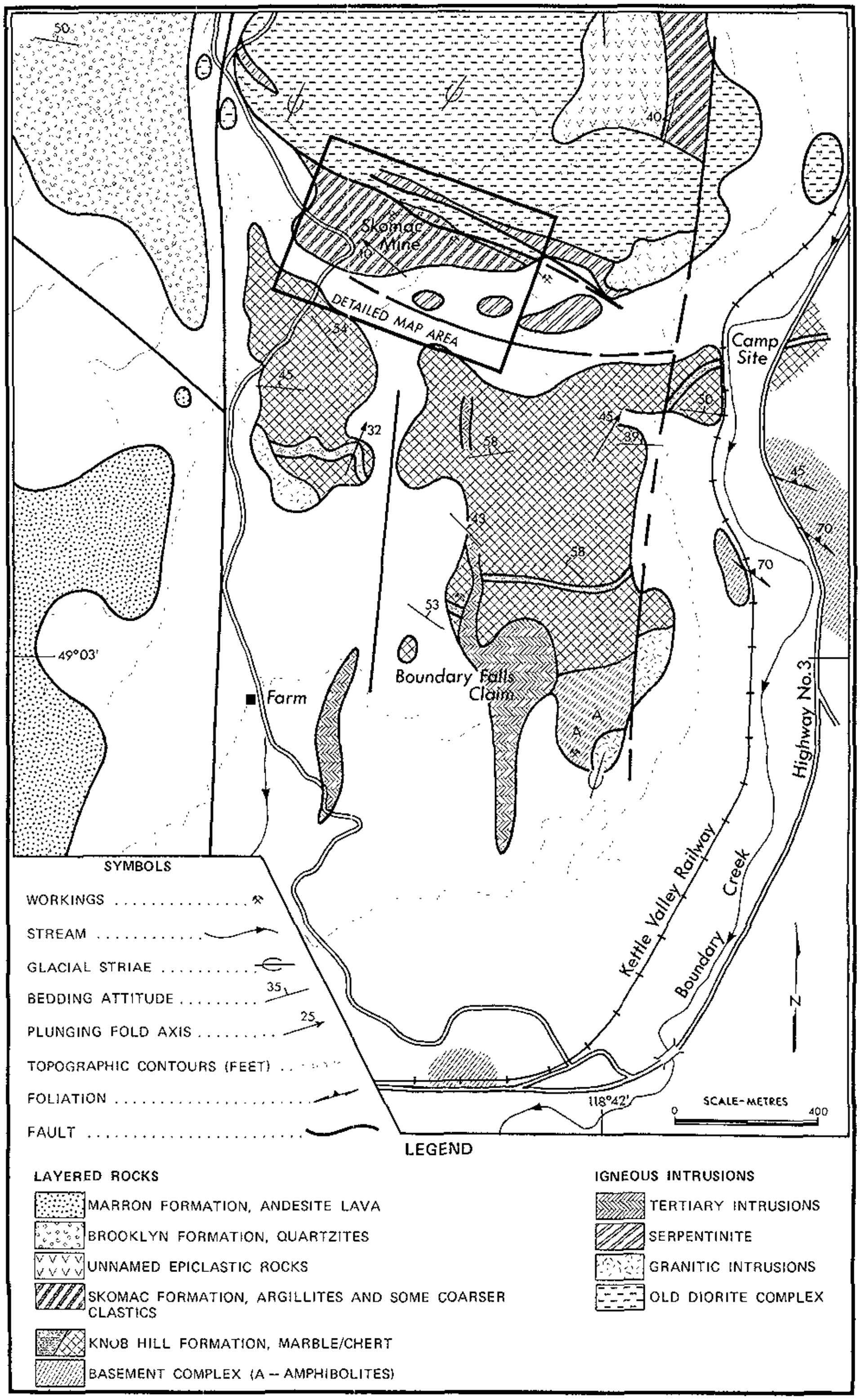


Figure 1. Geology of the Boundary Falls area, Greenwood

STRATIGRAPHY: The table of formations for the region, adapted from previous studies, is only partly applicable to the Boundary Falls area. Missing are important units from the Tertiary and Mesozoic assemblages (*).

Units	Lithology
Tertiary	
Marron Formation	*Felsic Lavas*
Kettle River Formation*	Clastic Sedimentary Rocks
Triassic	
Eholt Formation*	Basic Lavas with some Limestone Lenses
Brooklyn Formation	Limestone*, Sharpstone Conglomerate, Acid and Intermediate Volcanic Rocks
Premian-Carboniferous	
Skomac Formation	Black Shales and some Clastic Sedimentary Rocks
Knob Hill Formation	Quartzites, some Marble and Amphibolites
Basement Complex	Schists and Gneisses

Basement Complex: Rocks of the basement complex are exposed in a small area along Highway 3 and the Kettle Valley Railway. These are contorted quartz-mica schists and gneisses of archaic origin and unknown thickness.

Similar rocks occur beyond the east boundary of the map-area near the Oro Denoro mine (GEM, 1976, on pp. 1–13) and on the slopes of Mount Wright (GEM, 1970, pp. 413 to 425).

Knob Hill Formation: The Knob Hill Formation, as described by Seraphim (1956), at Phoenix consists of chert and metamorphosed volcanic rocks of assumed Early Paleozoic age. In the map-area the formation is mostly thinly bedded chert and quartzite with some intercalated argillaceous and carbonate facies.

The chert beds, estimated by Seraphim to be a few hundred metres thick on Deadman Ridge northeast of Phoenix, are at least 700 metres thick in the Boundary Falls area. The only marker is a sinuous northerly dipping band of marble near the middle of the pile that can be traced for a distance of about 150 metres westerly from the campsite on Highway 3.

Volcanic derived units are few, amounting to scattered outcrops of chlorite, schist, and amphibolite.

Skomac Formation: The name Skomac Formation is tentatively proposed for dark argillite and clastic beds exposed in and near the workings of the Skomac mine. These are correlated with similar beds east of Boundary Creek on Mount McLaren and the north slope of Mount Attwood, that unconformably overlie both basement schists and phases of the Knob Hill Formation. The age of the Skomac Formation has been determined by the Paleontology Subdivision of the Geological Survey of Canada as Paleozoic and tentatively (Carboniferous or Permian) from molluscan shells including *Warthia, Atomodesma,* and others similar to Bitaunioceras. These fossils were assembled by the writer from a small lense of fossiliferous grey limestone in argillite located about 500 metres west of the Skomac mine.

Thickness of the Skomac Formation, determined with difficulty because of folding, is estimated to be between 100 and 200 metres in the Boundary Falls area and, according to Granby geologists (personal communication), 300 to 700 metres on Mount Attwood.

Petrographically the rocks are rather siliceous. The laminar bedded carbonaceous argillites that are most common are interbedded locally with cherty sandstones and chert pebble conglomerate. Norm calculations from chemical data (Analysis, No. 1) of black pyritiferous argillite gives 74 per cent quartz.

Overlying what appears to be Skomac black argillite on the steep hillside above Boundary Creek in the northeast section of the map-area is a previously undescribed unit. This consists in its lower part of a conglomerate with chert blocks and a greenish grey argillite, plus a considerable thickness of light-coloured volcanic breccias and sediments above. The beds dip westerly and are truncated there by a diorite intrusion which forms the main mass of the hill.

Although the exact age of these rocks is uncertain they are placed chronologically between the Skomac and Brooklyn Formations.

TABLE 1—CHEMICAL ANALYSES SKOMAC MINE

	1	2	3	4	5	6
Oxides Recalculated to 100—						
SiO_2	85.56	59.37	52.43	47.05	59.78	59.32
TiO_2	0.33	1.00	0.22	<0.04	0.96	1.06
Al_2O_3	6.79	15.67	19.45	1.06	15.51	15.82
Fe_2O_3	1.55	3.59	1.15	2.63	2.24	2.15
FeO	2.25	2.40	5.57	5.82	3.51	4.33
MnO	0.01	0.19	0.14	0.13	0.90	0.12
MgO	1.37	3.60	8.59	42.70	4.15	4.27
CaO	0.56	7.23	8.06	0.61	5.26	6.03
Na_2O	0.04	3.35	3.51	—	3.58	3.60
K_2O	1.54	3.60	0.88	—	4.11	3.30
	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as Determined—						
$+H_2O$	—	1.28	3.24	8.63	1.66	1.91
$-H_2O$	0.09	1.16	0.28	0.20	0.20	0.45
CO_2	3.19	1.12	0.41	0.76	1.69	1.43
P_2O_5	0.21	0.24	0.20	0.20	0.32	0.28
S	1.38	0.01	0.01	0.02	0.01	0.02
SrO	0.004	0.10	0.25	0.0004	0.11	0.10
BaO	0.07	0.15	0.03	0.0006	0.15	0.13

Key to Analyses:
1—Skomac pyritiferous argillite, No. 5 adit Skomac mine.
2—Park Rill andesite, Marron Formation, 1 400 metres southwest of minesite.
3—Basic diorite, 800 metres north of minesite.
4—Serpentinite, 50 metres north of No. 4 adit.
5—Tertiary microdiorite dyke on Boundary Falls claim, 1 500 metres north of Boundary Falls.
6—Tertiary microdiorite dyke at No. 4 portal.

Brooklyn Formation: A small outlier of rather pure chert pebble conglomerate and sandstone in the northwest corner of the map-area is apparently all that remains of the Middle Triassic Brooklyn Formation. A similar rock, described by Granby geologists as having an "aeolian" origin, occurs at the northwest edge of the Ironsides pit at Phoenix.

The beds dip northerly, are slightly rusted, and are well indurated. Sections of massive chert in the pile appear to be reefs of underlying Knob Hill Formation, the probable source rock.

Marron Formation: The only bedded Tertiary rocks underlie the hilly terrain in the southwest part of the map-area. These are medium brown homogenous lavas comprising what is recognized as Park Rill andesites—the uppermost member of the Marron Formation. In thin section the lavas have a merocrystalline texture consisting of small equant crystals of biotite, pyroxene, and plagioclase and minor apatite and magnetite in brown glass.

Although bedding attitudes are obscure, the andesites have evidently been displaced downward and tilted easterly against the east-bounding fault of the Toroda Creek graben.

Igneous Intrusions: The igneous intrusions consist of Late Paleozoic-Early Mesozoic diorite, a few small Cretaceous(?) granitic intrusions, serpentine bodies, and numerous Tertiary dykes.

Old Diorite Complex: An old diorite complex, exposed immediately north of the Skomac mine, is correlated with unit 9 on MacNaughton's (1945) map of the Greenwood-Phoenix area.

The rocks of the complex are mostly in the diorite-gabbro range (Analysis, No. 3) although some contact phases and dyke offshoots trend to granodiorite. In thin section a typical sample consists of a mixture of subhedral plagioclase 50 to 60 per cent and amphibole 25 to 40 per cent, with a small amount of interstitial quartz and alkali feldspar.

The age of the diorite is either Late Paleozoic or Early Mesozoic, the intrusion being bracketed by the Permo-Carboniferous Skomac Formation which it cuts and the Middle Triassic Brooklyn Formation which contains diorite clasts. The cutting relationships are displayed in the vicinity of the mine where diorite and granodiorite apophyses, although commonly reduced to chlorite schist by intense shearing, clearly penetrate Skomac argillite beds. The upper age limit is defined by the sharpstone conglomerate beds exposed in highway cuts east of Phoenix where clasts of medium-grained diorite are mixed with Knob Hill chert and fragments of basement schist, and other rocks. The diorite clasts are thought to have been derived from a large diorite intrusion exposed a few kilometres to the southwest near the Winnipeg mine.

Granitic Intrusions: Small granitic intrusions, probably related to the Cretaceous Wallace Creek batholith, are exposed in the central and southeast parts of the map-area. These intrude the Knob Hill chert beds accompanied by aplite and quartzfeldspar porphyry dykes. In thin section the rocks consists of about 30 per cent quartz, some crushed alkali feldspar (usually microcline), altered plagioclase, fine-grained mica, clay, and carbonates.

Ultramafic Rocks: Splays and lenses of serpentized periodotite are found north and south of the mine site on major shear zones near the contacts of the Skomac argillite. The rocks are brownish grey where weathered and greenish black on fresh surfaces. Although little remains of the primary mineralogy, the rocks having been thoroughly altered to antigorite-talc-carbonate schist, norm calculations based on chemical data (Analysis, No. 4) indicate an original composition of approximately 60 per cent olivine and 40 per cent orthopyroxene.

There is no direct evidence on the age of the serpentine, although certainly it is younger than either the diorite complex or Skomac Formation which it intrudes. Church (GEM, 1970, p. 416) suggested a Cretaceous age for serpentine cutting quartz porphyry on the Lexington property and Lone Star mine near the international border. Granby geologists correlate the Lexington quartz porphyry with the Wallace Creek batholith dated 125 ± 5 and 140 ± 5 Ma. (GEM, 1974, p. 49; GEM, 1976, on pp. 1–13).

Tertiary Intrusions: The most significant Tertiary intrusions are microdiorite dykes found scattered generally throughout the central part of the map-area. Large microdiorite dykes cut through the workings of the Skomac mine and diggings on the Boundary Falls and Tunnel claims to the south.

Petrographically the rocks consist of about 50 per cent zoned plagioclase micro-phenocrysts, 10 per cent subhedral augite, and smaller crystals of feldspar and biotite with accessory magnetite and some interstitial quartz. A marked similarity in mineralogy, texture, and chemical composition indicates that there are feeders to the adjacent Park Rill andesite lavas (Analyses, Nos. 5 and 6).

STRUCTURE: The full picture of this geologically complex region is obscured by imperfect exposure, nevertheless a general structural synthesis is possible based on a broad view of the terrain and detailed study of the available outcrops.

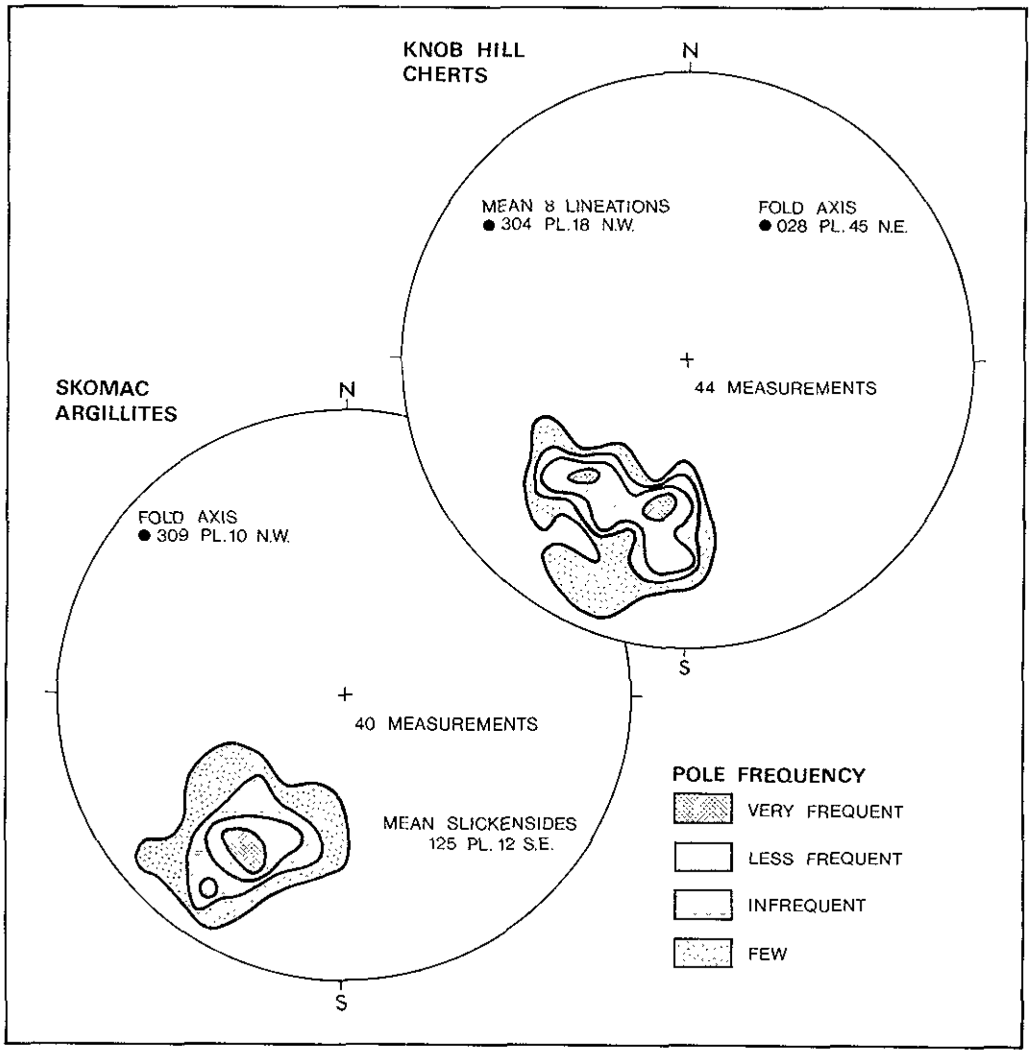
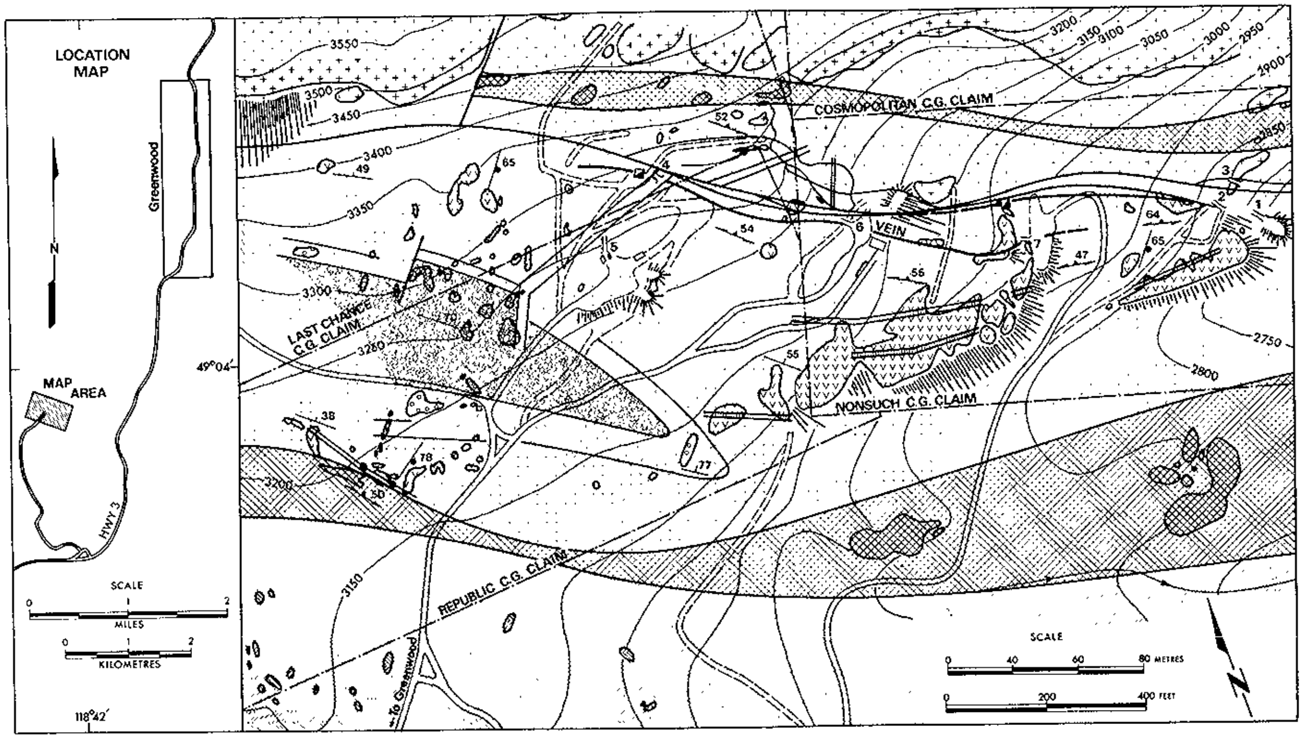


Figure 2. Equal area plot of bedding attitudes and lineations



LEGEND

BEDDED ROCKS

SKOMAC METASEDIMENTARY ROCKS

CONGLOMERATE AND SANDSTONE / SILTY ARGILLITE WITH CARBONATE CLASTS / BLACK ARGILLITE AND SLATES

BASEMENT COMPLEX

METAQUARTZITE AND AMPHIBOLITE

INTRUSIVE ROCKS

MICRODIORITE AND GRANODIORITE DYKES

SERPENTINIZED ULTRAMAFIC ROCKS

DIORITE AND GRANODIORITE

SYMBOLS

ROCK OUTCROP

TALUS

TOPOGRAPHIC CONTOUR (3150)

ROAD

BULLDOZER TRACK

ADIT

SHAFT

BEDDING ATTITUDE (21)

JOINT (19)

SCHISTOCITY (37)

FAULT

Figure 3. Detailed geology of the Skomac mine

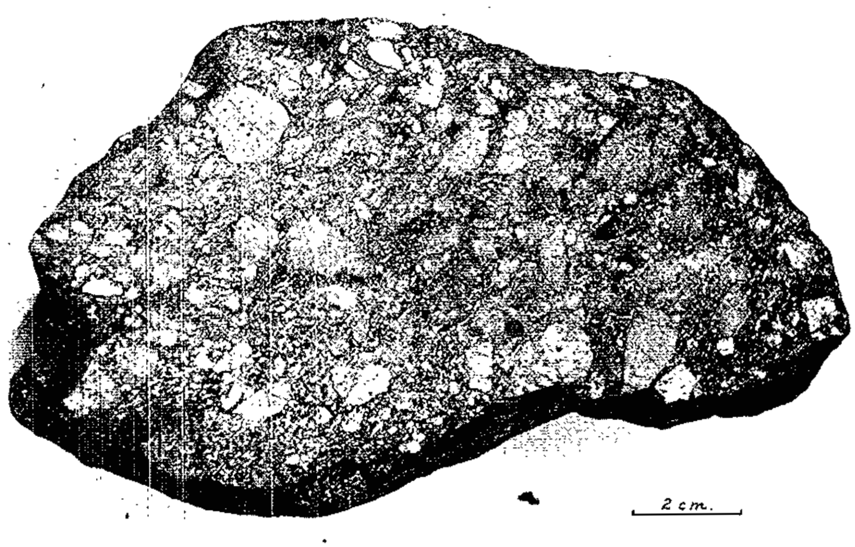


Plate IIA. Chevron folds in Skomac metasedimentary rocks

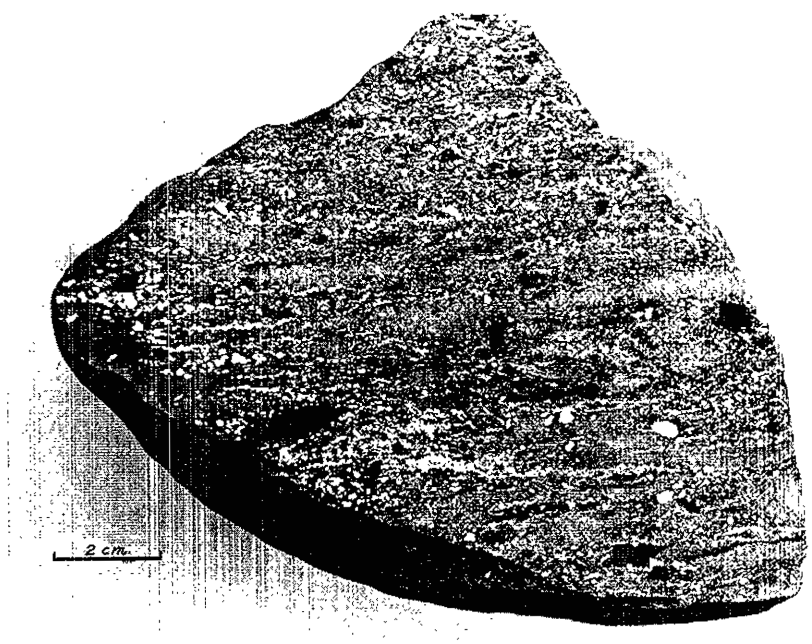


Plate IIB. Polished section of sample of Skomac quartz vein showing pyrite, galena, tetrahedrite, and sphalerite

Little can be said here about the basement schists and gneisses other than that the general trend of foliation is west and northwest. Dips are mostly northerly, although reversals and contortions are common.

The Knob Hill Formation, which has a more regular fabric than the basement schists, also trends northwest. Undulatory warping of the strata is combined locally with some spectacular rumples, the deflections plunging about 45 degrees to the northeast (Fig. 2).

Deformation of the Skomac Formation appears to be the result of vertical movement of the diorite complex against relatively incompetent shales and argillites during intrusion. Such appears to be the origin of the large sharp-crested syncline viewed west of the minesite (Fig. 3) and smaller chevron-type flexures (Plate IIA). Elsewhere, the effect of this deformation seems to have also touched the underlying Knob Hill Formation imparting a set of crinkle lineations, the mean attitude of which 18 degrees at 304 degrees is subparallel to the Skomac folding 10 degrees at 309 degrees.

The majority of fractures measured throughout the area dip steeply to the east or southeast and strike between 020 and 040 degrees, a direction along which there appears to have been some gliding related to folding of the Knob Hill Formation and a direction of Tertiary dyke intrusion and faulting. The interconnected northerly trending chain of faults cutting through the west part of the map-area is related to the Toroda Creek graben and represents major gravity and strike slip displacement.

MINING AND MINERALIZATION: The Skomac mine is on the southeast-facing hillside between elevations 850 and 1 000 metres (elevation 2,250 and 3,260 feet), approximately 2.5 kilometres north of Boundary Falls. There are seven adits comprising the workings for which production records are available only on Nos. 4 to 7 (Fig. 4). Adits Nos. 1 to 3 are on what appears to be a parallel vein system and are further down slope.

From an estimated total of 7 500 tonnes of rock mined, 1 688 tonnes of crude ore has been shipped yielding 16.4 kilograms gold, 653 kilograms silver, 43.6 tonnes of lead, and 23.9 tonnes of zinc.

The main break transecting the property is about 180 metres long, having an average dip of 50 degrees northeast and a somewhat variable southeasterly strike. Within the total strike distance there are four known ore zones or "shoots" labelled AA, A, B, and C. These consist of thickened mineralized quartz lenses, each of which are 15 to 35 metres in length.

Interruption of the vein is caused by pinching, fault offsets, and crosscutting dykes. In adits Nos. 4, 5, and 6 zones, A and B are separated by a 10-metre-thick crosscutting microdiorite dyke dipping 45 degrees northeast. Zones B and C are separated by a combination of pinching of the vein and offsetting faults with sinistral strike slip displacement.

Comparing the average assay results, there is a consistent dominance of lead over zinc and precious metal enrichment in the most southerly zones A and AA. Also, silver to lead ratios decrease regularly from AA to C.

Zone	Tonnes Shipped	Au *ppm*	Ag *ppm*	Pb per cent	Zn per cent
AA	257	4.46	538.3	2.1	1.8
A	176	5.83	973.7	4.4	2.4
B	258	2.40	507.4	3.3	2.0
C	288	2.06	308.6	2.6	1.4

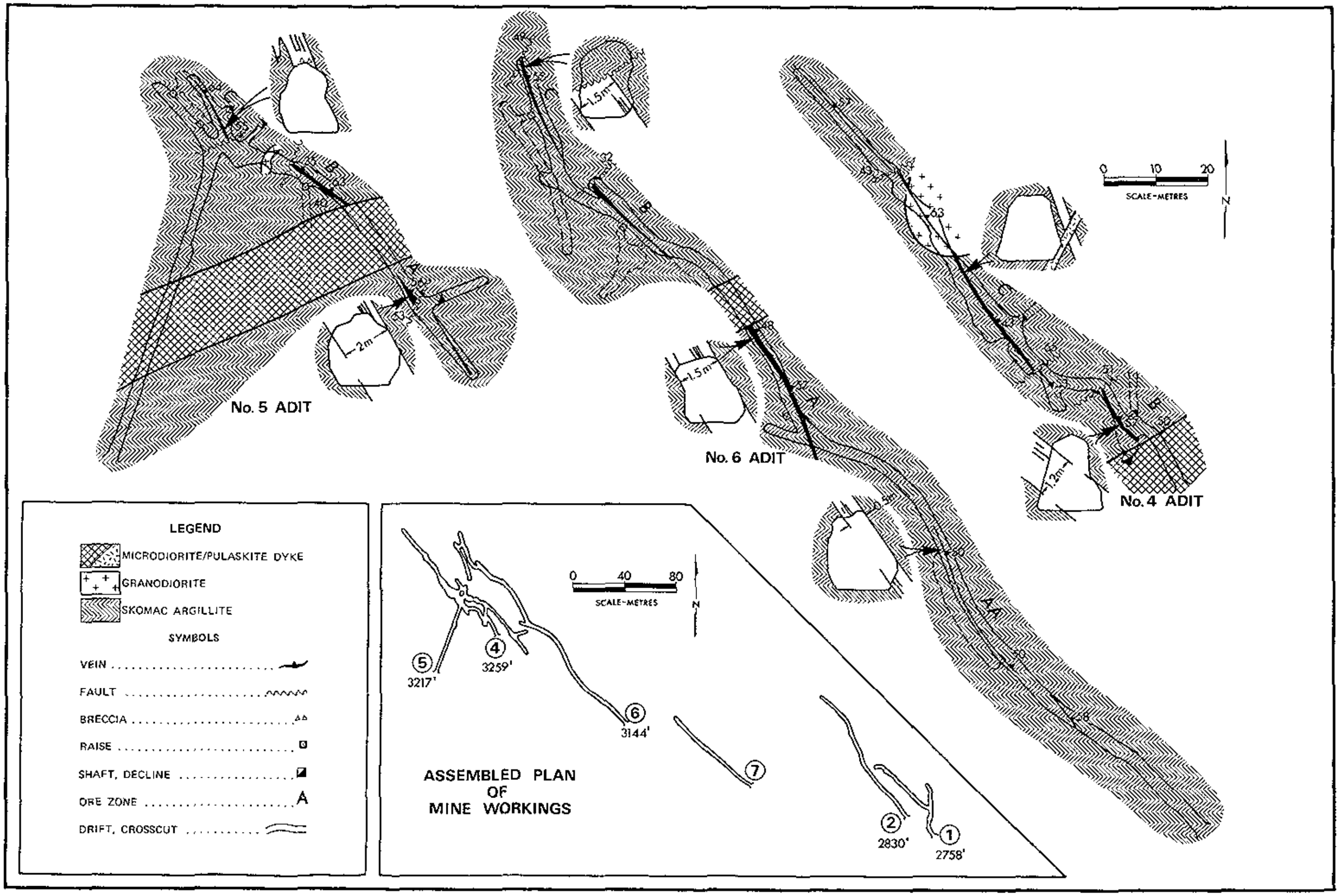


Figure 4. Underground geology of the Skomac mine

The estimated average modal composition of the ore shipped is 58 per cent (by weight) argillite, 25 per cent quartz, 10 per cent pyrite, 4 per cent galena, 2.5 per cent sphalerite, and 0.5 per cent chalcopyrite, accessory tetrahedrite, and perhaps some native silver(?) (Plate IIB).

Origin of the vein structure is thought to be the result of regional shearing stress deflected into and taken up by the incompetent formations along the diorite contact. The oreshoots are aligned plunging approximately 40° @ 015°, almost at right angles to the principal slip direction. They are probably channel ways developed consequent to shearing much in the manner postulated for the emplacement of Dentonia vein at nearby Jewel Lake (GEM, 1974, pp. 39 to 51).

Age of mineralization at the Skomac mine is certainly younger than the argillite and serpentine host rocks and may be Late Cretaceous or Early Tertiary. That the mineralization is older than the large crosscutting microdiorite dyke is clear, however, it can be demonstrated that a similar dyke on the Boundary Falls claim to the south has effected sulphide metasomatic replacement of adjacent carbonate beds. Alteration, and to some extent, pyritization of the crosscutting dyke at the Skomac mine, suggests that this intrusion may have followed closely in the wake of the main mineralization event.

REFERENCES

B.C. Ministry of Energy, Mines and Pet. Res.: Assessment Reports Nos. 5618, 6067; GEM, 1970, pp. 413–425; 1974, pp. 39–51; Geology in B.C., 1976, pp. 1–13.

Brock, R. W. (1905): Geological and Topographical Map of Boundary Creek Mining District, B.C., *Geol. Surv., Canada,* Map 828.

Little, H. W. and Thorpe, R. I. (1956): Greenwood (East Half), *Geol. Surv., Canada,* Paper 61-1, pp. 56–60.

McNaughton, D. A. (1945): Greenwood-Phoenix Area, B.C., *Geol. Surv., Canada,* Paper 45-20, 23 pp.

Minister of Mines, B.C., Ann. Repts., 1894, P. 55; 1896, pp. 577, 582; 1897, p. 586; 1898, pp. 1125, 1195; 1904, p. 213; 1913, p. 150; 1922, pp. 175–176; 1964, p. 110; 1965, p. 167.

Seraphim, R. H. (1956): Geology and Copper Deposits of the Boundary District, B.C., *C.I.M.,* Bull., Vol. 49, No. 3, pp. 684–694.

1977 — FUKI, DONEN, PB, KETTLE, VENUS
(82E/7)

Lawrie C. Reinertson, Noranda Exploration Company Limited
and
G. P. E. White, British Columbia Ministry of Energy, Mines and Petroleum Resources

FUKI, DONEN, PB, KETTLE, VENUS

LOCATION: Lat. 49° 32′ Long. 118° 52′ (87E/7)
GREENWOOD M.D. At 1 245 to 1 575 metres (3,800 to 4,800 feet) elevation from Hydraulic Creek southeast to Collier Lake. The area is southeast of Kelowna from 25 to 112 kilometres (15 to 70 miles).

CLAIMS: FUKI, DONEN, PB, KETTLE, VENUS.

OWNERS: Power Reactor and Nuclear Fuel Development Corporation of Japan (PNC), Tyee Lake Resources — Peregrine Petroleums Ltd., Lacana Mining Corporation.

OPERATORS: NISSHO-IWAI, TYEE LAKE RESOURCES — PEREGRINE PETROLEUMS LTD., NORCEN ENERGY RESOURCES LTD.

METAL: Uranium.

DESCRIPTION:

INTRODUCTION: Uranium was discovered on the Fuki claims in 1968 by I. Fukuoka and K. Kuroki, geologists with PNC. The initial search was probably based on similar uranium deposits at the base of the Tertiary found in Japan.

Stratigraphic columns from selected holes (Fig. 5) are presented on Figure 6; the section on geology and exploration techniques is predominately from L. Reinertson. Mineralogy was determined by members of the British Columbia Ministry of Energy, Mines and Petroleum Resources Analytical Laboratory in Victoria.

Descriptions are based in part on released assessment reports available for inspection and it is likely that these descriptions, although generalized, will not apply to the area in total.

GENERAL GEOLOGY: Monashee (Proterozoic ?) light and dark schists and gneisses, Valhalla and Nelson (Cretaceous) granites, granodiorites, and pegmatites, and Coryell (Tertiary) syenites, granites, and granite porphyries comprise the weathered basement complex on which the Miocene-Pliocene (plateau basalts) were deposited. Coryell plugs, dykes, and sills intrude Oligocene-Eocene (Phoenix and Midway volcanic rocks with minor sedimentary interlayers) to the southeast in the area, while in the central and northwest parts of the area Miocene-Pliocene rocks lie directly over the basement complex.

Plateau basalts, composed of 10-metre thick flows on average, usually with scoriaceous interfaces, are underlain by a basal conglomerate unit. Division into upper and lower units of the basalts has been made by some operators; in the Fuki-Donen area this break is rarely marked by sediments.

Glacial till overlies basement rocks, plateau basalts, and basal units. Although not reflected on the present land surface, the erosional remnants of the plateau basalts are confined to a northwest-trending paleochannel, possibly the result of a down-faulted block. The sides of the channel or basin have been observed to slope 40 to 45 degrees where uranium values have been encountered, and these slopes are known to have been further incised by stream channelling.

GEOLOGY OF THE BASAL UNIT: All units are friable or soft except in certain uraniferous beds where marcasite has indurated the rock. The basal conglomerate consists of poorly sorted fluvial conglomerate, sandstones, arkoses, and mudstones which commonly contain crude coal with leafy fragments. The greatest basal unit thickness (64 metres) is recorded in the Hydraulic Creek (northwest) area. Fragments in the conglomerates are polylithic cobbles and pebbles with interstitial quartz, arkose, or quartz and clay. Individual beds have rarely been traced for more than 10 metres laterally.

RADIOACTIVITY: Radioactivity has been recorded in all rock types of the basal unit as well as in the oxidized zone of the basement complex and the scoriae beds near the bases of the basalt flows. Significant quantities of uranium are found in the conglomerates, in the sandstones or arkoses, and in the mudstones. More than one zone of uranium may be

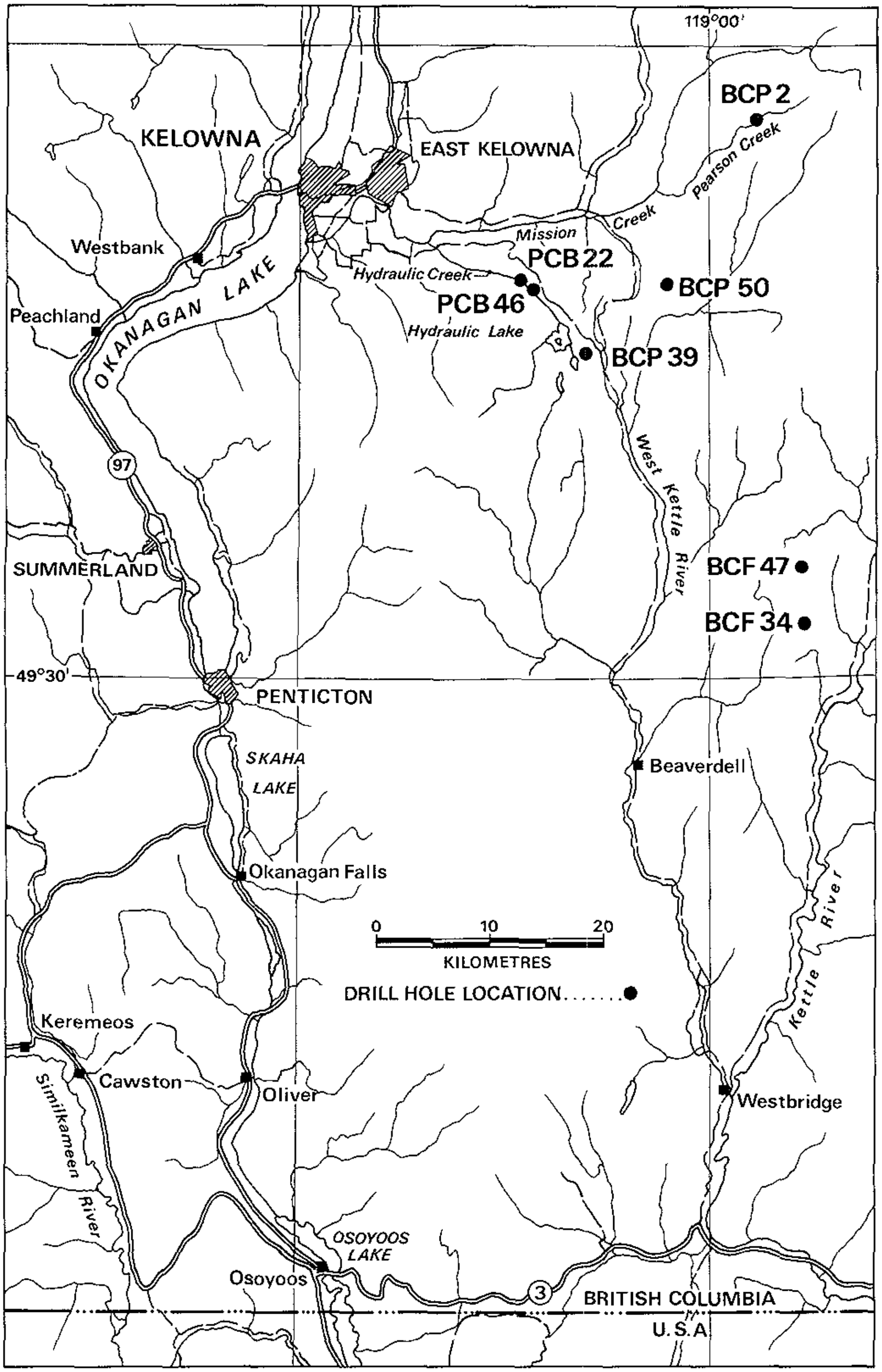


Figure 5. Drill hole location map, Hydraulic Lake-Fuki, Donen area

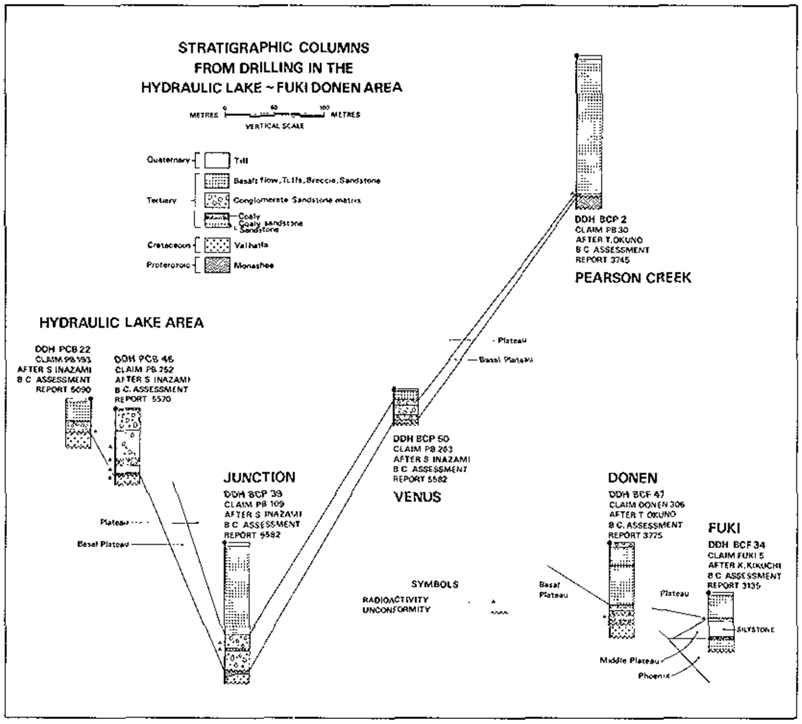


Figure 6. Stratigraphic columns from drilling in the Hydraulic Lake-Fuki, Donen area

present in one locality; as many as four zones were recorded in one hole in the Hydraulic Lake area. Carbon is a good absorbent for uranium and coaly beds are generally uraniferous. Uranium does not seem to be attracted by any particular clay or other interstitial material in conglomerates or sandstones, although more extensive studies would be required to be more definite. Uranium values are generally found nearer the margins of the buried basin. Higher uranium values are usually found in the basal unit where there has been a higher degree of sorting.

Except for the Fuki area, which is lower in elevation, most uranium occurrences are found at 1 370 ± 66 metres (4,200 ± 200 feet).

Valhalla intrusive rocks have a higher background radiometric count than other rocks in the area; fluorite and uraninite-bearing zones in the Valhalla are radioactive, such as at the Carmi molybdenum prospect. The plateau basalt flows have the lowest background count of rock types in the area.

Most units in the basal sediments have high permeability and porosity.

The uranium has probably been leached out of the Valhalla granites by meteoric water and deposited in porous, permeable sedimentary beds at the base of the plateau basalts. Some mechanical sorting may have taken place because radioactive beds occur in conglomerate beds where there is no obvious physical or chemical change in the overlying or underlying conglomerates. Impermeable capping does not seem to be a concentrating factor. Radioactive zones do not necessarily occur near the base of the sedimentary unit; present uranium occurrences, if not vertically underlain by Valhalla intrusive, are proximal to the granitic basement.

URANIUM MINERALOGY: Core samples of one drill hole in the Hydraulic Creek area were studied in order to determine the uranium minerals, but positive identification was not possible. It was concluded that any uranium mineral in the sample must be metamict or poorly crystalline so that it behaved much like amorphous material when X-rayed.

Marcasite and trace pyrite were identified as the main metallic phases in one of the samples. The clay-size fraction of the sample was found to consist mainly of kaolinite with minor amounts of illite and quartz.

In radioactive areas within one sample, X-ray diffraction analysis showed that the main constituents, which were blackened, opaline-like amorphous material, were cristobalite and marcasite with a trace of pyrite. On one other sample, X-ray film tests revealed that radioactivity was associated with whitish patches on a cut surface. Whereas emission spectrography on a portion of these patches revealed greater than 1 per cent uranium and less than 0.05 per cent thorium, X-ray diffraction analysis of the same patch showed only marcasite, cristobalite, and a trace amount of hydrated ferrous sulphate. Rozenite ($FeSO_4 \cdot 4H_2O$) was identified as a fine-grained white coating on the iron sulphides.

EXPLORATION TECHNIQUES: Aerial radiometric surveys generally outline Valhalla intrusive rocks, which are higher in radiometric count than any other rock unit in the area. Ground induced polarization would probably show some association with uranium where uraniferous basal conglomerates are overlain by glacial till because of the marcasite associated with the uranium beds. Gas emanometers are not definitive where glacial till overlies uraniferous basal conglomerates. Track etching may be used over till that is underlain by basal sediments but results over plateau basalts are reported to be indefinite.

Silt or water samples are more apt to indicate Valhalla granite. Values for water samples are 0.05 to 0.8 ppb uranium, silts 2 to 77 ppm uranium, but in general, geochemical surveys do not seem to be a successful exploration method. However, geochemical iron values may be more significant because of the marcasite associated with uranium mineralization. Groundwater seeps from beneath the basalt layers have indicated the presence of some of the deposits; however, groundwater seeps are not common in the area. Stream pH is 6.8 to 7.5 in the general area.

DRILLING: Percussion drilling apparently has been used successfully in the Lassie Lake area; in other areas collapse in the hole has occurred at scoriae interfaces in the basalts as well as in the friable sediments. Rotary drilling is more attractive because it allows probing inside the drill stem.

NQ core drilling is good but to assure core recovery in the friable sediments, HQ3 core drilling with proper mud mixture is recommended.

Down hole probes are usually successful and down hole probe counts compare favourably with uranium chemical analysis, probably due to the relatively small amount of thorium present (less than 0.05 per cent thorium reported).

REFERENCES: Assessment Reports 2484, 3135, 3745, 3775, 4629, 4630, 5090, 5115, 5570, 5582, 5730, 6116, 6168, 6211, 6243, 6319, 6390, 6418. *George Cross Newsletter,* April 20 (1976).

1980—GEOLOGY AND RANK DISTRIBUTION OF THE ELK VALLEY COALFIELD (82G/15; 82J/2, 7, 10, 11)

By D. A. Grieve and D. E. Pearson

INTRODUCTION: The Elk Valley coalfield is one of three coalfields within Jurassic-Cretaceous Kootenay Group sedimentary rocks in southeastern British Columbia. It is an elongate area over 100 kilometres in length which extends from the Crowsnest Pass area to Elk Lakes Provincial Park (Fig. 7). The coalfield may be reached from Highway 3 in Crowsnest Pass, from the Elk Valley Road (Sparwood via Elkford to the Elk Lakes), from the Fording and Line Creek Mine access roads, and from various forestry and exploration roads secondary to the major routes.

The authors began geological mapping in the Elk Valley coalfield subsequent to completion of detailed mapping and petrographic evaluation of the Crowsnest coalfield (Ministry of Energy, Mines and Petroleum Resources, Preliminary Maps 24, 27, 31, and 42; Pearson and Grieve, 1973 and in prep.). Regional-scale (1:50 000) mapping and preliminary coal rank determinations over the entire coalfield and detailed mapping (1:10 000) of portions of the southern half, have been completed (Geological Fieldwork, 1979, Paper 1980-1, p. 91; 1980, Paper 1981-1, p. 71). This report is a review of work completed to the end of 1980.

The Elk Valley coalfield is host to Fording Coal's Fording River Operations on Greenhills Range and Eagle Mountain, and currently developing mines at Line Creek and the southern end of the Greenhills Range, that belong to Crows Nest Resources and B.C. Coal, respectively. In addition, Elco Mining has proposed a minesite at Weary Ridge in the northern part of the coalfield, and all four companies are currently conducting exploration in undeveloped areas.

FIELD AND ANALYTICAL METHODS: Regional-scale mapping utilizes 1:50 000 NTS maps, compass, and altimeter. Detailed mapping is done using British Columbia Government air photographs enlarged to approximately 1:7 000 scale. Data are transferred to 1:10 000-scale orthophoto maps. Stratigraphic sections are measured using compass, chain, and pogo stick.

Coal samples for petrographic rank determination are collected routinely during field mapping from outcrop, trench, or cut exposures. Representative channel samples are periodically collected for petrographic maceral analysis; but no results are available as yet. Samples are crushed and passed through a 20-mesh sieve, pelletized using either resin and hardener, or a pneumatic molten thermoplastic technique, and polished. Coal rank (vitrinite reflectance in oil, or $\bar{R}_o$ max) is determined by averaging maximum reflectances in per cent of 50 vitrinite grains per sample. Coals are classified into ASTM rank categories as follows:

$\bar{R}_o$ max $\leq$ 1.12% = high-volatile bituminous;
$\bar{R}_o$ max $>$ 1.12% $\leq$ 1.51% = medium-volatile; and
$\bar{R}_o$ max $>$ 1.51% = low-volatile.

STRATIGRAPHY: Stratigraphy and sedimentation of the Jurassic-Cretaceous Kootenay Group have been defined and summarized by Gibson (1977, 1979). The Kootenay Group consists of, from oldest to youngest, the Morrissey, Mist Mountain, and Elk Formations. The Morrissey Formation is a basal sandstone unit, approximately 40 metres thick at its type-section locality south of Fernie. The resistant upper Moose Mountain Member forms a prominent 15 to 20-metre cliff throughout most of the Elk Valley coalfield.

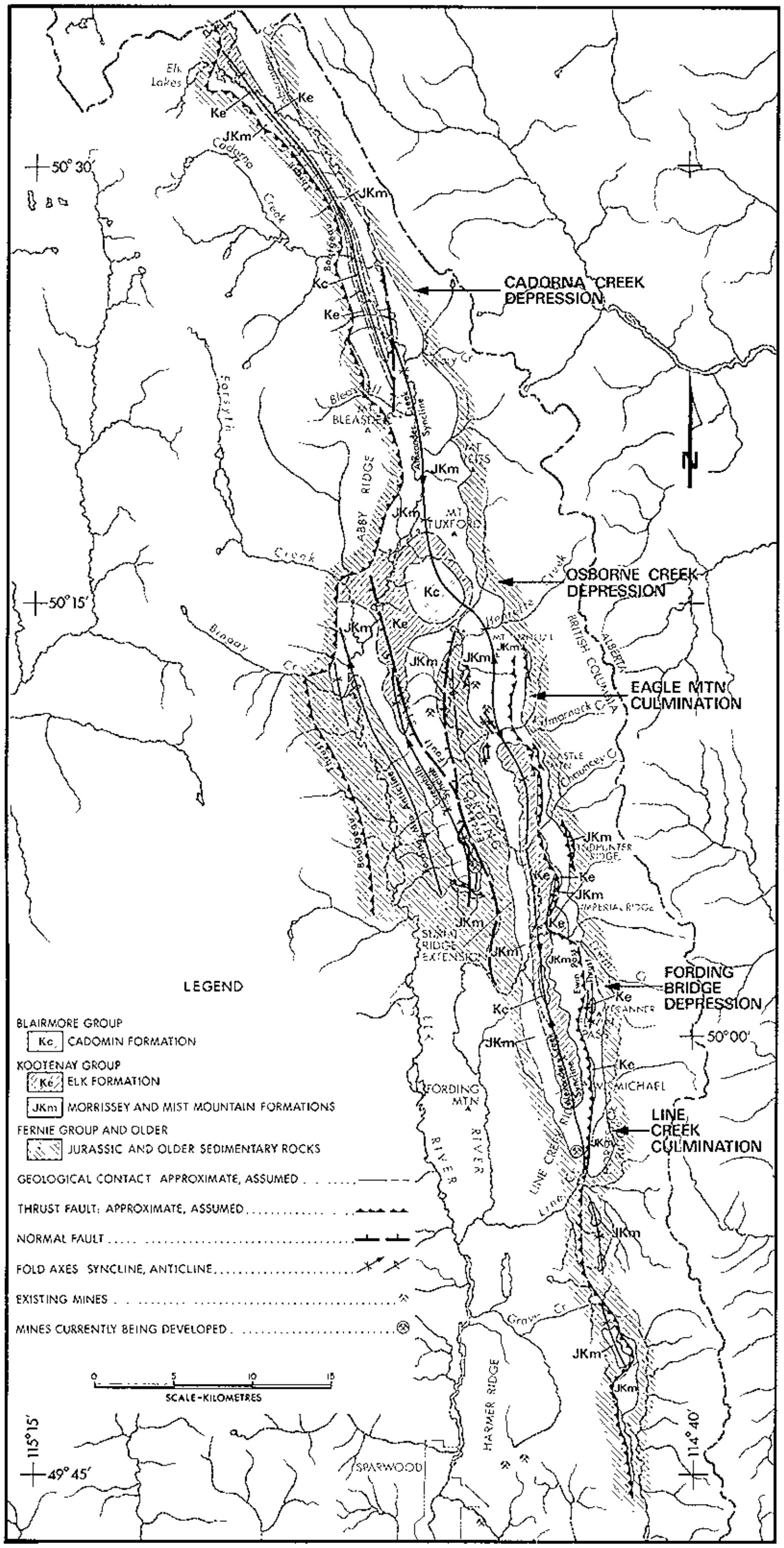


Figure 7. Geology, Elk Valley coalfield

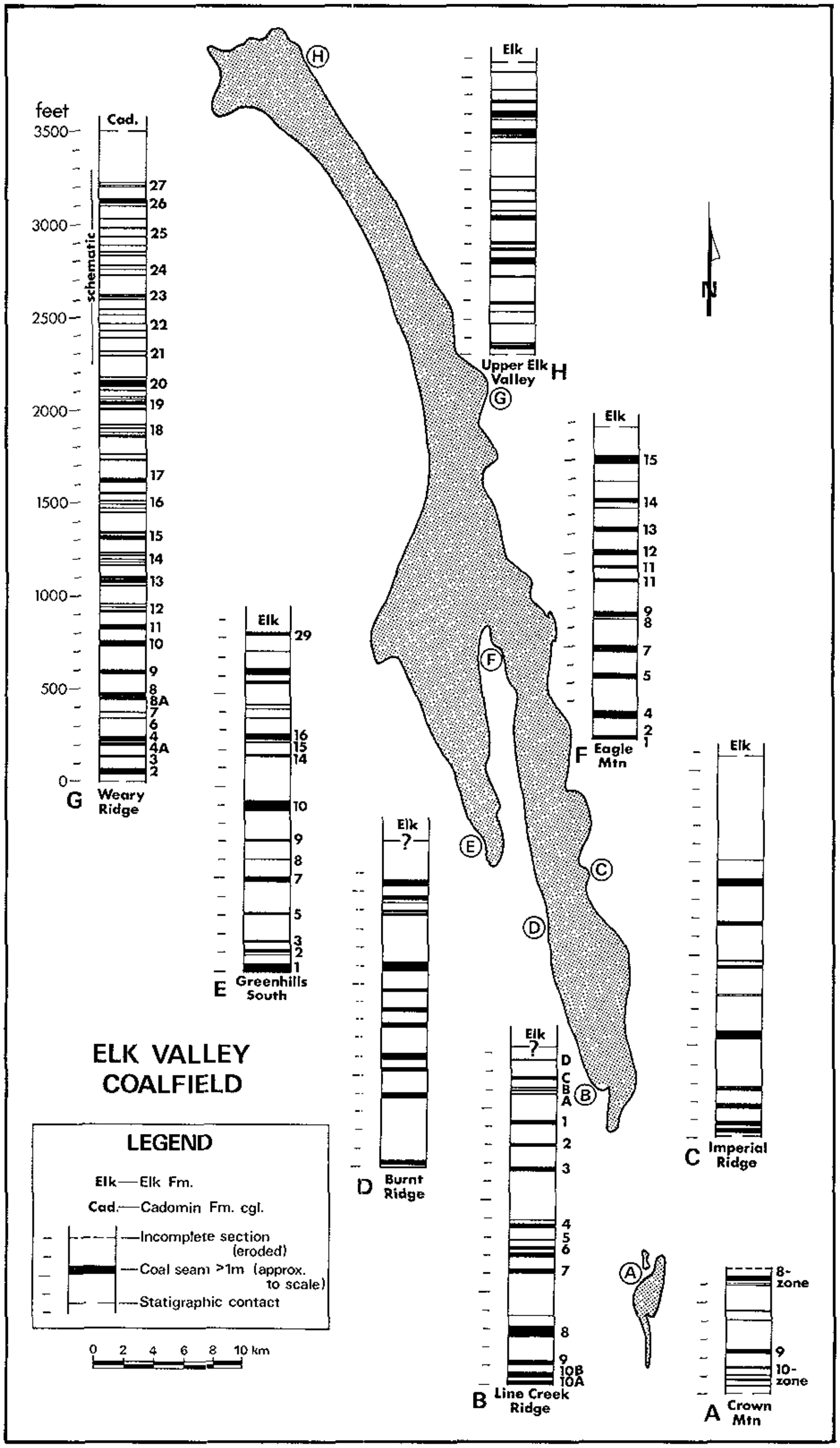


Figure 8. Selected stratigraphic columns of the Kootenay Group in the Elk Valley coalfield, showing relative position and approximate thickness of coal seams greater than 1 metre in thickness

Overlying the Moose Mountain Member is the coal-bearing Mist Mountain Formation, which averages 500 to 600 metres in thickness in the coalfield. Generally 8 to 10 per cent of its total stratigraphic thickness consists of coal seams up to 12 metres in thickness (Fig. 8). Interbedded with coal seams are shale, siltstone, sandstone, and rare conglomerate.

The Elk Formation overlies the Mist Mountain Formation; within the coalfield it includes thin, uneconomic coal seams, lenticular seams of "Elk coal" (brittle alginite-rich coal), shale, siltstone, sandstone, and some conglomerate. Thickness of the Elk Formation in the coalfield is variable; it is thinner than the Mist Mountain Formation. In the Elk Valley coalfield, we define the lower contact of the Elk Formation as the lowest stratigraphic occurrence of "Elk coal", or at a prominent and locally mappable sandstone unit beneath the lowest occurrence of Elk coal, but above the highest occurrence of "economic" coal.

The Kootenay Group is underlain throughout by interbedded sandstones and siltstones of the Passage Beds of the Jurassic Fernie Group; it is overlain in three locations by the resistant Cadomin Formation conglomerate of the Lower Cretaceous Blairmore Group. Kootenay Group rocks are in fault contact in several localities with older Mesozoic and Paleozoic strata (Fig. 7).

STRUCTURE: Kootenay Group exposures have generally been preserved in structural lows in southeast British Columbia. For example, the Elk Valley coalfield contains both limbs of the Alexander Creek syncline and the hangingwall of the Erickson normal fault (Fig. 7). The former structure is complicated by a series of undulations along its axis, by a continuous thrust fault zone in its east limb, and by minor folding and thrust faulting.

Both major structures are overridden by older strata on the Bourgeau thrust block in the north half of the coalfield (Fig. 7). The Bourgeau thrust appears to follow the west wall of the Elk River valley and extends to the south of the coalfield. It has had the effect of steepening and overturning Kootenay Group strata in its footwall throughout the northern part of the coalfield.

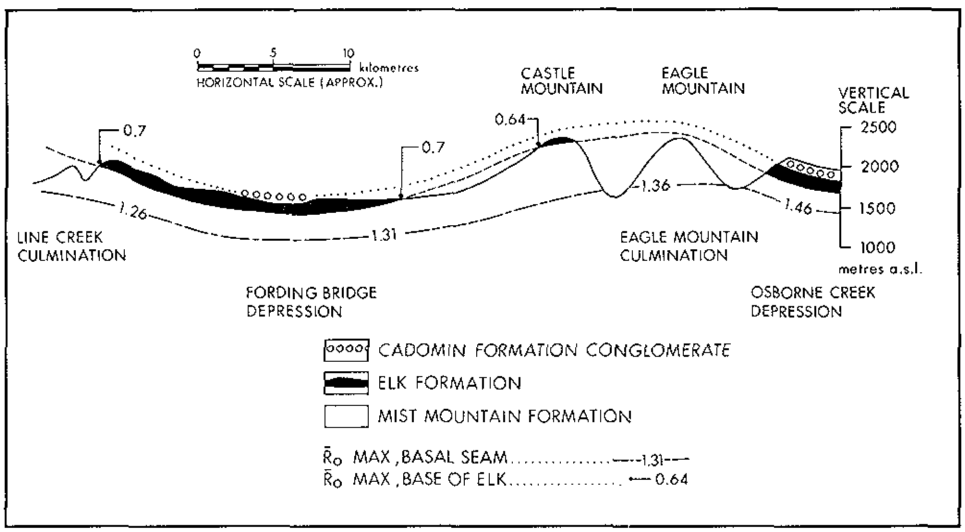


Figure 9. Schematic longitudinal section of southern portions of Elk Valley coalfield from Line Creek to Henrietta Ridge, showing plunge depression and culminations in the *Alexander Creek syncline, and selected reflectance data*

ALEXANDER CREEK SYNCLINE: The Alexander Creek syncline takes its name from a stream in the southern part of the coalfield; it is often called the Fording syncline. It is an open, asymmetric structure which trends north-northwest throughout the study area. The plunge of its axis is variable in direction and degree; consequently a series of plunge culminations and depressions is observed (Figs. 7 and 9). These undulations are recognized by the relative thicknesses of Elk Formation preserved, and by occasional occurrences of overlying Cadomin Formation conglomerate. For example, at the Fording Bridge depression Cadomin conglomerate exposures are present at an elevation of 1 700 metres, while at the Eagle Mountain culmination, 20 kilometres to the north, Elk Formation was not recognized up to an elevation of 2300 metres (Figs. 7 and 9). The Cadorna Creek depression, at the north end of the coalfield, was identified by the presence of Cadomin Formation within the Elk Valley at an elevation of 1 700 metres.

The east limb of the Alexander Creek syncline is thickened by zones of thrust faulting, including the Ewin Pass (or Fording) thrust which is continuous through the south half of the coalfield (Fig. 7). At Crown Mountain it emplaces Fernie Group strata on the Mist Mountain Formation. From Line Creek northward the fault cuts rapidly up-section and remains within the Elk and upper Mist Mountain Formations to north of Kilmarnock Creek. Dragfolding is evident adjacent to the trace of the Ewin Pass thrust, notably on the east faces of Todhunter Ridge, Castle Mountain, and Mount Banner.

A zone of thrusting in the basal part of the Mist Mountain Formation below Todhunter Ridge appears to rise out of the underlying Fernie Group. This movement has had the effect of repeating the basal sandstone (Morrissey Formation). Other localized zones of faulting and folding are evident, but their continuity has not been established. These include: the west limb in the Kilmarnock Creek area where tight folds perhaps related to a thrust fault were noted; the west limb on Eagle Mountain, where a thrust has repeated the lower part of the coal-bearing sequence in Fording Coal's Clode Pit; the west limb on Burnt Ridge, where persistent west-dipping overturned strata were observed; and both limbs north of the Cadorna Creek area, where deformation has led to small-scale folding and faulting. Other zones will undoubtedly be found as detailed mapping continues.

ERICKSON FAULT HANGINGWALL (GREENHILLS RANGE): The down-droppped block of the west-dipping Erickson normal fault contains Kootenay Group exposures which constitute the Greenhills Range (Fig. 7). The Erickson fault extends to the south into the Crowsnest coalfield where it forms the eastern boundary of coal deposits in the Michel area.

At the south end of the Greenhills Range, the Kootenay Group is in fault contact with Triassic, Permian, and Mississippian strata (Fig. 7). To the north, its trace has been interpreted by Fording Coal geologists to correspond with a fault whose trace follows the Fording Valley between Eagle Mountain and Greenhills Range. Our work, however, suggests that its trace is further to the west (Fig. 7) where it connects with a major normal fault at the north end of the Greenhills Range. Our reasoning, based on coal rank distribution, is outlined in the following section.

The Greenhills syncline, with a north-northwest trend, follows the Greenhills Range. The west limb of the syncline, which forms the east wall of the Elk River Valley north of Elkford, is in turn the east limb of the Fording Mountain anticline. These folds plunge northward, and consequently Kootenay Group strata are exposed at the level of the Elk River in the north part of the Range, near Britt Creek (Fig. 7). An adjacent tight syncline is exposed to the west of the Elk River near Bingay Creek, and this fold is interpreted to represent dragfolding below the Bourgeau thrust, whose trace is directly to the west of this point (Fig. 7).

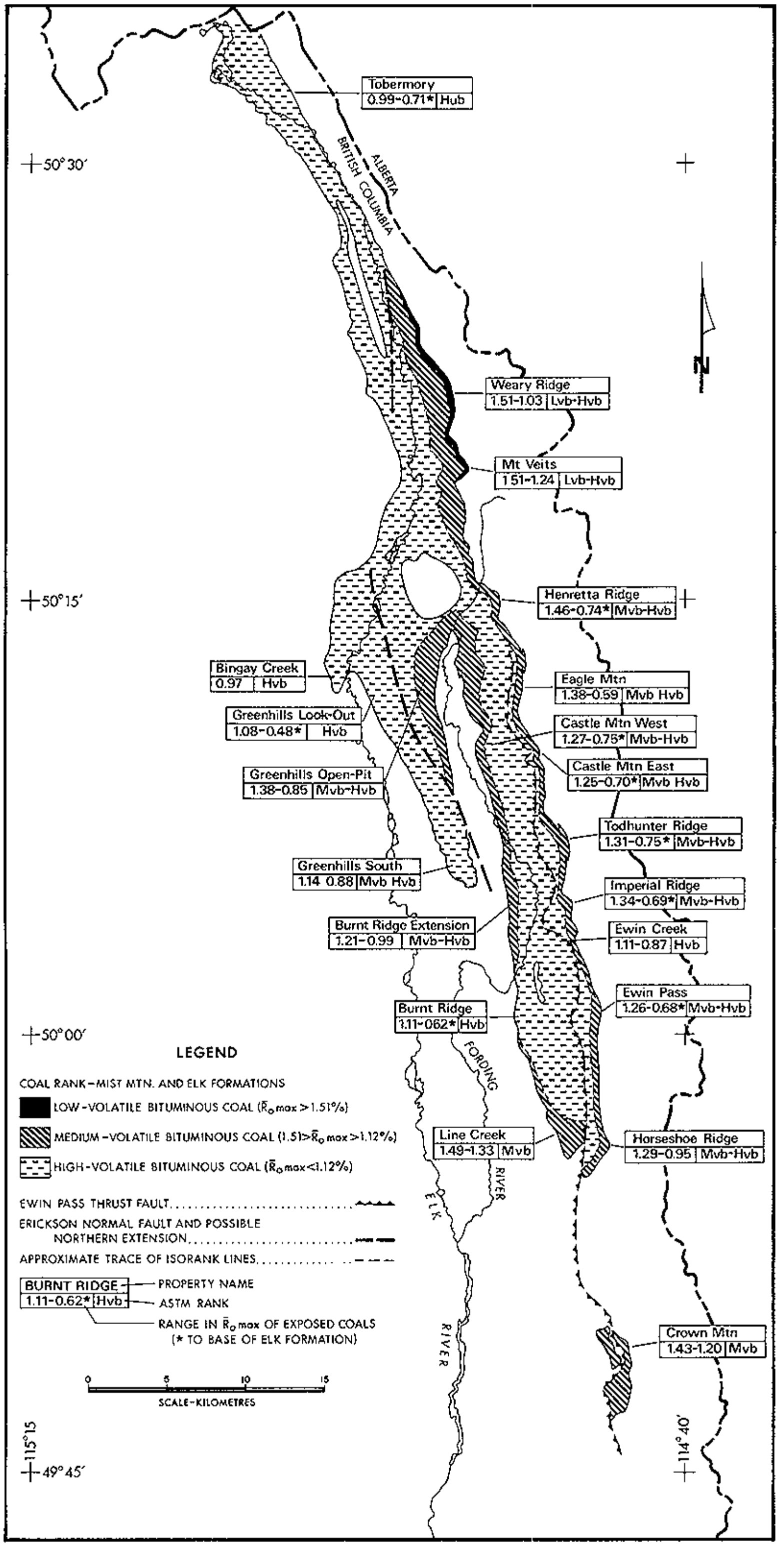


Figure 10. Rank distribution, Elk Valley coalfield

A high-angle normal fault within the southern part of the Greenhills Range may be a splay of the Erickson fault. It caused a maximum 100-metre downthrow on its west block, and displaced the axis of the Greenhills syncline (Fig. 7).

A postulated normal fault at the north end of the coalfield (Fig. 7) may be an extension of the Erickson fault (next section). Such a fault might explain the presence of Cadomin Formation outcrop in the northern Elk Valley (Cadorna Creek depression).

RANK DISTRIBUTIONS: Based on vitrinite reflectance of samples collected during field mapping, coals of the Kootenay Group in Elk Valley coalfield fall into the range of high to low-volatile bituminous. Distribution of coal ranks at surface and ranges in coal rank within individual sections are shown on Figure 10.

For the most part, complete Mist Mountain Formation sections are characterized by medium-volatile coals in their lower parts and by high-volatile coals in their upper parts. For example, reflectance ranges from the base of the Mist Mountain Formation to the base of the Elk Formation are 1.26 per cent to 0.68 per cent at Horseshoe Ridge, 1.31 per cent to 0.75 per cent at Todhunter Ridge, and 1.46 per cent to 0.74 per cent at Henretta Ridge.

Exceptions are in the Weary Ridge area, where the reflectance ranges from 1.51 per cent to 1.03 per cent within the coal-bearing section (low volatile to high volatile), and on the Greenhills Range and at the extreme north end of the coalfield, where entire sections are high volatile.

The low-volatile coals at Weary Ridge appear to represent the climax of a regional rank gradient. For example, reflectance on the basal seam increases from 1.35 per cent to 1.51 per cent between the Ewin Creek area and Weary Ridge. It is interesting to note that the undulations in the axis of the Alexander Creek syncline do not influence this apparent gradient (Fig. 9).

Entirely high-volatile (lower rank) sections on the Greenhills Range can be explained by considering relative timing of coalification and normal faulting. Previous studies (*see* Geological Fieldwork, 1977, Paper 1978-1, p. 47) have indicated that normal faulting postdates coalification. Coals on the down-dropped block of the Erickson fault were at a relatively higher "elevation" during coalification than coals presently adjacent to them across the fault, and therefore have a lower rank. This reasoning has led us to plot the trace of the Erickson fault west of the Fording Coal pits on Greenhills Range, rather than between Greenhills Range and Eagle Mountain as Fording geologists have done (Fig. 7). For example, there is no difference in the reflectance of the lowest seam (1.38 per cent) across the Fording Valley. However, the lowest seam on the west side of the Greenhills Range in this vicinity has a reflectance of 1.08 per cent, suggesting substantial normal fault movement west of the Fording Greenhills pits.

The north end of the coalfield appears to consist of lower rank coals, with 0.99 per cent reflectance on the lowest seam on Tobermory Ridge. The data are as yet too sparse to be able to detect a rank gradient. It is possible, however, that this portion of the coalfield has been down-dropped on a normal fault, perhaps the extension of the Erickson fault. The noted occurrence of a structural depression in this area (Cadorna Creek depression) adds weight to this hypothesis.

Near the Fording Bridge depression there are interesting contrasts between rank values of the basal seam on opposite limbs. For example, a reflectance of 1.49 per cent at Line Creek Ridge on the west limb contrasts with a reflectance of 1.23 per cent at Horseshoe Ridge on the east limb. In contrast, reflectances on the basal seam on Burnt Ridge and Burnt Ridge Extension (west limb) are respectively 1.11 per cent and 1.21 per cent, compared with values at Ewin Pass and Imperial Ridge (east limb) on 1.26 per cent and 1.34 per cent.

Detailed geological work is continuing in the Elk Valley coalfield.

REFERENCES

Gibson, D. W. (1977): Sedimentary facies in the Jura-Cretaceous Kootenay Formation, Crowsnest Pass area, Southwestern Alberta and Southeastern British Columbia, Bull., *Can. Petrol. Geol.*, Vol. 25, No. 4, pp. 767–791.

——— (1979): The Morrissey and Mist Mountain Formations—Newly Defined Lithostratigraphic Units of the Jura-Cretaceous Kootenay Group, Alberta and British Columbia, Bull., *Can. Petrol. Geol.*, Vol. 27, No. 2, pp. 183–208.

Graham, P. S., Gunther, P. R., and Gibson, D. W. (1977): Geological Investigations of the Coal-bearing Kootenay Formation in the Subsurface of the Upper Elk River Valley, British Columbia, *Geol. Surv., Canada,* Paper 77-1, Pt. B, pp. 203–210.

Pearson, D. E. and Grieve, D. A. (1978 and in prep.): Petrographic Evaluation of Crowsnest Coalfield, *C.I.M.,* Ann. Gen. Meeting, Vancouver, April 1978.

1981—GEOLOGY OF THE MOUNT BANNER AREA, ELK VALLEY COALFIELD (82G/15, J/2)

By D. A. Grieve

INTRODUCTION: The Mount Banner area is approximately 12 kilometres east of Elkford in the southern half of the Elk Valley coalfield (Fig. 11). It may be reached from the Fording and Line Creek mine access roads, and from secondary roads on Todhunter, Ewin, and Dry Creeks (Fig. 12). It is an area of moderate to high relief, with elevations which range from 1 500 to over 2 500 metres.

Coal rights in the study area belong to B.C. Coal Ltd. (including Lot 4588 and the Ewin Creek licences) and Crows Nest Resources Ltd. (including Central and North Block licences) (Fig. 12). The proximity of mining operations at Line Creek (Crows Nest Resources), Greenhills Range (B.C. Coal Ltd.), and the Fording Valley (Fording Coal Ltd.) suggests the area is in an ideal location to provide additional reserves in the future (Fig. 11).

Recent exploration has included construction of four adits, drilling of numerous rotary and diamond drill holes on the Ewin Pass property in the Central Block licences, and construction of two adits and drilling of two diamond drill holes on the south side of Ewin Creek in the Ewin Creek licences.

This study was undertaken to provide coal resource information, in response to an application for creation of an ecological reserve over the area.

FIELDWORK AND ANALYTICAL PROCEDURES: Field data were plotted on enlarged air photographs, and transferred later to 1:10 000-scale orthophotos. Important contacts and structural features were also plotted on 1:50 000-scale topographic maps, using compass and altimeter. Stratigraphic sections were measured using clinometer, chain, and pogo stick.

Small grab samples of coal exposures were collected routinely during mapping, while representative channel samples of seams were collected from road-cuts and/or trenches in certain localities. Grab samples were gently crushed using mortar and pestle, and passed through a 20-mesh screen. They were then mounted in resin or thermoplastic, ground, and polished. Channel samples were dried, riffled, and screened according to ASTM standards prior to mounting and polishing.

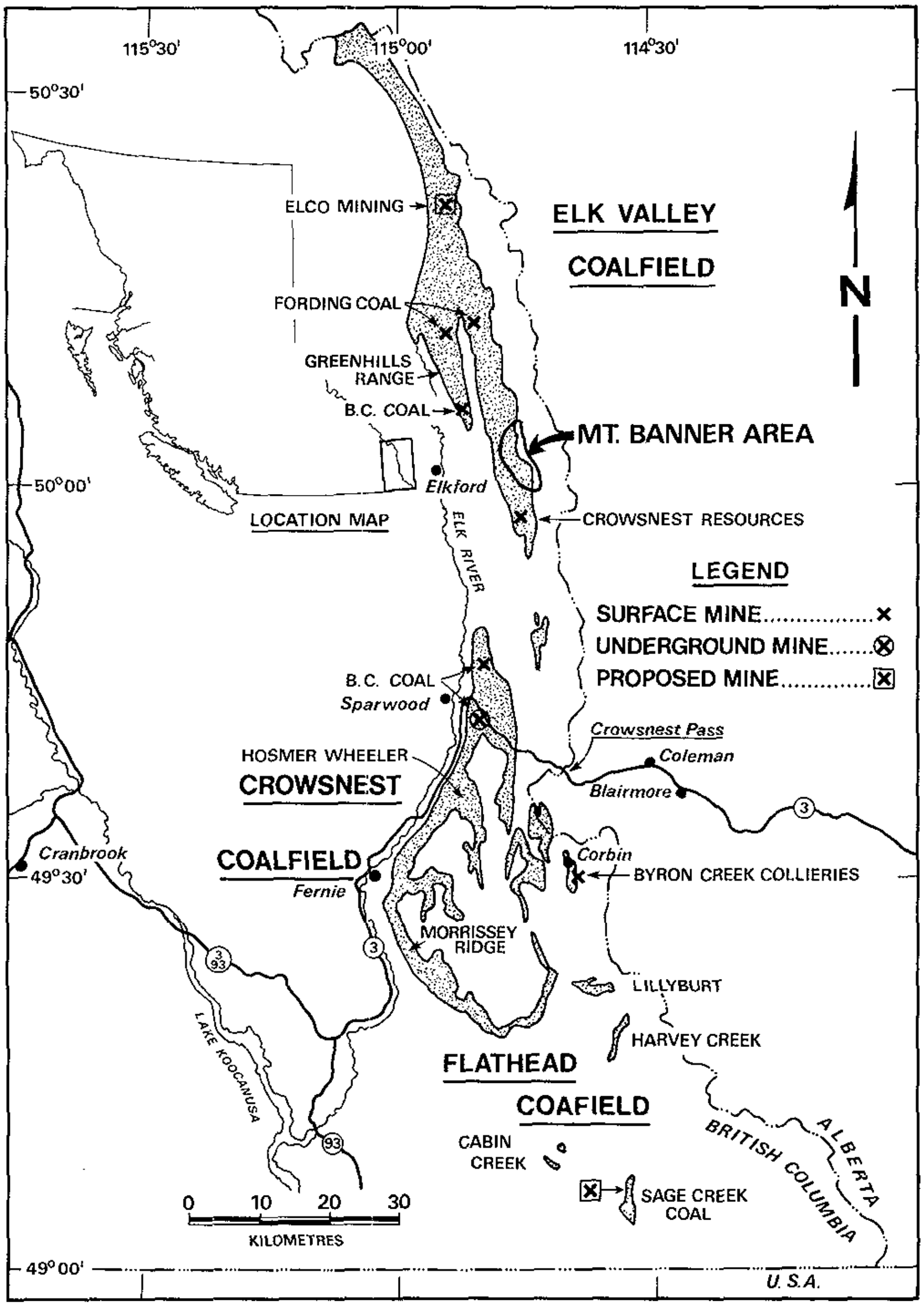


Figure 11. East Kootenay coalfields (stippled) with Mount Banner area indicated

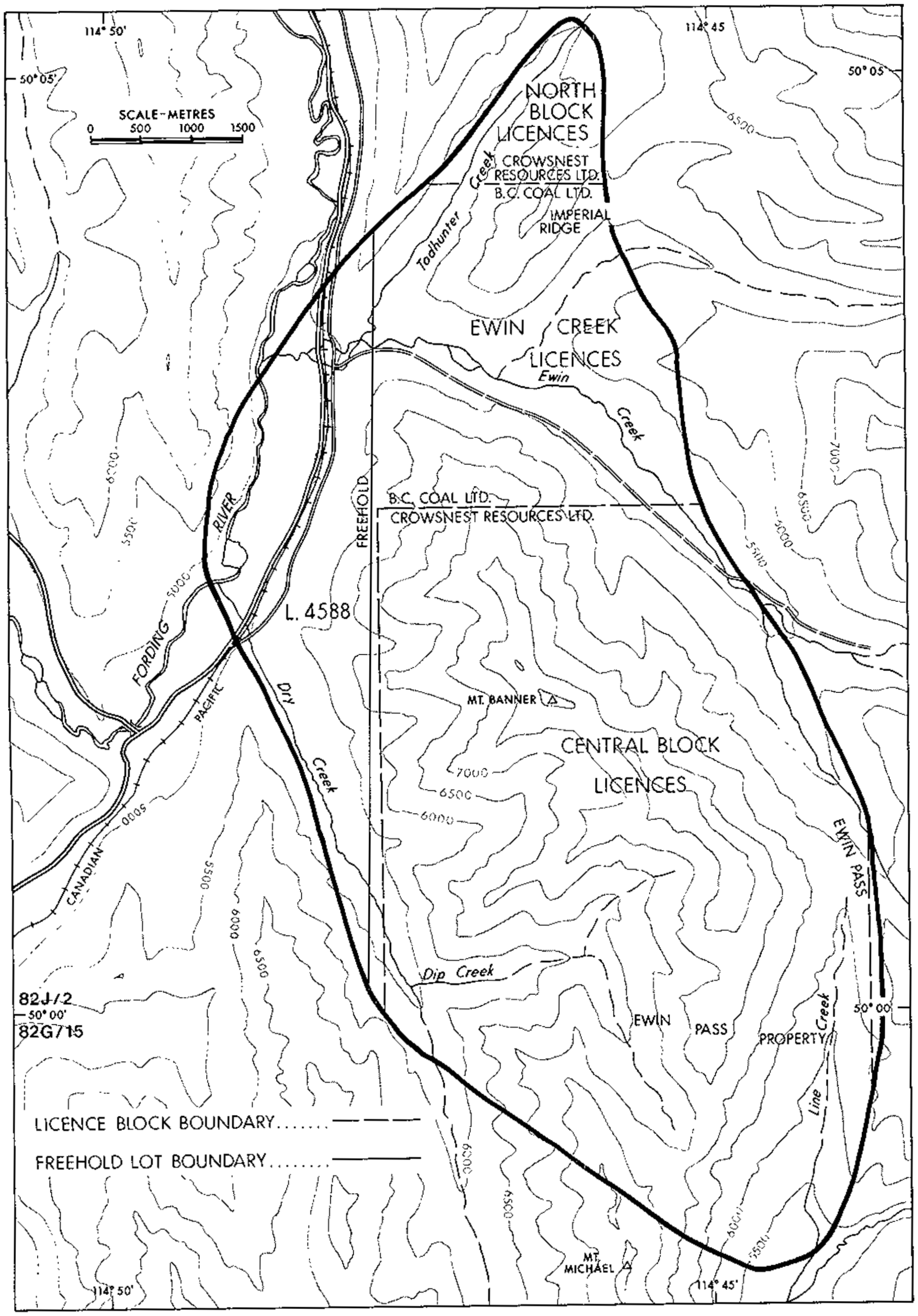


Figure 12. Coal lands tenure in the Mount Banner area

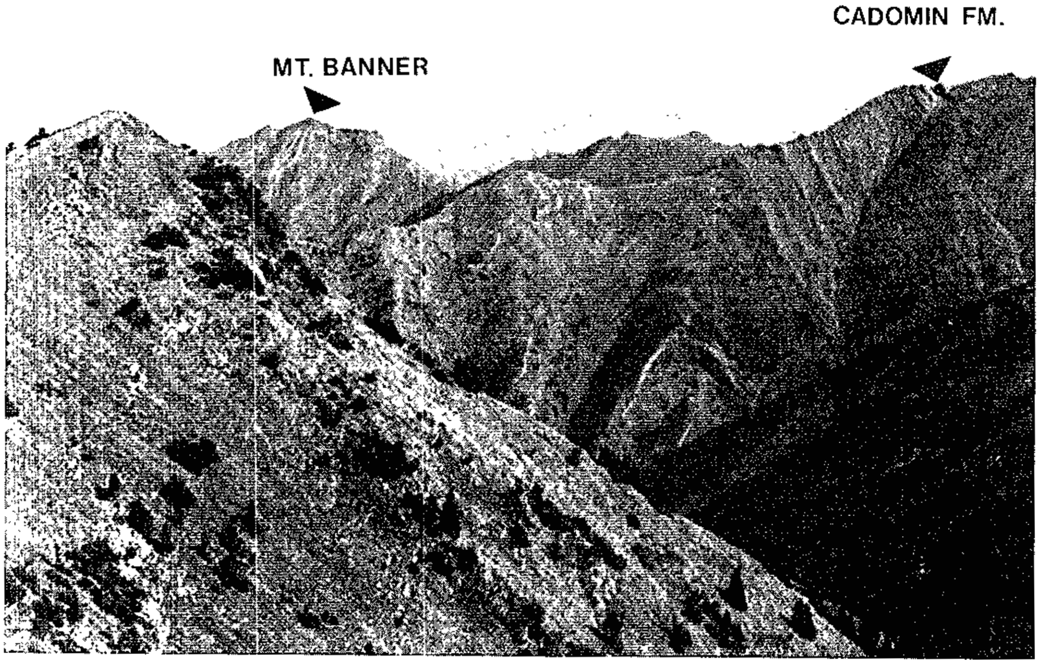


Plate III. View of the study area from the south, note anticline-syncline pair on east limb of Alexander Creek syncline, Cadomin Formation conglomerate exposed in the core of the syncline; Mount Banner Peak in the distance at the left of the photograph

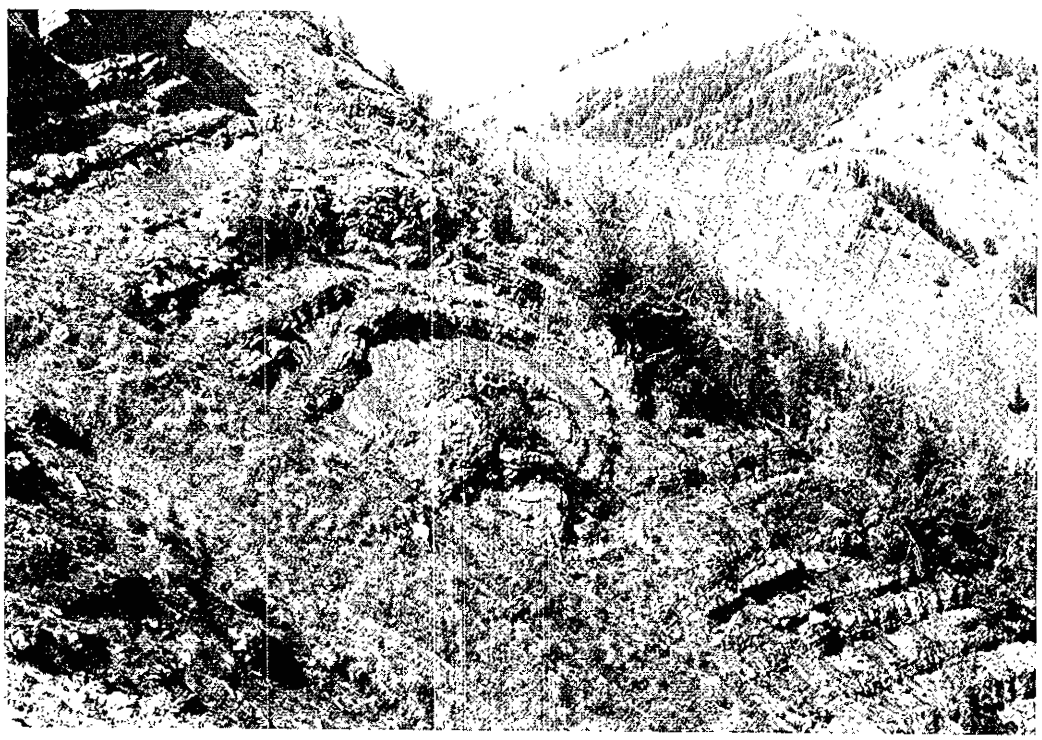


Plate IV. Northwest-plunging dragfold in the hangingwall of a splay of the Ewin Pass thrust

Coal rank was measured petrographically on grab samples by averaging maximum reflectance in per cent for 25 vitrinite grains per sample. Classification into rank categories was assigned as follows:

$\bar{R}_o$ max $\leq$ 1.12% = high-volatile bituminous;
$\bar{R}_o$ max $>$ 1.12% $\leq$ 1.51% = medium-volatile bituminous; and
$\bar{R}_o$ max $>$ 1.51% = low-volatile bituminous.

Petrographic maceral composition was measured on channel samples by counting 500 grains per sample. The following categories were recognized; vitrinite, exinite, semifusinite, fusinite, and other inertinites (including inertodetrinite, macrinite, and micrinite).

STRATIGRAPHY: The Jurassic-Cretaceous Kootenay Group comprises the East Kootenay coalfields. Kootenay Group, as defined by Gibson (1979), consists of, from oldest to youngest, the Morrissey, Mist Mountain, and Elk Formations. Shales and sandstones of the Passage Beds of the Upper Jurassic Fernie Group underlie the Kootenay Group, while the Cadomin Formation conglomerate of the Lower Cretaceous Blairmore Group overlies the Kootenay Group at two locations in the study area (Plate III).

Morrissey Formation is the basal sandstone unit of the Kootenay Group. It is generally medium grained, and throughout most of the study area it forms a prominent 15 to 20-metre cliff.

Mist Mountain Formation averages 500 metres in thickness in the study area, of which 9 to 12 per cent is composed of coal (Fig. 13). Coal seams range from less than 1 to over 15 metres in thickness. Interbedded with coal seams are shale, siltstone, sandstone, and rare conglomerate. Correlation of coal and interbedded strata is best carried out by geological mapping, lithological core-logging, and geophysical drill-hole logging. This study relied on the first method. Correlation of seams between Ewin Pass property and Imperial Ridge (Figs. 13 and 14) has not yet been demonstrated. It is possible, however, that one or more seams, particularly in the lower part of the section, are continuous between the properties.

Elk Formation is similar in most respects to Mist Mountain Formation, but there are no coal seams greater than 1.5 metres in thickness, and brittle alginite-rich "Elk coal" is present. The formation is estimated to be 250 to 300 metres thick in the study area. Its lower contact is arbitrarily placed at the lowest stratigraphic occurrence of Elk coal, or at a locally mappable resistant coarse-grained unit in strata typical of the Elk and Mist Mountain Formations.

STRUCTURE: The study area lies almost exclusively on the east limb of the north-south Alexander Creek syncline and is characterized by westerly dips ranging from 25 to 55 degrees (Fig. 14). A plunge depression occurs to the west of Mount Banner, as is evidenced by the occurrence of Cadomin Formation conglomerate above Dry Creek. An anticline-syncline pair of similar geometry to the Alexander Creek syncline can be traced through the southern part of the study area (Fig. 14; Plate III).

Thrust faults are also a major structural feature in this portion of the Elk Valley coalfield. The largest and most continuous is the Ewin Pass (or Fording) thrust, which can be traced several kilometres north and south of the study area (Grieve and Pearson, this volume). It is a west-dipping structure which lies in the Elk or upper Mist Mountain Formation throughout the study area (Fig. 14). On Mount Banner it has one major splay which passes immediately east of Mount Banner peak. Large zones of related deformation are associated with the thrust, including northwest-plunging dragfolds, particularly in the hanging-wall (Plate IV). The major stratigraphic effects of the Ewin Pass thrust in the study area were emplacement of Mist Mountain Formation on Elk Formation in the vicinity of Mount

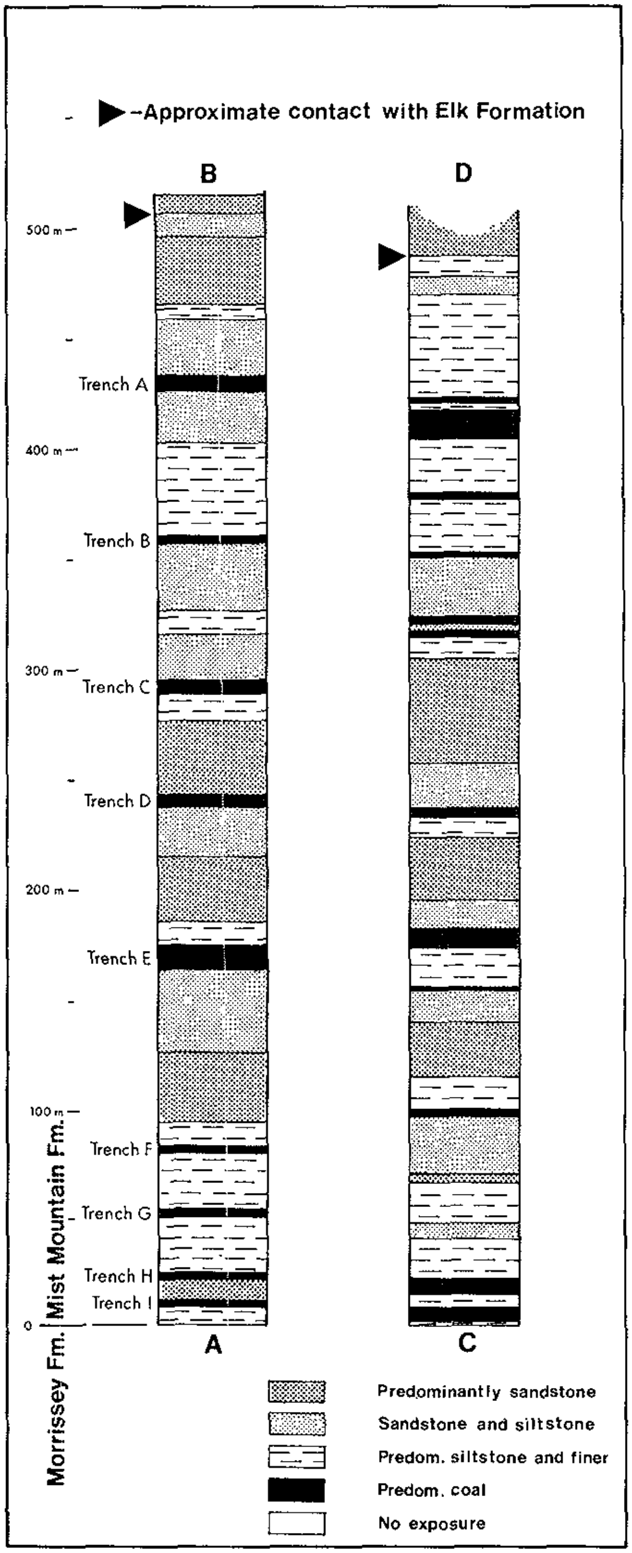


Figure 13. Generalized stratigraphic columns of the Mist Mountain Formation at Imperial Ridge (A-B) and Ewin Pass (C-D)

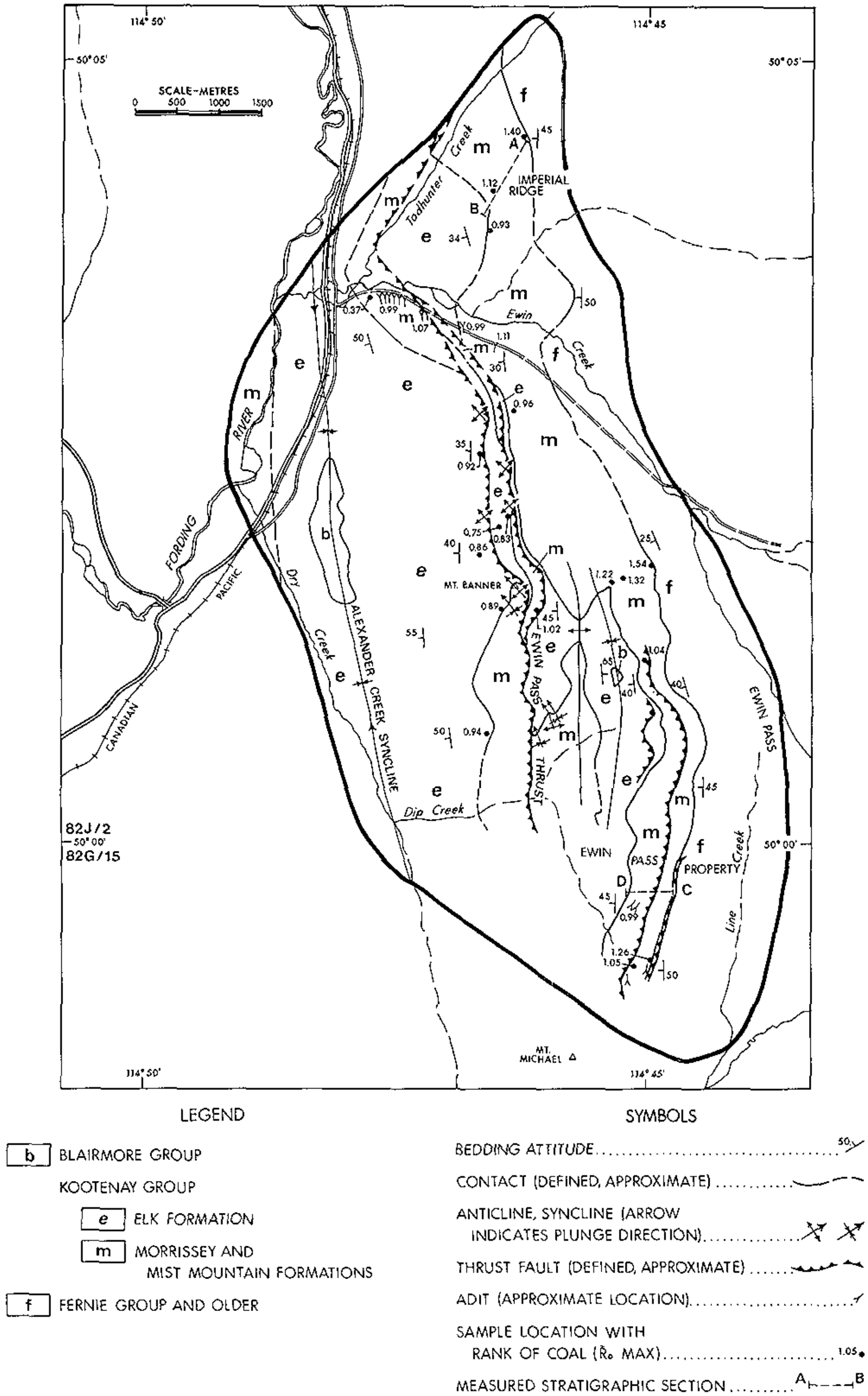


Figure 14. Geology of the Mount Banner area and rank of selected samples

Banner peak, and thickening of the Mist Mountain Formation on the south side of Ewin Creek (Fig. 14).

Numerous other less continuous west-dipping thrust faults occur at various stratigraphic levels throughout the study area.

RANK DISTRIBUTION: Rank values obtained on selected samples are indicated on Figure 14. Medium and high-volatile ranks characterize all of the samples so far examined, excepting one low-volatile value (1.54 per cent) read on the basal seam directly east of Mount Banner. Complete Mist Mountain Formation sections range from medium to high-volatile in rank from base to top on Imperial Ridge (1.40 per cent to 0.93 per cent) and Ewin Pass (1.26 per cent to less than 0.99 per cent), while the section east of Mount Banner ranges from low to medium-volatile (1.54 per cent to 1.22 per cent). The partial Mist Mountain Formation sections in the hangingwall of the Ewin Pass thrust are entirely high-volatile in rank, based on samples analysed so far. Coals in the Elk Formation are also entirely high-volatile in rank, with the basal Elk horizons corresponding to rank values of approximately 0.90 per cent.

MACERAL COMPOSITION: A series of nine channel samples from trenches on Imperial Ridge (Figs. 13 and 14) have been analysed for their maceral composition (Table 1). The range in compositions is best exemplified by the vitrinite content, which varies from 85.4 per cent in trench A to 55.0 per cent in trench G. On average, the stratigraphically highest seams contain more vitrinite than the lowest seams. Exinite was detected in only three of the uppermost four seams, and in quantities of less than 1.5 per cent. Semifusinite content, which ranges from 12.1 per cent to 36.6 per cent, is inversely proportional to that of vitrinite. Fusinite content ranges from 0.3% to 4.4 per cent, and other inertinite from 1.1 per cent to 5.3 per cent, and both are roughly proportional to semifusinite content.

For the purpose of coal quality prediction (next section) petrographic composition can be converted to total inert content. This quantity includes two-thirds of the semifusinite, all of the fusinite and other inertinites, plus a constant assumed mineral matter content of 5.03 per cent, derived from the Parr formula and utilizing values of 9.0 per cent ash and 0.6 per cent sulphur. Total inert content of the seams of Imperial Ridge (Table 1) ranges from 14.5 per cent in trench A to 38.0 per cent in trench G. As this range is fairly typical of the East Kootenay coalfields, it is safe to predict that the entire study area contains coals with similar compositions.

COAL QUALITY: Knowledge of vitrinite reflectance and total inert content of a coal allows rough prediction of certain coal quality parameters (*see* Pearson, 1980). Table 1 lists predicted values of Free Swelling Index (FSI), maximum dilatation, fluidity, and ASTM coke stability for the Imperial Ridge trench samples. These values suggest that the study area contains potentially good quality metallurgical coals. For example, five of the nine seams (trenches A, B, D, F, and I) are predicted to have an FSI greater than 8 and a coke stability factor of 60 per cent or greater. The uppermost two seams (trenches B and A) also have predicted maximum dilatation values of 150 and 200 per cent respectively, and predicted fluidity values of 2 500 to 5 000 d.d.m.

In general, these ranges of predicted properties (Table 1) are similar to those of the seams in the area of the B.C. Coal's Sparwood operations. For example, predicted properties of the seams in trenches G and H are very similar to actual properties of the Balmer or 10-seam, which occupies a similar stratigraphic position.

Predicted calorific values for the Imperial Ridge seams, all on the order of 36.5 megajoules per kilogram, are slightly in excess of that for the Line Creek thermal product.

TABLE 1

Petrographic Analyses and Predicted Quality of Seams On Imperial Ridge. Total Inerts Includes ⅔ Semifusinite + Fusinite + Other Inertinite + Assumed Mineral Matter *Content of 5.03 Per Cent*

								Predicted Quality Parameters			
Trench	$\bar{R}_o$ max	Vitrinite	Exinite	Semi-fusinite	Fusinite	Other Inertinite	Total Inerts	FSI	Maximum Dilatation	Fluidity	ASTM Stability
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	d.d.m.	Per cent
A	1.12	85.4	1.1	12.1	0.3	1.1	14.5	>8	200	2500–5000	60
B	1.17	82.0	1.4	12.5	1.2	2.8	17.4	>8	150	2500–5000	60–65
C	1.18	61.3	0	33.3	3.4	2.0	32.6	7	25–50	100–500	50–55
D	1.19	75.9	0.1	19.7	2.8	1.5	22.5	>8	100	1000–2500	60–65
E	1.23	60.0	0	34.2	3.7	2.1	33.7	7	25–50	100–500	50–55
F	1.31	73.4	0	23.7	1.8	1.1	23.8	>8	75–100	1000	60–65
G	1.33	55.0	0	36.6	3.1	5.3	38.0	6–7	25	<100	50–55
H	1.37	56.6	0	35.1	4.4	3.9	36.8	6–7	25	<100	50–55
I	1.40	73.7	0	18.9	2.6	4.8	25.1	>8	50–75	100–500	60–65

Based on analyses of adit bulk samples reported in exploration company assessment reports*, coals in the study area contain levels of sulphur ranging from 0.4 to 0.6 per cent, *values typical of East Kootenay coals. Exceptionally low raw ash and superb washability* characteristics are also indicated for certain of the seams.

COAL MINEABILITY: Probably substantial reserves of surface mineable coal exist on the Ewin Pass property, where little prestripping will be required to begin production of upper Mist Mountain Formation seams (Plate V). A much smaller quantity of surface mineable coal occurs in the small drainage basin 1 kilometre east of Mount Banner (Fig. 14).

Essentially, the remainder of the study area's coal resources will be accessible only by underground methods. The most attractive sites are Ewin Creek, east of the trace of the Ewin Pass thrust, and Imperial Ridge. Mines developed at or near creek levels at these sites could utilize hydraulic mining technology, taking advantage of the westerly dip of the seams.

The study area, therefore, has potential to provide coal to supplement both Crows Nest Resources' and B.C. Coal's operations in the Elk Valley coalfield. B.C. Coal's Ewin Creek licences, in particular, are advantageously located with respect to the Greenhills loadout facilities. Crows Nest Resources' Central Block licences, while they are not situated so as

* These data are confidential.

Plate V. View from the north into the Ewin Pass property, approximate Mist Mountain-Elk Formation contact marked with arrow, strata dip to the west or right-hand side of the photograph

to allow direct access to the Line Creek haul road, are located to allow short downhill hauls to the Fording River valley. From the east side of Mount Banner, for example, coal could be hauled down Ewin Creek, while coal from the Ewin Pass property, could be hauled down Dip Creek and Dry Creek (Fig. 12). Coal could then be processed and loaded out at a possible new site in the Fording Valley, or hauled approximately 20 kilometres south to the Line Creek facility.

ACKNOWLEDGMENTS

It is a pleasure to record my appreciation of field assistance provided by Mr. Gerry Pellegrin.

REFERENCES

Gibson, D. W. (1979): The Morrissey and Mist Mountain Formations—Newly Defined Lithostratigraphic Units of the Jura-Cretaceous Kootenay Group, Alberta and British Columbia, Bull., *Cdn. Petrol. Geol.*, Vol. 27, No. 2, pp. 183–208.

Pearson, D. E. (1980): The Quality of Western Canadian Coking Coal, *C.I.M.*, Bull., Vol. 73, No. 813, pp. 70–84.

1980—PETROLOGY AND CHEMISTRY OF THE CROSS KIMBERLITE (82J/2)

By D. A. Grieve

INTRODUCTION: The Cross kimberlite is exposed on the north side of Crossing Creek, 8 kilometres northwest of Elkford, at an elevation of 2200 metres. It may be reached on foot by way of an old fire access road or by helicopter.

The intrusion was first described by Hovdebo (1957) as a "bysmalith" with similarities with a volcanic breccia plug. The unusual composition was not noted at the time.

A Cominco exploration crew staked the exposure in 1976, following tentative identification of the rock-type as kimberlite. An ambitious regional exploration program was immediately launched, which succeeded in locating 40 other small intrusions, mainly in the Bull, White, and Albert River drainages (Roberts, *et al.*, 1980).

The Cross intrusion remains unique among these intrusions (*see* Grieve, 1981). Cominco geologists claim it is the only true kimberlite among the group, and is the only one of the intrusions younger than Middle Devonian (Roberts, *et al.*, 1980).

The exposure is approximately 70 metres square in extent on the side of a steep slope and appears to represent very nearly the uppermost portion of a pipe-like intrusion. Weathered intrusive material can be traced in a narrow zone a considerable distance down-slope. Roberts, *et al.* report a smaller satellite pipe adjacent to the Cross.

STRATIGRAPHIC AND STRUCTURAL SETTING: The Cross kimberlite intrudes the Pennsylvanian Rocky Mountain Group. It is in immediate contact with thin to medium-bedded crinoidal dolomite and dolomitic sandstone with thin interbeds of dark grey chert and black shale. Cliff-forming limestones of the Mississippian Rundle Group crop out at the level of Crossing Creek immediately below the exposure. Hovdebo (1957) estimated that approximately 185 metres of Rocky Mountain strata, which probably includes 100 metres of the currently recognized Ishbel Group (MacRae and MacGugan, 1977, Section 26), overlie the intrusion.

The Cross exposure lies in the Front Ranges within the Bourgeau thrust block, which has been transported from the west. Strata in the vicinity of the intrusion dip shallowly west and northwest on the west limb of a north-south-trending anticline. The position of the intrusion is not related to any known regional fault system. The shear zone at its eastern contact (*see* following) may have existed prior to intrusion, providing a plane of weakness.

NATURE OF CONTACT: The contact between the Cross kimberlite and the host strata is in part cross-cutting and intrusive (Plate VI). At the eastern edge of the exposure especially, it is, in part, a shear zone (Plate VII). Accordingly, bedding attitude variations adjacent to most of the contact perimeter are slight, with the exception of the eastern contact. Here, strata undergo a pronounced steepening to the east within 5 metres of the contact.

The contact is generally very steep and dips away from the core of the exposure. No thermal effects on wallrocks are observed. There is no evidence that the intrusion reached surface during emplacement.

AGE OF THE INTRUSION: Phlogopite separates of Cross samples were dated by both the K/Ar and Rb/Sr methods. The former attempt yielded a spurious age of 595 Ma, resulting most likely from concentration of argon into mineral phases during injection of the fluid-rich magma (*see* section on Petrogenesis, following). The age arrived at by the

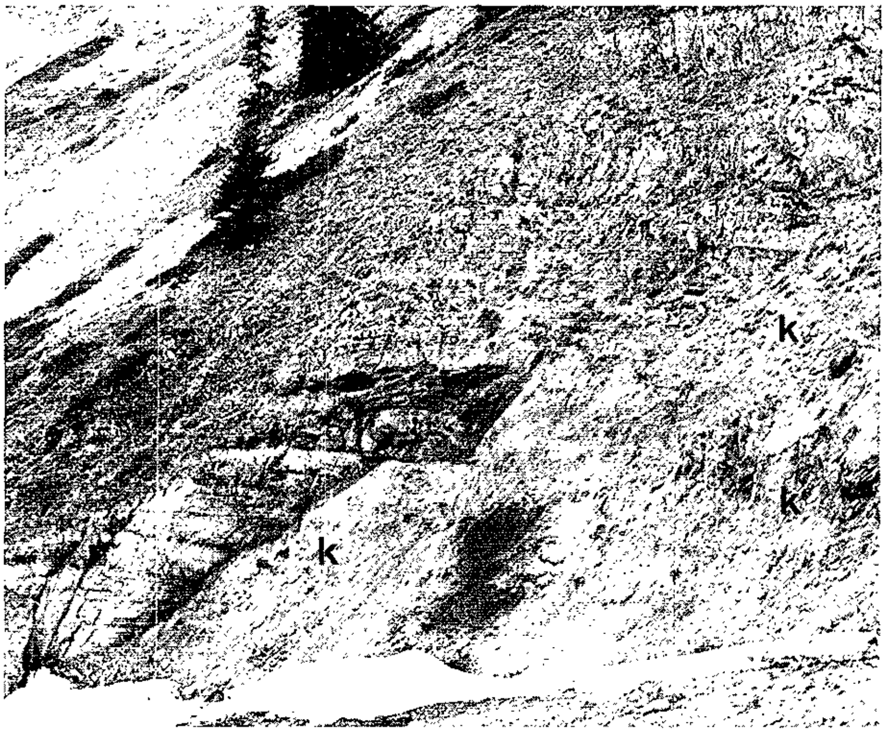


Plate VI. *View of western crosscutting contact of Cross Kimberlite (K) and the Pennsylvanian country rock*

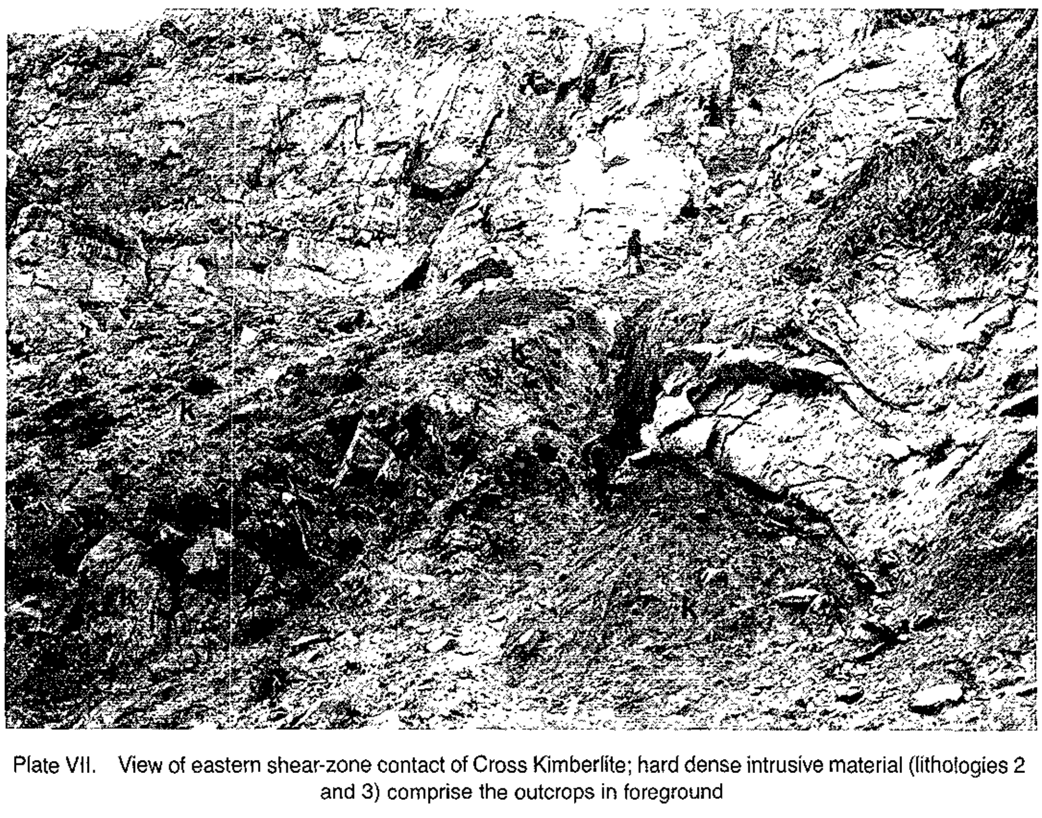


Plate VII. View of eastern shear-zone contact of Cross Kimberlite; hard dense intrusive material (lithologies 2 and 3) comprise the outcrops in foreground

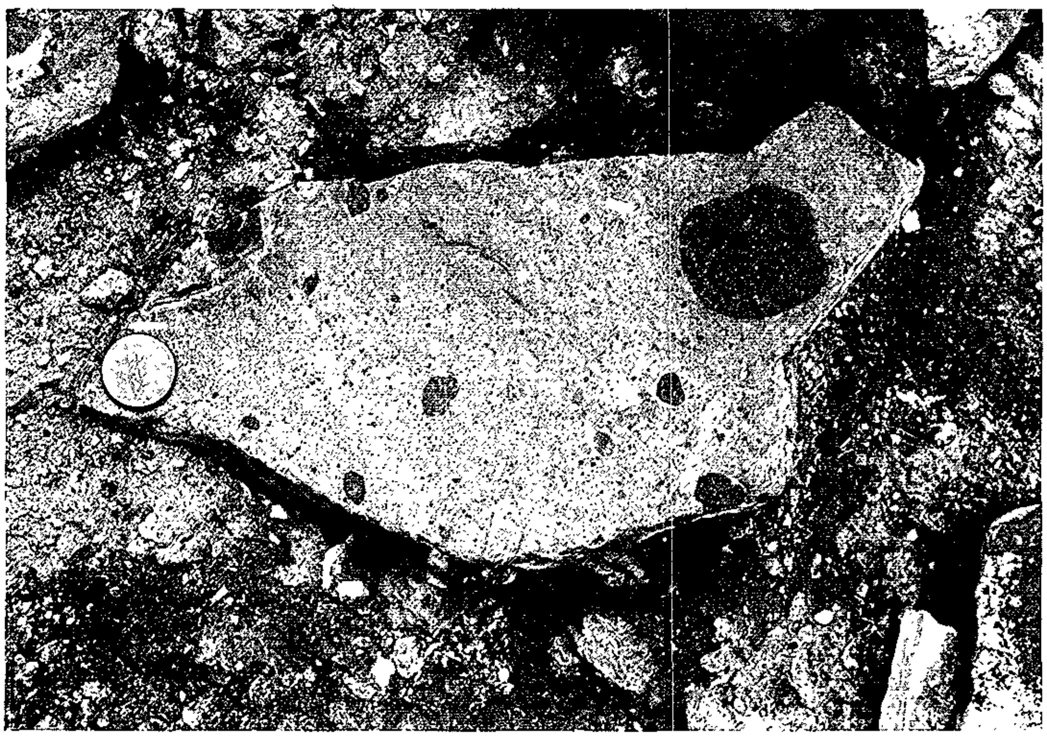


Plate VIII. Boulder of Cross Kimberlite showing texture of lithology 2

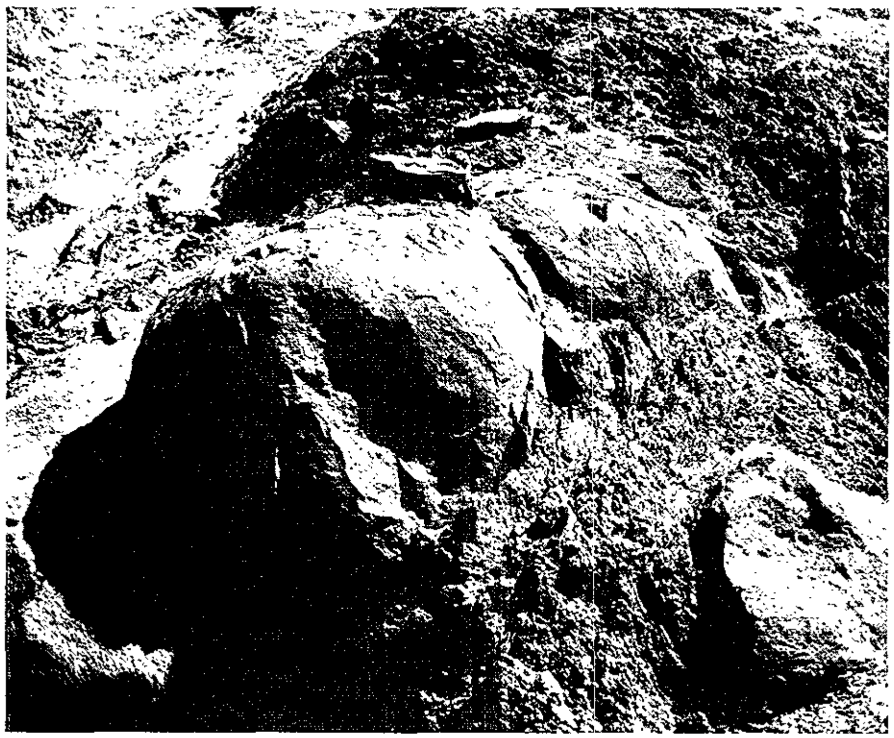


Plate IX. Rounded ultrabasic inclusion of 0.75-metre diameter in crumbly highly weathered material (lithology 1) near the western contact of Cross Kimberlite exposure

Rb^{87}-Sr^{87} method was 244 Ma, or Lower Permian (Leonardian). This age probably corresponds with deposition of the overlying Ishbel Group (MacRae and McGugan, 1977), confirming that the intrustion did not reach surface during emplacement.

PETROLOGY: The Cross kimberlite is an inclusion-rich, multilithological porphyritic diatreme with an altered calcareous groundmass. Various lithologies appear to represent separate intrusive phases and are commonly separated by shear surfaces subparallel to the eastern contact. They are distinguished megascopically by contrasting texture, colour, and hardness.

Inclusions range from microscopic to over 1 metre in size (Plates VIII and IX); most of the exposure is characterized by inclusions up to 10 centimetres. These inclusions consist mainly of xenoliths of altered ultrabasic rock, and sedimentary rock fragments, including chert, limestone and shale that are typical of the Paleozoic country rocks. They are rounded to subangular, and many of the large, rounded ones display a polished surface (Plate IX).

Phenocrysts, many of which are probably xenocrysts or crystal clasts separated from xenoliths or xenolith source material, are primarily altered olivine and round-edged phlogopite. There are minor amounts of altered pyroxene, including distinctive green chrome-diopside, and rare garnets. Composition of a garnet crystal analysed by X-ray diffraction is pyrope (65 per cent), almandine (15 per cent) and grossular plus uvarovite (20 per cent). The same crystal contains greater than 2 per cent chromium (Table I). Phenocrysts are generally less than 5 millimetres in size, although some larger phlogopite crystals occur.

TABLE 1. Semi-quantitative Spectrographic Analysis of Garnet Crystal

	Per Cent		Per Cent
Si	>10.0	V	0.025
Al	>10.0	Ti	0.1
Mg	>10.0	Ni	trace
Ca	3.0	Co	trace
Fe	5.0	Cr	>2.0
Cu	trace	W	0.03
Zn	trace	Zr	trace
Mn	0.3	Sr	trace
Ag	trace	Ba	trace

Outcrop colour ranges from pale greyish green in highly weathered portions of the outcrop, to dark greyish green and bluish green. Hardness ranges from crumbly, in highly weathered portions, to very hard.

Petrographically, Cross lithologies have several features in common. They all have a groundmass composed predominantly of calcite with numerous opaques, including magnetite and ilmenite. The groundmass also commonly contains serpentine, mica, talc, and accessory spinel and zircon. Small mica flakes are sometimes oriented at right angles over patches of groundmass, suggesting pyroxene replacement. Also ubiquitous are large, rounded to subangular grains composed of serpentine; sometimes these have a carbonate-plus-opaque mineral core. These are believed to have been primary olivine phenocrysts, and remnant crystal outlines in some cases substantiate this. They are commonly rimmed or veined with combinations of serpentine, mica, talc, carbonate, and opaques. All lithologies also contain phlogopite phenocrysts with rounded and corroded outlines with rims of fine mica, carbonate, and opaque minerals. Some phlogopite may be pseudomorphous after primary pyroxene; they are tabular-shaped and display extinction zoning, "twinning", and a second cleavage at right angles to the basal cleavage.

Also common in thin-section are inclusions of altered peridotite containing serpentinized olivine, altered pyroxene composed of micaeous minerals and carbonate with relict cleavage outlined by mica flakes, and, occasionally, garnet or brown spinel. Inclusions of ultrabasic breccia and carbonate rock also were noted.

X-ray diffraction confirms the presence of calcite, serpentine, phlogopite, and talc in most samples. Magnesian magnetite, ilmenite, ferroan spinel, zircon, and siderite occur in some samples, and clino and ortho-pyroxene are suspected in some.

Distinctive features of the major lithologic types are:

(1) Pale greyish green, weathered, crumbly material is associated with the western contact (Plate VI) and shear zones. It contains ochre pods up to 2 centimetres in diameter and large rounded xenoliths of serpentinized ultrabasic material (Plate IX) including other inclusion-bearing kimberlite phases. Spectacular kelyphitic rims and veinlets of talc and other clay minerals on inclusions and phenocrysts are visible in thin-section. Saponite is detected by X-ray diffraction.

(2) Dark greyish green, hard rock with a fine calcareous matrix, and which contains phenocrysts up to 1 centimetre and abundant xenoliths up to 10 centimentres, is very common throughout the exposure (Plate VIII).

(3) Dark greyish to bluish green, very hard, basaltic looking rock, with a fine calcareous groundmass and scattered phenocrysts and inclusions up to 5 millimetres, occurs in the core of the exposure.

(4) Material similar to types 2 and 3, but with visible hematite which replaces inclusions, rims, and groundmass, is common in the highest portions of the outcrop (Plate VII).

Other features worth noting are the presence of fibrous calcite on shear surfaces, and incipient chloritization of micas in most thin-sections.

Mineralogically, most of the Cross intrusion is a micaceous kimberlite (*see* McCallum and Mabarak, 1976, p. 11), with superficial resemblance to the lamprophyre series.

CHEMISTRY: In composition, the Cross samples (Tables 2 and 4) are typical of kimberlites (for comparison, *see* summary tables *in* Carmichael, *et al.,* 1974, p. 521, Table 10-7; and MacCallum and Mabarak, 1976, p. 12, Table 3), and contrasts with other ultrabasic rocks. For examples, SiO_2 and MgO contents (28.1 per cent and 25.2 per cent respectively) are low with respect to most peridotites, as is the ratio Mg:Fe (2.6:1) (Table 6). On the other hand, contents of TiO_2 (1.205 per cent), CaO (12.27 per cent), K_2O (0.587 per cent), MnO (0.216 per cent), P_2O_5 (0.38 per cent to 0.66 per cent), CO_2 (10.3 per cent) and H_2O (7.5 per cent) are relatively high (Tables 3 and 4), as is the ratio K:Na (10:1 to 100:1) (Tables 2 and 4).

Significant amounts of minor elements normally found in ultrabasic rocks, such as Ni, Cr, and Co, are noted, along with concentrations of elements normally associated with acidic rocks, such as Ba, Sr, Zr, and the rare earths La, Ce, and Nd (Tables 2 and 3).

PETROGENESIS: Source areas for kimberlites are believed to be the upper mantle, as evidenced by phenocrysts and inclusions. In particular, olivine, pyrope, chrome diopside, and varieties of garnet and spinel-bearing peridotite are thought to represent mantle assemblages. Kimberlite pipes are usually thought to have been intruded rapidly and explosively and to originate from feeder dykes (*see,* for example: Carmichael, *et al.,* 1974, p. 527; and MacCallum and Mabarak, 1976, p. 8). Composition of the magma as it ascends has been described as both a fluidized gas-solid mixture and as a fluidized gas-liquid-solid mixture. In both cases rapidly expanding gases (chiefly CO_2 and H_2O), emanating from the "magma" as confining pressures are reduced, provide the lubricating mechanism for intrusion. This allows for a relatively "cold" intrusion. It also allows for circulation of inclusions and phenocrysts within the magma, which produces rounding by abrasion, and for simultaneous or early autometamorphism of primary minerals into H_2O-rich and CO_2-rich phases that are stable at shallow depths.

TABLE 2. Semi-quantitative Spectrographic Analyses of Three Samples of Lithology 4 (Hematite-rich)

	Per Cent	Per Cent	Per Cent
Si	>10.0	>10.0	>10.0
Al	1.25	1.25	2.7
Mg	>10.0	>10.0	>10.0
Ca	4.0	10.0	7.5
Fe	6.0	6.0	10.0
Cu	trace	trace	trace
Ag	—	—	trace
Mn	0.17	0.15	0.2
P	—	—	0.3
V	trace	trace	trace
Ti	0.4	0.4	0.4
Ni	0.14	0.14	0.1
Co	0.01	0.01	0.01
Na	0.1	0.05	0.02
K	1.0	>2.0	1.0
Zr	0.02	0.02	0.012
Sr	0.08	0.11	0.15
Cr	0.2	0.2	0.15
Ba	0.2	0.3	0.2
B	0.01	0.01	trace
La	0.02	0.02	—
Ce	0.02	0.02	—
Nd	0.01	0.01	—
Nb	—	—	trace
Ga	trace	trace	—

TABLE 3. Quantitative Analysis for Contents of Au, Ag, Ba, Sr, and P_2O_5 in Two Samples of Lithology 4 (corresponds to first two columns in Table 2)

Au	>1 ppm	trace
Ag	18.93 ppm	17.48 ppm
Ba	0.2 per cent	0.25 per cent
Sr	0.08 per cent	0.13 per cent
P_2O_5	0.66 per cent	0.38 per cent

TABLE 4. Whole-rock Analysis of One Sample of Lithology 4 (corresponds to third column in Table 2)

	Per Cent
SiO_2	28.1
MgO	25.2
Al_2O_3	2.06
Fe_2O_3 / FeO	9.65*
CaO	12.27
Na_2O	0.006
K_2O	0.587
TiO_2	1.205
MnO	0.216
H_2O (total)**	7.5
CO_2	10.3

* Total Fe as Fe_2O_3
** Total water calculated as total loss on ignition minus CO_2 content.

The Cross kimberlite is characterized by rounded and abraded inclusions and phenocrysts, an implied primary mineralogy typical of mantle material, inclusions of implied garnet-bearing peridotitic composition, a secondary assemblage of CO_2-rich and H_2O-rich phases, no evidence of thermal contact effects on country rock, and evidence of forceful intrusion, at least on the eastern contact (Plate VII). It therefore appears to conform to the above general models of kimberlite genesis and intrusion.

Post-emplacement hydrothermal alteration probably produced fibrous calcite on shear surfaces, hematite replacements, and incipient chloritization of micas. Talc and clays, such as saponite, are probably weathering products.

The orogenic belt setting of the Cross kimberlite is somewhat anomalous (Carmichael, *et al.,* 1974, p. 523). During intrusion in Permian time, however, the host rock was part of a stable shelf assemblage developing on cratonic basement. The shear zone along the eastern contact (Plate IX) may have provided a pathway for intrusion if it existed at that time and if it was continuous at depth. No known corresponding regional fault system is known, however, and there are therefore no structural trends to follow in search of more kimberlites.

ECONOMIC POTENTIAL: Generally only a small percentage of kimberlite pipes contain commercially valuable diamonds. It is not probable, therefore, that the Cross represents an economic occurrence.

Sampling of kimberlites must be carried out carefully, as the various phases may have different economic potential. In the Letseng-la-terae pipes in Lesotho, for example, (Bloomer and Nixon, 1973) rock similar to lithology 1 is economically the most important, while rock analogous to lithology 3 is barren.

ACKNOWLEDGMENTS: Mr. G. G. Addie, District Geologist with the British Columbia Ministry of Energy, Mines and Petroleum Resources in Nelson, accompanied and assisted the author in the field. Drs. E. W. Grove and W. J. McMillan coordinated analytical stages of the study and provided advice. Discussions with Mr. D. L. Pighin of Cominco and Mr. B. Grant of Selco were most helpful. Dr. J. Kwong carried out X-ray diffraction analyses and advised on petrography.

K/Ar and Rb/Sr age-dating as carried out in the Geological Sciences Department at the University of British Columbia.

REFERENCES

Bloomer, A. G. and Nixon, P. M. (1973): The Geology of Letseng-la-terae Kimberlite Pipes, *in*, P. M. Nixon (ed.), Lesotho Kimberlites, *Lesotho National Development Corporation*, pp. 20–32.

Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974): Igneous Petrology, *McGraw-Hill Book Company*, 739 pp.

Grieve, D. A. (1981): Diatreme Breccias in the Southern Rocky Mountains, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1980, Paper 1981-1, pp. 96–103.

Hovdebo, M. R. (1957): Structure of the Brule-Crossing Creek Area, British Columbia, unpubl. M.Sc. thesis, *University of Saskatchewan*, 46 pp.

MacCallum M. E. and Mabarak, C. D. (1976): Diamond in State-line Kimberlite Diatremes, Albany County, Wyoming, Larimer County, Colorado, *Geol. Surv., Wyoming*, Rept. of Investigation, No. 12, 36 pp.

MacRae, J. and McGugan, A. (1977): Permian Stratigraphy and Sedimentology, Southwestern Alberta and Southeastern British Columbia, Bull., *Can. Petrol. Geol.*, Vol. 25, pp. 752–766.

Roberts, M. S., Skall, H. and Pighin, D. L. (1980): Diatremes in the Rocky Mountains of Southeastern British Columbia, *C.I.M.*, District Six Annual Meeting, Kimberley, October 1980.

1978—KASLO CLAIM (82K/3E)

By T. D. Lewis

LOCATION: Lat. 50° 03′ Long. 117° 08′ (82K/3E)
SLOCAN M.D. The Kaslo Claim is located at Retallack, an abandoned railway siding on the Kaslo-Nakusp branch of the Canadian Pacific Railway, 29 kilometres west of Kaslo and 21 kilometres east of New Denver.

CLAIMS: KASLO and HOMESTAKE.

OWNER: Crown-granted claim currently leased by PETER LEONTOWICZ, a prospector working under the *Prospectors Assistance Act.*

DESCRIPTION:

GENERAL GEOLOGY: Lead-zinc mineralization occurring in Slocan Group sedimentary rocks was reported on the Kaslo Claim, in south-central British Columbia. Mapping on a scale of 1:2 400 was done to determine geological setting, economic minerals present, and the type and extent of this mineralization (Fig. 15).

The Slocan sedimentary rocks are of Late Triassic to Early Jurassic age (Hedley, 1945), consisting primarily of black fissile phyllites, with interbedded limestone, calcareous phyllites, and brown gritty quartzites. The rocks trend 310 degrees, and generally dip southwesterly. However, dip angles vary due to folding. Cairnes (1934) has estimated the total thickness of the sequence to be about 2 075 metres. Greenstones and ultramafic rocks of the Kaslo Group unconformably underlie the sedimentary rocks to the east. Intruding all rocks are Nelson granites, granite dykes, and late-stage lamprophyre dykes.

STRUCTURE: The dominant structures on the Kaslo claim are synclinal-anticlinal folds with fold axes trending easterly to northeasterly, and plunging 15 degrees to 20 degrees easterly. Unravelling these structures was possible due to marker horizons consisting of *quartzite and limestone within the phyllites. Whereas the phyllites exhibited intense* folding that destroyed primary textures, the limestones and quartzites were more competent and bedding attitudes could be recorded. Boundinage structures developed within the limestone suggest limestones behaved in a plastic manner under stress. Four faults are interpreted in the vicinity of the Kaslo Claim. Two nearly parallel faults striking northwesterly and dipping southerly are believed to be associated with mineralization observed on the property (Figs. 16 and 17). Two barren faults cut the stratigraphy and offset preexisting faults.

MINERALIZATION: *Mineralized faults were encountered within the Hazel adit (Fig. 16),* which lies 120 metres west of the northwest corner of the Kaslo Claim. A fault within phyllites, 30.5 metres from the portal was noted to be on strike with mineralized showing on surface. The showing on surface consisted of vuggy, galena-rich fragments in the overburden. Outcrops nearby were sheared and rusty, with disseminated galena.

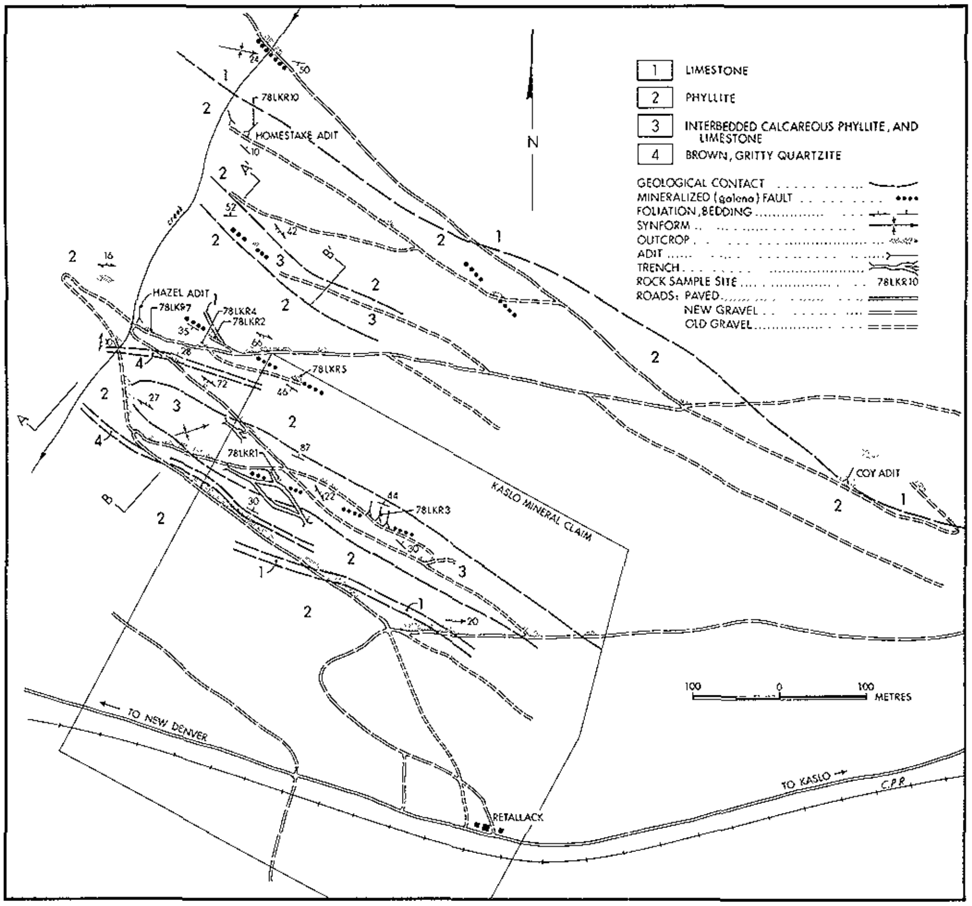


Figure 15. Geology map of the Kaslo claim

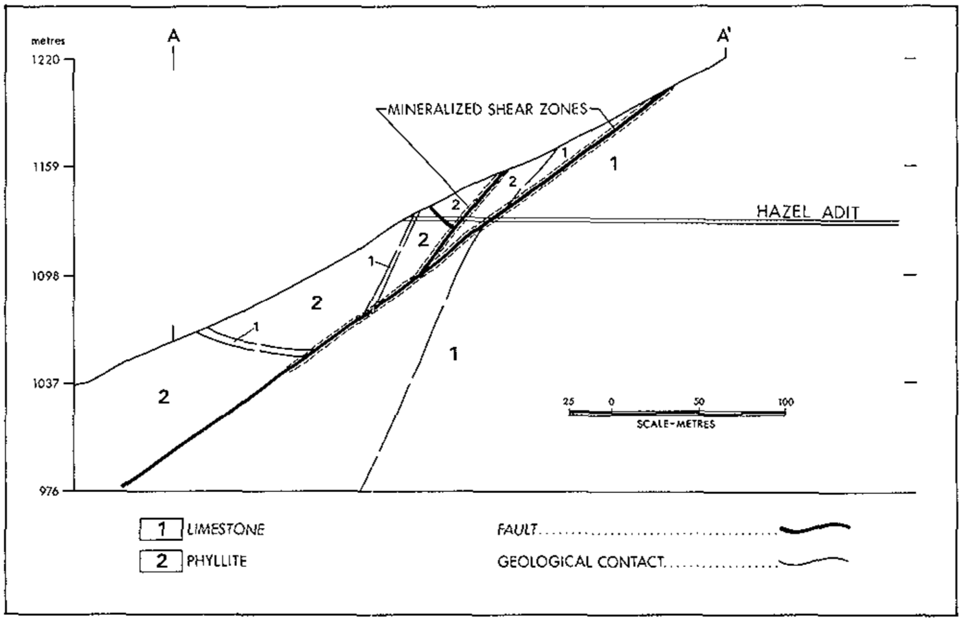


Figure 16. Geological section 'A-A' of the Kaslo claim

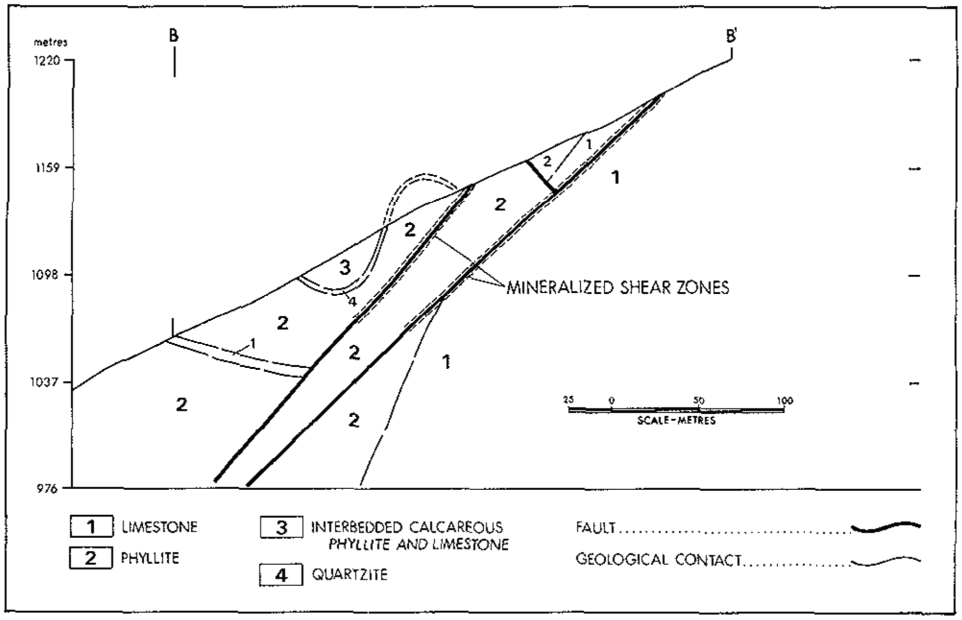


Figure 17. Geological section 'B-B' of the Kaslo claim

A second fault, 48.8 metres from the portal, forms a fault contact between phyllite and limestone. Disseminated galena and minor chalcopyrite were noted over 2.5 metres. Projected to the surface, the fault occurs within sheared limestone with associated galena-rich fragments within overburden.

EXPLORATION: Exploration on the Kaslo claim during 1978 comprises numerous roads and trenches along the south-facing slope. The purpose of these roads has been to allow access and expose outcrops and mineralization. To date, Peter Leontowicz, under the *Prospectors Assistance Act*, has exposed numerous showings of galena and possibly sphalerite. Mineralization appears to be associated with two faults. Further exploration is required to expose mineralization "in place".

SAMPLING: Samples were taken to determine economic minerals associated with the shear zones. Results from sampling for lead, zinc, gold, and silver follow:

	Au ppm	*Ag* ppm	*Cu* per cent	*Pb* per cent	*Zn* per cent
78 LK R1	<1	51	0.01	1.24	1.96
78 LK R2	<1	<10	0.009	0.99	0.92
78 LK R3	<1	<10	0.006	0.32	3.66
78 LK R4	<1	<10			
78 LK R5	<1	35	0.03	0.88	4.66
78 LK R6	<1	140			
78 LK R7	<1	<10			
78 LK R8	<1	160			
78 LK R10	<1	180	0.006	5.18	3.63
78 LK R11	<1	<10			

REFERENCES

Cairnes, C. E. (1934): Slocan Mining Camp, British Columbia, *Geol. Surv., Canada,* Mem. 173.

Hedley, M. S. (1945): Geology of the Whitewater and Lucky Jim Mines Areas, Slocan District, British Columbia, *B.C. Ministry of Energy, Mines & Pet. Res.*, Bulletin No. 22.

1977—REXSPAR
(82M/12W)

By V. A. Preto

LOCATION: Lat. 51° 34′ Long. 119° 55′ (82M/12W)
KAMLOOPS M.D. Claims comprise approximately 2 830 hectares centred on Red Ridge, approximately 5 kilometres south of Birch Island on the south slope of the North Thompson Valley, between Lute and Foghorn Creeks.

CLAIMS: ACTIVE, RADIO, ELLA, PA, JAM, etc., totalling approximately 150 plus 40 surveyed mineral claims including BLACK DIAMOND, SMUGGLER, SPAR, REX, etc. (Lots 5387 to 5405, 5408 to 5411, 5477 to 5482, 5484 to 5494).

FIGURE 18

GEOLOGY OF THE REXSPAR AREA

GEOLOGY BY J.H.L.MILLER AND A.J.SINCLAIR, JANUARY, 1979

LEGEND

CRETACEOUS OR LATER

11	FELSITE DYKES

CRETACEOUS

10	BALDY BATHOLITH: BIOTITE QUARTZ MONZONITE AND GRANODIORITE

PRE-UPPER TRIASSIC

EAGLE BAY FORMATION (2 TO 9)

9	FOLIATED GRANITIC SILLS
8	FINELY CRYSTALLINE LIMESTONE
7	GARNET – ACTINOLITE – BIOTITE – QUARTZ SCHIST AND MICACEOUS QUARTZITE
6	TRACHYTE UNIT: PYRITE SCHIST, FELDSPAR PORPHYRY, TUFF BRECCIA
5	RIBBON CHERT
4	QUARTZITE, SERICITE QUARTZITE, CALCAREOUS QUARTZITE
3	GREY PHYLLITE
2	CHLORITE – SERICITE SCHIST, CHLORITE SCHIST, VOLCANIC BRECCIA, SERICITE – QUARTZ SCHIST, MINOR BIOTITE DEVELOPED NEAR FOGHORN MOUNTAIN AND MOUNT McCLENNAN

MISSISSIPPIAN AND/OR LATER

SLIDE MOUNTAIN GROUP

FENNELL FORMATION

1	WEAKLY FOLIATED TO MASSIVE BASE AND PILLOW BASALT

SYMBOLS

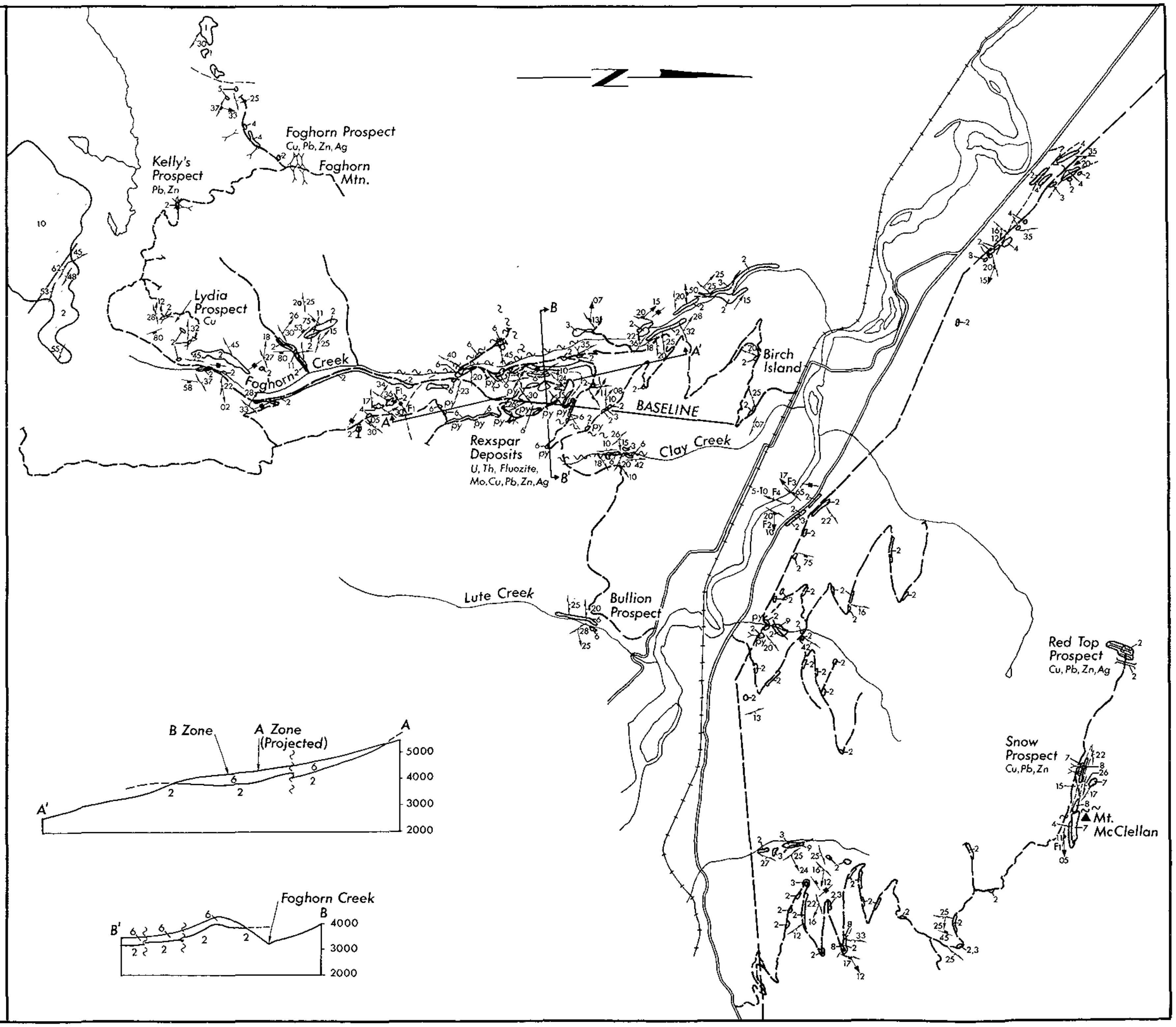
ATTITUDE OF SCHISTOSITY AND PLUNGE OF MINERAL LINEATION 16 25

ATTITUDE OF AXIAL PLANES OF FOLDS AND PLUNGE OF FOLD AXES (F1, F2, ETC.) DENOTE PHASE OF OLEFORMATION 17 65 F3

ATTITUDE OF PROMINENT JOINTS 80

SCALE-MILES 0 0.5 1

SCALE-KILOMETRES 0 1 2



OWNER: CONSOLIDATED REXSPAR MINERALS & CHEMICALS LIMITED, 4 King Street West, Toronto, Ontario M5H 1C2.

COMMODITIES: Uranium, thorium, fluorite, rare earths.

DESCRIPTION:

HISTORY: The showings on and near Red Ridge have received intermittent attention since 1918. Initially interest was for silver-lead and fluorite and, in the late 1920's, for manganese. Further work on the fluorite occurrences was done in the 1940's, and the presence of uranium mineralization was discovered in 1949. Extensive surface and underground work in the early and mid 1950's, mostly under the direction of F. R. Joubin, outlined three zones of commercial-grade uranium mineralization and one contiguous zone of fluorite mineralization. Geological studies and diamond drilling were resumed in 1969 and continued until 1976. This work has defined three zones of uranium mineralization, known as the A, B, and BD, with combined reserves of 1 114 158 tonnes of ore grading 0.773 kilogram of U_3O_8 per tonne. Engineering studies done on behalf of Consolidated Rexspar by Kilborn Engineering Ltd. indicate that these reserves are sufficient to support for a period of four and one half years a 1 270-tonne-per-day, five-day-per-week mining operation and a 910-tonne-per-day beneficiation plant that is to operate continuously. Fluorite mineralization, located adjacent to the uranium orebodies, if proven to be economic, could extend the life of the operation by an additional four years.

Consolidated Rexspar Minerals & Chemicals Ltd. and Denison Mines Limited, a major shareholder holding about 47 per cent of the issued shares, are at present finalizing plans for production.

GEOLOGY: All foliated rocks within the area mapped (Fig. 18) are part of the Eagle Bay Formation of pre-Late Triassic and probable Mississippian age (Campbell and Okulitch, 1976). In the extreme southwest corner of the map-area these are in probable fault contact with massive to weakly foliated basalt and pillow basalt of the Fennell Formation. To the south, on Granite Mountain, schists of the Eagle Bay Formation are intruded by massive quartz monzonite and granodiorite of the Cretaceous Baldy batholith.

South of the Thompson River, and especially in the vicinity of the Rexspar deposits, the foliated rocks are mostly of volcanic origin. Green chlorite and chlorite-sericite schist and silver grey sercite-quartz schist of map unit 2 are the most common rock type and contain several exposures of clearly recognizable dacitic and andesitic volcanic breccia which attest to the volcanic origin of a good part of these rocks (Plate X). Interlayered metasedimentary members of grey phyllite and slate (unit 3), quartzite (unit 4), and ribbon chert (unit 5) are distinctly less abundant than schists of metavolcanic origin. Uranium mineralization is found exclusively in map unit 6, locally known as the trachyte unit. On Red Ridge, and particularly in the vicinity of the orebodies, this rock consists of a rusty weathering, light grey, pyritic alkali feldspar porphyry which may be massive, brecciated (Plate XI A), or strongly schistose (Plate XI B) and lineated. In thin section this rock is seen to consist of megacrysts of alkali feldspar and of well-twinned albitic plagioclase set in a fine-grained, sugary groundmass of feldspar and sericite. The megacrysts range from nearly euhedral and undeformed to highly fractured and sheared. The groundmass varies from weakly fractured and massive to very strongly foliated, sheared, and flattened. Another common variety of unit 6, and particualrly near the A-zone and south of the BD zone, is a polymictic breccia which contains a predominance of feldspar porphyry fragments as well as fragments of other fine-grained, darker coloured rocks. Clast size in these breccias ranges from less than 1 centimetre to rarely more than 20 centimetres. The monomictic feldspar porphyry breccias, because of their setting, distribution, and appearance, can best be interpreted as intrusion or explosion breccias, whereas the polymictic varieties are considered to be lithic-crystal tuffs and tuff breccias. To the south and northeast of the mineral deposits, map unit 6 consists mostly of a well-foliated, yellowish

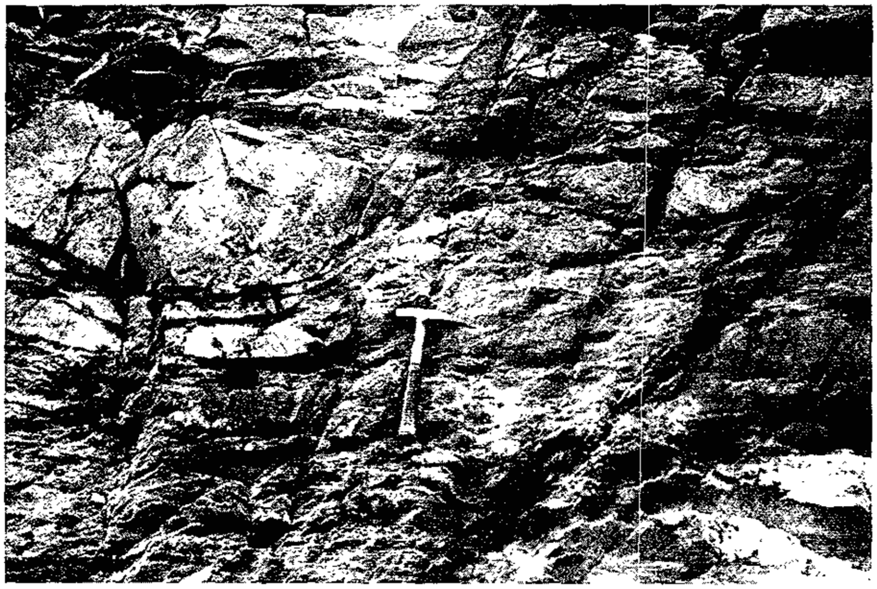


Plate XA. Metavolcanic breccia, map-unit 2, Red Ridge

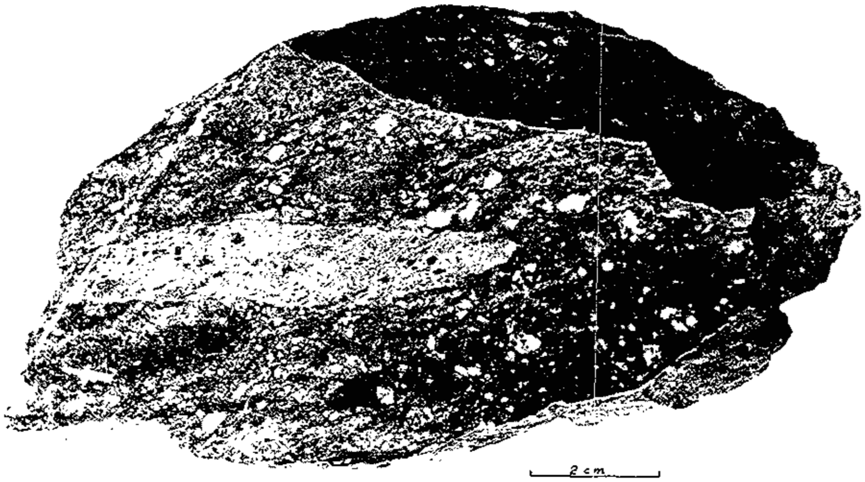


Plate XB. Polished hand specimen from exposure in plate

Plate XIA. Massive trachtye porphyry breccia, Rexspar A zone

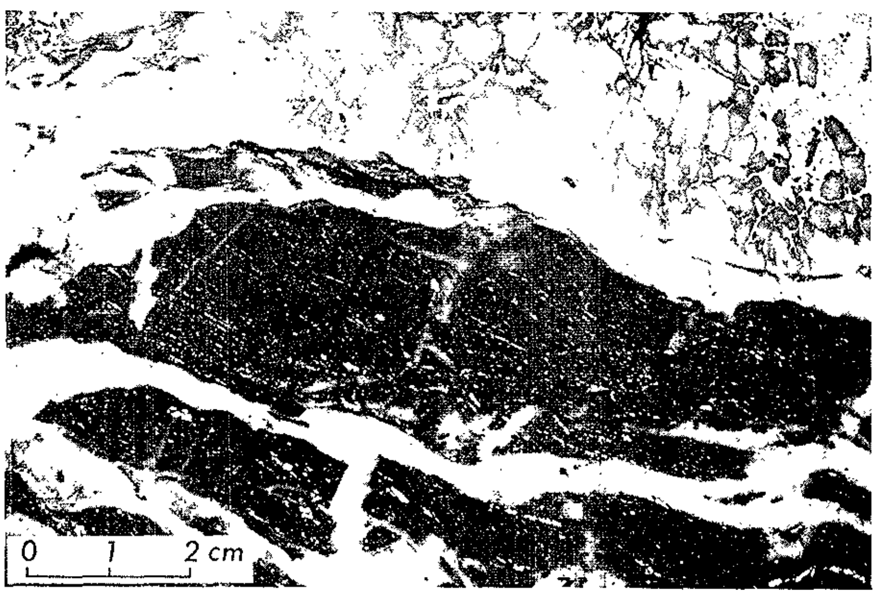


Plate XIB. Strongly foliated trachyte porphyry breccia, Rexspar A zone grey to rusty weathering, pyritic, light-coloured, fine-grained schist which generally is composed of sericite and feldspar, but which occasionally includes some very siliceous members. Small lithic clasts, generally 1 centimetre or less in size, are widespread and common throughout this schist. In summary, therefore, map unit 6 consists of a deformed and metamorphosed pile of lithic tuff and breccia mostly of trachytic composition, but with some rhyolite members, which in the vicinity of the Rexspar deposits includes coarser fragmental and probably intrusive phases. It follows therefore that the area of the mineral deposits, and particularly that between the B and BD zones, probably is a volcanic centre or vent from which part or all of map unit 6 was derived.

North of the Thompson River the predominant rock type is still green schist of unit 2, but there is a greater abundance of quartzite (unit 4), siliceous metasedimentary schist (unit 7), and carbonate (unit 8). The schistosity on the lower slopes dips moderately to the east and northeast, and on Mount McClennan dips are gentle to the north.

STRUCTURE: Mesoscopic structures, that are well displayed at a few key exposures along Highway 5 and on Mount McClennan, indicate that the prominent schistosity is parallel to the compositional layering and to the axial planes of small, rootless folds (Plate XII) that were probably formed during a first phase of deformation. The schistosity is in turn deformed by tight, recumbent east-trending second phase folds. These structures are refolded by upright third phase structures which trend northerly to northeasterly. Late kinks and prominent tension fractures represent a fourth and last set of structures which trend northerly and are commonly followed by post-tectonic felsic and mafic dykes of Cretaceous or later age. High-angle, northerly trending faults, possibly related to this period of deformation, occur along Foghorn, Clay, and probably Lute Creeks, and sharply control the distribution of rock units and of unit 6 in particular.

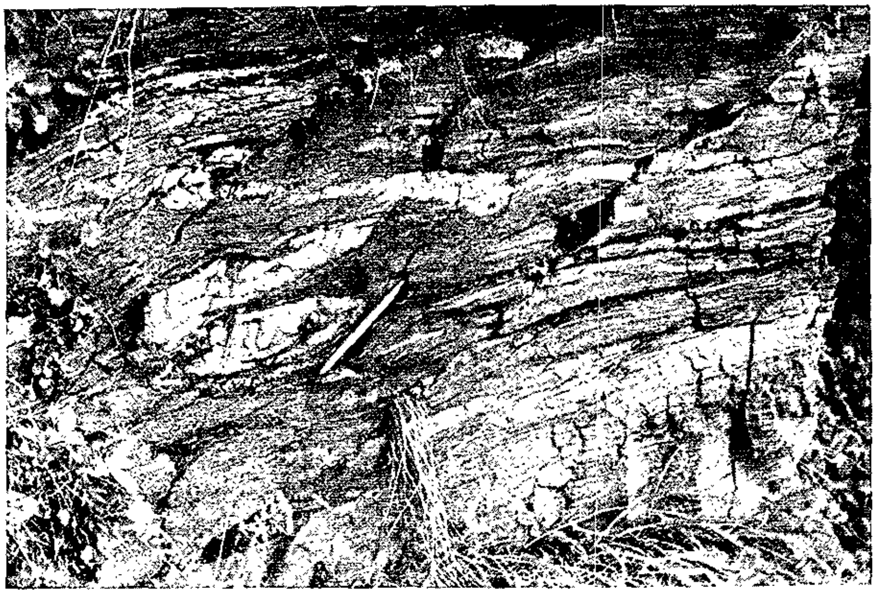


Plate XII. Rootless phase 1 folds outlined by quartzite layers in quartz mica schist, north face of Mount McClennan, looking east

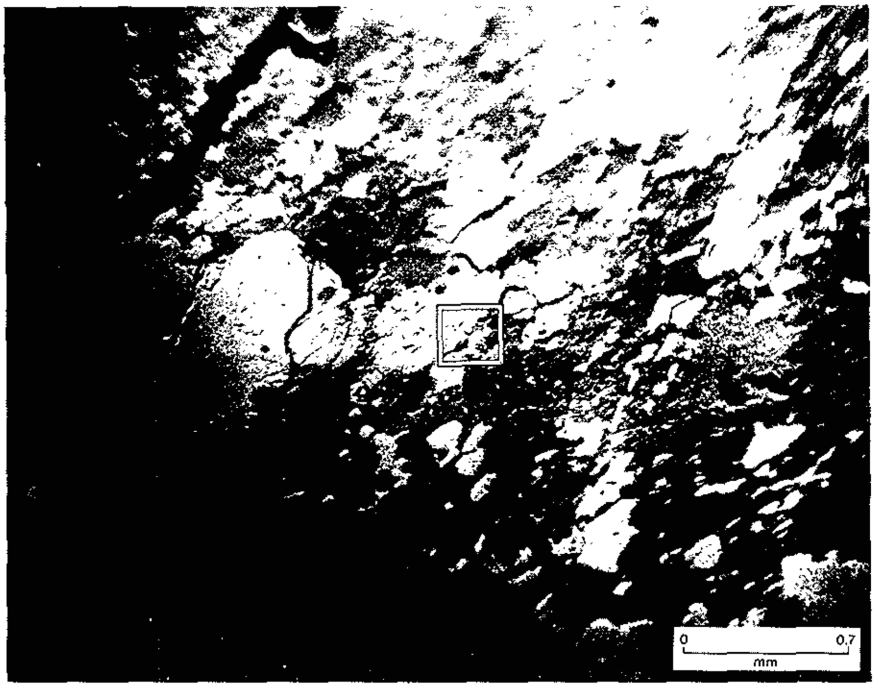


Plate XIIIA. Backscattered electron photograph of Rexspar ore from A zone

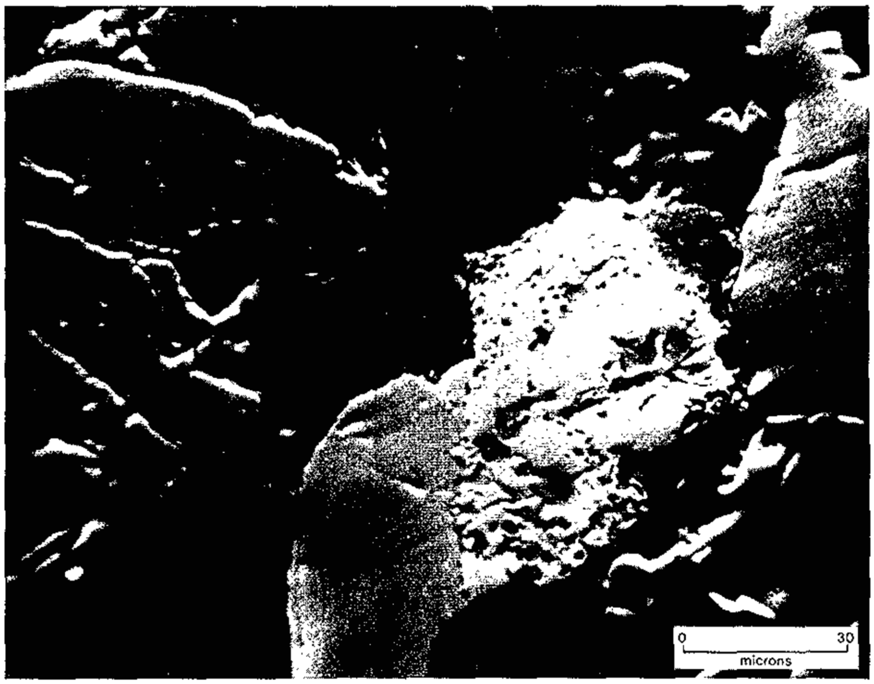


Plate XIIIB. Thorian uraninite grain (light grey) and monzonite (medium grey) in pyrite

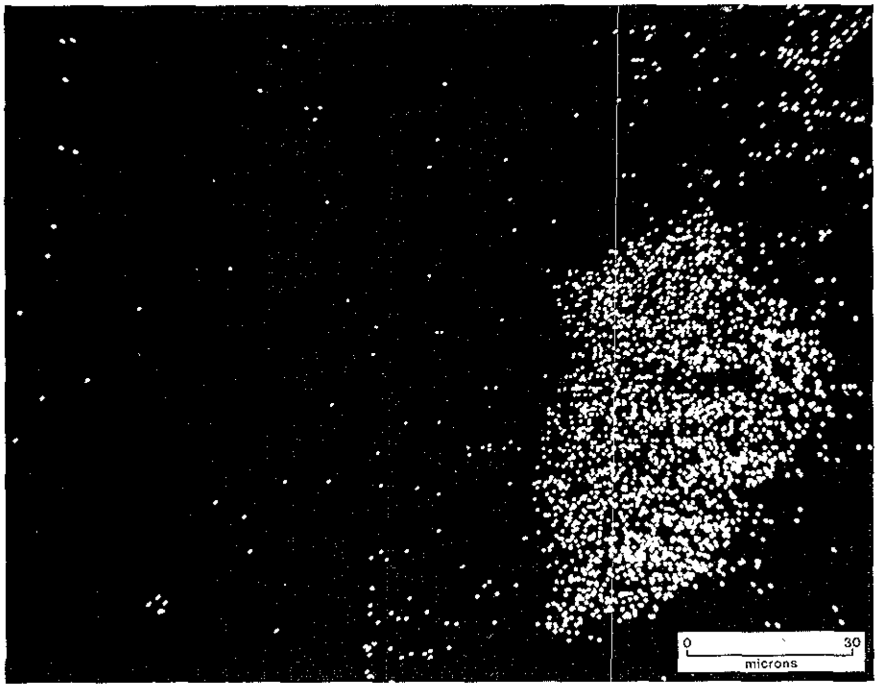


Plate XIIIC. Uranium thorium electron scan area in Plate XIIIB

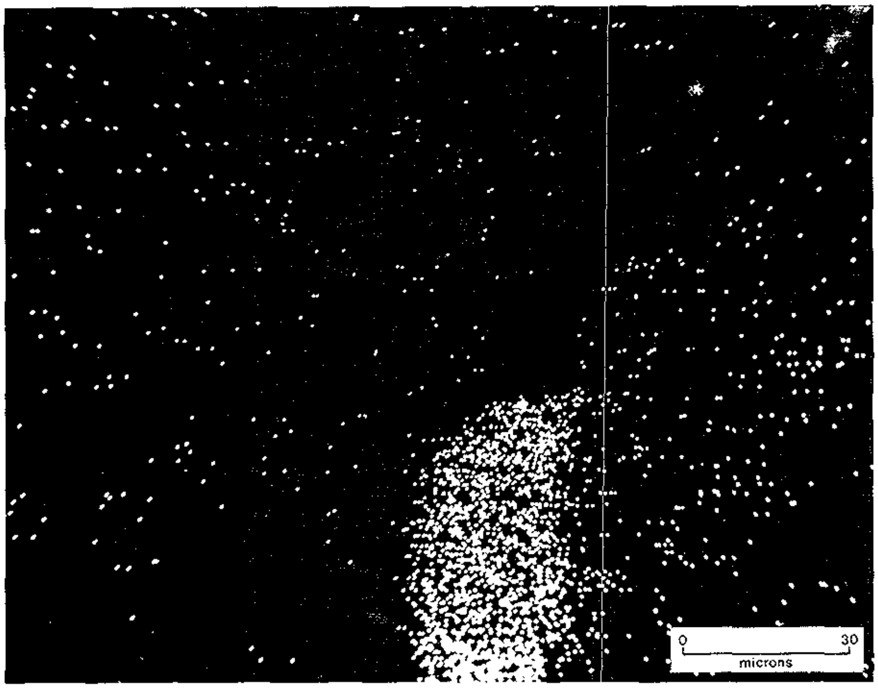


Plate XIIID. Cerium-lanthanum scan of area in Plate XIIIB

MINERALIZATION: Though the main economic interest in the area is centred around the uranium and fluorite deposits of Rexspar, several other prospects are known on Foghorn Mountain and on Mount McClennan.

Uranium-thorium mineralization is found exclusively in map unit 6 and, as far as can be determined by surface mapping and from old drill records, occurs mainly in the upper part of the unit. Dark-coloured zones of the "trachyte unit" which are extensively replaced by silver-grey fluorphlogopite and pyrite are by far the best host to mineralization. Drilling indicates that ore-grade material occurs in a series of dicontinuous lenses generally less than 20 metres thick and conformable with the schistosity in the trachyte. Fluorphlogopite-pyrite replacements, commonly with lesser amounts of fluorite and minor calcite, range from a few centimetres to several metres in size and generally occur as coarse-grained segregations which show both conformable and crosscutting relationships.

Previous work by officers of the Geological Survey of Canada (Lang, *et al.,* 1962) and British Columbia Ministry of Mines and Petroleum Resources (McCammon, 1954), as well as further optical, chemical, X-ray, and electron microprobe work during the present investigation has yielded the following results:

(1) The principal uranium-thorium minerals at Rexspar are uraninite, thorian uraninite, torbernite, metatorbernite, thorianite, and thorite. In addition some uranium and thorium occur in niobian ilmenorutile and monazite (Plate XIII).

(2) Rare earths are found in bastnaesite and monazite.

(3) Other minerals include pyrite, fluorphlogopite, apatite, fluorite, celestite, galena, sphalerite, chalcopyrite, molybdenite, scheelite, siderite, dolomite, calcite, barite, quartz, albitic plagioclase, and alkali feldspar.

(4) Uranium-thorium minerals occur as tiny, discrete grains inside fluorphlogopite flakes and surrounded by single or double pleochroic haloes (Plate XIV A) or as discrete grains scattered in the pyrite-fluorphlogopite matrix (Plate XIII).

(5) Radiation damage has caused pleochroic haloes in fluorphlogopite and the purple colouration in fluorite.

(6) Analyses indicate that thorium-uranium ratios range from nearly 1:1 to much greater than 1:1 (Table 1). Rare earths, and particularly cerium and lanthanum are present in very substantial amounts (Table 2).

(7) Oxidation of the ore has been negligible, probably because of the abundance of pyrite.

(8) Fluorite is commonly found in the zones of uranium-thorium mineralization, but the fluorite zone which could be of commercial grade is separate from ore-grade uranium-thorium mineralization.

(9) All phases of the "trachyte unit", including zones of fluorphlogopite-pyrite replacement and uranium-fluorite mineralization, display evidence of deformation and range from brecciated to markedly schistose and lineated. They appear to have been subjected to most or all of the deformation that affected the rest of the foliated rocks in the area, though their response was not uniform (Plate XV).

It appears therefore that the mineralized zones at Rexspar not only are located close to a part of the "trachyte unit" which might represent a vent area, but also that, assuming the strata are upright, they are concentrated in the upper part of the unit. The close association with pyrite-mica replacement and the occurrence of radioactive minerals within mica grains suggest that all these minerals formed at about the same time. The occurrence of fluorite in tension gashes produced by strain slip cleavage in fluorphlogopite (Plate XIV B) probably means that some of the fluorite was remobilized during deformation, since most fluorite seems to have been deformed together with the rest of the rock constituents

(Plates XVA and XVB). The setting and aspect of the pyrite-mica zones suggest that these were formed by deuteric, volatile-rich fluids during a late stage in the formation of the "trachyte unit". It follows, therefore, that the zones of uranium-thorium mineralization, and probably also of fluorite, could be syngenetic with the formation of the "trachyte unit" and thus be volcanogenic in origin.

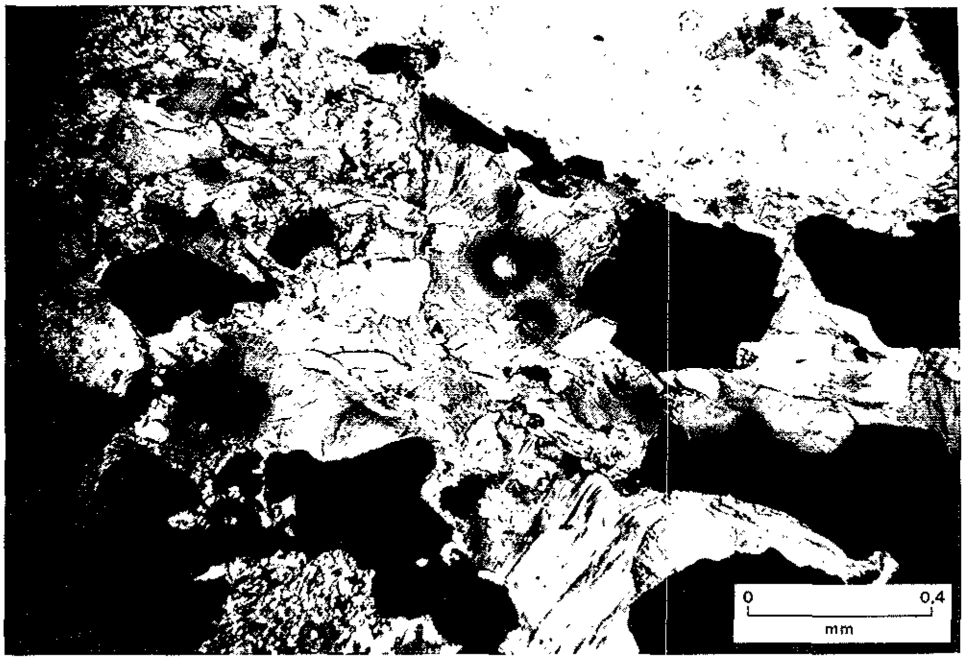


Plate XIVA. Pleochronic rings in fluorphlogopite, Rexspar A zone

Plate XIVB. Strain slip cleavage in fluorphlogopite with fluorite-filled tension gashes, Rexspar A zone

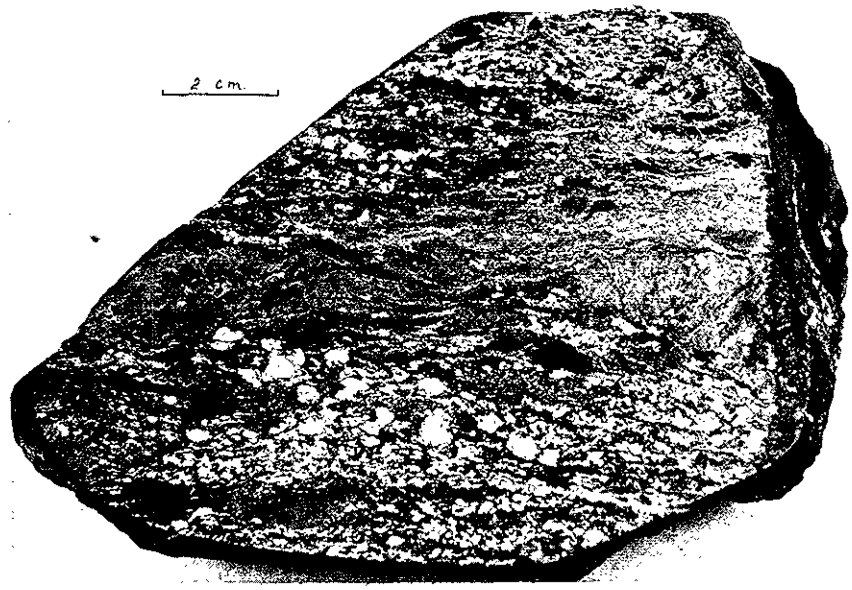


Plate XVA. Sheared pyrite and fluorite (dark grey) in ore from Rexspar A zone

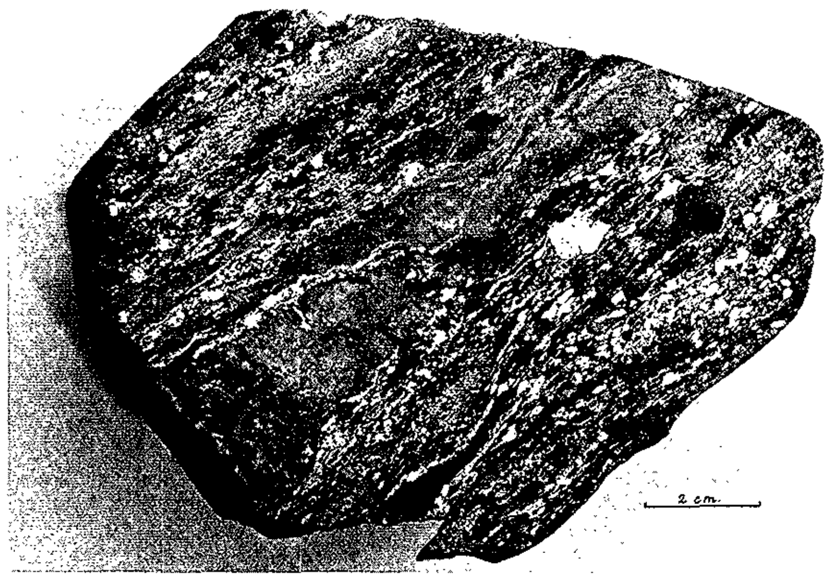


Plate XVB. Sheared pyrite and fluorite (dark grey) in ore from Rexspar A zone

TABLE 1—U and Th Content of Selected Hand Specimens from Rexspar (all values in ppm)

Sample		Total		Sinks +3.29 S.G. +40 mesh		Sinks +3.29 S.G. −40+60 mesh		Floats −3.29 S.G. +40 mesh	
No.	Zone	U	Th	U	Th	U	Th	U	Th
1	BD zone	687	3270	1017	2401	825	1949	963	2230
2	A zone	412	504	374	493	230	264	496	416
3	A zone	265	204	331	197	312	114	230	172
4	A zone	1468	2418	2646	4093	1472	2452	1165	1343
7	A zone	231	411	377	696	277	312	251	386
8	BD zone	53	47	21	65	27	10	41	47

Analyses done by gamma-ray spectrometric determination at the Analytical Laboratory of the Ministry.

TABLE 2—Semi-quantitative Emission Spectrographic Analyses of Selected Hand Specimens from Rexspar (*values are in weight per cent*)

Element	Sample No. and Zone					
	1-BD zone	2-A zone	3-A zone	4-A zone	7-A zone	8-BD zone
Si	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0
Al	8.5	7.5	>10.0	>10.0	9.0	>10.0
Mg	2.0	2.0	0.7	2.0	1.0	2.0
Ca	3.5	2.5	1.35	2.5	>20.0	1.5
Fe	16.0	>20.0	12.5	17.5	11.5	9.0
Pb	0.015	trace	0.015	0.03	trace	0.015
Cu	0.07	0.05	0.03	0.05	0.01	0.02
Zn	0.01	0.01	trace	trace	N/A	trace
Mn	0.12	0.15	0.13	0.1	0.1	0.14
Ag	trace	trace	trace	trace	trace	trace
V	0.05	0.05	0.05	0.05	0.05	0.03
Ti	0.3	0.35	0.3	0.35	0.35	0.15
Ni	trace	trace	trace	trace	trace	trace
Co	trace	trace	trace	trace	trace	trace
Na	0.15	0.08	> 2.0	0.15	0.15	2.0
K	> 2.0	> 2.0	> 3.0	> 3.0	> 2.0	> 5.0
Mo	0.01	trace	0.01	trace	0.015	trace
Zr	0.05	0.02	0.03	0.05	0.025	0.025
Sr	> 2.0	0.1	0.04	0.15	0.1	> 1.0
Ba	0.13	0.06	0.2	0.13	0.07	0.18
U	0.1	N.R.	N.R.	0.15	N.R.	N.R.
Th	0.23	0.04	0.02	0.23	0.04	N.R.
Li	0.015	0.03	0.01	0.04	trace	0.02
Nb	0.025	0.025	0.015	0.03	trace	trace
Y	0.01	0.015	0.01	0.02	0.05	trace
La	0.07	0.09	0.25	0.1	0.25	0.02
Ce	0.08	0.1	0.2	0.16	0.15	0.04
Nd	0.12	0.14	0.12	0.14	0.12	0.025
P	1.2	1.2	1.0	1.2	0.5	N/A
Sn	N.R.	trace	trace	trace	trace	trace
Ge	trace	trace	trace	trace	trace	trace
Cr	trace	trace	0.01	trace	trace	0.01
Be	trace	trace	trace	trace	trace	N/A
Yb	trace	trace	trace	trace	trace	trace

Analyses done at the Analytical Laboratory of the Ministry.

Another alternative to this interpretation is that the pyrite-mica rock with the associated uranium-thorium mineralization and the zones of fluorite mineralization were formed during one or more hydrothermal events some time after the formation of the "trachyte unit" but before deformation. Their spatial association with a probable vent area within the trachyte could be attributed to the pre-existence of suitable channelways. If such were the case, one would expect evidence of renewed fracturing and possibly veining of the trachyte by hydrothermal minerals associated with this event. One would also expect that evidence of this hydrothermal replacement and mineralization also be found in the schists below the trachyte. This does not appear to be the case at Rexspar. Uranium mineralization is found only in the trachyte and is always associated with the pyrite-mica rock. The schists below the trachyte, though somewhat pyritic, are barren of uranium and do not have any of the distinctive pyrite-mica rock. Also the mode of occurrence of the pyrite-mica rock as ill-defined masses, very variable in size and commonly chocked with trachyte fragments, can best be explained by assuming that it was formed by late magmatic solutions which permeated the trachyte during or shortly after its formation and not at some later time.

AGE: A K/Ar age of 236 ∓ 8 Ma has been obtained by S. S. Gandhi of the Geological Survey of Canada (personal communication, March 9, 1978) for fluorphlogopite from one of the mineralized zones. This must be considered a minimum age and used cautiously because of some analytical problems.

This Permo-Triassic age for the fluorphlogopite, and, by inference, for the mineralization, though somewhat young for the presumed Mississippian age of the Eagle Bay rocks, tends to confirm the interpretation that the mineralization at Rexspar is old, probably syngenetic with the host rocks, and not related to the Cretaceous Baldy batholith.

OTHER PROSPECTS: South of Rexspar, in the vicinity of Foghorn Mountain, the Lydia, Kelly's, and Foghorn prospects are base metal occurrences of limited extent associated with fracturing in greenschists of map unit 2. The Foghorn prospect is the larger of the three and the one that has been most extensively explored. Argentiferous galena, sphalerite, chalcopyrite, and pyrite occur in narrow, northeasterly trending quartz veins which in the early part of this century were developed with a 200-foot adit and a 40-foot shaft with a 40-foot drift at the bottom. These workings are now inaccessible and the adit portal sealed. During 1916-17, 81 tons of ore was shipped from the Foghorn property, from which 57,277 pounds of lead and 2,841 ounces of silver were recovered.

North of the Thompson River the Snow and Red Top prospects are base metal occurrences in siliceous schists of unit 7 and greenschists of unit 2. The Snow prospect, recently restaked as the Nimsic claims by Kerr, Dawson and Associates, is in garnet-actinolite-biotite-quartz schist of unit 7, immediately below a prominent 15 to 20-metre layer of crystalline limestone. The showings are exposed in old cuts and hand trenches, as well as in more recent bulldozer trenches, on the north slope of Mount McClennan, directly above the access road. They consist of nearly massive, heavily oxidized pyrite mineralization with galena, sphalerite, and chalcopyrite in layers as much as 50 centimetres thick, and parallel to the schistosity and compositional layering of the schists.

The Red Top prospect is at the end of the access road, approximately 1 kilometre west of the Snow workings. Pyrite, pyrrhotite, galena, sphalerite, and chalcopyrite occur as disseminations and minor replacements in rusty quartz-mica schist, calcareous schist, and greenschist. Mineralization is exposed in several enormous bulldozer cuts excavated across the schistosity and covering the entire top of a small wooded hill immediately west of Mount McClennan.

REFERENCES

Campbell, R. B. and Okulitch, A. V. (1976): Valemount to Kamloops, The Omineca Crystalline Belts and the Eastern Edge of the Intermontane Zone, *in* Guidebook for Field Trip C-11, *Geol. Assoc. Canada.*

Joubin, F. R. and James, D. G. (1957): Rexspar Uranium Deposits, *in* Structural Geology of Canadian Ore Deposits, *C.I.M.*, Congress Vol., pp. 85–88.

Lang, A. H., Griffith, J. W., and Steacy, H. R. (1962): Rexspar Property *in* Canadian Deposits of Uranium and Thorium, *Geol. Surv., Canada,* Econ. Geol. Series No. 16, pp. 205–207.

McCammon, J. W. (1954): Rexspar Uranium and Metals Mining Co. Limited, *Minister of Mines, B.C.,* Ann. Rept., 1954, pp. 108–111.

SOUTHWEST BRITISH COLUMBIA
(NTS Division 92)

1977—UPPER RENFREW CREEK AREA
(92C/9W)

By G. E. P. Eastwood

INTRODUCTION: Upper Renfrew Creek area lies toward the southwest side of Vancouver Island, northeast of the inlet of Port San Juan, as indicated on Figure 19. The community of Port Renfrew is strung out along the southeast and northeast sides of Port San Juan and a British Columbia Forest Products camp is located near the mouth of the Gordon River. Access may be made from Victoria through Jordan River and Port Renfrew or through Shawnigan Lake, and from Lake Cowichan through Honeymoon Bay and down Harris Creek. A main road follows the north side of the San Juan Valley, and a branch known as Granite Main Line more or less follows the east side of Renfrew (Granite) Creek. Subsidiary branches run along the crest and both slopes of the ridge to the east.

The upper valley of Renfrew Creek is broad and flat floored, flanked by moderately steep slopes to the east and west. From below a bridge at 370 metres elevation almost to the valley of the San Juan River, Renfrew Creek flows in a deep canyon. Five main tributaries and many smaller ones enter Renfrew Creek from the west; the main ones are numbered from south to north on Figures 19 and 20. A spur of the east ridge descends steeply to a saddle near the upper bend of Renfrew Creek and another ridge rises steeply to the west and southwest to a fairly uniform elevation of 830 metres. The back or Hemmingsen slope of this ridge is particularly steep. A pit for road ballast has been excavated in the saddle, partly in gravel and partly in rubbly bedrock.

The area shares the generally wet climate of the West Coast of the Island, but is sufficiently far inland to escape the fog and low cloud that cover the actual coastline during periods of generally fair weather. It was covered by a dense stand of tall conifers, but by 1977 most of the upper valley and the east ridge had been logged by British Columbia Forest Products. Underbrush was fairly light under the remaining timber, but had grown up thickly in parts of the logged-off areas.

In 1970 a British Columbia Forest Products road crew exposed magnetite and sulphides along Granite Main Line in the present zones 7 and 8. M. H. Levasseur located covering Reko claims in 1970–73 and transferred them to Reako Explorations Ltd. R. L. Roscoe was retained as consulting geologist, and an extensive magnetometer survey in 1972 was followed by diamond drilling in 1972–74. M. Dickens found three significant new showings on his Kestrel claims on the ridge west of the saddle early in 1975 and sold the claims to Reako. No further exploration was done in the area, but the claims remained in good standing in 1981.

The writer spent parts of the seasons of 1974–77 examining the mineral showings, logging selected diamond-drill core, and mapping or re-mapping the geology. For part of the area a map produced for the company at 1:2 400 was used as a base. This base area was infilled and extended by Brunton and polychain and planetabling, to produce the detailed map of Figure 21 covering 4.5 square kilometres. Reconnaissance mapping was done to the northwest on the NTS half-mile manuscript base to include the Kestrel showings. Figure 20 was produced by a reduction and enlargement of the respective mapping. The area of mineral zones 7 and 8 was planetabled at 1:1 200. Copies of drill-core assays were obtained from the company in order to calculate ore reserves.

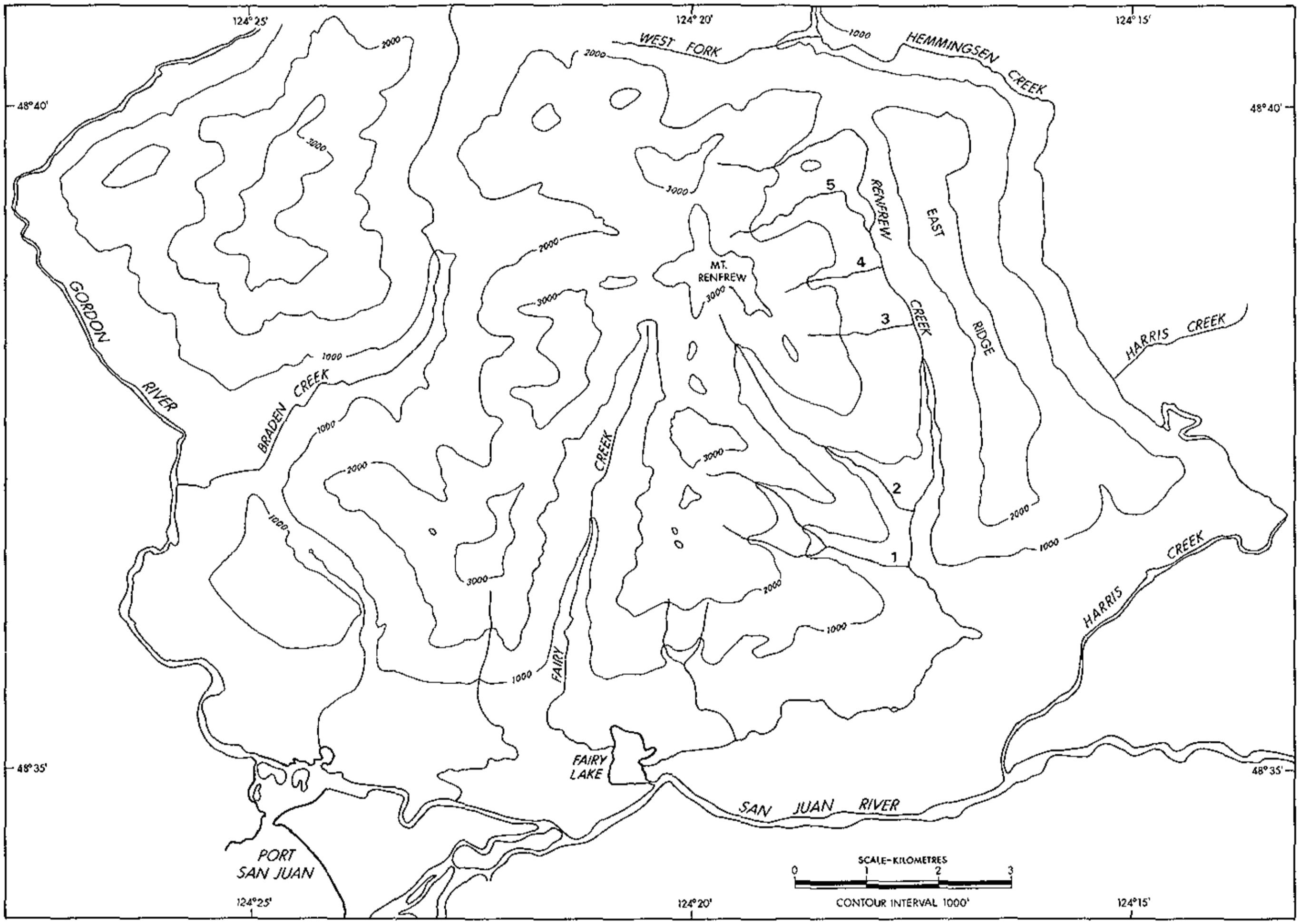


Figure 19. Index map, Upper Renfrew Creek area

TABLE OF FORMATIONS

AGE	UNIT	MAP UNIT No.	LITHOLOGY
Quaternary	Surficial deposits	—	Till; alluvial gravel
		Nonconformity	
?	Renfrew Dykes	9	Mafic quartz diorite
?	Younger Basalt Dykes	8	Basalt and gabbro
?	North Ridge Stock	7	Soda-potash granite
?	Felsite Porphyry	6	Rhyolite to rhyodacite porphyry; alaskite
?	Feldspar Porphyry	5	Feldspar porphyry
		Intrusive contact	
Middle Jurassic	Island Intrusions	4x	Intrusive breccia
		4b	Tonalite, trondhjemite
		4a	Meladiorite, hornblende tonalite, hornblende porphyry
		Intrusive contact	
Late Triassic	Older Basalt Intrusions	3	Basalt or andesite
		Intrusive contact	
Late Triassic	Quatsino Formation	2	Marble, limestone
		Apparent conformity	
Late Triassic	Karmutsen Formation	1	Basalt or andesite

GENERAL GEOLOGY: The rocks of the Upper Renfrew Creek area constitute part of the roof zone of a batholith underlying the mountains north of the San Juan Valley and extending from west of the Gordon River to east of the Fleet River. They consist of metamorphosed remnants of basalt or andesite, larger amounts of recrystallized limestone, and a multiplicity of intrusive rocks. Considerable areas are underlain by intrusive breccia, consisting either of fragments of more or less recrystallized basalt in intrusive rock or of fragments of an earlier phase of intrusive rock in a later. The disruption by intrusion has been so extensive that stratigraphic contacts between basalt and limestone are preserved only locally.

KARMUTSEN FORMATION: The best exposures of the Karmutsen are: off the north end of Branch 3510, along Branch 8010, in Renfrew Creek at the westerly elbow and upstream at the limestone contact, and on the north slope of the ridge west of the saddle. It is a greenish grey basalt or basic andesite, mostly massive, locally containing amygdules and/or feldspar phenocrysts, and resembles Karmutsen in other areas. East of the saddle pit the upper 3 or 4 metres are banded tuff. West of the fault this tuff has been largely altered to tremolite, and beside the road to the northwest it has been replaced by white and light greenish grey wollastonite. Most of the Karmutsen has been broken up and more or less recrystallized and digested by the Island Intrusions. The less recrystallized fragments were, in places, preferentially altered to skarn and mineralized with magnetite and sulphides.

QUATSINO FORMATION: Large and small areas of massive light grey to white marble and minor bedded limestone are correlated lithologically with the Quatsino Formation of more northerly areas. On Branch 0300 thin layers of volcanic chips near the contact with basalt define bedding, as they do in the Kennedy Lake area. This bedding dips northeast

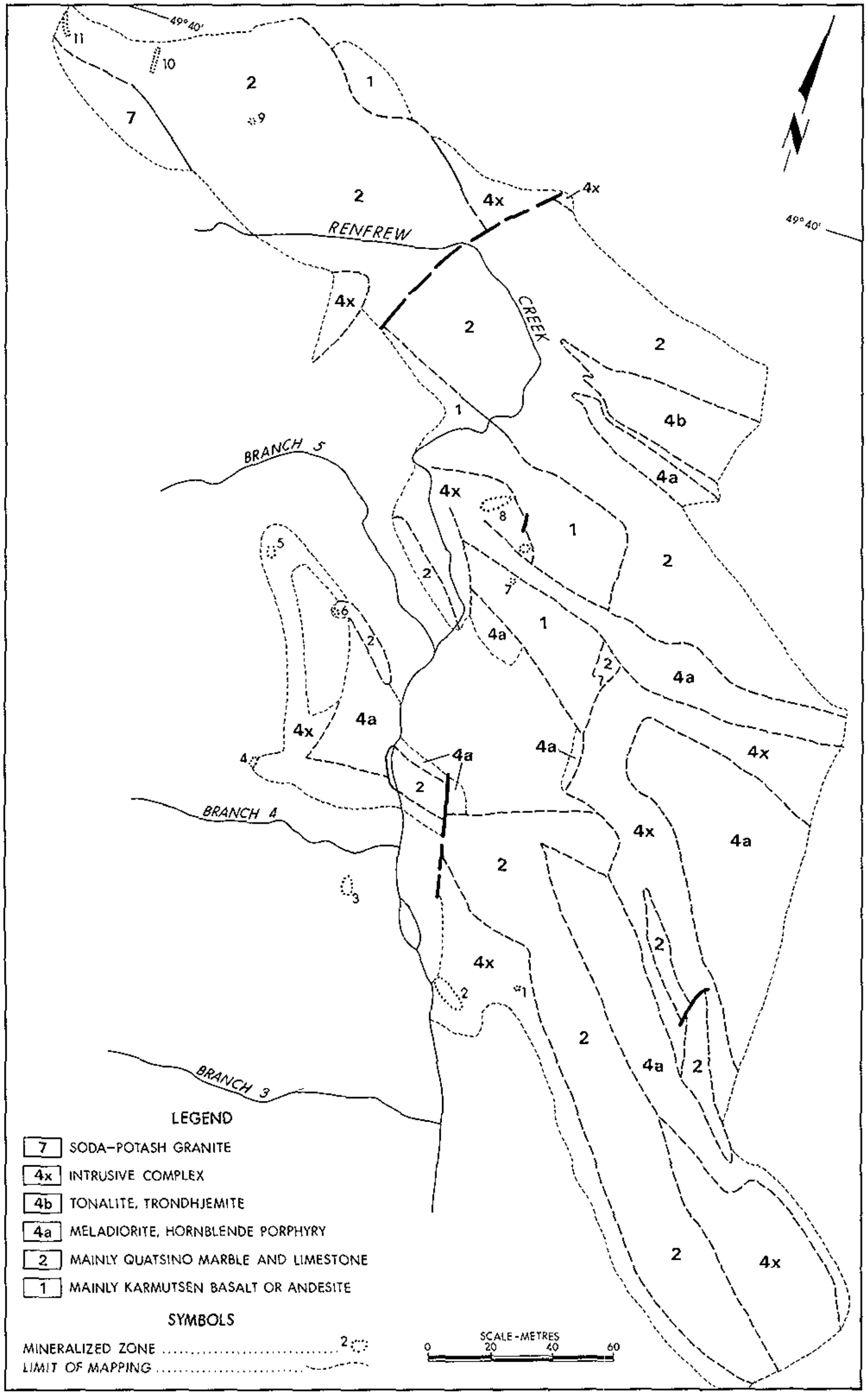


Figure 20. Generalized geology, Upper Renfrew Creek area

and indicates that the marble structurally overlies the basalt, both here and at the Granite Main Line. At the Main Line the basalt is broken up by tonalite, but the marble overlies both, separated by a 20-centimetre rind of garnetite.

Another stratigraphic contact is exposed off the north end of Branch 3510, where marble dips gently off basalt. A contact in Renfrew Creek above the main westerly bend dips 75 degrees south. However the tuff northeast of the saddle pit dips under the marble, and to the west, on the Hemmingsen slope, bedding in limestone above basalt dips gently to moderately southward. The limestone would appear to overlie the basalt stratigraphically. Widespread overturning is unknown on Vancouver Island, and this sequence accords with the normal sequence.

The upper contact of the formation has been eroded away. About 165 metres of the limestone has been preserved on the Hemmingsen slope of the north ridge. A thicker section may be present toward the north end of the east ridge, but the lack of internal markers or structures makes estimation impossible.

OLDER BASALT INTRUSIONS: The Quatsino marble is intruded by many dykes and small stocks of basalt or basic andesite, which have in turn afforded zones of weakness for intrusion of dykes of the Island Intrusions. The basalt intrusions are commonly more or less epidotized and locally are also altered to garnet and mineralized with a little magnetite and sulphides.

Basalt and andesite bodies are a common feature of the Quatsino Formation on Vancouver Island. Some authors have postulated that the dykes were feeders to flows of the overlying Bonanza Formation, but difficulties with this interpretation have accumulated. It is now known that the Bonanza is mainly acidic and fragmental and that eruption occurred at centres rather than from fissures. Generally the intrusions are most abundant in the lower part of the Quatsino and decrease markedly upward. The dykes do not resemble the Bonanza rocks, but so closely resemble massive Karmutsen flows that it is virtually impossible to assign a small isolated outcrop of basalt. Accumulated paleontological evidence indicates that Karmutsen volcanism was quickly, in geological terms, followed by Quatsino sedimentation, but it seems strange that the massive outpourings of lava should cease so abruptly. The writer would agree with Hoadley's (1953, p. 20) suggestion that the basalt intrusions represent the waning stages of Karmutsen volcanism, intruded into the calcareous ooze that became the Quatsino limestone.

ISLAND INTRUSIONS: These rocks occur in a wide range of sizes and compositions. A field distinction was based largely on colour index, and the lighter rocks were found to intrude the darker. At the junction of Branch 6000 with Granite Main Line there are good exposures of meladiorite fragments in leucocratic rock. Some fragments of mesocratic rock were found in the leucocratic farther up Branch 6000.

The rocks show a trondhjemitic differentiation trend, potash feldspars being entirely absent, and intermediate types such as granodiorite are therefore also absent. The meladiorite generally contains andesine and sparing quartz and can properly be termed quartz-bearing diorite or quartz diorite. However the mesocratic and some of the leucocratic rocks contain calcic oligoclase and relatively abundant quartz, and for them the alternate term tonalite is used to emphasize the distinction. For rocks containing sodic oligoclase and albite the name trondhjemite is used, to emphasize the complete lack of potash feldspar.

A hornblendite segregation in the meladiorite was analysed and the composition calculated as $(Ca,Na,K)_{1.98}(Fe^{11\ 1},Fe^{11},Ti,Mg,Mn,Al)_{5.39}Si_{6.41}Al_{1.59}O_{22}(OH,F)_2$, with a Niggli ratio of 0.52. This variety is tschermakitic hornblende in the classification of Leake (1968).

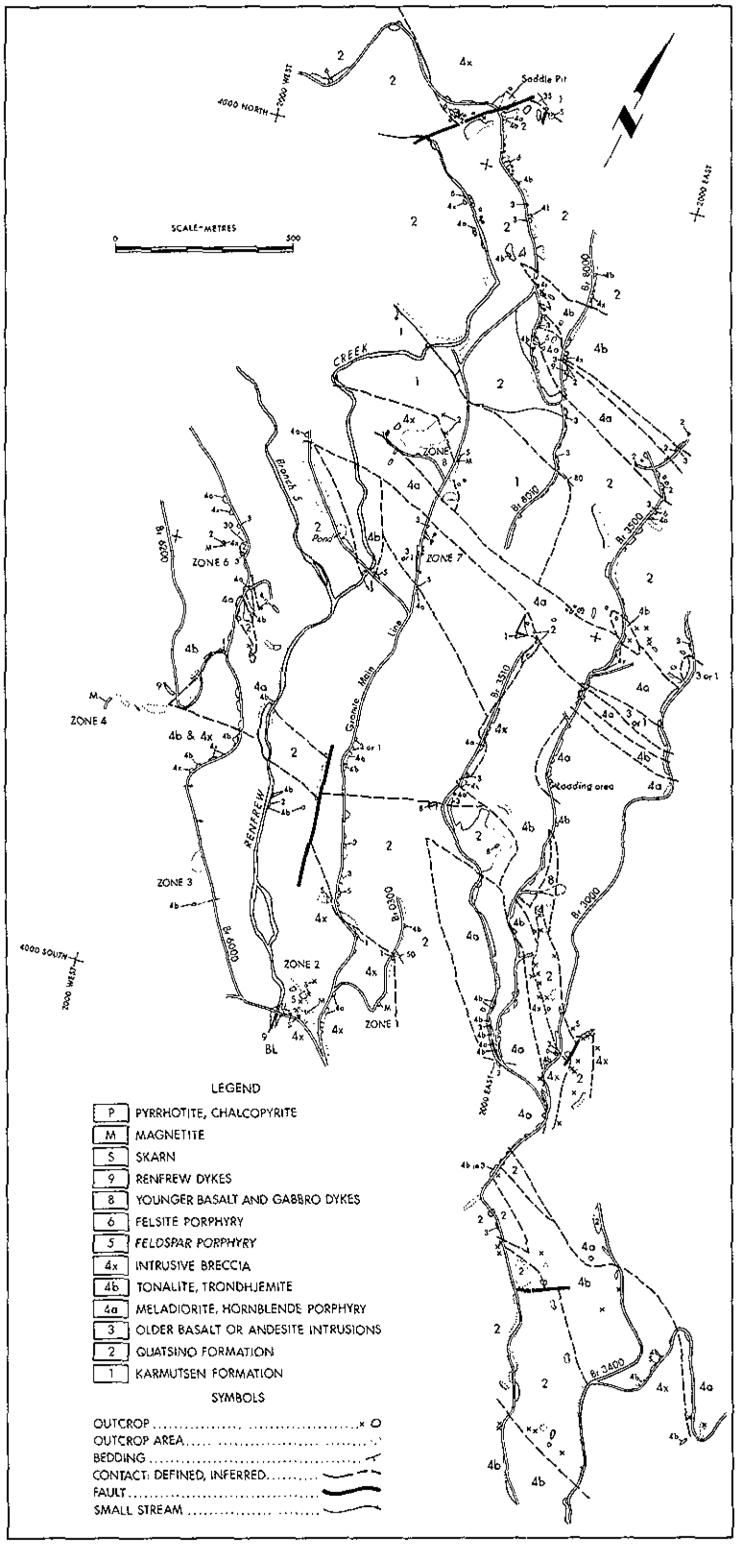


Figure 21. Outcrop geology, Upper Renfrew Creek area

The intrusions range in size from dykes a metre wide to dyke-like bodies or wedges 150 metres and more across, and from fairly massive bodies containing a few inclusions to a sparing matrix in intrusive breccia. The tonalite surrounding mineral zone 4 appears massive and homogeneous, and may be part of a much larger body.

MINOR INTRUSIONS: A few dykes of feldspar porphyry are exposed along and near Renfrew Creek above tributary No. 5. It is a crowded porphyry consisting of abundant phenocrysts of white feldspar as much as 5 millimetres across with smaller grains of chloritized hornblende and magnetite in a light grey aphanitic groundmass. A dyke near the upper bridge appears to intrude tonalite, but the age of the porphyry relative to other minor intrusions is unknown.

The commonest of the younger dykes are cream to light green felsite and felsite porphyry. Most of them are less than 2 metres wide. While they occur in most parts of the area they appear to be concentrated in the north, between Renfrew Creek and the north end of the east ridge. In thin section two dykes were identified as rhyolite porphyry, but a third is rhyodacite or quartz latite porphyry containing augite. Many of these dykes have been heavily pyritized, but no ore minerals were noted. In a few places felsite dykes appear to intrude tonalite or trondhjemite.

A granite stock crosses the north ridge at the limit of mapping. It intrudes the limestone but its age relative to other intrusions is unknown.

A few bodies of younger basalt and gabbro intrude trondhjemite, tonalite, and older rocks on and near the south parts of Branches 3500 and 3510. Accessory quartz is present, but the plagioclase is mostly labradorite and ferromagnesian minerals generally predominate. In the gabbro, biotite as well as hornblende is present. These bodies could be correlative with the Kennedy Intrusions of the Kennedy Lake area, which are tentatively dated as younger than 120 Ma.

A few narrow grey dykes are persistent along strikes of 020 degrees, transect all rocks they contact, and probably follow late fractures. They appear unique to the area and are termed the "Renfrew Dykes". In thin section the rock was identified as mafic quartz diorite close to the quartz shonkinite line.

STRUCTURAL GEOLOGY: The pattern of stratigraphic contacts described above suggests that the Karmutsen and Quatsino Formations were thrown into two synclines and an intervening broad anticline. The Karmutsen in the middle of the area may be explained as a window cut into the anticline along the bottom and lower walls of Renfrew Creek valley. On the east ridge much of the limestone capping the anticline has been eliminated by intrusion. The southwesterly syncline has been much broken by intrusion. Small bodies of limestone in zones 1 and 8 may perhaps have been carried down by magmatic convection.

Three faults were found to have appreciable displacement. The largest passes through the saddle pit, evidently causing the rubbling of the rock, and follows a gully down to Renfrew Creek. Southwest of the creek it is within limestone under flat ground, and its course has been projected. It offsets the northeast contact of the limestone 210 metres to the left. A second fault is marked by an open chasm between Granite Main Line and Renfrew Creek between the bridges. It offsets a strand of limestone 120 metres to the right. Another strand of limestone near the crest of the east ridge is apparently offset 60 metres to the left; in part the course of the fault is marked by a small creek. The faults also offset the Island Intrusions. Some of the felsite bodies are cut by small shear and gouge zones which may have developed at the same time as the faults. However, the faults may not be much younger than the batholithic rocks; the random orientations and senses of movement suggest adjustment to local stresses caused by cooling of the rocks.

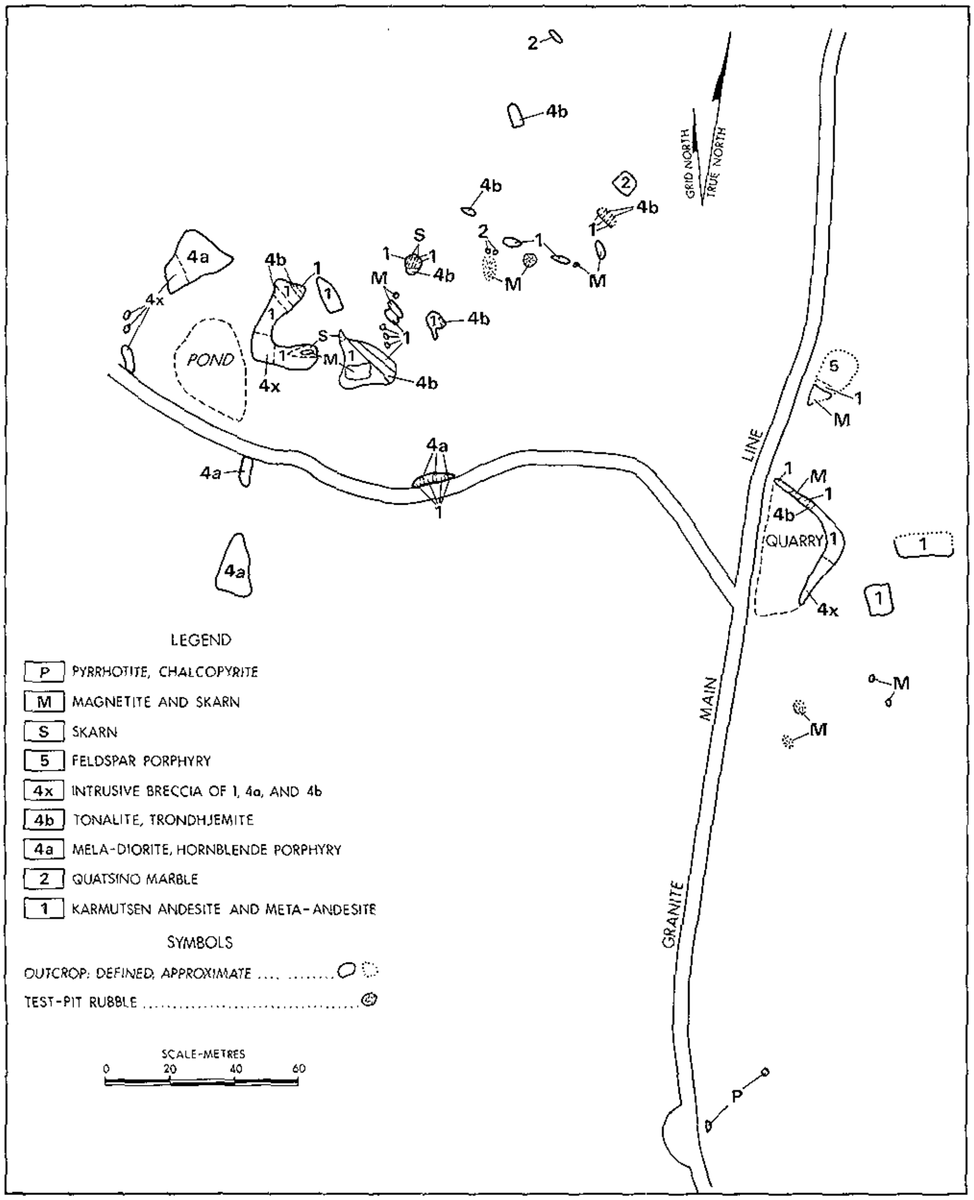


Figure 22. Detailed geology of Reko Zones 7 and 8

MINERAL DEPOSITS: The mineral deposits are of the replacement type, with the possible exception of zone 7. Most are accompanied by epidote-garnet skarn. The principal economic mineral is magnetite, accompanied in some zones by pyrrhotite, pyrite, and chalcopyrite. Where substantial sulphides are present pyrrhotite generally predominates over pyrite, except in zone 2. There are many occurrences of skarn through the area, with or without magnetite, but only 11 zones were judged to be in any way significant. These are shown on Figures 20 and 21 and their main characteristics are noted in Table 1.

TABLE 1—CHARACTERISTICS OF SIGNIFICANT SKARN ZONES, UPPER RENFREW CREEK AREA

Zone No.	Magnetite	Pyrite and Pyrrhotite	Chalcopyrite	Skarn	Limestone Host	Breccia Host	Tonalite Host	Remarks
1	abundant to massive	abundant to massive	minor	locally abundant	X	—	—	mineralization probably localized adjacent to andesite dykes
2, 3	patchy locally massive thick to thin disseminations	abundant to localized	sporadic	abundant to massive	—	X	—	
4	veins, pockets and masses	none	none	minor	—	—	X	
5	locally abundant	locally abundant	moderate	abundant	—	X	—	near limestone
6	common	none	none	abundant	—	?	—	near limestone
7	none	massive	networks	none	—	X	—	
8	pockets	minor	none	common	—	X	—	
9	massive	none	none	none	X	—	—	
10	mostly massive	none	none	minor	X	—	—	near andesite dykes
11	pockets and narrow bands	none	none	massive	—	—	—	host not determined

Zone 1 appears from the drilling to consist of a group of ore pods in a block of limestone. One is exposed in a road ditch over an area of 4.5 by 12 metres, and consists of 35 per cent magnetite, 35 per cent garnet, and 30 per cent pyrrhotite. Chalcopyrite occurs as small blebs, minute veinlets, and fine disseminations in these minerals.

Zone 2 consists of silicified rock and skarn containing variable magnetite and pyrite. It produced a strong magnetic anomaly and was systematically drilled. A trench exposed magnetite in garnetite. The pattern of mineralization indicated by the drilling is asymmetric synformal and plunging southeast. The southwest limb is near vertical and consists of fairly massive magnetite; this splits up in the keel and feathers out in the northeast limb. Much of the zone is submarginally mineralized rock.

Zone 3 was also found by drilling a magnetic anomaly, and has not been exposed. The incomplete drilling indicates an irregular body of fairly massive magnetite and pyrrhotite.

Zone 4 consists of irregular veins, pockets, and masses of magnetite in partly skarned tonalite. As exposed in the lower part of a small bluff it appears to be a thin wedge with a width at the base of the bluff of 6 metres and a length of 35 metres. However, inclined drill holes from the base of the bluff indicate a considerably thicker wedge whose full potential has not been determined.

Zone 5 is poorly exposed in timber and has been incompletely drilled. It appears to consist of three lenses of magnetite and sulphides at or near surface and some pockets at greater depth. The principal host appears to be altered basalt which is cut by many tonalite dykes, but the lenses extend into adjacent marble. The long axes are horizontal and trend northwest, and the intermediate axes plunge gently to moderately northeast. The sulphide content is relatively high, but magnetite varies widely.

No work has been done on zone 6. A mixture of magnetite and skarn is exposed over an area of 2 square metres and a height of 3.7 metres, forming a natural weir across a small creek. It is flanked by basalt and tonalite, but the nearby area is covered.

Zone 7 is indicated by two small exposures of massive pyrrhotite containing networks of chalcopyrite. It has been cut by two 4.5-metre packsack diamond-drill holes. Its extent and relations to enclosing rocks are unknown.

Zone 8 embraces at least nine pockets of magnetite scattered over an area of 210 by 80 metres, as shown on Figure 22. Scattered drill holes encountered similarly sporadic mineralization. The zone appears to have no potential.

Zone 9 is a body of almost pure magnetite emplaced directly in limestone. It is exposed over an area of about 8 by 15 metres, but high positive and negative magnetic anomalies over adjacent overburden indicate that it may be more extensive. Magnetite pebbles and float continue uphill almost to the crest of the ridge. About 60 metres northeast of zone 9 a vein of massive magnetite 50 centimetres wide dips 70 degrees southwest in the limestone; the exposed length is a few metres. Southwest of zone 9 a 120-centimetre lens of massive magnetite dips 70 degrees east-northeast.

Zone 10 is a narrow zone of outcrops of mostly massive magnetite trending at a small angle to a creek gully tributary to West Hemmingsen Creek. Downslope it appears to finger out among basalt dykes, but mostly the walls appear to be limestone. The width appears to range from 3 to 15 metres, over a slope length of 60 metres. Upslope the ground is mostly covered, but a small magnetite showing occurs 200 metres above.

TABLE 2—RESERVE ESTIMATES, UPPER RENFREW CREEK AREA

			Probable Reserves				
Zone 1				49.36% iron	9 300 tonnes		
Zone 2				37.52% iron	57 000 tonnes		
Zone 3		0.26 to 0.41% Cu		51.14% iron	14 680 tonnes		
Zone 4				38.17% iron	24 100 tonnes		
					105 080 tonnes		105 080 tonnes
			Possible Reserves				
Zone 5,	lower lens,	northwest block	1.21% Cu	44.4% Fe	6 120 tonnes		
Zone 5,	lower lens,	middle block	0.82% Cu		3 080 tonnes		
Zone 5,	lower lens,	southeast block	0.93% Cu		1 677 tonnes		
Zone 5,	middle lens,	block 1	0.34% Cu	43.5% Fe	4 915 tonnes		
Zone 5,	middle lens,	block 2	0.65% Cu		4 460 tonnes		
Zone 5,	middle lens,	block 3	1.12% Cu		3 950 tonnes		
Zone 5,	middle lens,	block 4	0.95% Cu	40.9% Fe	318 tonnes		
Zone 5,	upper lens		0.35% Cu	34.8% Fe	202 tonnes		
					24 452 tonnes	24 452	
Zone 9				65.0% Fe		2 560	
Zone 10				60.0% Fe		32 400	
						59 412	59 412 tonnes
							164 500 tonnes

Zone 11 occupies a wedge-shaped ridge between a creek canyon on the west and a shallow creek gully on the east, and appears to be at or near the contact between limestone and granite. It consists largely of garnetite which contains pockets and narrow bands of magnetite. The upper part has an estimated width of 45 metres, and the wedge was reported to have a slope length of 120 metres.

Ore reserve estimates were needed to assess the potential of the area (Table 2). Cutoff grades were set at the rather low figures of 30 per cent iron and 0.2 per cent copper. For zones 1 to 4 the drilling was deemed adequate to outline the ore, and probable reserves were calculated by determining the area and grade of vertical sections and integrating the sections. The tonnage factor used was determined from the average iron content. For zone 5 assumptions had to be made as to extensions and continuity, and the figures have to be considered possible reserves. Zones 6, 8, and 11 are regarded as having no potential. Zone 7 may have potential, but no reserves have been demonstrated. Possible reserves for zones 9 and 10 are based on visual estimates of size and grade.

REFERENCES

Eastwood, G. E. P. (1968): Geology of the Kennedy Lake Area, Vancouver Island, British Columbia, *B.C. Ministry of Energy, Mines & Pet. Res.*, Bull. 55.

Hoadley, J. W. (1953): Geology and Mineral Deposits of the Zeballos-Nimpkish Area, Vancouver Island, British Columbia, *Geol. Surv., Canada,* Mem. 272.

Leake, Bernard E. (1968): A Catalog of Analyzed Calciferous and Subcalciferous Amphiboles Together with Their Nomenclature and Associated Minerals, *Geol. Soc. Am.*, Special Paper 98.

Muller, J. E. (1977): Geology of Vancouver Island, *Geol. Surv., Canada,* O. F. 463.

1977—VERNON RIDGE AREA (92C/15E, 16W)

By G. E. P. Eastwood

A reconnaissance was made of the ridge extending west-northwest from the summit of Mount Vernon, as shown on Figure 23, in order to delineate a pyritized zone. Access was gained from the main log-haul road leading west from Caycuse and down the Nitinat River valley. The northeast slope was reached by a set of old roads which leave the main road 150 metres west of Vernon Creek. The road shown leading into the west part of the area was passable as far as the creek forks. MacMillan Bloedel's Granite Creek Line takes off from a divided section of the main road. Much of the ridge has been logged in recent years.

The magnetite mineralization shown was discovered in August 1974, during the building of the logging road, and five employees located 10 Lucky Strike claims. Some trenching was done in 1975-76. The writer made a brief examination in 1975 and noted the pyritization.

The bedrock consists predominantly of Bonanza volcanic rocks, probably mostly tuffs. Three or more flows are indicated by scattered exposures of amygdaloidal rocks. The rocks are mostly medium to dark grey where fresh, but breccia fragments are dusky red. Two exposures of breccia are also amygdaloidal and probably represent flow tops. The most southerly breccia exposure, in a small quarry, is not amygdaloidal and probably is truly pyroclastic. Most of the volcanic rock is porphyritic. Three bands of argillite and siltite dip into the ridge 600 metres west of Mount Vernon, separated by massive, light grey rocks which appear to be sills. The aggregate thickness of sedimentary rock is at least 14 metres. One outcrop of hornblende quartz diorite was found in the west part of the area.

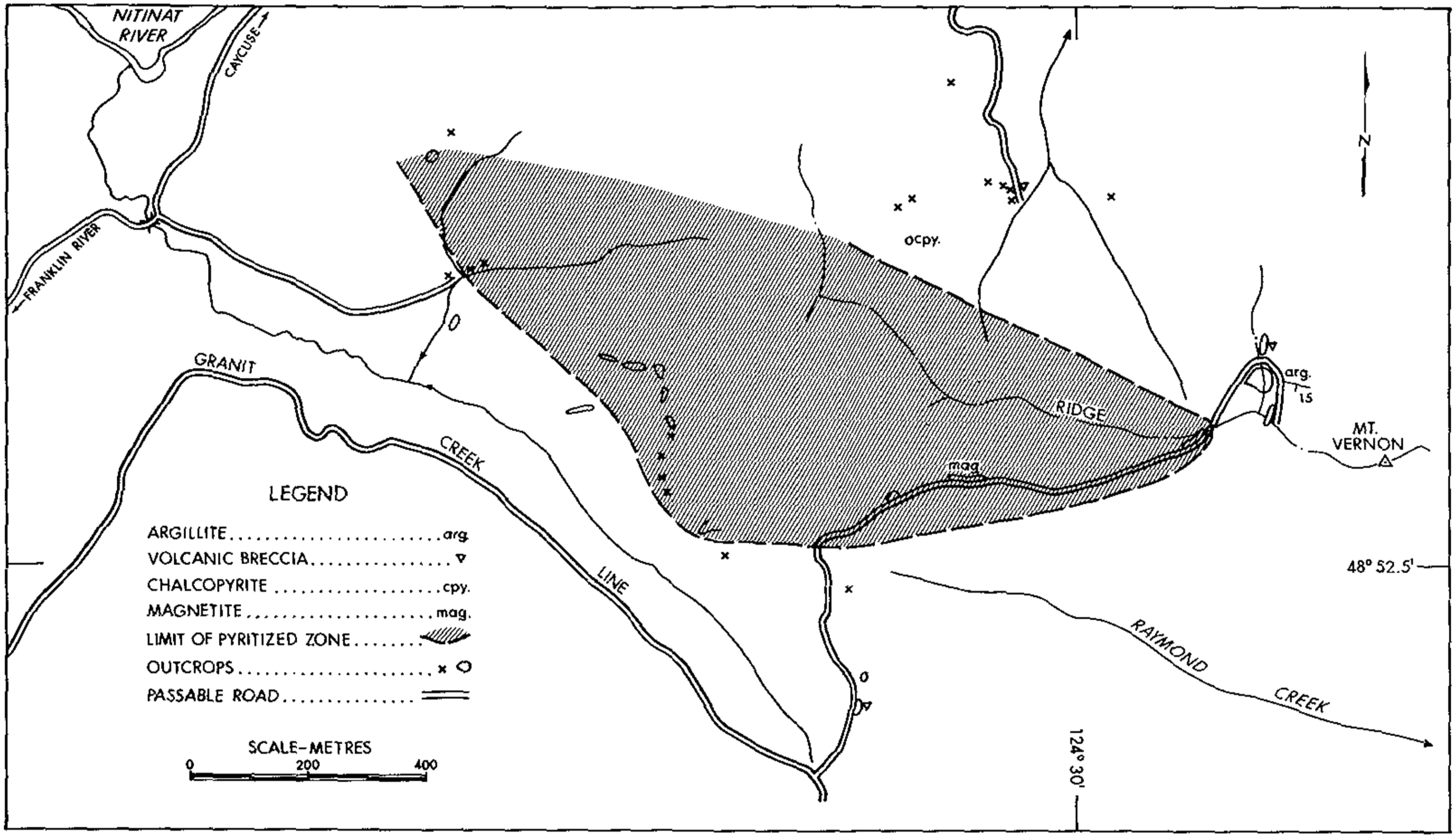


Figure 23. Geology of the Vernon Ridge area

A zone of pyritization, accompanied by more or less bleaching and alteration, is centred on the upper south slope of the ridge and extends from a saddle 800 metres west of the summit of Mount Vernon west-northwest for at least 4 000 metres. The soil developed on it is distinctively reddish. Minor pyrite is present outside the zone as widely scattered fracture-seams and sporadic grains, but the concentration within the zone is at least ten-fold. It occurs as veinlets and disseminated clots and crystals. Minor amounts of epidote occur around the periphery of the zone. A thin section of the altered rock, taken near the magnetite occurrence, discloses plagioclase phenocrysts in various stages of alteration to sericite and tremolite, in a fine-grained felted groundmass of tremolite, clinozoisite, and unaltered feldspar.

The magnetite and minor chalcopyrite occur in a pocket of skarn developed at one point in the pyritized zone. Trace chalcopyrite occurs as sporadic grains both within and outside the pyritized zone, and a small pocket was found in the outcrop indicated (Fig. 23).

The source of the alteration and pyritization has not been determined. A Bonanza volcanic centre has been suggested, but the amount of volcanic breccia appears to be too small. In any case, the area of alteration is large enough to contain a copper zone, and a reconnaissance soil sampling survey would appear to be warranted.

REFERENCES: *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork, 1975, Paper 1976-1, p. 40; 1977, Paper 1978-1, p. 23.

1977—QUINSAM AREA
(92F/13E, 14W; 92K/3W, 4E)

By G. E. P. Eastwood

Geological mapping of the Middle Quinsam area was begun in 1977 following the discovery of appreciable coal in the contained Upper Cretaceous beds. It was hoped that outcrop mapping would more clearly define the area occupied by these beds and shed light on their depositional environment and the structure of the area.

GEOGRAPHY: For the purposes of this report the Middle Quinsam area includes an area of Upper Cretaceous beds together with the flanking older rocks that extends south from Campbell Lake. The result of a reconnaissance from Quinsam Lake to Woodhus Creek are included, and therefore the report is titled the Quinsam area. The central and northern sections of the Middle Quinsam area are flat to undulating and contain many swamps, ponds, and lakes. Exposures of the coal measures are few and mostly man-made, in road cuts and on some bulldozed lines. The flanking igneous rocks have generally yielded a rough, hilly topography with abundant natural exposure, although the marginal area of the granitic rocks has been beveled flat between the highway and the Quinsam River. The principal cover is a mantle of Pleistocene drift which thickens from a discontinuous veneer south of Middle Quinsam Lake to at least 30 metres along Beavertail Creek. Bedrock is not exposed between Miller Creek and Campbell Lake. In contrast, the Iron River is deeply incised in an area of thin drift, resulting in abundant, semicontinuous bedrock exposure along its bed and banks.

Most of the area is covered with second-growth timber, largely conifers. A few charred logs and stumps are relics of a hot fire which swept through the area in 1938; thus most of the timber is less than 40 years old. There is little deadfall, and underbrush is light in better drained areas, though heavy near water.

The principal access roads are shown on Figure 24. The gravel roads leading east and west from Echo Lake are haul roads of Elk River Timbers, whose offices and shops are located at the west end of the lake. The road running southwest across the Quinsam River leads to the inactive Iron Hill mine, and will be referred to as the mine road; it is occasionally used for hauling logs. Many passable branch roads have been omitted from the map to reduce clutter; one group of roads takes off just east of the bridge at the outlet of Middle Quinsam Lake and approaches the Iron River. Bulldozed grid lines are generally passable when dry, but are rough. In some parts of the area overgrown logging-railway grades facilitate access on foot.

HISTORY: In 1883 a consortium headed by Robert and James Dunsmuir incorporated the Esquimalt and Nanaimo Railway and received a grant of land of nearly 2 million acres on the northeast side of Vancouver Island as partial consideration for construction of the railway. In 1902 James Dunsmuir became sole owner. In 1905 he sold the railway and land grant to the Canadian Pacific Railway, but reserved the rights to coal, coal oil, fireclay, and iron within the land grant. He had also become sole owner of the family's coal mines and lands in the Nanaimo and Cumberland areas, and consolidated this ownership in the Wellington Colliery Company, Limited. In 1910 he sold his interests to MacKenzie and Mann of the Canadian Railway. They recapitalized the property and sold it to British interests, which formed Canadian Collieries (Dunsmuir) Limited to operate the mines. As holder of the reserved rights the, Wellington Colliery Company was continued as a wholly owned subsidiary. Between 1945 and 1960 exploratory borings were made in the Middle Quinsam (3 holes) and Campbell River (27 holes) areas. The locations of 7 of these holes are shown on Figure 24. In 1957 the company name was changed to Canadian Collieries Resources Limited, and in 1964 Weldwood of Canada Limited commenced the purchase of all outstanding shares, converting the company to a wholly owned subsidiary, and thereby acquiring the Wellington Colliery Company. This latter subsidiary in 1973 concluded an agreement with Pan Canadian Petroleum Limited, The Esquimalt and Nanaimo Railway Limited, and Canadian Pacific Limited by which the rights to the reserved minerals over most of the Land Grant were surrendered to the Crown. The coal rights were retained in an irregular strip of land between the Qualicum River and Campbell Lake. In 1973 Weldwood compiled all available data on coal reserves of this strip and began investigation of several areas. In 1975, 11 boreholes were drilled in the Middle Quinsam area and Michele P. Curcio, coal consultant, prepared a structural map at a scale of 1:15 840. Copies of this map and an accompanying report were made available to the Ministry. Weldwood applied for coal licences on adjoining lands and made a preliminary joint venture agreement with Luscar Ltd. In 1976-77 a grid was surveyed with a baseline running 307 degrees and crosslines 037 degrees, selected portions were cleared by bulldozer, and grid drilling at 500-foot centres was begun. The companies reported that 158 holes were drilled for a total logged footage of 34,600 feet. Several trenches were cut in coal, and from one of them a short adit was driven to obtain unweathered coal for testing.

The Iron River magnetite deposit was discovered and a 60-foot adit driven sometime prior to 1907, when Einar Lindeman made the first recorded examination. No further work was done until 1951–56, when the Argonaut Mining Co. Ltd. leased the property from Canadian Collieries (Dunsmuir) Limited. Diamond drilling was followed by small-scale mining for mill tests. Texada Mines Ltd. optioned Lot 242 from Canadian Collieries Resources Limited and in 1965-66 and in 1971 did detailed geological mapping and further diamond drilling, followed by a magnetometer survey in 1974.

H. C. Gunning established the broad outlines of the geology in 1930 in his map of the Buttle Lake area. J. E. Muller sub-divided the rocks and revised the boundaries in mapping the Alberni area at 1:250 000 in the 1960's.

PRESENT WORK: A month was spent in the area in 1977. An area extending from near Campbell Lake to Gooseneck Lake and the mine road was scoured for outcrop, by driving out all passable roads and walking out other roads, bulldozed lines, and Beavertail Creek. This reconnaissance was extended west to the Campbell River and Strathcona Dam and south to Middle Quinsam Lake. Some outcrops were mapped south and east of this lake, but the coverage is incomplete. A traverse up the bed of the Iron River was replotted in the office on an enlarged section of an airphoto. A rough, incomplete reconnaissance was made eastward from the lower Iron River and along Woodhus Creek.

Outcrops were mostly located on 1:63 360 aerial photographs and transferred to standard 1:50 000 topographic maps. A plan of the company grid was obtained part way through the work and facilitated some locations. Some pacing was necessary along grid lines and the bed of the Iron River.

GENERAL GEOLOGY: The following bedrock sequence is present in or near the Quinsam area:

Group	Formation	Unit No.	Lithology
Tertiary Intrusions			Quartz diorite, dacite
Nanaimo Group	Comox	6	Clastic sediments
Island Intrusions		5	Granodiorite, quartz diorite
Vancouver Group	Bonanza	4	Pyroclastic rocks and related dykes
	Parson Bay	3	Argillite
	Quatsino	2	Limestone
	Karmutsen	1	Basalt

The Karmutsen basalt is exposed in a broad belt extending southward from the east part of Campbell Lake, and effectively separates the Comox beds in the Middle Quinsam area from those in the Campbell River area. The rock is generally massive, fine grained to dense, and dark greenish grey on fresh surfaces. On the Iron River near the magnetite deposit it is more or less sheared and altered to skarn. It is intruded by dykes of grey diorite and quartz diorite and light grey felsite and felsite porphyry.

No Quatsino limestone was found in the present mapping, but it occurs at the Iron Hill magnetite deposit to the southwest.

Argillite exposed east of the spillway of Strathcona Dam probably belongs to the Parson Bay Formation. The rock appears to be bedded, but it is hard, dense, black in colour, strongly pyritic, and laced by quartz veinlets. A block of similar argillite occurs in the road cut opposite the southeast end of the dam, and appears to be an inclusion in an intrusive phase of the Bonanza Formation.

Light to medium grey pyritic rocks exposed at and near Strathcona Dam and the Campbell River probably belong to the Bonanza Formation. The spillway bed and the first outcrop along the power line east of the Campbell River expose somewhat sheared fine-grained grey rock cut by dykes of light grey porphyry. In the spillway the fine-grained rock contains shadowy rounded fragments suggestive of agglomerate or lapilli tuff. The porphyry differs from the Island Intrusions in many ways and probably represents an intrusive phase of Bonanza volcanism.

In the channel of the Iron River 10 metres of thin chert-like beds and 2 metres of striped tuff are in places exposed beneath the Comox basal conglomerate. These exposures are too small to show at the scale of the map. The striped tuff is distinctive, consisting of dark grey to black bands as much as 5 millimetres thick interlayered with thinner medium to light grey or cream-coloured bands, and many blocks of it can be recognized throughout the conglomerate. These beds are probably Bonanza.

A large stock extending from Reginald Lake south to Upper Quinsam Lake was named Quinsam granodiorite by Gunning. The rock typically is coarse grained and consists of clusters of dark green hornblende crystals in a buff to pinkish matrix of feldspars and quartz. The hornblende contains abundant magnetite. Dykes cutting Karmutsen basalt north of Lukwa Lake are medium grained and grey, but are magnetic and probably are apophyses of the Quinsam stock. The outcrop south of Middle Quinsam Lake is granitic in general aspect, but the rock differs markedly from typical Quinsam: it is dark grey and porphyritic, with amber feldspar phenocrysts set in a fine-grained groundmass of light brown feldspar and abundant black minerals. It is slightly magnetic. It is tentatively regarded as a border phase of the stock. In a ditch just south of Gooseneck Lake the granodiorite is sheeted by gently dipping fractures and superficially resembles sandstone. Granitic rocks east of the lower Iron River are magnetic and variously resemble typical Quinsam and the dykes north of Lukwa Lake.

Muller mapped a small granitic stock astride the Iron River near the magnetite deposit and assigned it to the Island Intrusions. As shown on Figure 24 the rock immediately downstream from the orebodies is Karmutsen basalt, which is cut by one small dyke of alaskite and several of felsite and felsite porphyry. McCullough shows a small stock of quartz diorite indicated by diamond drilling near the west orebody and a large intrusion inferred to underlie the upper slopes east of the river; he believed them to be pre-Nanaimo. More recently it has been suggested that these intrusions may be Tertiary, but definite evidence has not been obtained. The writer found no dykes of any kind definitely cutting the Comox beds, and cobbles of the felsite porphyry occur in the conglomerate. The only indications of post-Comox heating are apparent metamorphism of sandstone near the west orebody and apparent hardening of coal.

Comox beds occur in three separate areas: northeast of Strathcona Dam, the Middle Quinsam area, and the Campbell River area. Northeast of the dam a solitary road cut exposure comprises some 10 metres of thin-bedded siltstone and fine sandstone dipping 13 degrees west. In the Middle Quinsam area Comox beds extend from east of the Iron River northward at least to Miller Creek and Beavertail Lake, and probably under very thick drift to Campbell Lake. Carlisle shows one outcrop of Comox of the south shore of Campbell Lake; this outcrop was not readily accessible by land, and was not seen by the writer. In the Campbell River area Comox beds are exposed sporadically from Quinsam Lake to Woodhus Creek, and drilling by Canadian Collieries (Dunsmuir) Limited indicates that they dip toward the Strait of Georgia beneath thick drift. A suggestion that the Quinsam and Campbell River areas of Comox sediments might be connected along the Quinsam River is not substantiated; outcrops adjacent to the Quinsam and lower Iron Rivers are of Karmutsen and intrusive rocks.

In the Middle Quinsam area the lower part of the Comox Formation changes markedly across Middle Quinsam Lake, suggesting that deposition began in two separate basins. A new 10-metre-high road cut of Highway 28 exposes conglomerate consisting of well-rounded pebbles and cobbles of Karmutsen basalt and a sparing matrix of dark green sandstone and compressed shale. The base is not exposed, but from the outcrop distribution this conglomerate would appear to be close to the base of the formation. The upper part of this member is exposed in Miller Creek beside the highway; it consists of well-rounded, varied pebbles in a grey sandstone matrix. Where the conglomerate is weathered, as north of Middle Quinsam Lake, both the cobbles and matrix are brown and it resembles glacial till; however the compressed condition of the finer matrix is diagnostic. Poorly sorted, poorly bedded greenish grey rocks exposed southeast of Snakehead Lake lie an unknown distance above the conglomerate. The grain size ranges from pebbles to a sparing light green clay. Fragments of Karmutsen, Parson Bay, and Bonanza rocks are common, and quartz and feldspar granules probably were derived from the Quinsam granodiorite. Two outcrops farther east, and presumably higher in the sequence, are of thin-bedded, moderately well-sorted sandstone. In Miller Creek at the haul road this sandstone is cross bedded, indicating deltaic conditions. South of Beavertail Lake grit and pebble conglomerate with interbedded shale appear to be sandwiched between thin-bedded sandstones; it is not clear where this fits in the sequence. Coal is exposed in one place north of Middle Quinsam Lake in a trench. The floor is not exposed but about 120 centimetres is visible, and it is capped by overburden. Thin-bedded sandstone is exposed to the south and lower in the section, and the position of it and the coal in the sequence is also unclear.

Southeast of Gull Lake, at the end of a bulldozed line, a different kind of conglomerate is exposed a few metres below a coal seam. It consists of varied angular and rounded pebbles in a hard maroon matrix. The coal seam is partly exposed in shallow trenches on two adjacent lines; it is capped by overburden and is powdery. To the northeast, on the first line, a second seam is exposed in an open cut, at a higher elevation and dipping gently north. About a metre of coal is exposed beneath a medium-bedded sandstone roof. Northeast of Gull Lake another open cut exposes about 1.5 metres of coal partly capped by shale. The coal-bearing sequence is overlain to the east by poorly bedded greenish grey grits, generally similar to the rocks southeast of Snakehead Lake, which in turn are overlain by better sorted, bedded sandstones.

The trench and adit east of Middle Quinsam Lake expose the following section:

Centimetres	*Glacial till*
30	Shale
60	Shaly coal rider
90	Carbonaceous shale
150	Coal

The lower part of the seam was covered. It is reported that pre-Comox rocks are exposed in the nearby creek about 20 metres lower, and therefore this seam may be the lowest. Considerable pyrite is present in the coal, and a partial analysis of a roughly channeled sample yielded the following results:

S—1.97% P_2O_5—0.62%   ASH—5.21%

Along the channel of the Iron River the conglomerate varies greatly in thickness; thicker sections are separated from the older rocks by a metre or two of arkose. The conglomerate is a striking rock consisting of angular blocks of pebble and cobble size and varied lithologies as well as well-rounded boulders of granitic rock set in a white or maroon matrix. The white appears to send dykelets down into the maroon, but it may be an alteration product, for many of the blocks show thin white shells. In the centre of the inset of Figure 24 the following section was observed, with thicknesses estimated:

Metres	
3.0	Medium to thick-bedded sandstone
5.0	Coal with shale partings
0.45	Brown sandstone bed
0.60	Coaly shale
0.18	Brown sandstone bed
1.38	Coaly paper shales
0.30	Brown sandstone bed
0.90	Coaly, gritty grey sandstone
1.50	Coaly, pebbly shales and pebble conglomerate
1.50	Medium-bedded gritty sandstone
2.0+	Conglomerate

A change in the strike of the beds causes the coal to emerge farther upstream, thinned to about 1.5 metres. Still farther upstream the coal appears to pinch out entirely. Coal exposed in the river bank 110 metres downstream from the main outcrop in the river bed is clearly correlative, but coal in the access road west of the west magnetite orebody is 37 metres above the bed and evidently is part of a higher seam. The proximity of the lower seam to the conglomerate would indicate that it is correlative with the No. 1 seam east of Gull Lake.

Comox outcrops east and southeast of Gilson Lake are mostly sandstone. A cutbank of Woodhus Creek exposes a section:

Coal
Sandstone
Conglomerate

The coal outcrop on Quinsam Lake was not seen due to high water in the Quinsam River, and this occurrence is taken from the Weldwood map.

STRUCTURAL GEOLOGY: In the area north of Middle Quinsam Lake the overall dip of the Comox beds is to the east-northeast at about 08 degrees. Variations in strike and dip occur from place to place, and minor warping is visible in individual exposures. Southeast of the long lake the beds are broadly arched, dipping east and southeast on one flank and north to northwest on the other. A shallow trough crossing the Iron River between the coal outcrops has produced the change in strike previously noted. The dips in this part of the area are locally as much as 27 degrees, but more commonly 10 degrees to 15 degrees.

The west boundary of the Middle Quinsam area of Comox beds has been sketched from outcrop locations. Obviously there is a considerable area of uncertainty between the highway and Middle Quinsam Lake. Right-handed jogs northwest of Snakehead Lake and at Beavertail Lake probably result from faulting. A pronounced topographic lineament is formed by the valley of Beavertail Creek and continues through the west arm of the lake and along the haul road. The contact itself may be a fault for, if the basal conglomerate rested on Quinsam granodiorite it should consist largely of debris from that rock, whereas it consists almost entirely of Karmutsen debris. Another fault is indicated by the pronounced lineament through the long lake and northwest of Gull Lake, and by the wedge of Comox to the southeast. The lineament dies out to the northeast, but continues to the mine road in the west. The contact southeast of this lineament may be an ordinary nonconformity, since the conglomerate contains many granitic pebbles.

The east boundary of the Middle Quinsam area is mainly sketched from aerial photographs along the abrupt change from the rough Karmutsen topography to the plain presumably underlain by Comox beds. South of the Quinsam River it is partly controlled by two boreholes, which intersected sandstone containing some shale and coal, and by outcrops in the Iron River. The thickness of sediment in these holes (156 and 205 metres) close to the contact suggests that this contact may be a fault. Sandstone exposed about 50 metres west of the west orebody has a crinkly foliation and thus appears to be sheared as well as metamorphosed; it may be indicative of such a fault. In the river channel a southeast-dipping shear zone may be a thrust fault, but the relationships of the rocks are not clear.

There are probably many small faults in the area which are detectable only in good exposures with varied lithology. One small normal fault has dropped sandstone down 2 or 3 metres against the main coal outcrop in the Iron River.

The boundary of the Karmutsen belt with the Campbell River area has been sketched from aerial photographs, modified slightly by outcrop and borehole information. The thicknesses of sediment in the boreholes suggests that the contacts east of Quinsam Lake may be faults.

ECONOMIC GEOLOGY: The mineral potential of the area lies in the coal seams in the Comox Formation and the iron and copper in the Iron River deposit. The coal is pyritic and is not regarded as of metallurgical grade. The owners therefore propose to market it for thermal power generation. As many as three mineable seams are present, but average thicknesses and areal extent could not be determined from the few exposures.

Magnetite and associated chalcopyrite in garnet-epidote skarn form two orebodies on the Iron River. The west orebody is exposed on a knoll topping the bank on the inside of a river bend and is surrounded by overburden. The east orebody is exposed to the east in the river bed and evidently continues under overburden in the right bank; the host skarn grades outward to altered Karmutsen basalt. Reserves were estimated in 1956 at 800,000 tons of probable ore grading 36 per cent iron and 0.35 per cent copper. The 1965-66 and 1971 drilling of the east orebody appears to have increased the tonnage significantly.

REFERENCES

GENERAL GEOLOGY

Carlisle, Donald: Geology, Bute Inlet, Southwest Part, *Geol. Surv., Canada,* O.F. Map 345.

Gunning, H. C. (1931): Buttle Lake Map-area, Vancouver Island, British Columbia, *Geol. Surv., Canada,* Summ. Rept., 1930, Pt. A, pp. 61–64.

Muller, J. E. (1969): Geology, Alberni, British Columbia, *Geol. Surv., Canada,* Map 17-1968.

——— (1974): Geology and Mineral Deposits of Alert Bay-Cape Scott Map-area, Vancouver Island British Columbia, *Geol. Surv., Canada,* Paper 74–8, p. 15.

——— (1977): Geology of Vancouver Island, *Geol. Surv., Canada,* O.F. Map 463.

Muller, J. E. and Carson, D. J. T. (1969): Geology and Mineral Deposits of Alberni Map-area, British Columbia, *Geol. Surv., Canada,* Paper 68–50, pp. 6-7, 17-18, 21–25, 31-32.

IRON-COPPER

Lindeman, Einar (1910): Iron Ore Deposits of Vancouver and Texada Islands, Mines Br., *Dept. of Mines, Canada,* Pub. No. 47, pp. 20-21.

McCullough, P. T. (1974): Geophysical Report on the Iron River Property, Assessment Rept. 5300.

Minister of Mines, B.C., Ann. Rept., 1952, p. 228; 1956, p. 131; 1965, p. 233; 1966, p. 70.

B.C. Ministry of Energy, Mines and Pet. Res.: GEM, 1971, p. 252, 1974, p. 182.

Young, G. A. (1926): *Geol. Surv., Canada,* Ec. Geol. Series No. 3, Vol. 1, pp. 71–73.

COAL

Muller, J. E. and Atchison, M. E. (1971): Geology, History, and Potential of Vancouver Island Coal Deposits, *Geol. Surv., Canada,* Paper 70–53, pp. 18-19, 27, 31, 49.

HISTORY

Turner, Robert D. (1973): Vancouver Island Railroads, *Pacific Railroad Publications, Inc.,* San Marino, California.

1977—GEOLOGY OF THE TULAMEEN COAL BASIN (92H/10)

By S. H. Evans

INTRODUCTION: *The Tulameen Coal Basin is located immediately west of Coalmont,* (49°31′, 120°41′). Coalmont is accessible by paved road from Princeton, 18 kilometres to the south. Entrance to the basin proper is from Coalmont, west up the Granite Creek road, and thence by various logging and mining exploration roads to different areas of the basin.

The Tulameen Coal Basin is bound by valleys on most sides, and merges with the surface of the Interior Plateau only on the west (Fig. 25). To the north and east lies the valley of the Tulameen River, to the southeast is that of Granite Creek, to the southwest is Blakeburn

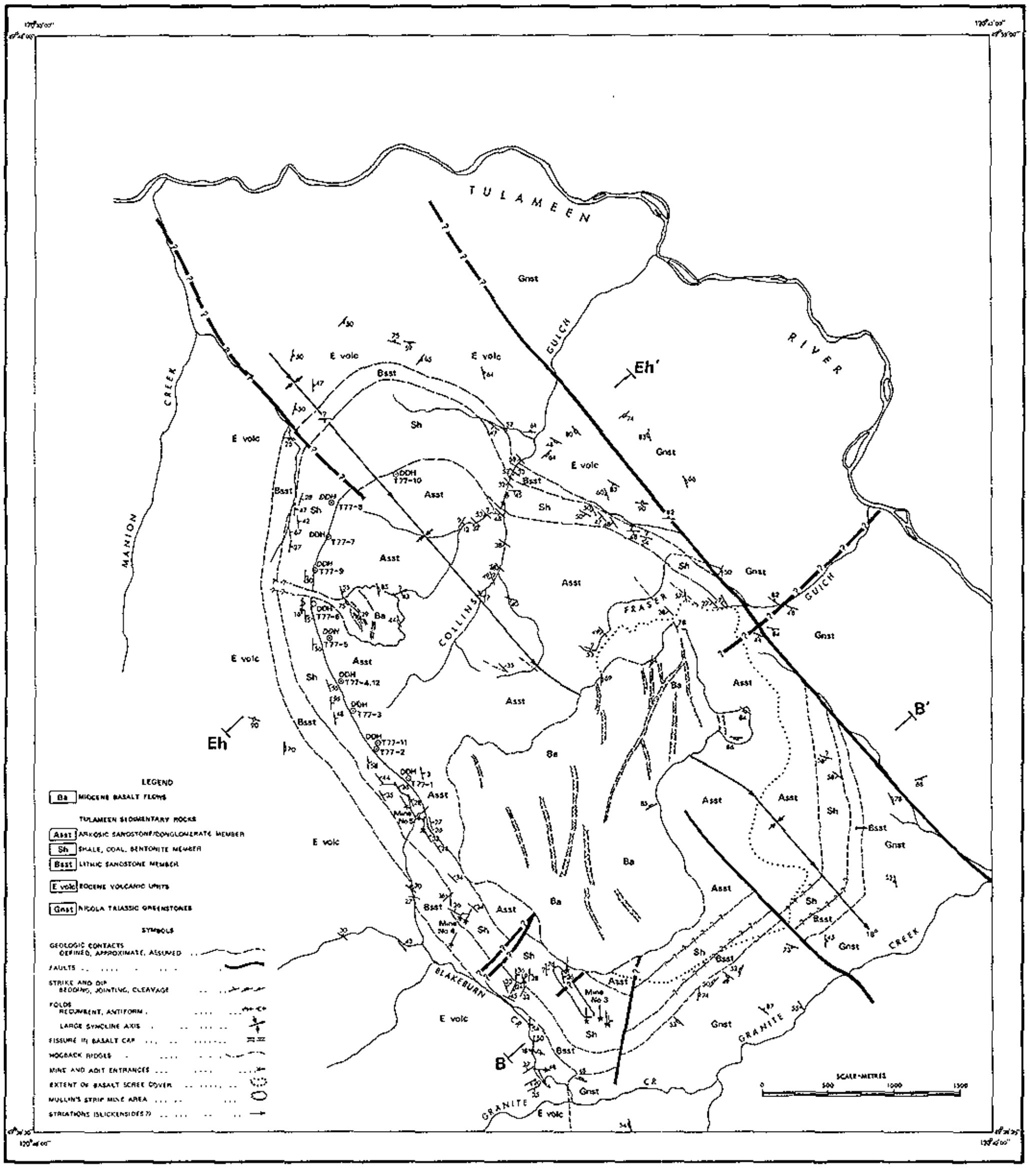


Figure 25. Geology of the Tulameen Coal Basin

Creek, and to the northwest is Manion Creek. The basin, a distinct geologic structure, underlies a plateau which ranges in elevation from 1100 to 1400 metres. The soft sedimentary rocks of the basin are rimmed and retained on the north and east by hills of resistant rocks. To the north and northeast, these resistant rocks are Eocene andesite flows, while to the east they are mid-Triassic greenstones of the Nicola Group. Relief between the Tulameen River and these buttressing hills is 600 metres. In the southeast and south, the sedimentary rocks are less well retained by walls of greenstone, and covered by a Miocene basalt caprock. Relief between Granite Creek and the sediments is 350 metres. On the southwest, the rocks of the basin are essentially unconfined, and relief along Blakeburn Creek reaches 150 metres.

The sedimentary basin is oval in plan, with a northwest to southeast long axis of 5.4 kilometres, and a short axis of 3.4 kilometres. The sedimentary rocks of the basin thus underlie an area of 18.5 square kilometres. Approximately one-third of this area is covered by basalt. Collins Gulch drains the northern third of the Tulameen basin. This creek flows in a northerly direction through a pronounced watergap in the northeastern section of the resistant rimming hills. Smaller areas of the basin are drained by Blakeburn Creek, Fraser Gulch, Holmes Creek, or Manion Creek. The area is generally heavily wooded, except where mining activities have created open meadows, or where resistant rock outcrop allows only thin soil development. Cross country traverses are, in many places, very challenging. Exposure of the underlying and overlying resistant rock types is uniformly excellent. Unfortunately, the same cannot be said of the sedimentary units. Collins Gulch provides relatively complete exposures of all the rock types in the basin. However, natural outcrop elsewhere is confined to widely scattered, low, overgrown exposures along creek beds. On the other hand, the coal-bearing member has been widely exposed by exploration and mining work. Total outcrop may reach 1 per cent of the area of the underlain by sediments; of the outcrop 80 per cent is of the coal and enclosing shales.

MINING HISTORY AND PREVIOUS GEOLOGICAL WORK: The overland trail of the Hudson's Bay Company in 1848 was routed through Collins Gulch. Since coal outcrops in this ravine, it may be presumed that the Tulameen coal was one of the first mineral resources identified in British Columbia. However, it was not until the creeks of the area had been developed for placer gold in the late 1800's that mineable coal was discovered near the present site of the ghost town of Blakeburn. Also, it wasn't until the first decade of the twentieth century, that large-scale exploration of the deposit was begun by Columbia Coal and Coke Company. In five years of development work, from 1909 to 1913, this company drove four tunnels in the Blackburn area, one in Fraser Gulch, and two at Bear's Den. These adits did not meet the company's expectations, and the claims were sold in August 1913, to Coalmont Collieries.

Initially, Coalmont Collieries developed the seams near Blakeburn. The primary problem in exploiting these seams was transportation to the railhead or Coalmont. At first this problem was solved by motor transport, and in 1920 a tramway was installed to haul coal from Blakeburn to a treatment plant mill in Coalmont. These original workings were known as the No. 3 mine. As coal reserves in the No. 3 decreased, two other mines were opened to the northwest. These were the No. 4 mine, opened in 1924, and the No. 5, opened in 1932. Primarily these mines provided steam coal to the railroad; they operated up to World War II. The No. 3, No. 4, and No. 5 mines closed in 1935, 1938, and 1940 respectively, after producing a total of 2,364,561 short tons of coal (Shaw, 1952).

Small-scale private prospecting occurred in the Collins Gulch and Hayes-Vittoni areas between 1940 and 1953. In 1954, the first strip mine in the area was opened by Mullin's Strip Mine, Ltd. This working removed the coal pillars between the old No. 3 mine tunnels and the surface. This mine provided coal to a Granby Mines power plant at Princeton. The mine closed in 1957 when Granby closed their Copper Mountain property. This mine produced 163,439 tons of coal (Dept. of Mines Report, 1957).

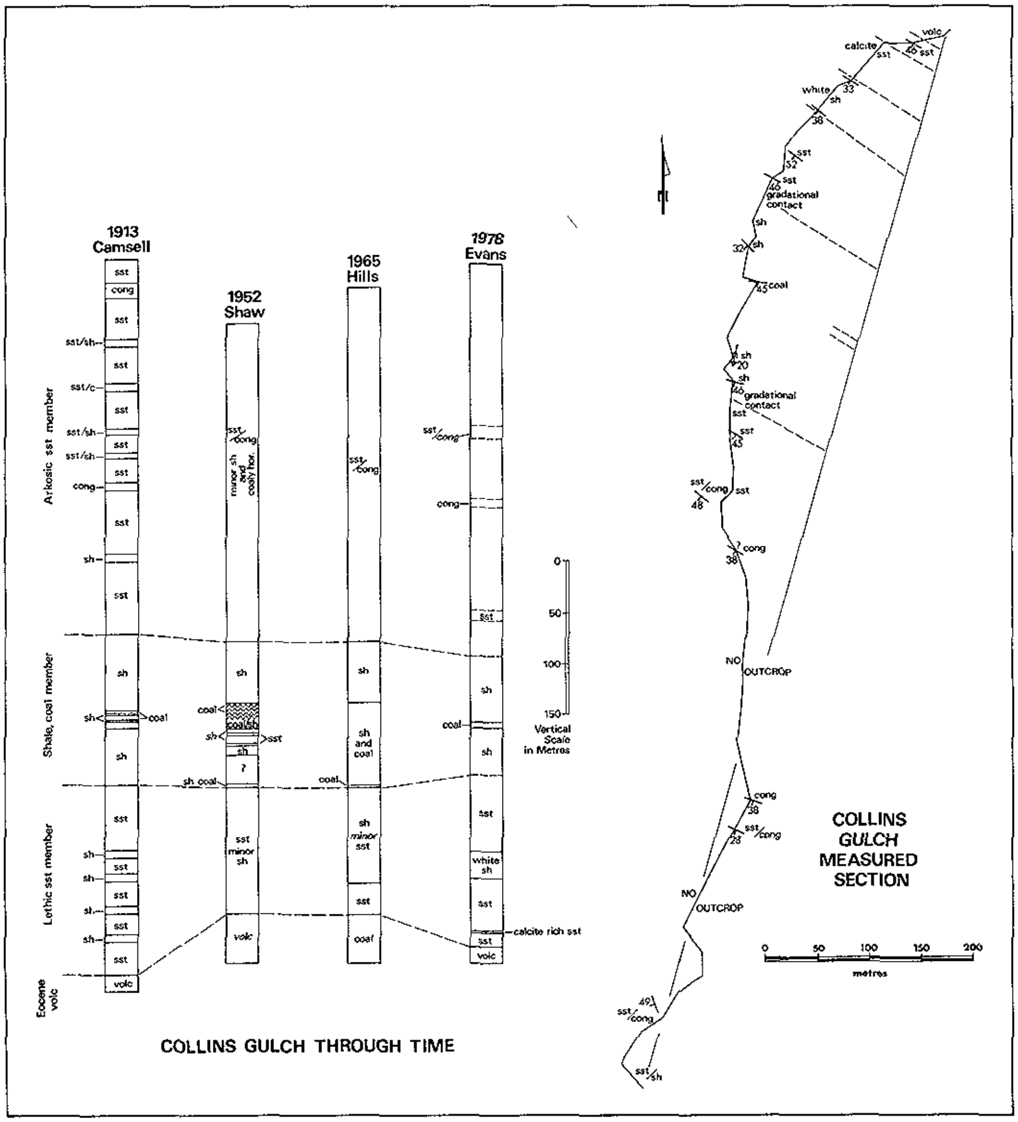


Figure 26. Measured section in Collins Gulch and various interpretations of the stratigraphic section

In the 1960's, the most active prospecting was undertaken by Imperial Metals and Power, Ltd. They carried out trenching throughout the area, especially in the northwestern section, where they also drilled four holes. Imperial did not attempt to open a mine. In 1977, Cyprus-Anvil Corp. optioned the Imperial leases. Prospecting work has included bulk sampling of the reopened Imperial trenches, and the drilling of a dozen holes in 1977. Plans for 1978 are to drill further prospect holes, and re-examine the area around Blakeburn.

The geology of the Tulameen Coal Basin was first reported by Charles Camsell in his 1913 report on the general geology of the Tulameen area. Camsell was responsible for naming the basin, and his mapping delineated the main rock units in the area and their distributions. He was also the first to measure the Collins Gulch section (Fig. 26). He identified the general synclinal shape of the structure. He mapped no faults, but suggested their presence.

In 1952, the second report on the geology of the Tulameen basin was written by W. S. Shaw. Shaw re-examined the Collins Gulch section (Fig. 26) and made slight changes in the distributions of the major units. He made two important revisions to the earlier work. He re-interpreted the fold structure, which Camsell envisioned as an open fold, as an asymmetric syncline, with a steepened eastern limb. Shaw also mapped two faults in the area of the old mine workings.

In 1965, L. V. Hills wrote a Ph.D. thesis on the palynology and age of Early Tertiary coal basins of southern British Columbia, including the Tulameen, and palynological correlation among these coal basins. He also re-examined the Collins Gulch section.

Since Hill's work, two smaller reports have been done on the Tulameen basin. The first of these was a report by Dolmage Campbell and Associates, Ltd. This report primarily reviewed Shaw's work, and analysed coal reserves and BTU characteristics. In 1973, a report on the petrography of the coal in the Blakeburn (Mullin's) Strip mine was published by J. Roger Donaldson. This report analysed the coal for rank, macerals, microlithotypes, and coking potential. The coal was found to be high volatile "B" bituminous in rank, 90 per cent vitrinite, and not amenable for coking.

This report is being undertaken to provide an up-to-date analysis of the geology, and to produce a 1:5000-scale map of the area. This report will cover the rock types, structure, and sedimentology of the Tulameen Coal Basin. Currently, a thesis on the petrography of the coals of the Tulameen basin is being undertaken at Western Washington State University by Eilene Williams. This report forms part of a thesis at the University of British Columbia which will also include a study of the use of numerous tephra layers as stratigraphic marker.

STRATIGRAPHY: The classic measured section for the Tulameen basin is Collins Gulch. The present study again re-examined the section (Figs. 25 and 27). Rock descriptions are taken from samples collected in Collins Gulch and at other exposures throughout the basin. Most colours used in the descriptions are Munsell colours, and these are marked by the inclusion of their Munsell code number in the text.

NICOLA GREENSTONES: The stratigraphically lowest rocks in the Tulameen area are mostly greenschists of the Late Triassic Nicola Group. In the field area, these metavolcanic rocks range from basaltic to andesitic in composition. The greenstones crop out extensively and are generally massive. In some areas, good schistosity has developed and, in the southeast corner of the field area, phyllites occur. In outcrop, weathered surface colours vary from moderate yellowish brown (10YR 5/4) to moderate brown (5YR 4/4). Fresh dry surfaces range from dusky green (5G 3/2) to pale green (10G 6/2). From a distance, fresh slide scars appear very felsic, almost white. Where locally contact metamorphosed, rocks may be light brownish grey (5YR 6/1) when fresh and dry.

The original mineralogy of the metavolcanic rocks is, of course, obscure; thin sections are usually cloudy. The most common primary mineral is plagioclase; some is euhedral, with twinning and zoning, but most is partly resorbed. A rounded, high relief, highly birefringent, altered mineral, probably olivine, also occurs.

The most prominent secondary mineral is calcite. Amounts of calcite present in a given thin section vary from a few, up to 40 per cent. Chlorite also occurs. Secondary pyrrhotite occurs in metagreenstones in the southwestern corner of the field area, near Blakeburn. In this area, hornblende porphyry dykes have intruded and contact metamorphosed the Nicola rocks.

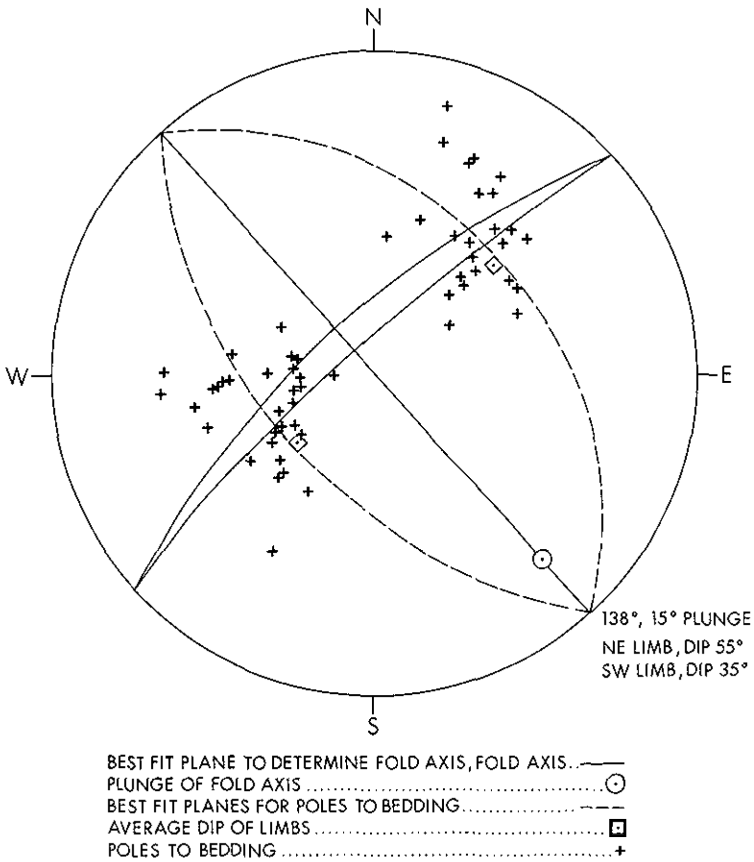


Figure 27. Structural elements in the Tulameen coalfield

HORNBLENDE PORPHYRY DYKES: These dykes are porphyritic, holocrystalline, with phenocrysts of basaltic hornblende up to 5 millimetres in length. Weathered, these rocks are similar in colour and aspect to the enclosing greenstones, and it is difficult to distinguish between the two rock types in outcrop. Hence, these dykes have not been previously identified. The dykes are narrow; the largest measures only 30 metres across. However, the size of the phenocrysts visibly decreases near the chilled margins of the dykes.

In thin section, the hornblende occupies up to 50 per cent of the rock. Plagioclase groundmass makes up most of the rest. Secondary calcite may occur. Pyrrhotite also occurs, but is mainly found in the surrounding greenstones. Mineralogically, these rocks are similar to the Eocene flow rocks, described next. However, the dykes have a much higher hornblende content than the Eocene volcanics and lack plagioclase phenocrysts. The question as to whether or not these two rock types are related remains open.

EOCENE VOLCANIC ROCKS: Eocene volcanic rocks overlie an unconformity developed on Nicola metavolcanic rocks, which spans a time hiatus of some 150 million years. The stratigraphically lowest of the Eocene rocks is a sequence of andesite flows and volcaniclastic beds. The Eocene volcanic rocks outcrop extensively around the northern and western margins of the basin. The flow rocks and volcaniclastic beds are interlayered, and locally sediments have been found within them. Camsell (1913) reported an occurrence of coal in Cedar Creek (now called Manion Creek) which appears to be within the volcanic strata. The relative volume of volcaniclastics appears to increase upsection. Clastic units seem to predominate around Collins Gulch and Blakeburn Creek, whereas flow strata form Jackson Mountain and Hamilton Hill. This suggests that the volcanic centre was northwest of the basin.

In hand specimen, the flow rocks have weathered to a light brown (5YR 6/4) or moderate brown (5YR 3/4). Fresh dry surfaces, which are widespread in outcrop, are medium light grey (N6) to dark grey (N3). They are aphanitic to plagioclase porphyritic. They appear andesitic in composition, and may be moderately magnetic.

In andesite flows between 70 and 90 per cent of the rock volume consists of fine needles of microcrystalline plagioclase, which shows pronounced flow texture. Large plagioclase phenocrysts are zoned and twinned, and make up 15 per cent of some flows. Smaller phenocrysts present include varying amounts of basaltic hornblende and magnetite.

The volcaniclastic beds are variable in colour and composition. The most extensive units may descriptively be called "red beds", in that exposures appear distinctively vermilion. Fresh dry hand specimen surfaces vary from pale red (5R 6/2), to pale red purple (5RP 6/2), to pale pink (5RP 8/2). These rocks may be either brecciated or conglomeratic, and clast size varies from millimetre scale to boulders 1 or 2 metres across. Other volcaniclastic units are of differing shades of light grey or green. In thin section, minerals are not generally recognizable. However, some ash beds do show graded bedding. The origin of these structures, whether they are original or derived from later reworking by water, is not known.

One distinctive variety of volcaniclastic rock occurs just beneath the contact with the sedimentary sequence of the basin. This unit shows intensive brecciation and quartz veining. Veins show well-developed, fan-shaped open space crystallization. Sharp, clean crack walls indicate that the quartz crystallized as post-brecciation, low temperature veins.

TULAMEEN COAL MEASURES: Because of the occurrence of local sediments within the Eocene volcanic units, the contact between the volcanics and the main sedimentary succession of the Tulameen basin is somewhat obscure. It is convenient to place this contact between the highest of the volcaniclastic "red beds", and the lowest of the distinctive lithic sandstones of the basin proper. The volcaniclastic marker horizon, described above in the Eocene volcanics section, occurs directly beneath this contact. The presence of this unit in close conjunction with the basal sandstone has been observed in two widely separated locales—Collins Gulch and just west of the No. 4 mine workings. Since these areas are 3 kilometres apart, it is felt that these two units can be used to define the contact throughout the basin. Wherever one chooses to place the contact, the units above and below it are clearly conformable.

LITHIC SANDSTONE MEMBER: In outcrop, the basal member of the Tulameen sedimentary succession appears very weathered. Fresh surfaces are rare, but where present show a dry colour of greenish grey (5GY 6/1). Weathered surfaces are light olive grey (5Y 6/1), with some surfaces stained blackish red (5R 2/2). The lower units of the basal member are coarsely clastic, and show indistinct bedding. Sandstones higher in the section show increasingly well-developed bedding. The uppermost unit of the basal member shows a fine banding of organic matter that marks bedding. This banding may be due to a sort of "varve" effect produced by annual leaf fall.

Whereas most outcrops of the lithic sandstone member are small and weathered, there is one notable exception. Just south of the lowest portal of the No. 4 mine there is an exposure of sandstone 90 metres in height. This outcrop is very distinctly bedded, and the strike of the bedding changes from one side of the outcrop to the other. It seems likely that this exposure is an old alluvial fan.

As stated, grain size decreases upwards in the section. Near the contact with the Eocene volcanic rocks, clasts are up to 1 millimetre in size; mineral grains in the banded unit near the top of lithic sandstone member are only 0.1 millimetre in diameter. Lithic fragments comprise about 60 to 70 per cent of the clasts in the rock throughout and mineral grains and plant debris the rest. In thin section, weathering obscures the nature of the lithic fragments, and grain boundaries are indistinct. However, the fragments appear to be subangular and show the fine needles of microcrystalline plagioclase typical of the Eocene volcanic flow rocks. Mineral grains are usually angular to subangular, with an occasional euhedral crystal. The minerals are quartz, potash feldspar, and plagioclase. The plagioclase may be twinned, zoned, or both. Muscovite and biotite were also observed. Generally low amounts of secondary calcite, chlorite, and epidote occur; but in one outcrop calcite fills nearly all interstitial space and causes the rock to react with acid. Plant debris occurs throughout the lithic sandstone member and increases in amount upsection. Identifiable fossils are rare because most of the sediments were reworked.

Sandwiched in the middle of the basal member is a unit of white shale. This shale weathers to a distinctive greyish red (10R 4/2) colour and outcrops boldly. It is laminated; laminations are from 2 millimetres to 100 millimetres thick, and plant fragments are abundant and well preserved along bedding surfaces. The unit may be of volcanic origin, but thin sections are not definitive. However, its distinctiveness and resistance make it a good marker throughout the basin.

The thickness of this member is variable. It averages 30 metres but in Collins Gulch it is about 170 metres thick. The contact between the lithic sandstone member and the shale member above is gradational.

SHALE AND COAL MEMBER: The shale member of the Tulameen sedimentary pile is highly fissile. The shale splits easily into planar laminations from less than a millimetre up to several millimetres in thickness. Thicker layers are commonly well cemented and locally fossiliferous. Exposures may be up to 5 metres in height, and show small-scale folds. Fresh surfaces are dark grey (N3) to greyish black (N2), whereas weathered surfaces vary between light brown (5YR 5/6) and moderate brown (5YR 3/4). The rock is too fine grained to show mineralogy in thin section but spores and woody fragments, which have undergone partial silicification, can be recognized.

The main coal seams occur near the centre of the shale member. However, drill hole data from Cyprus-Anvil Corp. shows that coal may occur anywhere in the shale member. A seam 0.5 metre thick occurs directly above the banded sandstone of the basal member, and others occur in the arkosic member. Where exposed, the coal shows numerous shale and bentonitic partings. The coal shows cleat with spacings of a few centimetres. Reflectance and analysis of pellet mounts suggest a coal rank of high volatile bituminous C or B. Rank appears to decrease to the northeast (Eilene Williams, personal communication, March 1978). Vitrinite makes up about 90 per cent of the macerals, with some resinite and sclerotinite. Pyrite and calcite also occur in the coal.

Numerous bands of conspicuous white bentonite occur throughout the shale member. X-ray data indicate that silica and expandable clays are the primary minerals of these layers. Kaolinite occurs in thin bands, and as a coating in the coal cleat. These layers are laterally extensive, but they vary greatly in thickness and have wavy contacts. A study of heavy minerals reveals such possible volcanic mineral as zircon and rutile. Abundant woody fragments also occur. This suggests that the bentonite beds are tuffaceous in origin, but that they have been reworked by water prior to deposition.

L. V. Hills (1965) has obtained a K/Ar date for a biotite separate from a bentonite in Collins Gulch. This number dates essentially the whole Eocene package at about 46.8 Ma.

ARKOSIC SANDSTONE AND PEBBLE CONGLOMERATE MEMBER: The contact between the shale member and the overlying arkosic sandstone member is gradational. Shale and coal interbeds occur above the first sandstone layers, however, there is a general trend for the unit to coarsen upwards. In outcrop, these sandstones are light coloured, white to buff. Where visible, beds are between 0.5 and 2 metres in thickness, but in many places these units are massive. Pieces of coalified wood occur that are up to a metre in size; they may be oriented randomly or aligned with bedding. Thicker, more resistant units of this member form subdued but recognizable hogback ridges in many places in the basin. No sedimentary structures suitable for current analysis were found. The coarser clastics commonly form lenses within the finer sediments and lower surfaces of some beds are convex downwards, indicating some cut and fill deposition.

In hand specimen, weathered surfaces show a dark yellowish orange (10YR 6/6) colour, while fresh surfaces are white (N9) to pinkish grey (5YR 8/1). Clast sizes range from 0.1 millimetre to 20 millimetres. Clasts are predominantly subangular quartz, a clayey, poorly cemented matrix. Sorting is generally poor, the clasts have high sphericity, and no imbrication is visible.

In thin section, quartz clasts make up about 50 per cent of the rock's volume; lithic fragments make up another 20 per cent; most of the remainder is clay matrix. Hills (1965) also identified plagioclase, microcline, and orthoclase. in the present study, dye was used to mark potassium feldspar. The stain was picked up by mottled, isotropic areas of the thin section contained within residual grain boundaries. This suggests that feldspars in the present sections are fully weathered. The mineral clasts suggest a plutonic component in these sandstones, while the lithic fragments indicate a volcanic component.

Original thickness of this member is unknown; it is truncated by an unconformity. In Collins Gulch it is at least 400 metres; elsewhere, it is thicker.

BASALT CAPROCK: The Tulameen sedimentary rocks are overlain in two places by horizontal flows of basalt. Whole rock K/Ar dating has established the age of these rocks as 9 ± 0.9 Ma. This places the basalts in the same time range as the widespread plateau basalts. The contact between the Tulameen sedimentary rocks and the basalts is an angular unconformity, with a time hiatus of about 35 million years.

The basalts outcrop well and have conspicuous columnar jointing. In the area of main outcrop, there are at least five flow units. Distribution of the basalt is obscured by extensive talus around the main outcrop. Blocks of basalt up to 30 metres across have been observed in Granite Creek. Total area of outcrop for the basalts is about six square kilometres.

In hand specimen, the basalts are aphanitic to porphyritic; some have olivine phenocrysts. They may be massive, vesicular, or amygdaloidal with fillings of chabazite and calcite. Weathered surfaces are greyish red (10R 4/2) to moderate brown (5YR 4/4), fresh surface are medium dark grey (N4). In thin section, the rock is composed generally of about 50 per cent plagioclase needles up to 0.6 millimetre long. Pyroxene occurs interstitially, and phenocrysts of olivine up to 0.8 millimetre in diameter make up the remainder of the rock. The plagioclase groundmass may be random or up to 50 per cent aligned. Total thickness of the basalts is about 100 metres.

NAMING OF THE TULAMEEN SEDIMENTARY ROCKS AND CORRELATION WITH OTHER BASINS: Camsell (1913) originally termed the sedimentary rocks of the Tulameen the "Coldwater Series" (1913, p. 89) and lumped them with other "Coldwater" rocks described by Dawson. By Shaw's time, this name had evidently fallen into disuse and Shaw (1952) suggested that the Tulameen rocks should remain unnamed, as their relationship with the Allenby Formation of the Princeton basin was not established. Hills (1965) also avoided naming these sediments, however, he did establish a time and palynological correlation with the Princeton rocks. This author believes that the Tulameen sediments should be considered as part of the Allenby Formation. The author has therefore referred to the main lithologic subdivisions of the Tulameen sedimentary rocks as "members", using the American Geological Institute's definition of that term.

STRUCTURE: The most prominent structural feature of the Tulameen Coal Basin is the open syncline which gives the Tulameen its basinal form. This fold was first recognized by Camsell (1913), and Shaw (1952) determined its asymmetric nature by contouring the coal horizon. A pi diagram of the structure (Fig. 28) confirms the overall asymmetry of the syncline. The diagram suggests a trend of 138 degrees for the fold axis, with a 15 degree

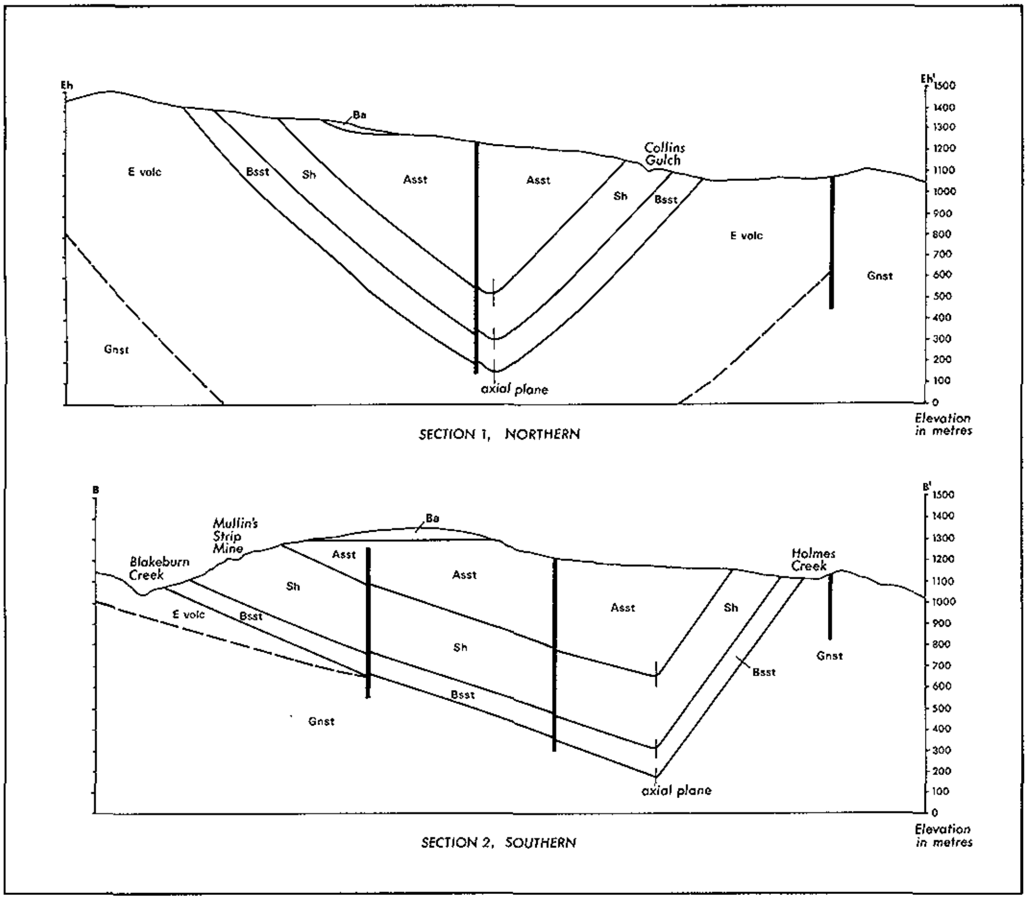


Figure 28. Geological cross-sections, Tulameen coalfield

plunge southeastward. The limbs appear planar, though this may be due to bias in the data collecting; most measurements were taken from the shale member. There is also a lack of data from the hinge area of the fold. The northeastern limb has an average dip of around 55 degrees, and the southwestern limb about 35 degrees.

This simple picture is complicated somewhat along the southwestern limb. In the northwestern sector, the dip of this limb closely approximates that of the northeast limb, 55 degrees. Further southeastward, the dip becomes progressively less, reaching a minimum of 14 degrees in the extreme south of the area. Thus, in the northwest the fold is essentially an open, symmetric syncline. The structure becomes progressively more asymmetric to the southeast.

The structure described above is referred to as a syncline. One locality within the basin with upright graded beds, and load casts, and cut and fill convex bedding surfaces found elsewhere in the basin support the interpretation.

The area is crisscrossed by high-angle faults. These faults are commonly difficult to identify in the field, and much evidence for their existence is drawn from old mine maps and reports.

In spite of these difficulties, numerous faults may be distinguished along the perimeter of the basin. Also, at least a few of them probably extend completely across the basin.

In the Blakeburn area, two major faults were identified by Shaw (1952). The larger of the two trends 42 degrees. It is downthrown to the north, and the fault is occupied by a dyke of unknown composition. Shaw suggested that the dyke was probably basaltic and acted as a feeder for the overlying basalt cap. The dyke does not outcrop. By contouring the Coalmont Collieries mine plans, Shaw determined that this larger fault had a displacement of about 150 metres. However, this fault shows little surface expression. Some apparent displacement may be accounted for by leveling of the southwestern fold limb, and by block rotation in response to the intrusion. True displacement along this fault is therefore not known.

Block displacement is illustrated by a small fault immediately southwest of the one described above. The fault is mapped on the No. 3 mine plans, and is visible on the surface, where it separates the upper and lower sections of the Mullin's Strip Mine. The fault strikes 50 degrees and is downthrown to the southeast. The strike and dip of strata exposed in these two sections differ, as do the outcrop patterns. Each mine face has about the same strike but north of the fault the seam appears horizontal whereas south of it the apparent dip is about 15 metres.

The second fault mapped by Shaw is 500 metres southeast of the above small fault. It was also suggested by mine plans, and apparently displaces Nicola surface outcrops as well. The strike of this fault is 012 degrees; displacement is about 40 metres; and the downthrown side is to the northwest.

To the east, about halfway across the southeastern boundary of the basin, is another fault. This fault is mapped on two criteria. First, there is a pronounced change in the outcrop pattern of the Nicola in this area. Second, there is a lineament along which this discontinuity occurs that extends across Granite Creek. The apparent displacement of the Nicola contact is 200 metres. The lineation strikes 130 degrees, and the downthrown side is to the east.

To the east, roughly parallel this last fault, another lineament forms the northeastern boundary of the sedimentary rocks. This lineament shows up well in airphotographs, and a fault interpretation for it is supported on the ground by the abrupt pinching out of the sedimentary and Eocene volcanic strata along this line. North of the map-area, an intrusive unit is also apparently truncated against this linear. The fault strikes 130 degrees, its displacement is unknown, and its downthrown side is to the west.

The next suspected fault occurs along the line of Fraser Gulch. Basalt scree buries most of the critical outcrop area for this fault, but there is a clear displacement of the sedimentary strata in this area. This fault has a strike of 48 degrees, and aligns well with the main fault between No. 3 and No. 4 mines on the other side of the basin. The faults may be continuous; however, the downthrown side of the Fraser Gulch fault is to the south, the reverse of that of the fault in the southeast corner. Thus, if they are part of the same system, scissoring has occurred. Displacement in Fraser Gulch may be on the order of 250 metres. The timing of this fault relative to the eastern boundary fault, which crosses it here, is not known.

Several watergaps occur in the Eocene volcanic hills around the northern rim of the basin. However, only along the tributary of Manion Creek is there a fault with mappable displacement. This fault strikes 134 degrees, which aligns it with the fault which cuts the southeast boundary. As is Fraser Gulch, apparent displacement of these two faults is opposite, the northwestern fault having a downthrown side to the west. It cannot clearly be stated that these faults are continuous, but if they are, scissoring has again occurred. Offset is about 16 metres.

Other faults, too small to map, occur throughout the basin. Small-scale, high-angle normal and reverse faults, and thrust faults with associated dragfolds are especially visible in the coal seams. Particularly in the Mullin's Strip Mine area the seam seems tectonically thickened and displays complex offset relationships. Along the steep northeastern limb of the syncline, mine adits have found the coal to be pulverized. It is suggested that these faults are the result of differential movement of the rock units during folding. As the coal is the least competent of the rock units, much of this movement was probably taken up in the coal.

The last conspicuous structural features in the field area are joint sets which have developed in the areas of basalt outcrop. These joints form fissures up to 10 metres across and 10 metres deep. These fissures seem to be largely aligned normal to the directions in which retention is least, toward Blakeburn Creek and on the Fraser Gulch side. It has been suggested (R. L. Armstrong, personal communication, 1978) that the sedimentary units are squeezing out slowly under the pressure of the overlying rock. This creates the tensional forces in the caprock which results in the observed joints, and also the extensive scree.

GEOLOGIC HISTORY AND ENVIRONMENTS OF DEPOSITION: The Eocene was a time of extensive volcanism in British Columbia, including the Tulameen area. In the Tulameen area, the eruptions deposited a series of andesite flows and volcaniclastic rocks onto a terrain underlain by the Triassic Nicola greenstones. The surface onto which the volcanic rocks extruded was probably of moderate relief, some 300 metres in the Princeton area, according to McMechan (1975) with structure and drainage trending northwest to southeast. Lava flows seem to be concentrated along the northwest rim of the present basin, flanked to the east and south by volcaniclastic rocks. Also, in the south sedimentary units were deposited directly on the Nicola basement. This suggests that the centre of volcanism was to the northwest, however, since the basin is fault bounded to the east, the location of the centre is not definite.

The volcanic rocks provided a ready source of material for detritus and sedimentary rocks formed locally throughout the period of volcanism. Camsell (1913) even reports the occurrence of coal within the volcanic sequence. By Middle Eocene times, volcanism had waned, and sedimentation became dominant. The exact nature of the depositional basin is difficult to determine. It may have been a graben-like valley, as the conformable contact between the volcanic and the sedimentary rocks does not suggest folding. The presence of an alluvial fan on the western margin suggests that, at least during deposition of the lithic sandstone, the location of the basin boundary was similar to the present boundary.

Since the lithic fragments appear to be derived mainly from the Eocene volcanic rocks, current direction was probably southeastward. The fining of the sequence upward indicates an active flowing water regime, with water velocities decreasing as the streams aggraded their channels.

With the beginning of the deposition of the shale member, a relatively quiet period of accumulation began. Only occasional eruptions of tephra signal volcanic activity. Coal formation began almost at once, as indicated by the occurrence of coal directly overlying the uppermost lithic sandstone unit in drill core T-77-3. Palynological data from Hills (1965) suggest that the environment was one of a lowland bordered by hills. Climate in the lowland was subtropical, while the hills produced a cool temperate vegetation. Relief sufficient to produce this difference is on the order of 300 metres (Rouse, personal communication, 1978).

It seems likely that the lowland was a slowly subsiding river valley, with a limnic environment for the formation of the coals. Shaw (1952) suggested that volcanic eruptions may have dammed the valley to create the required lake. This seems unlikely, as volcanism had waned greatly by the time of deposition of the shale member. Also, the occurrence of coal throughout the member suggests slow subsidence and relatively constant watertable conditions.

The question remains, however, whether the basin was a broad, open limnic basin formed in a syncline, or a narrow, confined basin, as found in a graben. Using the criteria of Hacquebard and Donaldson (1967, 1968), the Tulameen appears to fit most closely into the graben model. The shales are uniformly fissile and contain small, sharp folds and numerous faults. The main coal seams are thick and continuous throughout the basin, and the coal rapidly deteriorates in rank while increasing in shale content in a lateral direction.

This model does not fit perfectly. The coals of the Tulameen contain up to 90 per cent vitrinite (Donaldson, 1973; this study). This is much more than the 40 per cent reported for the graben-formed Pictou field (Hacquebard and Donaldson, 1967) and suggests an open fold basin. Also, the microlithotypes and the presence of pyrite in the coal suggest an open basin. Finally, the occurrence of apparently reworked tephra layers further indicates flowing water.

The picture which emerges, then, is one of a limnic valley formed in a graben. The graben was not enclosed, but allowed inflow and outflow. The valley was surrounded by hills with a relief of about 300 metres. The graben is oriented northwest to southeast, and the reduction in rank of the coal to the northeast indicates that boundary was about the same place as it is now. To the south and west, the coal appears to get both thicker and cleaner. It is thought that the southwestern portion of the basin originally extended farther than today's basin, which has been truncated by erosion. Southeastward extent is unknown.

Conditions changed drastically after the quiescent period. Renewed uplift to the north may have been the cause of this change, but this is uncertain. In any case an inflood of new coarse clastic material occurred, which buried and preserved the earlier sediments. These new clastics are predominantly coarse-grained quartz and other minerals derived from a plutonic origin. Lithic fragments from a volcanic terrain also occur that may be of local derivation, or may be from farther north. Hills (1965) suggested that the transport direction was from the north. The present study has uncovered nothing to change this view.

Erosion precludes a determination of the original thickness of the arkose. However, coalification rank indicates a depth of burial for the shale of at least 3 000 to 4 000 metres. It was probably during this time of deep burial that folding and faulting took place. Uplift and exposure by erosion followed. At about 9 million years ago, late stages of plateau volcanism reburied the area under at least five flows, totalling 100 metres, of flood basalt. During Pleistocene time the area was completely inundated by glaciers. At maximum, the ice surface in this area was perhaps 2 500 metres above sea level. Upon retreat, the glaciers left rounded, rolling topography, U-shaped valleys, but only thin and scattered areas of till cover. Granite Creek has subsequently re-established its V-profile, and the oversteepened edges of the basalt plateau have collapsed to form scree aprons.

ACKNOWLEDGMENTS: The author would like to thank Cypress-Anvil Corporation, Ltd., and especially their coal geologist Tom Adamson, for making available the extensive data collected in their exploration program in the Tulameen area. I would also like to acknowledge the effort of my field assistant, Diane MacFarlane. Finally, I am grateful to the numerous professors and students who have acted as sounding boards for my ideas. First among these are W. H. Mathews, G. E. Rouse, and M. A. Barnes. Others include R. L. Armstrong, M. Bustin, Paulette Bond, Eilene Williams, D. Grieve, and others.

REFERENCES

Camsell, C. (1913): Geology and Mineral Deposits of the Tulameen District, B.C. *Geol. Surv., Canada,* Mem. 26.

Donaldson, J. R. (1973): The Petrography of the Coal from the Blakeburn Strip Mine in the Tulameen Coal Area, British Columbia. *Geol. Surv., Canada,* Paper 72–39.

Hacquebard, P. A., and Donaldson, J. R. (1967): Petrology of Canadian Coals in Relation to Environment of Deposition, Symposium on the Science and Technology of Coal, Mines Branch, *Dept. of Energy, Mines and Resources,* pp. 84–97.

Hills, L. V. (1965): Palynology and Age of the Early Tertiary Basins, Interior of British Columbia, unpublished Ph.D. Thesis, Dept. of Geology, *University of Alberta.*

McMechan, R. D. (1976): Princeton Basin, Geological Fieldwork, 1975, Paper 1976–1, *B.C. Ministry of Energy, Mines & Pet. Res.,* pp. 99–103.

Shaw, W. S. (1952): Princeton Coalfield, British Columbia, *Geol. Surv., Canada,* Paper 52–12.

1977 — HIGHMONT (IDE, AM)
(921/6)

By Alan Reed, Consultant, Highmont Mining Corporation
and
Gordon P. E. White, British Columbia Ministry of Energy, Mines and Petroleum Resources

INTRODUCTION: The property is located at latitude 50 degrees 26 minutes and longitude 121 degrees 01 minutes on the south side of the Highland Valley, on the northwest flank of Gnawed Mountain at an elevation of approximately 1 650 metres (Fig. 29). The property consists of claims IDE, NM, NEW IDE, ANN, KEN, LYNN, KENNCO SHEBA, and NEW MINEX that are owned by Highmont Mining Corporation Ltd.

During 1977 four NQ diamond-drill holes totalling 1 071 metres (3,264 feet) were drilled on the IDE 7 and AM 6 Fraction (Fig. 30).

DESCRIPTION: The following numbered drill holes penetrated the Skeena phase of the Guichon Creek batholith:

HOLE NUMBER	AZIMUTH degrees	INCLINATION degrees	LENGTH metres
77-1	270	−45	268
77-2	270	−45	261
77-3	090	−45	260
77-4	270	−43	282

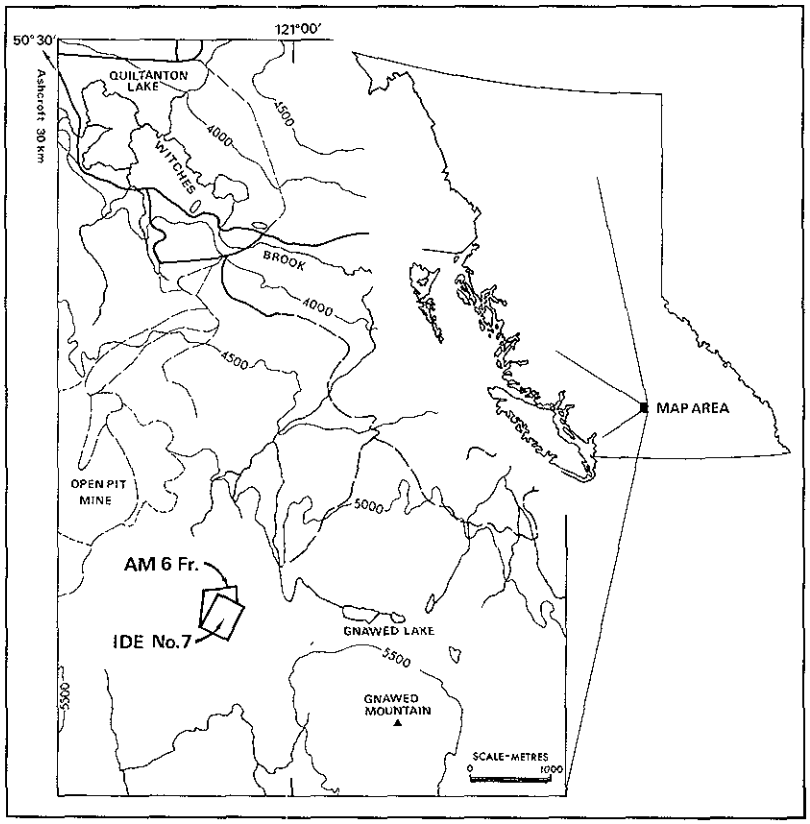


Figure 29. Location maps of Highmont deposit

After logging, the drill core was split longitudinally and one half the core was assayed in 3.3-metre (10-foot) sections at Afton Mines Ltd.; the other half of the core is stored near the 5400 level adit on the Highmont property.

Quartz, bornite, and molybdenite or quartz, chalcopyrite, and molybdenite are found on fracture surfaces in Skeena quartz diorite phase of the Guichon Creek batholith. Less frequently but also on fracture surfaces in the quartz diorite, chlorite, hematite, epidote, calcite, serpentine, gypsum, sericite, and potassium feldspar are present. Pyrite is present occasionally on fractures or as fine-grained disseminations. Tourmaline and molybdenite were recorded in diamond-drill hole 77-3 at 128.6 metres (395 feet).

Drill intersections of the Molly No. 1 and Molly No. 2 zones returned assays as follows:

HOLE NUMBER	DRILL POSITION metres (feet)	COPPER per cent	MOLYBDENITE per cent
77-1	179.8–195.1 (590–640)	0.033	0.048
77-1	234.7–246.9 (770–810)	0.084	0.060
77-1	256.0–267.6 (840–878)	0.009	0.070
77-2	149.4–161.5 (490–530)	0.112	0.189
77-4	216.5–219.5 (710–720)	0.316	0.339
77-3	189.0–195.1 (620–640)	0.094	0.193

REFERENCES: Assessment Report 6556.

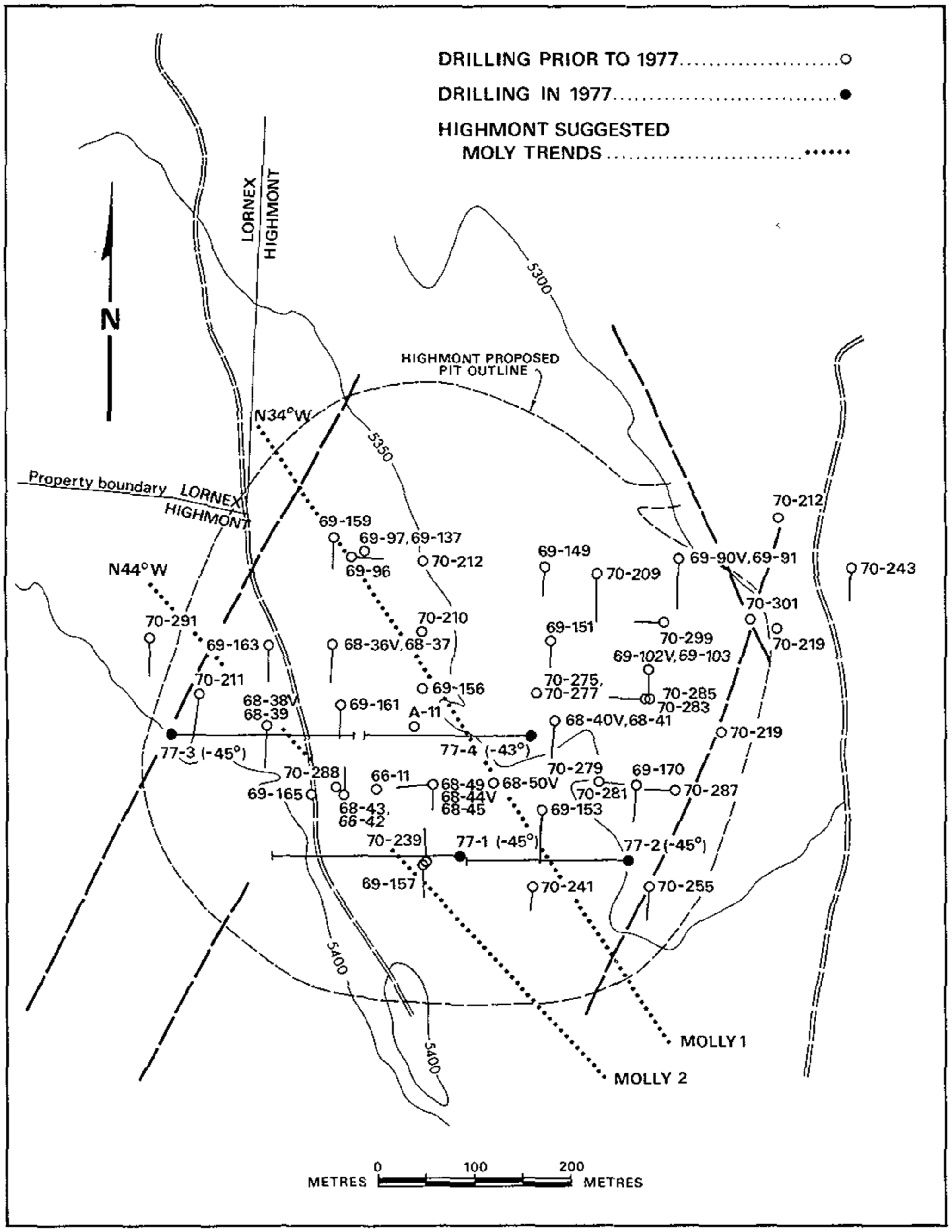


Figure 30. Drill hole plan, Highmont deposit

1978 — A REPORT ON THE GEOLOGY OF THE CACHE CREEK-NICOLA CONTACT SOUTHWEST OF ASHCROFT (92I/11)

By John H. Ladd

INTRODUCTION: Geologic mapping, on the scale of 4 inches = 1 mile (1:15 840) was conducted during the summer of 1977 in a 74-square-kilometre area southwest of Ashcroft. This area is bounded on the east by the Thompson River between Oregon Jack and Minaberriet Creeks, then the Trans-Canada Highway north to Cornwall Creek (Fig. 31). The northern boundary runs from roughly 1 kilometre north of Cornwall Creek where it crosses the Trans-Canada Highway, westerly for 5 kilometres to the summit of a 4,000-foot hill south of the creek. The western boundary is located part way up the east face of Cornwall Hills and the southern boundary is just south of Oregon Jack Creek. The Pennsylvanian-Permian Cache Creek Group, the Triassic Nicola Group, the Jurassic Ashcroft Formation, Mesozoic intrusions, and possible Tertiary volcanic rocks are found within the area.

The purpose of mapping in this region is twofold. First, Danner (1975) suggests that the Cache Creek-Nicola contact is of great importance because it juxtaposes two rock groups whose faunal groups represent radically different depositional environments. The Nicola Group contains normal North American fusilinids but the fusilinids of the Cache Creek Group are a warm water Tethyan variety. This contact has recently been mapped in detail on either side of the area by Travers (1978) and Grette (1977). Thus this project fills in the gap between those two areas. Second, this region is also the site of numerous copper showings. The location and nature of each showing was determined.

This area was mapped previously by Duffell and McTaggart (1952) at a scale of 1 inch to 4 miles. The southeastern portion of the area was included on a more detailed map by Carr (1962).

Access to the area is provided by the Trans-Canada Highway and the public road which runs west from the highway to Hat Creek Valley. Additional access is available on ranch roads. Thick vegetation hampered fieldwork only in areas above 3,000 feet elevation in Cornwall Hills. Areas between outcrops below this elevation are covered by Quaternary sediments.

ROCK DESCRIPTIONS

CACHE CREEK GROUP: The Cache Creek Group contains a wide variety of rock types and shows considerable variation in structural style and metamorphic grade. As a result, several of the six map units are very inhomogeneous. However, the rocks within each unit share a common structural style and each could best be described as a tectonostratigraphic unit.

The ultramafic unit consists of several small outcrops of serpentinite. The original composition of the rock is unknown; no original textures survived serpentinization.

The mafic unit includes gabbro, basalt porphyry, basalt, and greenschist. The gabbro is medium grained, green and white or black rock, that sometimes shows a layered structure. It consists primarily of plagioclase, pyroxene, and amphibole. Sericite and chlorite alteration is extensive but many of original crystal outlines are recognizable. The basalt porphyry contains altered and broken phenocrysts of plagioclase, olivine, pyroxene, and amphibole in a fine-grained matrix. The basalt is a uniform fine-grained green rock. The basalt is not foliated and, where grains are large enough to be seen in thin section,

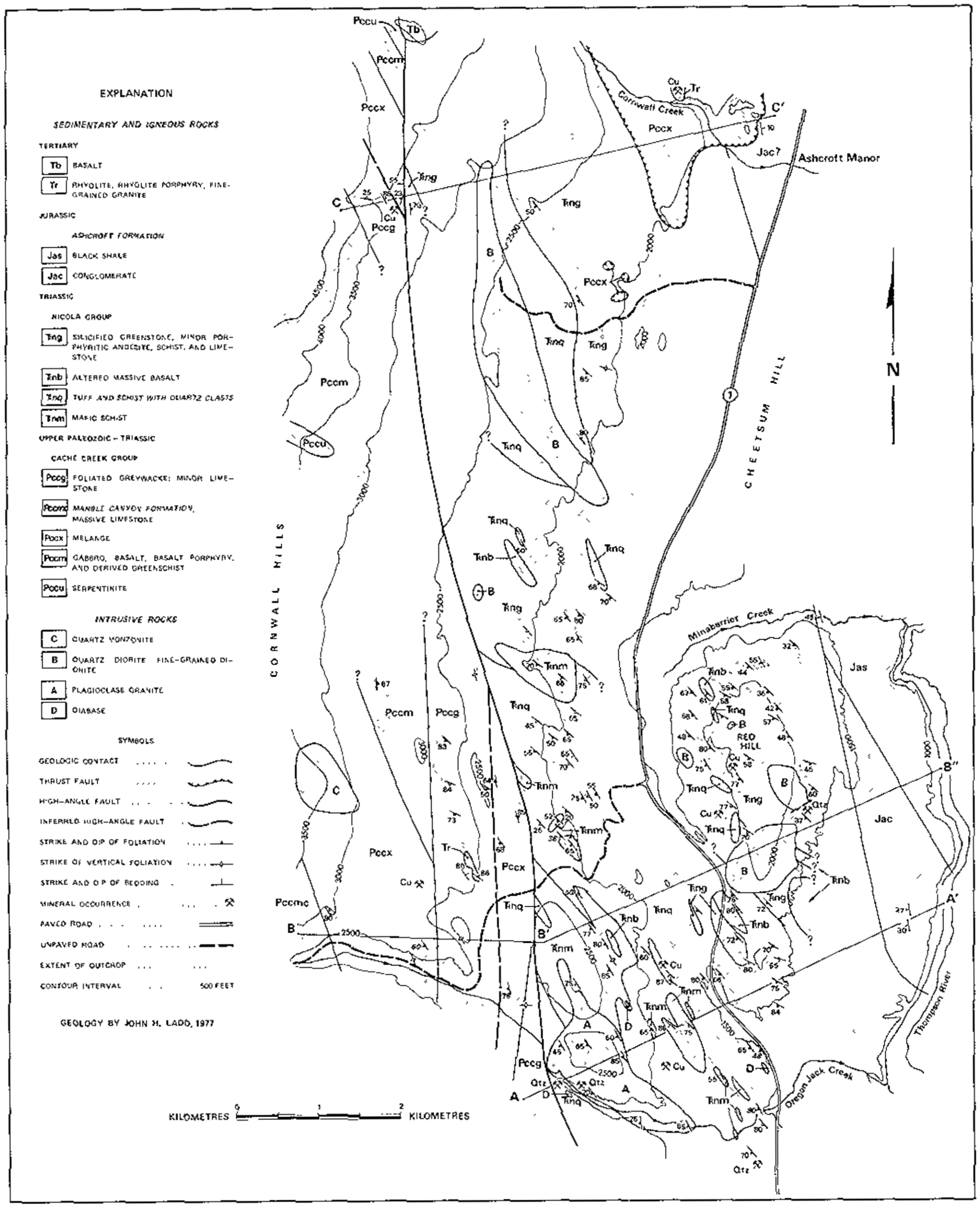


Figure 31. Geology of the Red Hill area

consists primarily of plagioclase with lesser amounts of pyroxene and amphibole. The southernmost outcrops in this unit are greenschists. Chlorite makes up the bulk of the rock and only minor amounts of plagioclase and amphibole are present. The greenschist outcrops are presumably the metamorphic derivatives of gabbro and basalt found further north. All outcrops in the mafic unit are massive and they are often cliff-forming with cliffs that range up to 300 metres in height.

The Marble Canyon Formation is the name applied by Duffell and McTaggart (1952) to thick, massive limestones within the Cache Creek Group. Their term is applied here to outcroppings of massive limestone in the southwestern corner of the map-area which appear to be connected with other massive limestone outcrops farther to the west. The limestone is clean and contains no macrofossils. It is light grey on a fresh surface and white where weathered.

The melange unit consists of massive blocks of rock of numerous types lying in a highly sheared and deformed matrix. Clasts in this unit appear to be derived from the mafic unit and the Marble Canyon Formation. In the northeastern corner of the map-area, the melange matrix consists of highly deformed black argillite and there are blocks of massive basalt, pillow breccia, grey chert, and clean limestone. The argillite often has a striped appearance as a result of white quartz or chert bands within it. These "stripes" are also deformed. Blocks of massive rock in the melange range in size from 50 square metres to 100 metres by 1 kilometre. Along Oregon Jack Creek, most blocks within the melange consist of zeolite-bearing vesicular basalt or augite basalt porphyry. The augite phenocrysts are altered to analcime. On average the blocks are much smaller than in the northern melange outcrops; many are only a few metres long. In some outcrops blocks are surrounded by a sheared matrix of the same composition, while in others the deformed matrix is black cherty argillite. This cherty argillite is relatively well indurated compared to the argillite in the north, and is complexly folded and faulted.

The final map unit within the Cache Creek Group is a volcaniclastic semischist. In the field it consists of well-foliated grey schist or massive grey rock. No alteration is evident. The samples that were collected are highly weathered but contain mainly quartz and feldspar. The foliation in the rock is caused by bands of mica, subparallel cracks filled with calcite and siderite, and the preferred orientation of larger grains in the fine-grained groundmass. Massive zones in the unit are greywacke and there are also lenses of limestone within this unit.

NICOLA GROUP: The Nicola Group consists primarily of volcanic flows and volcaniclastic sedimentary rocks. Different rock types grade into each other, are extensively interbedded, and are affected in varying degrees by metamorphism. As a result, it is impossible to clearly group rocks into different units. However, a classification with four general subdivisions is proposed. The most distinctive Nicola Group unit is tuffaceous and characterized by large quartz grains. Some tuffs are rhyolitic and white in colour with a matrix of microcrystalline quartz and feldspar. Others are dacitic and green in colour, with a matrix of microcrystalline chlorite, quartz, and feldspar. Outcrops are variably massive to schistose. The degree to which the schistosity is developed fluctuates across section, which suggests that it is controlled by composition, not metamorphic conditions. The schistosity is produced by alternating layers of sericite and muscovite within the matrix; it postdates the quartz grains. In some samples there are also a few orthoclase phenocrysts.

The mafic schists are derived from mafic volcanic rock, presumably basalt. Most is green coloured in hand sample. Generally the schists are chlorite rich but a few outcrops within the unit are grey and rich in an as yet undetermined mineral. The schistosity is produced by irregular and subparallel bands of chlorite. In some samples there are relict phenocrysts of either plagioclase, pyroxene, or pseudomorphs of those minerals.

The silicified greenstone unit contains a wide variety of rock types. In general, rocks within this unit are more intensely altered than other Nicola rocks. Alteration to chlorite and epidote is responsible for the green colour. Most outcrops contain abundant secondary chert, consequently many outcrops look like green chert. In thin section the chert is seen to consist of microcrystalline interlocking quartz grains that act as a matrix for larger grains of varying mineralogy. The presence of plagioclase phenocrysts in many samples suggests that much of this unit is the metamorphic equivalent of plagioclase andesite which is common elsewhere in the Nicola Group. Numerous relict pyroxenes or amphiboles are present in other samples suggesting that they were originally basalt. Several outcrops have been bleached white, so that they resemble the quartz-eye tuff — but they have no quartz eyes. Outcrops of this type are especially common near gossan zones. Foliation is present in some outcrops but not in others. It is evidently compositionally controlled because distinctive beds of schist in unfoliated rock can be traced for nearly a kilometre. Minor occurrences of dirty, recrystallized limestone were found within this unit on the east side of Red Hill.

The final Nicola map unit is altered massive basalt. Because it is massive, the basalt tends to form small cliffs. Although generally chloritized, the basalt is not epidotized and not silicified. The main mineral constituents are feldspar and chlorite.

ASHCROFT FORMATION: The Ashcroft Formation consists of conglomerate and black shale. The conglomerate contains large but well-rounded cobbles that are generally 5 centimetres in diameter but range up to 20 centimetres. Some clasts are identical to rocks found in nearby Nicola outcrops, including silicified greenstone and plagioclase andesite. Other clasts are greywackes, porphyries of various composition, and limestone. The matrix is a fine-grained, rust-coloured sandstone and is so well indurated that the outcrop surfaces break off across cobbles instead of around them. The shale is fine grained and black and locally shows well-developed slaty cleavage.

TERTIARY (?) ROCKS: Two units have been found that are tentatively classified as being of Tertiary age. One is a massive pale grey-blue vesicular basalt which caps the summit of a 4 000-foot hill in the northwestern corner of the map-area. It shows no alteration or deformation, and overlies serpentinite of the Cache Creek Group. The other unit consists of isolated occurrences of rhyolite, rhyolite porphyry, and microcrystalline granite which crop out in the Cache Creek Group. They too are unaltered, undeformed, and show no relationship to the surrounding structure, so they are interpreted to be a younger rock.

INTRUSIVE ROCKS: Three types of intermediate to felsic plutonic rocks were found. The evidence suggests that they are not related. An alkaline granite pluton crops out along Oregon Jack Creek. It has a porphyritic-phaneritic texture. The large grains are almost entirely quartz, similar to those in Nicola quartz-eye tuffs. Smaller grains are roughly equal parts plagioclase and orthoclase with lesser amounts of quartz. Sometimes chlorite and muscovite are present. The plagioclase ranges from oligoclase to andesine (An_{30} on average), and comprises about 25 per cent of the rock. This is unusually high for a granite, so it is possible that this rock is an albitized granodiorite. The pluton has been sheared so it has a well-developed cleavage in all localities. In certain areas, where it interfingers with Nicola mafic schist, it is a mylonite.

The string of plutons on Red Hill and east of the Trans-Canada Highway to the northwest is granodiorite, quartz diorite, and microdiorite. The granodiorite and quartz diorite are similar in all respects except that the former contains slightly more than 20 per cent quartz and the latter slightly less. The rock is medium to coarse grained. Despite being intensely altered, it is massive and unfoliated. Besides quartz, the rock contains plagioclase and orthoclase, both intensely sericitized. Together these two minerals make up about 50 per cent of the rock. Plagioclase in the collected samples is too altered to determine the An content. The remainder of the rock is partially altered amphibole and pyroxene, chlorite, and epidote. Many outcrops contain abundant mafic inclusions. These are fine grained and contain sericitized feldspar, amphibole, and chlorite. In outcrop they form irregular green areas, usually a few tens of centimetres across. Boundaries between the inclusions and the felsic rock are jagged, but show no evidence of chemical interaction. The microdiorite is a fine-grained rock consisting largely of sericitized feldspar with lesser amounts of chlorite and a few quartz and epidote grains.

On Cornwall Hill a quartz monzonite pluton outcrops in a large cliff. This rock is coarsely crystalline, unaltered, and unfoliated. It contains generally 50 per cent or more plagioclase with lesser amounts of quartz, orthoclase, and biotite. The average plagioclase composition is An_{36}. A later stage rock, which consists of plagioclase and quartz, intrudes the biotite-bearing rock in one locality. Included in this later stage unit is a nearby felsic, welded tuff that appears to be associated with the pluton. It is fine grained and pale green, with a layering which locally shows a swirl structure. Most of the rock appears to be glass or cemented ash, with tiny needle-shaped plagioclase grains.

Several small diabase dykes intrude Nicola Group rocks. In hand sample the diabase is fine to medium grained and speckled with white and dark green grains. The rock contains on average 65 to 75 per cent plagioclase; the rest is clinopyroxene. There are lesser amounts of chlorite and pyrite.

STRUCTURAL GEOLOGY AND METAMORPHISM

CACHE CREEK GROUP: The style of deformation and degree of metamorphism vary considerably between different units within the Cache Creek Group. The volcaniclastic semischist, with only an undeformed foliation, shows the least intense deformation. Many blocks within the melange unit appear undeformed, but the matrix that surrounds them is highly sheared. The juxtaposition of a wide variety of rock types also suggests that significant movement has occurred. If the serpentinite, gabbro, basalt, and pillow breccia are ophiolites, they represent a section of oceanic crust which may have been fault emplaced. It is likely, therefore, that the different units within the Cache Creek Group are separated by faults. The linear trend to the map pattern of the different units also suggests that the Cache Creek Group might be made up of several elongate fault slices. The volcaniclastic semischist unit might have been sediment deposited between the fault blocks. This would explain that unit's less deformed nature. In the only occurrence of graded bedding found in the semischist, the outcrop is right side up.

NICOLA GROUP: No evidence of small or large-scale folding was found within the Nicola Group, although there are numerous kink bands. Most evidence of bedding and all sedimentary structures in the area were destroyed. However, most of the rocks show a cleavage which generally strikes north 20 degrees west to north 40 degrees west and dips 50 to 70 degrees southwest. Contacts between the different units are parallel or subparallel to the cleavage, so it is assumed that the cleavage surface gives an estimate of the bedding surface. If this is the case, then the Nicola Group forms a large upturned block dipping to the southwest. Carr (1962) and McMillan (1975) also found the Nicola Group on the east side of the Thompson River to be a large upturned northwest-dipping block. Although chlorite alteration is pervasive throughout the Nicola Group, significant epidote alteration, silicification, and gossans are restricted to rocks near the granodiorite-quartz diorite-microdiorite plutons, and are particularly impressive on Red Hill, which has several outcrops of granitic rocks. There are also gossan zones immediately northwest of Red Hill and along Oregon Jack Creek near the plagioclase granite pluton. The band that has epidote alteration, silicification, and a high density of gossan zones includes all of the dioritic plutons, approximately parallels the strike of the Nicola cleavage, and parallels the direction of elongation of the large pluton west of the Trans-Canada Highway and northwest of Red Hill. Perhaps the altered rocks are remnants of roof rocks over an extensive elongate pluton. The trend of this inferred pluton lines up with the Spatsum pluton east of the Thompson River.

ASHCROFT FORMATION: Bedding in the Ashcroft Formation generally strikes north 5 degrees west to north 15 degrees west and dips 25 to 35 degrees southwest. In one locality grading between a sandstone layer and a conglomerate indicates that bedding is right side up. Therefore it appears that the conglomerate overlies black shales exposed along Thompson River. However, outcrops of conglomerate are separated by more than a kilometre from the shale outcrops, and it is possible that the structural relationship between the two units is more complex.

CONTACT RELATIONSHIPS: The Cache Creek Group is thrust over the Nicola Group and the Ashcroft Formation. The main contact between Cache Creek and Nicola Groups runs north-northwest through the western section of the map-area. For the most part, it is covered by Quaternary sediments but in the one outcrop where it is exposed, highly deformed Cache Creek black argillite lies over Nicola greenstone. The fault plane at that locality strikes north 15 degrees west and dips 55 degrees southwest. In the northeastern corner of the map-area, several detached klippen of Cache Creek rock lie directly over various Nicola rocks. These detached blocks lie 2 to 3 kilometres east of the main contact. The smaller, more southern blocks are clean massive limestone like that of the Marble Canyon Formation. Near these blocks is an outcrop of Nicola Group plagioclase andesite. This is the only outcrop where highly deformed Nicola Group rocks are seen, which suggests they were deformed during emplacement of the block. The large klippen at the northern edge of the map-area contains massive limestone, grey chert, basalt, pillow breccia, and black argillite. Immediately west of the Trans-Canada Highway and north of Cornwall Creek, Cache Creek limestone overlies poorly indurated conglomerate. This conglomerate strongly resembles Ashcroft Formation conglomerate mapped by Travers (1978) 2 kilometres to the southeast.

The Nicola-Ashcroft contact is not exposed in the map-area. Because the orientation of beds in the Nicola Group is different than that in the Ashcroft Formation, the contact must either be an angular unconformity or a fault. Because Ashcroft conglomerates contain Nicola clasts and are presumably stream deposits, it is likely that they were deposited in channels in Nicola Group rocks. Thus the contact is probably an angular unconformity.

The plagioclase granite pluton shows a variable relationship with the surrounding country rock. On the east side, it appears to grade into the quartz-eye tuff. This suggests that the granite was emplaced and the tuff deposited during the same volcanic event and therefore that the granite is a hypabyssal intrusion. To the north the granite is in fault contact with mafic schist of the Nicola Group. The granite is tectonically interfingered with the schist and both are extensively sheared. To the southwest, the pluton is in intrusive contact with the quartz-eye tuff.

Small bodies of granodiorite to quartz diorite to microdiorite intrude the country rock. Epidote alteration and silicification are widespread and country rock in direct contact with the plutonic rock shows the greatest degree of metamorphism. In one locality, on the east side of Red Hill, thick quartz veins mark the contact between the pluton and the country rock.

The contact between the quartz monzonite pluton and the Cache Creek Group is not exposed.

MINERALIZATION: Copper showings occur in both the Nicola and Cache Creek Groups. The most impressive showing is exposed in an old pit near the summit of Red Hill. Chalcopyrite occurs with pyrite and quartz in veins which strike north 60 degrees east and are exposed for about 15 metres. They are at an angle to the strike of the cleavage. The veins are in Nicola greenstone which has been subjected to intense epidote alteration, chloritization, and bleaching. Secondary copper minerals, predominantly malachite and azurite, are widespread in the greenstone. At the base of the west side of Red Hill, there is a minor showing of malachite and azurite in a gossan zone. In general, however, the gossan zones are devoid of copper mineralization at the surface. Two minor showings of copper occur in the quartz-eye tuff unit, about 1 kilometre east of the plagioclase granite pluton. The more northerly showing consists of chalcopyrite partially altered to malachite in a narrow quartz vein. Malachite and azurite were also found in a small outcrop of quartz-eye tuff about 2 kilometres to the south. Pyrite is associated with all these deposits.

Copper showings are found in two principal locations in the Cache Creek Group. An isolated knob, 1 kilometre north of Oregon Jack Creek, rises about 25 metres above the surroundings. It consists of a massive white to light brown-coloured rock made up primarily of siderite with lesser amounts of quartz. Small areas carry 1 to 3 per cent chalcopyrite which has been partially altered to malachite which produces irregular blue bands throughout the rock. The siderite-quartz body is surrounded by altered limestone that is part of a melange unit in the Cache Creek Group. The quartz-siderite body is approximately circular in plan. In the northwestern corner of the map-area, two similar chalcopyrite-bearing "dykes" were found. These "dykes" are subvertical and strike north 2 degrees west and north 25 degrees west. Chalcopyrite in them is partially altered to malachite.

Chalcopyrite-bearing sodic rhyolite porphyry of Tertiary (?) age forms one large outcrop in Cornwall Creek. Chalcopyrite and pyrite are evenly disseminated throughout the rock. Pyrite is also found but there is no malachite.

Although copper minerals are found in fairly high concentrations, especially at Red Hill and on the knob north of Oregon Jack Creek, judging from evidence at surface, the showings are of small size. Therefore it is unlikely that any of these deposits will be economically viable.

Swarms of large dyke-like bodies of quartz are found in two localities and might be of economic interest. The largest number are found along Oregon Jack Creek near the margin of the plagioclase granite pluton. Much quartz is found as debris in talus slopes, but "dykes" that are in place strike northwest toward the interior of the pluton. These quartz "dykes" are generally a few metres in width. A few others of similar size are located on the east side of Red Hill along the margin of the quartz diorite intrusion.

REFERENCES

Carr, J. M. (1962): Geology of Part of the Thompson River Valley Between Ashcroft and Spences Bridge, *Minister of Mines, B.C.*, Ann. Rept., 1962, pp. 28–46.

Danner, W. R. (1975): Notes on the Cache Creek Group, Mimeograph Sheet for a Field Trip to the Western Intermontane Belt, 4 pp.

Duffell, S. and McTaggart, K. C. (1952): Ashcroft Map-Area, British Columbia, *Geol. Surv., Canada*, Mem. 262, 122 pp.

Grette, J. F. (1979): Cache Creek and Nicola Group Rocks near Ashcroft, British Columbia, M.Sc. thesis, *University of British Columbia.*

McMillan, W. J. (1975): Stratigraphic Section from the Jurassic Ashcroft Formation and Triassic Nicola Group Contiguous to the Guichon Creek Batholith, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1974, Paper 1975-1, pp. 27–34.

Travers, W. B. (1978): Overturned Nicola and Ashcroft Strata and Their Relation to the Cache Creek Group, Southwestern Intermontane Belt, British Columbia, *Cdn. Jour. Earth Sci.*, Vol. 15, pp.; 99–116.

1978—GEOLOGY OF THE CALLAGHAN CREEK ROOF PENDANT (92J/3)

By J. H. L. Miller and A. J. Sinclair
Department of Geological Science, The University of British Columbia

The Callaghan Creek roof pendant, approximately 110 kilometres north of Vancouver, is in the Vancouver Mining Division. The map-area is about 26 square kilometres (10 square miles) centred on latitude 50 degrees 07 minutes north and longitude 123 degrees 06 minutes west (NTS 92J/3). It is bounded on the south by Highway 99, about 50 kilometres north of Squamish. The eastern and western margins are formed by contacts of the roof pendant with the Coast Plutonic Complex, as is much of the northern margin. Two mining operations are located within the area. Northair Mines Ltd. has its mine site on the east side of Callaghan Creek at an elevation of 990 metres, approximately 10 kilometres north of Highway 99. Van Silver Explorations Ltd. has a mill 1 kilometre north of Highway 99 on the east side of Brandywine Creek.

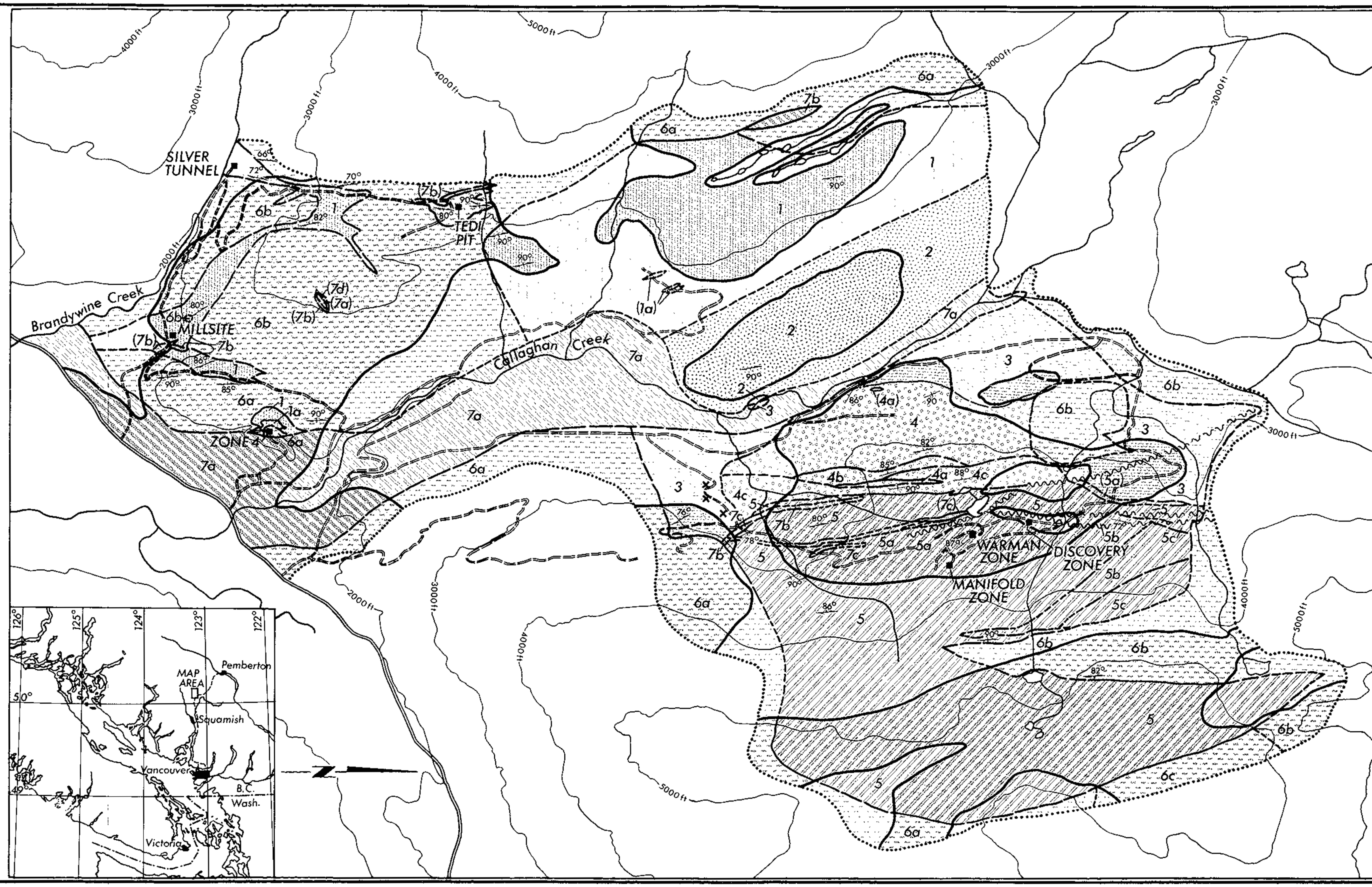
Callaghan Creek roof pendant is one of many northwesterly trending volcanic and volcanic-sedimentary pendants within the southern part of the Coast Plutonic Complex (Fig. 32). The pendant rocks are variably metamorphosed and commonly characterized by a strong northwesterly trending foliation. The Coast Plutonic Complex in the area consists of many plutons ranging in composition from diorite through quartz diorite to quartz monzonite. A western zone of intrusions is predominantly Cretaceous whereas an eastern zone is Early Tertiary. Contacts between roof pendants and surrounding plutonic rocks are sharp; commonly they are narrow shear zones subparallel to the main foliation of the roof pendant. Several centres of Tertiary volcanic rocks form a north by northwesterly trending belt containing local flow and pyroclastic accumulations with basaltic to rhyolitic compositions. Mesozoic volcanic rocks in the map-area (units 1 to 5 inclusive) are thought to correlate with the Gambier Group of presumed Early Cretaceous age (Roddick and Woodsworth, 1975).

Greenstone (unit 1) is dark grey-green, fine grained, well sheared, and primarily andesitic in composition. Marble (unit la) occurs as several moderately sheared pods that are interbedded with greenstone and chert layers, varying from 1 millimetre to 1 metre in thickness, within unit 1. Skarn minerals and sulphides of economic interest occur within the southernmost pod.

Andesitic agglomerate (unit 2) is a massive, epiclastic rock containing 30 per cent dark grey-green matrix; the remainder is composed of dark grey-green, porphyritic fragments and slightly less abundant medium grey-green, dacite fragments. The fragments are well rounded to subangular, are commonly ovoid in shape, and are up to 1 metre in diameter.

Andesitic crystal tuff (unit 3) is a dark grey, fine-grained rock containing abundant subhedral, zoned plagioclase clasts and less abundant subhedral hornblende clasts. The clasts average 1 centimetre in length and generally comprise approximately 20 per cent of the rock. Locally they show variations from 5 to 40 per cent within a distance of 10 centimetres. Small hornblendite dykes crosscut southern exposures of andesitic crystal tuff and are assumed to represent a feeder zone for unit 3. Hornblende within the dykes has a K/Ar model age of 127 ± 4 Ma.

Matrix-supported dacitic agglomerate (unit 4) is a massive, epiclastic rock consisting of 50 per cent medium grey-green matrix and 50 per cent medium to light grey-green, dacitic to rhyodacitic fragments. The fragments are subangular, elongate, and up to 30 centimetres in length. Crossbedding and graded bedding observed in the basal section of this unit



LEGEND

PLEISTOCENE TO TERTIARY

7 — **GARIBALDI GROUP:** (a) OLIVINE BASALT; (b) EQUIGRANULAR RHYODACITE; (c) PORPHYRITIC RHYODACITE; (d) BRECCIA

CRETACEOUS TO UPPER JURASSIC

6 — **COAST PLUTONIC COMPLEX:** (a) QUARTZ DIORITE WITH MINOR DIORITE; (b) HORNBLENDE DIORITE WITH MINOR HORNBLENDE QUARTZ DIORITE; (c) GRANODIORITE

GAMBIER GROUP (?)

5 — **ANDESITIC AGGLOMERATE:** (a) EPICLASTIC VOLCANIC BRECCIA; (b) ARKOSIC WACKES WITH MINOR INTERBEDDED MUDSTONES; (c) ANDESITIC CRYSTAL TUFF

4 — **DACITIC AGGLOMERATE, MATRIX SUPPORTED:** (a) SILICEOUS SILTSTONE; (b) DACITIC AGGLOMERATE, FRAGMENT SUPPORTED; (c) TUFFACEOUS SANDSTONES AND SILTSTONES WITH MINOR INTERBEDDED RHYOLITIC TUFF

3 — **ANDESITIC CRYSTAL TUFF:** (x) HORNBLENDITE DYKE (124±4 Ma)

2 — **ANDESITIC AGGLOMERATE**

1 — **GREENSTONE, ANDESITIC IN COMPOSITION:** (a) MARBLE WITH MINOR INTERBEDDED CHERT AND GREENSTONE

MINERAL OCCURRENCES

NORTHAIR MINES LTD.

1. DISCOVERY ZONE
2. WARMAN ZONE
3. MANIFOLD ZONE

VAN SILVER EXPLORATIONS LTD.

4. SILVER TUNNEL
5. MILLSITE
6. TEDI PIT
7. ZONE 4

SYMBOLS

GEOLOGICAL BOUNDARY: DEFINED, APPROXIMATE, ASSUMED
AREAS OF ABUNDANT OUTCROP
LIMIT OF GEOLOGICAL MAPPING
FAULT: APPROXIMATE, ASSUMED
BEDDING
SCHISTOSITY
PROSPECT, PORTAL
WATERCOURSE
LAKES, PONDS
ROADS: PAVED, GRAVEL
CONTOUR

FIGURE 32
GEOLOGY OF THE CALLAGHAN CREEK AREA

SCALE–METRES 0 500 1000
SCALE–MILES 0 0.5 1.0

indicate that stratigraphic tops are to the east. Siliceous siltstone (unit 4a) is very fine grained and dark grey. It occurs as pods within the matrix-supported dacitic agglomerate (unit 4) and also the sandstones and siltstones (unit 4c). Fragment-supported dacitic agglomerate (unit 4b) contains about 10 per cent matrix and has similar fragment types, colours, and textures as unit 4. Tuffaceous sandstones and siltstones (unit 4c) contain interbedded, very fine-grained dark grey siltstones, pale brown arkosic wackes, and minor amounts of very fine-grained pale grey rhyolite tuffs. Wackes comprise 70 per cent of the unit; siltstones make up 25 per cent.

Andesitic agglomerate (unit 5) has a fine-grained, dark grey-green tuffaceous matrix, averaging 40 volume per cent. Fragments are porphyritic andesite (70 per cent), equigranular andesite (22 per cent), porphyritic dacite (5 per cent), sandstone (2 per cent), and equigranular dacite (1 per cent). Fragments are rounded to subangular, ovoid, and up to 70 centimetres in diameter. Epiclastic volcanic breccia (unit 5a) has a very fine-grained black matrix, comprising an average of 15 per cent of the rock unit. Porphyritic andesite (38 per cent), andesitic crystal tuff (32 per cent), equigranular andesite (20 per cent), equigranular dacite (8 per cent), siliceous siltstone (1 per cent), and glass (1 per cent) are fragments. Fragments are angular to subangular, elongate; they have an average diameter of 3 centimetres but range up to 30 centimetres. Arkosic wacke (unit 5b) and minor amounts of interbedded mudstone are pale to medium grey and brown and coarse to fine grained. Poorly developed crossbedding and graded bedding indicate stratigraphic tops are to the east. Andesitic crystal tuff (unit 5c) has an aphanitic, dark grey matrix surrounding broken clasts of subhedral, zoned plagioclase. These clasts comprise an average of 25 per cent of the rock but may vary from 20 to 40 per cent over a distance of 8 centimetres. Clasts of plagioclase average 0.8 millimetres in length.

Quartz diorite (unit 6a) is fine to medium grained and pale to medium grey-green with a typical granitic texture. Quartz constitutes about 16 per cent of the rock. Hornblende diorite (unit 6b) is generally medium grained and medium grey-green with a granitic texture. Hornblende composes approximately 20 per cent of the rock. Granodiorite (unit 6c) is medium grained with anhedral patches of salmon-pink perthite interrupting the monotony of an otherwise pale grey-green rock. The rock has a granitic texture with potassium feldspar comprising approximately one-fifth of the rock.

Olivine basalt (unit 7a) occurs as a sequence of flows which are medium mauve-brown, amygdaloidal, porphyritic, and exhibit a well-developed columnar jointing. Equigranular rhyodacite (unit 7b) is pale pink to tan, fine grained to aphanitic, and equigranular. This rock unit occurs in elongate north-south pods, as dykes and, locally, as blankets capping feeder dykes. Porphyritic rhyodacite (unit 7c) is pale pink to tan with phenocrysts of (in decreasing order of abundance) quartz, plagioclase, sanidine, and biotite. These phenocrysts constitute about 50 per cent of the rock. This rock unit is similar in occurrence to unit 7b. Epiclastic breccia (unit 7d) has a dark grey to black, aphanitic matrix which averages 40 per cent and supports fragments of quartz diorite (60 per cent) and basalt (40 per cent). The fragments are subangular to angular and generally spherical in shape.

Seven mineral occurrences are known in the map-area: (1) Silver Tunnel, (2) Millsite, (3) Tedi Pit, (4) Zone 4, (5) Discovery zone, (6) Warman zone, and (7) Manifold zone. The first four mineral occurrences are held by Van Silver Explorations Ltd. (now in receivership) and the last three are held by Northair Mines Ltd. Limited production has come from the Silver Tunnel and Tedi Pit areas; whereas the Manifold, Warman, and Discovery zones are in production at present.

The Silver Tunnel mineral occurrence is within well-sheared greenstone (unit 1) and a dyke of equigranular rhyodacite that is oriented north-south with a vertical dip. Sulphide minerals occur primarily in veinlets crosscutting the dyke or greenstone. They also occur as disseminations and interstitially and as massive sulphides that are locally layered parallel to the regional foliation within the greenstone. The Millsite mineral occurrence is within greenstone (unit 1) near a small body of hornblende diorite (unit 6b). Sphalerite-galena veins and stringers with less abundant chalcopyrite and hematite-bearing veins occur within the greenstone. Stockwork copper mineralization is present within a pod of hornblende diorite. The Tedi pit mineral occurrence is in greenstone (unit 1). The sulphides occur primarily as disseminations and massive sulphides that are locally layered parallel to the regional foliation, and also in veins. Zone 4 mineral occurrence is contained entirely within a marble pod (unit 1a). Sulphides are in intimate association with calc-silicate minerals; both the sulphides and calc-silicate minerals occur in sporadic patches.

Pyrite, sphalerite, galena, chalcopyrite, and tetrahedrite, in decreasing order of abundance, occur in similar relative proportions in the Silver Tunnel, Tedi Pit and sphalerite-galena veins of the Millsite area. Trace amounts of argentite, electrum, bornite, and ruby silver also occur in Tedi Pit. In Zone 4 the sulphides occur in approximately this order of decreasing abundance: sphalerite, chalcopyrite, pyrrhotite, pyrite, galena, covellite, argentite, and electrum.

Manifold, Warman, and Discovery zones appear to represent faulted segments of a single mineral-rich sheet that is oriented north 40 degrees west with near vertical dips. The ore zones parallel volcanic stratigraphy defined in the mine area. Sulphides are disseminated in quartz-carbonate gangue, form thin sulphide-rich sheets within layered quartz-carbonate beds, locally occur as massive sulphides, and are contained in abundant small quartz and/or carbonate veins. The minerals at Northair, in order of decreasing abundance are: pyrite, sphalerite, galena, chalcopyrite, tetrahedrite, argentite, bornite, ruby silver, and electrum. Trace amounts of gold and stromeyerite have also been reported (Manifold, 1976).

The Northair deposits are thought by some to have originally formed as distal volcanogenic exhalites at the time the host rocks were deposited about 127 Ma ago during the Late Cretaceous. Subsequently intrusions of the Coast Plutonic Complex were emplaced; a late-stage effect of this intrusion is thought to have been local mobilization of exhalite minerals into veins. Additional movement of sulphides may have occurred in response to the high thermal regime associated with Tertiary volcanism (Miller and Sinclair, 1979).

REFERENCES

Dickson, M. P. and McLeod, D. A. (1975): Northair Mines: Grassroots to Senior Financing; *Cdn. Min. Jour,* April, pp. 79–82.

Green, N. L. (1977): Unpublished Ph.D. Thesis, Dept. of Geological Sciences, *University of British Columbia.*

Little, L. M. (1974): Unpublished B.Sc. Thesis, Dept. of Geological Sciences, *University of British Columbia.*

Manifold, A. H. (1976): Some Aspects of Northair Mines, Brandywine property, preprint of paper, *C.I.M.,* District 6 Annual Meeting, Vancouver, October 13–15.

Mathews, W. H. (1958): Geology of the Mount Garibaldi Map-Area, Southwestern British Columbia, Canada, *Geol. Soc. Amer.,* Bull, Vol. 69, No. 2, pp. 161–178.

Miller, J. H. L., and Sinclair, A. J. (1979): Geology of an Area Including Northair Mines Ltd., Callaghan Creek Property; *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1978, Paper 1979-1, pp. 124-131.

Miller, J. H. L., and Sinclair, A. J. (1978): Geology of Part of the Callaghan Creek Roof Pendant, *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1978, Paper 1979-1, pp. 96–102.

Miller, J. H. L., Sinclair, A. J., Wetherell, D. G., and Manifold, A. H. (1978): Mineral Deposits in the Callaghan Creek Areas, Southwestern British Columbia (abstract), *C.I.M.*, Bull., March, p. 129.

Roddick, J. A. and Woodsworth, G. J. (1975): Coast Mountain Project: Pemberton (92J West Half) Map-Area, British Columbia; *Geol. Surv., Canada,* Paper 75-1, Pt. A, pp. 37–40.

Woodsworth, G. J., Pearson, D. E., and Sinclair, A. J. (1977): Metal Distribution Patterns across the Eastern Flank of the Coast Plutonic Complex, South-Central British Columbia, *Econ. Geol.,* Vol. 71, pp. 170–183.

1977—ISLAND COPPER (92L/11W)

By G. E. P. Eastwood

The mine geology was described in some detail by Northcote in 1970 and 1972, necessarily in considerable part from drill core. In recent years the north and west walls of the open pit have been pushed back, by removal of waste rock, in preparation for mining at greater depth. The extensive exposures of fresh and altered rock and of ore essentially corroborate earlier observations, and a full redescription is unnecessary.

In brief, Bonanza pyroclastic rocks striking west-northwest and dipping moderately south are cut by a large digitating dyke of quartz feldspar porphyry which also strikes west-northwest but is vertical or steeply north-dipping. Around the dyke the pyroclastic rocks have been repeatedly brecciated and rehealed, mainly by quartz. The dyke itself has been broken up in the central and eastern parts of the pit in one or more episodes of brecciation. The brecciation grades outward to fracturing, which fades out in north wall exposures distant from the dyke. Rock alteration also shows a general outward progression, from silicification through biotitization and propylitization to fairly fresh rock in the upper part of the north wall. Chalcopyrite and molybdenite occur mainly in the silicified and biotitized rocks. It is now known that the progressive decrease in disruption and alteration to the south is truncated by a fault, named the End Creek fault. It is exposed in the upper part of the west wall, where it is essentially vertical, and appears to pass under cover in the south wall.

Pale green, fine-grained bedded tuffs have been exposed along the upper north wall of the pit. Some thin bands of volcanic breccia with fragments ranging up to 3 centimetres across are intercalated. These beds are wrapped around a broad arch which plunges south-southwest at about 30 degrees into the altered and mineralized zone in the centre of the pit. In the west wall they are overlain by dark lapilli tuff, which is increasingly altered toward the porphyry. The End Creek fault separates the porphyry and altered volcanic rock from massive, hematite-streaked, brownish grey tuffs exposed in the south wall. These tuffs are cut by veins of epidote, chlorite, and calcite-zeolite, and by films of pyrite.

The copper-molybdenum mineralization decreases gradually to the north and south, and the orebody is defined by a cutoff grade of 0.3 per cent copper. Below −80 metres of elevation a submarginal zone in the centre splits the orebody into north and south zones. This submarginal zone is notably hard and difficult to drill. Core from a hole drilled in this zone, together with exposures deep in the pit show that it is characterized by a greater degree of replacement of the rocks by quartz and magnetite than in the flanking ore zones. Highly altered volcanic rock is indistinctly brecciated and healed with quartz containing finely disseminated magnetite, which in turn is cut by veinlets of white quartz. In places there is almost complete replacement by the white quartz, leaving only scattered patches of disseminated and massive magnetite. Remnants of porphyry are more obviously brecciated, and the fragments are partly replaced by disseminated magnetite. In places *both the dark magnetite-bearing quartz and the white quartz are laced with pyrite and* chalcopyrite. Apparently sulphides could not survive in the core of the structure until a relatively late stage in its evolution.

REFERENCES: *B.C. Ministry of Energy, Mines & Pet. Res.*, GEM, 1970, pp. 267–269; 1972, pp. 293–303.

EAST CENTRAL BRITISH COLUMBIA
(NTS Division 93)

1978—NIFTY DEPOSIT
(93D/9W)

By T. D. Lewis

LOCATION: Lat. 52° 35′ Long. 126° 25′ (93D/9W)
The Nifty Property is located on the east side of the Noosgulch River, approximately 35 kilometres northeast of Bella Coola. Access to the property is gained by a 15-minute helicopter flight from Firvale, situated on the Bella Coola River.

OWNER: United Minerals Limited.

OPERATOR: PAN OCEAN OIL LIMITED.

DESCRIPTION:

INTRODUCTION: The Nifty deposit has been optioned by Pan Ocean Oil Limited to explore for barite and sulphide horizons within a volcano-sedimentary pile of interbedded fine-grained to lapilli tuff and tuffaceous siltstones. Five diamond-drill holes were recently drilled by Pan Ocean on the east side of the Noosgulch River, but failed to intersect economic sulphide occurrences.

Interest in the property stems from galena-sphalerite pods within felsic tuffs. In 1977, the property was mapped on a scale of 1:100 by J. R. Woodcock, and further exploration was warranted to explore the extent of sulphide mineralization.

During the first week of July, the author, accompanied by Al Rivard, visited the property. At this time, the drilling was complete, and the core had been logged and stored in core racks by two Pan Ocean geologists, R. Bailes and G. McArthur. Information presented in this report was largely supplied by these geologists, plus information gathered from core logged in DDH 78-2 and outcrop examination (Fig. 33).

GENERAL GEOLOGY: The volcano-sedimentary pile which hosts the Nifty deposit is Middle Jurassic age or older (Baer, 1966). Subsequent to deposition, the area has been tilted eastward at 55 degrees and the rocks strike 115 degrees. Intruding all rock types are late-stage porphyritic mafic dykes.

Deposition of the volcanic debris occurred within a subaqueous environment. Rapid phase changes within the stratigraphic section suggests a distal, pulsating volcanic source. Textural and compositional changes within the section suggest three main stages of deposition:

Upper Unit—Dominantly interbedded fine andesitic tuffs and bedded siltstones. Thickness of this unit is estimated at 50 to 60 metres.

"Ore-Bearing" Unit—Dominantly felsic lapilli tuff with thin, interbedded andesite lapilli tuff, and siltstone. In addition, jasper breccias and barite horizons occur. Coarser fragments and an increase in felsic fragments are characteristic of this unit. Approximate thickness estimated at 40 to 50 metres.

Lower Unit—Dominantly altered, fine tuffs in a matrix of bleached grit with ellipsoidal chlorite and epidote spots. Unknown thickness.

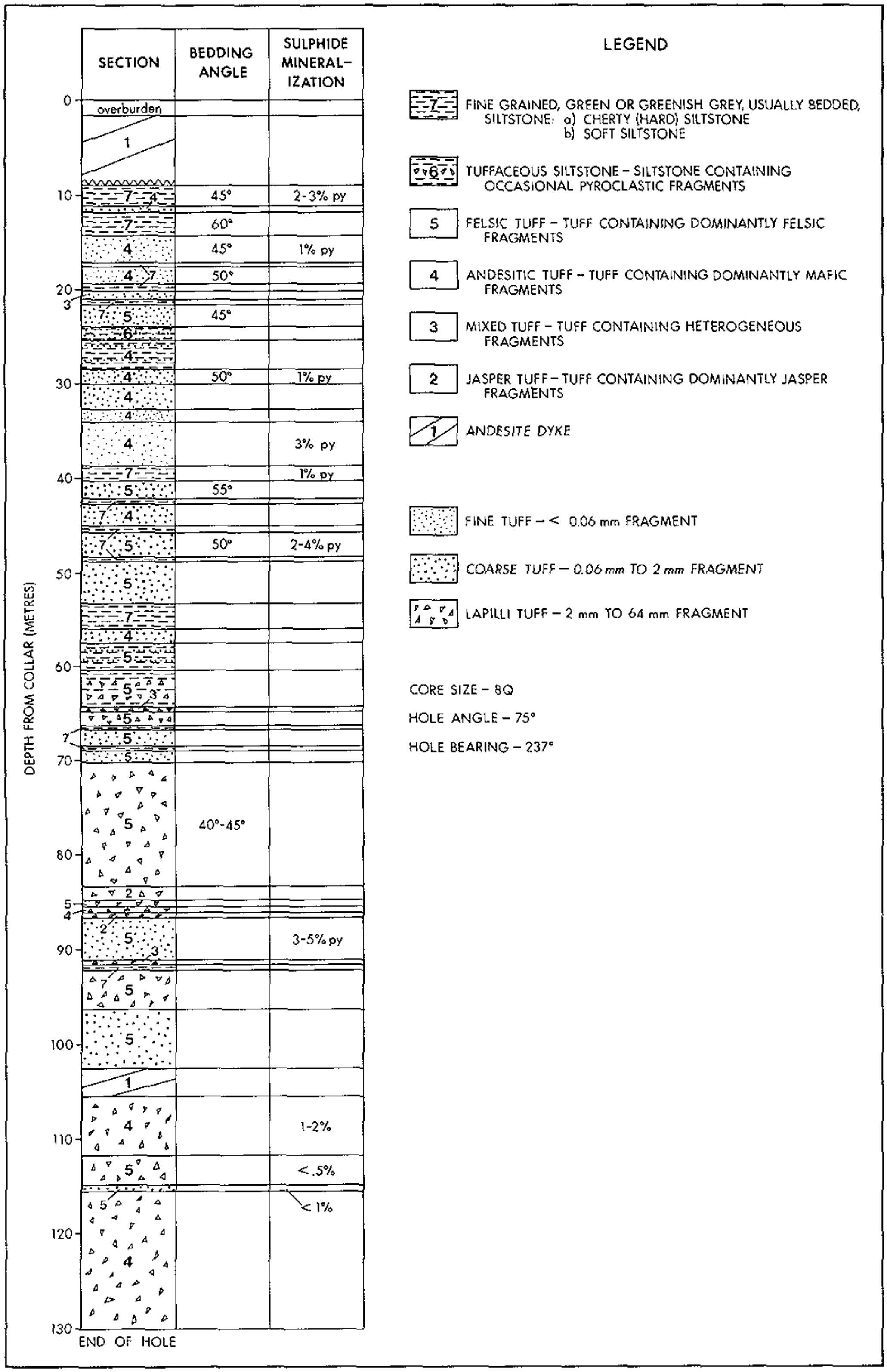


Figure 33. Section of diamond drill hole 78-2, Nifty deposit

Two main types of sulphide mineralization were noted on the Nifty property. First, massive pods of dominantly galena, sphalerite, and lesser pyrite occur within a felsic lapilli tuff. Felsic fragments are incorporated within the pod; stratification of the sulphides is evident. Second, disseminated pyrite forms part of the matrix in the felsic tuff.

GEOCHEMISTRY: Rock samples from the Nifty property were analysed in the Ministry of Energy, Mines and Petroleum Resources laboratory in Victoria. Samples taken within the "ore zone" were assayed for gold and silver by fire assay. Lead, copper, and zinc for these samples were assayed using atomic absorption (*see* Table 1).

In addition, semi-quantitative spectrographic analysis (*see* Table 2) of the samples, plus determination of refractive indices were done to determine rock types. Field description, refractive indices, and resulting rock types are presented in Table 3.

REFERENCES

Baer, A. J. (1966): Bella Coola and Laredo Sound Map-Area, British Columbia, *Geol. Surv., Canada,* Paper 66-25.

For information concerning refractive indices and rock types, see *Geology, Exploration and Mining in British Columbia,* 1971, p. 150.

TABLE 1—ASSAY RESULTS FOR SAMPLES FROM THE NIFTY DEPOSIT

	Au ppm	Ag ppm	Cu %	Pb %	Zn %
78 NR- 2	<1	12	0.018	0.066	0.081
78 NR- 3	<1	84	0.010	0.080	0.23
78 NR- 4	<1	232	0.010	0.49	1.37
78 NR- 5	<1	141	0.022	31.70	8.80
78 NR- 6	<1	30	0.015	0.15	0.090
78 NR-1210	—	—	—	—	—
78 NR-1211	—	—	—	—	—
78 NR-1212	—	—	—	—	—
78 NR-1215	<1	<10	0.005	0.003	0.005
78 NR-1217	<1	<10	0.012	0.009	0.007
78 NR-1220	<1	<10	0.003	0.004	0.005
78 NR-1227	<1	<10	0.009	0.002	0.002
78 NR-1230	<1	<10	0.007	0.002	0.006
78 NR-1231	<1	<10	0.007	0.001	0.004

TABLE 2—NIFTY DEPOSIT, SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSIS

	78 NR-1212	78 NR-1215	78 NR-1217	78 NR-1220	78 NR-1227	78 NR-1230	78 NR-1231	78 NR- 2	78 NR- 3	78 NR- 4	78 NR- 5	78 NR- 6	78 NR-1210	78 NR-1211
Si	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0	<2.0	>10.0	>10.0	>10.0	>10.0	>10.0
Mn	0.12	0.15	0.12	0.06	0.1	0.15	0.1	0.05	T	0.015	0.01	T	0.07	0.17
Al	10.0	9.0	9.0	>15.0	7.5	>10.0	9.0	>10.0	0.4	5.0	5.0	0.4	7.5	>10.0
Mg	0.7	0.6	0.5	0.5	0.4	0.75	0.6	0.6	T	0.1	0.3	0.02	0.25	0.6
Pb	—	T	T	T	T	T	T	0.1	0.1	(0.4–1.2)	>10.0	0.15	T	—
Ca	1.0	2.5	1.5	1.0	1.0	3.0	1.5	1.0	<1.0	<1.0	1.0	<1.0	1.0	3.0
Fe	4.5	5.0	5.5	8.0	5.0	6.0	5.0	9.0	2.5	5.5	7.5	13.5	4.0	9.0
V	0.01	0.01	0.01	0.02	T	0.01	T	0.02	0.015	0.01	T	T	T	0.015
Cu	T	T	0.015	T	0.01	0.01	T	0.015	T	0.01	0.03	0.03	T	0.01
Ag	—	—	—	—	—	—	—	T	T↑	↑T↑	↑T↑	T↑	—	↓T↓
Zn	—	N.D.	N.D.	T↓	N.D.	N.D.	N.D.	0.03	0.25	(0.5–1.5)	>5.0	0.05	—	T↓
Na	1.0	>2.0	>2.0	>2.0	>2.0	>3.0	>2.0	0.45	—	1.5	0.3	—	1.5	>3.0
K	>3.0	1.25	1.25	>4.0	1.25	1.25	1.35	>3.0	—	>2.0	1.0	—	>2.0	>2.0
Ti	0.3	0.2	0.2	0.45	0.1	0.25	0.15	0.4	0.01	0.1	0.1	T	0.08	0.4
Zr	0.01	T	T	T	T	T	T	T	T	T	T	T	T	T
Ni	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Co	T	T	T	T	T	T	T	T	—	T	T	T	T	T
Sr	T	0.02	0.02	T	T	T	T	0.02	>2.0	>1.0	T	T	T	T
Cr	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Ba	0.1	0.15	0.15	0.1	0.03	0.025	0.05	(0.5–1.5)	M.C.	>>10.0	0.25	T	0.25	0.1
Traces:	Ga,Mo,Y, Yb	Ga	Ga,Mo,Y, Sc	Ga,Y,Yb, Sc	Ga,Mo	Ga,Mo,Y, Yb,Sc	Ga,Mo,Y, Yb,Sc	Ga,Mo,Y, Yb,Sc	Mo	Ga,Mo, Cd		Bi,Mo	Ga,Mo	Ga,Mo↓, Y,Yb,Sc

TABLE 3

Sample Number	Description
78 NR—2	Grab sample of monolithologic, felsic breccia, containing yellowish to light brown, subrounded to subangular felsic fragments up to 3 millimetres across. Dominantly pyrite mineralization within the matrix. Sample taken from main showing area.
78 NR-3	Grab sample of barite taken within a trench at Station 18.
78 NR-4	Grab sample of banded, felsic, fine-grained chert schistose siltstone (?) taken at Station 16.
78 NR-5	Grab sample taken at main showing of a 1-metre-square pod of massive sulphide within a felsic lapilli tuff.
78 NR-6	Grab sample of jasper breccia with felsic fragments within a dominantly pyritic matrix.
78 NR-1210	Grab sample taken from DDH 78-1, 23.49 metres from the collar. Rock is a quartz-plagioclase porphyritic dyke. Thought to be equivalent to Unit 15 (*see* Figure 33).
refractive index 1.498	*Implies rock type is rhyolite.*
78 NR-1211	Grab sample taken from DDH 78-1, 84.49 metres from the collar. Rock is an andesitic dyke.
refractive index 1.578	*Implies rock type is andesitic basalt.*
78 NR-1212	Grab sample taken from DDH 78-1, 142.44 metres from the collar. Rock is a crystal-ash-dust tuff with chloritic spots. Thought to be equivalent to Unit 2(??).
refractive index 1.522	*Implies rock is a rhyodacite.*
78 NR-1215	*refractive index 1.530—Implies rock is a rhyodacite.*
78 NR-1217	Grab sample taken from DDH 78-3, 43.01 metres from the collar. Rock is a grey andesitic dust tuff.
refractive index 1.530	*Implies rock is a rhyodacite.*
78 NR-1220	Grab sample taken from DDH 78-3, 147.62 metres from the collar. Rock is lower, hematitic ash tuff.
refractive index 1.598	*Implies rock type is andesitic basalt.*
78 NR-1227	Grab sample taken from DDH 78-2, 54.6 metres from the collar. Rock is a bedded, light to pale green, felsic dust tuff (possibly siltstone). This rock is thought to be equivalent to Unit 14.
refractive index 1.506	*Implies rock type is rhyolite.*
78 NR-1230	*refractive index 1.542—Implies rock type is andesite.*
78 NR-1231	Grab sample taken from DDH 78-2, 73.20 metres from the collar. Rock is a coarse lapilli tuff.
refractive index 1.514	*Implies rock type is rhyolite.*

1978 — SAM CLAIM
(93E/11W)

LOCATION:	Lat. 53° 38′	Long. 127° 16′	(93E/11W)

CLAIM: SAM (6 units).

OWNER: CLIFFORD McNEILL.

DESCRIPTION: The Captain Swannell lead-zinc-silver prospect is located approximately 130 kilometres south of Smithers on the northeastern slope of Swing Peak Mountain at an elevation of 1 503 metres (4,930 feet). Galena, sphalerite, pyrite, and smaller amounts of chalcopyrite, arsenopyrite, and tetrahedrite occur within a 3-metre wide and 90-metre long shear zone replacement fissure zone in Kasalka Group (?) intermediate to acid porphyritic volcanic rocks. The fissure strikes 150 degrees, dips steeply to the southwest, and cuts bedding planes of the country rock, which have a trend of 140 degrees/75 degrees northeast. In 1929 a tunnel about 120 metres in length was driven at an elevation of 1 482 metres (4,895 feet) to test the showing. Above the tunnel, near the top of the mountain, a 1.5-metre quartz vein with galena, sphalerite, and abundant manganese occurs within Kaketsa Group (?) grey rhyolite.

WORK DONE: During 1978, "Cap" McNeill constructed a 7.5-kilometre caterpillar road from a landing on Tahtsa Reach to the property. He constructed a camp at elevation 1 300 metres (4,260 feet) in the creek valley below the showings.

1978—NEW MOON, COPPER CLIFF, MISTY DAY, HALF MOON
(93E/13)

LOCATION:	Lat. 53° 57′	Long. 127° 45′	(93E/13)

CLAIMS: NEW MOON (20 units), COPPER CLIFF (12 units), MISTY DAY (12 units), HALF MOON (8 units).

OWNER: Charles Kowall.

OPERATOR: NORCEN ENERGY RESOURCES LIMITED, 715 Fifth Avenue SW., Calgary, Alberta T2P 2X7.

DESCRIPTION: The NEW MOON volcanogenic massive sulphide prospect is located 100 kilometres southwest of Smithers, just west of Morice Lake, at an elevation of 1 500 to 1 600 metres (Fig. 34). In 1968 Phelps Dodge first explored the ground. During 1971-72 Aggressive Mining conducted an electromagnetic survey and completed 5 diamond-drill holes to test a 150-metre long, 25-metre wide shear zone. The zone carries galena, sphalerite, and pyrite in a quartz gangue (Plateau showing).

In 1977 and 1978, Charles Kowall found occurrences of sulphides in glacial moraines and in place by trenching over a length of 3 kilometres.

A sequence of Hazelton Group (Telkwa Formation) rocks more than 900 metres thick consisting of green and red andesitic to rhyolitic flows, breccias, and volcanic wackes with interfingering bands of limestone and limy chert has been intruded by feldspar porphyry

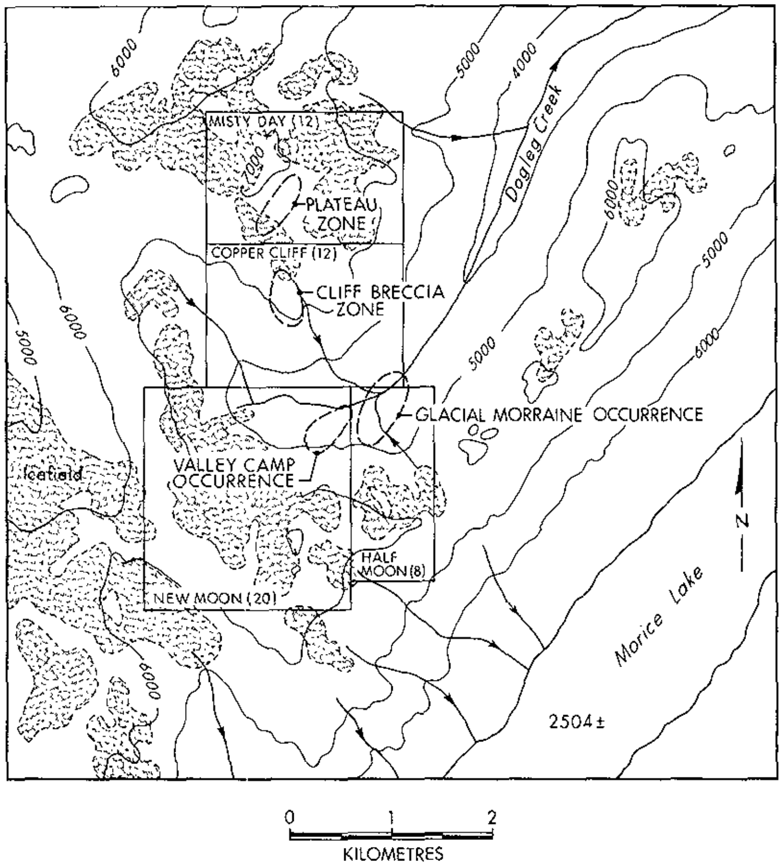


Figure 34. Sketch map of the New Moon property

dykes. To the east they are cut by a quartz monzonite pluton. The general attitude of layering is 120 degrees/10 degrees northeast. The volcanic rocks have undergone extensive chloritization and epidotization; the limestone has locally been converted to skarn. Mineralization occurs in silicified shear zones and as distinct bands. It consists of chalcopyrite, bornite, sphalerite, galena, pyrite, and specular hematite.

Four main areas of mineralization have been observed:

(1) *Plateau Zone* (ex-Phelps Dodge)—Galena, sphalerite, and pyrite occur in quartz stringers in a northeasterly trending (030 degrees/60 degrees east) zone that is over 25 metres wide and 150 metres long in quartz porphyry close to the contact with tuffaceous rhyolite. The results of a 5 drill hole program, to test an extrapolated strike length of 305 metres, are not known.

(2) *Cliff Breccia Zone*—Chalcopyrite, pyrite, and galena occur in a silicified and brecciated andesite in an east-west fault zone in a cliff immediately south of the Plateau Zone.

(3) *Valley Camp Occurrence*—Brecciated dark green andesite float with chalcopyrite "cement" occurs on the valley floor of the upper part of Dogleg Creek (local name).

(4) *Glacial Moraine Occurrence*—Scattered and linear zones of massive sulphide float *occur on lateral and terminal moraines at the east end of the property.* Numerous boulders up to 1.5 metres in diameter with varying amounts of banded or matrix filling chalcopyrite ± pyrite ± sphalerite ± galena ± bornite ± hematite ± magnetite occur in andesitic, limy, and cherty rocks. The origin of the mineralization is assumed to be the ice-covered cliffs to the south.

Grab samples of mineralized float gave the following results:

Sample Number	Brief Description	Au ppm	Ag ppm	Cu %	Pb %	Zn %
NM-1	chalcopyrite-pyrite-hematite stringers in cherty volcanic rock	<1	10	3.93	.023	.087
NM-2	near massive ZnS + PbS	<1	10	0.67	9.15	20.2
NM-3	chalcopyrite-hematite banded in chert	<1	10	2.34	0.034	.046

WORK DONE: During 1978, Great Plains Development Company of Canada, Ltd., conducted geological, geochemical, and geophysical (ground electromagnetic) surveys over the property.

1980—CAPOOSE
(93F/6)

By Tom Schroeter

The Capoose precious and base metal prospect is situated a few kilometres north of Fawnie Nose, approximately 110 kilometres southeast of Burns Lake (*see* Fig. 35). Access is via four-wheel-drive vehicle road off the main Kluskus logging road south of Vanderhoof or by helicopter.

During the 1980 season, Granges Exploration Aktiebolag completed approximately 3962 metres of diamond drilling in 21 holes.

LOCAL GEOLOGY: The Fawnie Range in the vicinity of the Capoose property is composed of a conformable sequence of interbedded greywacke, shales, and metamorphosed volcanic pyroclastic rocks and flows of rhyolitic and andesitic composition. This sequence unconformably overlies andesitic volcanic rocks of the Takla Group. Tipper (1963) postulates that volcanism took place intermittently in later Middle Jurassic time in an unstable basin accumulating fine sediments. The northwesterly trending sedimentary trough was bounded on the north and northeast by a landmass in which Topley Intrusions were beginning to be exposed. The pile of Hazelton Group (or younger) rocks is estimated to be greater than 460 metres thick (Tipper, 1963, p. 32). The east side of the Capoose property, a topographic low, is underlain by interbedded greywacke, maroon tuffs, and limy argillites of probable Late Jurassic (Callovian) age (Upper Hazelton Group?). Fossils found in limy argillite of this sequence have been identified by H. Frebold (Tipper, 1963, p. 29) as follows:

> No. 4 GSC Locality 20116—2.3 kilometres from the north end of Fawnie Nose
> Belemnites sp. indet.
> *Rhynchonella* sp. indet.

Limestone blocks were noted in argillite, immediately below the contact with rhyolite. Unfortunately only a broad Jurassic or Cretaceous age can be applied.

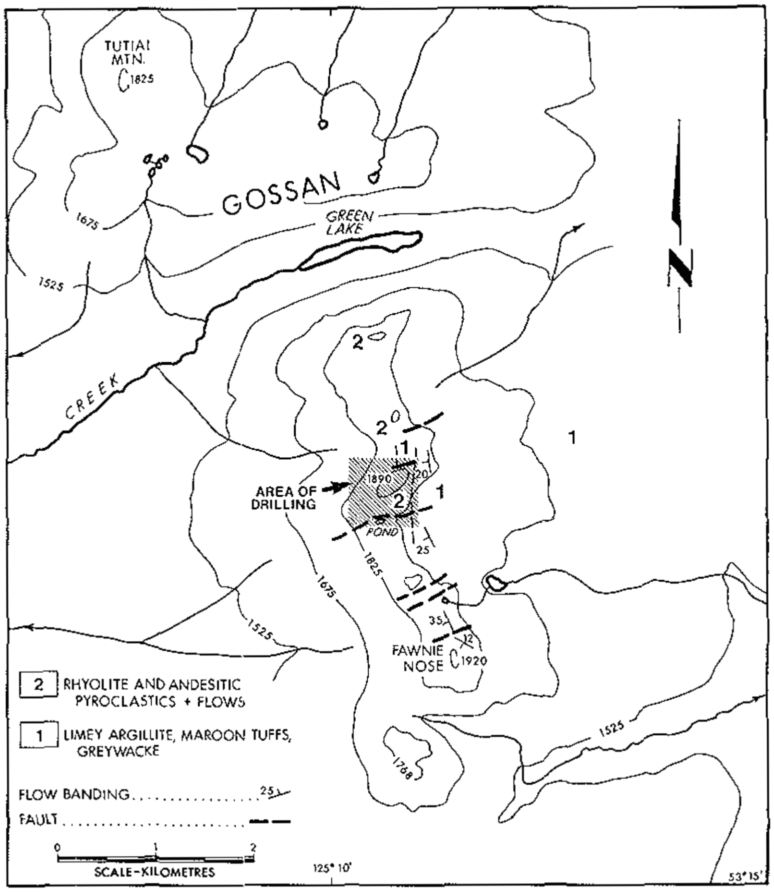


Figure 35. Geological sketch map of part of the Capoose property

Conformably overlying the limy argillite unit with an attitude of 170 degrees/20 degrees west is an acidic unit consisting of rhyolitic pyroclastic rocks and flows. Phenocrysts of highly embayed quartz are set in a cryptocrystalline groundmass of quartz and feldspar. Flow banding in the rhyolite averages 135 degrees/15 degrees west; a strong vertical jointing strikes 90 degrees parallel to the major structural zones. Local "balling" or pisolitic formation within rhyolite has produced beds with "balls" up to 30 centimetres in diameter. Pisolites are actually nuclei growths and exhibit rare spherulitic radiating textures, indicative of rolling during or after growth. The unit has been altered to garnet to varying degrees (*see* Alteration).

Dark green andesitic tuffs, breccias and flows, some hornfelsed with well-developed secondary biotite, lie in contact with the rhyolite; they have also been garnetized.

ALTERATION AND TEXTURE: Amber brown garnets of compositions $Sp_{63}Al_{29}Gr_8$ (Mn-rich) are an ubiquitous feature of metamorphosed rhyolitic and andesitic rocks in the vicinity of mineralization. Some are fresh and others are totally altered or replaced by a mixture of quartz ± sericite ± opaques. They are sometimes highly poikilitic, and show no evidence of rolling during growth. Garnet occurs as disseminations, fracture fillings, vein fillings in quartz, and replacement nuclei. Hydrothermal solutions cracked the garnets and they have been subsequently healed by sulphides (mainly pyrite). The matrix of the rhyolite is highly sericitized.

The predominant texture observed is one of nucleation and/or dispersion exhibited by pseudomorphs after garnet. A dispersion rim of quartz and/or sericite is common. The textures suggest that crystallization took place rapidly under strong chemical or energy gradients. Dentritic growth textures are also exhibited. It is thus postulated that growth was diffusion-controlled because the composition of the large garnet crystals differed appreciably from the quartz feldspar groundmass. The skeletal texture of garnets implies difficulty in nucleation.

Globular to botryoidal and fracture filling hematite is common in rhyolite.

Epidote and chlorite are common alteration products in the andesitic rocks.

STRUCTURE: The predominant structures in the area are east-west faults which cause small linear depressions on Fawnie Range. Drilling has also identified several fault gouges. Broad warping of thin bands in the argillite unit occurs.

MINERALIZATION: Three zones of precious and base metal mineralization have been discovered. Brief descriptions are as follows:

Zone 1—area of most previous diamond drilling has defined a steep west-facing zone in garnetized rhyolite.

> Galena, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, and sphalerite occur as disseminations (particularly galena), replacing garnets (nuclei and attendant dispersion halos), and as fracture and/or vein fillings. Mineralization is in fine-grained rhyolite tuffs, breccias, and flows, and in meta-andesite. Tetrahedrite, pyrargyrite, electrum, native gold, and cubanite have been reported. Precious metals also occur within galena and sphalerite. Pyrite is ubiquitous and may have formed throughout the mineralizing event. Garnet replacement and mineralization are closely related. Belemnites in limy argillites underlying the rhyolite unit have been locally replaced by pyrite. It is interesting to note that a previous sample collected by the writer assayed 0.03 per cent molybdenum and 0.03 per cent tungsten. (Schroeter, 1979, p. 123).

Zone 2—area to the west of Zone 1.

Zone 3—area to the north-northwest of Zone 1; characterized by more massive sphalerite, pyrrhotite, and chalcopyrite in rhyolite and hornfels.

SUMMARY: It is postulated that a magmatic source provided heat and mineralizing solutions that invaded rhyolitic and andesitic rocks possibly near an old volcanic centre, resulting in replacement of garnets by sulphides and formation of mineralized veinlets and possibly more massive bodies of mineralization.

REFERENCES

Schroeter, T. G. (979): *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1979, Paper 1980–1, p. 123.

Tipper, H. W. (1963): Nechako River Map-Area, British Columbia, *Geol. Surv., Canada,* Mem. 324.

1977 and 1978—SAM GOOSLY PROPERTY (93L/1E)

LOCATION: The Sam Goosly silver-copper-gold-antimony property is located approximately 40 kilometres southeast of Houston. Access is currently via a 55-kilometre logging road running through Buck Flats; however, a new direct 38-kilometre road is being constructed from Houston to the property down the Dungate Creek valley.

DESCRIPTION: **1977**—The property was discovered by Kennco Explorations, (Western) Limited in 1968 and extensively explored by them during the period 1968 to 1971. In 1973 the property was optioned by the present operators, Equity Mining Corporation, and has subsequently been developed through various feasibility stages. In 1977 Equity entered into a preliminary agreement with Placer Development Limited who conducted a diamond-drill program consisting of 25 short NQ holes totalling approximately 1 295.5 metres on the Southern Tail zone. This brings the total number of drill holes completed on the property to 207. The agreement was terminated and subsequently Granby and Boliden of Sweden came to a preliminary agreement with Equity and have become participating partners pending formal agreement.

Some important textures observed in the 1977 core included rounded fragments of near-massive tetrahedrite enclosing small angular fragments of host-rock brecciated dust tuff with disseminated pyrite. Fragments of dust tuff contained in the breccia have been crackled and healed and rimmed by tetrahedrite. Brecciation and veining are conspicuous throughout (Fig. 36).

Five bulldozer test pits (Nos. A, B, C?, C, and D) from the Southern Tail zone were used to supply ore (approximately 65 tons) for further metallurgical testing. The pits are located along a north/south line for a distance of approximately 275 metres across the Southern Tail zone. A highly fractured and sulphide healed creamy coloured dust tuff is the host rock in all five pits. It is cut by post-mineral dykes of quartz feldspar porphyry (with apparent width of 10 metres in pit B) and andesite (with width of 1.8 metres in pit C). Shearing in pits A and D is strong at 010 degrees/55 degrees southwest which parallels the assumed general attitude of the orebodies on the property.

A small program of backhoe trenching was conducted in the northeast section of the cleared mill site to test for the source of massive galena-sphalerite float found the previous year. Although no direct source was discovered, more pieces of mineralized float were encountered. Bedrock, which averaged between 2 metres and 3 metres in depth, consisted of a dust tuff similar to that of the Southern Tail zone with varying amounts of chalcopyrite, pyrite, tetrahedrite, and tourmaline-filled fractures.

1978—In 1978 Placer Development entered into an agreement with Equity Mining to participate in the development of the Sam Goosly ore deposit. During the fall, Placer diamond drilled 15 holes totalling approximately 2 133.5 metres and in January 1979 drilled an additional 6 holes totalling 913.2 metres. Besides confirmation drilling on known sections within the ore zones, the programs were designed to test for economic mineralization at relatively shallow depths (for example <150 metres) beneath areas designated as proposed millsite and proposed tailings pond, both located west-northwest of the Main zone.

The proposed mill site and tailings pond appear to be underlain by a complex zone of "intermixed pyroclastics" which include lapilli, ash, and dust tuff units of varying thicknesses. The presence of local layers of distinctly welding rhyolitic tuff and beds of light-coloured volcanic conglomerate with a tuffaceous matrix makes this unit distinctive from

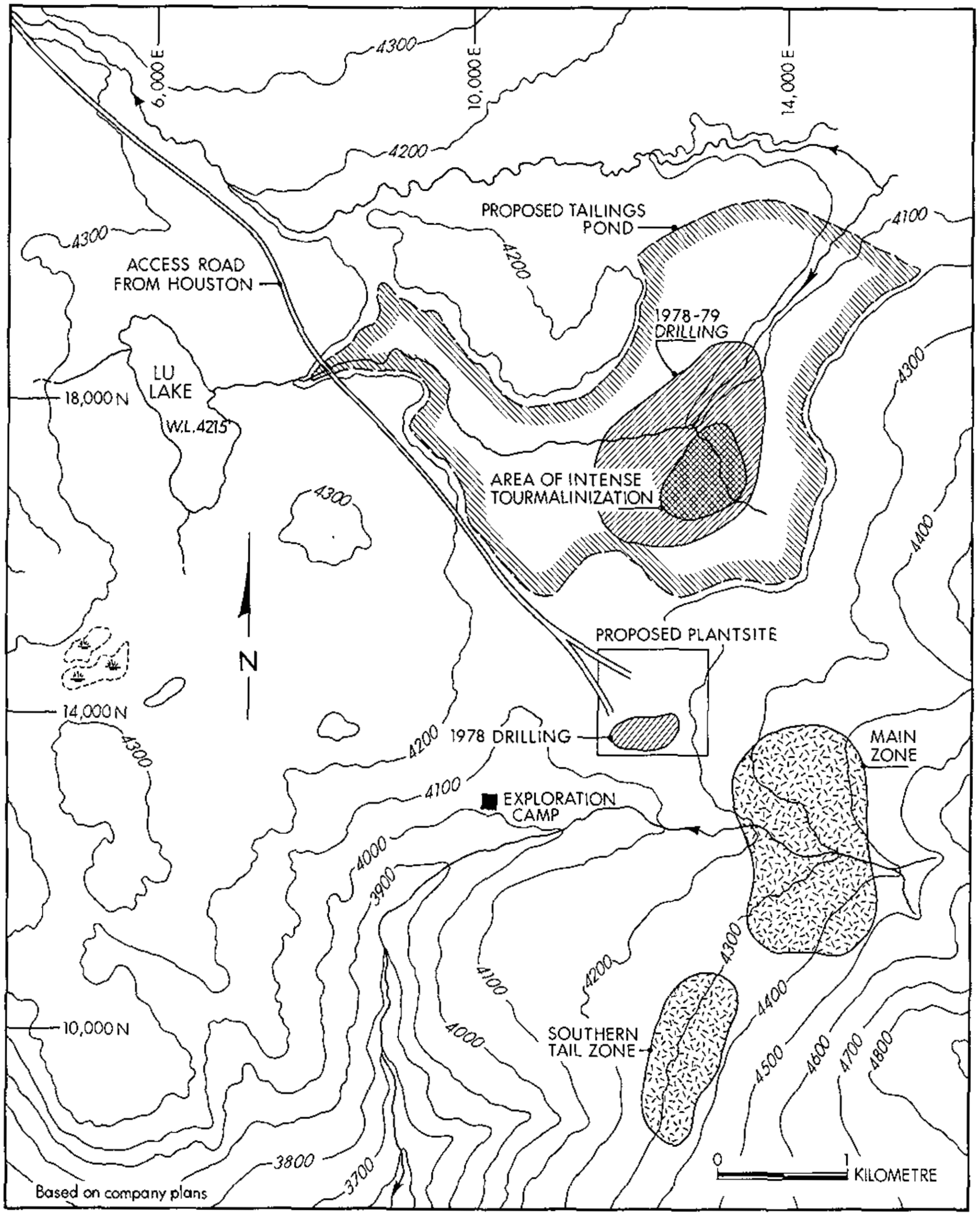


Figure 36. Sketch map of the Sam Goosly property

other units described previously. Within and intermixed with the pyroclastic rocks are massive, porphyritic flows and locally flow breccias greater than 200 metres in apparent thickness as noted in drill holes 54, 55, 219, 221, 222, and 225. Feldspar phenocrysts altered entirely to sericite are set in a fine, matted matrix of quartz and feldspar that are also highly altered to mica. Pervasive tourmaline, that occurs as veinlets, fine disseminations, and coarse rosettes, is commonly associated with pyrite. It is abundant in intermixed pyroclastic rocks, flow rocks, and coarse volcanic conglomerates. In places, tourmaline occupies (has replaced) as much as 80 per cent by volume of the total rock. Sericitization has been prominent in most rocks.

Graded bedding is visible in the volcanic conglomerate unit. Well-rounded clasts up to 8 centimetres in diameter exist in a fine-grained equigranular matrix.

Post-mineral trachyandesite dykes are more common than post-mineral feldspar porphyry dykes.

Pyrite is by far the most abundant sulphide mineral present. Sixty centimetres or more of massive pyrite have been noted. Minor amounts of late-stage galena-sphalerite-bearing quartz veinlets (<12 centimetres in width) cut the clastic rocks. These small veinlets apparently are the same as high-grade float found on the surface. Chalcopyrite is rare in flow rocks where it occurs principally as disseminations. Tetrahedrite was observed to occur in trace amounts in polished sections.

Regionally, it appears that the area immediately northwest of the Main zone is characterized by the presence of intermixed pyroclastic rocks and dacitic flows with abundant pervasive tourmaline and pyrite alteration.

REFERENCES: *B.C. Ministry of Energy, Mines & Pet. Res.*, GEM, 1969, pp. 142–148; 1970, pp. 126–129; 1973, pp. 333–338; 1974, p. 255; Exploration in B.C., 1975, p. 138; Geological Fieldwork, 1974, p. 79; 1976, pp. 55-56; 1977, p. 64; Assessment Report 5346; Mineral Inventory 93L-1.

1979—PRELIMINARY REPORT ON STRATIGRAPHY AND GENESIS OF THE SAM GOOSLY COPPER-SILVER-ANTIMONY DEPOSIT (93L/1E)

By D. G. Wetherell and A. J. Sinclair
Department of Geological Sciences, The University of British Columbia

INTRODUCTION: The Sam Goosly copper-silver-antimony deposit occurs in an inlier of steep westerly dipping sedimentary, pyroclastic, and volcanic rocks of probable Cretaceous age that are thought to be correlative, in part, with the Skeena Group and with the Kasalka Group (Wetherell, 1979). Four major stratigraphic units have been recognized within this inlier (Fig. 37). Three of these, the Clastic, Pyroclastic, and Sedimentary-Volcanic Divisions, were defined by Ney, Anderson, and Panteleyev (1972) and by Wojdak (1974). An upper Volcanic Flow Division, which conformably overlies and is in part interbedded with pyroclastic and sedimentary-volcanic rocks, was identified by Wetherell (*ibid.*). Local occurrences of graded beds within clastic and fragmental rocks generally become finer grained to the west and thus indicate that the Mesozoic rocks are probably upright.

CLASTIC DIVISION (UNIT I): The Clastic Division, with an estimated thickness of 2 400 metres (Ney, *et al.*, 1972), the lowermost exposed unit in the Cretaceous inlier, is composed of lower and upper members. The lower member (unit Ia) consists of immature, poorly to moderately sorted polymictic conglomerate and interbedded lithic sandstone. These rocks are greenish grey to dark grey and are composed of angular to rounded clasts of chert, quartzite, tuff, and volcanic rocks of mafic to intermediate composition. Conglomerates have a greywacke matrix (Ney, *et al.*, 1972) and sandstones have about 15 to 20 per cent silty matrix. Beds in the lower member are ill defined with thicknesses of up to 10 metres.

Greenish grey to white chert pebble conglomerate and quartz sandstone form the upper member (unit Ib) of the Clastic Division and immediately overlie the polymictic conglomerate unit (Fig. 37). These rocks are moderately sorted, mature, and locally have well-defined bedding up to 15 metres thick. Graded beds are not uncommon; they generally exhibit normal grading with west-facing tops and range from 5 centimetres to 1 or 2 metres in thickness. Conglomerates contain subrounded to rounded chert pebbles up to 20 millimetres across plus about 5 to 10 per cent sandy matrix. Sandstones are composed of angular to rounded chert, quartz, and quartzite grains 0.05 millimetre to 3 millimetres in diameter. Muddy matrix material forms about 6 per cent of the rock.

Lenses of thinly laminated welded tuff are interbedded with sedimentary rocks in the upper part of the chert pebble conglomerate unit. The tuff, which is cream to grey-green in colour, contains minor rock fragments and ovoid clasts in a fine-grained matrix. The strike length of these lenses is indeterminate because of poor outcrop exposure, but thicknesses generally are less than 5 metres.

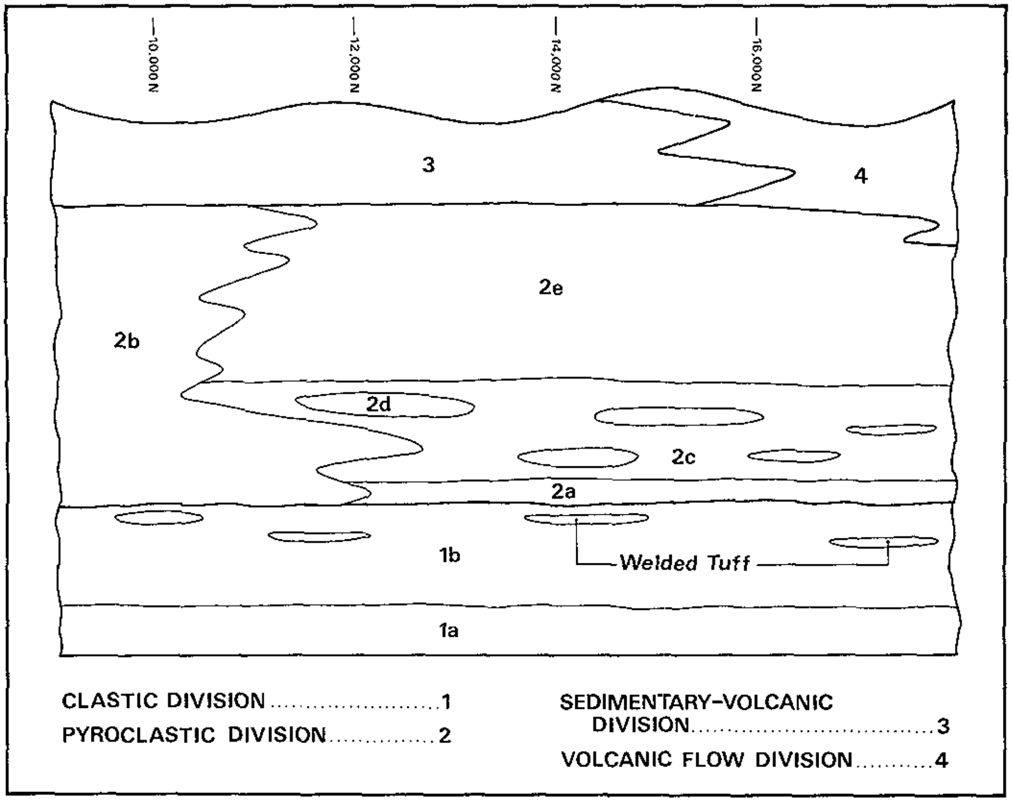


Figure 37. Generalized Mesozoic stratigraphy at Sam Goosly

PYROCLASTIC DIVISION (UNIT II): The Pyroclastic Division, a heterogeneous sequence of tuff, breccia, and reworked pyroclastic debris, conformably overlies unit Ib and has a maximum thickness of 975 metres. Unit II is the host of the Sam Goosly copper-silver-antimony ores. Five subunits of contrasting lithology are recognized within the Pyroclastic Division: pyroclastic flows, dust tuff, coarse pyroclastic rocks, volcanic conglomerate, and welded tuff (Fig. 37). With the exception of the dust tuff unit, these subdivisions are identical to those described by Wojdak (1974). This unit has been expanded to include Wojdak's brecciated dacite unit as well as the dust tuff, a grouping based on lithologic similarities and on apparent stratigraphic continuity between the two rock units.

The pyroclastic flow unit (IIa), the basal member of the Pyroclastic Division, has a minimum thickness of 30 metres and is composed of pyroclastic flows, flow breccias, and minor amounts of ash tuff. Pyroclastic flows and flow breccias are interbedded and consist of angular tuff and volcanic fragments suspended in a fine-grained tuffaceous matrix. Flows generally are more uniform in texture and contain fewer coarse fragments than do flow breccias, although contacts between these rock types are gradational. Ash tuff contains local rounded clasts up to 10 millimetres in diameter suspended in an aphanitic groundmass composed of quartz, plagioclase (An_{56}), biotite, sericite, and chlorite. Rocks of unit IIa commonly are characterized by fluidal structure, a feature that helps to distinguish them from overlying pyroclastic rocks. Pervasive chlorite alteration gives rocks of this unit a greenish grey colour.

The dust tuff unit (IIb) consists mainly of fine-grained rock with uniform texture that, in large part, is characterized by a conspicuous absence of well-defined bedding. Maximum development of this unit is in the southern part of the property where it is about 900 metres thick (Fig. 37). In this area, dust tuff conformably overlies the Clastic Division and underlies the Sedimentary-Volcanic Division. The basal contact is sharp although lenses of chert pebble conglomerate are not uncommon in the lower part of unit IIb. The upper contact is gradational and is fixed arbitrarily at the point where the rocks lose their massive character and become well bedded. A tongue of dust tuff extends about 600 metres north into the central part of the property and locally is interfingered with coarse pyroclastic rocks of unit IIc. This tongue, corresponding to the brecciated dacite unit of Wojdak (1974), has an average thickness of about 120 metres. It is gradational with overlying coarse pyroclastic rocks over an interval of 30 metres or less. The tongue is underlain by unit IIa (Wojdak, 1974) and locally by unit IIc (section 12,400 N); the contact generally is distinct. The major rock type of unit IIb is pale tan to dark green dust tuff which contains angular quartz fragments up to 0.2 millimetre across set in a sericitic matrix. Local interbeds of ash tuff up to 15 metres thick differ from dust tuff only in grain size and abundance of coarse quartz fragments. Lapilli tuff of unit IIb contains 40 to 80 per cent dust tuff fragments suspended in a sulphide-rich tuffaceous matrix and predominantly occurs as beds up to 18 metres thick within the northward projecting tongue. Brecciated dust tuff is similar in character to lapilli tuff, but breccia fragments are less rounded and the matrix consists almost entirely of sulphides. Locally, breccia is gradational with less fractured tuff on one side and lapilli tuff on the other, a relationship that suggests some "lapilli" tuff may be milled breccia with rotated fragments. The coarser grained rocks of the dust tuff unit are characterized mainly by the monolithologic nature of the constituent rock fragments.

Coarse pyroclastic rocks (unit IIc), which occur in the north and central part of the property, have a maximum thickness of about 300 metres (Fig. 37). They consist of lapilli and ash tuff with minor lenses of dust tuff. The coarser rocks contain a heterogeneous assortment of lithic fragments and are readily distinguished from the compositionally uniform rocks of unit IIb. Lapilli and ash tuff are interbedded, commonly with gradational contacts. The thickness of individual beds ranges from 30 centimetres to over 30 metres, but most beds are less than 9 metres thick. Except for size and abundance of fragments, lapilli and ash tuff are identical. Lapilli tuff contains 20 to 90 per cent tuffaceous, sedimentary, and volcanic fragments that range from 5 millimetres to over 100 millimetres in diameter. Fragments make up less than 30 per cent of the ash tuff and average 1 millimetre or less in diameter. Both rock types generally are greenish grey, but less altered rocks from north of the Main zone deposit (DDH 53) are characterized by a pale maroon hematite stain within fragments and matrix. Dust tuff of unit IIc occurs in beds generally less than 6 metres thick and commonly is gradational with ash tuff. The rock is identical to rocks of unit IIb and has been grouped with unit IIc only because of its close spatial relationship to coarse pyroclastic rocks.

Volcanic conglomerate (unit IId) consists primarily of reworked pyroclastic debris and occurs as lenses and interbeds within the coarse pyroclastic unit (Fig. 37). Local lenses are also present within the dust tuff and pyroclastic flow units. The thickness of individual beds ranges from 1 metre to about 23 metres, but lenses, which consist predominantly of reworked pyroclastic debris, commonly are 50 metres to 90 metres thick. Graded beds are present locally, but both normal and reverse grading have been observed; tops are indeterminate. The rocks of unit IId are green to grey and composed of subangular to rounded fragments of tuff, volcanic rock, and minor lithic sandstone that range from 3 to about 80 millimetres in diameter. Fragments make up 50 to 90 per cent of the rock and generally are supported by a white siliceous matrix or cement. Locally the rocks resemble lahars and have a muddy, fragmental matrix composed of angular quartz, plagioclase, and volcanic rock fragments suspended in about 20 per cent interstitial mud.

The welded tuff unit (IIe), the uppermost unit within the Pyroclastic Division, conformably underlies the Sedimentary-Volcanic Division and overlies coarse pyroclastic rocks of unit IIc (Fig. 37). This unit has a maximum thickness of about 520 metres and contains interbedded lapilli, ash, and dust tuff as well volcanic conglomerate and sandstone. Beds have gradational contacts and range up to 12 metres thick. Commonly, lapilli and ash tuffs are welded and consist of angular to subrounded fragments of volcanic rock, tuff, quartz, and quartzite. Fragments commonly are elongate subparallel to one another and appear to have been flattened. They are suspended in an aphanitic matrix with fluidal texture. Dust tuffs of unit IIe are uniformly textured and no indication of welding has been observed. Except for the local presence of plagioclase, these rocks are similar to dust tuff of unit IIb. Sedimentary rocks of unit IIe contain rounded clasts of tuff and characteristically have a tuffaceous matrix and a pale tan colouration. These features make the rocks distinct from the darker, silica-cemented rocks of unit IId.

Four marker beds composed of ash tuff occur within the Pyroclastic Division. They strike 013 degrees to 018 degrees and dip 40 degrees to 45 degrees westerly, an attitude that is consistent throughout the Sam Goosly deposit (Wetherell, Sinclair, and Schroeter, 1979). These marker beds range in thickness from 1.5 metre to 9.1 metres.

SEDIMENTARY-VOLCANIC DIVISION (UNIT III): The Sedimentary-Volcanic Division lies conformably above the Pyroclastic Division and beneath the Volcanic Flow Division (Fig. 37). It has an estimated thickness of 330 metres and consists of interbedded conglomerate, sandstone, and tuff. Individual beds range from less than 5 millimetres thick near the basal contact to over 12 metres in the central part of the section. Sedimentary rocks are pale tan. They are composed of subrounded to rounded fragments of tuff and rarely volcanic rock suspended in a matrix of quartz-rich sand. Matrix material comprises 30 to 50 per cent of the conglomerate and 80 to 90 per cent of the sandstone. Pyroclastic rocks of unit III are ash and dust tuff. Ash tuff contains about 40 per cent sericitized rock fragments of uncertain origin as well as some quartz and volcanic fragments. Dust tuff is a greenish grey, thinly bedded rock that is present mainly near the base of the section. Beds consist of alternating pale and dark-coloured layers 3 millimetres to 10 millimetres thick.

VOLCANIC FLOW DIVISION (UNIT IV): The Volcanic Flow Division conformably overlies and is in part interbedded with the Sedimentary-Volcanic and Pyroclastic Divisions (Fig. 37). It is the uppermost exposed unit within the Cretaceous inlier and has a known thickness of 550 metres. Rocks of this unit consist of porphyritic andesite and dacite flows. Andesite is grey-green and commonly contains over 25 per cent subhedral plagioclase phenocrysts (An_{57}) set in a groundmass of plagioclase, potassium feldspar, and lesser quartz. Mafic minerals and much of the groundmass have been altered to chlorite and sericite. Dacitic rocks are yellowish grey, generally finer grained than the andesites, and consist of about 5 to 30 per cent subhedral plagioclase in a groundmass of orthoclase, plagioclase, and quartz. Locally, orthoclase constitutes about 50 per cent of the rock.

MINERAL DEPOSITS: Copper-silver-antimony ores at Sam Goosly occur in the Pyroclastic Division. They form two roughly tabular deposits: the Main zone and the Southern Tail. These deposits are controlled mainly by structure and generally are discordant with the enclosing pyroclastic rocks. The Main zone strikes north-south and dips 45 degrees to 60 degrees westerly, whereas the Southern Tail strikes about 025 degrees and dips 30 degrees to 50 degrees westerly (Wetherell, 1979). The two areas are separated only because mineralization within intervening rocks is below cutoff grade; sulphides are continuous between them. The dominant sulphides at Sam Goosly are pyrite, pyrrhotite (primarily in the Main zone), chalcopyrite, tetrahedrite, and arsenopyrite (mainly in the Southern Tail). Other important minerals include magnetite, specular hematite, sphalerite, galena, various sulphosalts, and trace amounts of gold. Despite differences in the relative abundance of various minerals, the textural relationships and paragenetic sequence observed in each deposit are nearly identical, a feature which indicates a genetic relationship between the two areas (Wetherell, 1979).

Alteration assemblages in the Main zone and Southern Tail are also similar. Tourmaline and scorzalite are present in both deposits, although scorzalite is most abundant in the Main zone. Tourmaline is commonly intergrown with sulphides and is present as veins and disseminations in each deposit. Andalusite is also present in both deposits, but it is more closely associated with sulphide minerals in the Main zone than in the Southern Tail, where sulphides are associated with quartz-sericite alteration that has replaced andalusite locally. Sericite replacement rims are present around some andalusite grains intergrown with sulphides in the Main zone; these rims may be analogous to quartz-sericite alteration in the Southern Tail. Corundum, dumortierite, and spinel occur as veins and disseminations in the Main zone but have not been observed in the Southern Tail deposit.

Other mineralized areas at Sam Goosly are a zone of porphyry copper-molybdenum mineralization within and adjacent to a quartz monzonite stock about 900 metres west of the ore deposits and a zone of tourmaline breccia within the Volcanic Flow Division about 1 100 metres northwest of the Main zone. The mineralogy, textures, and paragenesis in these areas are similar in many respects to those observed in the ore deposits (Wetherell, 1979). This and the intimate association of tourmaline and sulphides in all four mineralized areas strongly suggests that all formed during the same mineralizing event. Whole rock samples of alteration yielded K/Ar ages of 58.5 ± 2.0 Ma for the tourmaline breccia zone and 58.1 ± 2.0 Ma for the Southern Tail deposit. These ages are identical, within the limits of analytical error, to that of the quartz monzonite stock which is 57.2 ± 2.3 Ma* (Carter, 1981). On the basis of the above relationships, Wetherell (1979) suggests that the copper-silver-antimony ores and the tourmaline breccia at Sam Goosly are related to a porphyry-type convection system that developed within and adjacent to the quartz monzonite stock.

* Recalculated model age using presently accepted decay constants ($\lambda_{\epsilon} = 0.581 \times 10^{-10}$/yr; $\lambda_{\beta} = 4.96 \times 10^{-10}$/yr; $K^{40}/K = 1.167 \times 10^{-4}$). Previously reported age is 56.2 ± 3 Ma.

REFERENCES

Carter, N.C. (1981); Geology and Geochronology of Porphyry Copper and Molybdenum Deposits in West Central British Columbia, *Ministry of Energy, Mines & Pet. Res.*, Bull. 64, 150 pp.

Ney, C. S., Anderson, J. M., and Panteleyev, A. (1972): Discovery, Geologic Setting and Style of Mineralization, Sam Goosly Deposit, B.C., *C.I.M.*, Bull., Vol. 65, No. 723, pp. 53–64.

Wetherell, D. G. (1979): Geology and Ore Genesis of the Sam Goosly Copper-Silver-Antimony Deposit, British Columbia, Unpub. M.Sc. thesis, *Univ. of British Columbia*, 208 pp.

Wetherell, D. G., Sinclair, A. J., and Schroeter, T. G. (1979): Preliminary Report on the Sam Goosly Copper-Silver Deposit, *B.C. Min. of Energy, Mines & Pet. Res.*, Geological Fieldwork 1978, Paper 1979–1, pp. 132–137.

Wojdak, P. J. (1974): Alteration at the Sam Goosly Copper-Silver Deposit, British Columbia, Unpub. M.Sc. thesis, *Univ. of British Columbia*, 116 pp.

1977 — POPLAR (93L/2W; 93E/15W)

DESCRIPTION:

Four diamond-drill holes of NQ size totalling 727.8 metres were drilled on the Canyon-East Creek area of the Main zone. The previously known copper-molybdenum mineralization that occurs in a highly altered and fractured biotite feldspar porphyry with a good quartz stockwork was confirmed.

Two diamond-drill holes of NQ size totalling 269.8 metres were drilled on the China Creek area (Eastern zone) located approximately 3.3 kilometres to the east of the Main zone. Two varieties of host rocks were encountered along with two dyke types. Biotite feldspar porphyry (BFP) has intruded andesite. The dark green-coloured andesite varies from being massive to porphyritic (up to 40 per cent plagioclase phenocrysts 2 millimetres in length) and locally displays a fragmental texture. Rock in the vicinity of the BFP is very strongly fractured with irregular carbonate filling and some quartz veins up to 5 millimetres in width. Chloritization is pervasive and epidote occurs in patches locally. Pyrite and hematite are present with minor chalcopyrite and trace molybdenite. Chlorite and hematite are abundant in microslips and gouging within the andesite.

The crowded BFP has a light greyish green colour and is medium to coarse grained. The following is a average mode:

60 per cent subhedral plagioclase phenocrysts (2 × 4 millimetres average)
15 per cent biotite "books" (2 × 3 millimetres average)
5 per cent hornblende (5 millimetres long)
15–20 per cent groundmass of quartz and plagioclase
1-2 per cent finely disseminated magnetite

In general the well-fractured rock has a relatively fresh appearance. Locally chlorite and epidote have formed after the mafics and the plagioclase has undergone weak sericitization. Potash feldspar envelopes and flooding are present locally up to 2 per cent by volume. Quartz veining is generally weak. Pyrite is disseminated and also occurs in quartz veins with minor amounts of chalcopyrite and molybdenite.

A fine-grained light grey to cream-coloured pre-mineral quartz feldspar porphyry (QFP) dyke is composed mainly of a groundmass that is totally sericitized, occasional quartz eyes, and approximately 1 per cent biotite "books" (2 to 3 millimetres). Pyrite and minor chalcopyrite occur in amounts up to 3 per cent.

The only other rock type noted is a post-mineral andesite dyke.

REFERENCE: *B.C. Ministry of Energy, Mines and Pet. Res.*, Geological Fieldwork, 1977, Paper 1978–1, p. 65.

1978—BOB CREEK (93L/7E)

LOCATION: Lat. 54° 18′ Long. 126° 37′ (93L/7E)

CLAIMS: GODFREY (5 units), CLOUD (3 units), LORNE (8 units), BUCK (20 units), HC (4 units)

OWNER: Mid Mountain Mining Ltd.

OPERATOR: Du Pont of Canada Exploration Limited.

DESCRIPTION: The Bob Creek prospect is located approximately 12 kilometres south of Houston. Gold, zinc, silver, and copper values are associated with widespread pyritization in acid volcanic rocks. Mineralized acid volcanic tuffs and breccias crop out in a 610-metre-long gossan in a gorge in Bob Creek, and are exposed in trenches west of Bob Creek. Intermediate volcanic rocks of andesitic composition crop out on the west side of the property (Fig. 38).

A small gabbroic stock has intruded the andesitic rocks near the southern boundary of the claim group. The rhyolitic rocks are overlain to the east and north by post-mineral Tertiary andesites and basalts.

The principal metallic minerals in order of abundance are pyrite, sphalerite, chalcopyrite, galena, silver in unknown form, and gold, both as free gold and in a sulphide matrix. The sulphides occur as tiny fracture fillings, in small lenses, and as coarse disseminations within the rhyolites and rhyolite breccias.

Pyrite is ubiquitous within the acid volcanic rocks and occurs as disseminations, in small veins with quartz, coating fracture surfaces, and filling voids in breccias.

Sphalerite in amounts up to 3 per cent occasionally fills the voids in the breccia. It also accompanies quartz-pyrite veinlets.

Kaolinization and sericitization have been extensive in the rhyolites and breccias.

WORK DONE: During the winter and spring of 1978 Du Pont, under an option agreement with Mid Mountain Mining Ltd., conducted geophysical, geochemical, and geological surveys and completed 6 diamond-drill holes totalling approximately 751 metres.

REFERENCE: Assessment Report 6912.

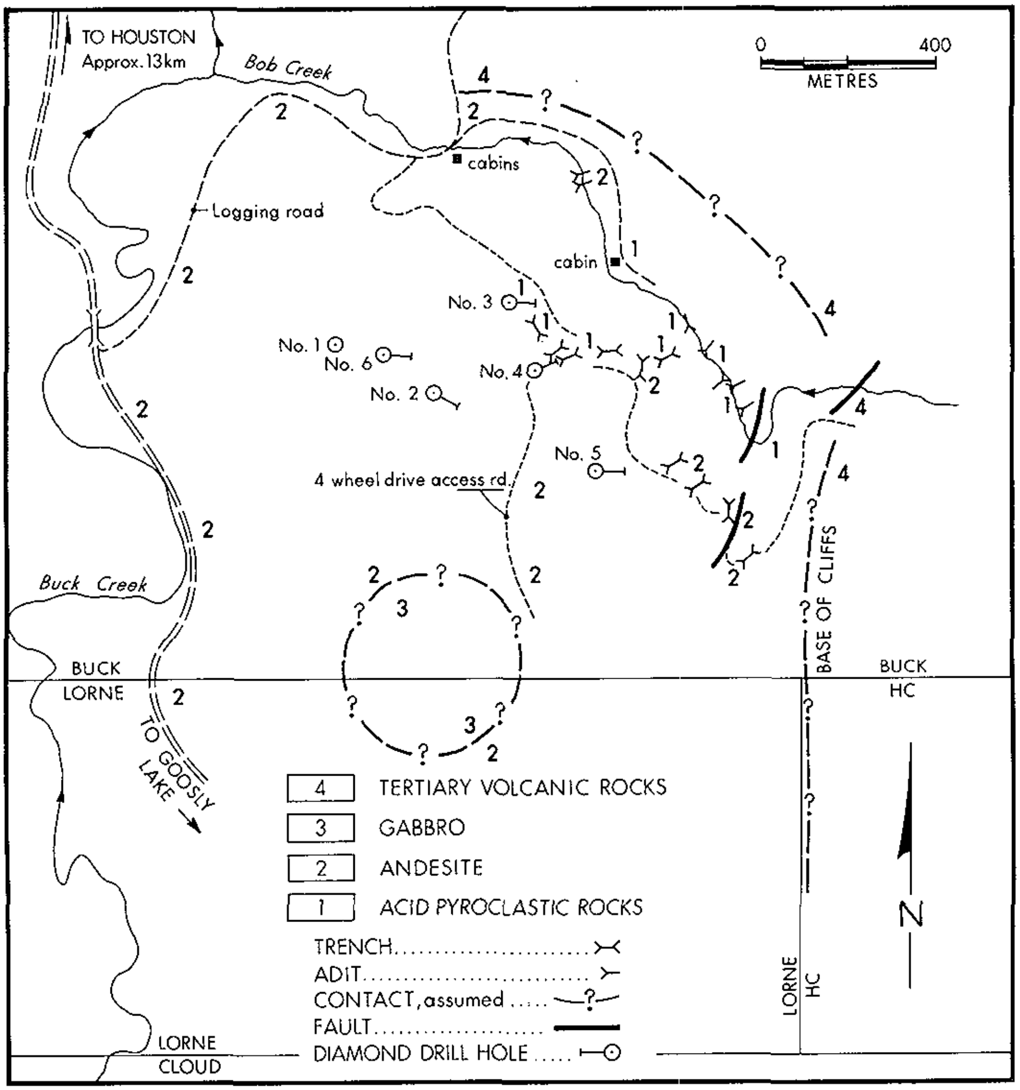


Figure 38. Geological sketch of the Bob Creek prospect

1977—GROUSE
(93L/7E)

The Grouse group of claims is located 5 kilometres north of Houston on Mount Harry Davis. Recent road building to a new communications tower on a knob immediately north of the microwave tower has exposed a sequence of acid pyroclastic rocks (lithic tuffs) hosting sphalerite-galena-chalcopyrite mineralization. Two main showings exist: a "Main" showing and a "Southwest" showing located 45 metres to the southwest. The Main showing consists of sphalerite, galena, and chalcopyrite in veins, in interstices, and as disseminations within a "bleached" (saussuritized) pale green to dark grey-coloured acid pyroclastic rock. Mineralization is exposed over a length of 18 metres (Fig. 39). Purple fluorite veining also occurs. Unmineralized and unaltered acid pyroclastic rocks are

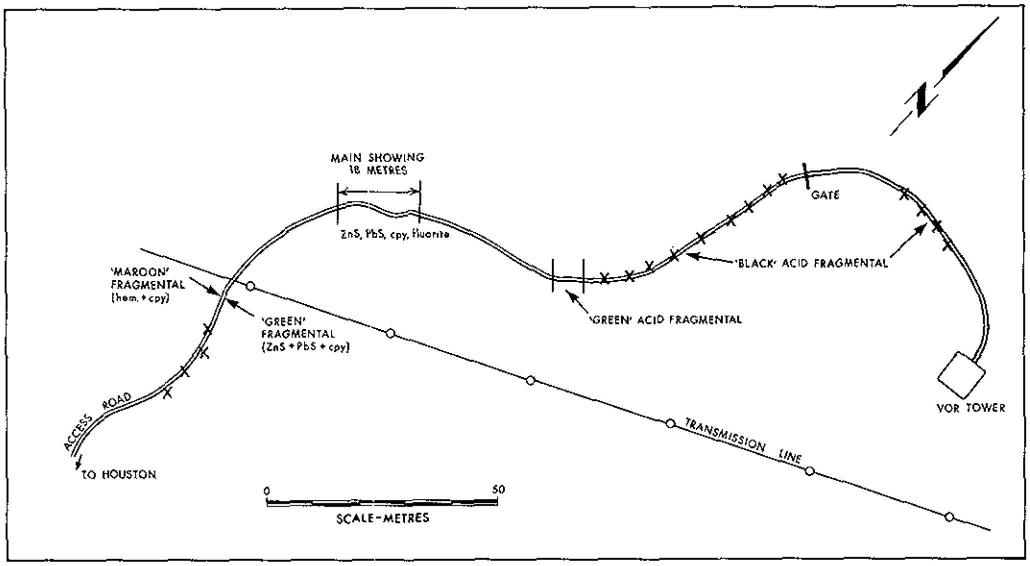


Figure 39. Sketch map of the Grouse prospect

massive dark grey to dark green in colour. The Southwest showing consists of sphalerite, galena, and chalcopyrite in the matrix and in fractures within altered green and maroon (hematitic) acid pyroclastic rocks.

Characteristic grab specimens collected for assay return non-significant values of silver, gold, copper, and lead. However, assays for zinc ran as high as 21.5 per cent in a brecciated acid fragmental with "bands" and fillings of sphalerite (yellow jack) and lesser purple fluorite (up to 1.76 per cent F).

REFERENCES: *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1977, Paper 1978–1, p. 66.

1977—LAKEVIEW
(93L/7E)

LOCATION: The Lakeview copper-silver-zinc prospect is located 10 kilometres north of Houston at an elevation of 1 135 metres. Access is via a four-wheel-drive road.

HISTORY: In 1926, four open cuts were made and a shallow shaft sunk along a length of 92 metres on a mineralized unit in rhyolite containing specular hematite, malachite, chalcopyrite, and pyrite.

Between 1966 and 1971 geochemical surveys, geophysical surveys, road construction, stripping, trenching, and diamond drilling (6 holes totalling 112 metres) were completed on the property. Results were inconclusive.

In 1977 John Bot of Smithers restaked the property and carried out a limited sampling program.

DESCRIPTION: A mineralized vein system containing chalcopyrite, pyrite, hematite, and sphalerite accompanied by chloritization, epidotization, and silicification occurs within a "bedded" volcanic sequence of Hazelton Group acid pyroclastic rocks with intercalated limestone—specular hematite beds. (Fig. 40). The length of the mineralized zone is greater than 400 metres along a strike of 040 degrees; dips are near vertical to 70 degrees to the northwest. Individual mineralized bed(s) are up to 3 metres in width with an average of 1.8 metres of massive specular hematite, chalcopyrite, and pyrite. One diamond-drill hole near the dump at the southern end of the vein apparently assayed 7.7 per cent copper, 141.07 grams per tonne silver, 0.85 grams per tonne gold, and 0.6 per cent zinc over 1.37 metres.

Surface samples collected assayed:

SAMPLE No.	CHARACTER	COPPER PER CENT	SILVER ppm	GOLD ppm	ZINC PER CENT	LEAD ppm	MINERALIZATION
L-1B	acid pyroclastic	.032	<10	<1	0.49	50	cpy
L-1C	acid pyroclastic	.039	<10	<1	0.13	350	cpy
L-5A	limestone	0.026	<10	<1	0.026	50	spec. hem.
L-5B	acid pyroclastic	0.014	<10	<1	4.2	200	spec. hem. ZnS
L-5C	acid pyroclastic	0.90	<10	<1	0.13	175	spec. hem.
L-5D	limy skarn	0.014	<10	<1	0.63	100	
L-6	andesite ?	0.54	12	<1	0.20	725	cpy
L-7A	high-grade, South dump	5.5	167	<1	3.6	188	spec. hem. ZnS, cpy
L-7B	high-grade, South dump	5.3	518	<1	0.14	400	spec. hem. cpy
L-7C	skarn, South dump	3.7	14	<1	1.1	200	cpy
L-7D	high-grade, South dump	3.4	278	<1	0.17	275	spec. hem. cpy
L-8	silicified and hematized limestone	1.3	31	<1	1.2	200	cpy, mal, az.
L-9	silicified and hematized limestone	0.59	<10	<1	7.6	200	ZnS
L-10	epidote skarn	0.21	154	<1	12.5	1575	spec. hem. cpy
L-11A	pyroclastic, North dump	0.047	<10	<1	3.6	50	spec. hem. cpy
L-11B	pyroclastic, North dump	1.00	<10	<1	0.093	<50	cpy, mal.
L-12A	limestone	0.097	<10	<1	12.6	225	spec. hem. cpy
L-12B	andesite	3.48	<10	<1	0.35	1175	cpy
L-13A	epidote skarn	0.26	82	<1	0.26	75	mal
L-13B	pyroclastic	0.33	<10	<1	0.57	<50	spec. hem. cpy
L-13C	pyroclastic	12.9	17	<1	0.12	125	spec. hem. cpy
L-13D	epidote skarn	0.12	<10	<1	0.18	<50	spec. hem.

Silver values are apparently directly related to the amount of chalcopyrite present, and zinc (and lead) values appear to be directly related to the amount of specular hematite present.

Post-mineral basic volcanic dykes averaging 1.3 metres in width cut the volcanic sequence and the mineralization.

Approximately 200 tonnes of ore remain on the property in old dumps.

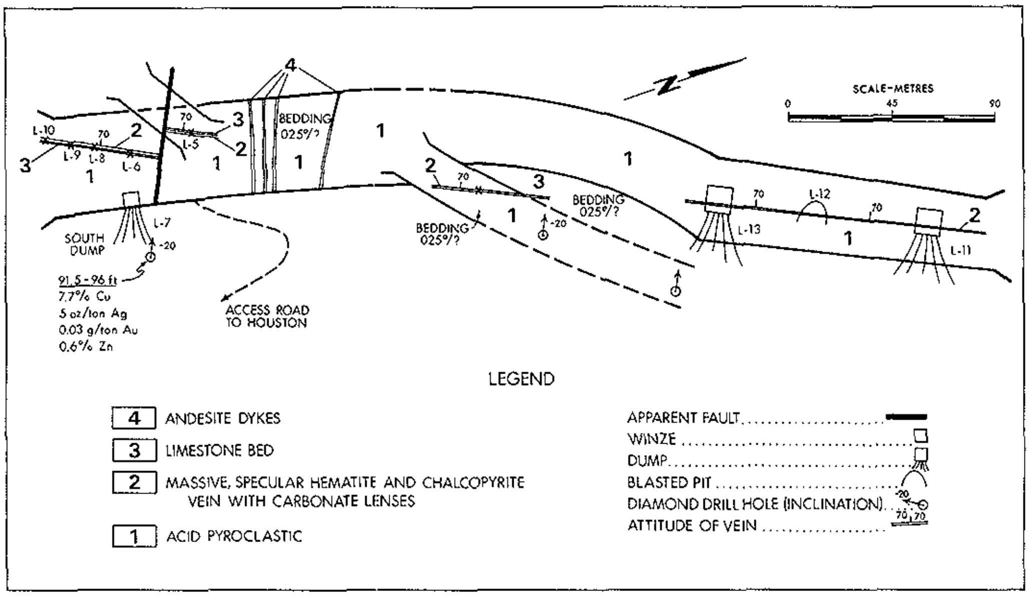


Figure 40. Sketch map of the Lakeview prospect

REFERENCES: *Ministry of Mines, B.C.,* Ann. Repts., 1926, p. 122; 1966, p. 102; 1967, p. 108; 1968, p. 138; *Ministry of Energy, Mines & Pet. Res.,* GEM, 1969, p. 121; 1970, p. 1515; 1971, p. 173; Assessment Report 2145.

1978—MINERAL HILL (93L/10E)

LOCATION:	Lat. 54° 31′	Long. 126° 43′	(93L/10E)

CLAIMS: MINERAL HILL (16 units), MINERAL HILL A (2 units), MINERAL HILL B (2 units)

OWNERS: P. J. Huber and Granby Mining Corporation.

OPERATOR: GRANBY MINING CORPORATION, 15th Floor, 1066 West Hastings Street, Vancouver.

DESCRIPTION:

The property was explored for copper, lead, and zinc in 1926–28 by means of a shaft, an adit, and some trenching. In 1962 Southwest Potash Corporation carried out geochemical and magnetometer surveys (Assessment Reports 509 and 510) over the Alaskite zone (Fig. 41). In 1964 Canex Aerial Exploration Ltd. explored the Alaskite zone and drilled one hole. From 1965 to 1969 Molymine Explorations Ltd. did some stripping and blasting, additional geochemistry, an induced polarization survey, percussion drilling, and diamond drilling. In 1966 Cominco Ltd. mapped the area and drilled 8 holes in the Alaskite zone and the granitic intrusive rock. Except for minor amounts of trenching, done for assessment purposes by P. J. Huber, no further work was carried out on the property until Granby optioned it in 1975. Granby carried out additional soil geochemical surveys and completed 12 percussion holes totalling 683 metres in 1976. No work was done in 1977. In 1978, with the aid of the Government Mineral Exploration Incentive Program, Granby completed 7 percussion holes totalling 515.3 metres and 3 diamond-drill holes totalling 902.5 metres. The percussion drilling and one drill hole were done to test a relatively unknown area and the other two drill holes were designed to test known mineralized surface areas at depth. The property is underlain by the Babine shelf facies of the Telkwa

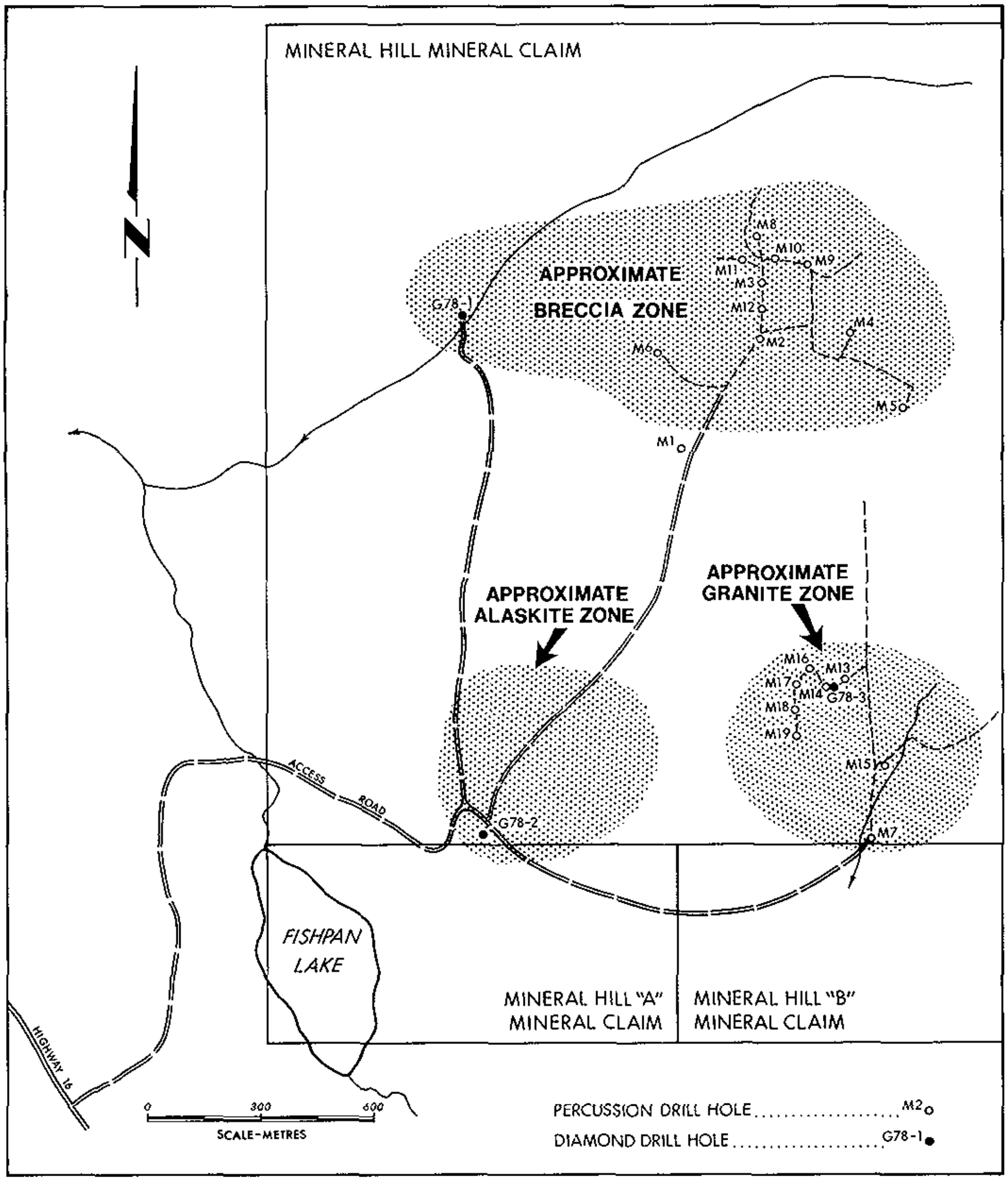


Figure 41. Mineral Hill

Formation of the Hazelton Group (Tipper and Richards, 1976). Mineralized hornfels rocks of the above formation have been intruded by a body of granite, alaskite, and fine-grained monzonite. Hole 78-1 was drilled in the Breccia zone and intersected hornfelsed lapilli tuffs (green to grey in colour) and minor hornfelsed sedimentary rocks. The rock is moderately to intensely bleached and locally resembles a skarn. Minerals include garnet, pyroxene, and andalusite (?). A purplish brown hornfels is composed mainly of secondary felted biotite. Molybdenite and pyrite mineralization in varying amounts was encountered in a quartz stockwork throughout the drill hole. Molybdenite also occurs as thin films on chloritic smears on fracture planes. Chalcopyrite and pyrite were noted.

Hole 78-2 was drilled in the Alaskite zone and intersected molybdenite mineralization in a quartz stockwork throughout. Hornfels was the main host rock, as in 78-1, except for a 37.9-metre section of alaskite from 33.7 to 71.6 metres.

Hole 78-3 was drilled at the east end of the Granite zone and intersected sparse molybdenite mineralization.

Mineralization consists primarily of molybdenite with minor amounts of widely distributed pyrite and chalcopyrite. Pyrrhotite, galena, tetrahedrite, and hematite occur in varying amounts. Gangue minerals include quartz, feldspar, siderite, and rare fluorite.

REFERENCES

Minister of Mines, B.C., Ann. Rpt., 1965, pp. 75-76.

Tipper, H. W. and Richards, T. A. (1976): Jurassic Stratigraphy and History of North-central British Columbia, *Geol. Surv., Canada,* Bull. 270.

1977—SUMMIT (BURBRIDGE LAKE)
(93L/10W)

HISTORY: In 1969 Mel Chapman of Smithers staked the Burbridge Lake (Summit) prospect. In 1973, the property was optioned by Hudson's Bay Oil and Gas, who carried out a program of geological mapping, a ground magnetic survey, geochemical soil sampling, and 366 metres of diamond drilling in 3 holes. In 1974, Cities Service Minerals Corporation optioned the property and completed induced polarization and magnetometer surveys and 495 metres of diamond drilling in 2 holes. In late 1976 Asarco Exploration Co. of Canada Ltd. optioned the property and during 1977 completed 650 metres of diamond drilling in 6 holes.

GEOLOGY: The property is underlain by andesitic, dacitic, and rhyolitic tuffs and flows of the Telkwa Formation. The rocks have been regionally metamorphosed to the greenschist facies (Fig. 42). Foliation occurring along bedding planes is locally very strong with a general trend to the northwest and variable dips to the southwest. A dioritic sill-like complex between 150 and 200 metres thick and at least 1 500 metres in length intrudes the Telkwa Formation. The upper part of the sill is porphyritic and may be granodioritic in composition. It becomes dioritic toward the bottom. The sill has also undergone regional metamorphism; it is pervasively altered to clay and carbonate + chlorite + sericite + quartz and contains 10 to 15 per cent disseminated and fracture-controlled pyrite. The upper part of the sill is mineralized with very finely disseminated chalcopyrite and fracture coatings of molybdenite. They are associated with a zone approximately 75 to 90 metres thick that consists of intense stockwork fracture and quartz veining that continues for at least 365 metres along the strike of the sill. The lower part of the sill is mineralized with 3 to 10 per cent disseminated pyrite and only minor amounts of chalcopyrite.

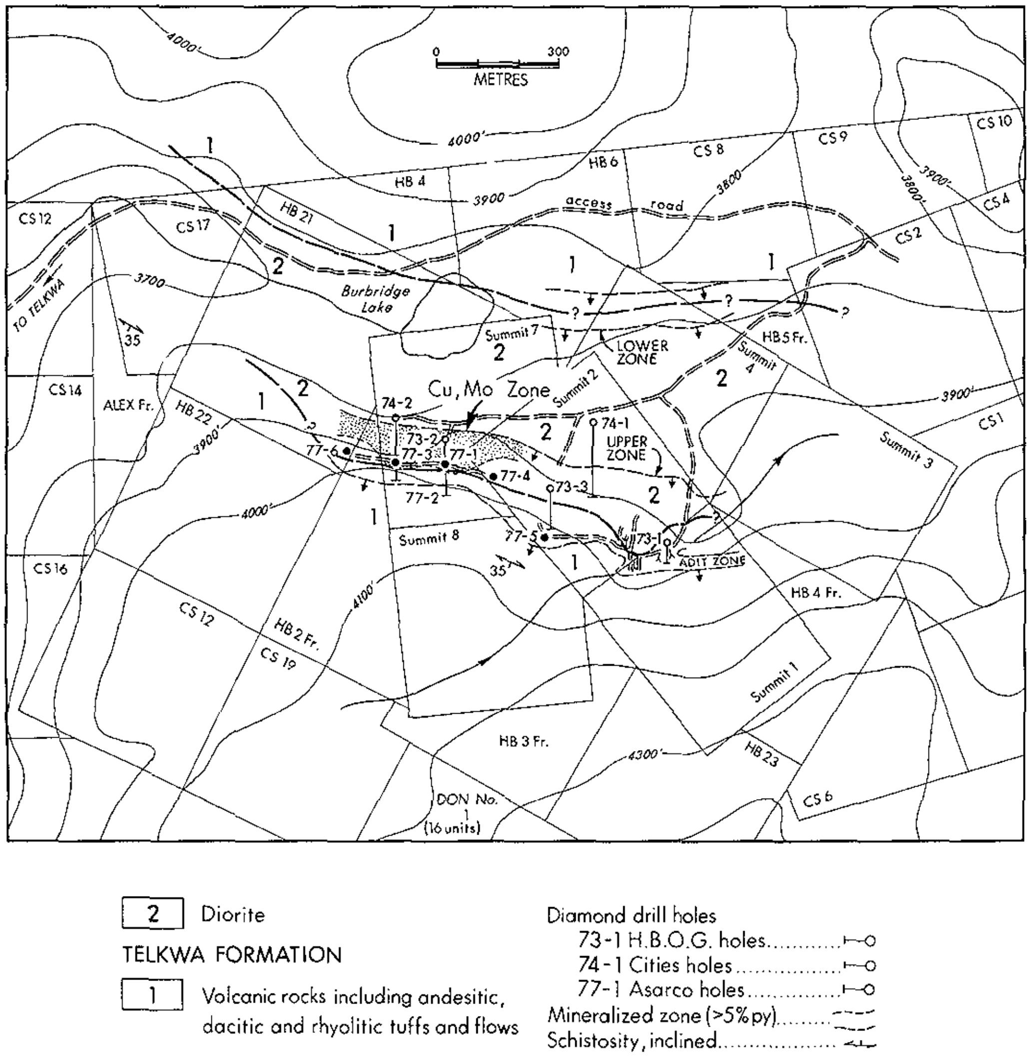


Figure 42. Sketch map of the Burbridge Lake prospect

In the upper zone the volcanic rocks exhibit intense epidote alteration. Massive lenses of pyrite are exposed in the Adit zone. The zone was explored in the early 1900's for gold associated with coarse-grained pyrite in quartz and massive lenses of magnetite within a fine-grained dacitic tuff unit.

REFERENCES: *B.C. Ministry of Energy, Mines and Pet. Res.,* GEM, 1973, p. 349; Geological Fieldwork, 1974, Paper 1975-1, p. 82; 1977, Paper 1978-1, p. 67; Assessment Report 5422; Mineral Inventory 93L-223.

1978—TELKWA COAL
(93L/11E)

LOCATION: Lat. 54° 37′ Long. 127° 08′ (93L/11E)

OWNER: Lloyd Gething.

OPERATOR: CYPRUS ANVIL MINING CORPORATION.

DESCRIPTION: Bulkley Valley Collieries (Telkwa coal mine) is located approximately 10 kilometres south of Telkwa, straddling Goathorn Creek. Under an option agreement with Lloyd Gething, Cyprus Anvil diamond drilled 6 holes, three of which were stopped at 150 metres in deep overburden. The other three holes encountered Skeena Group sedimentary rocks, with or without coal seams, overlying Hazelton Group maroon volcanic rocks. In general, the area appears to be very complexly block faulted over short distances making reconstruction and correlation of rock units very difficult.

WORK DONE: During 1978, Lloyd Gething and a partner mined, by a horizontal tunnel, a 4.2-metre coal seam (Betty seam, No. 4 mine extension). They had advanced approximately 60 metres and with the use of an old shake were able to put out 30 tonnes of coal per hour. This thermal coal has a Btu content of 13 000, an ash content of 7 per cent and a sulphur content of 0.6 per cent.

1978—CRATER
(93L/11E)

LOCATION: Lat. 54° 32′ Long. 127° 07′ (93L/11E)

CLAIMS: COPPER 1 (8 units), COPPER 2 (6 units), MARMOT 1 to 14, HANKIN 1 to 16, RON 1 (4 units), OLD TOM 1 and 2, REX (15 units) AL (15 units).

DESCRIPTION: The claims are located approximately 30 kilometres south of Smithers, on the north end of the ridge between Webster and Loring Creeks in the Telkwa Range.

A sequence of Hazelton Group (Telkwa Formation) volcanic rocks greater than 300 metres in thickness has been broken by faults and intruded by granodiorite and felsite dykes. The axis of a north-south-trending anticline that plunges to the north runs through the middle of Crater Lake. The volcanic rocks consist of alternating beds of red and/or green agglomeratic fragmental rocks, brick red tuffs, and massive green andesitic flows, with minor amounts of purple andesitic tuff and clastic sedimentary rocks.

Malachite, bornite, chalcopyrite, chalcocite, tetrahedrite, specular hematite, and magnetite occur in epidote-quartz-calcite-bearing shear zones in predominantly green fragmental andesitic volcanic rocks. Where mineralized, the andesitic rocks have been altered to a fine matted mixture of sericite (25 per cent), chlorite (25 per cent), carbonate (20 per cent), kaolin (15 per cent), epidote (8 per cent), leucoxene (3 per cent), hematite (2 per cent), magnetite (1 to 2 per cent), chalcopyrite *and/or pyrite (<1 per cent). Massive green andesitic flows up to 15 metres thick contain up to 5 per cent fine-grained disseminated magnetite.*

WORK DONE: During 1978 Mecca Minerals conducted a small diamond-drill program to test for disseminated-type sulphide mineralization within individual flow rocks.

REFERENCE: Assesment Report 4811.

1977—CRONIN MINE
(93L/15W)

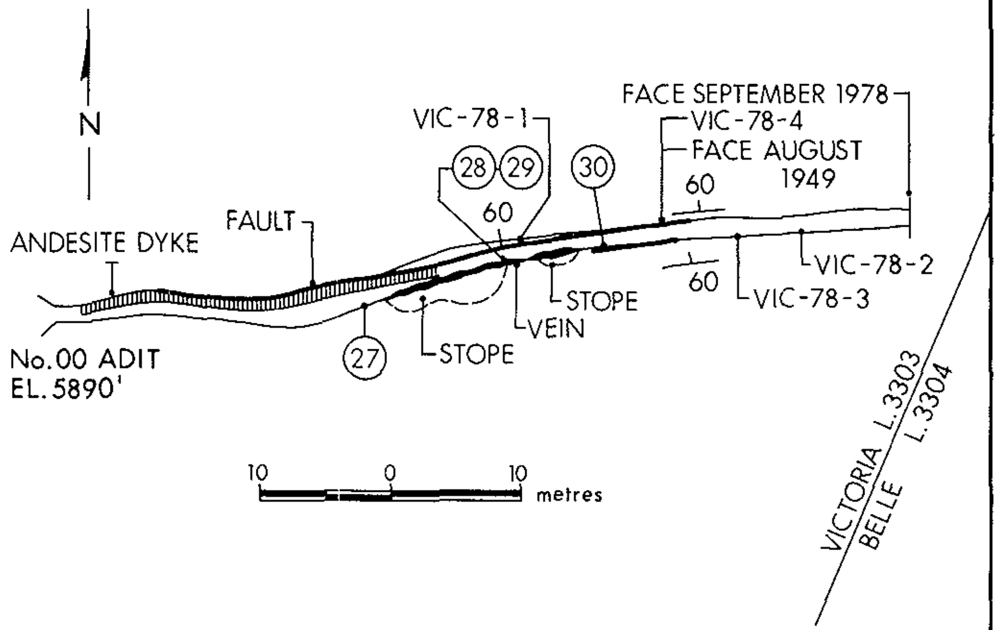
The Cronin silver-lead-zinc-gold-cadmium mine is located in the Babine Range approximately 30 kilometres northeast of Smithers. During 1977 Hallmark Resources Ltd. completed 41.5 metres of exploratory raising in two raises and 50 metres of drifting along a mineralized quartz-sphalerite-galena-chalcopyrite-pyrite-arsenopyrite-tetrahedrite vein (No. 2 vein) from the No. 1 level at elevation 1 543.8 metres (5,065 feet). The projected target is the Wardell vein which on surface is strongly mineralized. Underground the mineralized vein pinches and swells from almost nil to 1.5 metres in width, and averages 0.5 metre. The footwall is greyish green rhyolite, the hangingwall argillite. In places the ore is closely brecciated.

Approximately 300 tonnes of better sorted ore has been stockpiled outside the No. 1 level. Character samples collected from underground and from the stockpile assay:

Sample No.	Sample Description	Silver ppm (oz./ton)	Gold ppm (oz./ton)	Lead Per Cent	Zinc Per Cent	Copper Per Cent
C-77-1	massive ZnS + PbS + stringer cpy + py in qtz	564 (16.59)	1.7 (0.05)	8.5	25.7	3.0
C-77-2	cpy + py stringers in qtz	231 (6.26)	1.4 (0.04)	0.23	0.12	1.6
C-77-3	highly brecciated quartz vein with ZnS	140 (4.12)	<1	0.87	20.6	0.35
C-77-4	massive fine-grained PbS + ZnS + cpy	2567 (75.5)	1.7 (0.05)	42.5	20.4	0.33
C-77-6	massive PbS-ZnS-cpy in qtz	455 (13.38)	2.7 (0.08)	9.2	6.7	0.60
C-77-7	brecciated qtz vein with ZnS + py	75 (2.21)	2 (0.06)	0.67	5.1	0.27
C-77-10	massive (100 millimetres) qtz vein with py-PbS-ZnS	1035 (30.44)	2 (0.06)	16.6	6.7	0.55
C-77-11	massive qtz vein with py-PbS-ZnS	302 (8.88)	1 (0.03)	8.3	31.0	0.41
C-77-12	massive PbS-py in qtz	218 (6.41)	2 (0.06)	6.1	0.079	0.018

Development ceased in August.

REFERENCES: *Minister of Mines, B.C.,* Ann. Rept., 1949, pp. 94–98; GEM, 1973, pp. 347-348; 1974, pp. 263-264; Geological Fieldwork, 1974, Paper 1975-1, p. 81; 1975; Paper 1976-1, *B.C. Ministry of Energy, Mines & Pet. Res.,* pp. 66-67; Geology in B.C., 1975, pp. 67–70.



SAMPLE No.	Au oz/ton	Ag oz/ton	Co %	Ni %	U ppm	Th ppm	Mo %
VIC-78-1	1.97	—	1.5	.28	259	49	—
VIC-78-2	0.32	—	.25	.05	81	113	18.9
VIC-78-3	0.88	—	.68	.23	134	16	—
VIC-78-4	—	—	.006	.004	21	13	—

SAMPLE No.	Au oz/ton	Ag oz/ton	Co %	Equiv. % U_3O_8
27	Tr	—	—	.009
28	2.81	0.2	3.2	0.12
29	5.09	1.0	3.8	0.011
30	0.01	—	—	0.006

modified after J.S.Stevenson, 1949

Figure 43. Assay plan of adit, Victoria mine

1978 — VICTORIA MINE
(93M/4E)

LOCATION: Lat. 55° 10′ Long. 127° 38′ 93M/4E

CLAIMS: VICTORIA (Lot 3303), BELLE (Lot 3304), VIEW Fr. (Lot 3305), BELLE Fr. (Lot 3306), MAMMOTH (Lot 3307), RED CROSS (Lot 3310), MONOPLANE (Lot 3313), BOWL Fr. (Lot 3315), LITTLE HELEN (Lot 3319), PATRIOTIC (Lot 3311), HAZELTON VIEW (Lot 3299), LEAD PICK, HOMESTAKE (Lot 3309), TIGER.

OWNER: William McGowan.

OPERATOR: J. M. Hutter, RR 1, Telkwa V0J 2X0.

DESCRIPTION: The VICTORIA prospect is located approximately 10 kilometres south of Hazelton in the Rocher Deboule Range. This is a gold-cobalt-nickel-uranium-molybdenum prospect. Four veins exist on the property, three of them parallel to each other and occur with a granodiorite (Rocher Deboule batholith); the fourth occurs in the contact zone between granodiorite and hornfelsed sedimentary rocks to the south (Fig. 43).

Mineralization consists of cobalt-nickel sulpharsenides (mainly arsenopyrite), molybdenite, and uraninite in a predominantly hornblende gangue in replacement zones within the granodiorite.

In September 1978 the writer sampled four locations within the adit at elevation 1 768 metres. Mineralization consisted of massive arsenopyrite with erythrite (cobalt bloom) within hornblendite in a granodiorite host. The adit is approximately 80 metres (263 feet) in length.

V1C-78-1 Grab of mostly decomposed granodiorite with arsenopyrite and erythrite

V1C-78-2 Grab of decomposed granodiorite with molybdenite

V1C-78-3 Grab of hornblende-rich rock with arsenopyrite + pyrite + erythrite

V1C-78-4 Grab of decomposed granodiorite with manganese staining

WORK DONE: During 1978, J. Hutter, Jr. completed construction of an access road to the camp at elevation 1 265 metres and re-opened and retimbered two adits at elevation 1 605 and 1 768 metres. Mr. Hutter plans to reconstruct part of the 60-year-old aerial tramline to transport ore down the mountain side.

REFERENCES: *Minister of Mines, B.C.,* Ann. Repts., 1916, pp. 114–116; 1917, p. 113; 1918, p. 119; 1925, p. 136; 1927, p. 132; 1928, p. 159; 1948, pp. 80–82; 1950, p. 99.

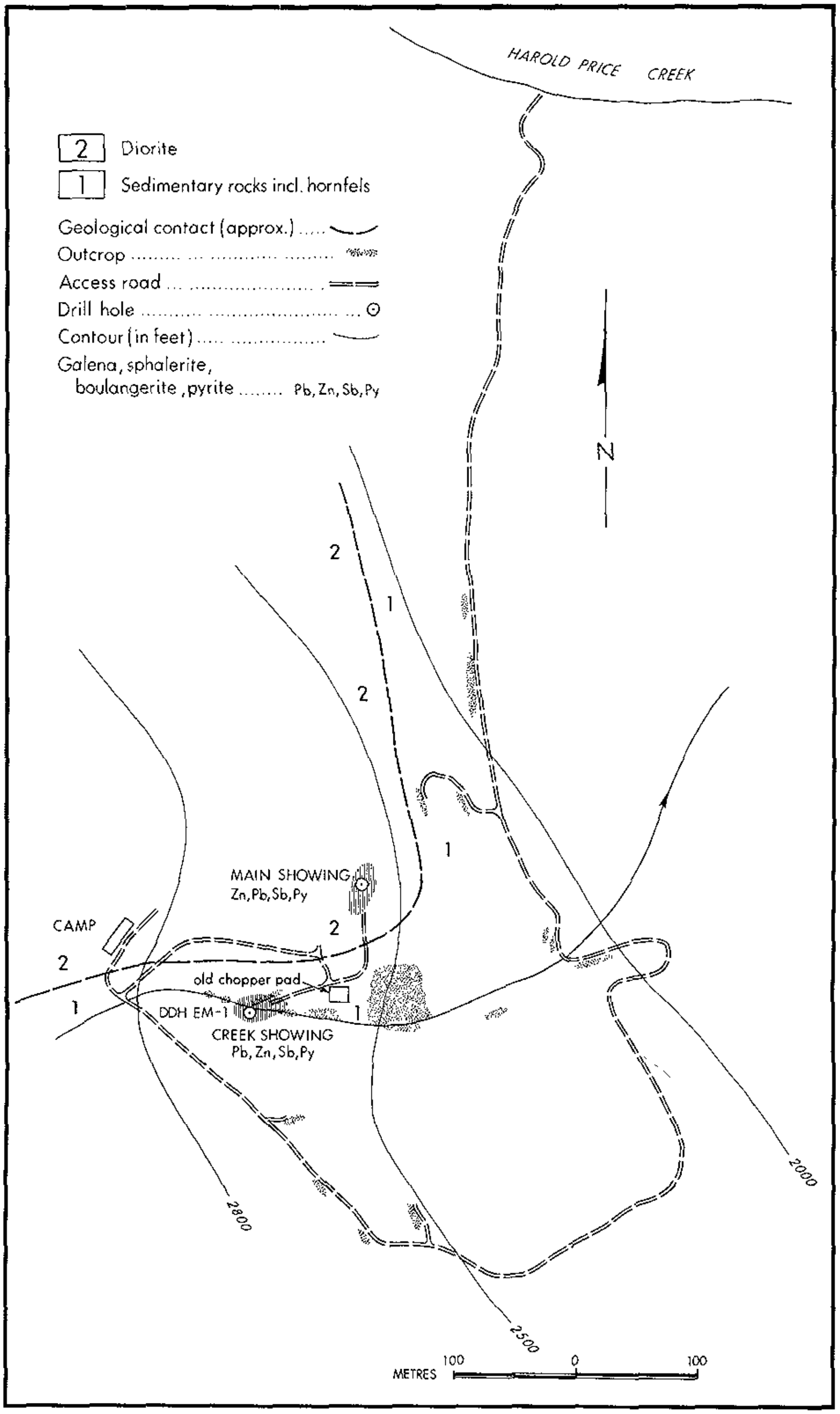


Figure 44. Geological sketch map, Max claim

1978—MAX
(93M/6E)

LOCATION:	Lat. 55° 16′	Long. 127° 08′	(93M/6E)

CLAIMS: MAX (6 units), MARTIN 1 to 6 (totalling 56 units).

OWNER: REBEL DEVELOPMENTS LTD.

DESCRIPTION: The MAX claim is located approximately 25 kilometres east of Hazelton. In December 1977, bulldozer trenching exposed two main showings: the Main showing and the Creek showing. During January 1978, a 2000-metre winter access road was constructed from Harold Price Creek to base camp at elevation 800 metres, and 6 diamond-drill holes, totalling 303.5 metres, were completed. Diorite was encountered in all holes. Small veinlets (up to 6 centimetres in width) containing sphalerite, galena, and pyrite with minor amounts of pyrrhotite and boulangerite in a quartz-carbonate gangue occur in small quantities (Fig. 44). The fresh diorite is quartz-poor and contains abundant magnetite. Plagioclase has been moderately altered to sericite and hornblende has altered to biotite. Adjacent to mineralized veins the diorite contains more quartz and the plagioclase has been completely sericitized. Biotite hornfels is well developed adjacent to the diorite, which is intrusive into volcanic and sedimentary rocks, including quartzite, chert, sandstone, greywacke, and siltstone. Partial replacement of some of the beds by sulphides has occurred. Mineralization in both showings consists of massive sphalerite, galena, stibnite, pyrite, boulangerite, chalcopyrite, jamesonite, and marcasite in quartz-carbonate gangue. A sample taken over a 12-centimetre width on the Creek showing assayed 1.66 grams per tonne gold, 3 406.55 grams per tonne silver, 0.60 per cent copper; and 4.37 per cent zinc.

WORK DONE: During the summer of 1978, geological and geochemical surveys were performed and one Winkie drill hole was put down on the Creek showing. A limited amount of linecutting was also completed.

1977—MOLLY BLUE
(93M/13E)

HISTORY: The prospect was first held by Magnum Consolidated Mining Co. Ltd. (a subsidiary of Canadian Exploration Limited) in the early 1960s. In 1963 Amax Exploration, Inc. staked the ground and during 1964 and 1965 conducted some hand trenching and sampling. In 1966 work included geological mapping and diamond drilling of one hole totalling 453 metres that was conducted from a base camp at elevation 1 737 metres. In 1977 John Bot staked the open ground and did reconnaissance prospecting.

GEOLOGY: The property is underlain by a pear-shaped granodioritic stock 1 524 metres long by 610 metres wide that trends in an east-west direction. The stock is cut by a quartz vein stockwork of varying intensity (Fig. 45). An aureole of pyrite up to 60 metres wide extends from the margin of the stock into Bowser Group sedimentary rocks, which consist of interbedded argillite and greywackes with minor amounts of conglomerate and limestone. Adjacent to the stock a hornfels with secondary brown biotite developed in the pelitic sediments, and a skarn with epidote and red garnets and up to 15 per cent pyrite, 0.5 per cent copper, and some scheelite and pyrrhotite developed in limy sedimentary

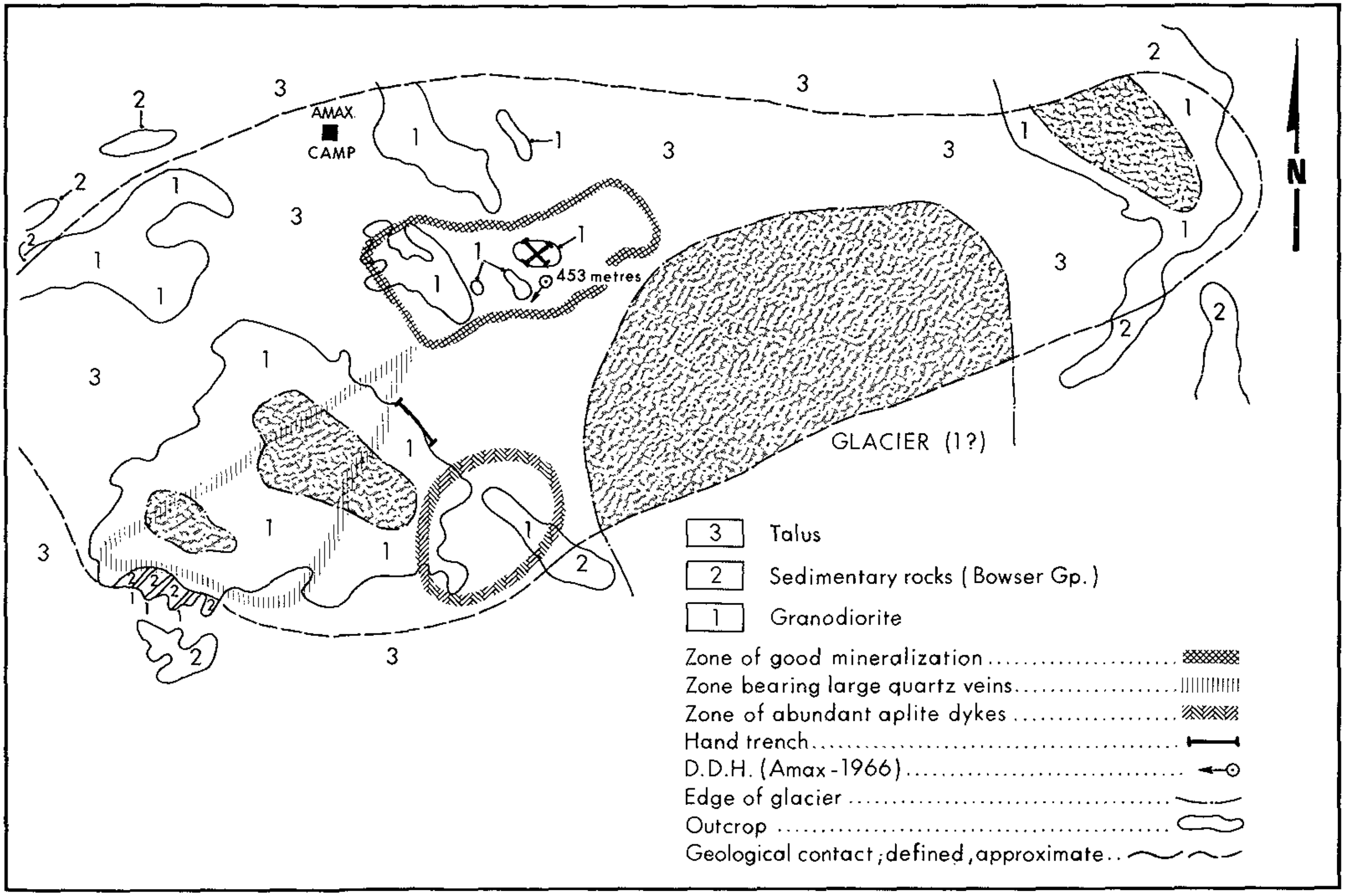


Figure 45. Geology of the Molly Blue prospect

rocks. In the vicinity of the stock the sedimentary rocks have been warped so that they roughly conform to the attitude of the contact. Dips within the sedimentary rocks are generally less than 45 degrees.

The granodioritic stock is porphyritic and homogeneous. An average modal composition is: 15 per cent medium-grained anhedral quartz; 5 per cent biotite "books"; 10 per cent potassic feldspar phenocrysts; 70 per cent subhedral plagioclase.

The potassic feldspar phenocrysts appear to be better developed near the centre of the stock.

The contact of the stock with metasedimentary rocks is sharp but there are stoped metasedimentary roof pendants and dykes of granodiorite cut metasedimentary rocks. Within the stock there are concentrations and mafic material as well as later dykes and a quartz vein stockwork that is mineralized with varying amounts of molybdenite, chalcopyrite, pyrite, stibnite, and rare scheelite.

Potash feldspathization exists as envelopes extending up to 10 centimetres into the wallrock; it is associated with an early phase of quartz vein stockwork. Molybdenum mineralization is present. Some potassic feldspar is associated with late vuggy quartz-feldspar-pyrite veins but it rarely extends into the wallrock more than 1 centimetre. No significant molybdenum mineralization exists with this later alteration phase.

Toward the core of the stock the rock has been pervasively sericitized and argillized in shear zones.

Pyrite is associated with all vein sets. Disseminated magnetite is associated with biotite booklets and post-mineral quartz veins.

Veining appears to be the most important control of mineralization and alteration. It occurred over a relatively long period of time. Three main types of veins have been recognized:

(1) *Early quartz vein stockworks*
—restricted area
—veins hairline to 1 centimetre in width
—some fractures are "dry" with molybdenite, pyrite, and minor amounts of chalcopyrite
—contemporaneous with potash feldspathization and aplite veins

(2) *Main quartz vein stockworks*
—occurs throughout the stock and extends into the metasedimentary rocks
—veins less than 1 centimetre to 1.5 centimetres
—vuggy, containing quartz, potassic feldspar, and pyrite
—associated calcite, molybdenite, sphalerite, and chalcopyrite
—gypsum and fluorite present
—haloes of potassic feldspar extend 1.5 centimetres into wallrock
—one predominant vein set, 055 degrees/70 degrees northwest, but there are other sets with significant molybdenum mineralization, quartz veins occur in sets up to 15 per foot

(3) *Large quartz veins*
—youngest quartz veins mostly confined spatially with a trend of 055 degrees/70 degrees northwest
—vuggy, from 2.5 centimetres to 0.6 metre in width with pyrite, molybdenite, chalcopyrite, and stibnite
—occur as many as four in ten feet

Four varieties of dyke rocks have been recognized:

(1) *Aplite*
—partly contemporaneous and partly later than the main quartz vein stockwork and main potash feldspathization
—a zone of intense aplite veining occurs with trend (050 degrees/70 degrees northwest) and veins comprise up to 50 per cent of the rock over a 15-metre width
—veins range in width from 2.5 centimetres to 3 metres
—texturally veins vary from being granular to quartz eye porphyries with quartz, potassic feldspar, biotite, molybdenite, and pyrite

(2) *Granodiorite*
—similar to the main stock but with larger quartz eyes
—irregular with a width up to 7 metres, trends 055 degrees/55 degrees northwest
—contains disseminated pyrite and malachite

(3) *Mafic-rich granodiorite*
—similar in composition to the main stock but more mafic rich, the dark grey rock contains 10 per cent white feldspar phenocrysts up to 2.5 centimetres in length contained in a groundmass consisting of 15 per cent biotite, 10 per cent quartz, and 70 per cent white feldspar
—width of dykes ranges from 2.5 centimetres to 1.5 metres; they are scattered throughout the stock with random attitudes and steep dips

(4) *Younger basalt (diabase)*
—massive rock composed of 50 per cent fine-grained plagioclase, 45 per cent mafics, and 5 per cent pyrite
—dykes trend northeasterly and dip steeply to the northwest

All dyke rocks except the basalt both cut and are cut by different vein types.

MINERALIZATION: Character samples of the host granodiorite taken for assay returned values ranging from 0.01 per cent to 0.17 per cent copper and from 0.009 per cent to 0.11 per cent molybdenite. One sample of intrusive skarn taken near the contact with metasedimentary rocks assayed 0.27 per cent copper and 0.52 per cent tungsten.

REFERENCES: *Minister of Mines, B.C.,* Ann. Rept., 1966, p. 81; *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1977, Paper 1978-1, p. 68; Mineral Inventory 93M-82.

WEST CENTRAL BRITISH COLUMBIA (NTS Division 103)

1977 — HECATE GOLD (103G/8)

LOCATION: The Hecate gold property is located 113 kilometres south of Prince Rupert near the west coast of Banks Island, approximately 3 kilometres inland from Survey Bay. Access is by floatplane and then tractor road.

DESCRIPTION: Falconbridge Nickel Mines Limited and MacIntyre Mines Limited have been exploring for gold on Banks Island since the late 1950's. Jim MacDougall with Falconbridge has contributed greatly to the geological knowledge of the Island. At least nine gold-bearing zones have been recognized on the current Banks Island gold property that is held under option by Hecate Gold Corporation from Falconbridge (Fig. 46). The zone of interest at present is the Bob zone on which underground drifting and sampling are continuing. The decline was advanced approximately 244 metres from the portal and 36.6 metres from the surface at a grade of 15 per cent, by December 1977.

Mineralization consists of pyrite, arsenopyrite, chalcopyrite, sphalerite, and galena occurring in a predominately quartz with minor calcite gangue that is located within a shear zone(s) in a foliated granodiorite. The sulphides are, for the most part, coarse grained but locally are distinctly banded. Minor amounts of graphite exist.

The attitude of the main shear (vein) structure is 090 degrees/85 degrees north. Several auxiliary quartz shear veins have similar strikes with shallower dips (for example, 60 degrees north).

The narrower quartz ($\pm$pyrite) veins exhibit wallrock bleaching (sericite ?), especially within the first 30 metres from the portal.

Gouge is common in the wider zones (that is, >15 centimetres) and consists mainly of clay and chlorite.

The host granodiorite ranges from being massive to strongly foliated. Where foliated, the mafic minerals have been brecciated. A typical mode is: feldspar, 60 per cent; quartz, 20 to 25 per cent; green amphibole, 10 to 20 per cent; brown biotite (after amphibole), 5 per cent; accessories, 1 to 2 per cent. Plagioclase is only weakly to moderately sericitized. Mafic minerals have been weakly chloritized and partially replaced by opaques.

Bands and pods of marble occur within the granodiorite; at their contacts a red-brown diopside-garnet skarn zone has developed. The skarn is composed mainly of granular garnet with intergrown diopside and minor infillings of calcite and quartz. A typical mode is: garnet, 70 per cent; diopside, 20 per cent; biotite, 2 per cent; calcite, 5 per cent; quartz, 2 per cent; pyrite, 1 per cent. Banding in the marble is cut by the sulphide mineralization.

A number of grab specimens of "ore" were taken for analyses from the stockpile and the results are listed on page 141 (HG-14 and HG-30 taken underground):

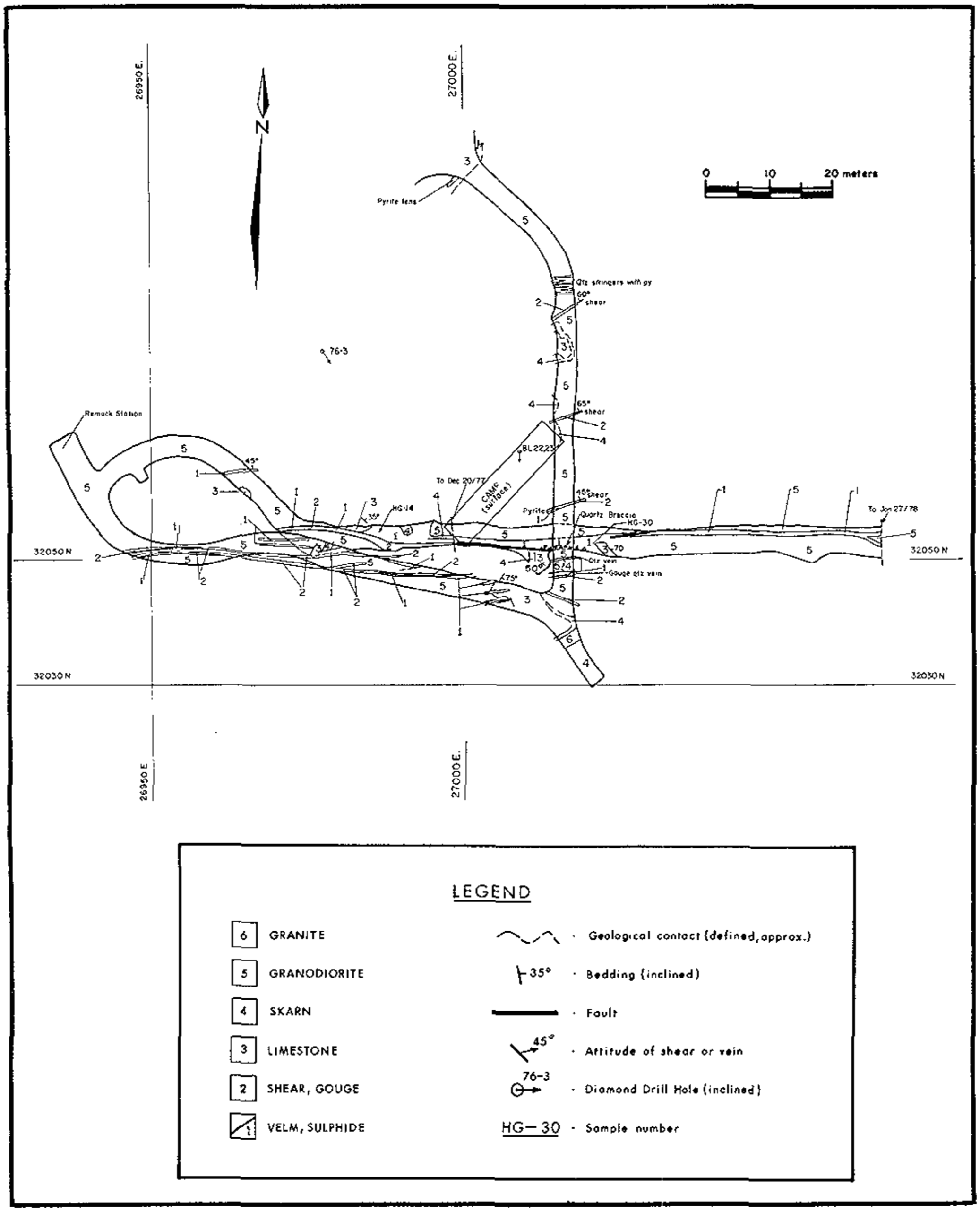


Figure 46. Banks Island Gold property (Hectate Gold)

SAMPLE No.	SAMPLE DESCRIPTION	GOLD ppm (oz./ton)	SILVER ppm (oz./ton)	COPPER per cent	ZINC per cent	LEAD per cent
HG-6	cpy-py in qtz-carb	627 (18.44)	737 (21.68)	12.30	0.32	0.015
HG-7	py in qtz-carb	37 (1.09)	79 (2.32)	0.34	0.06	0.023
HG-8	banded arseno-py-ZnS + minor py + py in qtz	26 (0.77)	31 (0.91)	0.31	7.00	0.045
HG-9	py-arseno-cpy in qtz	<10	<1	0.021	0.025	0.003
HG-10	banded arsenopyrite-ZnS-cpy-py in qtz	80 (2.35)	93 (2.74)	0.42	8.7	0.065
HG-11	cpy-py-ZnS in qtz	1	77 (2.27)	0.65	2.9	0.035
HG-12	massive py in qtz + minor cpy	48 (1.41)	53 (1.56)	0.21	0.024	0.03
HG-13	py in qtz	1.7	36 (1.06)	0.01	0.05	0.003
HG-14	massive py + minor cpy in qtz	42 (1.24)	183 (5.38)	1.34	0.033	0.033
HG-15	py + cpy in qtz	167 (4.91)	302 (8.88)	2.75	0.11	0.03
HG-16	skarn (gnt-diop) with qtz vein	7.5 (0.22)	<10	0.047	0.01	—
HG-19	massive ZnS + py + PbS + arsenopy + cpy in qtz	26 (0.765)	235 (6.91)	1.95	18.6	15.7
HG-20	arsenopy + py + ZnS in qts-carb	27 (0.794)	20 (0.59)	0.097	3.8	0.11
HG-22	massive arsenopy + ZnS + py + cpy in qtz	75 (2.206)	14 (0.41)	1.15	15.1	0.07
HG-23	banded PbS-ZnS-arsenopy + cpy in qtz-carb	20 (0.588)	10 (0.29)	0.16	9.98	0.02
HG-25	massive py + cpy in qtz	17 (0.50)	274 (8.06)	3.58	0.11	0.11
HG-29	massive cpy-py in qtz	52 (1.529)	304 (8.94)	12.03	0.25	0.02
HG-30	massive py-cpy-arsenopy in qtz	79 (2.324)	113 (3.32)	0.31	0.031	0.12
HG-32	massive ZnS-PbS-py-cpy in qtz	29 (0.853)	267 (7.85)	0.97	27.4	20.0
HG-35	massive cpy-py breccia	6 (0.176)	208 (6.12)	13.5	0.41	0.06
HG-36	massive py-arsenopy-ZnS-cpy in qtz-carb	42 (1.235)	46 (1.35)	1.03	7.63	0.023

It is apparent that precious metals are contained within pyrite, chalcopyrite, and arsenopyrite. Galena does not appear to carry appreciable amounts of silver.

1977—BELL MOLYBDENUM
(103P/6W)

HISTORY: A large group of claims was initially staked by Mastodon-Highland Bell Mines Limited in 1965, and a program of geological mapping and geochemical surveys was conducted. In 1966 Bell Molybdenum Mines Limited was formed, and 12 NQ diamond-drill holes totalling 966 metres were completed to test molybdenite mineralization occurring within an intrusive stock in hornfelsed Bowser sedimentary rocks. An additional 24 BQ holes totalling 4497 metres were drilled on a 122-metre grid spacing in 1967.

In 1975 Climax Molybdenum Corporation of British Columbia, Limited optioned the property; additional claims were staked and the property was remapped. During 1976, BQ diamond-drill holes totalling 2830 metres were completed. Seven were located on the Southwest Zone of the property and the eighth in the area of good mineralization within the Main Zone (Fig. 47). During 1977 an additional 9 vertical drill holes totalling 2678 metres were completed to test for additional molybdenite mineralization outside the Main Zone.

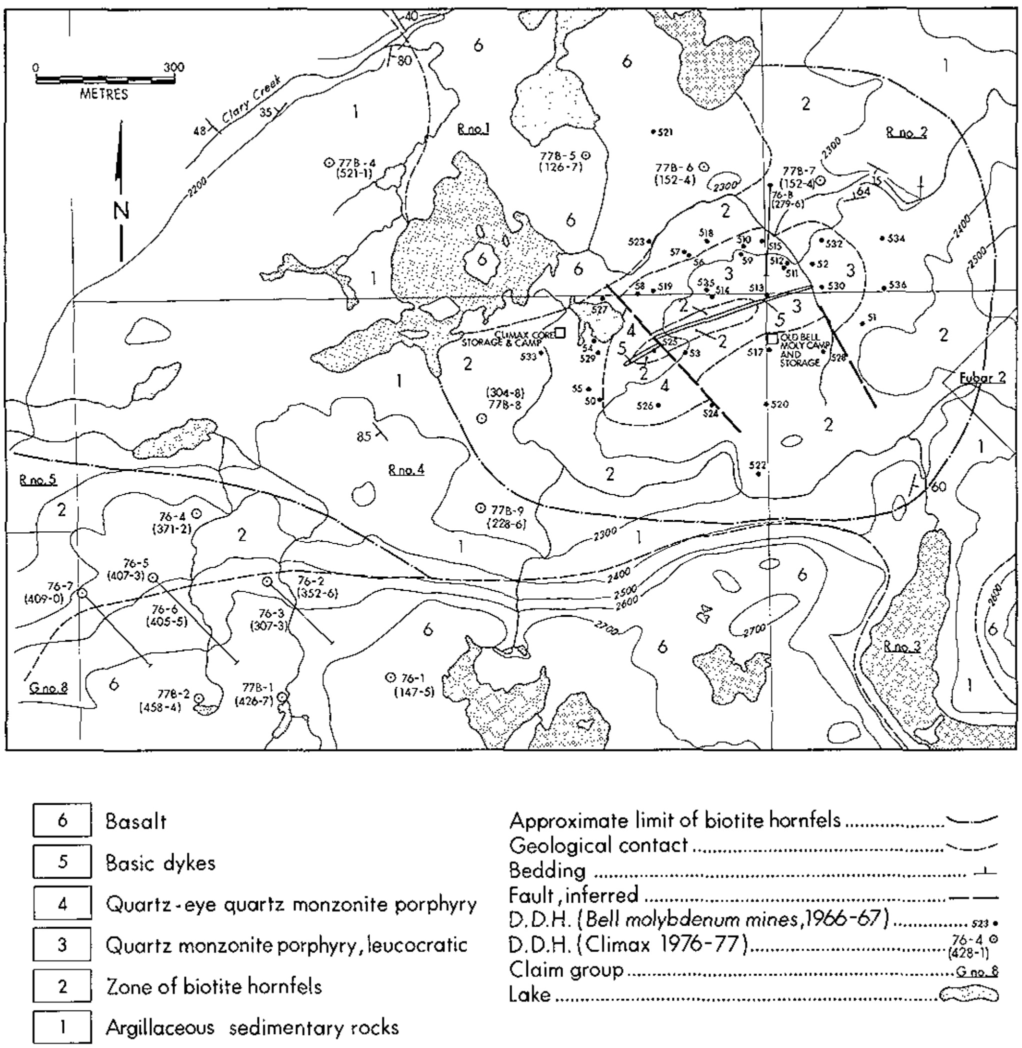


Figure 47. Geology of the Bell molybdenum prospect

GEOLOGY: In the Southwest Zone the typical sequence encountered in drill holes included:

(1) collaring in medium to dark grey locally vesicular olivine basaltic lava flows

(2) cutting through approximately 85 metres of basaltic lava and into an unconsolidated sequence of coarse gravel, sand, silt, and clay measuring up to 60 metres in thickness

(3) bedrock consisting of strongly bleached and fractured brown secondary biotite hornfelsed sedimentary rocks of the Bowser Group

(4) a leucocratic quartz monzonite at depth

The hornfels is locally intruded by numerous medium to dark grey-brown feldspar porphyry dykes that are related to the quartz monzonite stock. Molybdenite mineralization in the form of selvages in quartz veinlets occurs in both the quartz monzonite and biotite hornfels. Pyrite and pyrrhotite are common as disseminations and in fracture fillings.

In the holes drilled to the north and northwest of the Clary Creek stock, weakly mineralized hornfelsed sedimentary rocks of the Bowser Group were encountered. They are cut by feldspar porphyry and younger basic dykes, similar to those found elsewhere on the property.

REFERENCES: *Minister of Mines, B.C.,* Ann. Rept., 1967, pp. 44–47; *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1976, Paper 1977-1; p. 58; 1977, Paper 1978-1, p. 69.

NORTHEAST BRITISH COLUMBIA
(NTS Division 94)

1977—SPUR
(94D/2W)

The property is underlain by a northwesterly trending sequence of moderately easterly dipping (average 30 degrees) Takla Group (?) basic to intermediate subaerial volcanic rocks and intercalated volcaniclastic rocks. Mineralization appears to occur mainly within or near a contact zone of a basic lava flow(s) and a series of volcaniclastic units. It consists of chalcocite, bornite, chalcopyrite, and malachite-azurite in fracture fillings, in irregular vein systems, and as disseminations. Pyrite is locally abundant but for the most part is conspicuously absent. Hematite is more abundant and scattered throughout. Small high-grade pods of massive sulphides exist with values up to 16 per cent copper and 757 grams per tonne silver (Fig. 48). Mineralization appears to be further controlled by a major north-northeasterly trending fault and a number of crosscutting faults. Assay results indicate an average copper: silver of approximately 1:1 (*see* table below) which suggests that the silver is tied up within the copper minerals.

SAMPLE No.	DESCRIPTION	GOLD ppm (oz./ton)	SILVER ppm (oz./ton)	COPPER per cent	LEAD per cent	ZINC per cent	Cu:Ag
SPUR-2	volcaniclastic with dissem py + minor cpy	<1	12 (0.35)	0.05	—	—	0.14
SPUR-6	volcaniclastic	<1	11 (0.32)	0.02	—	—	0.06
SPUR-7	disseminated bn-cpy-chalcocite in andesite	<1	184 (5.4)	6.3	0.02	0.08	1.17
SPUR-7A	disseminated bn-cpy-chalcocite in andesite	<1	34 (1.0)	2.9	<0.02	0.07	2.9
SPUR-8	disseminated cpy-bn in contact between andesite and volcaniclastic	<1	14 (0.41)	0.89	<0.02	0.02	2.17
SPUR-9A	disseminated + fracture filled cpy-bn in volcaniclastic	<1	243 (7.15)	11.4	0.02	0.03	1.59
SPUR-10	disseminated + fracture filled cpy-bn in volcaniclastic	<1	31 (0.91)	1.5	<0.02	0.01	1.65
SPUR-10B	disseminated + fracture filled cpy-bn in volcaniclastic	<1	22 (0.65)	0.56	<0.02	0.02	0.86
SPUR-11	disseminated cpy-bn in volcaniclastic	<1	10 (0.29)	0.41	0.06	0.01	1.41
SPUR-11A	disseminated cpy-bn in volcaniclastic	<1	30 (0.88)	0.80	<0.02	0.02	0.91
SPUR-14	disseminated bn + cpy in breccia	<1	125 (3.68)	2.4	0.05	0.02	0.65
SPUR-15	massive bn in andesite	<1	421 (12.38)	13.4	0.03	0.06	1.08
SPUR-16	massive bn in andesite	<1	757 (22.27)	15.8	<0.02	0.04	0.71
SPUR-17	massive bn in andesite	<1	662 (19.47)	10.8	0.02	0.05	0.56
SPUR-19	massive bn in andesite	<1	539 (15.85)	16.3	0.04	0.02	1.03

REFERENCES: *B.C Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork 1977, Paper 1978-1, p. 68; Assessment Report 5681; Mineral Inventory 94D-103.

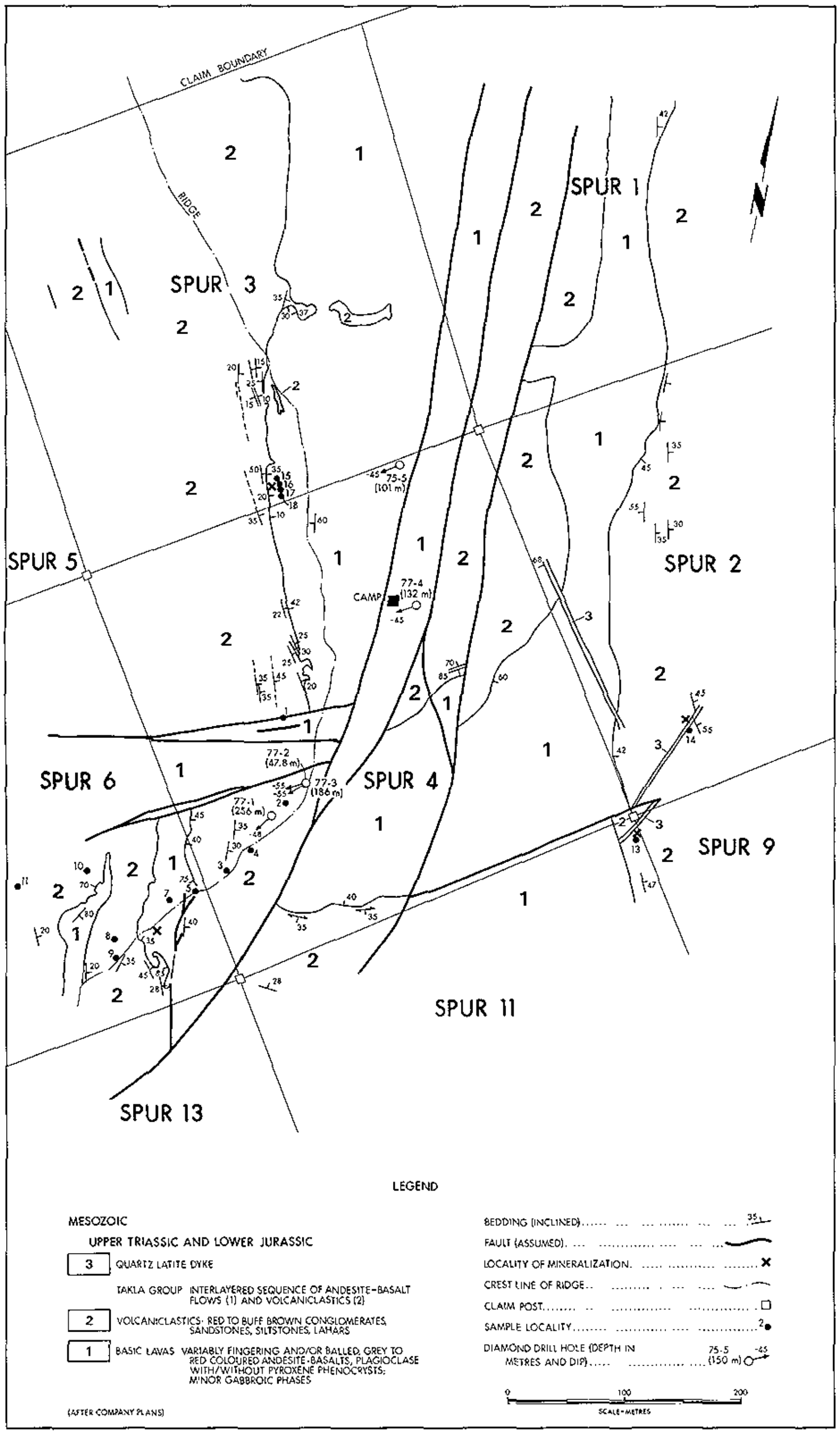


Figure 48. Geology of the Spur claims

ROCK TYPES

Quartz Latite Dyke—intrudes both the basic lavas and volcaniclastic rocks.

Volcaniclastic Rocks—The volcaniclastic rocks range in colour from buff-brown to brick-red. Rock types include crystal tuff, lapilli tuff, lithic tuff, and agglomerate. Sedimentary textures preserved include: graded bedding, channel grooving, load casts, convolute bedding, crossbedding, truncation and/or bed disruption near lava contacts.

Contacts with lavas are generally sharp but locally exhibit rafting of fragments from the underlying basaltic lavas (autobrecciation).

(1) *Lithic tuff*—Colour varies from mauve to red-brown to green and is blotchy in appearance. Grain size varies from fine-grained clasts less than 4 millimetres in size (ash) to clasts 2.5 centimetres in diameter (lapilli). Bedding is well developed but clasts occur at an angle to the bedding. Minor amounts of chalcopyrite exists as disseminations and small blebs. Hairline quartz-filled fractures are locally abundant.

(2) *Lapilli tuff*—Fine sand-sized angular to subrounded volcanic fragments and quartz grains occur in a fine-grained red-brown ash matrix. Hematite occurs scattered throughout. Fine-grained graded bedding is poorly developed and lapilli fragments are elongated and drawn out. Trace amounts of chalcopyrite and bornite exist as disseminations. Calcite occurs in fractures and tension gashes are filled with quartz.

(3) *Crystal tuff*—Similar to other tuffaceous units but with a predominance of crystals, notably quartz.

(4) *Agglomerate*—Coarse-grained intermediate volcanic rock with subangular clasts of variable composition healed by fractures of fine-grained mudstone and locally by lava infilling. Clasts range in size from 5 centimetres (lapilli) to 20 centimetres (bombs). Many clasts are elongated. Zones of volcanic breccia occur within the agglomeratic unit. Chalcopyrite and bornite locally (3 to 6 per cent) are disseminated and replace clasts of volcanic breccia.

Basic Lavas—Basic lavas include grey to red andesite-basalt. Flow tops in contact with volcaniclastic rocks are commonly irregular and sometimes exhibit autobrecciation.

(1) *Basalt*—Its upper contact with volcaniclastic rocks is irregular, and tuffaceous material fills the irregularities. Layered olive-green zeolites occur in amygdules parallel to the contact and also occur as irregular clots filling open spaces and vesicles. The relatively fresh variety of basalt consists of scattered large green grains (pyroxene and/or relict olivine) set within a fine-grained green matrix. Where hematitization has occurred the rock has a dark brown-red colour and pyroxene grains have been replaced by hematite. In places the red hematite outlines flow banding. Carbonate and zeolite amygdules are common. Very locally there are zones of abundant epidote. Locally the basalt has been brecciated and "balled" such that numerous variably sized fine-grained basalt "balls" are cemented by tuffaceous and zeolitic material.

    Mineralization consists of chalcocite, bornite, and chalcopyrite as blebs and clots, on breccia fragments, coating fractures, and as very fine disseminations. Malachite and azurite occur as fracture coatings. Pyrite is locally present but is generally sparse. Trace amounts of galena have been observed. Bornite blebs replace relict green pyroxene crystals in amounts up to 5 per cent.

(2) *Andesite*—The andesite is a very fine-grained, massive, dark grey flow rock. Locally flow tops are brecciated. Hematite is disseminated in various amounts.

    A possible intrusive equivalent of the andesite is a *microdiorite* which may underlie the andesite.

    Mineralized andesitic dykes with fine-grained chalcopyrite and bornite on fractures intrude volcaniclastic rocks.

(3) *Rhyolite*—A light grey to white possibly tuffaceous rhyolite appears to be locally interbedded with the basalt. Flow banding and flow breccia textures are common. Chalcocite, bornite, and chalcopyrite are disseminated in the rock in amounts up to 5 per cent.

(4) *Gabbro*—Coarse-grained, granular gabbro contains up to 2 per cent finely disseminated bornite and up to 5 per cent chalcopyrite and bornite as clots on small fractures and replacing mafic minerals.

1977—GEOLOGY, K/Ar DATES, AND ASSOCIATED SULPHIDE *MINERALIZATION OF WREDE CREEK ZONED ULTRAMAFIC COMPLEX* (94D/9E)

By R. H. Wong, C. I. Godwin, and K. C. McTaggart
Department of Geological Science, The University of British Columbia

INTRODUCTION: Wrede Creek ultramafic complex, one of several zoned or Alaskan-type ultramafic bodies in the McConnell Creek and Aiken Lake map-areas of north-central British Columbia, is centred at longitude 126 degrees 08 minutes west and latitude 56 degrees 40 minutes north (Fig. 49). The complex lies within the Ingenika Range, approximately 8 kilometres north of Johanson Lake.

Sulphide mineralization closely associated with the Wrede Creek complex is covered by NIK claims 1 to 9 which were staked in 1976 and subsequent years and are owned by BP Minerals Limited. Work to date includes geologic mapping at a scale of 1:5000 (1:2000 locally), overburden geochemistry, magnetometer and induced polarization surveys, 2550 metres of trenching, 3050 metres of percussion drilling, 3100 metres of diamond drilling, and construction of 8 kilometres of access road from Johanson Lake. Access to Johanson Lake is either by light aircraft or via 400 kilometres of gravel road northeast from Fort St. James.

The writers gratefully acknowledge BP Minerals Limited for release of data concerning the property, and the British Columbia Ministry of Energy, Mines and Petroleum Resources without whose funding, microprobe analyses and K/Ar dating would not have been possible.

REGIONAL GEOLOGY: Regional geology of the area has been described by Lord (1948) and Roots (1954). Remapping of the McConnell Creek map sheet was completed by the Geological Survey of Canada in 1976 (Richards, 1976). Ultramafic and gabbroic bodies in the area have been briefly described by Irvine (1974 and 1976).

Zoned ultramafic bodies occur along the eastern edge of the Quesnel Trough, a northwesterly trending, partly fault-bounded structure underlain predominantly by volcanic and sedimentary strata of Early Mesozoic age. Plutonic rocks of Jurassic age are prominent throughout the Quesnel Trough.

PROPERTY GEOLOGY: Wrede Creek complex, approximately 5 kilometres in diameter, was emplaced in andesitic to basaltic flows and tuffs of the Upper Triassic Takla Group (Fig. 50). The complex is fault bounded on its western and northeastern margins and is in contact with hornfelsed rocks of the Takla Group elsewhere. The ultramafic complex displays a crudely concentric zoning, progressing outward from a core of dunite to an *apparently continuous rim of pyroxene-rich rocks. Olivine pyroxenite occurring immediately* adjacent to dunite grades outward into pyroxenite $\pm$ magnetite. Peridotite that

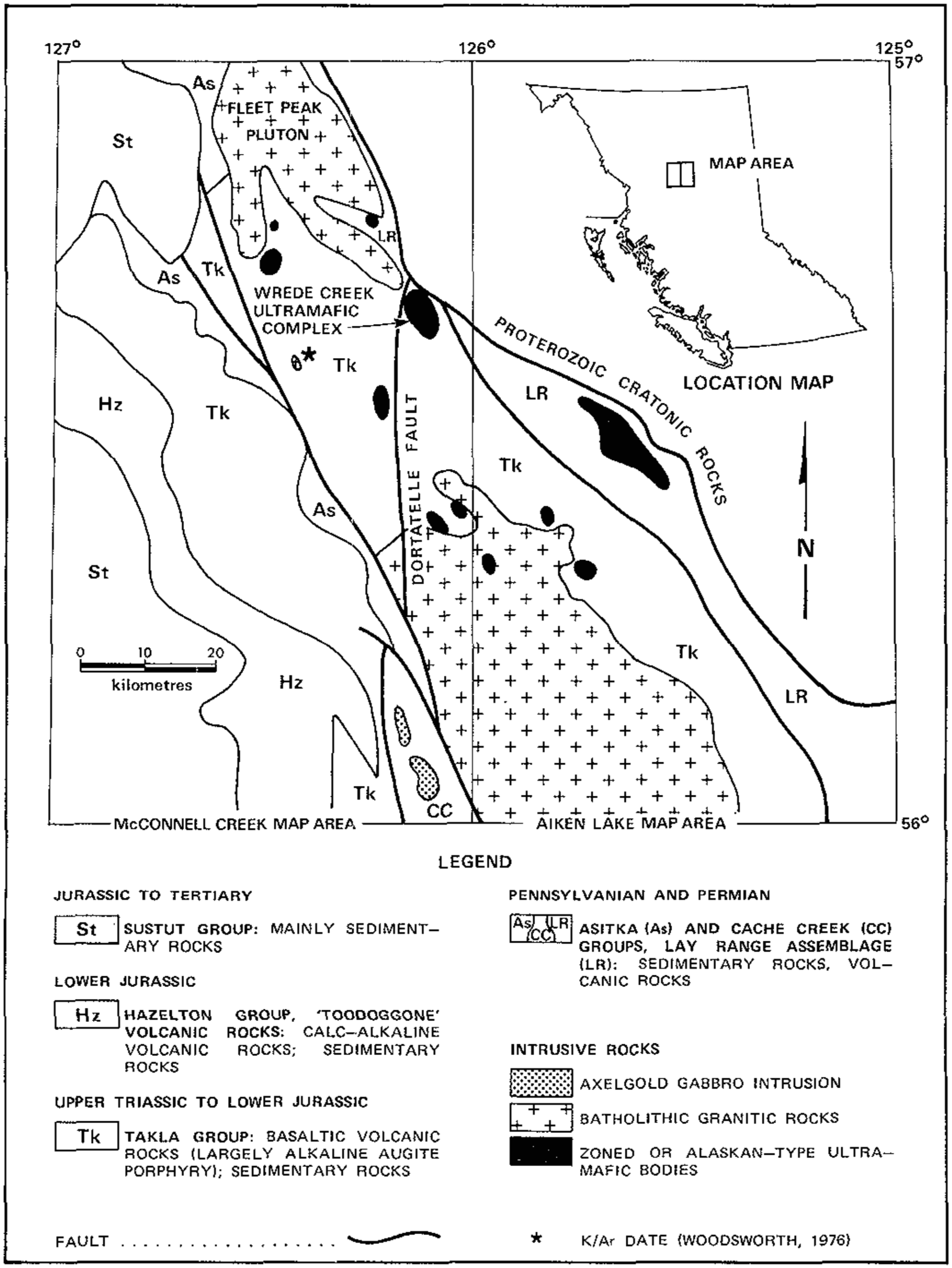


Figure 49. Location and regional geology of the Wrede Creek ultramafic complex

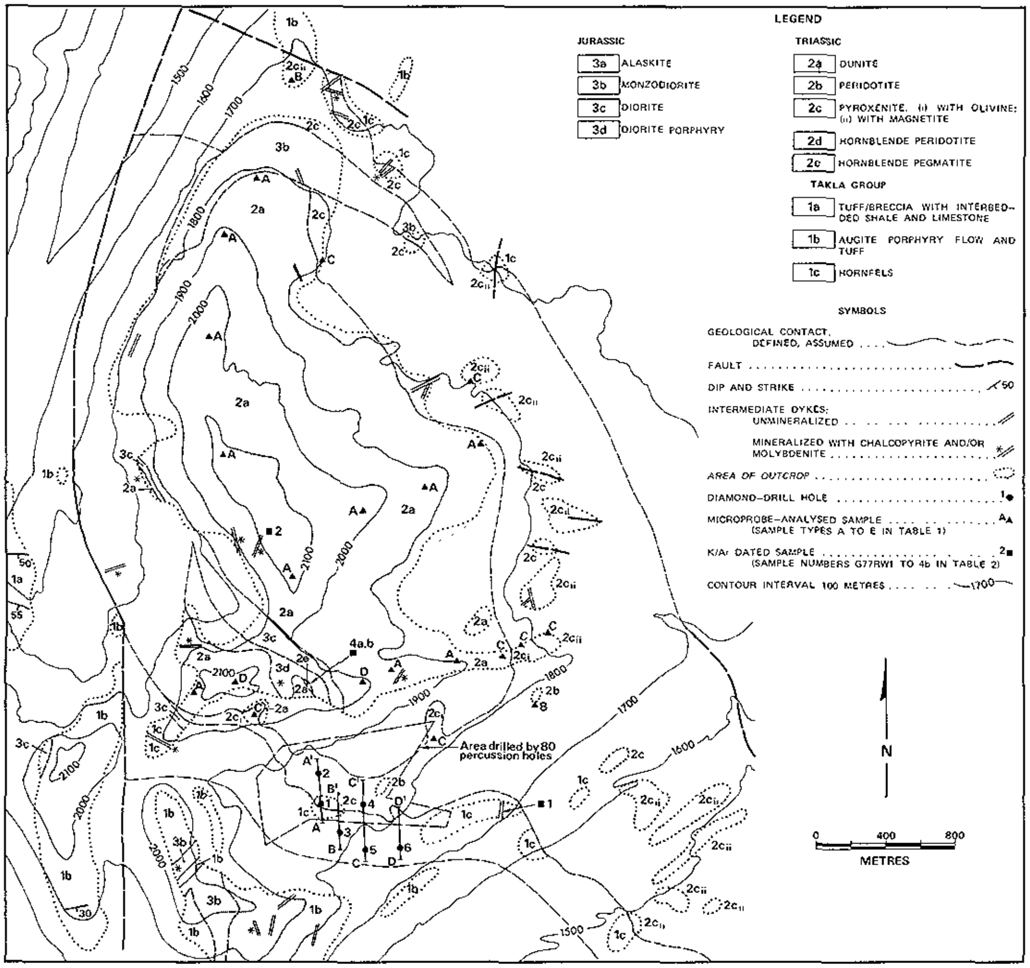


Figure 50. Geology of the Wrede Creek zoned ultramafic complex

occurs locally within olivine pyroxenite contains up to 50 per cent olivine. Hornblende peridotite, commonly containing abundant secondary magnetite, locally constitutes the peripheral unit of the ultramafic body. Irregular zones of hornblende pegmatite, composed of approximately equal amounts of hornblende and calcic plagioclase, occur throughout the complex. Olivine pyroxenite and hornblendite dykes, apparently of magmatic origin, intrude the dunite. Gravitational layering is rarely observed in the ultramafic rocks. The major north-trending fault which bounds the ultramafic body on the west is probably an extension of the Dortatelle fault (cf. Richards, 1976) and appears to have truncated zoning along this side of the complex.

Microprobe analyses (Table 1) indicates that mineralogy of the Wrede Creek ultramafic rocks is similar to that of zoned complexes elsewhere (compare Taylor, 1967). Olivine is highly forsteritic, averaging Fo_{90} in the dunite and Fo_{84} in the pyroxentite. Pyroxene is exclusively diopsidic augite and contains from 0.5 to 4.4 weight per cent Al_2O_3. MgO/FeO trends for olivines and pyroxenes are compatible with differentiation and crystallization of the main ultramafic rock types in the sequence: dunite, peridotite, pyroxenite.

A well-defined contact metamorphic aureole, with metamorphism up to the hornblende hornfels facies, and the existence of dykes of ultramafic composition suggest that the ultramafic body was emplaced magmatically. K/Ar dating of hornblendes from a hornblende pegmatite gave ages of 219 ± 10 Ma and 225 ± 8 Ma (Table 2). These ages are coincident with those of the adjacent Takla volcanic rocks, suggesting a genetic relationship between the two.

Porphyritic, equigranular, and pegmatitic intrusions of dioritic to granitic composition occur as narrow to large (0.5 metre to 150 metres wide) dykes cutting both ultramafic and volcanic rocks. Most of the dykes are medium-grained, hornblende-bearing diorite in which plagioclase of oligoclase to andesine composition composes 75 to 85 per cent and prismatic hornblende 15 to 30 per cent. Dykes of quartz diorite to quartz monzonite composition are less common, biotite becoming more prominent in the quartz and orthoclase-bearing rocks. Very narrow (less than 0.5 metre) dykes of pink, pegmatitic alaskite, made up predominantly of microcline with lesser amounts of quartz and plagioclase, are the least abundant dyke lithology.

TABLE 1—Average Composition of Olivines and Pyroxenes in Ultramafic Rocks from the Wrede Creek Ultramafic Complex, British Columbia[a]

	A[b]: DUNITE	B: PERIDOTITE		C: PYROXENITE		D: PERIDOTITE DYKES		E: PYROXENITE DYKES	
	Olivine	Olivine	Pyroxene	Olivine	Pyroxene	Olivine	Pyroxene	Olivine	Pyroxene
Na_2O	.01	—	.10	—	.17	.01	.21	—	.17
MgO	49.09	47.32	17.13	45.37	16.02	47.14	16.01	46.20	16.53
Al_2O_3	—	—	.68	—	2.18	—	2.81	—	1.94
SiO_2	40.36	40.41	54.41	40.00	52.81	39.81	52.46	40.36	53.08
CaO	.13	.03	24.67	.03	23.63	.09	24.47	.10	23.82
TiO_2	.01	.01	.11	.02	.26	.01	.38	.01	.24
MnO	.20	.16	.08	.32	.11	.24	.07	.23	.12
FeO[c]	10.22	12.47	2.44	15.42	4.83	13.48	3.54	14.34	3.95
NiO	.19	.19	.02	.13	.03	.19	.04	.16	.02
TOTAL	100.21	100.59	99.64	101.29	100.04	100.97	99.99	101.40	99.87
No. of Analyses	29	2	4	4	10	3	9	2	3

a: All analyses done on the electron microprobe, Department of Geological Sciences, The University of British Columbia.
b: Sample type identified on Fig. 50 by letters A to E.
c: Total iron as FeO.

TABLE 2. Potassium-Argon Analytical Data[a] from the Wrede Creek Ultramafic Complex, British Columbia

Sample Number[b]	Location[b] Lat.(N): Long.(W)	Rock Unit; Rock Name[b]	Mineral Dated	%K ± S[c]	$^{40}Ar^{*d}$ / ^{40}Ar Total	$^{40}Ar^{*d}$ (10 cm^3 STP/g)	Apparent[e] Age (Ma)	Time[f]
G77RW1	56°40′ 126°08′	3c; hornblende diorite	hornblende	0.959 ± 0.007	0.790	6.740	172 ± 6	Middle Jurassic
G77RW2	56°40′ 126°08′	2d; hornblende pegmatite	biotite (secondary)	8.98 ± 0.18	0.967	57.258	157 ± 5	Middle Jurassic
G77RW4$_a$	56°40′ 126°08′	2d; hornblende pegmatite	hornblende	1.224 ± 0.063	0.881	11.078	219 ± 10	Late Triassic
G77RW4$_b$	56°40′ 126°08′	2d; hornblende pegmatite	hornblende	1.188 ± 0.088	0.881	11.078	225 ± 8	Late Triassic

a: All analyses done in the Geochronology Laboratory, Department of Geological Sciences, The University of British Columbia.
b: See Fig. 50.
c: "S" is the range of the duplicate analyses from the mean value.
d: "Ar*" indicates radiogenic argon.
e: Constants used are $\lambda_e = 0.581 \times 10^{-10} yr^{-1}$; $\lambda_B - 4.962 \times 10^{-10} yr^{-1}$; $^{40}K/K = 1.167 \times 10^{-4} yr^{-1}$ (Steiger and Jaeger, 1977); error is one standard deviation.

K/Ar dating of hornblende from a diorite dyke gave an age of 172 ± 6 Ma (Table 2). A K/Ar date of 182 ± 7 Ma on biotite was obtained from a quartz diorite stock some 20 kilometres west of the Wrede Creek complex (Woodsworth, 1976). Both ages are correlative with Jurassic plutonism generally referred to by Lord (1948) as the Omineca Intrusions, and represented further to the south by the Hogem Batholith. Early and later phases of the Hogem Batholith have been dated by Garnett (1978) as 180 to 217 Ma* and 166 to 186 Ma*, respectively.

MINERALIZATION AND ALTERATION: Sulphide mineralization associated with the Wrede Creek complex occurs in two principal hosts: in dioritic to granitic dykes, and in pyroxenitic and adjacent hornfelsed rocks.

Disseminated and fracture-filling pyrite, chalcopyrite, molybdenite, and rare bornite occur in widely distributed dioritic to granitic dykes within and adjacent to the ultramafic body (Fig. 50). Sulphides are generally confined to the dyke rock, but some occur in adjacent hornblende pegmatite. Secondary biotite from a sulphide-mineralized specimen of hornblende pegmatite yielded a K/Ar age of 157 ± 5 Ma (Table 2). Hydrothermal alteration of the dyke rocks ranges from a propylitic assemblage of chlorite-epidote-carbonate in the pyrite-rich rocks, to a potassic assemblage of sericite and secondary biotite in the chalcopyrite and molybdenite-bearing rocks.

The most extensive occurrence of sulphide mineralization is in pyroxenite, hornblende peridotite, and hornfels along the southern edge of the ultramafic complex. This area was investigated by shallow (less than 50 metres) percussion drilling with subsequent deeper diamond drilling (Figs. 50 and 51). Three of the diamond-drill holes (3, 4, and 6) penetrated the contact between hornfels and adjacent ultramafic rock. This contact appears to be relatively flat lying near the surface and to steepen at depth, suggesting that it represents the roof of the ultramafic body in this area. In one diamond-drill hole (2), pyroxenite occurs in fault contact with dunite. Extreme and extensive saussuritization of hornblende peridotite adjacent to the hornfels is seen in diamond-drill hole 4. The saussuritization is interpreted as an effect of local metasomatism that occurred during or immediately after emplacement of the ultramafic complex. Several dykes, most of them of diorite porphyry but some of quartz diorite, quartz monzonite, and alaskite, were intersected in most diamond drill holes but constitute a relatively minor part of the bedrock.

Chalcopyrite and molybdenite fracture-fillings are found in significant amounts within pyroxenite, hornblende peridotite, and hornfels. Accompanying minerals include pyrite, quartz, calcite, epidote, chlorite, microcline, plagioclase, and crystalline minerals identified by X-ray diffraction as the zeolites, chabazite and stilbite. In places, molybdenite and chalcopyrite are intergrown in druses with these zeolites. Pyrite occurs as disseminations in all rock types but is most abundant in dioritic dykes where it is invariably the predominant and commonly the only sulphide. Narrow dykes of coarse-grained to pegmatitic alaskite, although very minor in amount, commonly contain the most abundant disseminated chalcopyrite and molybdenite.

Tremolite alteration of pyroxenite is marked by patches of pale green colouration which occur sporadically throughout the drill core. Epidote in hornfels is prominent along fractures and as pervasive alteration of plagioclase. Porphyritic diorite dykes generally display only weak chlorite and/or epidote alteration. Zeolites are prominent in zones from 50 to 60 metres wide in drill holes 4 and 6.

GENESIS OF MINERALIZATION: Zones of significant molybdenite and/or chalcopyrite in pyroxenite, hornblende peridotite, and hornfels (Fig. 51) are generally sporadic and discontinuous. While it is tempting to ascribe this mineralization to the presence of diorite

* Published dates are revised based on the new decay constants listed in Table 2.

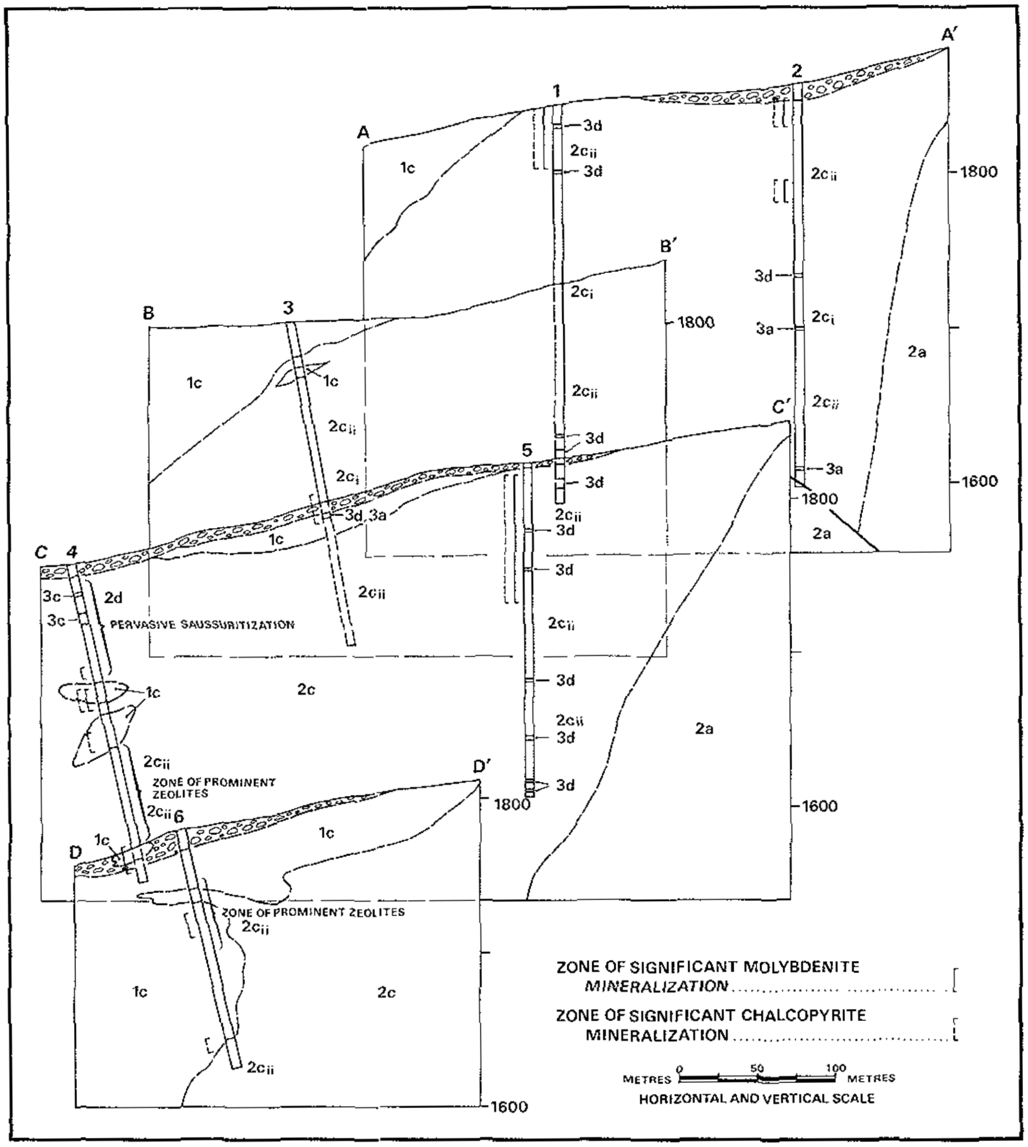


Figure 51. Cross-sections of the Wrede Creek ultramafic complex (For location of sections see Figure 50)

dykes, many outcrops of which contain similar sulphides, three features argue against this conclusion. First, the relative proportion of intersected dyke material is strikingly low. Second, the dykes intersected are not especially well mineralized (except for pyrite) or strongly altered. And last, no strong spatial relationship between diorite dyking and mineralized zones is readily apparent. Only the wallrock adjacent to alaskite dykes is strongly mineralized with chalcopyrite and molybdenite.

Alternatively, the origin of the sulphide mineralization, which is generally near the contact of the ultramafic complex, may be related to the manner in which the ultramafic complex was emplaced. Evidence has been presented that the ultramafic body is of magmatic origin. Others (Walton, 1951; Ruckmick and Noble, 1959; Taylor and Noble, 1960) believe zoned ultramafic bodies in southeastern Alaska to be magmatic. The effect of intrusion of a hot, anhydrous, ultramafic magma into an approximately coeval, undoubtedly water-rich volcanic pile must therefore be considered. Ruckmick and Noble (1959) suggest that the ultramafic magmas which formed the Union Bay complex of southeastern Alaska absorbed aqueous fluids from the surrounding wallrock. Such a mechanism could be responsible for extensive metasomatism at the periphery of these ultramafic bodies. Indeed, McTaggart (1971), favours "marginal metasomatism involving CaO, Fe, Al_2O_3, SiO_2, and so on" to produce the hornblende and diopside-rich rocks of the zoned complexes. Whether such a process is responsible for the hornblende and diopside-rich rocks at Wrede Creek is debatable; however, inward-progressing, fracture-controlled zones of extensive saussuritization at the outer margin of the ultramafic body suggest that fluids did invade the peripheral rocks of the complex. Perhaps copper and molybdenum were also derived from the surrounding rock during this stage and were introduced into the ultramafic body in sulphur-bearing hydrothermal solutions. Volcanic rocks of the Takla Group are noted for their inherently high copper contents (Monger, 1976). Derivation of molybdenum, however, is more problematical because there does not appear to be any significant thickness of argillite or other potentially molybdenum-rich strata in the immediate area. Deposition of sulphides may have been influenced by fracturing localized at the ultramafic contact.

A similar hypothesis involves the process of sulphurization as described by Cheney (1974). Sulphurization, with respect to the Wrede Creek complex, may have occurred if the ultramafic rocks developed fractures soon after crystallization. Sulphur-bearing hydrothermal fluids drawn into the still-hot dilatant zones would extract iron, nickel, copper and trace amounts of other metals from the crystallized rock, depositing these metals as sulphides as the solutions cooled. Cheney (1974) suggests that silicate magmas of dioritic composition may also develop as the fluids interact with the hot anhydrous rocks. While this theory might explain the occurrence of copper and iron sulphides and dioritic rocks within the ultramafic, it does not account for the significant amounts of molybdenite present. In addition, K/Ar dating indicates that the dioritic rocks are probably of much younger age than the ultramafic rocks.

In view of the association of chalcopyrite and molybdenite, particularly in pegmatitic alaskite dykes, perhaps the most reasonable source of the mineralizing solutions is a differentiated intrusion either at greater depth or somewhat removed from the area of drilling. With respect to the latter supposition, the Fleet Peak pluton, a major intrusive body of monzodiorite composition, outcrops just to the north of the ultramafic complex. Lord (1948) notes that "pink pegmatite dykes are scattered throughout the granitic mass but are nowhere abundant. They also occur in the adjacent intruded rocks as far as 1½ miles from the nearest exposed granitic contact." Late-stage volatile and metal-rich fluids, permeating upward along the same structural zone that controlled emplacement of the ultramafic body, are envisaged as the mineralizing solutions in this hypothesis. Diorite dykes present might represent early differentiates of such a system. Alaskite dykes and veins cross cutting dioritic rocks show relative ages consistent with this hypothesis.

The occurrence of zeolite and sulphide intergrowths suggests either low temperatures of the mineralizing solutions or, more probably, some remobilization of sulphides during the low-grade regional metamorphism which occurred in Tertiary time.

In conclusion, most sulphides occurring along the periphery of the Wrede Creek ultramafic complex, are probably best likened to a porphyry type of mineralization. Classical zones or facies of hydrothermal alteration, if present, are difficult to delineate because of the unusually mafic nature of the host rock. The source of the hydrothermal fluids can only be speculated on as yet but localization of sulphides at the contact of the ultramafic body is probably related to both large and small-scale structural controls. It is also possible that some of the sulphides, chalcopyrite, and pyrite in particular, are related to metasomatism which took place at the ultramafic contact during or soon after emplacement of the ultramafic body.

REFERENCES

Armstrong, R. L. (1978): Pre-Cenozoic Phanerozoic Time Scale-Computer File of Critical Dates and Consequences of New and In-Progress Decay Constant Revisions; *in* Contributions to the Geologic Time Scale, (Eds. George V. Cohee, Martin F. Glaessner and Hollis D. Hedberg), *American Association of Petroleum Geologists,* Studies in Geology No. 6, pp. 73–92.

Cheney, E. S. (1974): Examples of Application of Sulphur Isotopes to Economic Geology; *Transactions of SME,* March, 1974, Vol. 255, pp. 31–38.

Garnett, J. A. (1978): Geology and Mineral Occurrences of the Southern Hogem Batholith; *B.C. Ministry of Energy, Mines & Pet. Res.,* Bull. 70.

Irvine, T. N. (1974): Ultramafic and Gabbroic Rocks in the Aiken Lake and McConnell Creek Map-Areas, British Columbia, *in* Report of Activities, A, *Geol. Surv., Canada,* Paper 74-1A, pp. 149–152.

_______ (1976): Studies of Cordilleran Gabbroic and Ultramafic Intrusions, British Columbia; Part 2: Alaskan-type Ultramafic-Gabbroic Bodies in the Aiken Lake, McConnell Creek, and Toodoggone Map-Areas, *in* Report of Activities, Pt. A, *Geol. Surv., Canada,* Paper 76-1A, pp. 76–81.

Lord, C. S. (1948): McConnell Creek Map-area, Cassiar District, British Columbia, *Geol. Surv. Canada,* Mem. 251.

McTaggart, K. C. (1971): On the Origin of Ultramafic Rocks, *Geol. Soc. America,* Bull., Vol. 82, pp. 23–42.

Monger, J. W. H. (1976): Lower Mesozoic Rocks in McConnell Creek Map-Area (94E), British Columbia, *in* Report of Activities, Pt. A, *Geol. Surv., Canada,* Paper 76-A, pp. 51–54.

Richards, T. A. (1976): Takla Project (Reports 10–16): McConnell Creek Map-Area (94P, East Half) British Columbia, *in* Report of Activities, Pt. A, *Geol, Surv., Canada*, Paper 76-1A, pp. 43–50.

Roots, E. F. (1954): Geology and Mineral Deposits of Aiken Lake Map-Area, British Columbia; *Geol. Surv., Canada,* Mem. 274.

Ruckmick, J. C., and Noble, J. A. (1959): Origin of the Ultramafic Complex at Union Bay, Southeastern Alaska; *Geol. Soc. America,* Bull., Vol. 70, pp. 981–1018.

Steiger, R. H. and Jaeger, E. (1977): Subcommission on Geochronology: Convention on the Use of Decay Constants in Geo- and Cosmochronology, *Earth Planet Sci. Lett.*, Vol. 36, pp. 359–362.

Taylor, H. P., Jr. (1967): The Zoned Ultramafic Complexes of Southeastern Alaska, *in* Alaska (P. J. Wyllie, Ed.), *in* Ultramafic and Related Rocks, New York, (*John Wiley and Sons, Inc.*), pp. 96–118.

Taylor, H. P., Jr., and Noble, J. A. (1960): Origin of the Ultramafic Complexes in Southeastern Alaska; *Internat. Geol. Cong.*, 21st, Copenhagen, Pt. 13, pp. 175–187.

Walton, M. S., Jr. (1951): The Blashke Island Ultrabasic Complex with Notes on Related Areas in Southeastern Alaska, *N.Y. Acad. Sci.,* Trans., Vol. 13, pp. 320–323.

Woodsworth, G. J. (1976): Plutonic Rocks of McConnell Creek (94D West Half) and Aiken Lake (94C East Half) Map-Areas, British Columbia, *in* Report of Activities, Pt. A, *Geol. Surv., Canada,* Paper 76-1A, pp. 69–72.

1978—SHAS
(94E/2W, 3E)

LOCATION: Lat. 57° 15′ Long. 126° 59′ (94E/2W, 3E)

CLAIMS: SHAS 31, 33, 35 to 38, SHA 1 (6 units), SHA 2 (2 units).

OWNER: International Shasta Resources Ltd.

OPERATOR: ASARCO EXPLORATION COMPANY OF CANADA, LIMITED.

DESCRIPTION: The SHAS gold-silver prospect is located approximately 300 kilometres north of Smithers in the Toodoggone River area, north and east of the north end of the Black Lake airstrip.

The property is underlain by porphyritic flows and pyroclastic rocks and minor amounts of sedimentary rock, that are similar in appearance to Toodoggone Group rocks in the area.

Significant quartz veining, that trends southeasterly, is 0.5 to 10 metres in width and 250 metres in length on the surface. It occurs within an altered crystal and lapilli tuff unit in the sequence of Toodoggone (?) volcanic rocks. The zone of quartz veining and altered tuffs is approximately 60 metres wide at its widest point. On the weathered surface the tuffs are light brown-orange in colour with resistant quartz crystals and lapilli-size fragments. Typically the rocks are composed of crystals up to 3 mm in diameter of bright orange feldspar (50 to 60 per cent) (with abundant fine-grained hematite), and round quartz (20 per cent) in a fine-grained greyish to brownish feldspar-rich matrix. Pyrite occurs as a fine dusting throughout the altered tuff unit; it is also present in most of the quartz veins and stockworks. An unidentified silver-grey mineral (argentite?) occurs within the quartz stockwork zone and gold-silver values occur in quartz-rich rocks having a grey hue due to a fine-grained sulphide mixture.

This showing is similar to the Lawyers gold-silver prospect that is located approximately 15 kilometres to the north, although Shas has no amethyst veins.

WORK DONE: During 1978 Asarco, under an option agreement with International Shasta conducted geological and geophysical surveys over the property. Trenches were resampled and new trenches were blasted.

1980—TOODOGGONE RIVER
(94E)

By Tom Schroeter

INTRODUCTION: The Toodoggone River area is situated approximately 300 kilometres north of Smithers. Geographically, it is one of the most isolated areas in the Province, being several hundred kilometres from the nearest settlement and without road access. The "Omineca Mining Road" from Germansen Landing terminates at Moosevale Flats, approximately 65 kilometres south of the Toodoggone River area. Access to the area at the present time is by fixed-wing aircraft, floatplane, or helicopter. Nearly all traffic has come from Smithers. The Sturdee airstrip, completed to a useable length of over 1 620 metres, was the centre of activity during 1980. A Hercules aircraft supplying the Baker mine was a frequent user of the strip, as were several other charter aircraft. The gravel strip is equipped with landing lights. The area discussed in this report is a northwesterly trending belt 80 kilometres in length and 35 kilometres in width and is approximately centred on the Baker mine (Fig. 52).

Mining exploration dates back to the early 1930's when placer claims near the junction of Belle Creek and the Toodoggone River were worked and several small blocks of claims covered lead-zinc showings near the head of Thutade Lake. Exploration remained very quiet until the late 1960's when numerous companies entered the area, searching primarily for the large tonnage, low-grade copper ± molybdenum porphyries. Numerous claims were staked, the most significant to date being the Chappelle claims which include the Baker mine, currently being brought into production by Du Pont Exploration of Canada. The 1970's saw little exploration, with the notable exceptions of the Baker (ex-Chappelle) gold-silver prospect and the Lawyers gold-silver prospect. Minor work was carried out on the McClair, the Shas, the Kemess, and the Fin (ex-Pine) prospects, to name a few. 1980 heralded the beginning of a new era for this rich gold-silver "province", as it did for many other areas of the Province. At the end of 1980 approximately 4 000 active units exist within the Toodoggone area with approximately 3 000 of those being staked in 1980. (Fig. 52, Table 1).

REGIONAL GEOLOGY: The Toodoggone area lies within the eastern margin of the Intermontane Belt. The oldest rocks are wedges of crystalline limestone up to 150 metres or more thick. These have been correlated with the Asitka Group of Permian age. The next oldest rocks belong to the Takla Group of Upper Triassic age and consist of andesitic flows and pyroclastic rocks including augite-tremolite andesite porphyries and crystal and lapilli tuffs. The Omineca Intrusions of Jurassic and Cretaceous age (K/Ar 186 to 200 Ma obtained by the Geological Survey of Canada), range in composition from granodiorite to quartz monzonite. Some syenomonzonite bodies and quartz feldspar porphyry dykes may be feeders to the Toodoggone rocks which unconformably overlie the Takla Group. The Toodoggone volcanic rocks (named informally by Carter, 1971) consist of complexly intercalated volcanic and volcanic-sedimentary rocks of Early and Middle Jurassic age, 500 metres or more in thickness. They rest on the west flank of "basement" rocks along a northwesterly trending belt at least 90 kilometres in length by 15 kilometres in width (*see* Geological Survey of Canada, Open File 306). A K/Ar age of 186 ± 6 Ma was obtained by Carter (1971) on a hornblende separate from a sample collected from a volcanic sequence 14 kilometres southeast of Drybrough Peak. Three principal subdivisions are recognized:

(1) *Lower Volcanic Division*—dominantly pyroclastic assemblage including purple agglomerate and andesitic tuffs (grey to green to purple).

(2) *Upper Volcanic Division*—overlying intermediate alkalic assemblage including trachytic crystal and lithic tuffs with intercalated dust tuff and quartz feldspar porphyries. Welded tuffs exist locally. The characteristic orange colour of the trachytic rocks resulted from oxidation of the fine-grained matrix to hematite while the rock was still hot—possibly during late-stage pneumatolysis. A coeval period of explosive volcanism, including the formation of "laharic" units and intrusion of syenomonzonite bodies and dykes, was accompanied by explosive brecciation along zones of weakness (predominantly large-scale faults and attendant splays) with varying degrees of associated silicification and precious and base-metal deposition. Rounded fragments of Omineca intrusive rocks occur rarely in Toodoggone tuffs.

(3) *Upper Volcanic*—Sedimentary Division—lacustrine sedimentary rocks (sometimes varved) and interbedded tuff beds; possibly younger andesitic flows.

Many Toodoggone rocks have a matrix clouded with fine hematite dust implying a subaerial origin; however, some varieties may have accumulated in shallow water. The host rock for mineralization (Division 2) is an orange to chocolate brown crystal tuff with

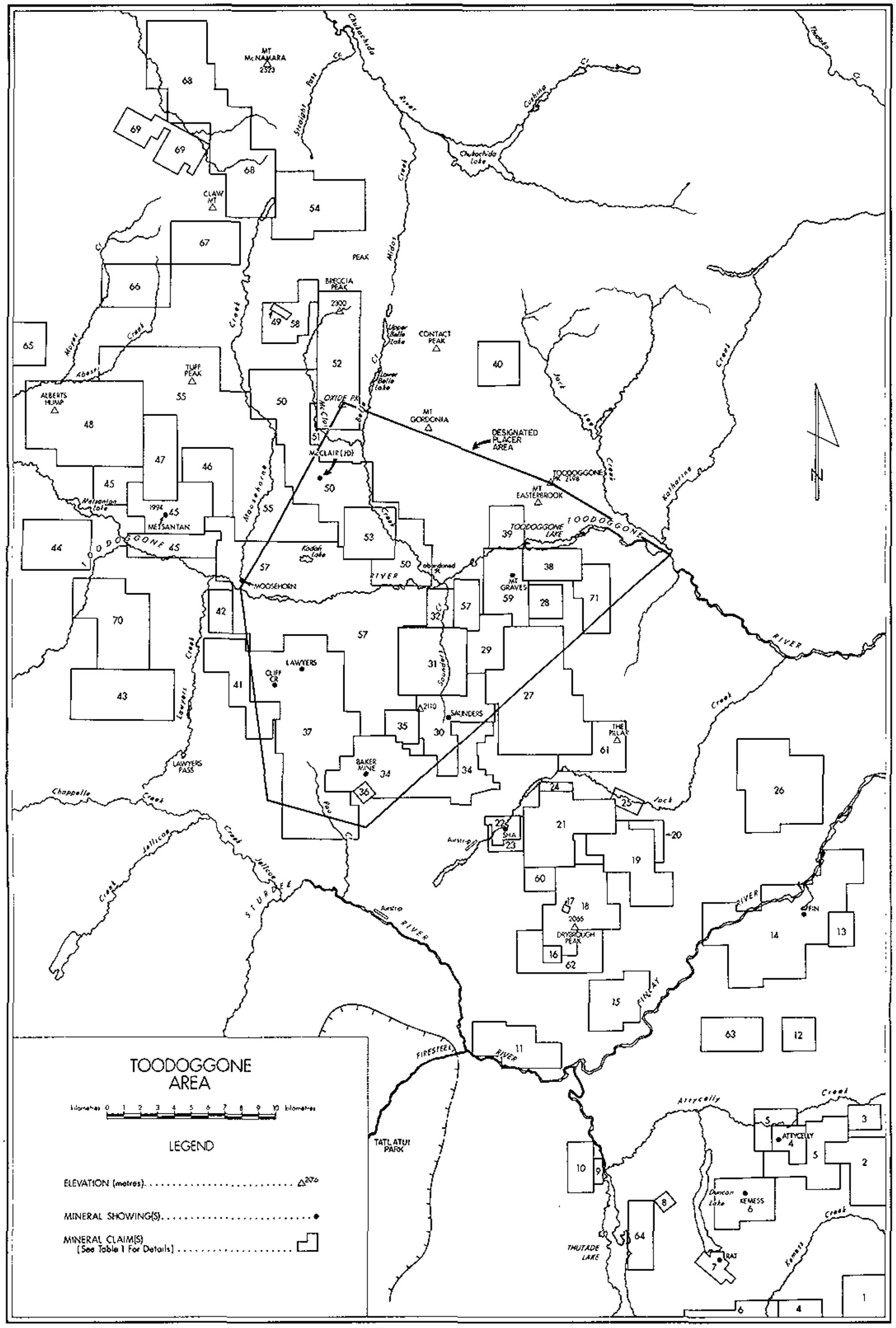


Figure 52. General setting of the Toodoggone area

TABLE 1
(*See* Fig. 52)

No.	Claim Name	Operator
1.	Aura	Serem
2.	Mess (1–4)	Serem
3.	Audrey (1-2)	Inca Res.
4.	Audrey East, Audrey West	Inca Res.
5.	Kem (1–9)	Inca Res.
6.	New Kemess (1-2)	Kennco
7.	Rat	Cominco
8.	Crown Grants	Cominco
9.	Atty	Taiga Cons.
10.	Firesteel	Serem
11.	Fire (1–3)	Du Pont
12.	Rich	Taiga Cons.
13.	Mex	Cominco
14.	Fin (1–9), Zip, Gem, Kid	B. Pearson
15.	Grace (1–4)	D. MacQuarrie
16.	Amigo	Cominco
17.	RN	Winderra Mins.
18.	Aca, Pul, Acapulco, Gotch (1-2)	Serem
19.	Jock (1–5)	Taiga Cons.
20.	Gossan (1–5)	Lacana
21.	Jock (1–5)	Serem
22.	Shas	Int'l Shasta
23.	Silver Reef	C. Kowall
24.	Pill	J. Weishaupt
25.	Brenda	J. Weishaupt
26.	Nub Mtn.	Serem
27.	Orange, Argus (1–4), Arg (1-2) OJ (1–4)	Serem
28.	To #2	Du Pont
29.	GWP	Great Western Pet.
30.	Golden Neighbour (1–4), Camp, Camp Fr., Jolly Roger, Artful Dodger	Lacana
31.	Saunders	Taiga Cons.
32.	Canyon #1	Lacana
33.	Fagan #1	Lacana
34.	Chappelle	Du Pont
35.	Pel	Du Pont
36.	Crown Grants	Ozie Maconald
37.	New Lawyers (1–4), Law (1–3), Breeze, Road (I–III), Perry (1-2), Mason (1-2), GTW (1–3) plus Fractions	Serem
38.	Duke (1-2)	Serem
39.	To #1	Du Pont
40.	Mul (1-2)	Du Pont
41.	Silver Pond, Silver Ck., Silver Butte, Silver Peak, Silver Grizzly	Great Western Pet.
42.	Kodah	Serem
43.	Lass (1–4)	Du Pont
44.	Edo (1–4)	Du Pont
45.	Metsantan (1–5)	Lacana
46.	Ant (1–3)	Du Pont
47.	Mets (1-2)	Taiga Cons.
48.	Al (1–6)	Texasgulf
49.	Har	Serem
50.	Scree (1–3), Moose (1–3), JM, JD, JB, JS, JR, McLair (1–5) plus Fractions	Texasgulf
51.	Air (1-2)	Du Pont
52.	Poo, On, Lou, Oxide	Serem
53.	Belle (1-2)	Taiga Cons.
54.	Moose (1–4)	S. Young
55.	Atlas (1-2)	Serem
56.		Lacana
57.		Lacana
58.	Graves (1–4)	Great Western Pet.
59.	Hercules	Serem
60.	CO	Serem
61.	Sun	Serem
62.	Star	Serem

minor and varying proportions of lithic, dust, and vitric tuff. Broken crystals of plagioclase and quartz are set in a fine-grained "hematized" matrix of quartz and feldspar. Chemically, the rocks are andesite and trachyandesite. Carter (1971) determined the composition of a suite of rocks collected from the Toodoggone area to range from latite to a dacite (less than 30 weight per cent quartz). Apatite is a common accessory mineral.

To the west, are Upper Cretaceous to Tertiary pebble conglomerates and sandstones of the Lower Tango Creek Formation of the Sustut Group (Eisbacher, 1971). These unconformably overlie Takla Group volcanic rocks and Toodoggone volcanic rocks.

STRUCTURE: The structural setting probably was the most significant factor in allowing mineralizing solutions and vapours to migrate through the volcanic pile in the Toodoggone area. The area has been subjected to repeated and extensive block faulting that started in Jurassic and continued until Tertiary time. Some major structural breaks extend for 60 kilometres or more, such as the McClair Creek and Lawyers systems. Prominent gossans commonly are associated with structural zones but many contain only pyrite, both as disseminations and in fracture fillings in both Toodoggone and Takla Group rocks. Thrusting of Asitka Group limestones over Takla Group rocks probably occurred during Middle Jurassic time.

Today, Toodoggone rocks display broad open folds with dips less than 25 degrees. Sustut Group sedimentary rocks have relatively flat dips and appear to be devoid of any major structural disruptions in the area mapped.

MINERALIZATION: The Toodoggone area is host to many polymetallic mineral prospects. Four main types are recognized:

1. *"Porphyry" Cu ± Mo ± Ag ± Au*

   —mainly associated with Omineca intrusions. Chalcopyrite and pyrite, with or without molybdenite, occur in fractures, as disseminations, or in quartz veins within intrusive and the host volcanic rocks (mainly Takla Group andesitic rocks). Chalcocite and covellite may form secondary zones up to 30 metres thick. Silver may exceed 3.5 g/tonne and gold 0.5 g/tonne in these porphyries, and be a significant component, for example, Riga, Fin (ex-Pine), Pillar, Rat, Mex, Kemess.

2. *Skarn*

   —at contacts of limestone and enclosing rock resulting in formation of small bodies of magnetite, galena, and sphalerite; an example is Castle Mountain, and west of Duncan Lake.

3. *Precious and Base Metal Epithermal Au + Ag ± Cu ± Pb ± Zn*

   (1) *Fissure-vein type*—This is the most important economic type—associated with predominantly silicified zones (quartz veins and/or old volcanic "centres") related to repeated, extensive block faulting and possible tensional fractures formed during late doming. Fault zones guided intrusions, hydrothermal activity, and important later mineralizing solutions. An episodic, near-surface sealing cap, or "low pH cap" consisting mainly of illite and sericite, occurs in the hangingwall and may have acted as a trap to mineralizing solutions. Hydrostatic boiling is a key to mineral deposition and may occur anywhere in the system, depending on the salinity and temperature of the water. The width of fault gouge, silicified fragments, and the amount of quartz and calcite filling are highly variable—ranging from hairline fractures to greater than 75 metres. Horsetailing and bifurcation are common (for example, Lawyers). The host stratigraphy plays a minor role, if any, in orebody localization.

Principal ore minerals are contained in open space fillings and include fine-grained argentite (acanthite >80 per cent silver), electrum, native gold, and native silver with minor amounts of chalcopyrite, galena, and sphalerite. Rare constituents include bornite, polybasite, stromeyerite, and secondary chalcocite, covellite, malachite, and cerussite. Gangue minerals include in order of decreasing abundance: amethystine to white quartz, chalcedony, adularia, albite, calcite, hematite, magnesium-rich siderite, ankerite, chlorite, kaolinite, manganese oxide, and rare barite and fluorite. Deposits occur in veins, stockworks, irregular branching fissures, or large recurrently brecciated fault zones. Common textures include comb structures, symmetrical banding, crustifications, and drusy cavities—all typical of epithermal deposits formed at shallow depths and low temperatures. Alteration is commonly restricted in extent in vein systems. Mineralization tends to be non-uniform and to occur in shoots; it rarely exceeds more than 20 per cent of the vein system. Acanthite and electrum occur in clouded areas which may result from boiling. Sharp-edged breccia fragments are sometimes strongly replaced by quartz, adularia, or sericite. Several episodes of fracturing occurred; breccia fragments are enclosed within later mineralized veins.

Preliminary chemical date suggests the following:

(a) Toodoggone rocks are quartz normative.
(b) K_2O/Na_2O ratios increase toward mineralization.
(c) Sulphur values are very low (<0.04 per cent).
(d) Trace elements, including Cu, Pb, Zn, Ag, Au, Hg, Sr, Ba, Mo, Sb, Se, Te, Th, U, W, As, and Bi are all low, except in mineralized zones where slight anomalies exist.
(d) SiO_2, H_2O, and K_2O increase whereas Al, Fe, Na, Ti, P_2O_5, and Ba decrease in zones of mineralization.
(f) The Ag:Au ratio of this type of occurrence is approximately 25:1.

(2) *Hydrothermally Altered and Mineralized Type*—associated with major fault zones and possible subsidence of volcanic centres followed by a doming of caldera cores. Pyrite is the most common sulphide present with minor amounts of galena, sphalerite and rare molybdenite and scheelite. This type of deposit is probably somewhat older or contemporaneous with fissure-type mineralization. Volcanic centres are strongly leached and solfatarically altered in varying intensities to clay minerals and silica; some areas contain alunite (for example, Alberts Hump and Kodah). Epidote is a common alteration mineral in both pervasively altered and fracture zones. A "low pH cap" may overlie areas of mineralization.

Examples: Kodah, Alberts Hump, Silver Pond.

4. *Stratabound (?) Pb-Zn-Cu*

Galena ± sphalerite ± chalcopyrite occur in or adjacent to lenses of limestone with interbedded chert within Takla Group (?) volcanic agglomerates and tuffs. Low-grade silver values are usually associated with this type of deposit which may have been deposited on the flank of a volcano adjacent to a limestone reef.

Examples: Firesteel and Attycelley.

Mineral Prospects

1. *Baker Mine—Du Pont*

Construction on the Baker gold-silver mine continued during the summer and fall of 1980 and production at a rate of approximately 90 tonnes per day began in April 1981. Capital costs were estimated at $18 million. Access is provided by aircraft to the Sturdee Airstrip from Smithers, then via a 13-kilometre road to the minesite. Mineable reserves are listed at 90 000 tonnes containing 31.5 grams per tonne gold and 640 grams per tonne silver. Mining will be carried out by both surface cuts and underground methods.

Seven quartz vein systems have been identified in the area of the mine. The main vein (Vein A), consisting of two or more subparallel veins, has been traced over a length of 435 metres, a width of 10 to 70 metres and a vertical depth of at least 150 metres. A variety of quartz vein textures and crosscutting relationships indicate a complex history of mineralization with multiple depositional stages. Fine-grained argentite, pyrite, electrum, chalcopyrite, bornite, native gold, sphalerite, galena, polybasite, and stromeyerite occur within a highly fractured and brecciated quartz system in Takla Group andesites (*see* Barr, 1980 for detailed description). Alteration minerals include pervasive laumontite, chlorite, pyrite, anhydrite, and silica. One sample of high-grade ore assayed 0.23 per cent molybdenum. Tellurium values for selected high-grade specimens ranged between 16 ppm and 38 ppm.

2. *Lawyers—Serem*

The Lawyers gold-silver prospect is located approximately 12 kilometres north of the Baker mine. During 1980 Serem completed 2 895 metres of diamond drilling in 18 holes on the "Amethyst Gold Breccia Zone". The drilling was done on two tiers on 30.5-metre spacings to test the steeply dipping fissure structure. The mineralized zone varies from 60 to 75 metres in width and has been partially drill tested along a north-south length of 610 metres and to a vertical depth of 60 metres.

Fine-grained argentite (acanthite), electrum, native gold, native silver, with minor amounts of pyrite, chalcopyrite, sphalerite, and chalcocite occur in a gangue of predominant amethystine to white quartz and some calcite. Mineralization is in the Upper Volcanic Division of "Toodoggone" crystal tuffs. Secondary minerals include malachite, chalcocite, and cerussite. Hematite and manganese oxide are common alteration products. Typical epithermal textures are observed in the fissure zone. Mineralization appears to be more closely associated with the quartz-eye-deficient (<5 per cent) "orange" crystal tuff than the underlying quartz-eye-rich (>5 per cent) "green to grey" crystal footwall tuff. Grades of mineralization are erratic; some nearby float assays over 20 ounces per ton gold and 700 ounces per ton silver. The highest grade intersection from drilling was obtained from DDH-80-13: 1 705 grams per tonne silver and 130 grams per tonne gold over a 6-metre interval.

The Cliff Creek Breccia Zone, located approximately 1 600 metres to the west of the Amethyst Gold Breccia Zone, lies in the same structural setting and has similar characteristics.

3. *Saunders—Lacana*

During 1980 Lacana investigated by trenching and mapping a large anomalous zone containing at least four quartz vein systems in "Toodoggone" volcanic rocks. Chalcopyrite, pyrite, sphalerite, molybdenite, and scheelite occur in amethystine to white quartz fissures over a north-northwesterly trending gold and silver geochemical anomaly 1 220 metres in length and 300 metres in width. Significant ferricrete occurs adjacent to the quartz veins. The area appears to have been strongly hydrothermally altered, possibly suggestive of a near-vent environment.

4. *Metsantan—Lacana*

A quartz stockwork with galena, pyrite, chalcopyrite, and gold-silver values exists within "orange" "Toodoggone" crystal tuffs of the Upper Volcanic Division. Hydrothermal alteration has produced abundant epidote and silica veining.

5. *McClair—Texasgulf*

   Fissure zones of re-brecciated mineralized material occur within the Upper Volcanic Division of "Toodoggone" crystal tuffs. Rounded to subangular fragments of quartz, chert, jasper, and sulphides, including galena, sphalerite, chalcopyrite, and pyrite with gold and silver values, occur in a fine matrix of brecciated crystal tuff cemented by silica. Manganese staining is prominent as is hematite veining.

6. *Fin—Rio Tinto*

   During 1980, Rio Tinto diamond drilled 10 holes totalling approximately 1 020 metres. The environment is similar to that of the Kemess property (*see* Cann and Godwin, 1980), where a highly altered intrusive complex that is part of the Omineca Intrusions has intruded Takla Group volcanic rocks and produced "porphyry"-type mineralization with anomalous copper-silver-gold-molybdenum values. At the Fin, the intrusive is strongly altered to quartz, sericite, epidote, and chlorite and contains abundant fractures of laumontite. It is quite possible that the intrusives at Fin and Kemess represent subvolcanic feeders to the "Toodoggone" volcanic rocks.

REFERENCES

Barr, D. A. (1978): Chappelle Gold-Silver Deposit, British Columbia, *CIMM*, Bull., Vol. 72, No. 790, pp. 66–79.

_______ (1980): Gold in the Canadian Cordillera, *CIMM*, Bull., Vol. 73, No. 818, pp. 59–76.

Cann, R. M. and Godwin, C. I. (1980): Geology and Age of the Kemess Porphyry Copper-Molybdenum Deposit, North-Central British Columbia, *CIMM*, Bull., Vol. 73, No. 821, pp. 94–99.

Carter, N. C. (1971): *B.C. Ministry of Energy, Mines & Pet. Res.*, GEM, pp. 63–70.

Eisbacher, G. H. (1971): A Subdivision of the Upper Cretaceous-Lower Tertiary Sustut Group, Toodoggone Map-Area, British Columbia, *Geol. Surv. Canada,* Paper 70-68.

Gabrielse, H., Dodds, C. J., Mansy, J. L., and Eisbacher, G. H. (1977): Geology of Toodoggone River (94E) and Ware West-Half (94F); *Geol. Surv., Canada*, Open File 483.

Schroeter, T. G. (1975): *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1975, Paper 1976-1, pp. 68–70.

_______ (1976): *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1976, Paper 1977-1, pp. 66-67.

_______ (1978): *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1978, Paper 1979-1, p. 103.

_______ (1980): *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1980, Paper 1981-1, pp. 124–131.

1979 — DRIFTPILE CREEK
(94K/4W)

By D. G. MacIntyre

LOCATION:	Lat. 58° 04′	Long. 125° 55′	(94K/4W)
CLAIMS:	D 2, 4, 6, 8, 10, 12, 14, 16, 19 to 34, 37 to 48, P 2, 4, 6, 8, 19 to 32, 34, 37, 39, 41, 43, 45, 47, 49, 51, Goof 1, 2, and 4 and 5 Fractions.		
ACCESS:	Access to the property is via floatplane to Mayfield Lake, located in the Gataga River valley, thence via helicopter to the property 14 kilometres south-southwest of the lake.		

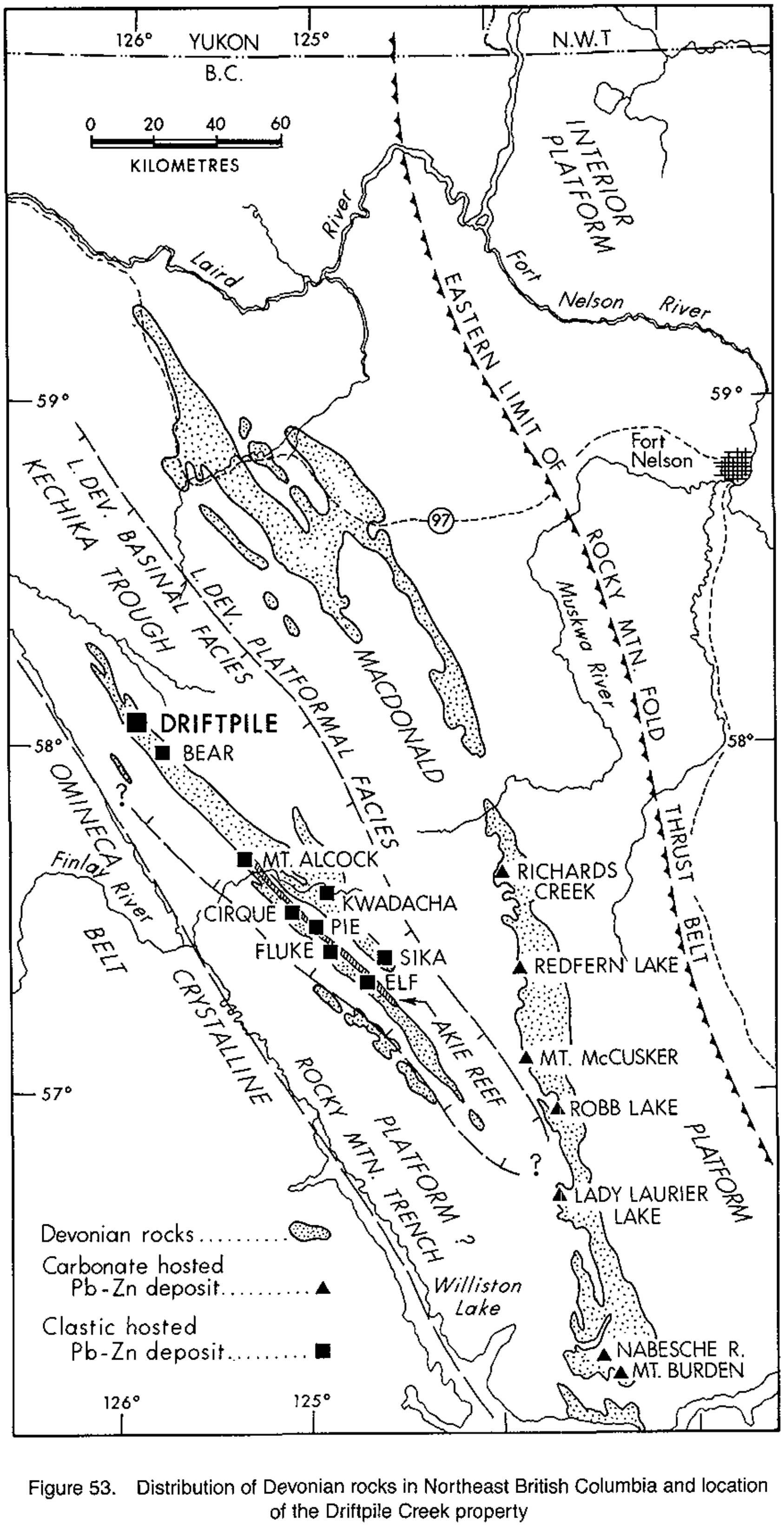


Figure 53. Distribution of Devonian rocks in Northeast British Columbia and location of the Driftpile Creek property

OWNER: Placer Development Limited.

OPERATOR: WELCOME NORTH MINES LTD.

METALS: Zinc, lead, barite.

DESCRIPTION:

INTRODUCTION: The following report is based on geological fieldwork done in the Driftpile Creek area from June 20 to July 2, 1979 (MacIntyre, 1980) and on company reports filed for assessment (Wise, 1974; Kowalchuk and Rivera, 1976; and Carne, 1978, 1979). In addition, discussions with R. Carne, supervising geologist for Archer, Cathro and Associates, on the geology of the Driftpile Creek area and mineral occurrences provided much useful information. Logistical support and camp accommodation for this project were provided by Archer, Cathro and Associates and their generous assistance is gratefully acknowledged.

EXPLORATION HISTORY: Although numerous carbonate-hosted lead-zinc deposits were discovered in Devonian platformal carbonates of northeastern British Columbia in the late 1960's and early 1970's (Thompson, 1972), it was not until 1973 that the first clastic hosted occurrences were discovered in time equivalent basinal facies rocks of the Driftpile Creek area. These discoveries were made by Canex Placer Limited while following up anomalous stream sediment data. The paucity of outcrop and presence of deep surface oxidation at Driftpile Creek necessitated extensive geochemical and geophysical surveys (Wise, 1974; Kowalchuk and Rivera, 1976) during the early stages of exploration. The property was subsequently optioned to the Gataga Joint Venture* and in 1978 nine drill holes totalling 1 016 metres were drilled (Carne, 1978). An additional 21 drill holes totalling 2 417 metres were drilled in 1979 (Carne, 1979). This work has defined several finely laminated pyrite and bedded barite horizons, that locally contain significant concentrations of zinc and lead, within siliceous shales of probable Middle Devonian age.

Discovery of the Driftpile Creek deposit accelerated exploration activity along the entire 180-kilometre belt of Devonian shales and ultimately led to the discovery of the Mount Alcock, Cirque, Pie, Fluke, Elf, and Kwadacha occurrences (Fig. 53). To the end of 1979 Driftpile Creek and Cyprus Anvil's Cirque (MacIntyre, 1980b) are the only deposits that have been extensively explored by diamond drilling.

PHYSIOGRAPHY: The physiography of the Driftpile Creek area is characterized by northwest-trending ridges, locally rising to 2 200 metres elevation, truncated by broad northeast-trending drainage corridors. The most prominent ridges are generally capped by resistant strata, whereas valleys and low ridges are usually underlain by recessive shale formations. Alpine glaciation has carved numerous cirque valleys into the most resistant ridges, producing excellent exposures of the stratigraphic succession, particularly on the steeper northeast-facing slopes. By contrast, valleys are filled with fluvioglacial and lacustrine deposits and, with the exception of downcutting creeks, contain very little outcrop.

This is particularly true of the drainage basin at the head of Driftpile Creek which was apparently the site of a glacial lake during late Pleistocene time. Carne (1979) has described four main levels of wave-cut terraces on the Driftpile Creek property that developed during a gradual 150-metre lowering of the lake level. Sulphide mineralization exposed below the highest wave-cut terrace, which is located at 1 350 metre elevation, is deeply oxidized and leached making evaluation of surface exposures on the Driftpile Creek property extremely difficult.

* Aquitaine Co. of Canada Ltd., Chevron Canada Ltd., Getty Mining Pacific Ltd., and Welcome North Mines Ltd.

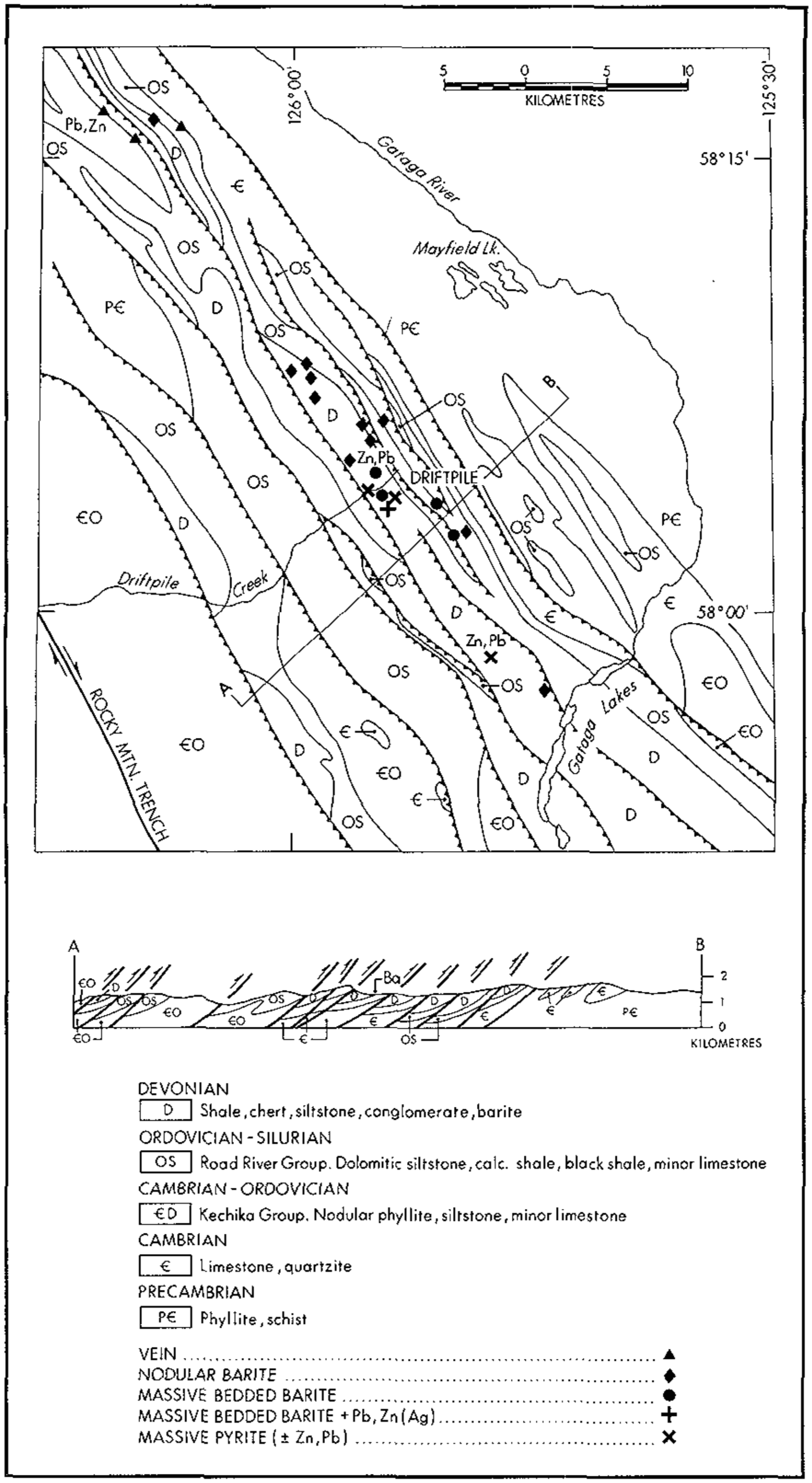


Figure 54. Geology of the Driftpile Creek district

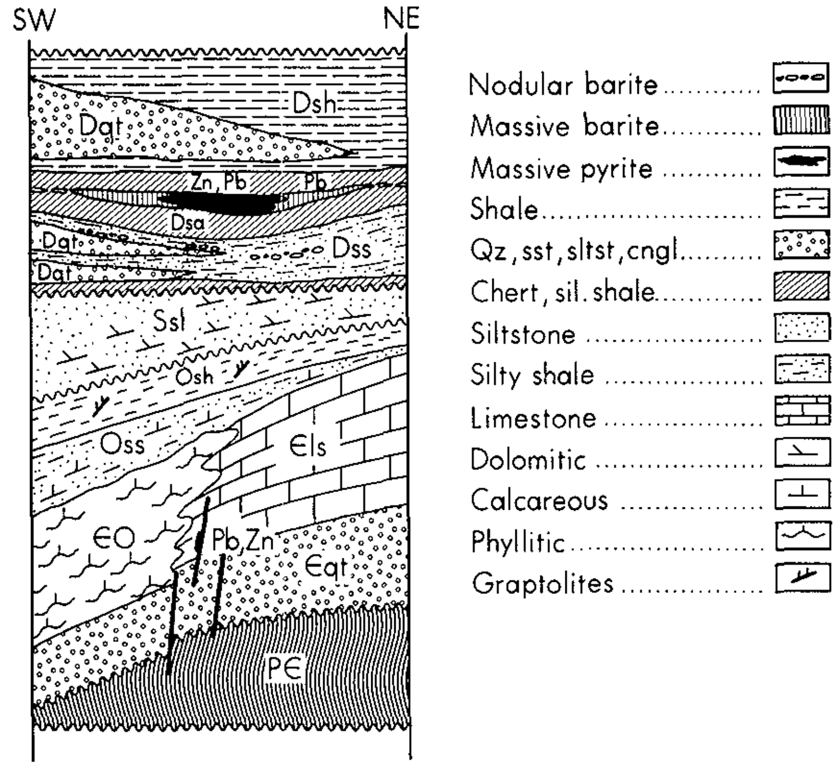


Figure 55. Idealized stratigraphic column, Driftpile Creek district

GEOLOGIC SETTING: The Driftpile Creek area is underlain by Early Paleozoic basinal facies continental margin sedimentary rocks of the Kechika Trough, a southeasterly extension of the Selwyn Basin (Fig. 53). These rocks are preserved in a series of northwest-trending overturned synclinoria that have been broken by southwest-dipping imbricate thrust faults (Fig. 54) that may be rooted in a major detachment surface above a crystalline basement. These structures are typical of the Rocky Mountain Thrust and Fold Belt and were formed by northeast-directed compression of supracrustal rocks during Mesozoic and Cenozoic times. Late high-angle normal faults are also common, offsetting older thrust faults and locally displacing stratigraphic units by as much as several hundred metres.

DISTRICT STRATIGRAPHY: An idealized stratigraphic column for the Driftpile Creek district is shown on Fig. 55. Basement rocks in the area are phyllites and schists of Proterozoic age (unit P€) which are exposed in the Gataga River valley east of Driftpile Creek. These rocks were apparently folded and faulted in Early Cambrian time (Taylor, 1979) prior to establishment of a well-defined structural trough along the continental margin (Cecile and Norford, 1979). Within the trough, in the Driftpile Creek area, Lower Cambrian quartzites unconformably overlie the Proterozoic basement rocks and these

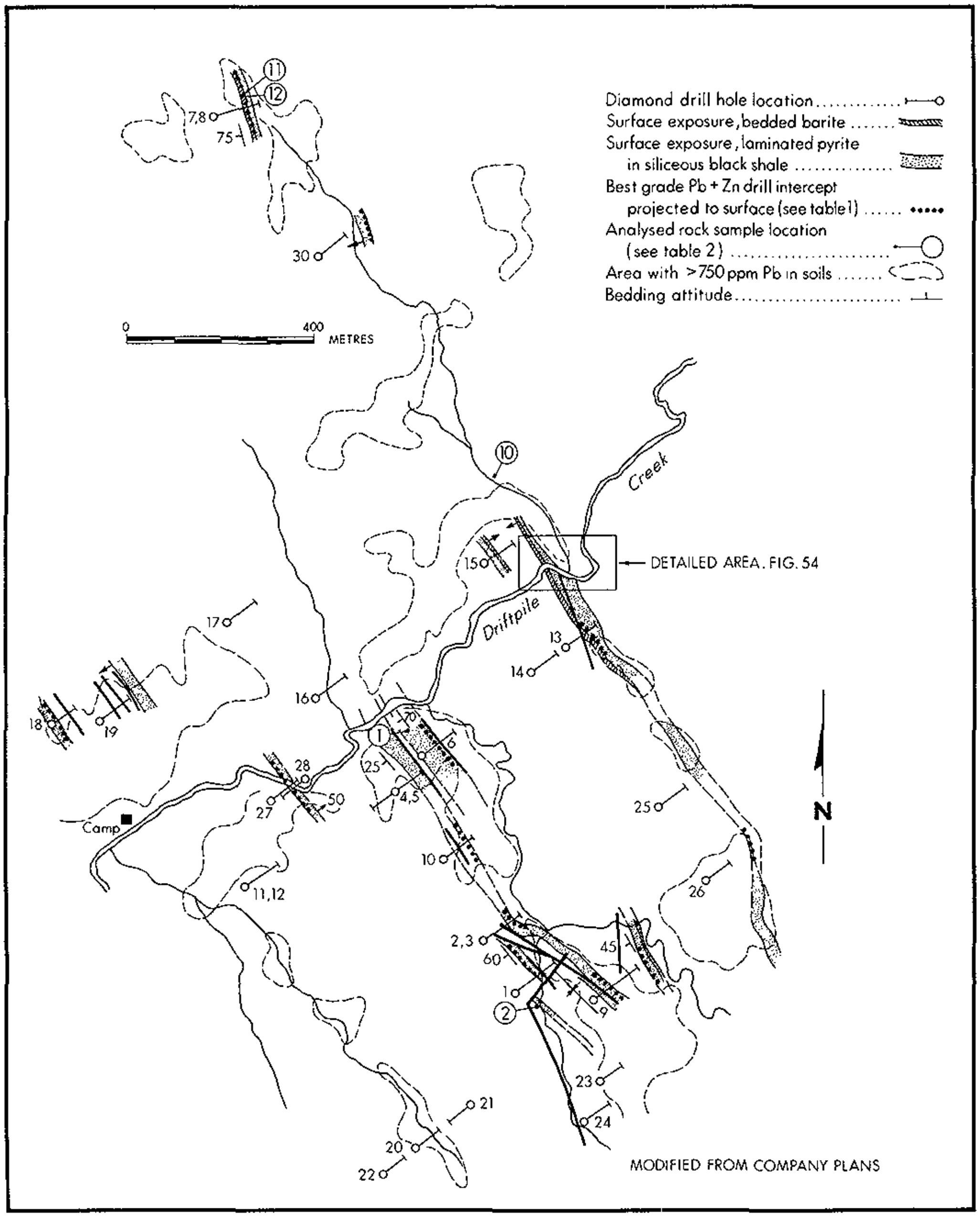


Figure 56. Showing and drill-hole locations, Driftpile Creek property

quartzites (unit €qt) are overlain by massive grey micritic limestone (unit €ls). According to Fritz (1980) the limestone ranges in age from latest Early to Late Cambrian and represents large carbonate build-ups in shallow waters bounding a subsiding trough. The carbonate unit apparently grades into basinal facies nodular phyllitic mudstones and black shales to the west and south (unit €O Kechika Group).

In the Driftpile Creek area the Cambrian limestone is overlain by a thin unit of cream-weathering platy calcareous siltstone and silty shale (unit Oss) of probably Early Ordovician age. This unit is conformably overlain by black graptolitic shale (unit Osh) with minor chert interbeds. Units Oss and Osh represent sediments deposited during an eastward-directed marine transgression that saw basinal facies strata progressively onlap shelf carbonates east of the Kechika Trough.

Ordovician black shale is unconformably overlain by orange to brown-weathering laminar and flaser-bedded dolomitic siltstone and silty limestone (unit Ssl). This unit, which is present throughout the Kechika Trough, thickens westward and typically coarsens up-section. These clastic sediments were deposited in the Kechika Trough during extensive erosion of dolomitic shelf carbonates in Middle Silurian time. Uplift apparently progressed westward as indicated by the coarsening upward and thickening westward characteristics of the unit.

The Silurian siltstone is overlain, apparently disconformably, by black clastic sedimentary rocks of Devonian age. In Driftpile Creek area the Devonian succession has a thin basal chert unit which is overlain by silty black shale containing thin orange-weathering calcarenite and pyritic tuff interbeds (unit Dss). This unit thins to the west, where it interfingers with quartzose proximal turbidites (unit Dqt). The latter thin and fine eastward and according to the paleocurrent measurements of Carne (1979) define several major submarine fans. The quartz-rich detritus was probably derived from an uplifted terrane located west of the Kechika Trough.

Silty shale and quartzose proximal turbidities are overlain by a resistant unit of rhythmically bedded carbonaceous black chert, siliceous argillite, and shale (unit Dsa) which, in the Akie River District, is of latest Middle Devonian age (MacIntyre, 1980a). This unit is host to the bedded barite-sulphide deposits of the Driftpile Creek and Akie River districts; it is characterized on a district wide scale by the presence of thin nodular barite and pyrite laminae. The typical blue-grey-weathering colour of this unit has led to the name Gunsteel Formation although formational status has not yet been established. Unit Dsa is generally less than 100 metres thick but may be significantly thicker on the Driftpile Creek property.

The siliceous unit grades up-section into black pyritic shales which, to the west, have quartzose turbidite interbeds similar to those underlying the siliceous unit. The black shales, which are probably Late Devonian to Mississippian in age, represent pelagic sediments deposited during a major Late Devonian eastward-directed marine transgression. Crustal subsidence apparently advanced eastward with time as indicated by onlapping of shales (Besa River Formation) and retreat of carbonate build-up (Dunedin, Pine Point Formations) within the carbonate platform. A concomitant uplift in the area west of the Kechika Trough resulted in coarse clastics being shed progressively eastward with time.

PROPERTY GEOLOGY: The Driftpile Creek property is underlain by Devonian shales, siliceous argillites, and cherts. These rocks occupy the core of a northwest-trending synclinorium that has been overridden by southwest-dipping thrust plates of Ordovician and Silurian age rocks. The Devonian rocks are isoclinally folded and cut by a complex series of imbricate thrust and normal faults. Folding has produced a pervasive cleavage in the less competent shale units; cleavage planes generally dip to the southwest. The Devonian rocks are relatively recessive and outcrop is generally restricted to down-cutting

Plate XVI. Massive banded pyrite with dark grey carbonate nodules

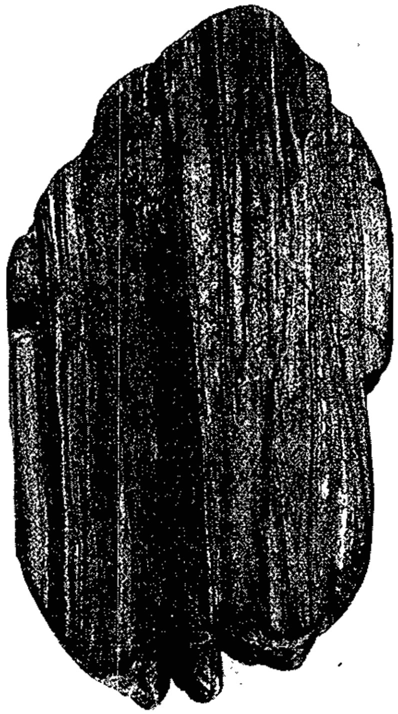


Plate XVII. Sample of dark grey barite with diffuse bands of galena (white) collected from trenches near diamond drill hole 7

Plate XVIII. Drill core showing deformed partly recrystallized laminae of white barite

Plate XIX. Drill core of finely laminated pyrite showing graded bedding and slump structures creek gullies. This, combined with the structural complexity, has greatly hampered mapping of the property and therefore most geologic information has come from diamond drill core.

MINERAL OCCURRENCES: Several occurrences of oxidized massive sulphide and bedded barite have been found in outcrop and as float in the area north and south of Driftpile Creek (Fig. 56). Drilling has helped to define the extent and nature of the surface showings. Several northwest-trending zones of stratabound pyrite and barite have been intersected in the drilling. These mineralized intervals are contained within a sequence of carbonaceous chert, argillite, and shale (unit Dsa). Fine-grained massive pyrite (Plate XVI), which locally contains laminae of sphalerite and minor amounts of galena, typically occurs near the base of the mineralized intervals. It apparently grades laterally into massive dark grey bedded barite (Plate XVII) that contains diffuse bands of galena. Drill core assays from this pyrite-barite transition zone range up to 27 per cent combined lead-zinc (Table 1). To the east, mineralized barite grades into barren bedded barite (Plate XVIII). Massive pyrite and bedded barite are overlain by interbedded siliceous shale and laminated pyrite. The pyritic intervals typically contain several per cent zinc and low concentrations of lead. Graded bedding, soft sediment slumping, micro-faulting and diagenetic carbonate nodules are common features of the pyrite mineralization (Plates XIX, XX, XXI).

The number of mineralized intervals within the siliceous unit at Driftpile Creek is not clear. Carne (1979) believes that as many as four horizons may be present. However, these may be fault and fold repeats and it seems more likely to the author that there is only one main mineralized interval, as there is at other occurrences in the district.

TABLE 1—DRIFTPILE CREEK—BEST DRILL INTERSECTIONS

DRILL HOLE	ASSAY LENGTH (Ft)	Pb+Zn (%)	Zn/(Zn+Pb)	Type
78-1	1.0	7.36	.85	PY
2	1.5	5.45	.96	PY
3	2.0	3.39	.93	PY
4	4.0	14.31	.89	PY
5	1.5	6.45	.80	PY
6	3.5	11.23	.88	PY
7	5.0	21.78	.05	BA
8	5.0	7.99	.35	PY
9	1.3	9.96	.77	PY
79-10	5.0	9.56	.93	PY
13	5.0	4.26	.93	PY
14	4.0	6.24	.92	PY(BA)
15	5.0	3.22	.92	PY
16	6.5	3.48	.90	PY(BA)
18	2.4	24.60	.99	PY
20	5.0	6.07	.83	PY
23	7.7	3.78	.51	PY
26	3.3	8.70	.82	PY
28	4.8	27.73	.77	PY
30	6.0	6.33	.85	PY

PY = massive pyrite and/or laminated pyrite in siliceous shale
BA = massive laminated barite
PY(BA) = laminated pyrite with minor barite

Plate XX. Drill core of very fine-grained pyrite and argillite laminae disrupted by secondary dark grey carbonate nodules

Plate XXI. Drill core showing chaotic mixing and slumping of pyrite laminae about secondary carbonate nodules

LITHOGEOCHEMISTRY: Samples of massive barite (BA), pyritic and baritic shale [PY (BA) and BA (PY)], siliceous argillite (SA), and chert (CH) were collected from the Dsa unit at Driftpile Creek (Fig. 57) and analysed at the British Columbia Ministry of Energy, Mines and Petroleum Resources Laboratory for SiO_2, Fe_2O_3, K_2O, SrO, BaO, total C, Ag, Co, Cu, Mn, Ni, Pb, Zn. Results are given in Table 2 and mean values for samples collected on a district-wide scale are given for comparison.

The SiO_2 content of the Dsa and Dch samples range from 74.92 to 93.78. These values are consistent with the mean SiO_2 values determined for samples collected elsewhere in the district (A and B, Table 2). Massive barite and pyrite samples have variable SiO_2 contents depending on the amount of siliceous shale included with the sample. The siliceous samples are generally more carbon rich and have slightly higher silver concentrations than the mineralized samples. Lead is variable and Zn, Co, Cu, and Ba are relatively low in abundance.

The iron contents of the samples analysed reflect the amount of pyrite present. In general, samples containing pyrite also have relatively high Cu, Mn, Co, Ni, and Zn and variable Pb concentrations (samples 8, 9, Table 2). Silver, on the other hand, is anomalously low in the pyritic samples, an unfortunate characteristic of the Driftpile Creek mineralization.

The K_2O content is relatively low in the PY, CH, and BA samples as would be expected. The SA samples have K_2O contents in the range of 1.8 to 2.4 per cent, slightly less than Vine and Tourtelot's 2.41 average for black shales.

The massive barite samples (1, 5, 6, 7, 10, 11, 12) collected from the Driftpile Creek property have variable concentrations of Pb and Zn. Zinc (and to some extent Mn) is intimately associated with the amount of pyrite present in the barite as indicated by the close correlation of Fe_2O_3 and Zn values. Lead, on the other hand, varies from very low in the pyritic barites to a high of 4.31 per cent in sample 12. This sample has diffuse bands of galena and only minor pyrite in a dark grey barite host (Plate XX). On a district-wide basis (C, Table 2) massive barite is generally low in Pb with anomalous but variable Zn and Mn concentrations. The best grade Pb and Zn mineralization apparently occurs in the barite-pyrite transition zone. This zoning pattern is slightly different from that defined for West German deposits (Meggen and Rammelsberg) where very litte Zn and Pb is concentrated in the massive barite facies (Large, 1980).

SUMMARY: The Driftpile Creek deposit is one of several stratiform barite-sulphide deposits that occur in the widespread Middle Devonian carbonaceous siliceous shale and chert unit of the Kechika Trough. Deposition of these siliceous rocks and formation of the mineral deposits occurred at the beginning of a major marine transgression that progressed eastward with time. The model favoured for formation of the deposits is one of dewatering of metal-rich shales in response to increasing hydrostatic pressure with the metal-enriched brines migrating along permeable aquifers until encountering an inter-basin fault that provided an escape route to the seafloor. The exhaled metalliferous brines then accumulate in euxinic seafloor depressions where, depending on water temperature, fO_2 and Eh-pH conditions, barite and/or pyrite precipitated (Finlow-Bates, 1980). Deeper seated faults within the Kechika Trough may have tapped heat at depth thus providing a driving mechanism for the dewatering process.

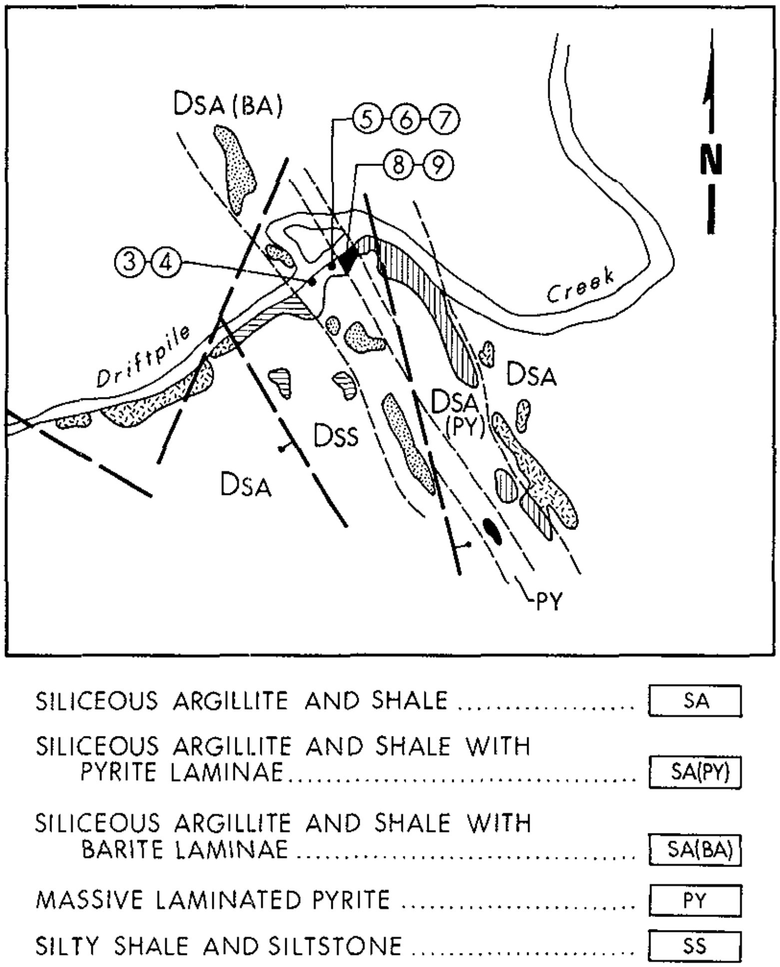


Figure 57. Geology and sample locations, Driftpile Creek showing

TABLE 2—DRIFTPILE CREEK—DEVONIAN SILICEOUS FACIES (Dsa) SAMPLES

Sample No.	Dsa Subunit	SiO_2 %	Fe_2O_3 %	K_2O %	SrO %	BaO %	total C %	Ag ppm	Co ppm	Cu ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
1	BA	17.56	0.84	0.17	0.04	43.3	0.28	0.3	<2	3	120	4	10	0.47%
2	CH	93.78	0.40	0.59	<0.01	0.7	2.16	1.4	<2	5	10	13	276	38
3	SA	75.35	0.56	2.35	<0.01	0.9	1.54	0.3	<2	3	37	5	31	28
4	SA	74.92	0.25	1.86	<0.01	1.1	3.07	0.3	<2	3	20	10	600	49
5	BA	15.27	0.74	0.25	0.09	43.1	0.46	<0.3	<2	3	425	2	23	435
6	BA(PY)	16.92	4.20	0.17	0.04	38.4	0.69	0.3	2	8	349	13	7	1.22%
7	BA	25.51	0.30	0.50	0.06	38.3	0.32	0.3	<2	3	16	4	8	34
8	PY(BA)	29.47	18.79	0.18	0.03	15.2	1.81	<0.3	2	20	1200	24	<3	2.57%
9	PY(BA)	24.75	26.99	0.76	0.01	5.2	1.75	<0.3	6	38	2300	39	107	6.44%
10	BA	25.19	0.40	0.44	0.07	39.4	0.39	<0.3	<2	3	7	3	24	93
11	BA(PY)	2.70	3.13	0.11	0.06	39.5	0.20	<0.3	<2	5	56	3	1.48%	1.95%
12	BA	2.13	1.38	0.14	0.05	37.9	0.20	<0.3	<2	9	17	<2	4.31%	0.19%
A	CH	94.6	0.44	0.47	<0.01	0.3	n.d.	1.0	<2	14	11	11	38	56
B	SA	79.2	1.10	1.81	0.02	0.7	n.d.	1.5	4	21	22	22	29	96
C	BA	25.7	1.10	0.30	0.13	38.4	n.d.	<0.3	<2	20	103	10	14	0.23%

Subunit Descriptions: BA—massive bedded barite; BA(PY)—massive bedded barite with pyrite; PY(BA)—pyrite and minor barite laminae in black shale; SA—black siliceous shale or argillite; CH—black chert
A—mean of 13 CH samples from Driftpile Creek District
B—mean of 48 SA samples from Driftpile Creek District
C—mean of 12 BA samples from Driftpile Creek District

REFERENCES

Carne, R. C. (1978): Driftpile Lead-Zinc District, *B.C. Ministry of Energy, Mines & Pet. Res.*, Assessment Report 6666.

_______ (1979): Driftpile Creek, *B.C. Ministry of Energy, Mines & Pet. Res.*, Assessment Report 7149.

_______ (1979a): Driftpile Creek, *B.C. Ministry of Energy, Mines & Pet. Res.*, Assessment Report 7658.

Cecile, M. P. and Norford, B. C. (1979): Basin to Platform Transition, Lower Paleozoic Strata of Ware and Trutch Map-Areas, Northeastern British Columbia, *in* Current Research, Pt. A, *Geol. Surv., Canada*, Paper 79-1a, Report 36.

Finlow-Bates, T. (1980): The Chemical and Physical Controls on the Genesis of Submarine Exhalitive Orebodies and Their Implications for Formulating Exploration Concepts, A Review, *Geol. Jb.*, Vol. 40.

Fritz, W. H. (1980): Two Cambrian Stratigraphic Sections Near Gataga River, Northern Rocky Mountains, British Columbia, *in* Current Research, Pt. C, *Geol. Surv., Canada*, Paper 80-1c, pp. 113–119.

Large D. (1980): Geological Parameters Associated with Sediment-Hosted Submarine Exhalitive Pb-Zn Deposits: An Empirical Model for Mineral Exploration, *Geol. Jb.*, Vol. 40, pp. 59–129.

MacIntyre, D. G. (1980a): Driftpile Creek-Akie River Project, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork 1979, Paper 1980-1, pp. 55–67.

_______ (1980b): Cirque Barite-Zinc-Lead-Silver Deposit, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1979, Paper 1980-1, pp. 68–74.

_______ (1981): Akie River Project, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1980, Paper 1981-1, pp. 32–47.

Taylor, G. (1979): Geological Map of the Ware East-Half and Trutch Map-Areas, *Geol. Surv., Canada*, Open File Report 609.

Thompson, R. I. (1972): Robb Lake Property, *B.C. Ministry of Energy, Mines & Pet. Res.*, GEM, 1972, pp. 463–476.

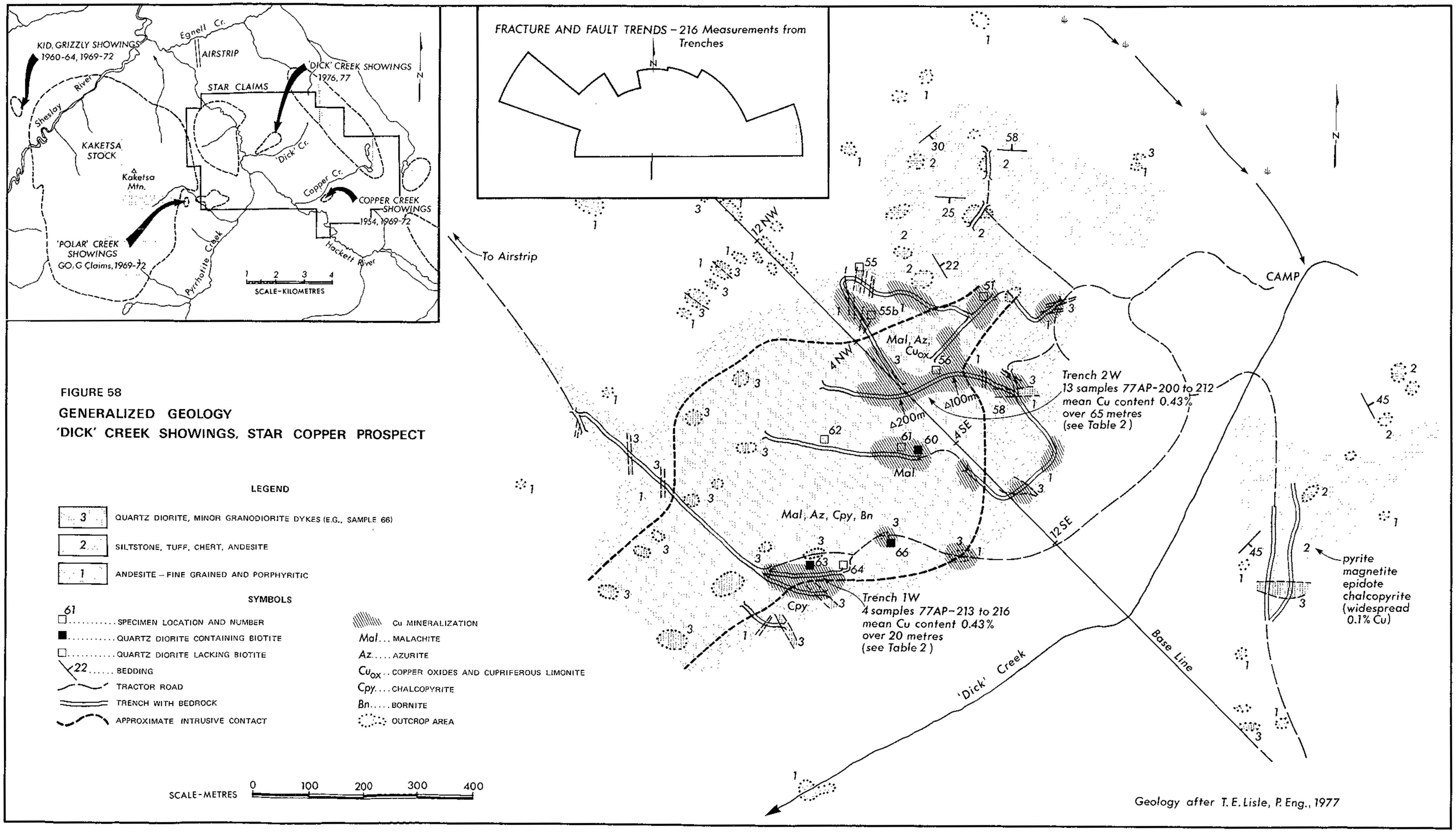


FIGURE 58
GENERALIZED GEOLOGY
'DICK' CREEK SHOWINGS, STAR COPPER PROSPECT

NORTHWEST BRITISH COLUMBIA
(NTS Divisions 104 and part of 114)

1977—STAR COPPER PROSPECT
(104J/4,5)

By A. PANTELEYEV

INTRODUCTION: The Star copper prospect of United Cambridge Mines Limited is approximately 50 kilometres northwest of the community of Telegraph Creek. The STAR claims were located in June 1976 after porphyry copper-type mineralization was noted in scattered outcrop and float boulders in a large area of rusty rocks and soils. The 'Dick Creek' showings on which the STAR claim is centred are new discoveries made by prospector-geologists during the course of geological reconnaissance in an area of known mineral potential. Other similar showings in the area are those at Copper Creek to the southeast (called Callison Copper in 1955 but known since the turn of the century when the Telegraph Trail was in use); GO, G to the southwest (on 'Polar Creek,' a tributary of Pyrrhotite Creek); and KID, GRIZZLY to the northwest. All these copper showings are associated with small diorite to quartz diorite plugs and irregular dykes that intrude Triassic volcanic rocks in the vicinity of the Kaketsa stock (*see* Fig. 58 and Plate XXII).

The main area of current exploration interest is on southwesterly and west-facing slopes immediately to the north of Dick Creek. Dick Creek is a small, westerly flowing tributary of the Hackett River approximately 6 kilometres from its confluence with the Sheslay River.

Plate XXII. Bulldozer trenches at the Star prospect

Outcrop is sparse, even on the relatively open sidehill slopes, and is virtually nonexistent in densely brush-covered gulleys and the main valleys. The best showings are exposed in a number of tractor trenches to the north of Dick Creek between elevations of 825 and 1 075 metres. In the trenches secondary copper minerals and chalcopyrite with rare bornite are found near the eastern margin of a small quartz diorite intrusion. The adjoining volcanic rocks are pyritized and give rise to a widespread yellow to reddish brown capping and rusty soils.

The rusty soil appears to be largely locally derived and is mantled here and there by a thin veneer of clayey soil. This makes soil geochemistry a useful exploration tool and a soil copper anomaly of greater than 400 ppm in an area of background 125 to 150 ppm copper very closely outlines the known mineralized portion of the intrusion (T. E. Lisle, personal communication, 1978).

The writer twice visited the property and examined the trenches and main showings. The assistance of Mr. T. E. Lisle during both visits was invaluable. Later access to geological maps prepared by Mr. Lisle has greatly assisted preparation of this report and is gratefully acknowledged.

A second mineralized zone in volcanic rocks east of Dick Creek is said to have 'skarn' mineralization consisting of epidote, pyrite, and fine-grained chalcopyrite and magnetite. It was not examined by this writer but has been briefly described by T. Schroeter in Geological Fieldwork, 1977, Paper 1978-1, page 70.

GEOLOGY: The mineralized intrustion is a bulbous, northeasterly elongated quartz diorite stock. It is at least 1 100 metres long and up to 550 metres in width and has a multitude of subsidiary dykes. Host rocks for the intrusions are primarily andesitic flow rocks with subordinate sedimentary (tuffaceous ?) units. The intrusions are lithologically similar to quartz diorite and diorite of the nearby Kaketsa stock and are, therefore, believed to be cogenetic and coeval with the main intrusion that underlies Kaketsa Mountain to the west. The Kaketsa stock has been previously radiometrically dated to be Triassic (218 ± 8 Ma hornblende, 214 ± 6 Ma biotite).

The most pronounced structures in the region are a set of northwesterly and subsidiary northeasterly trending photolinears. The structures are probably large faults that have dissected the east flank of Kaketsa stock and its bordering intrusions and have influenced development of the Hackett River Valley. In the Dick Creek area similar trends were noted. Northwesterly zones with crushed, clay altered rocks form strong linear depressions, and the intervening rocks are broken by northeasterly trending fractures, joints, and small faults. The fracture pattern observed and suggested by the plot of fracture trends on Figure 58 appears to be a conjugate set of northwesterly fracture zones in which fault movements took place and a subsidiary set of northeasterly trending crossfractures and joints.

Quartz diorite in the Dick Creek grid area is very light grey when freshly broken and yellowish to pinkish grey where weathered. Strongly fractured rocks are limonite stained and strongly clay altered. In hand specimen intrusive rocks are fine to medium-grained and porphyritic with 0.5 to 1-millimetre-sized crystals of plagioclase and hornblende in a fine granular matrix of predominantly feldspar and quartz. About 10 to 20 per cent of the rock is composed of randomly distributed plagioclase and hornblende phenocrysts from 2 to 4 millimetres in size. Modal composition of nine specimens determined from thin section point counts along with average composition and a comparison with the average composition of 44 specimens from Kaketsa stock are shown following (Table 1). Seven of the specimens are quartz diorite; one with 7 per cent quartz is diorite; and one specimen (No. 66) from a rare dyke within the main intrusion is granodiorite in composition.

In thin section the quartz diorite is generally weakly altered with clear, twinned plagioclase or saussuritized plagioclase common. Rocks with clay or sericite alteration of feldspar are less common. Hornblende is partially to totally replaced by chlorite whereas biotite is not chloritized. If any pyroxene was originally present, it is now totally chloritized or replaced by tremolite/actinolite. Country rocks are fine-grained andesite with average grain size of 0.1 millimetre and porphyritic andesite or basaltic andesite with about 20 per cent clinopyroxene and plagioclase phenocrysts from 2 to 4 millimetres in size in a fine-grained matrix. Primary textures remain; plagioclase is saussuritized and pyroxene is partially made over to actinolite or uralitic amphibole. Chlorite and actinolite along with lesser epidote and calcite are the main alteration minerals. Rare veinlets contain fine granular intergrowths of quartz and traces of chlorite and actinolite and some fractures contain zeolite.

In detail, plagioclase in quartz diorite is present as crowded equant crystals or subhedral laths, many as composite aggregated and complexly twinned grains. Albite and Carlsbad-albite twinning are common with complex oscillatory-normal zoning. Ten to 12 compositional zones are present in most crystals but as many as 25 large zones and numerous additional minor zones were noted in some grains. Anorthite contents range widely from labradorite in crystal cores to oligioclase on margins (An_{60} to An_{23}) but the main portion of crystals is made up of calcic andesine (An_{40} to An_{50}). Many of the calcic andesine zones show preferential saussurite or clay alteration. Oligoclase crystal rims are commonly resorbed, myrmekitic intergrowths with K-feldspar and quartz.

TABLE 1—MODAL COMPOSITION OF DICK CREEK INTRUSIONS

Sample	Quartz	Plagioclase	K-feldspar	Hornblende (chloritized)	Biotite	Opaques	Alteration and Accessory
S77AP-51	13.0	55.0	9.2	16.4	—	3.5	2.9
S77AP-55b	7.0	66.7	0.5	18.9	—	2.6	4.3
S77AP-58	19.3	63.0	1.6	8.2	4.9	1.5	1.6
S77AP-60	21.9	51.6	2.5	—	20.0	1.4	2.7
S77AP-61	12.1	55.4	10.6	15.0	—	3.3	3.6
S77AP-62	14.0	62.4	1.8	15.8	—	3.7	2.3
S77AP-63	18.2	51.0	6.8	13.2	0.2	4.3	6.2
S77AP-64	11.3	65.0	0.8	12.4	tr?	4.8	5.7
Average N=8	14.6	58.7	4.2	12.5	3.2	3.1	3.7
S77AP-66	32.8	46.2	14.4	4.9	—	0.9	0.8
Average Kaketsa Stock N=44	7.5	62.9	9.1	10.0*	2.6	2.1	0.8

* Note—Kaketsa stock has an average content of 5.0 per cent pyroxene.

Most K-feldspar forms discrete interstitial grains 0.1 to 0.2 millimetre in size or rare rims on plagioclase. K-feldspar is microperthitic and is generally more intensely replaced by fine-grained clay minerals or sericite than is plagioclase. Quartz also occurs primarily as 0.1 to 0.2-millimetre interstitial grains. Where larger quartz grains (to 0.4 millimetre) occur, they are commonly fractured.

Hornblende is chloritized and displays a full range in alteration from incipient chlorite replacement along cleavage planes to total replacement. Biotite is pale to medium brown in colour when present as large flakes and tan to pale green coloured when present as minor secondary biotite as in sample No. 63 (and possibly No. 64). Accessory minerals are apatite, sphene, magnetite, pyrite, and zircon. Alteration minerals are chlorite, actinolite, epidote, calcite, sericite, clay minerals, pyrite, chalcopyrite, fine-grained magnetite, zoisite ?, goethite, and the zeolites laumontite and stilbite.

ALTERATION: Intrusions and adjoining country rocks are weakly hydrothermally altered to a propylitic assemblage. Saussuritization (a submicroscopic intergrowth of albitized plagioclase, zoisite, epidote, calcite, sericite, and clay minerals), which imparts a cloudy or 'muddy' appearance to plagioclase is the most widespread alteration type observed. The intensity of plagioclase alteration varies from widespread weak replacement of a few preferred compositional zones to less commonly pervasive replacement by saussurite. In more localized zones clay minerals (illite and montmorillonite) predominate and in rare specimens microscopic sericite (white $2M_1$ mica) has formed up to 4 per cent by volume. However, in none of the samples examined is metasomatism sufficient to totally eradicate original polysynthetic twinning.

Quartz veinlets are rare and, where present, are devoid of sulphide minerals. Veinlets consist of a fine granular mosaic of quartz with up to 5 per cent chlorite and actinolite. Minor veinlets and fracture coatings with fine granular laumontite and rare veins to 5 millimetres in width with radiating laths of stilbite were noted.

Hornblende is mainly chloritized but is also replaced in part by actinolite, epidote, calcite, and fine-grained opaque minerals. The examined specimen with 20 per cent primary biotite appears to be part of a small compositional zone with gradational contacts within the main body of hornblende quartz diorite. No internal intrusion contacts were recognized. Presence of biotite is accompanied by an increase in accessory apatite. The one specimen (No. 63) with fine-grained secondary biotite is part of a very restricted alteration zone of minor secondary biotite development.

Country rocks from near the intrusive contact show very little thermal metamorphic affects. These rocks have propylitic alteration, predominantly saussuritized plagioclase and chlorite-actinolite replacement of mafic minerals along with lesser epidote, calcite, magnetite, and pyrite. This represents a degenerative breakdown and replacement of primary minerals without prograde recrystallization and no appreciable development of hornfels.

The most pronounced alteration in outcrop is caused by near surface weathering and oxidation. This supergene alteration results in a partially leached capping of clay altered limonitic rocks up to a few metres in thickness. The rocks are fine granular assemblages of quartz, albite, gypsum, zeolite, muscovite, clay minerals, chlorite, limonite, and pyrite. They are most abundant in the northerly trenches near the top of the hill where faults and fractures are most strongly developed. Limonite is mainly a dark yellow-orange amorphous compound or goethite where crystalline. Jarosite is present locally. There is a notable abundance of gypsum in fractures. None is seen in less altered rocks further to the south and at depth and, therefore, is assumed to be entirely supergene in origin. Stilbite from fractures in the northern trenches forms pale bluish radiating crystals. It is probably an early-formed alteration or metamorphic mineral that has absorbed copper from solutions during weathering.

MINERALIZATION: Distribution of mineralized outcrops and assays from tractor trenches show that areas with average copper content in excess of 0.4 per cent copper are relatively widespread in the Dick Creek showing area (*see* Table 2).

In the northerly, uphill trenches where weathering and oxidation are most pronounced, few copper sulphides are visible and the obvious copper minerals present are black copper oxide, malachite, brochantite $[Cu_4(SO_4)(OH)_6]$, and cupriferous limonite.

In the southerly, downhill trenches where rocks are less weathered, copper minerals are present as primary disseminated chalcopyrite and traces of bornite as well as fracture-controlled malachite and azurite. The bornite occurs as discrete very fine grains or, more commonly, as intergrowths with chalcopyrite. Where chalcopyrite and bornite are abu-

TABLE 2—ASSAYS FROM TRENCH WALL CHIP SAMPLES, TRENCHES 1W and 2W

Trench 2W

Sample No.	Location (Relative to stations 100 m and 200 m)	% Cu* (TOTAL)	% Cu (oxide)	Au ppm	Ag ppm
77AP-200	45-50 m	0.21	0.11	0.13	0.35
77AP-201	145-150 m	1.2	1.09	0.06	0.26
77AP-202	140-145 m	0.51	0.42	0.04	0.31
77AP-203	135-140 m	0.32	0.24	0.14	0.34
77AP-204	125-130 m	0.16	0.095	0.20	0.66
77AP-205	115-120 m	0.24	0.11	0.11	0.53
77AP-206	150-155 m	0.65	0.53	0.23	0.63
77AP-207	160-165 m	0.095	0.029	0.35	0.67
77AP-208	170-175 m	0.10	0.020	0.38	0.78
77AP-209	185-190 m	0.10	0.047	0.18	0.35
77AP-210	100-105 m	0.45	0.36	0.19	0.34
77AP-211	110-115 m	1.0	0.75	0.53	1.19
77AP-212	120-125 m	0.53	0.34	0.33	0.58
Average Trench 2W across 65 metres		0.43	0.24		

Trench 1W

Sample No.	Location (Relative to Line 4 SE)	% Cu (TOTAL)	% Cu (oxide)	Au ppm	Ag ppm
77AP-213	10-15 m west	0.30	0.14	0.03	0.20
77AP-214	20-25 m west	0.71	0.39	0.59	2.11
77AP-215	30-35 m west	0.42	0.24	<0.02	0.31
77AP-216	35-40 m west	0.28	0.13	0.06	<0.14
Average Trench 1W across 20 metres		0.43	0.23		

Assays by W. M. Johnson, analyst, British Columbia Ministry of Energy, Mines and Petroleum Resources.
Mo content ranges from 2 to 29 ppm.
* Cu (oxide) includes only readily soluble copper, for example, oxide, carbonate, sulphide; Cu (TOTAL) gives total copper content.

nant, magnetite is present but pyrite is relatively subordinate or absent. Most commonly chalcopyrite occurs alone or together with pyrite. There appears to be a broad diffuse zone or halo of pyritic rocks surrounding the copper mineralized zone. Pyrite is the dominant sulphide mineral in volcanic rocks surrounding the quartz diorite intrusion but overall pyrite content rarely exceeds 1 per cent. Copper sulphides generally replace mafic minerals and are therefore truly disseminated whereas pyrite is present both as disseminations and fracture filling.

Supergene mineralization is restricted to a thin oxidized capping under which there is no appreciable secondary copper sulphide enrichment zone. The copper minerals that have formed are copper oxides, carbonates, sulphates, and cupriferous limonites. This is compatible with the relatively arid, slightly acid environment which would be expected in this area of relatively basic intrusions and volcanic rocks and overall low sulphide content (generally less than 1 per cent).

Gold values are erratic and generally low (average 0.006 ounce per ton) but two samples contain approximately 0.015 ounce gold per ton. It might be of significance that the gold content of the more strongly oxidized rocks in Trench 2W are higher than that in the less oxidized rocks of Trench 1W.

In summary, the Dick Creek copper showings are similar to other known copper showings associated with quartz diorite in the Kaketsa stock area. However in this locality *disseminated* copper sulphides (both chalcopyrite and bornite) are more widespread in the quartz diorite intrusion than in the other areas. The development of secondary copper minerals (mainly copper oxides) might have resulted in some copper enrichment in the thin limonitic capping.

REFERENCE: *British Columbia Ministry of Energy, Mines & Pet. Res.*, GEM, 1972, pp. 547–549 (GO, G).

1978—MOLY-TAKU (104K/6W)

LOCATION:	Lat. 58° 27′	Long. 133° 22′	(104K/6W)

CLAIMS: BORDER 10 (15 units), BORDER 11 (15 units), CRAG 1 (20 units), CRAG 2 (12 units), CRAG 3 (9 units), SUE 1 (16 units), SUE 2 (20 units), CRAG 4 (12 units), BORDER 5 (16 units), ERIC 1 (20 units), BORDER 4 (12 units), BORDER 6 (9 units), MOLY 3 (18 units), MOLY 4 (18 units), BORDER 1 (16 units), BORDER 2 (18 units), BORDER 3 (18 units), BORDER 13 (20 units), BORDER 12 (18 units), TAKU 1 (18 units), TAKU 2 (18 units), BORDER 8 (20 units), BORDER 9 (17 units), MOLY 1 (1 unit), MOLY 2 (4 units).

OWNER: Frank Onucki.

OPERATOR: OMNI RESOURCES INC.

DESCRIPTION: The MOLY-TAKU molybdenum prospect is located approximately 25 kilometres southeast of Tulsequah on the British Columbia-Alaska border near Mount Ogden. Several tonnes of molybdenite-bearing alaskite occur in terminal and medial moraines on the surface of an active glacier.

A number of mining companies examined the area in the 1960's. In 1967 a small diamond drill was skidded onto an accessible site and still remains there. One drill hole was collared in a tongue of alaskite (Fig. 59).

Country rock on the property consists of a sequence of Permo-Triassic metasedimentary and metavolcanic rocks. These include "tactite", a diabase sill, and a thin to thick-bedded sequence of shales and carbonates. Two types of "tactites" are present:

(1) a white calc-silicate rock containing calcite, dolomite, wollastonite, and tremolite.
(2) a fine-grained, green, diopside-epidote-garnet unit with or without fine-grained disseminated pyrite, magnetite, or locally sphalerite.

These rocks strike northwesterly and dip steeply to the northeast.

An irregular body of light-coloured Cretaceous to Tertiary alaskite intrudes the sequence. The rock is variably coarse to fine grained in texture and consists of approximately 40 per cent phenocrysts of quartz and feldspar set in a fine-grained cream-coloured groundmass. Mafic minerals are usually lacking.

Molybdenite occurs as follows: in quartz veinlets ranging in thickness up to 0.25 centimetre, associated with irregular clots of quartz and as fine disseminations in the alaskite. Molybdenite and pyrite also occur in quartz veinlets within silicified dark green tactite.

At the drill site southeast of the drill hole, the tactite is contorted and silicified at the contact with the alaskite. Molybdenum-bearing alaskite float on the active glaciers apparently came from near the drill site area (Lower Moly zone) and the steep rugged headwall to the southeast (Upper Moly zone) which was not visited.

WORK DONE: Preliminary surface sampling consisting of 96 samples taken.

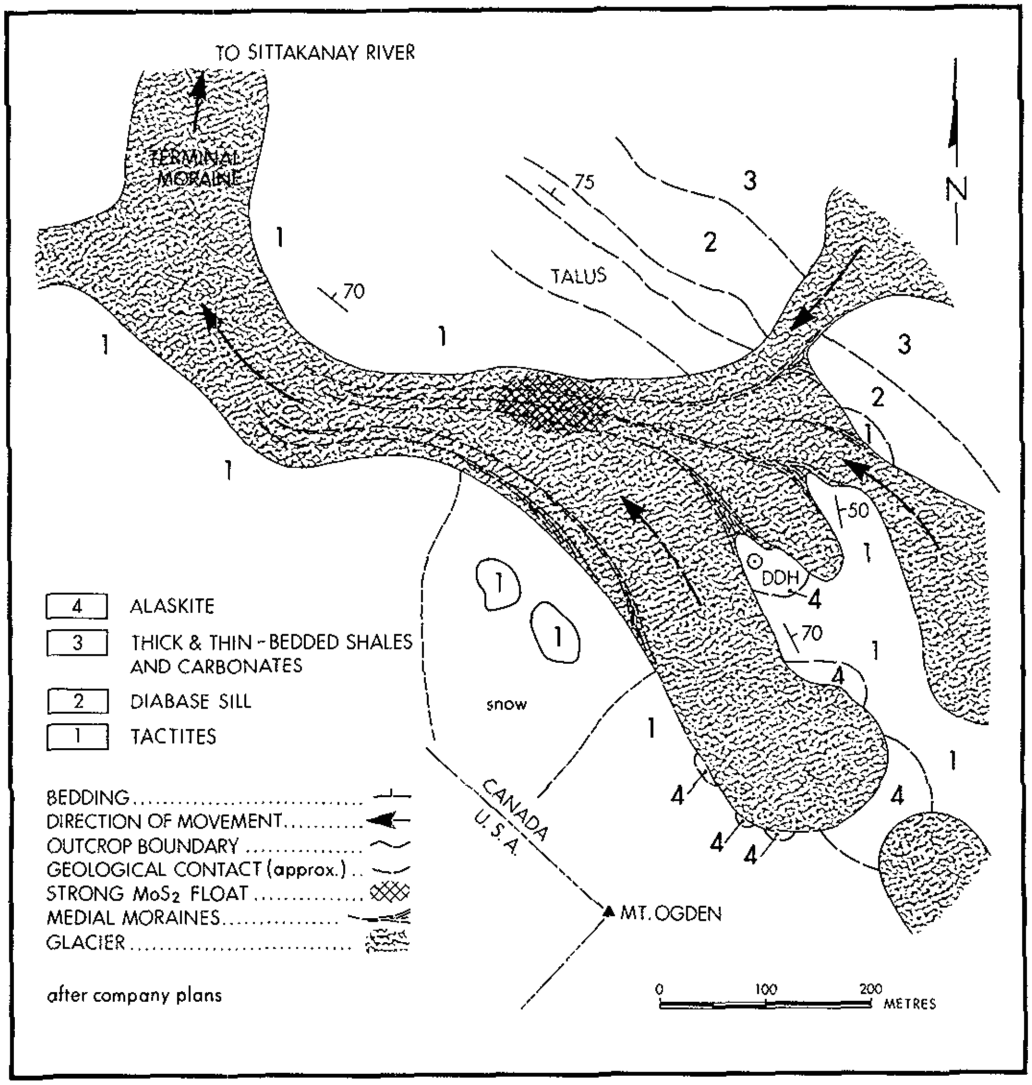


Figure 59. Geological sketch map of Moly-Taku property

1978—CY, ENG (104N/10W)

LOCATION: Lat. 59° 39′ Long. 132° 59′ (104N/10W)

CLAIMS: CY 1 to 8, ENG 1 to 3 (totalling 187 units).

OWNER: MATTAGAMI LAKE MINES LIMITED.

DESCRIPTION: The CY, ENG claim group is located in the Mount Weir area approximately 40 kilometres east of Atlin, in the heart of the Surprise Lake batholith. Three main textural varieties of alaskite have been noted: very coarse grained, uniform medium grained, and fine grained porphyritic. The average modal composition is quartz (20 to 40 per cent), orthoclase (20 to 50 per cent), plagioclase (10 to 40 per cent), and biotite (<2 per cent). In general the rocks are only weakly altered (local kaolinization of feldspars and minor chloritization and epidotization).

To the south part of the claim group, the alaskitic quartz monzonite is in contact with chert, argillite, chert pebble conglomerate, and chert breccia belonging to the Cache Creek Group.

Zeunerite [$Cu(UO_2)_2(AsO_4)_2 \cdot 10-16\ H_2O$], molybdenite, galena, sphalerite, pyrite, fluorite, beryl, wolframite, magnetite, and hematite have been noted in various rock types on the property. In addition, a zone of supergene alteration including kasolite [$Pb(UO_2)SiO_4 \cdot H_2O$], wulfenite ($PbMoO_4$), and minor amounts of vandendriesscheite ($PbU_7O_{22} \cdot 12\ H_2O$?) exist on the southwest flank of Mount Weir. Mineralization is assumed to be associated with local fractures or faults.

On top of Mount Weir, tension fractures filled with smokey quartz veins and carrying galena and sphalerite occur in coarse-grained alaskite. Quartz veins are up to 20 centimetres in width and are exposed along a length of 40 centimetres. Euhedral quartz crystals up to 3 centimetres long occur in vuggy veins. A uranium anomaly coexists with the base metal mineralization here.

Elsewhere near the summit of Mount Weir, near massive magnetite±hematite veins, 1 to 2 metres across, intrude alaskite with a general trend of 050 degrees/65 degrees northwest. The quartz-rich zones have a general trend of 160 degrees/75 degrees west.

On the CY 6 claim a yellow-orange-coloured supergene zone exposed over an area of 10 metres by 40 metres contains the minerals kasolite, wulfenite, and vandendriesscheite. Shallow test pits dug to bedrock showed intensely weathered rock that is anomalous in uranium. Not far from this occurrence, a mafic-rich dyke carrying disseminated sphalerite exists.

On the west side of Caribou Creek, on the CY 8 claim, several mafic dykes (?) up to 4 metres in width and trending 050 degrees/60 degrees northwest intrude the alaskite.

Disseminated sphalerite occurs within the dykes (?) in volumes up to 20 per cent. Purple fluorite and beryl are also minor constituents.

On the northeast flank of Mount Weir, mafic-rich dykes (?) with sphalerite, galena, magnetite, hematite, quartz, and danalite [$(Fe, Mn, Zn)_4Be_3(SiO_4)_3S$] intrude alaskite.

WORK DONE: Geological mapping; geochemical survey, approximately 100 silt, 200 soil, and 100 rock samples analysed (radon in soil included); electromagnetic surveys; grid chaining; hand trenching; and ground and airborne radiometric surveys.

1978—MIR
(104M/10W)

LOCATION:	Lat. 59° 37.5′	Long. 132° 50′	(104N/10W)

CLAIMS: MIR 2, 3, 5 to 7 (totalling 100 units).

OWNER: UNION OIL COMPANY OF CANADA LTD.

DESCRIPTION: The MIR claims being explored by the MUG Syndicate (Malabar Mines Ltd., Union Oil, and Getty Mines), is located approximately 50 kilometres east of Atlin and southwest of Trout Lake.

The property is underlain by alaskitic quartz monzonite of the Surprise Lake batholith. In places it is banded with interlayers of aplitic and pegmatitic phases.

The MIR claims lie on the western flank of the "Trout Lake Graben" which is a north-south-trending feature that bisects the Surprise Lake batholith.

Galena, sphalerite, chalcopyrite, pyrite, magnetite, and hematite accompanied by secondary uranium minerals, like kasolite [$Pb(UO_2)SiO_4 \cdot H_2O$] occur as polymetallic veins or with quartz stockwork mineralization within alaskitic quartz monzonite. Magnetite is usually a significant component; secondary manganese is commonly associated with the base metal sulphides. Sulphides can be either massive or disseminated.

Uranium anomalies occur in radon springs and silt samples and are particularly high in areas of bog. The presence of major structural lineaments appears to be favourable for uranium migration. Aplitic phases of the alaskitic quartz monzonite host are commonly more radioactive.

On the MIR property, and also in other areas within the Surprise Lake batholith, a dull yellowish green waxy looking mineral occurring as a thin coating along fractures has been identified by X-ray techniques as a clay mineral. Its diffractogram closely resembles that of tosudite, an aluminum silicate hydrate with minor amounts of Fe, Mg, Ca, Na, and K. A small amount of kaolinite is also mixed with it.

WORK DONE: A minor amount of trenching by Union Oil has exposed some occurrences of polymetallic veining associated with quartz. Three diamond-drill holes totalling 449.6 metres were also completed to test uranium geochemical anomalies on the MIR 3 and MIR 7 claims. Geological mapping and geochemical and geophysical surveys were conducted.

1977—ATLIN SILVER (RUFFNER) MINE (104N/11W)

The Atlin Silver mine is located approximately 22 kilometres northeast of Atlin on Vaughan Mountain. During the summer months of 1977, drifting and raising on an "as-you-go" basis on the main working (entrance) level (4300) and two sublevels (4250 and 4210) revealed a "pinch and swell" vein zone of about 0.9 metre containing abundant chlorite gouge within a mafic quartz monzonite. The haulage level was the 4100.

Grab samples from underground yielded the following assays:

Sample No.	Description	Silver ppm (oz./ton)	Gold ppm (oz./ton)	Cu per cent	Pb per cent	Zn per cent
AR-13	massive 100 mm qtz vein with PbS + cpy + arsenopyrite from 4250 sublevel	509 (14.97)	2 (0.06)	0.092	3.3	5.8
AR-14	massive 100 mm qtz vein with PbS + cpy + arsenopyrite from 4250 sublevel	965 (28.38)	3 (0.09)	0.15	3.6	5.7
AR-15	1 metre qtz vein with PbS + cpy + arsenopyrite from 4250 sublevel	2880 (84.71)	<1	0.083	5.4	10.3
AR-16	qtz vein withpy + PbS + ZnS + MoS_2 from 4250 sublevel	1640 (48.24)	1 (0.03)	0.13	1.92	3.2
AR-18	PbS + arsenopyrite + ZnS in qtz vein from 4210 sublevel	225 (6.62)	1	0.055	0.59	2.2

In addition a sample of lead and zinc concentrate was collected from the mill.

Sample No.	Description	Silver ppm (oz./ton)	Gold ppm (oz./ton)	Cu per cent	Pb per cent	Zn per cent
AR-19	Pb concentrate collected Aug. 23/77	4694 (138.06)	4 (0.12)	0.67	43.5	6.1
AR-20	Zn concentrate collected Aug. 23/77	981 (28.85)	<1	0.55	4.3	43.8

The mill apparently averaged 50 tons per day in two shifts. Twenty persons worked on the site, including eight underground. The average heads were reported to be Zn, 2 per cent; Pb, 2.5 per cent, and Ag, 15.6 ounces per ton (530.4 ppm). The mine closed in early September.

REFERENCES: *Minister of Mines, B.C.* Ann. Rept., 1923, pp. 89–91; *B.C. Ministry of Energy, Mines & Pet. Res.,* GEM, 1969, p. 28; Geological Fieldwork, 1976, Paper 1977-1, p. 69.

1978—CINBAR
(104N/11W)

LOCATION: Lat. 59° 40′ Long. 133° 27′ (104N/11W)

CLAIMS: CINBAR (9 units), CB (18 units).

OWNER: YUKON REVENUE MINES LTD

DESCRIPTION: The Cinbar property is located on the west side of Boulder Creek, approximately 20 kilometres east of Atlin. The claims are underlain by Cache Creek Group greenstones interbedded with thin sections of limestone and quartzite. On the west side of the claims there are three small stocks of peridotite and metadiorite. The Surprise Lake batholith, consisting of alaskite, occupies the northeastern part of the claim group.

Pyrrhotite and pyrite with minor amounts of chalcopyrite, tetrahedrite, galena, sphalerite, fluorite, cassiterite, and scheelite occur as disseminations and irregular, massive lenses in altered talcose basic volcanic rocks and peridotite. Traces of molybdenite were noted. Galenobismuthite ($PbBi_2S_4$) with a minor amount of tetradymite (?) (Bi_2Te_2S) have also been identified by X-ray techniques.

WORK DONE: During 1978, Yukon Revenue carried out magnetic surveys, mapping, and trenching over a 300-square-metre area.

1978—AP
(104O/7E)

LOCATION: Lat. 59° 19′ Long. 130° 45′ (104O/7E)

CLAIMS: AP (20 units).

OWNER: DU PONT OF CANADA EXPLORATION LIMITED

DESCRIPTION: The AP claims are located approximately 80 kilometres south-southeast of Swift River, just north of Ash Mountain in the Jennings River area. Tungsten mineralization occurs in quartz veinlets and as disseminations in garnet-diopside skarn zones in contact with host argillaceous quartzite to metachert of the Oblique Creek Formation, and granitic rocks, similar in appearance to the Surprise Lake and Seagull batholiths (that is, with smokey grey quartz eyes). The structure (faulting) on the property is complex.

WORK DONE: Du Pont carried out geochemical surveys and preliminary geological mapping.

1977—LOGTUNG
(104O/13E)

LOCATION: The five JAM claims (98 units) and one CAMP claim (2 units) which comprise the British Columbia portion of the Logtung property are located at the headwaters of West Logjam Creek, approximatley 8 kilometres east of Smart River. The well cut and surveyed British Columbia-Yukon border line forms the northern boundary of the British Columbia part of the property (Fig. 60).

Access to the JAM claims is by a 13-kilometre road which joins the Alaska Highway at Kilometre 1213.

DESCRIPTION: The Logtung tungsten-molybdenum property was discovered by Cordilleran Engineering Ltd. (managers of the program for the 1976 Bath Uranium Partnership Ltd.—now Logtung Resources Ltd.) while prospecting for the source of a prominent tungsten geochemical anomaly in the Logjam Creek-Two Ladder Creek area in late 1976. Six claims (100 units) were staked in British Columbia and 138 claims in the Yukon. The property was optioned to Amax Potash Limited in 1977 who reconstructed a 13-kilometre access road to the property from the Alaska Highway, set up a trailer camp, and

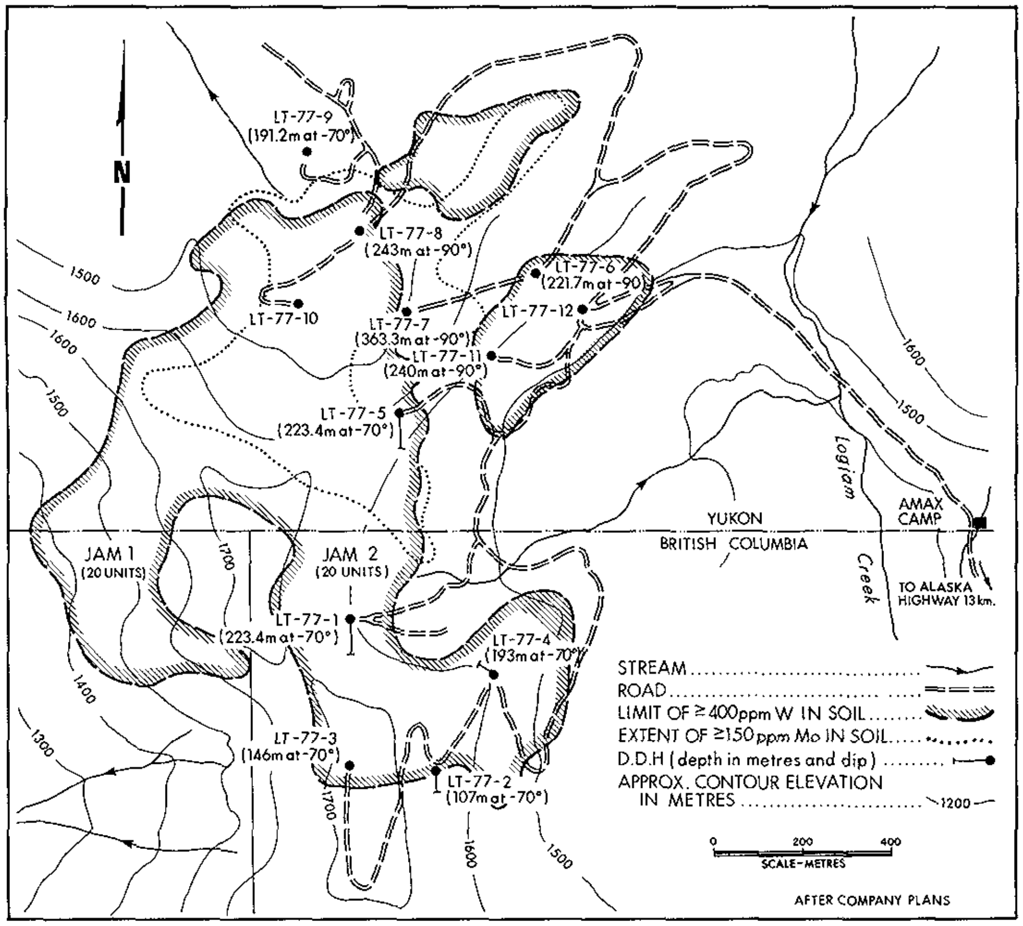


Figure 60. Sketch map of the Logtung property

completed over 2 840 metres of diamond drilling in 14 holes (475.4 metres in 4 holes on the British Columbia side of the property).

Late Paleozoic (?) metasedimentary rocks flanked to the east and west by northerly elongate diorite bodies underlie the headwaters of West Logjam Creek. A younger quartz monzonite stock forms the southeastern boundary of the showing; several quartz monzonite porphyry dykes occur as off-shoots. The metasedimentary rocks are variously altered to brown hornfels or interbanded light green cherty skarn or light to dark green garnet-diopside skarn in the vicinity of the mineralized zones.

Three mineralized zones are recognized: the British Columbia Zone, the Central Zone, and the Yukon Zone. The latter two are probably a single contiguous zone.

Scheelite and molybdenite occur mainly in a well-developed quartz vein stockwork in and near the quartz monzonite porphyry dykes and in the quartz monzonite stock near its contact. Narrow quartz-scheelite veins and rare quartz-molybdenite veins cut the metasedimentary rocks. Disseminated scheelite is locally associated with bands or pods of dark green skarn.

Fluorite, beryl, sphalerite, galena, rarely chalcopyrite, wolframite, and cosalite occur as accessory vein minerals in all rock types.

REFERENCES: Mineral Inventory 104O-16; *British Columbia Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1977, Paper 1978-1, p. 70.

1978—ATAN
(104P/1E)

LOCATION:	Lat. 59° 08′	Long. 128° 07′	(104P/1E)
CLAIMS:	ATAN 1 to 4 (totalling 34 units).		
OWNER:	AMOCO CANADA PETROLEUM CO. LTD.		
DESCRIPTION:	The ATAN lead-zinc prospect is located approximatley 20 kilometres east of Deadwood Lake, 110 kilometres south of Watson Lake. Sphalerite and galena occur as pods, as disseminations, and in veinlets in massive to thin-bedded Atan Group limestone (up to 150 metres thick) of Early Cambrian age. Resistant 'ribs' of sphalerite (light brown) and galena (grey) give the limestone a ribboned appearance. The Atan limestone is part of a block-faulted anticlinal structure that is flanked to the west by phyllites of the Kechika Group and to the east by thick alluvium. Pyrite is generally less than 5 per cent by volume and does not necessarily correlate with zones of lead-zinc mineralization. Secondary hydrozincite is common in mineralized lead-zinc outcrops. Gypsum-carbonate veining is less abundant.		
WORK DONE:	Geochemical survey, 368 soil, 7 silt, and 21 rock samples; three diamond-drill holes.		

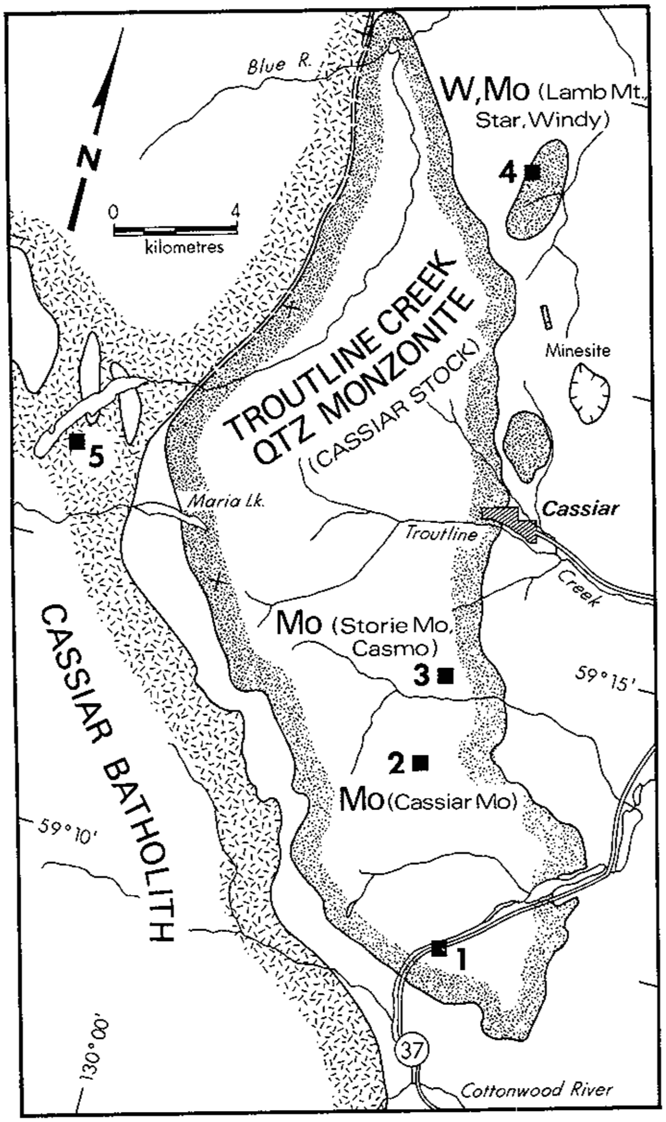


Figure 61. Geology and K/Ar Dates, Cassiar district, McDame map-area

1980—CASSIAR MAP-AREA (104P/4,5)

By A. Panteleyev

Geological mapping and investigation of the many mineral occurrences in the Cassiar region have been carried out since 1978. Progress reports have been published in Geological Fieldwork, A Summary of Field Activities (Panteleyev, 1979, 1980, 1981).

The regional geologic setting of the Cassiar batholith in McDame and Jennings River map-areas (104P and O) has been described by Gabrielse (1963, 1969). Results of radiometric dating in the region were discussed by Christopher, White, and Harakal (1972). Using a number of previously published data, they stated the age of the Cassiar batholith is 102 ± 3 Ma. In addition, Christopher, *et al.* (1972) provided a number of new Late Cretaceous and Tertiary dates from other intrusions in the region. Included in the younger dates were two Late Cretaceous K/Ar dates of 71.7 ± 2.6 and 68.3 ± 2.7 Ma which Christopher, *et al.* (1972) stated represent "a young phase of the Cassiar intrusions, occurring along the eastern margin of the Cassiar batholith, (and) place an upper limit on the age of the molybdenum mineralization on the Cassiar Molybdenum property" (site No. 2, on Fig. 61).

The following K/Ar data (*see* table) provide documentation that the megacrystic porphyry intrusion emplaced along the eastern margin of the Cassiar batholith in the vicinity of the town of Cassiar, is a discrete, younger pluton of Late Cretaceous age. Geological mapping of the Late Cretaceous Troutline Creek quartz monzonite or Cassiar stock shows that this intrusion is separated from rocks of the Cassiar batholith in the south by a septum of metamorphic rocks but in the north between Maria Lake and Blue River has intruded the older batholith.

REFERENCES

Christopher, P. A., White, W. H., and Harakal, J. E. (1972): Age of Molybdenum and Tungsten Mineralization in Northern British Columbia, *Cdn. Jour. Earth Sci.*, Vol. 9, pp. 1727–1734.

Gabrielse, H. (1963): McDame Map-Area, Cassiar District, British Columbia, *Geol. Surv., Canada,* Mem. 319, 138 pp.

——— (1969): Geology of Jennings River Map-Area, British Columbia (104O), *Geol. Surv., Canada,* Paper 68-55, 37 pp.

Panteleyev, A. (1979): Cassiar Map-Area (104P), *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1978, Paper 1979-1, pp. 51–60.

——— (1980): Cassiar Map-Area (104O), *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1979, Paper 1980-1, pp. 80–88.

——— (1981): Lithogeochemical Study of the Cassiar Moly Deposit, Cassiar Map-Area (104P), *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1980, Paper 1981-1, pp. 48–54.

K/Ar ANALYTICAL DATA, CASSIAR DISTRICT, McDAME MAP-AREA 104P

Sample No.	Location (Figure 61)	Lithology	Material Analyzed	Per Cent K	Ar^{*40} ($10^{5}mi^{6}cc/gm$ STP)	Ar^{*40} / TOTAL Ar^{40}	Apparent Age (Ma)
(1) 79AP-21	Number 1 129°50′23″W 59°09′39″N	Megacrystic quartz monzonite porphyry	Hornblende	1.199 ± 0.007	3.641	65.3	76.5 ± 2.7
(2) 79AP-21	129°50′23″W 59°09′39″N	Megacrystic quartz monzonite porphyry	Biotite (black)	7.33 ± 0.06	22.129	96.2	76.1 ± 2.7
(3) 79AP-21	129°50′23″W 59°09′39″N	Megacrystic quartz monzonite porphyry	Biotite (brown)	8.12 ± 0.07	22.291	93.2	69.3 ± 2.4
(4) 78AP-60a	Number 2 129°50′45″W 59°12′30″N	Mineralized greisen	Muscovite (hydromuscovite?)	8.42 ± 0.02	24.618	97.9	73.7 ± 2.6
(5) 78AP-43	Number 2 129°51′42″ 59°12′53″	Porphyritic quartz monzonite	Biotite	7.78 ± 0.03	22.720	93.4	73.6 ± 2.5
(6) 78AP-127	Number 3 129°51′39″ 59°14′55″ (approximate)	Mineralized K-feldspar vein	Muscovite	8.77 ± 0.02	25.440	92.7	71.4 ± 2.5
(7) 78AP-126	129°51″39′ 59°14′55″	Quartz feldspar porphyry	Biotite	7.69 ± 0.03	22.110	92.8	72.5 ± 2.5
(8) 78AP-158	Number 4 129°53′36″ 59°24′21″	Porphyritic quartz monzonite	Biotite	7.92 ± 0.08	23.236	89.7	73.9 ± 2.5
(9) 79AP-40	Number 5 130°04′29″ 59°16′50″	Porphyritic quartz diorite (foliated)	Biotite	7.20 ± 0.05	30.179	97.3	105 ± 4

Per cent K determined by the Analytical Laboratory, Ministry of Energy, Mines and Petroleum Resources.
Ar determination and age calculation by J. E. Harakal, University of British Columbia.
Constants Used: *$\lambda = 0.584 \times 10^{-10} yr^{-1}$; λ^{6} $4.72 \times 10^{-10} yr^{-1}$; $K^{40}/K = 1.19 \times 10^{-4}$ (sample 3)*
$\lambda = 0.581 \times 10^{-10} yr^{-1}$; λ^{6} $4.96 \times 10^{-10} yr^{-1}$; $K^{40}/K = 1.167 \times 10^{-4}$ (samples 1, 2, 4, 5)

1977—HUM BIRD
(114P/10W)

LOCATION: Lat. 50° 43′ Long. 136° 58′ (114P/10W)
ATLIN M.D. Fourteen kilometres east of the Tatshenshini River on an eastern tributary of Shini Creek, 7 kilometres west-northwest of Samuel Glacier, between 1 000 and 1 700 metres elevation.

CLAIMS: HUM BIRD 1 to 31, 33 to 41.

OWNER: YUKANDA MINES LIMITED, 404, 1550 Richmond Avenue, Victoria, B.C.

METALS: Silver, zinc, lead, copper.

DESCRIPTION:

HISTORY: In the early 1900's Mr. John Frazer, an Indian prospector, found mineralization on the now HUM BIRD property. Sometime in the 1940's a Yukon prospector by the name of Eric Fredrickson restaked the property and dug a few pits in the showing. He held claims on the property until his death in the early 1960's. In July, 1968, T. Worbetts and D. Craft staked the property (Fig. 62). It was subsequently optioned to Ronex Exploration Ltd. who explored the property in 1968, 1969, and 1970. Ronex established a grid and conducted a geochemical survey and geophysical surveys (EM 16, magnetometer, and Turam). Very limited diamond drilling followed. In 1975 Asarco optioned the property and conducted geological mapping. The option was subsequently dropped. In 1977, Yukanda Mines Ltd. constructed a 32-kilometre access road to the property from Kilometre 139 on the Haines Road. Camp equipment and a small mill were brought onto the property; however, neither systematic sampling nor diamond drilling were conducted.

GEOLOGY: The property is underlain by an interbedded sequence of limestone, chlorite schist, graphitic schist, sericite schist, and altered (greenschist facies) andesitic volcanic rocks of probable Triassic age belonging to the Mush Lake Group. Generally the rocks, which strike north-south and dip 40 degrees to the west, have been folded, faulted, and sheared. Near the western boundary of the property there is a body of diorite.

MINERALIZATION: Replacement and vein-type occurrences of sphalerite, galena, tetrahedrite, chalcopyrite, and pyrite mineralization are contained in silicified and carbonatized limestone and schist associated with shear zones. Six mineralized zones occurring along a strike length of approximately 3 500 metres are known: the Creek showing, Camp showing, Discovery showing, Cliff showing, Ridge showing, and Southeast showing. Where tetrahedrite is absent, for every per cent of lead there are approximately 40 ppm silver.

In the Creek showing banded sphalerite-galena-pyrite-chalcopyrite occurs in a siliceous gangue and is bounded by folded and contorted talc-sericite schist.

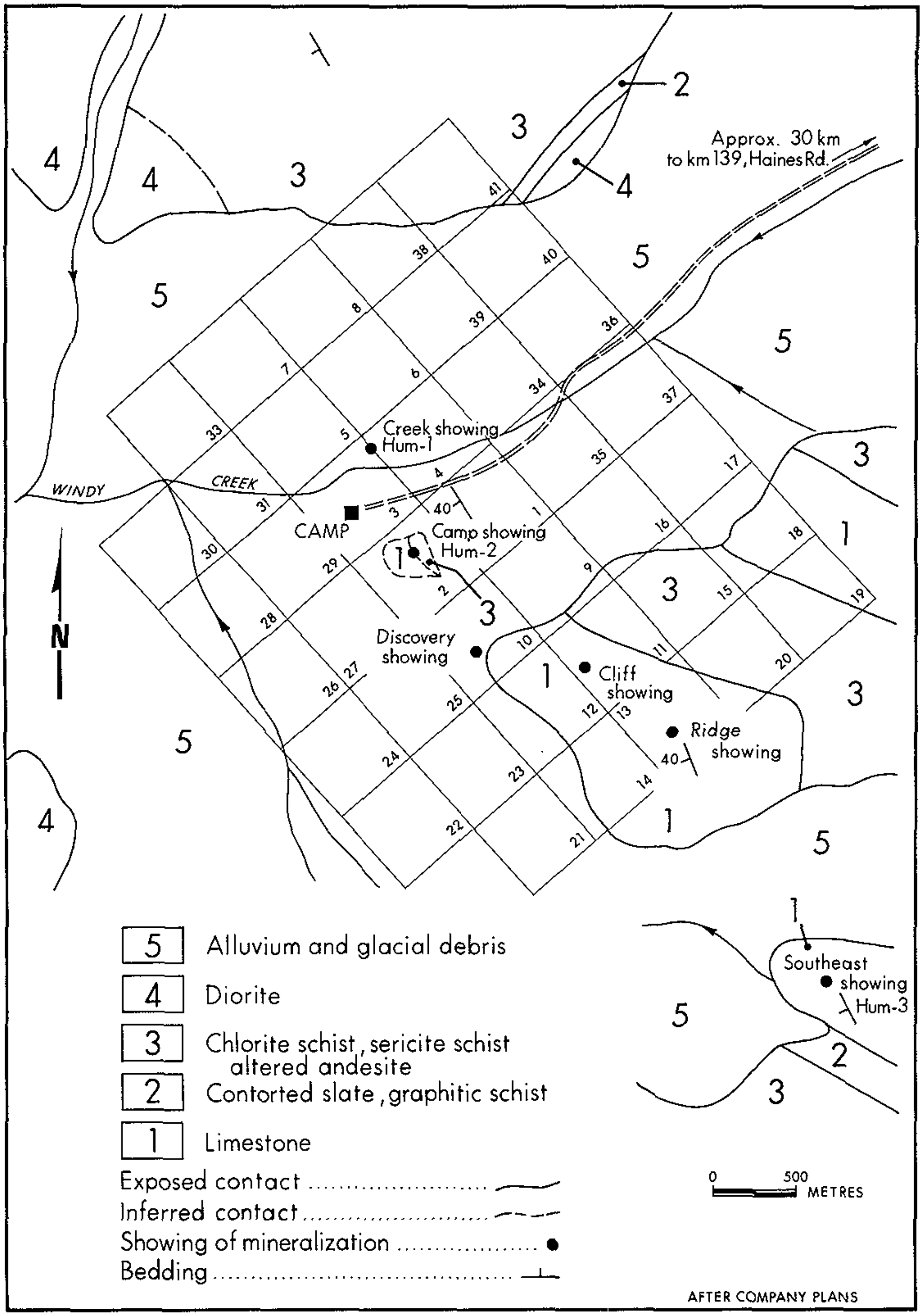


Figure 62. Geology of the Hum Bird area

A character sample (HUM-1) assayed:

Gold ppm (oz./ton)	Silver ppm (oz./ton)	Lead per cent	Zinc per cent	Copper per cent
<1	221	4.9	25.0	0.024
(−)	(6.5)			

In the *Camp showing,* sphalerite, galena and pyrite occur within silicified limestone in contact with sericite schist. The unmineralized limestone is grey and impure with a bedding attitude of 185 degrees/50 degrees west.

A character sample (HUM-2) assayed:

Gold ppm (oz./ton)	Silver ppm (oz./ton)	Lead per cent	Zinc per cent	Copper per cent
<1	230	5.2	16.0	0.035
(−)	(6.7)			

In the *Discovery showing,* disseminated grains and clots of sphalerite, galena, and chalcopyrite are contained within carbonatized, silicified, and brecciated grey limestone.

Similar types of mineralization have been located on the *Cliff* and *Ridge showings.*

In the *Southeast showing,* chalcopyrite, tetrahedrite and pyrite are disseminated and fill fractures within a silicified limestone; it is similar to the other showings on the property.

A character sample (HUM-3) assayed:

Gold ppm (oz./ton)	Silver ppm (oz./ton)	Copper per cent	Zinc per cent
1	291	0.84	1.2
(−)	(8.56)		

REFERENCES: *B.C. Ministry of Energy, Mines & Pet. Res.,* GEM, 1975, p. G196; Geological Fieldwork, 1977, Paper 1978-1, p. 71; Mineral Inventory 114P-18, 24, 25, 26.

Queen's Printer for British Columbia ©
Victoria, 1985