Province of British Columbia
Ministry of Mines and Petroleum Resources

E R R A T U M

REXSPAR URANIUM DEPOSIT

(82M/12W)

By V. A. Preto

Second paragraph under Introduction—

Extensive work in the early and mid 1950's outlined three zones of commercial-grade uranium mineralization and one contiguous zone of fluorite mineralization. Considerable drilling since 1969, augmenting the earlier work, has indicated that the three zones, known as the A, B, and BD, contain an estimated 1 108 410 tonnes of material averaging 0.770 kilograms U_3O_8 per tonne amenable to open-pit mining methods. The company is presently finalizing plans for a 1 270-tonne-per-day, five days a week, mining operation and for a 907-tonne-per-day beneficiation plant that is to operate continuously.

a summary of field activities
of the geological division,
mineral resources branch

Geological Fieldwork 1977

ISSN 0381–243X

Victoria
British Columbia
Canada

January 1978

FOREWORD

This is the fourth year of publication of *Geological Fieldwork,* a publication designed to acquaint the interested public with the preliminary results of fieldwork of the Geological Division as soon as possible after completion. The reports are written without the benefit of extensive laboratory or office studies. To speed publication, figures have generally been draughted by the authors.

This edition of *Geological Fieldwork* features a revised format. The 'Other Investigations' section includes a number of reports by graduate students and professors of geology which deal with studies related to ongoing projects of the Division.

A fuller account of the work of the Division will be presented in *Geology, Exploration and Mining in British Columbia, 1977.*

Technical editing of this publication was done by N. C. Carter and production editing and layout by Rosalyn J. Moir.

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TERTIARY STRATIGRAPHY IN SOUTH CENTRAL BRITISH COLUMBIA (82E)

By B. N. Church

Much of the interior of British Columbia is covered by a deeply dissected assemblage of Early Tertiary lavas, associated pyroclastic rocks, and intercalated fluvial and lacustrine sedimentary rocks. These lie in a northwesterly trending belt about 160 kilometres wide extending roughly 800 kilometres from the Republic Mining District in Washington State to the Babine Lake area in central British Columbia. Stratigraphic thicknesses range to more than 2 500 metres and averages of a thousand metres are common. The basal zone is composed, in part, of granite pebble conglomerate, while the upper surface is often coincident with gently rolling uplands. In some areas the succession is capped by a veneer of 'plateau' basalt which is the erosional remnant of once widely distributed Miocene and Pliocene lava flows.

Current investigations of these rocks have been stimulated by recent discoveries of uranium mineralization and renewed interest in lignite deposits. Little information is available on the composition, regional stratigraphy, structure, or history of the Tertiary assemblage and it is the purpose of this present study to provide additional geological data.

The areas of detailed mapping, shown on Figure 1, coincide with a segment of the region covered by the Uranium Reconnaissance Program in 1976. Some of the more interesting results of this geochemical survey were found in the Tertiary outliers near Penticton, Kelowna, and Rock Creek. Approximately 1 200 square kilometres have been mapped at 1:50 000 scale, by way of 83 separate traverses and 1 460 geological stations in 1977.

STRATIGRAPHY

Working laterally from the White Lake basin between Keremeos and Penticton, the various Tertiary formations can be followed without much difficulty using the stratigraphic subdivisions proposed by the writer (Church, 1973). A few new sedimentary units have been recognized in the Marron section but these are only locally important. The Springbrook basal conglomerate is largely missing in the northern part of the basin, where these rocks are replaced by rhyolite ash and breccia deposits that appear to have had their source in the Shingle Creek stock. Above this unit and extending to Riddle Creek, west of Penticton, are radioactive mafic phonolites and rhomb porphyry lavas of the Yellow Lake member. The tan trachyte

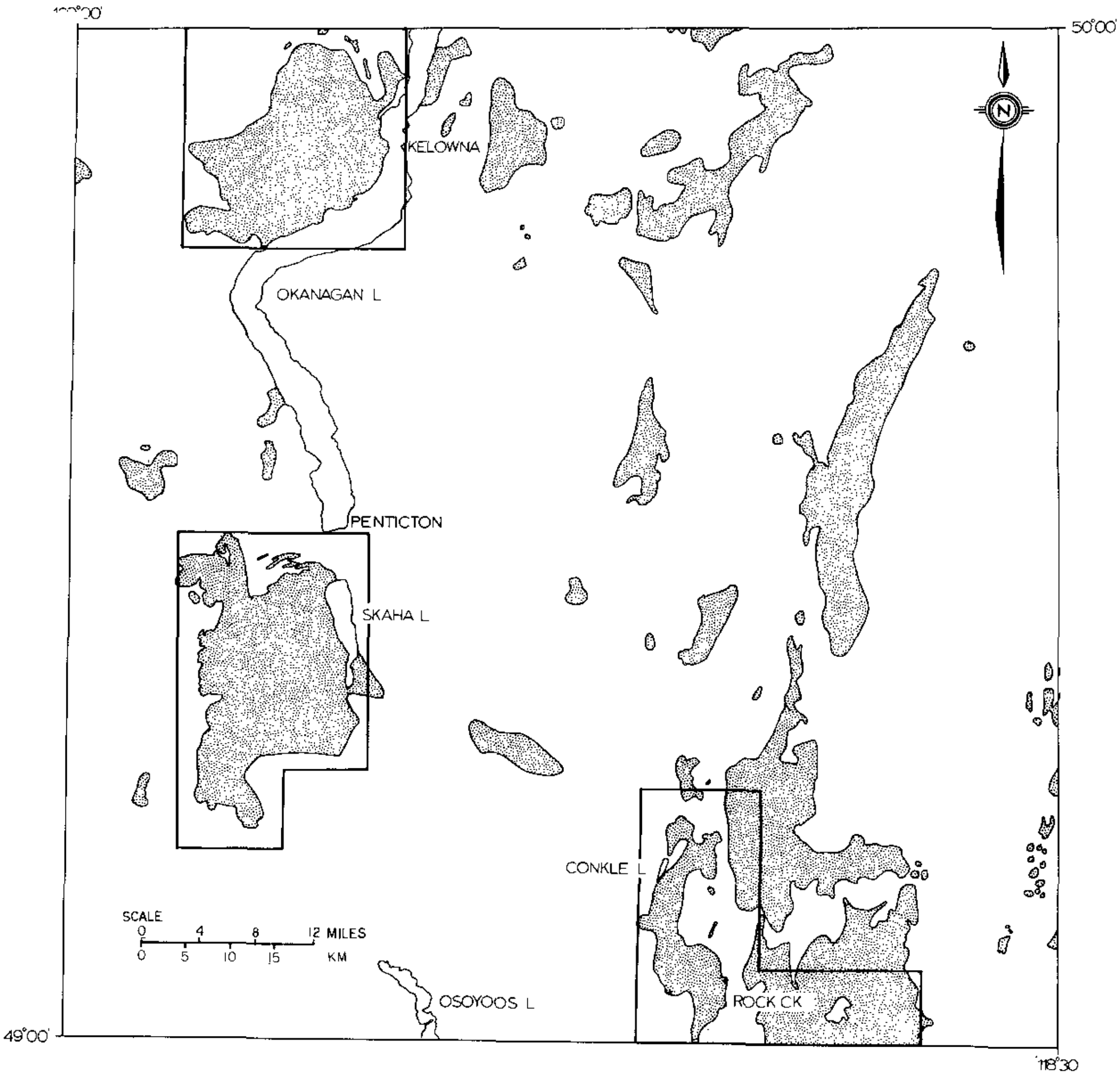

Figure 1. Outliers of Tertiary volcanic and sedimentary rocks in the Okanagan Valley and Kettle River region of south central British Columbia (areas of detailed mapping outlined).

belonging to the Nimpit Lake member in the middle part of the Marron Formation extends beyond Summerland where the lavas are replaced by ash flow deposits of the same composition. The most significant changes in the stratigraphy are noted in the northwest sector of the Penticton outlier where several new volcanic formations are recognized above the Marron unit.

The Marama dacite was traced north along the axis of the Okanagan Valley from the south end of Skaha Lake to Giants Head at Summerland and Mount Boucherie in the Kelowna area. These lava accumulations form an array of well-developed domes of apparent contemporaneous age. Perhaps the most interesting discovery in the chronology of the volcanic sequence is the occurrence of Marama dacite resting on deeply eroded Marron volcanic rocks (Yellow Lake member). It seems probable now that the Marama Formation is Late Eocene or possibly Oligocene (?) age.

The Tertiary stratigraphy west of Kelowna (Westbank) is relatively straightforward although modified somewhat from the Penticton section. The sequence is as follows:

Uppermost:	Lambly Creek basalt ('valley basalt')
	Carrot Mountain basalt ('plateau basalt')
	Marama dacite
	Marron Formation – Nimpit Lake member (tan trachytes)
	– Kitley Lake member (trachyandesites)
Lowermost:	Trepanier rhyolite

Yellow Lake mafic phonolites and romb porphyry lavas, widespread further south, are unknown in the Kelowna area.

Prospecting in the Kelowna outlier appears to have been directed to geochemical responses near isolated exposures of Carrot Mountain basalt. Reconnaissance scintillometer surveys conducted during the mapping program show most of the rocks as having relatively weak radioactive emission response compared to similar formations near Penticton, although the Trepanier rhyolite yields about twice normal radioactive background.

Tertiary geology between Rock Creek and Midway is almost an exact repetition of the type Marron section in the White Lake basin, 70 kilometres to the northwest, with the exception of the Kearns Creek basaltic andesite which is missing, and a hornblende andesite unit was found to occur below the Park Rill member. To the north near Conkle Lake, the Yellow Lake member attains a thickness of about 450 metres, and is comprised of more than 25 lava flows and pyroclastic beds including a sequence of phonolites and a peculiar, weakly radioactive assemblage of analcite-bearing, augite-bearing, and anorthoclase rhomb porphyry lava species. At the base of the succession rhyolite breccias and tuffs are locally present in place of conglomerates and sandstones of the Kettle River Formation. Above the Marron Formation, equivalents of the Marama and White Lake beds were not found, however, east of Midway in the area of the headwaters of Norwegian Creek, a slide breccia melange has a striking resemblance of the Skaha Formation, the youngest Quaternary beds in the Penticton area.

STRUCTURE

Northerly trending graben structures extend across the interior of the Province from the Fraser River lineament on the west to the Flathead Valley on the east, with the central zone displaying the thickest volcanic accumulations. Here, the association of alkaline lavas with rifting is well documented. Structural control of the Tertiary volcanic outliers relates to a herringbone pattern of pronounced conjugate shears of northeast and northwest orientation, important elements in a north-south stress scheme which also produced the many graben and half graben structures.

MINERALIZATION

Uranium exploration on the west side of the Okanagan Valley has disclosed several interesting radioactive zones. *One of the more interesting of these is the Brinex—Comaplex discovery on the ASH—AGUR claims* 25 kilometres northwest of Penticton. The principal radioactive response here appears to be related to a northwest-trending shear zone which transects basal units of the Marron Formation. The highest scintillometer counts, greater than 1000 cps, are measured over crushed acid volcanic rocks exposed below Marron lavas on Riddle Creek. The full extent of the anomaly, about 3 kilometres, includes most of the rocks of the Tertiary outlier. Rectangular porphyry and rhomb porphyry alkaline lavas belonging to the Yellow Lake member of the Marron Formation are prevalent in this area, displaying average background counts in the range of 200 to 300 cps. Source of these lavas appears to be a Coryell-type stock, also somewhat radioactive, exposed at the southwest margin of the outlier.

The actual presence of uranium was first detected in stream waters and sediments by the Uranium Reconnaissance Program survey. This showed that Aneas Creek, which follows a strong northwest-trending lineament through the Summerland area, was somewhat enriched in uranium as were some adjacent streams and a number of alkali ponds. At the same time, working south of Penticton near Oliver, Brinex exploration, directed by Culbert and Leighton (in press), discovered surprisingly high uranium levels in a cluster of stagnant alkali ponds. Water sample s from four of these ponds were submitted by the Ministry for analysis. The results confirmed relatively high concentrations of uranium and showed corresponding high pH values:

Sample	U *ppm*	pH
1	9.1	8.4
2	17.5	8.6
3	0.6	7.2
4	2.3	8.2

It is speculated that the uranium was derived from the underlying Oliver granite or perhaps leached from scattered glacial deposits containing eroded fragments of Tertiary volcanic rocks exposed to the north. In any case, the ponds are interesting even if not of commercial importance, because they may reflect conditions of current uranium concentration which is evident elsewhere in the Quaternary stratigraphic record of the region.

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BASAL-TYPE URANIUM DEPOSITS
SOUTH CENTRAL BRITISH COLUMBIA
(82E and 82L)

By P. A. Christopher

Exploration for 'basal type' uranium deposits in the Okanagan area was stimulated in 1977 by encouraging exploration results obtained by several companies and by the release of uranium geochemical data by the Federal and Provincial Governments for NTS areas 82E, 82L, and 82M in May.

A program of regional mapping between Beaverdell and Lumby was carried out at a scale of 1:20 000 to help define geological settings of known deposits, to provide an improved geological base for a litho-geochemical study of potential source rocks, and to clarify the distribution of plateau basalts and potentially favourable underlying sediments.

Mapping and sampling of basement rocks were carried out near Lassie Lake where mineralized areas have been located by Power Reactor and Nuclear Fuel Development Corporation (PNC) on the Fuki and Donen claims and by Lacana Mining Corporation (Norcen Energy Resources' option) on the Beverly claim. In the Hydraulic Lake area (*see* Geological Fieldwork, 1976), mapping was modified and extensive sampling of basement rocks was completed.

Geological mapping in NTS area 82L north of Hydraulic Lake showed that with the exception of Eocene (?) acid volcanic rocks at Bluenose Mountain, Tertiary volcanic rocks mapped by Jones (1959) between Harris Creek and Wood and Kalamalka Lakes are olivine plateau basalts which are underlain by poorly consolidated sediments. The Harris-Vidler Creek area is underlain by extensive acid flows, tuffs, and associated volcaniclastic sedimentary rocks. Devitrification of these volcanic rocks along fault zones appears to be releasing uranium and may explain the geochemical anomalies in stream sediments and waters found during the 1976 Uranium Reconnaissance Program. Sediments associated with the volcanic rocks are of interest as possible sites for uranium deposition.

Mapping of the Blizzard, Beverly, etc., claims of Lacana and the Fuki-Donen claims of PNC has demonstrated that high uranium background granitic rocks are associated with the uranium deposits. Syenitic (Coryell) rocks and leucocratic, often pegmatitic phases of quartz monzonite composition are the key basement rocks. The quartz monzonite appears to have features that correlate with Valhalla rocks described by Little (1960) in the Nelson area and with phases of the Loon Lake batholith in adjacent Washington State.

About 200 rock samples were collected for a litho-geochemical study of basement rocks as part of an M.Sc. thesis project to be carried out by Thomas K. Sills and supervized by Dr. A. A. Levinson at the University of Calgary. The cooperation and assistance of PNC, Noranda, Kerr Addision, Norcen, Union Carbide, and K. L. Daughtry in obtaining samples for this study are appreciated.

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VINE PROPERTY

(82G/5)

By Trygve Höy

The Vine property, owned by Cominco Ltd., is located approximately 10 kilometres south of Cranbrook. Access is provided by a gravel road that follows Peavine Creek north from Highway 3 at the north end of Moyie Lake.

Work on the property to date has included geological mapping, soil sampling, an airborne geophysical survey, and trenching.

Five trenches, spaced approximately 25 metres apart, have exposed massive and disseminated sulphides in a shear zone in Middle Aldridge siltstone and quartzite just north of the Moyie fault. The shear zone and associated sulphides trend approximately 120 degrees and generally dip northwest at 45 to 85 degrees.

The width of the massive sulphide mineralization decreases from approximately 2 metres in trench 2 to 1.5 metres in trench 1 to the south, and to 25 to 30 centimetres wide in trenches 3 and 4 to the north. Stringer and disseminated sulphides are conspicuous in the shear zone for several metres on either side of the more massive sulphides. This minor mineralization is also visible in trench 5, 75 metres north of trench 2.

Assays of two chip samples across the width of the more massive sulphide zone in trenches 2 and 4 are as follows:

	Width	Gold *ppm*	Silver *ppm*	Copper *per cent*	Lead *per cent*	Zinc *per cent*
H77–V–1, Trench 2	2 m	4	144	0.21	12.75	4.06
H77–V–2, Trench 4	20 cm	5	106	0.10	13.28	7.12

ESTELLA–KOOTENAY KING AREA
(82G/12, 13)

By Trygve Höy

A study of the structure, stratigraphy, and lead-zinc mineralization of Purcell rocks in southeastern British Columbia was initiated during the 1976 field season when approximately 140 square kilometres of mountainous terrain east of the Rocky Mountain Trench in the Estella-Kootenay King area was mapped at a scale of 1:25 000. This mapping was extended to the north and east during the 1977 field season and will be released in early 1978 as a preliminary map. Regional mapping will be completed during the 1978 field season, and will include the Purcell rocks between the Wild Horse River in the south and east and Diorite Creek in the north.

The study is designed to determine the stratigraphic and structural setting and controls of lead-zinc mineralization in the Aldridge Formation and emphasizes the use of sedimentary structures and detailed stratigraphic correlations in interpreting the depositional environment of Purcell rocks. It is suggested that thickness and facies changes in the Aldridge Formation, which are apparent within the confines of the map-area, may be related to syndepositional faulting (Höy, 1976).

GEOLOGY

Structure: The structure of the area is dominated by a large, open, recumbent anticline. Its axial plane is west dipping and bedding in its upper limb, in the western part of the area, is easterly dipping while bedding in the lower limb is overturned to the west (section A-B, Fig. 2).

A number of north-trending, upright faults repeat the upper part of the Aldridge, the Creston, and the Kitchener Formations in the eastern part of the area, and later east-west-trending faults disrupt both the bedding and the north-south faults. A low angle, west-dipping fault in the northeast part of the map-area has displaced hangingwall rocks westward relative to footwall rocks (section C-D, Fig. 2).

Stratigraphy: The oldest rocks within the map-area, quartzite, siltstone, and shale of the Fort Steele Formation (F) have a thickness in excess of 2 000 metres. The Fort Steele Formation is comprised of at least three upward-fining sequences that grade from coarse, cross-bedded quartzites at the base to finely laminated siltstone at the top. Within each of these major cycles are numerous smaller scale, upward-fining cycles. Sedimentary structures within the coarser sandstones at the base of the cycles indicate that these are fluvial deposits displaying generally a northerly transport direction. The argillite and siltstone at the top of the cycles may be flood deposits on mudflats removed from the main fluvial channels. These contain abundant dessication cracks.

The siltstones and argillites of the Fort Steele Formation grade upward into dark grey to black argillite at the base of the Aldridge Formation. The lower unit of the Aldridge (A-1) includes 1 800 to 2 500 metres of dark argillite, buff-coloured siltstone, a prominent dolomite unit near the base (included as part of the Fort Steele Formation by Rice, 1937; Leech, 1960) and a distinctive buff-coloured siltstone-argillite unit near the top that hosts both the Estella and Kootenay King deposits. This latter unit is comprised of thin, graded

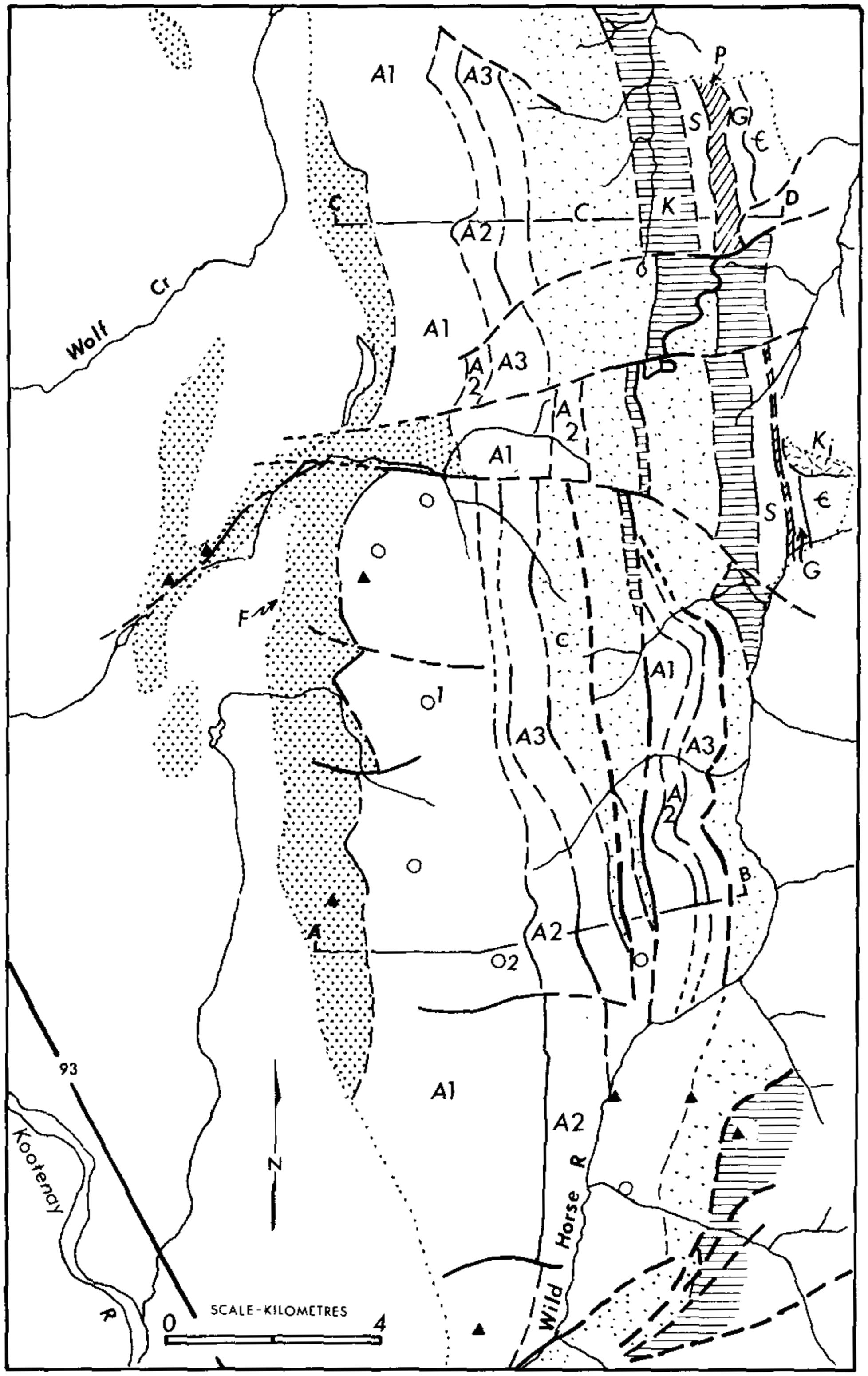
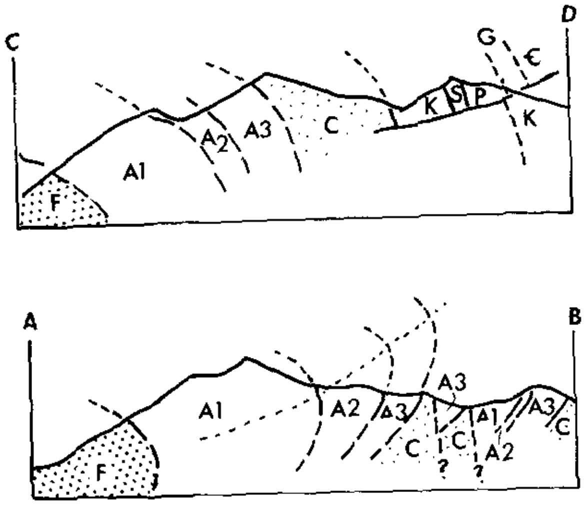


Figure 2. Geology of the Estella-Kootenay King area.



LEGEND

CRETACEOUS (?)

K; QUARTZ MONZONITE, SYENITE

CAMBRIAN

€ - DOLOMITE

HELEKIAN

G - GATEWAY FORMATION

P - PURCELL LAVA

S - SIYEH FORMATION

K - KITCHENER FORMATION

C - CRESTON FORMATION

A - ALDRIDGE -A1 - ARGILLITE, SILTSTONE; MINOR DOLOMITE, QUARTZITE

A2 - QUARTZITE, SILTSTONE, ARGILLITE

A3 - ARGILLITE, MINOR SILTSTONE

F - FORT STEELE FORMATION

GEOLOGICAL CONTACT - DEFINED, APPROX., ASSUMED

FAULT - DEFINED, APPROX.

MINERAL OCCURRENCE.

▲ CU, (PB)

○ PB, ZN, AG, AU

1 - ESTELLA 2 - KOOTENAY KING

siltstone layers, finely laminated layers, and layers with numerous small sedimentary structures such as convolute bedding, scours, and ripple cross-laminations. Associated with these units are occasional coarse, graded quartzite layers; the buff unit is interpreted to consist dominantly of distal turbidite deposits and interlayered pelagic beds.

A-2 comprises approximately 500 metres of interlayered massive to graded siltstone-quartzite and dark argillite. These are interpreted as being more proximal turbidites (AE beds in the Bouma model; Walker, 1976).

A-3 consists of 500 to 800 metres of finely laminated dark argillite and siltstone. It grades upward into the Creston Formation, through several hundred metres of interlayered argillite and light green siltstone.

The Creston Formation (C) includes approximately 1 500 metres of green, purple, and white quartzite, siltstone, and argillite. These are fan delta and mudflat deposits. They are overlain conformably by 700 to 1 000 metres of green dolomitic argillite, buff-weathering dolomite, limestone, and minor quartzite of the Kitchener Formation (K), approximately 400 metres of more argillaceous dolomite and argillite of the Siyeh Formation (S), and massive, porphyritic, or amygdaloidal lava flows. The Purcell lavas thin from approximately 500 metres in the north to less than 100 metres in the central part of the area.

The lithologies and depositional environments of the Creston, Kitchener, Siyeh, and Purcell lavas as well as the overlying Gateway Formation, will be described more fully in a preliminary map and report intended for release early in 1978.

Economic Geology: Two important lead-zinc showings and numerous smaller lead-zinc and copper showings occur within the map-area (Fig. 2). The Estella deposit is 'a replacement by sphalerite, galena, and pyrite' (Hedley, 1951, p. 186) in a zone of fracturing and shearing adjacent to a small 'syenite' stock that has intruded the buff-weathering unit of A-1 (*see* description in 'stratigraphy' section). The Estella deposit, mined intermittently from 1951 to 1967, produced 120,724 tons of ore grading: lead, 4.73 per cent; zinc, 8.97 per cent; silver, 1.74 ounces per ton.

The Kootenay King is a stratiform lead-zinc deposit. Galena, sphalerite, and pyrite occur as fine laminations at the top part of a coarse sandstone unit in the buff-weathering unit of A-1. Total production, in 1952 and 1953, was 14,617 tons grading: lead, 5.36 per cent; zinc, 6.65 per cent; silver, 1.94 ounce per ton.

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REXSPAR URANIUM DEPOSIT

(82M/12W)

By V. A. Preto

INTRODUCTION

Consolidated Rexspar Minerals & Chemicals Limited holds mineral rights to approximately 2 830 hectares of ground centred on the original Rexspar fluorite-uranium showings on Red Ridge, approximately 5 kilometres south of Birch Island. This property has received intermittent attention since 1918, initially for fluorite and silver-lead, then for manganese and since 1949, for uranium.

Extensive work in the early and mid 1950's outlined three zones of commercial-grade uranium mineralization and one contiguous zone of fluorite mineralization. Considerable drilling since 1969, augmenting the earlier work, has indicated that the three zones, known as the A, B, and BD, contain an estimated 1 202 550 tonnes of material averaging 0.565 kilograms U_3O_8 per tonne amenable to open-pit mining methods. The company is presently finalizing plans for a 1 380-tonne-per-day, five days a week mining operation and for a 985-tonne-per-day beneficiation plant that is to operate continuously.

GEOLOGY

The rocks in the vicinity of the Rexspar deposit are greenschists of the Eagle Bay Formation of probable Mississippian age (Campbell and Okulitch, 1976) which dip moderately to the north and northwest. Chlorite schist and chlorite-sericite schist are the most common rock types within unit 1 (Figs. 3 and 4) but conspicuous exposures of recognizable dacitic and andesitic volcanic breccia indicate that the schists were mainly derived from volcanic rocks. Interlayers of grey phyllite, slate, and sericitic quartzite also indicate that part of the succession is of sedimentary origin. Carbonate rocks are absent near the deposits, but are widespread on both sides of the Thompson River near Vavenby, 13 kilometres to the east.

Uranium mineralization occurs in unit 3 which consists of alkali feldspar porphyry (McCammon, 1954), porphyry breccia, lithic-crystal tuff, and tuff breccia of trachytic composition and, at some localities, pyritic schist of rhyolitic composition. Most rocks in the 'trachyte' unit are rich in potash feldspar and sericite, with lesser amounts of albitic plagioclase, and are virtually lacking in quartz and mafic minerals. The pyritic schists of rhyolitic composition contain abundant quartz as well as feldspar, but only form a small part of unit 3 (Fig. 3). Rocks of the 'trachyte' unit are light grey in colour and are usually stained rusty brown or yellow due to widespread pyrite. They may be massive, brecciated, or markedly schistose and lineated. Most thin sections studied show a fine-grained groundmass of feldspar and sericite containing large, fractured, and sheared crystals of potash feldspar and albitic plagioclase and rock chips of trachytic composition. Fracturing and shearing of groundmass, phenocrysts, and rock clasts are ubiquitous but vary greatly in intensity. Some specimens are truly mylonites with an intensely sheared and granulated matrix and crushed phenocrysts while others show only some fracturing.

Parts of the 'trachyte' unit, and particularly the relatively massive feldspar porphyry found on the B zone, are probably of intrusive origin, while breccias found on the A, BD, and fluorite zones and south of the BD

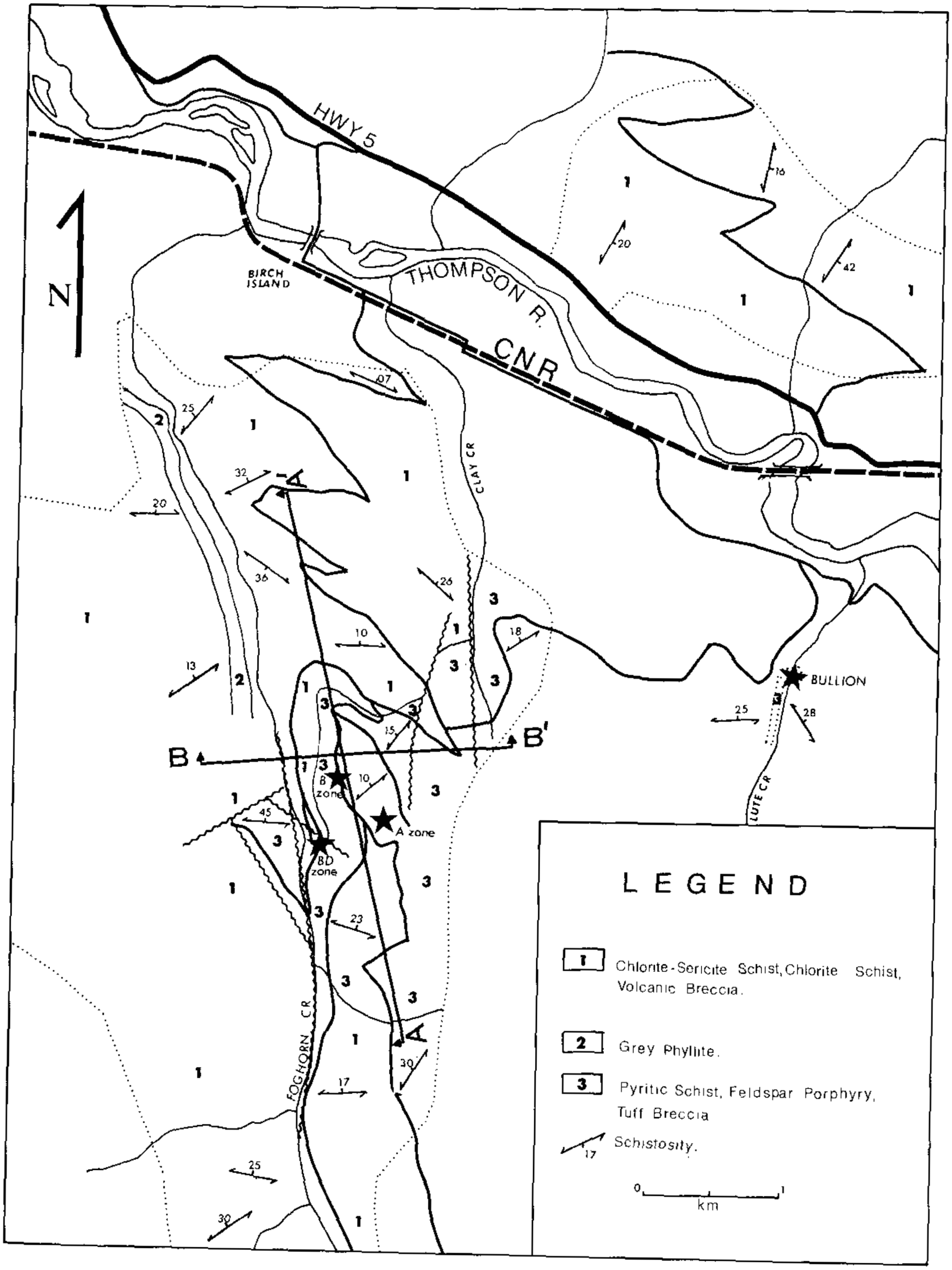

Figure 3. Generalized geology of the Rexspar property.

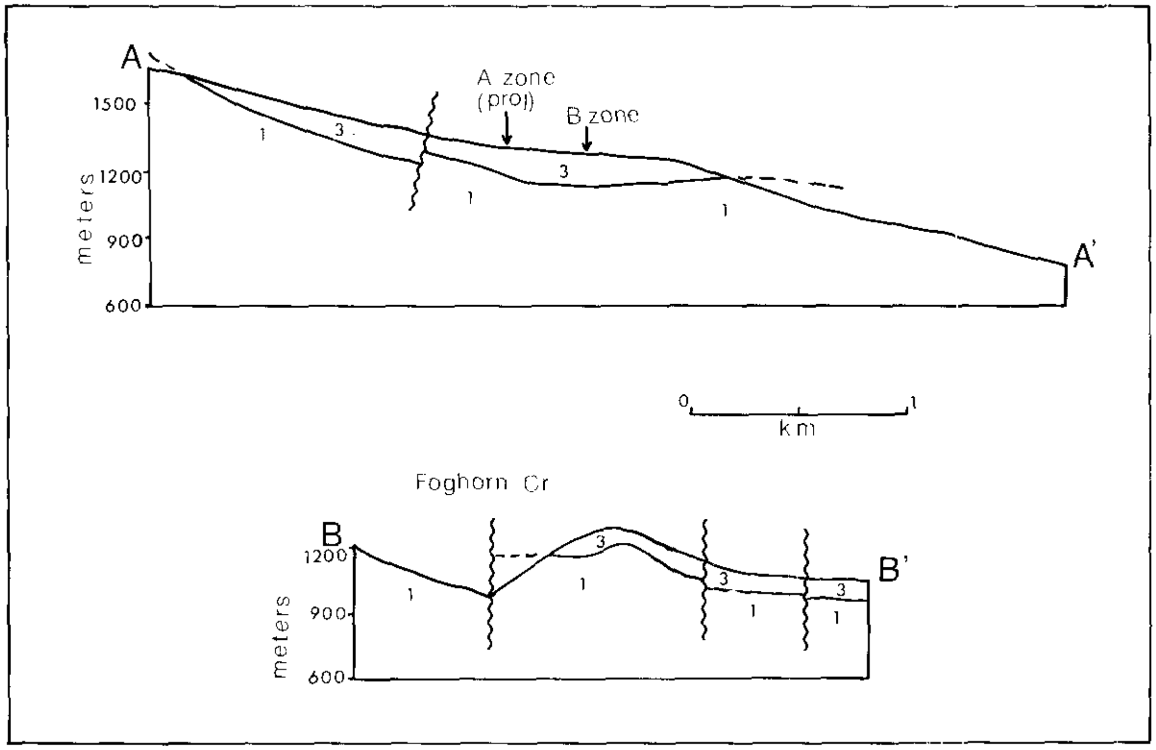

Figure 4. Cross-sections to accompany Figure 3.

zone appear to be mainly of extrusive origin. Although conformable with the schists above and below it, the 'trachyte' unit is apparently a mixture of intrusive porphyry and its extrusive equivalent tuffs and tuff breccias. If a crosscutting feeder system to this highly differentiated volcanic-intrusive pile has been preserved, it is probably in the vicinity of the B zone or between the B and BD zones, where most of the massive feldspar porphyry occurs.

The main radioactive zones occur in darker coloured areas of the 'trachyte' unit which are extensively replaced by silver-grey fluorphlogopite and pyrite. Recent drilling indicates that ore-grade material occurs in a series of discontinuous lenses generally less than 20 metres thick and conformable with the schistosity. 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. All phases of the 'trachyte' unit, including the zones of fluorphlogopite-pyrite replacement and uranium-fluorite mineralization, display some evidence of deformation, ranging from nearly massive to markedly schistose and lineated. They appear to have been subjected to most or all of the deformation that affected the surrounding rocks of unit 1, although their response was not uniform.

The fluorite zone lies immediately north of the A zone. As previously described (McCammon, 1954), this zone is tabular, strikes northeast, and dips gently to the northwest parallel to the schistosity of the host rocks. Mineralization consists of fluorite and celestite with pyrite, in lithic tuff and tuff breccia of the 'trachyte' unit. Radioactivity is weak to moderate in this zone.

Previous work by officers of the Geological Survey of Canada and British Columbia Ministry of Mines and Petroleum Resources indicates that the principal radioactive minerals at Rexspar are uraninite, uranothorite, bastnaesite, torbernite, and metatorbernite. Analyses done at the British Columbia Ministry of Mines and Petroleum Resources (McCammon, 1954) consistently indicate appreciable amounts of thorium oxide and traces of rare earths in all three radioactive zones. The close relationship between fluorphlogopite-pyrite replacement and uranium-fluorite mineralization and the commonly deformed nature of the mineralized rock indicate that mineralization occurred during the development of a high-level intrusive-extrusive system of highly differentiated trachytic rocks. The fluorphlogopite, pyrite, fluorite, and uranium-bearing minerals were probably deposited during a late stage in the evolution of this igneous system by deuteric, volatile-rich fluids. The considerable amount of thorium and widespread rare earths associated with the uranium tend to support the thesis that this element is of primary origin rather than secondary.

The structure of the Rexspar area is complex and further complicated by poor and widely scattered outcrops. A few key exposures along Highway 5 and on the slopes north of the Thompson River show that the prominent schistosity, which is parallel to the compositional layering and was probably produced during the first phase deformation, is deformed by tight, recumbent, east-trending second phase folds. These structures are in turn refolded by upright third phase structures which trend northerly to northeasterly. Late kinks and prominent tension fractures trend northerly and represent a fourth and last set of structures.

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SOUTHWEST BRITISH COLUMBIA

VANCOUVER ISLAND

By G.E.P. Eastwood

VERNON RIDGE AREA (92C/15E, 16W)

A reconnaissance survey defined the area of pyritization previously described under the name Lucky Strike. The zone is centred on the upper south slope of Vernon Ridge, extending from a saddle 800 metres west of the summit of Mount Vernon west-northwest for at least 4 000 metres. The maximum width is 1 500 metres. Within the zone the rock has been bleached, silicified in part, and mineralized with disseminated clots and discrete grains of pyrite. Sporadic grains of chalcopyrite occur both within and outside the zone. In places silicification extends beyond the pyritization, and there is a crude shell of epidotization.

The fresh rock is mostly grey to dark grey and commonly porphyritic with plagioclase phenocrysts. Aphanitic phases were found in and outside the pyritized zone to the west. Reddish fragments were found in the rock both north and south of the ridge, and would suggest that it is part of the Bonanza Formation. A bedded section was found on the ridge 500 metres west of Mount Vernon summit; three bands of silty argillite, 3.5 to 6 metres thick, are separated by thinner bands of massive light grey rock. Their attitude is 100 degrees 15 degrees south, and the section emerges on the north, west, and south. The rock above the bedded section is partly greenish and amygdaloidal and partly massive and intrusive in appearance.

The source of the alteration and pyritization has not been determined. A Bonanza volcanic centre has been suggested, but the amount of volcanic breccia found is low. 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.

Reference: *B.C. Ministry of Mines & Pet. Res.,* Geological Fieldwork, 1975, p. 40.

BOB, HAB (92L/7)

Brief visits were made to the property after Imperial Oil Limited concluded a short program of diamond drilling. Mineralization is associated with bodies of limestone and basalt contained in the Nimpkish batholith near its northeast margin and extending 2.8 kilometres southeast from the Steele Valley. The limestone has been interpreted as an interlava lens in the Karmutsen Formation, but it appears larger and cleaner than usual for such lenses, and may be an infolded section of the Quatsino Formation. Five mineralized zones were identified. Zone F is beside a road just northwest of Steele Creek and consists of about 1.5 metres of fairly massive magnetite capped by limestone and overlying garnet-epidote skarn at the top of Karmutsen basalt. Zone E is the Bonanza mine, an open cut just below the Beaver Cove road, from which Chester F. Millar of M.B.H. Developments Ltd. mined 5,649 tons of ore in 1968 and 1971. Some magnetite and chalcopyrite remain in garnet-epidote skarn, which is intruded by a post-mineral feldspar porphyry dyke in the headwall of the pit, but the sidewalls are in fresh basalt. Some black limestone rubble was found at the entrance suggesting that limestone may have capped the ore prior to mining. Zone A is on the crest of the ridge, south of a small triangular lake known as White Fang Lake. Extensive skarn contains scattered magnetite, pyrite, and chalcopyrite, and was explored by 10 diamond-drill holes. The overall grade was found to be low.

Zone B is on the upper slope northwest of zone A. Limestone and skarn are both extensive and suggest a canoe-shaped structure, with skarn both overlying and underlying the limestone. Considerable magnetite and sulphides are present in the skarn. This zone has not been drilled. Zone H is 350 metres to the northwest, and is represented by a single small outcrop of limestone and mineralized skarn. Six holes had been diamond drilled with encouraging results. The writer logged core from a hole which had been stepped back to gain greater depth; the upper third of the hole cut mainly intrusive rocks, but the lower two-thirds was mainly in partly altered andesite or basalt containing sporadic chalcopyrite and pyrrhotite.

References: *B.C. Ministry of Mines & Pet. Res.,* GEM, 1973, p. 258; 1974, p. 213; Assessment Reports 4350, 4898.

WASHLAWLIS HILL (92L/11W)

A day was spent on this hill following a report that considerable coarse volcanic breccia was present which could be marginal to a Bonanza volcanic centre. This hill rises to an elevation of over 150 metres from a small plateau between Washlawlis Creek and the north fork of Waukwaas Creek 3.5 kilometres east of Rupert Arm. A quarry at 140 metres elevation in the east end of the hill exposes a southeast-dipping section through the contact between the Parson Bay and Bonanza Formations. Rock of mixed sedimentary and volcanic origin grades upward through tuff to a massive porphyritic volcanic rock. Some 60 metres west of the quarry and 35 metres higher on the hill, rounded and angular bodies appear in the porphyritic rock. The rounded bodies are widespread, 5 to 8 centimetres across, and differ from the matrix only slightly in appearance. The angular bodies are 2.5 to 4 centimetres across and are less common and more distinct from the matrix. Some bodies of angular breccia partly enclose patches of the volcanic rock 30 centimetres and more across. The structures in these rocks resemble pillows, pillow breccias, and autobrecciated lavas more than out-thrown volcanic breccia. They continue to the summit, where they are overlain but also partly interbedded with conglomerate containing well-rounded pebbles of varied lithologies. This conglomerate may be a basal Cretaceous outlier.

Most of the north face of the hill is a bluff, which may be a modified fault scarp. Toward the east, two smaller hills are separated from the main hill by deep gullies. They contain breccia and quasi-breccia similar to that higher on the south side, and have evidently been down-dropped. The Parson Bay beds strike toward these hills, but do not appear in them. East of the quarry, Bonanza volcanic rocks with vague fragment-like structures are again exposed, and are probably separated from the Parson Bay beds by a concealed fault.

Reference: *B.C. Ministry of Mines & Pet. Res.,* Geological Fieldwork, 1974, p. 76.

ISLAND COPPER (92L/11W)

Selected exposures in the open pit were examined and a section of drill core was logged. Pale green, fine-grained bedded tuffs had 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 with the tuffs. 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 rocks from massive, hematite-streaked, brownish grey tuffs exposed along 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 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. The core shows highly altered volcanic rock indistinctly brecciated, healed with quartz containing finely disseminated magnetite, then cut by younger 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. While magnetite and quartz are present to some degree in the orebody, the characteristic hardness of the submarginal zone appears to reflect a much greater abundance.

Reference: *B.C. Ministry of Mines & Pet. Res.*, GEM, 1972, pp. 293-301.

NICOLA PROJECT

(92I/2b, c, g, h)

By W. J. McMillan

INTRODUCTION

The early part of the 1977 field season was spent mapping an area west of Craigmont mine in Promontory Hills at scale 1:12 000. Later mapping at scale 1:15 840 was begun to tie on to previous work done by Preto (1974, 1975a, 1975b, 1976). Much of the area south of Nicola Lake and the highway from Quilchena to Merritt, including part of Iron Mountain, was completed. This was previously mapped by Cockfield (1948) and Schau (1968).

MAP SHEET 92I/2h

Along Nicola Lake, working westward from Quilchena (Fig. 5), outcrops are amygdaloidal to massive grey lavas. These are generally porphyritic with 20 to 40 per cent medium-grained augite phenocrysts in a matrix of felted very fine-grained plagioclase laths. Both are set in a chilled groundmass which is either K-feldspar rich or K-feldspar free. Near Quilchena, there are local areas of moderate to intense epidote alteration but rock textures frequently survived. Westward the rocks are massive to well-foliated greenstones grading to green schists. Small areas are flooded by epidote alteration. Remnant augite crystals and textures in less altered and deformed areas indicate that the country rock was augite porphyry with rare augite crystal tuff layers. Amygdaloidal and vesiculated flows appear to have been uncommon. About 8 kilometres west of Quilchena, a narrow fault wedge carries a mixed assemblage of fragmental volcanic rocks and volcaniclastic grits with local argillaceous limestone lenses. For approximately 0.8 kilometre west of the fault wedge, mixed volcanic sandstones, grits, and argillites are interbedded with volcanic breccias and andesitic lavas. This sequence gives way westward to a series of massive to porphyritic andesitic lavas with scattered breccia zones.

Southward, up the slope overlooking Nicola Lake, in fault block A, the sequence is more complex. A zone of similar amygdaloidal augite porphyritic flows comprise the easternmost outcrops but they have brick red matrices and probably represent subaerial flows. Westward, amygdaloidal flows similar to those seen on the highway occur. These are affected by a zone of moderate to intense epidote veining and 'flooding' which appears to trend northeast across the area to roughly coincide with the transition zone from grey to red augite porphyry. Further to the west there is another narrow zone of red, often amygdaloidal, massive to foliated augite porphyry, then massive to foliated grey augite porphyry. These in turn give way to relatively acidic flows and fragmental volcanic rocks which continue to the bounding fault. Reliable strike and dip measurements are lacking but lithologic units seem to have northerly trends.

In contrast, near the bounding fault foliation surfaces and bedding, where seen, typically strike southeast subparallel to the fault. The foliation appears to be of tectonic origin and, locally, kink folds are well developed.

In fault block B, massive red and grey augite porphyries, which are intruded by narrow bodies of diorite, give way westward to a mixed assemblage of intermediate volcanic breccias and augite porphyry flows (?) with occasional limestone layers. Westward again are augite porphyry, andesitic volcanic rocks, and relatively acid massive to fragmental volcanic rocks. The acid and more basic members appear to intertongue. Layers of sandy to silty volcaniclastic rocks and crystal tuff within the andesitic members indicate that the sequence has a northerly to northeasterly strike with steep dips. Intrusions of diorite and porphyritic microdiorite cut the acid and intermediate rocks. Finer grained parts of the intrusions strongly resemble associated andesitic flows, consequently the two are not always distinguishable. The intrusions appear to crosscut the lithology and may represent volcanic feeder dykes.

West of fault block B is a unit composed dominantly of interlayered andesitic flows and volcanic breccias. Two major and one minor reefoid limestone members crop out within this unit and are excellent marker beds, although they are discontinuous on a regional scale. Fragmental rocks vary from grey to red in colour and include sedimentary, flow, and pyroclastic breccias. One breccia which has proven to be useful in mapping has scattered limestone lenses and clasts as well as volcanic clasts. When the unit is traced northward, the limestones pinch out, the relative proportion of andesitic flows decreases, and there are significant thicknesses of volcanic sandstone, grit, and some argillite. Westward, to the edge of the map sheet are dark coloured massive andesite to plagioclase porphyry lavas and volcanic breccias. Breccias in this unit are often monomictic, carrying plagioclase andesite fragments which resemble adjacent flows. Polymictic volcanic breccias form discontinuous layers locally and are useful marker beds.

Interpretation of faults in the area south of Nicola Lake is based on lineaments, changes of lithology, and changes in orientation of lithologic layering (Fig. 5). Along the fault bounding blocks A and B, changes in strikes suggest a right lateral offset. Judging from the regional setting, younger reverse or normal movement is also likely.

Correlating these rocks southward, all the rocks in fault block A would be placed in Preto's Central belt whereas those in fault block C would be Western belt. Rocks in fault block B are problematical because there are quartz-bearing acidic members but in view of the dioritic intrusions and red to grey augite porphyry flows, they most reasonably correlate with Central belt rocks.

SHEET 92I/2g

Continuing westward from sheet 2h to 2g, mixed andesite flows and breccias continue to a major northwest-striking fault. Marker beds and breccia-flow contacts generally trend north to north-northwest, east of the fault but consistently strike northeast, west of it. West of the fault, the southeast corner of the map sheet is dominated by polymictic and monomictic breccias. Northwestward, breccias become uncommon and there is a sequence of monotonous plagioclase porphyritic andesites with minor amounts of breccia, rare skarn lenses, and, near Nicola, argillite interlayers.

SHEETS 92I/2b, 2c

Mapping was continued near Garcia Lake west of the area studied previously by Preto and was extended westward to Iron Mountain. Work in this area was not completed during the field season. On sheet 2b,

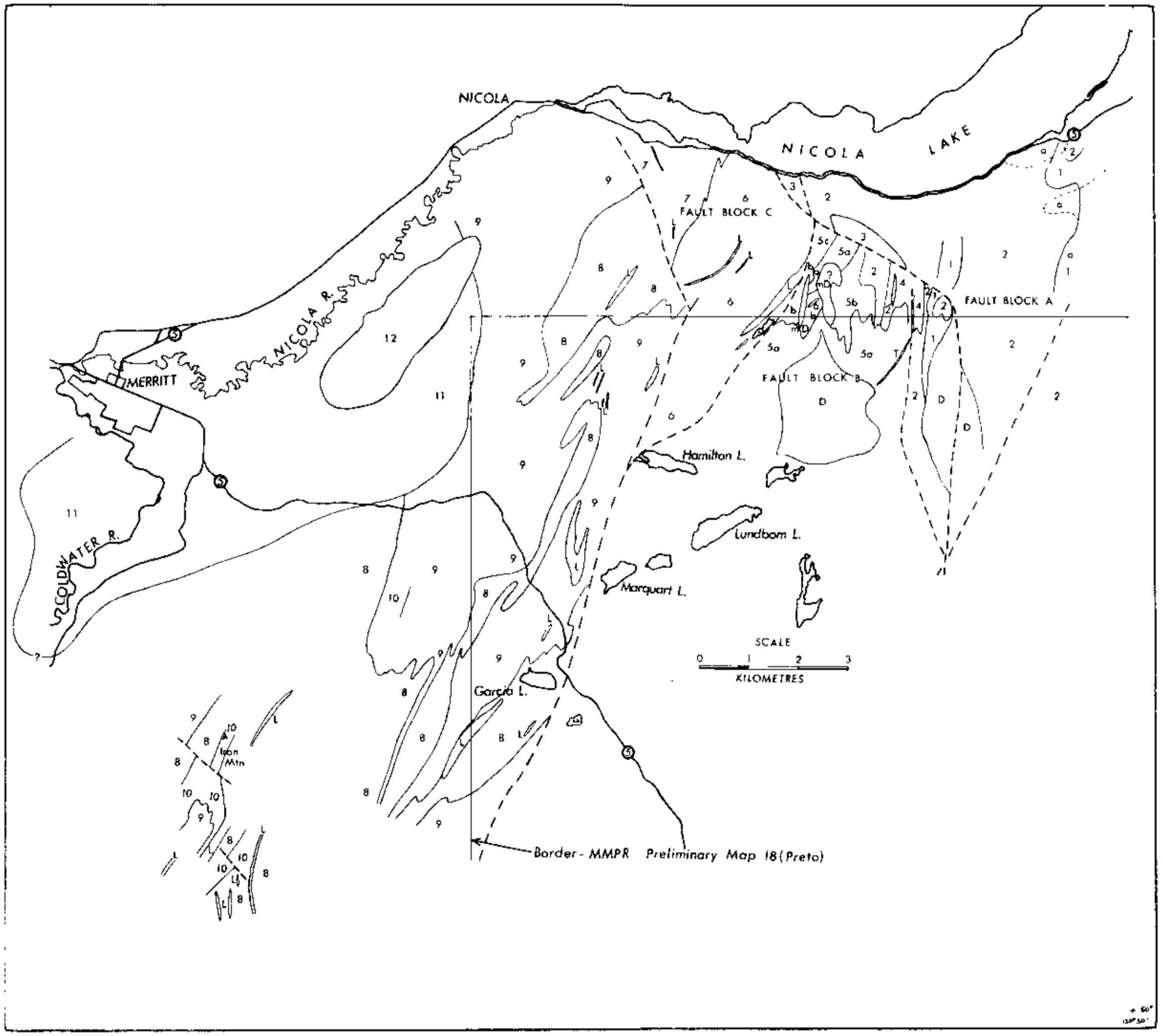

Figure 5. Geology of the Nicola Group south of Merritt (NTS 92I/2b, 2c, 2g, 2h)

LEGEND

NICOLA GROUP

FAULT BLOCK A

(LOCAL MODERATE TO INTENSE EPIDOTE ALTERATION)

1 RED, GENERALLY AMYGDALOIDAL (a) AUGITE PORPHYRY FLOWS

2 AMYGDALOIDAL (a) TO MASSIVE AUGITE PORPHYRY, CHLORITE SCHIST DERIVED FROM AUGITE PORPHYRY, RARE AUGITE CRYSTAL TUFF

3 FRAGMENTAL VOLCANIC ROCKS OF INTERMEDIATE COMPOSITION, MINOR ARGILLITE

FAULT BLOCK B

(LOCAL MODERATE EPIDOTE ALTERATION)

4 INTERMEDIATE VOLCANIC BRECCIA, INFREQUENT LIMESTONE (L) AND TUFF (T) LAYERS, AUGITE PORPHYRY (2)

5 AUGITE PORPHYRY, ANDESITIC FLOWS (a), ACID VOLCANIC ROCKS AND BRECCIA (b), LESSER CLASTIC VOLCANIC SEDIMENTARY ROCKS (c)

D DIORITE, MICRODIORITE (mD)

FAULT BLOCK C

6 INTERLAYERED ANDESITIC FLOWS AND INTERMEDIATE RED TO DARK GREY BRECCIAS, TUFFS, REEFOID LIMESTONE (L), VOLCANIC SANDSTONE TO GRIT

FAULT BLOCK C *(continued)*

7 INTERLAYERED ANDESITIC FLOWS AND INTERMEDIATE, OFTEN MONOMICTIC, VOLCANIC BRECCIAS

8 VARIABLY PORPHYRITIC PLAGIOCLASE ANDESITIC FLOWS; MINOR INTERLAYERS OF VOLCANIC BRECCIA, SKARN, AND ARGILLITE

NICOLA TO GARCIA LAKE TO IRON MOUNTAIN

8 VOLCANICLASTIC ROCKS AND VOLCANIC BRECCIA OF INTERMEDIATE COMPOSITION; LOCAL ANDESITIC FLOWS

9 ANDESITIC FLOWS; LOCAL BRECCIA, BLEACHING AND LIMESTONE PODS (SOME IS REEFOID), MINOR ARGILLITE

10 VOLCANIC ROCKS AND BRECCIAS OF ACIDIC COMPOSITION

COLDWATER SERIES

11 SANDSTONE, SHALE, COAL

PLATEAU LAVAS (MIOCENE ?)

12 BASALT

SYMBOLS

FAULT . . . .

GEOLOGICAL CONTACT . . . .

andesitic flows and intermediate volcanic breccias predominate but there are also pods and layers of barren to fossiliferous limestone and, in some areas, massive to brecciated acidic volcanic rocks. Local bleaching and epidote alteration of pyritic andesites can produce rocks which closely resemble these acidic members.

Close to Iron Mountain, there is an assemblage consisting of intermediate volcanic breccias, amygdaloidal andesitic flows, red to green flow-banded to brecciated acidic volcanic rocks and reefoid limestones.

In both these areas flow layering and bedding trend north-northeast (about 020 degrees).

COLDWATER SERIES

Coal-bearing sandstones and shales of the Cretaceous (?) Coldwater series form the Merritt coalfield which underlies Nicola River valley and laps onto the hills to the south in the area between Merritt and Nicola. Bedrock exposures in the coalfield are very limited but on the west at least the coal-bearing series appears to unconformably overlie oxidized Nicola volcanic rocks. No other outcrops were found near the coalfield border but work done by White 30 years ago (*Minister of Mines, B.C.,* Ann. Rept., 1946, pp. 250-280) suggests that it is locally faulted.

MIOCENE (?) LAVAS

Plateau basalts of Miocene (?) age unconformably overlie rocks of the Coldwater series south and west of the village of Nicola. The plateau basalts form a broad, flat-topped hill faced by a scarp along the southwest side of Nicola River valley. Apparently, the base of the basalts dips northwest and the basalt outcrop is probably wedge shaped in cross-section, thickening northwestward.

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PROMONTORY HILLS
(92I/2e)

By W. J. McMillan

INTRODUCTION

Rocks of the Late Triassic Nicola Group in Promontory Hills are exposed in a subrectangular panel. They are cut off by the Guichon batholith on the north and the Coyle stock to the south, and are unconformably overlain by rocks of the Cretaceous Kingsvale and Spences Bridge Groups to the east and west respectively.

Mapping was undertaken at scale 1:12 000 in this area west of Craigmont mine for several reasons. First, at least locally and in particular at Craigmont mine, the rocks are tightly folded, and their stratigraphy is unresolved. Second, although it is a skarn body, the geometry of the mineralization at Craigmont is generally conformable with that of the host rocks. Third, regional trends of the sedimentary and volcanic stratigraphy in Promontory Hills indicate that some part of the section there should correlate with that at Craigmont. The study is not yet complete and results presented here are preliminary.

STRUCTURAL GEOLOGY

To resolve the stratigraphy it was necessary to interpret the geometrical distribution of the rocks. This was done by tracing mappable, persistent beds and zones with distinctive lithology. From sedimentary structures such as graded beds, sole markings, scouring, and rip-up clasts, stratigraphic tops were determined wherever possible. Reverse grading is common in volcanic terrains so 'tops' based on grading alone were assumed to be unreliable. One large, upright to slightly overturned, subisoclinal fold with northeast-striking axial surface and apparent low easterly plunge was delineated. Beds north of it consistently face toward the north and those to the south face south (Figs. 6 and 7), therefore the fold is an anticline. Few top determinations were possible north of Promontory Lookout or south of the fold, and in view of rapid facies changes, it is possible that other large folds exist.

STRATIGRAPHY

Stratigraphic reconstructions have been made based on the structural interpretation. The core of the major fold presumably contains the oldest exposed member of the Nicola Group. Predominantly composed of red ash tuff, volcanic sandstone, and volcanic breccia, the unit also has massive zones and layers of dark grey to red augite plagioclase andesitic lava. Bedding in the unit takes the form of colour laminations and grading in the sandy to silty zones and elongated clasts or macro-grading of clasts in the breccias. The finer grained rocks appear to be both of air fall tuffs and water-worked sandstones. Accretionary lapilli were found in breccias but only as random, sometimes broken clasts. It is probable that much of the breccia is reworked material derived from mass wastage of subaerial flow and pyroclastic debris. Andesitic lavas are thickest near the powerline (Fig. 6) and uncommon away from it. In part these rocks are concordant, but in part they appear to be discordant. The zone of the thickest andesite accumulation may have been a volcanic vent area and although crosscutting probably occurred, some of what appears to be discordance may have resulted from material flowing out onto relatively steep initial slopes.

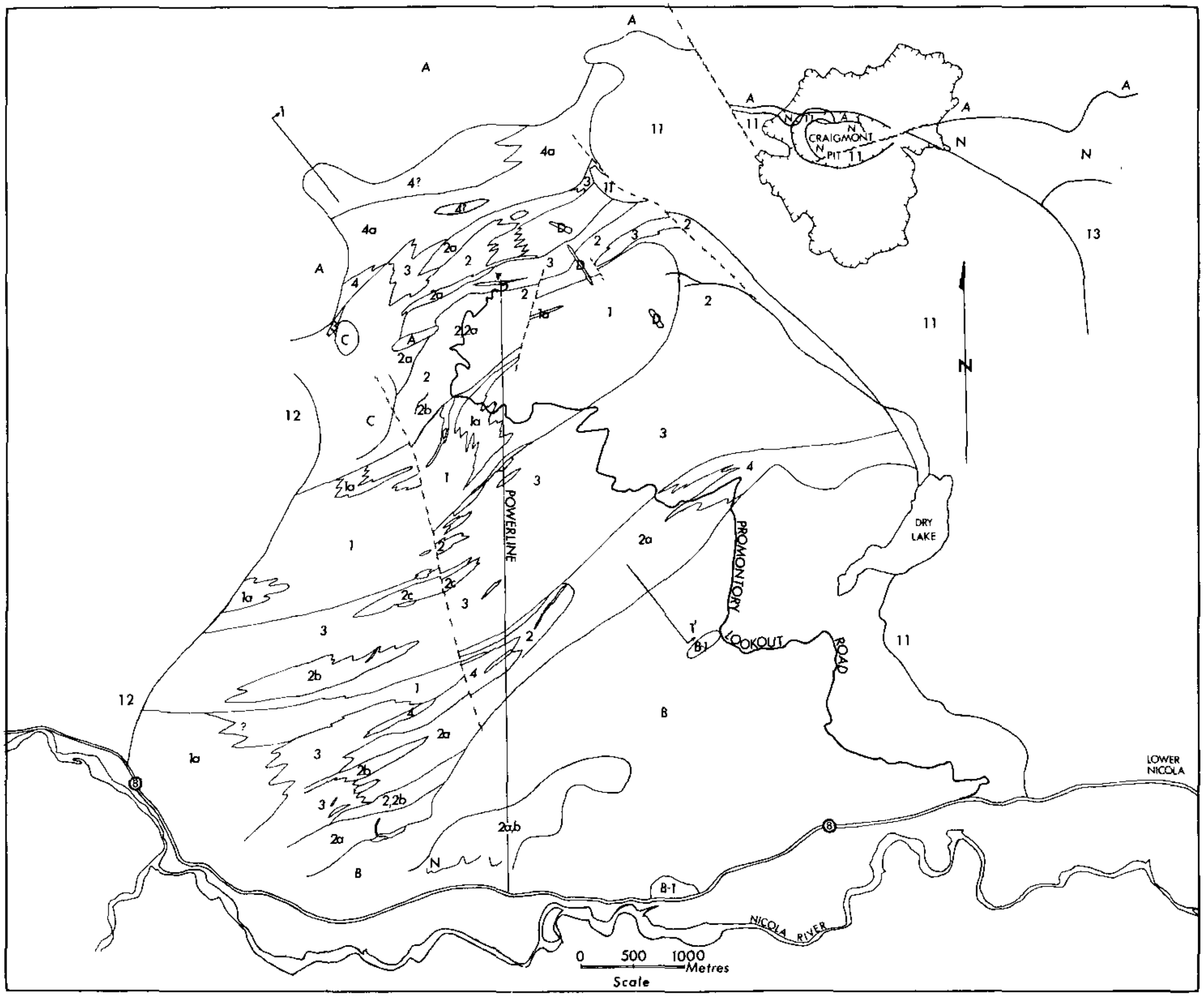

Figure 6. Geology of Promontory Hills.

LEGEND

NICOLA GROUP – UPPER TRIASSIC (CARNIAN ?)

1 VARIABLY RED SANDSTONE, RED ASH TUFF, AND RED TO GREEN TO PURPLE VOLCANIC BRECCIA; BRECCIA POLYMICTIC, OFTEN FELDSPATHIC, LOCALLY CARRIES ACCRETIONARY LAPILLI; INTERCALATED AUGITE PLAGIOCLASE ANDESITIC LAVAS (1a); EXTENSIVE QUARTZ-EPIDOTE-CALCITE VEINING WITH ASSOCIATED PYRITE OR SPECULARITE AND SOME COPPER MINERALIZATION.

2 CHERTY LOOKING QUARTZOFELDSPATHIC, OFTEN PYRITIC, FLOWS, BRECCIAS, AND TUFFS, FELDSPATHIC SANDSTONE, GREYWACKE, INTERMEDIATE TUFF (2a), ARGILLITE, LOCAL MARINE FOSSILS.

3 ARGILLITE, PEBBLE CONGLOMERATE, LIMY GRIT, VOLCANIC SANDSTONE, ARGILLACEOUS SILICEOUS LIMESTONE AND VOLCANICLASTIC ROCKS (3a) NEAR PROMONTORY LOOKOUT; SOUTH OF UNIT 1, IT CONSISTS OF SANDY ARGILLACEOUS LIMESTONE WITH PODS OF REEFOID LIMESTONE AND INTERLAYERS OF VOLCANICLASTIC AND QUARTZOFELDSPATHIC FLOW ROCKS. ARGILLITES AND LIMESTONES CARRY MARINE FOSSILS.

4 MIXED FRAGMENTAL VOLCANIC ROCKS (4a) AND MASSIVE TO PORPHYRITIC ANDESITIC VOLCANIC ROCKS. THE FRAGMENTAL ROCKS ARE GENERALLY FELDSPATHIC, PYRITIC, AND DARK GREY.

N NICOLA ROCKS, UNDIVIDED; GENERALLY METAMORPHOSED OR METASOMATIZED.

INTRUSIVE ROCKS

A GUICHON CREEK BATHOLITH – GRANODIORITE, QUARTZ DIORITE.

B COYLE STOCK – DIORITE TO QUARTZ MONZONITE, LOCAL ALASKITE; QUARTZ AND CARBONATE VEINING WITH ASSOCIATED SPECULARITE, SOME CHALCOPYRITE; HYBRIDIZED ZONES (B1).

C QUARTZ PLAGIOCLASE PORPHYRY (NICOLA AGE ?).

D HORNBLENDE QUARTZ PLAGIOCLASE PORPHYRY DYKES (POSSIBLY KINGSVALE AGE).

KINGSVALE GROUP (CRETACEOUS)

11 BASALT, ANDESITE, HORNBLENDE NEEDLE PORPHYRY (DACITE ?), VOLCANIC BRECCIA, BASAL SANDSTONE AND CONGLOMERATE.

SPENCES BRIDGE GROUP (CRETACEOUS)

12 MASSIVE TO PLAGIOCLASE PORPHYRITIC ANDESITIC LAVAS, VOLCANIC BRECCIA.

COLDWATER SERIES (LATE CRETACEOUS ?)

13 LARGELY SANDY MUDSTONES.

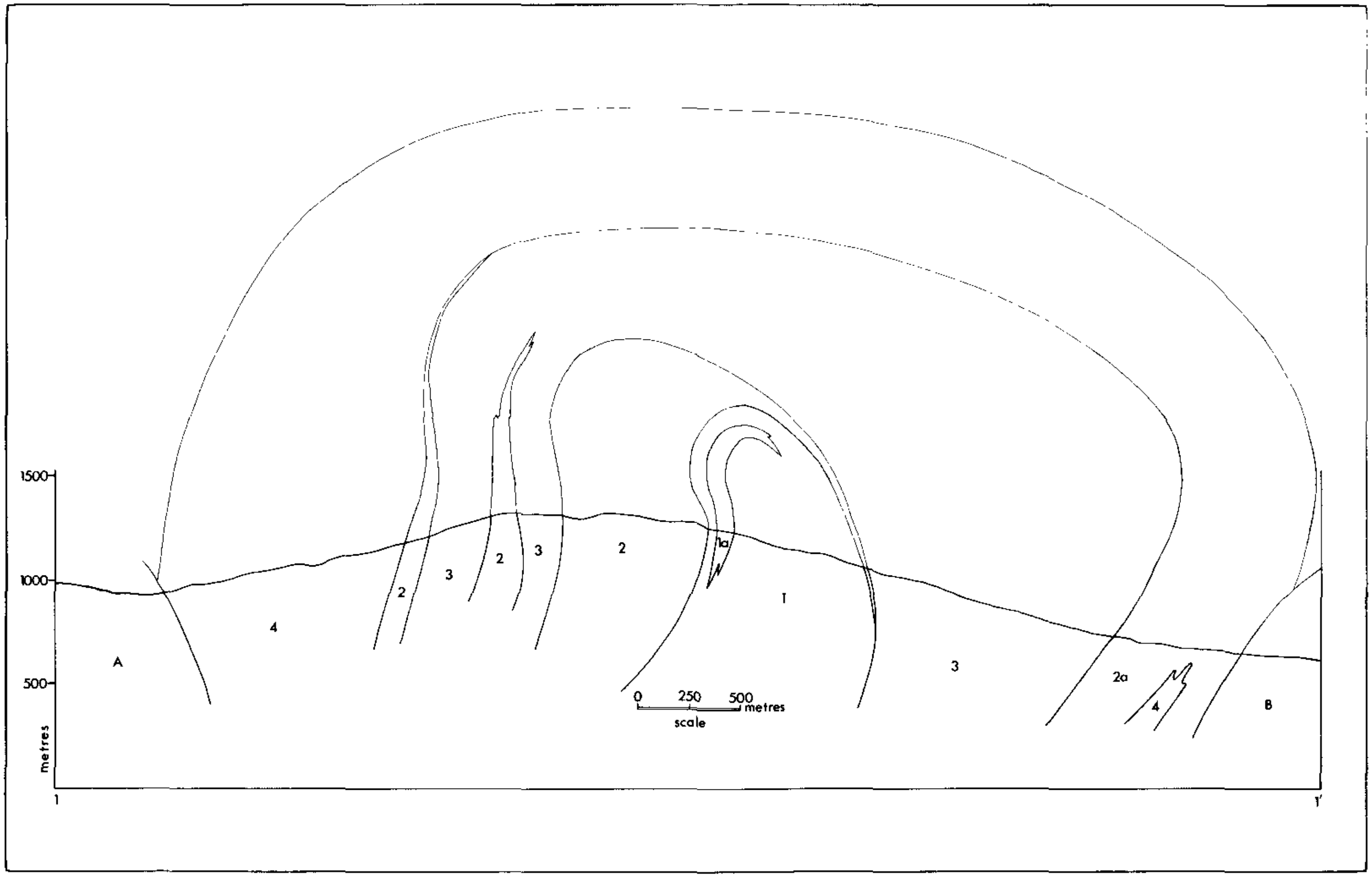

Figure 7. Interpretive geologic section, Promontory Hills (for location and legend, *see* Figure 6).

North of the Major Fold: Overlying rocks change rapidly along and across strike and are, to a degree, repeated across strike. Consequently units 2 and 3 on the map (Fig. 6) form areas which pinch out along strike and are repeated up section. North of the fold core along the powerline is a thick pile of quartzofeldspathic flows, tuffs, and breccias of rhyodacitic (?) composition with local thin black and brown argillite layers and minor impure limestone pods. Westward, along section 1-1′ (Fig. 7) the same unit consists largely of quartzofeldspathic wackes, greywackes, marine black argillites, and tuff. These appear to represent mixed tuffs and sedimentary rocks derived from quartzofeldspathic igneous rocks like those along the powerline. Up section, this felsic unit is overlain by a mixed assemblage of siliceous argillaceous limestones, limy grits, volcanic sedimentary breccias, and argillites. There are few recognizable fossils in the limestone but there is much fossil debris. Argillite interbeds frequently carry marine halobid pelecypods and a few poorly preserved ammonoids were found. Tentatively these beds have been assigned a Carnian age. Apparently the limestones represent lime muds and sands deposited in an off-reef setting and the grits and sedimentary breccias represent material washed or slumped in. Continuing northward, there is a mixed assemblage of quartzofeldspathic igneous and sedimentary rocks with interlayers of volcaniclastic rock which contain angular, equant to elongated clasts that are generally less than 10 millimetres in maximum dimension. Near the top of this section are pod-like areas of limy rock which vary in composition from argillaceous and siliceous limestone to clean white marble. The uppermost exposed unit consists of black feldspathic volcaniclastic rocks and similar-looking andesitic flows. On weathered surfaces, volcaniclastic members are seen to range from fine-grained laminated siltstones to rocks with 5 to 10-millimetre-sized clasts; they are typically pyritic. Rare tuff (?) layers have alternating feldspathic and magnetite-rich laminae. Andesitic rocks vary from fine grained to porphyritic and resemble those in the basal unit. Exposure is very poor in this area and in conjunction with contact metamorphic effects from the nearby Guichon Creek batholith distinction of rock types becomes difficult.

South of the Major Fold: South of the fold, the basal unit is overlain by a thin discontinuous veneer of massive to brecciated quartzofeldspathic igneous rock (rhyodacite ?). Above are pods of reefoid limestone with abundant corals, bryozoa, crinoid columnals, brachiopods, and gastropods. In places the reefoid bodies directly overlie the basal unit. Quartzofeldspathic rocks, which tend to be finely spherulitic flows here, comprise only scattered lenses within a dominantly calcareous section. There are also lenses of volcanic sandstone, greywacke, and tuff (?). Exposures are abundant west of the powerline in this area but very poor east of it. Limestones tend to be granular and some consist in large part of fossil debris. Along the powerline, the overlying unit is a mixed assemblage of volcaniclastic rocks and greywackes, with layers of limestone, andesitic flows, and layers of red volcanic breccia. Eastward, volcaniclastic rocks diminish and andesitic flows dominate. These are generally olive green and amygdaloidal; flow breccias are common. West of the powerline, the calcareous section is thicker and seems to be thickening westward. Near the top of the calcareous zone west of the powerline, there is a red breccia zone with minor associated andesitic flows which resembles the basal unit. Above it, to the south, is a mixed assemblage of limestones and volcaniclastic rocks; many of the volcaniclastic layers pinch out westward. The Coyle stock cuts off the section at this level but inliers (roof pendants ?) of volcaniclastic rocks in the stock exposed along the powerline suggest that volcaniclastic sedimentation continued.

FAULTS

Faults inferred from the mapping have north-northwest to northwest and northeast trends. It is likely that considerable syn-volcanic faulting occurred. One northeast-striking fault near Promontory Lookout is inferred to have been active during the felsic volcanic activity because there is a marked change in thickness of the lower quartzofeldspathic unit across it. The overlying limy unit does not seem to be offset, but the upper contact of the underlying unit is. Southward, the fault swings round into the bedding plane and dies out. Several other faults have apparent minor offset of some units but marked changes in thickness of others across them. It seems likely that these too were initiated during volcanism and later reactivated. Reactivation likely occurred during a post-Cretaceous episode of block faulting. Kingsvale Group rocks west of Craigmont mine are cut by northwest-striking faults, and northwest-trending Kingsvale (?) dykes cut Nicola rocks east of Promontory Lookout.

INTRUSIVE ROCKS

The panel of Nicola Group rocks in Promontory Hills is bounded on the north and south by granitic intrusions. On the north, the succession is cut and metamorphosed by the Late Triassic Guichon Creek batholith. Near its contacts the batholith ranges from quartz diorite to granodiorite in composition. To the south, Nicola rocks are cut and metamorphosed by the Coyle stock. The stock varies from diorite to quartz diorite to quartz monzonite in composition and has small areas which are alaskitic. No ages are available for the Coyle intrusion, but it has a marked northeast elongation like that of the country rock, has similarly elongated inliers or roof pendants of Nicola strata, and has diffuse, hybridized contacts. It cuts rocks interpreted to be the youngest Nicola rocks exposed and is in turn cut by dykes of Kingsvale (?) age. Presumably it is a Late Triassic subvolcanic pluton intruded during the waning stages of Nicola volcanism.

Cretaceous Rocks: The older rocks are unconformably overlain by sedimentary and volcanic rocks of Cretaceous age. To the west, these are largely basaltic andesites and fragmental volcanic rocks of the Spences Bridge Group. To the east are dacitic to basaltic flows, coarse to fine sedimentary rocks, and fragmental volcanic rocks of the Kingsvale Group.

IRON MASK BATHOLITH
(92I/9, 10)

By K. E. Northcote

INTRODUCTION

Regional mapping at 1:15 840 of a strip 3 kilometres wide was completed along the north side and around the northwest end of the Iron Mask batholith. Intrusive contacts with Nicola rocks and the trace of the Nicola-Kamloops unconformity were of particular interest. This information will update the Ministry of Mines and Petroleum Resources' Preliminary Map 26.

Contacts between rock units are better defined, rock descriptions are improved, and relationships between rock units are better understood as a result of detailed mapping and logging drill core from certain mining properties. The area around Afton mine southeast of Sugarloaf Hill was mapped at a scale of 1:4 800. Core from 27 diamond-drill holes totalling 5 200 metres was logged from Canadian Superior's Comet Project southeast of Iron Mask Lake and core from four diamond-drill holes totalling 900 metres was logged from Nahatlatch Resources' 1977 drilling on the Rainbow claims east of Sugarloaf Hill.

The next phase of the program will be to combine regional geology with detailed property geology provided by Gordon P. E. White, District Geologist, Kamloops, in a joint publication.

VOLCANIC–PLUTONIC RELATIONSHIP

Numerous outcrop areas of Nicola rock were located which contain Cherry Creek and Cherry Creek-like angular fragments in volcanic rock and rounded cobbles and pebbles in sedimentary units. Additional areas were found where these or similar rock units are intruded by Cherry Creek unit so that volcanic-plutonic relationships and the shallow subvolcanic environment postulated for Cherry Creek rocks appears valid (Northcote, 1974, 1976). However, the possibility that some rocks of perhaps Early Cretaceous age, as postulated by Cockfield (1948), Le Cheminant (1972), and others, cannot be discounted until all similar rock units, particularly less intensely altered, hematitic, friable members underlying the pre-Tertiary unconformity, have been positively dated. Fossil ammonites, collected in 1974, in mature sedimentary rocks from the east fork of Alkali Creek are indeterminate (E. T. Tozer, personal communication). During the 1977 field season a second locality, south of Hughes Lake, of presumably the same rock unit contains two types of ammonites which hopefully will yield a reasonably accurate age, possibly Early Jurassic (H. W. Tipper, personal communication).

RELATIONSHIP AMONG INTRUSIVE UNITS

There appears to be a complete gradation from medium to coarse-grained rock, commonly forming the matrix of the Iron Mask unit, through medium to coarse-grained Pothook diorite, with varied mafic content, through Cherry Creek macro-varieties to related Cherry Creek micro and porphyritic varieties. Locally, intrusive contacts are evident among these units as well, particularly in areas of dyking of macro-Cherry Creek varieties by micro and porphyritic Cherry Creek varieties.

The youngest Cherry Creek rocks are commonly richest in K-feldspar and albite. Some of these varieties are the result of injection of highly differentiated magma that crystallized as dykes. However, most of the K-feldspar and albite enrichment appears to be the result of permeation of K and Na-rich differentiates through previously crystallized more basic Cherry Creek rocks. Thus, the composition of the rock is changed and original textures become obliterated. Brecciation and mineralization commonly accompanied K and Na enrichment.

A myriad of very closely related Cherry Creek-Pothook varieties resulted from differentiation of magma, intrusion and permeation by K and Na-rich differentiates, contamination by assimilation of more basic material, and rapidly fluctuating conditions of pressure, temperature, and volatile content during crystallization. It becomes very arbitrary and perhaps somewhat meaningless to attempt to subdivide these varieties to the extreme. However, zones of brecciation, K and Na enrichment, and structural linears can be delineated and are the most significant zones for mineral exploration within the batholith.

Picrite appears to be one of the oldest rocks present in the area of the Iron Mask batholith. Refractive indices can be used to help distinguish picrite from Nicola and some fine-grained, dark Iron Mask varieties. Picrite is cut by hornblende-rich Cherry Creek-like rocks in the Iron Mask mine area. Cherry Creek rocks, younger than picrite, are commonly contaminated at picrite contacts. Picrite appears to predate some varieties of Iron Mask unit as well. Material from the Larsen dump near Bowers Lake shows picrite cut by the coarse-grained gabbroic variety of the Iron Mask unit. It is possible that picrite flowed up from a deep source through deep-seated structures to be emplaced in earliest Nicola time and was followed and engulfed by different Iron Mask magma from a higher crustal level, which produced the intrusive units of the Iron Mask batholith.

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CENTRAL BRITISH COLUMBIA

GRANITE MOUNTAIN PROJECT
(93B/8)

By A. Panteleyev

A mapping project of the Granite Mountain pluton, host for Gibraltar mine, was undertaken during 1977. Major objectives of the mapping project were to define the size and boundaries of the pluton, to describe the enclosing rocks and their contact relations with the pluton, to determine if any subdivision of the pluton into distinct rock types or phases was practical, and to define the size of the adjoining Sheridan Creek stock and its relationship to the Granite Mountain pluton.

Bedrock mapping was done at a scale of 1:15 840 (1 inch = ¼ mile) over an area of approximately 390 square kilometres (150 square miles). Two hundred and sixty-five rock samples were collected, providing a sample density of at least one sample per square kilometres over 60 per cent of the map-area. Some samples will be chemically analysed to determine the rock compositions and a large number will be analysed to define minor element trends (Cu, Mo, S, Pb, Zn, Mn, Ag, and possibly others) within the Granite Mountain pluton.

Preliminary results of mapping are shown on Figure 8. Granite Mountain pluton is 127 square kilometres (49 square miles) in size and therefore is a valid, albeit small, batholith. The younger Sheridan Creek stock is 35 square kilometres (15 square miles) in size and appears to be mainly in fault contact with Granite Mountain batholith. Another small stock is present along the northeast contact of Granite Mountain batholith near Burgess Creek.

Based on hand specimen identification, three phases are recognized in Granite Mountain batholith: diorite in the south, quartz diorite in the mineralized central part, and leucocratic quartz diorite in the northern half. Boundaries between the three main rock types shown on Figure 8 are approximate and will be refined when petrologic data are available. Dykes are rare and, where present, are generally less than 5 metres in width. Sheridan Creek and Burgess Creek stocks are quartz diorite to granodiorite in composition.

All three phases of Granite Mountain batholith are medium to locally coarse-grained porphyritic rocks which are foliated to some degree. Zones of strongest foliation trend east-westerly (azimuth 100–280 degrees) and commonly have gentle southward dips. In the most intensely foliated zones granitic textures are obliterated and the rocks are quartz-bearing chlorite schists and chloritic sericite schists. Such schistose rocks are common in narrow sinuous zones within a broad band of strongly to moderately foliated rocks that envelopes the mine area and follows the quartz diorite-leucocratic quartz diorite boundary. A second area in which schistose rocks are common is along the southwest contact where greenstone (greenschist) is wedged between Granite Mountain batholith and Sheridan Creek stock.

Country rocks in contact with Granite Mountain batholith in the south are Cache Creek phyllitic siltstone, greenstone, and rare limestone. In the north the batholith has intruded andesite flows, breccia, greywacke, siltstone, and conglomerate. Within this assemblage there is some sandstone composed of mainly quartz and

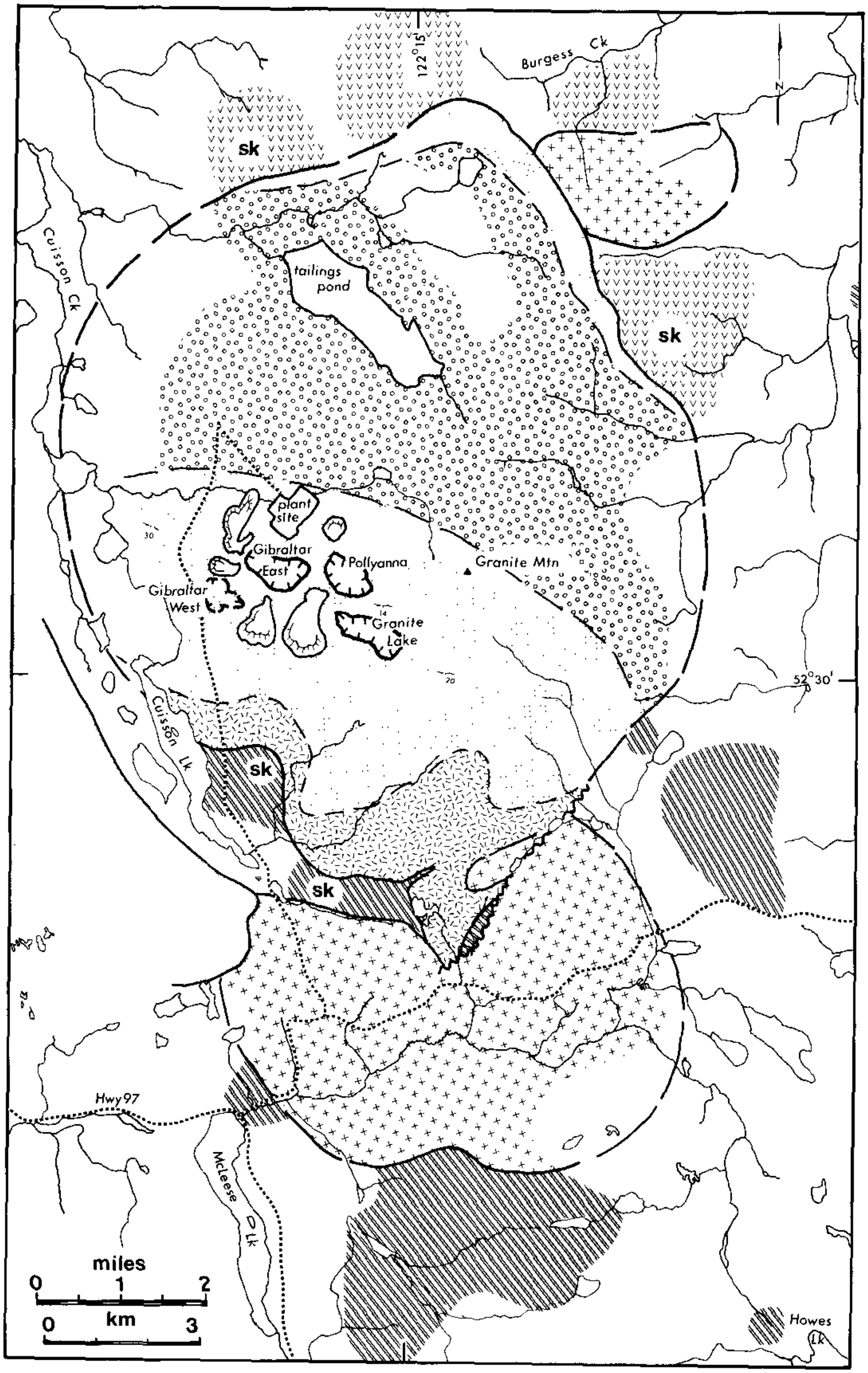

Figure 8. Geology of the Granite Mountain Pluton.

GRANITE MOUNTAIN MAPPING PROJECT

LEGEND

COVER ROCKS

OVERBURDEN

TERTIARY

BASALT

INTRUSIVE ROCKS

SHERIDAN CREEK STOCK, BURGESS CREEK STOCK

QUARTZ DIORITE, GRANODIORITE

GRANITE MOUNTAIN BATHOLITH

LEUCOCRATIC QUARTZ DIORITE – GRANITE MOUNTAIN PHASE

QUARTZ DIORITE - MINE PHASE AND NORTHERN BORDER PHASE

DIORITE – SOUTHERN BORDER PHASE

BEDDED ROCKS

JURASSIC ?

ANDESITE, GREYWACKE, QUARTZOSE FELDSPATHIC WACKE, SILTSTONE

PALEOZOIC (CACHE CREEK GROUP)

SILTSTONE, SHALE, GREENSTONE, CHERT, GREYWACKE, LIMESTONE

SYMBOLS

GEOLOGIC CONTACTS: APPROXIMATE, INFERRED, FAULT

FOLIATION

SKARN . . . . sk

QUARTZ- EPIDOTE–CALCITE–CHLORITE (HEMATITE) AND EPIDOTE–GARNET–MAGNETITE–QUARTZ (CHALCOPYRITE) ASSEMBLAGES IN VOLCANIC ROCKS

ROAD

WASTE DUMP

MINE PIT

feldspar grains and rare granitic clasts. The presence of such clastic rocks with a mixed volcanic and granitic provenance suggests that they are relatively young, possibly Early Jurassic in age.

In a number of locations along the contact, skarn is present (shown as SK on Fig. 8). Skarn assemblages most commonly contain garnet-epidote-magnetite and rare chalcopyrite. In the northwestern locality the skarn minerals are epidote-quartz-calcite-chlorite with rare specular hematite.

Conclusions drawn from this mapping project are as follows:

(1) Economic mineralization appears to be restricted to one of the three main phases of Granite Mountain batholith, namely quartz diorite. The diorite border phase and leucocratic quartz diorite in the north are only weakly mineralized.

(2) Ore deposits and the important mineral showings are within or close to strongly foliated rocks, all well within the batholith.

(3) The presence of chalcopyrite, magnetite, and hematite in some of the skarn zones indicates that economically significant mineral deposits may have formed peripheral to the batholith.

The writer acknowledges the able assistance in the field of D. B. Hopper and B. D. Ripley. Cooperation of Gibraltar Mines Limited's staff is appreciated.

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NORTHWEST BRITISH COLUMBIA

KUTCHO CREEK MAP–AREA
(104I/1W)

By A. Panteleyev

During 1976 J.W.H. Monger, D. E. Pearson, and the writer discovered sparse coral and other fauna in limestone associated with fragmental rocks and sericite schists 3 kilometres west of Kutcho Creek. Later identification by E. W. Bamber (J.W.H. Monger, personal communication, 1976) of the coral as a Scleractinian type of Mesozoic age has raised concern that similar rocks east of Kutcho Creek which host massive sulphide deposits are also Mesozoic rather than Paleozoic as suggested earlier (Geological Fieldwork, 1976, p. 75; Geology in British Columbia, 1975, p. G 87).

Detailed examination during 1977 of the bedded succession west of Kutcho Creek lends support to the suggestion that the mineralized rocks to the east are indeed Mesozoic. This conclusion is based on the observation that the fossiliferous limestone unit is both overlain and underlain by quartzose volcaniclastic rocks and sericite schists which are lateral equivalents of the mineralized rocks to the east. Recent regional mapping by the Geological Survey of Canada also interprets the Kutcho Creek volcanic rocks and the overlying sedimentary assemblage to be part of a Mesozoic map unit (L. Thorstad, personal communciation, 1977).

Thus there now exists an apparent conflict between the sole radiometric date, a 275±15 Ma rubidium-strontium isochron date reported earlier (Geological Fieldwork, 1976, p. 75) and the combined stratigraphic and faunal evidence.

GNAT PASS DEPOSIT
(104I/5W)

By A. Panteleyev

The Gnat Pass porphyry copper deposit (June, Stikine, September mineral claims) of Deas Lake Mines Limited was located in 1960 and actively explored from 1965 to 1968. In addition to extensive surface work, a total of 57,035 feet (17 384 metres) of diamond drilling was completed in 102 diamond-drill holes. Most of the work was done in the main or 'Hill' zone although a few drill holes were put down in small, subsidiary mineralized zones including the 'Creek' zone. Reserves are reported to be 18 million tonnes containing 0.44 per cent copper or 32 million tonnes containing 0.389 per cent copper allowing for 20 per cent dilution by wallrock containing 0.15 per cent copper (Ministry of Mines and Petroleum Resources, Mineral Deposit Inventory File).

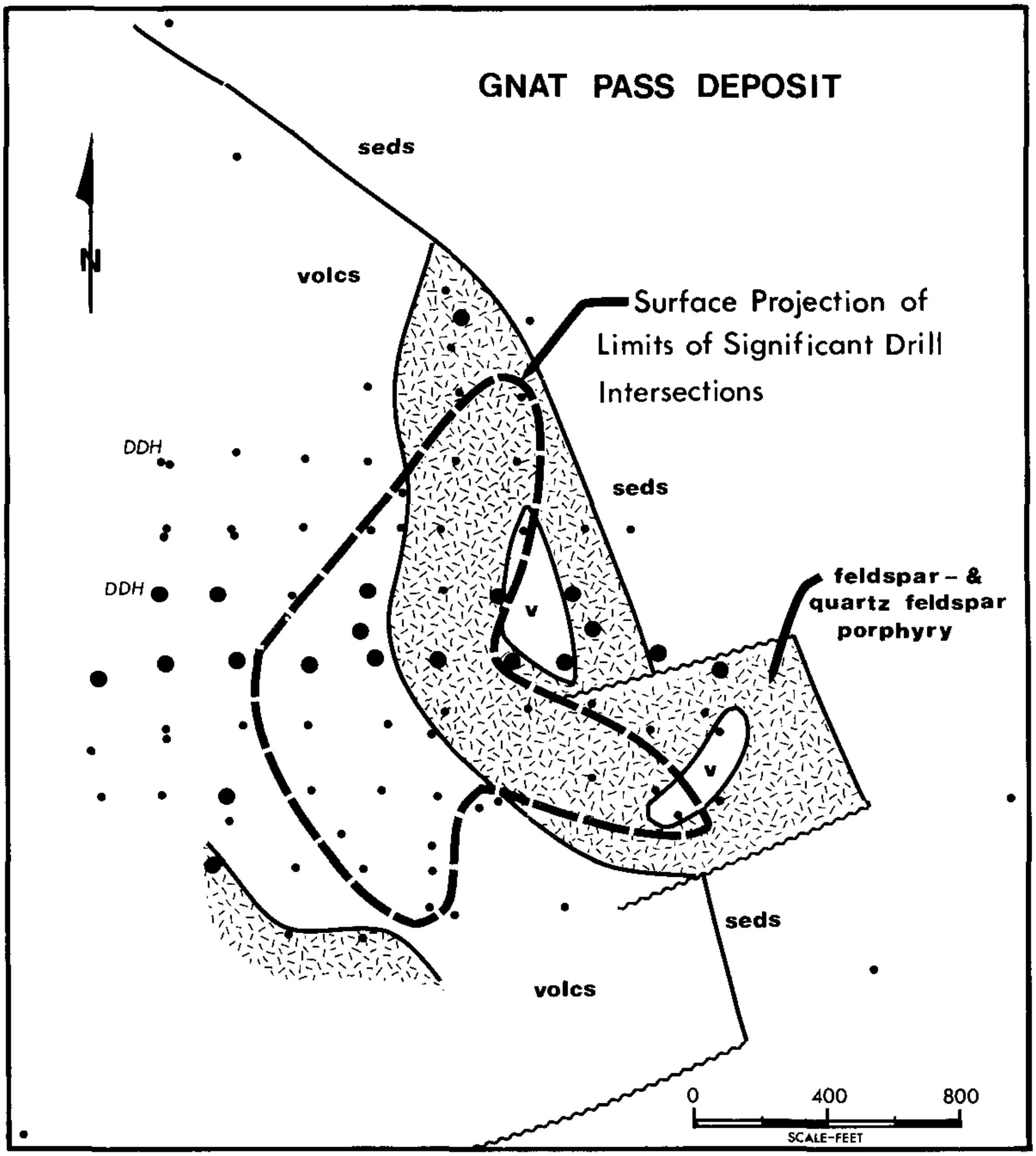

Figure 9. Gnat Pass deposit, simplified geology.

The proximity of the newly completed Stewart-Cassiar road (Highway 37) and the paucity of recorded geologic data made it desirable to review the economic potential and geology of this deposit. Resulting conclusions based on geologic mapping and examination of 20 diamond-drill holes are:

The deposit is small and has been thoroughly tested. The limited size potential of the main (Hill) zone has been demonstrated by extensive drilling and surface stripping (Fig. 9).

The main zone of economic interest is made up of a network of north and northwesterly trending fracture zones that are associated with irregular eastward-dipping feldspar porphyry and quartz feldspar porphyry intrusions. Feldspar porphyry intrusions are commonly pyritic whereas copper mineralized zones are present mainly as narrow chalcopyrite-magnetite-hematite and rare bornite-bearing fracture zones in andesite and pyroxene basalt or as narrow chalcopyrite-tourmaline-carbonate breccia zones proximal to or within feldspar porphyry intrusions. Gold and silver content is insignificant.

The presence of quartz-bearing feldspar porphyry and feldspar porphyry with a siliceous groundmass makes it questionable whether this deposit is a member of the alkaline suite or syenite-type porphyry copper deposit.

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COAL INVESTIGATIONS

CROWSNEST COALFIELD

By David E. Pearson and D. A. Grieve

INTRODUCTION

Systematic 1:7 000 scale mapping of Crowsnest Coalfield continued in the 1977 field season when approximately 100 square kilometres was mapped. The area covered by this mapping project is indicated on Figure 10. Preliminary maps to be published during 1978 relating to this project will cover Fernie Ridge from Coal Creek, Fernie to Hosmer Ridge (contiguous with Sheet 2, Preliminary Map No. 24); and the northern portion of the Southern Dominion Coal Block. These preliminary maps will contain both measured sections and petrographic data on rank for each seam over 1 metre.

FERNIE RIDGE

Detailed mapping of Fernie Ridge has established that several seams previously mined in Coal Creek can be traced northward and correlated with seams exposed on Hosmer Ridge. A major rank change takes place in this section as the isorank plane separating high from medium-volatile bituminous coals cuts down section to the north (Fig. 10). Thus fixed carbon contents of coals decrease along the seams and computed coke stabilities decrease both up stratigraphic section and northward toward the Northern Dominion Coal Block.

MORRISSEY RIDGE

Mapping along Morrissey Ridge has not been completed but the following data have been gathered. The ridge exposes a strike section of coal measures and most of the seams identified in Coal Creek can be traced southward to Morrissey Creek. The ridge is capped by Blairmore Group rocks, and much of the ridge is underlain by Elk Formation. One noteworthy feature is the rank of the coal. At the south end of the ridge, coals in the lower third of the succession have a rank of low-volatile bituminous (reflectance, in oil, $\bar{\bar{R}}o$ $>$1.51 per cent, volatile content (d.m.m.f.) $<$22 per cent).

The key area of Morrissey Creek will be mapped in 1978.

SOUTHERN DOMINION COAL BLOCK

This area, centred on Mount Taylor, occupies a gentle syncline with a north-south-trending axis. Beds at the top of the mountain are vertical and overturned, which implies that erosion has removed an overlying thrust-separated panel of rock. The important Flathead fault (Price, 1965), which is a shallow-dipping normal fault, juxtaposes Elk member rocks with only 170 metres of coal measures immediately north of

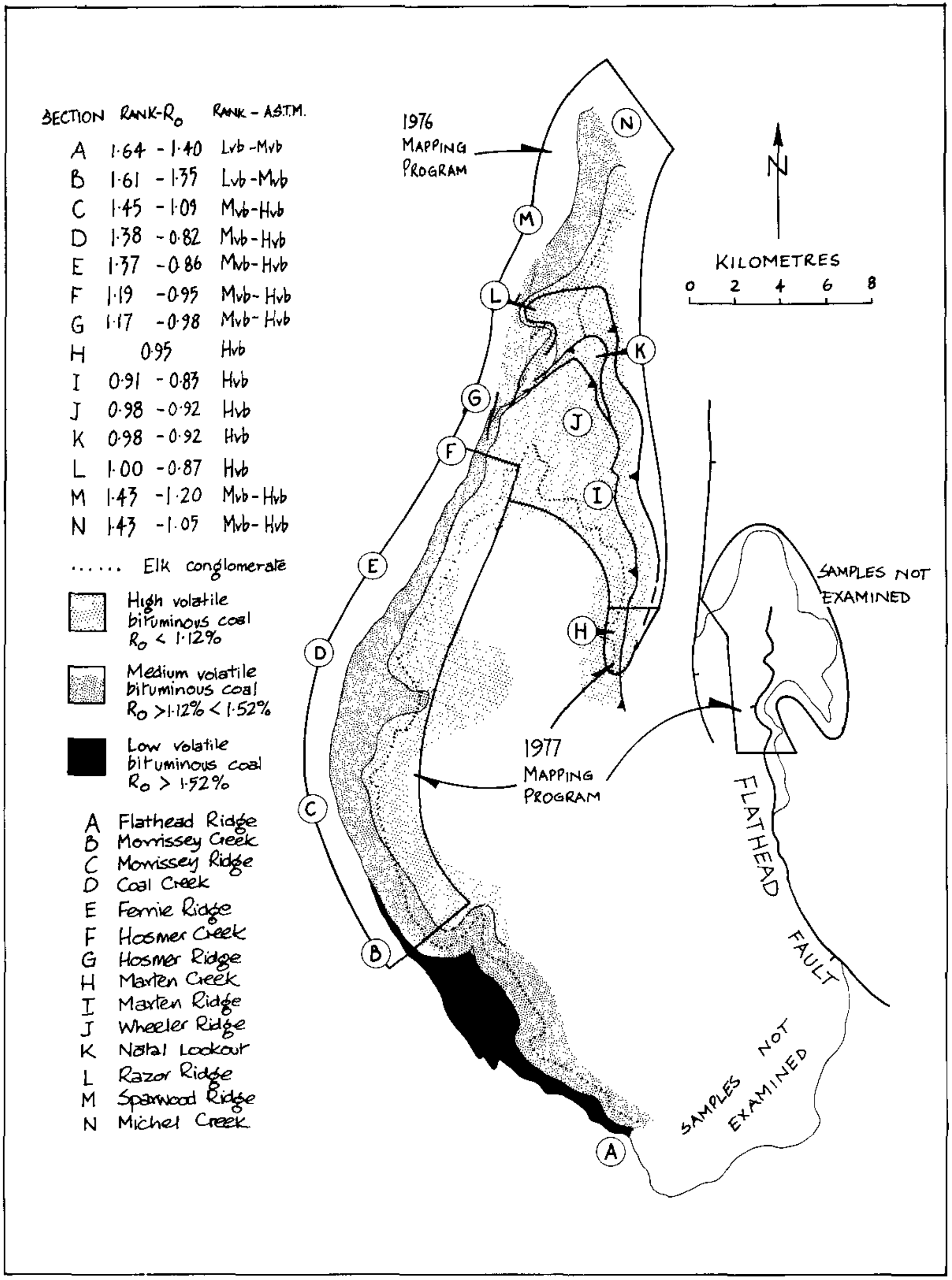

Figure 10. Preliminary rank map over Crowsnest Coalfield.

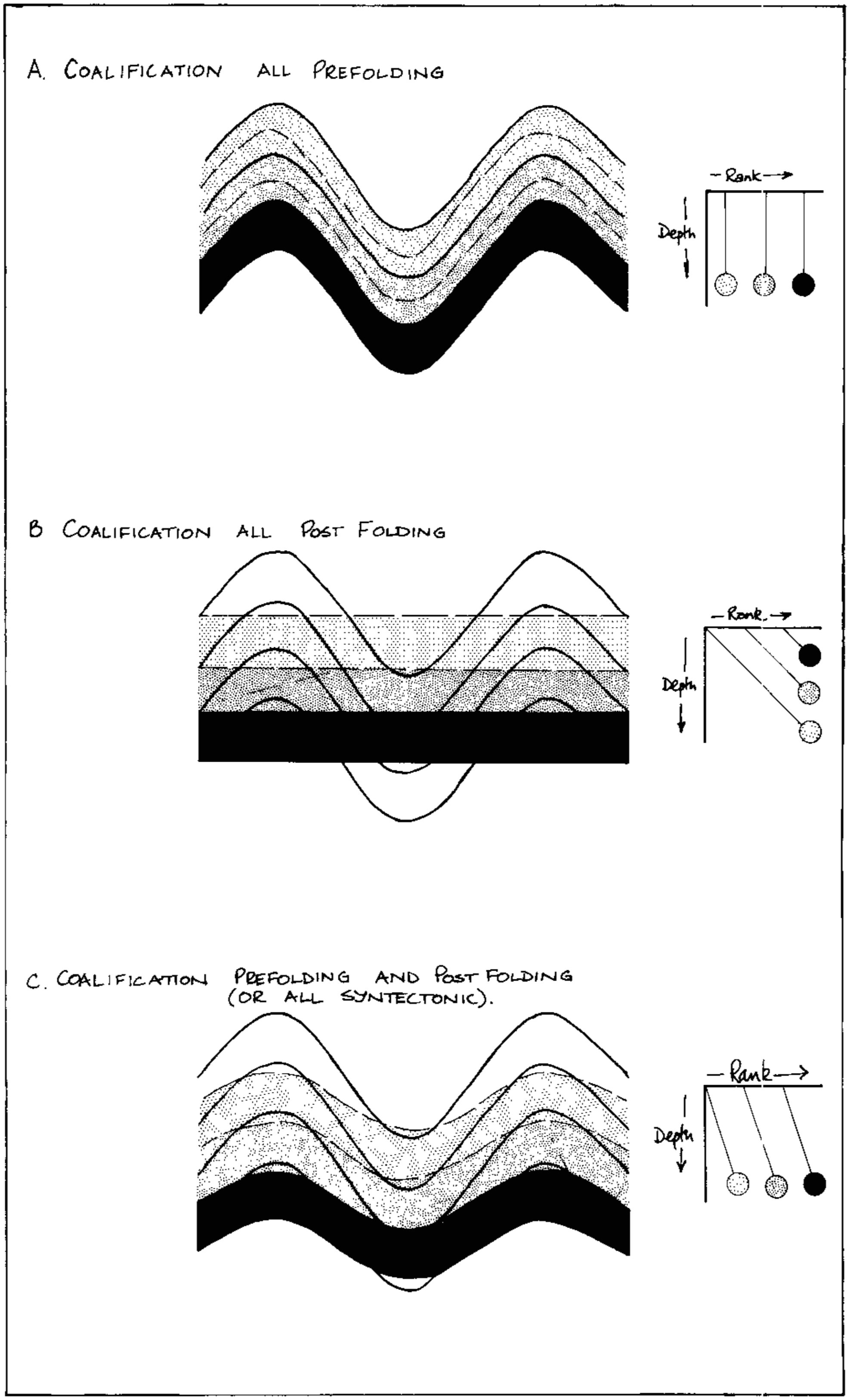

Figure 11. Sections showing possible configurations of coalification planes and coal seams together with rank/depth graphs.

Leech Creek, but the fault terminates rapidly northward so that at the north end of Mount Taylor the full 470 metres of succession is preserved. Samples collected from this area have yet to be analysed petrographically.

RANK STUDIES

Because the coking power of a metallurgical coal depends principally upon rank and only to a lesser extent upon the maceral composition of that coal, a Leitz MPV-1 photometer for coal petrographic work has been used to produce an accurate rank map of the Crowsnest Coalfield. A generalized version of this map together with the rank range of coals found in 13 principal sections is shown on Figure 10.

A number of important features which deserve amplification are as follows:

All of the coal samples so far examined are hard bituminous, but the distribution is not symmetrical. Low-volatile coals, for example, are exposed only in the south of the coalfield. Medium-volatile coals rim the west margin of the coalfield, whereas high-volatile coals form the inner margin of the coalfield where coal measures are in contact with overlying formations.

The complete coal-bearing succession preserved on Razor Ridge has a high-volatile rank (Fig. 10, locality L), as do the virtually complete stratigraphic sections of Natal Lookout, Wheeler Ridge, Hosmer Ridge, Marten Ridge, and Marten Creek. Given the correct petrographic composition, these coals should produce high crucible swelling numbers (FSI's) indicating high caking capacity, but coke stabilities (ASTM) will probably be below 50.

From the mining point of view it is important to determine the time of coalification relative to folding and thrusting. Work by the Teichmüllers in Germany and Hacquebard and Donaldson (*1970, 1974*) in Canada has outlined the principles involved in such interpretations (Fig. 11).

In coalification that occurred prefolding, rank changes systematically with stratigraphic position and the rank remains the same along any seam (Fig. 11, a). In areas where coalification occurred postfolding, changes in rank occur systematically with stratigraphic position, but more importantly, **rank changes down the dip of the seam** (Fig. 11, b). This is important for mining because it means coal quality increases with depth. Finally, in areas where coalification commenced prior to, continued during, and terminated after folding, isorank lines are curved and dip in the same direction as seams though at a shallower angle (Fig. 11, c). *Rank/depth diagrams for these three principal types of coalification are shown on the right-hand side of* Figure 11.

Our thoughts at present are that a large amount of coalification postdates thrusting because the rank does not change markedly over the major structures shown on Figure 10.

In Crowsnest Coalfield and elsewhere, mapping of ridges provides little information on the relative age of coalification because coal seams and isorank planes outcrop in strike section. The vital information can only be gathered in valleys which cross the strike. Such valleys are those of Michel Creek, Coal Creek, and Morrissey Creek.

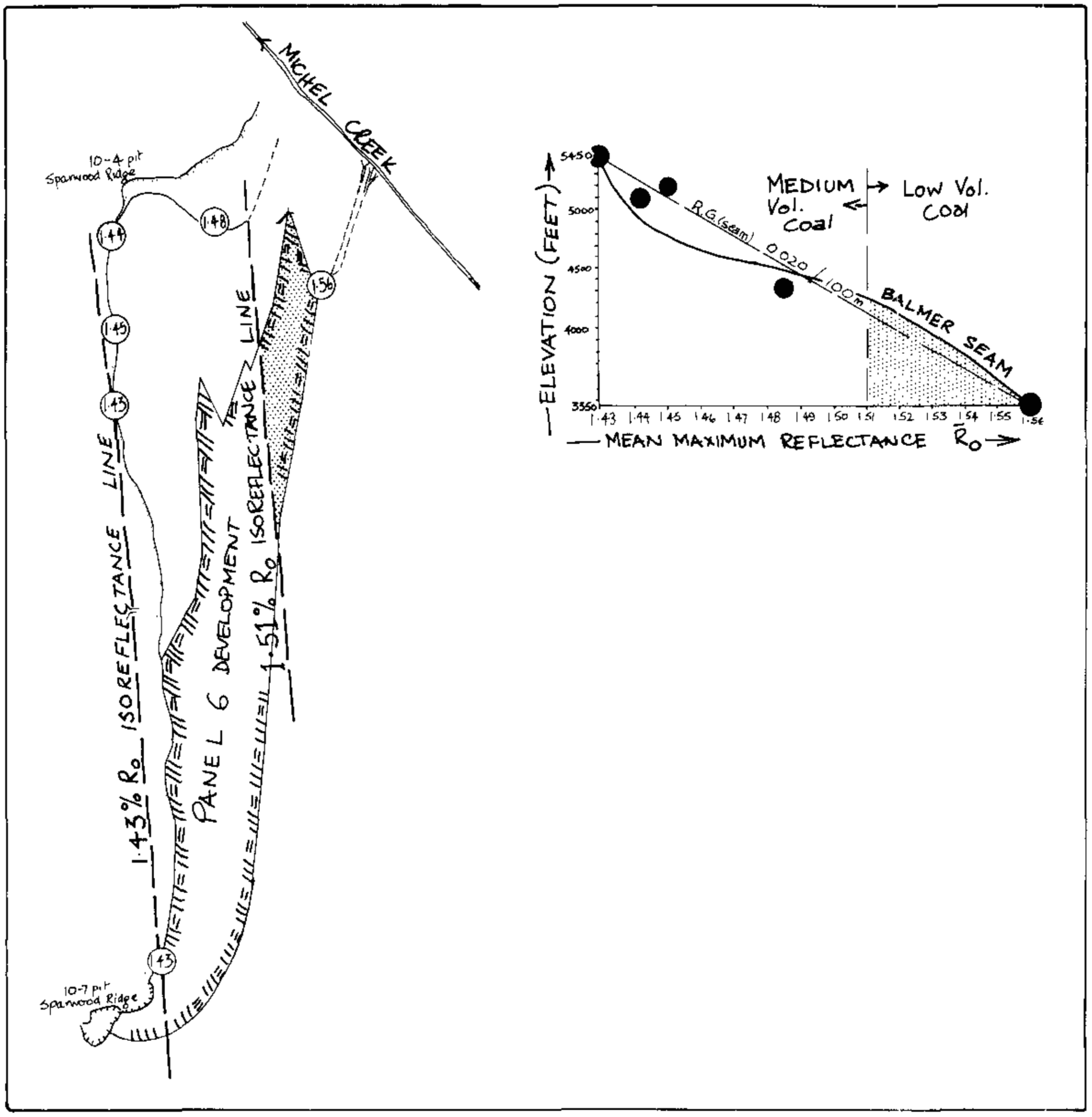

Figure 12. Coalification map of Balmer seam over the 'Panel 6' development with location of petrographic samples, location of isorank lines, and cross-section of Balmer seam showing rank change with elevation.

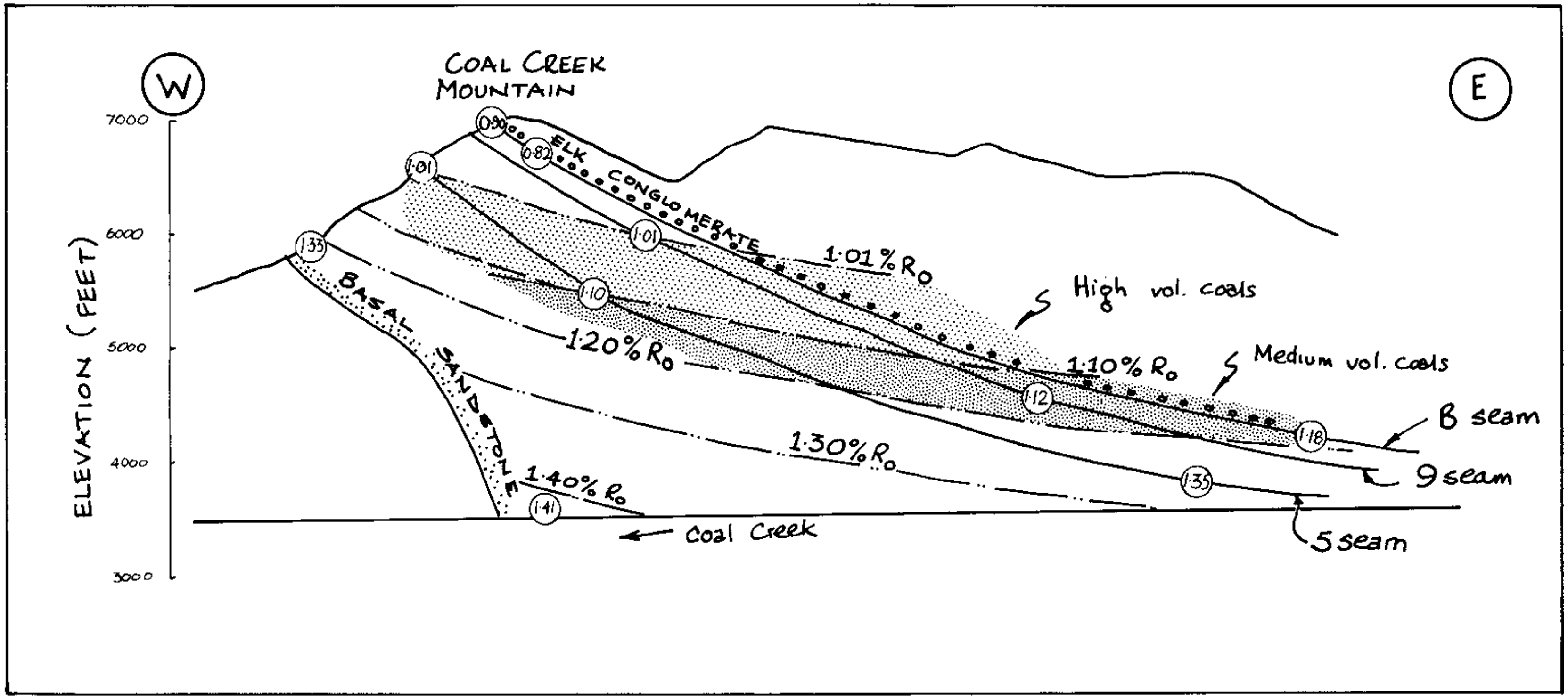

Figure 13. Cross-section of the north side of Coal Creek, Fernie, showing positions of petrographic samples, rank change of seams with depth, and approximate positions of isorank lines (even though some data points are anomalous).

(a) **Michel Creek**

Five samples of Balmer coal covering an interval of 600 metres (2,000 feet) have been ranked petrographically (Fig. 12). The highest elevation sampled was from 10 seam at 1 661 metres (5,450 feet) on Sparwood Ridge, where a rank of $\bar{R}o$ = 1.43 per cent was obtained. This is the same rank as Balmer coal at the 10-7 pit 3 kilometres to the south. The lowest elevation sampled was in Kaiser Resources' new hydraulic mine at 1 021 metres (3,350 feet) elevation, at the dewatering site of the Panel 6 development. Here, a rank of $\bar{R}o$ = 1.56 per cent was obtained. It is therefore obvious that the rank of Balmer coal **changes down the dip of the seam.** Consequently, coking power of Balmer coal must be variable and this is apparent from the coalification map of Balmer seam in the area of the new Panel 6 mine (Fig. 12) from which it can be seen that nearly one-fifth of proposed production will be of low-volatile bituminous coal.

(b) **Coal Creek**

Eight samples of coal from seams B, 9, and 5 in Coal Creek have been examined (Fig. 13). In each case they demonstrate conclusively that these coals change rank from high volatile to medium volatile **down the dip of the seam.** Thus, coal quality increases with depth. It can even be predicted that 'O' seam, the equivalent of Balmer coal in this section, although of medium-volatile rank on the ridge of Coal Creek Mountain, is probably of low-volatile rank only 150 metres (500 feet) beneath the valley floor (Fig. 13).

RANK GRADIENT (R.G.'s)

Changes in rank can be quantified in terms of percentage rank change per 100 metres (%$\bar{R}o$/100 m).

Thus, in any stratigraphic section or borehole, the distance between the top and basal coal seams records a rank gradient referred to as R.G.(m.s.). If there has been postfolding coalification, that is, if the rank of a seam changes, it too can be quantified and referred to as R.G.(s). Finally, that amount of coalification contributed to the total stratigraphic gradient [R.G.(m.s.)] prior to folding can be determined from the following formula:

$$R.G.(p.f.) = R.G.(m.s.) - R.G.(s)$$

For the Coal Creek and Michel Creek sections these gradients have been computed and are shown graphically on Figure 14. From these graphs it is apparent that 39 per cent of the total coalification gradient in Coal Creek occurred postfolding, compared to only 25 per cent in the Michel Creek section.

This fact, together with the recognition of low-volatile coals exposed at the south end of the coalfield, suggests that the whole southwestern margin of the coalfield was more deeply buried than the rest of the Fernie Basin. This may be evidence that the Hosmer Nappe, a major recumbent anticline exposed on the Three Sisters west of Fernie and in the Lizard Range southwest of Fernie once extended further to the northeast.

The writers acknowledge the assistance of Frank Gigliotti and Mickey Welder during the field season.

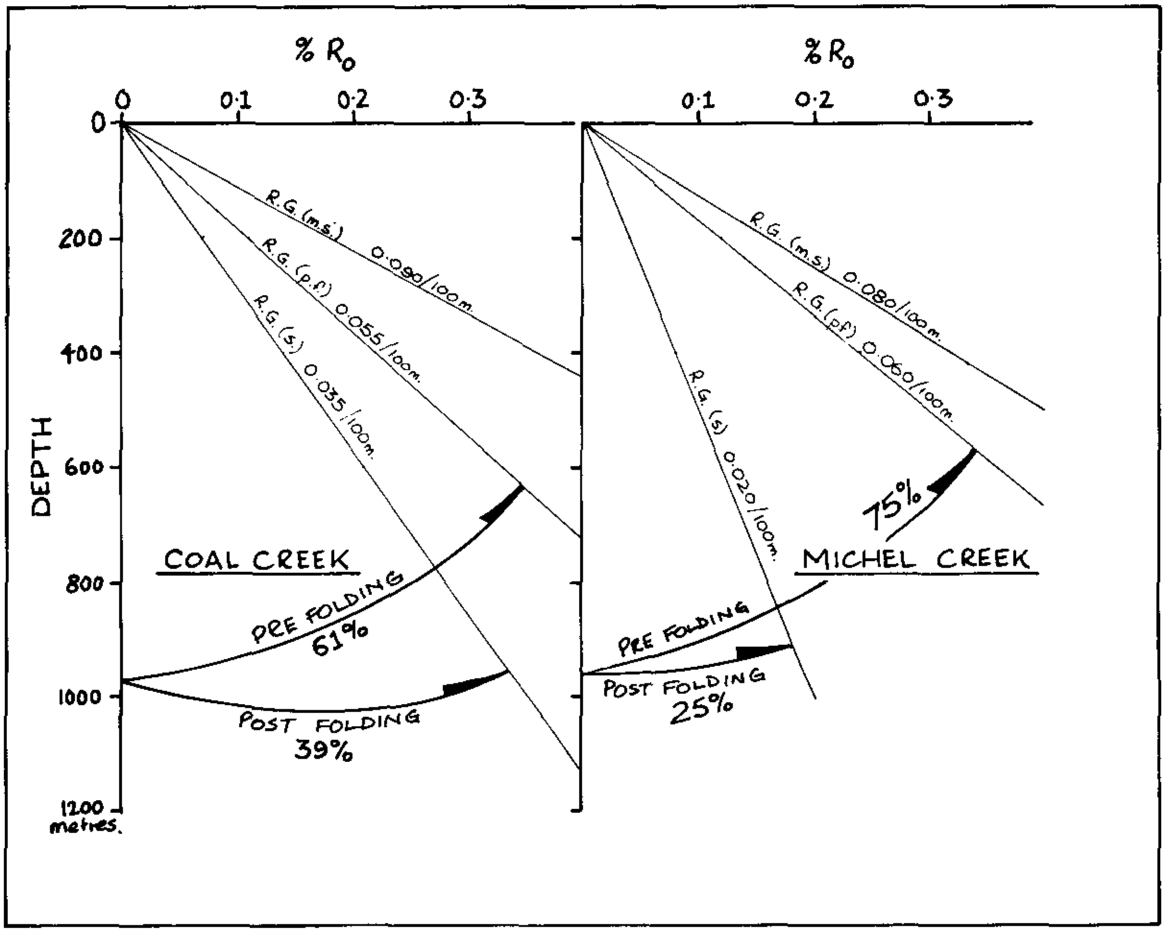

Figure 14. Rank-gradient graphs for Michel Creek Balmer seam and Coal Creek 'B' seam.

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

By G.E.P. Eastwood

In 1962 Weldwood of Canada Limited acquired all the assets of Canadian Collieries Limited, including the coal rights held fee simple by way of the Esquimalt and Nanaimo Railway Land Grant. In 1973 Weldwood compiled all available data on coal reserves of these lands and began investigation of several untested areas, including the Quinsam area west of Campbell River. In 1975, 11 boreholes were drilled from which a structural map at 1:15 840 scale was prepared and submitted in a report to the Ministry. In 1976-77 a grid was surveyed and drilling at 500-foot centres was begun. Several trenches were cut in coal, and from one of them a short adit was driven to obtain unweathered coal for testing.

The coal in the Quinsam area could represent a significant addition to the reserves of Vancouver Island, and a program of reconnaissance geological mapping of the area was undertaken.

The writer spent one month producing an outcrop map of most of the area between the upper section of Campbell River and Iron River. In addition, a reconnaissance was made from the lower Iron River eastward past Quinsam Lake. Outcrops were mostly located on 1:63 360 aerial photographs and transferred to 1:50 000 base maps.

Coal seams occur in the Upper Cretaceous Comox Formation, which is poorly exposed over most of the Quinsam area. North of Miller Creek and Beavertail Lake Pleistocene drift is very thick and no Comox rocks are exposed. Between Beavertail and Middle Quinsam Lakes there are scattered exposures of greywacke and conglomerate, flanked on the east by Karmutsen volcanic rocks and on the west by granodiorite of the Quinsam batholith. A coal seam had been exposed in a trench 560 metres north of Middle Quinsam Lake. A ridge of granitic rocks south of Middle Quinsam Lake partly divides the basin, and the lower parts of the sections to the north and south differ considerably. The base of the formation was not seen, but probably lies at the base of a cobble and boulder conglomerate. In a new exposure along Highway 28 north of Gooseneck Lake the conglomerate consists almost entirely of material eroded from the Karmutsen Formation, and the cobbles are well rounded. Pebble conglomerate and pebbly greywacke lie somewhat higher in the section. In a bulldozer cut southeast of the second lake south of Middle Quinsam Lake, the rock is a sedimentary breccia consisting of varied angular fragments in a maroon matrix, and in the bed of the Iron River the conglomerate is a mixture of this breccia plus well-rounded granitic boulders. Karmutsen-derived material is relatively minor. A coal seam lies a few metres above the sedimentary breccia, and an open cut on the same line exposes a second seam with a sandstone roof. Coal with a shale roof exposed in an open cut northeast of the second lake south of Middle Quinsam Lake appears to represent a third seam. These seams pass under well-exposed greywacke and sandstone to the east. Where freshly exposed in a bulldozer cut the greywacke is dark green and gritty and resembles highway cuts southeast of Snakehead Lake. Evidently Karmutsen-derived material was able to enter the south part of the basin in quantity after the coal was laid down. Only one seam was found in the Iron River, and as it has a sandstone roof and lies at least 27 metres above the mixed conglomerate it is probably No. 2 seam. Coal exposed in an open cut and short adit east of Middle Quinsam Lake lies over the nose of the dividing ridge, and may be No. 1 seam near the base of the Comox Formation. A partial analysis of a sample taken adjacent to the adit yielded the following results:

$S - 1.97\%$ $P_2O_5 - 0.62\%$ ASH $- 5.21\%$

The Comox beds have been warped, tilted, and faulted. North of Middle Quinsam Lake the overall dip is east-northeast at about 8 degrees. 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 crosses the Iron River to the east. The dips in this part of the area are locally as much as 27 degrees, but more commonly 10 to 15 degrees.

Near the Iron River iron-copper deposit, sheared Karmutsen rocks have been thrust northwest over the mixed conglomerate. Upstream, a steep normal fault has dropped the coal seam 2 or 3 metres. A fault is inferred to underlie Beavertail Lake and Creek, and another may underlie Snakehead Lake. A fault almost certainly underlies the long lake, dropping Comox beds down against the ridge of granitic rocks. A pronounced airphoto linear through Lukwa Lake has been interpreted as a boundary fault, dropping Comox beds down against the Karmutsen belt, but the writer found Karmutsen outcrops west of this line. The nature of the Comox boundary in this part of the area is simply not known, because the closest Comox outcrop is more than a kilometre from the Karmutsen outcrops.

MOUNT SPIEKER AREA
(93P/3)

By R. D. Gilchrist, B. P. Flynn, and R. L. Hauser

INTRODUCTION

The Mount Spieker map-area lies between 55 degrees 10 minutes and 55 degrees 13 minutes latitude and 121 degrees 28 minutes and 121 degrees 10 minutes of longitude. It is bounded by Bullmoose Creek on the northwest and by the Wolverine River on the southwest, encompassing an area of approximately 200 square kilometres. Field mapping was plotted on aerial photographs at a scale of 1:15 000 and final maps will be published on orthophoto mosaics at the same scale.

Upper Jurassic to Middle Cretaceous strata of the Minnes, Bullhead, and Fort St. John Groups underlie the area and contain the coal-bearing Gething and Commotion Formations. The best developed coals of the Gething Formation are the upper and lower Bird seams, which lie close to the top of the formation The Gates Member contains at least four continuous coal seams totalling approximately 12 metres in thickness.

STRATIGRAPHY

The northwest face of Mount Spieker provides an excellent, nearly continuous exposure of Moosebar through Boulder Creek strata. Here, a number of sections were measured and a lesser number were measured at other locations throughout the map-area. Sections were plotted at a scale of 1:250. Following are brief descriptions of distinctive characteristics of the mapping units and their contacts in the area.

Minnes Group: The Minnes Group is generally composed of thin to thickly interbedded sandstones, siltstones, shale, and coal. The contact with the overlying Cadomin Formation, basal unit of the Bullhead Group, is abrupt but appears conformable. Cadomin conglomerates rest on 5 to 15 metres of siltstones with no gradation between the two.

Bullhead Group

CADOMIN FORMATION: The Cadomin Formation rarely forms a marker horizon within the map-area due mainly to its lack of outcrop in alpine areas (Mount Reesor excepted). The conglomerates are split by thick sandstone-siltstone sequences into two or three conglomerate horizons ranging in thickness from 7 to 20 metres. Clasts range from pebble to cobble size with maximum cobble size up to ±10 centimetres.

GETHING FORMATION: The contact between Gething and Cadomin Formations is placed above the last **major** conglomerate unit. Sandstones, siltstones, and shales are interbedded with a number of conglomerate beds. The sandstones are usually crossbedded, weather in platy stacks, and form resistant ridges between the recessive siltstones, shales, and coaly horizons.

Fort St. John Group

MOOSEBAR FORMATION: The Moosebar shales conformably overlie the Gething Formation. The contact is drawn below a 0.5-metre glauconitic, medium-grained sandstone or conglomerate, which is overlain by distinctive black clay shales. On Mount Reesor, the Moosebar Formation was measured to be 80 to 90 metres thick. Rusty weathering ironstone concretions and sideritic-rich mudstone beds in the order of 10 to 20 centimetres thick occur throughout the formation, although they are most prevalent in the lower half.

The upper part of the Moosebar Formation was mapped as a separate unit with the lower contact drawn at the first siltstone or fine-grained sandstone above the black clay shales. This contact was observed to be quite abrupt in places. The siltstones are characterized by bioturbation, worm burrows, and tracks. Black, roughly crescent-shaped worm burrows, which become more abundant up section, are especially indicative. This unit varies from 100 to 140 metres thick in the northern part of the map-area but appears to thin southward, although no complete sections are exposed in the southern part of the map-area. The upper contact is drawn just below a 15 to 20-metre-thick well-crossbedded, fine to medium-grained sandstone which weathers in stacks.

COMMOTION FORMATION

Gates Member: This unit varies from 190 to 230 metres thick and consists of conglomerate, sandstone, siltstone, shale, and coal. The lower contact is at the base of a crossbedded sandstone unit which is generally devoid of the worm burrows, typical of the aforementioned unit. However, 70 to 150 metres above the base is a medium-grained sandstone characterized by large, 1 centimetre wide by 4 to 6 centimetres long, sand-filled worm burrows. Coal seams are found in the middle of the formation within a series of repeated rock units. Pebble conglomerate beds of 5 to 20 metres thick occur near the top of the Gates Member in some locations.

Hulcross Member: The base of the Hulcross is drawn at the first occurrence of grey, rusty weathering, rubbly silt shales. The contact is gradational as the top of the Gates is often silty and recessive. Sideritic concretions and 1 to 3-metre resistant indurated siltstone horizons are other distinguishing characteristics. The member is usually 120 to 150 metres thick.

Boulder Creek: The lower contact is gradational and is placed between the grey silt shales of the Hulcross and the overlying fine-grained, light grey to white, resistant sandstones. The contact zone weathers rusty and is easily distinguishable in the field. Conglomerates, sandstones, siltstones, and some coal horizons constitute Boulder Creek strata which are approximately 130 metres thick. Granule conglomerates with pebble lenses are predominant over the northeastern half of the map-area, with pebble conglomerates characterizing the southwestern half. The upper contact is above the last conglomerate bed and below the grey rubbly silt shale and mud shale of the overlying Shaftesbury Formation.

STRUCTURE

The map-area is transected by two northwesterly trending thrust faults dipping to the southwest. The Mount Spieker thrust, lying on the northeast of Mount Spieker, strikes northwest and dips 10 to 15 degrees to the southwest. On its eastern edge Gates Member is thrust over Boulder Creek and Shaftesbury strata. On the east side of the north ridge off Mount Spieker, the thrust repeats up to 20 metres of the Moosebar Formation. Below the thrust plane, rocks of the Commotion as well as the Moosebar and Gething are overturned, due probably to drag along the thrust. Where the thrust cuts through Moosebar strata, a zone of faults and folds (including some small east-dipping thrusts) is exposed.

The Two Creek thrust lies to the east of the Mount Spieker thrust and faults Boulder Creek, Hasler, and Gates strata over the younger Shaftesbury rocks. At one location the thrust plane is distinct in outcrop and strikes 149 degrees and dips westerly at 38 degrees. Above the thrust plane for a distance of 15 metres the Boulder Creek rocks are extremely folded and fractured.

PRELIMINARY CONCLUSIONS

The area west of Mount Reesor and east of Windfall Creek was examined to determine the prospect of finding strata younger than the Minnes Group. A ridge extending from Mount Reesor to Windfall Creek offers nearly continuous outcrop across strike. In a few localities, well-developed sandstone and siltstone units were found containing coal seams up to 1.5 metres thick. However, the seams were generally localized and not very continuous. Throughout the area, strata are strongly contorted with chevron folding and faulted anticlinoriums being the dominant structural styles. The conclusion was that the strata observed was Minnes Group, and that in fact, no younger strata exists west of the Cadomin outcrop on the southwest slope of Mount Reesor.

Closely spaced sections along nearly continuous outcrop on the northwest face of Mount Spieker helped to illustrate the rapid facies changes that occur within the Gates and Boulder Creek Members of the Commotion Formation. Considerable changes in lithologies have been observed within distances of less than 30 metres.

The less competent lithologies show considerable minor folding and faulting adjacent to antiformed, competent sandstone and conglomerate units.

The upper Moosebar unit is relatively easy to distinguish in outcrop, core, and some geophysical logs (mainly neutron).

CORRELATION STUDIES IN THE PEACE RIVER COALFIELD
(93P)

By P. McL. D. Duff, F.R.S.E.

OBJECT OF STUDY

The main object of the present study was to complete a survey begun in 1976, of a representative suite of drill cores from each of the areas being explored by mining companies in the Peace River Coalfield. It is hoped from this preliminary work to lay down guidelines for the correlation of the entire coalfield, and, where necessary, to define methods of correlation within certain properties. Results of the survey to date are encouraging and it appears that selection of specific stratigraphic intervals for more intensive examination should help to resolve some of the current correlation problems.

A particularly interesting marker horizon has been found near the base of the Moosebar Formation which may extend throughout the entire length of the coalfield. In many boreholes examined it has been found that two or more thin (1 to 3 centimetre) bentonitic beds are present. In some cases thin bands of what appears to be relatively unaltered volcanic ash have been observed and there may be every possible gradation from ash to bentonite, always apparently about the same horizon. These bands have been picked up in virtually every borehole so far examined. Although specimens from Cinnabar Peak to the Nichimen property only have been examined, there are similar bands recorded at the Quintette and Saxon properties.

Another promising 'marker' in the Gething Formation is a marine tongue, rich in fossils, below the Chamberlain seam in the Sukunka area. Between the base of the Moosebar Formation and this horizon are the Bird-Skeeter-Chamberlain group of coals. Non-marine bivalves also form a prominent marker band in this area above the Skeeter seam. Further north, in the Cinnabar Peak area, it appears the Trojan group of seams is at about the same horizon as the Bird-Chamberlain groups and careful study of intervening boreholes should verify or refute this hypothesis.

Gates Member strata have not provided as rich a record of the fauna as the Gething Formation, but in addition to considerable non-marine and brackish fossils, a marine band has been seen in cores from drill holes between the Wolverine and Murray Rivers. Considerable cores containing this horizon remain to be examined.

REPORTS OF DISTRICT GEOLOGISTS

MINERAL PROPERTY EXAMINATIONS

SOUTHEAST BRITISH COLUMBIA

By G. G. Addie

CHINA CREEK URANIUM–BEARING MIGMATITES (82F/4E)

The China Creek uranium prospect is situated approximately 7 kilometres south of Castlegar on Highway 3A. The original property named MOTA was located in 1967 and was examined by Norex Uranium Ltd. Seven diamond-drill holes were completed, the deepest being 152 metres, and the claims were subsequently allowed to lapse. In 1975 the U3 and U3O8 claims were restaked by Peter Leontowicz. Since then a considerable number of units have been located, 78 of these belong to the 'China Creek consortium' composed of: Groundstar Resources Limited, Tandem Resources Ltd., Golden Granite Mines Ltd., Nevex Mines Ltd., and Nomad Mines Ltd. This consortium is financed by Stampede International Resources Ltd. and Northwest Ventures Ltd.

Country rocks in the area comprise a layered succession of mixed gneisses with medium-grained granite gneiss and medium to coarse-grained granite augen gneiss forming the bulk of this gently folded unit. No Nelson granite has been identified on the property. Agmatitic migmatite consisting of amphibolite and massive leucocratic pegmatite lenses transgress the country rock gneisses in arcuate zones. The field relationships indicate that of these main rock units the gneisses are oldest and have been injected and cut in turn by sill-like amphibolite dykes and then by pegmatite along extensive fracture zones which largely follow the amphibolite. A number of younger granitic dykes and small plutons cut the migmatites and are in turn cut by swarms of basalt dykes.

The main uranium mineral is uraninite. It is possible that this is in solid solution with a small amount of thorianite. A secondary uranium mineral with bright green fluorescence originally thought to be autunite has been X-rayed and found to be an amorphous uranium silicate. This mineral is ubiquitous and relatively non-radioactive. It cannot be identified by radiometric surveys, but is readily detected using an ultraviolet lamp. The uraninite has been found to have a 'nugget' effect in sampling. Thus a large sample (approximately 1 kilogram) yields better grades than small samples from the same place. The leachability and grade of the uranium are the two critical factors in the economic evaluation of this deposit.

JACKASS URANIUM CLAIMS (82F/5E)

These claims, owned by S. Patszty and A. Terekoff, are accessible by way of a powerline road west from South Slocan and are at an elevation of 1 000 metres.

Host rocks are quartz feldspar pegmatite 'sills,' approximately 15 metres thick, which are identical to those at China Creek 29 kilometres to the south-southwest. The 'sills' strike approximately east-west and dip 24 degrees south. The strike length has been examined over 2 kilometres and is open at both ends.

The general geology of migmatites in this area is best described by Reesor in Bulletin 129, *Structural Evolution and Plutonism in Valhalla Gneiss Complex, British Columbia.* In this area the 'Hybrid gneiss,' as described by Reesor, is the dominant rock type.

An amorphous uranium silicate is ubiquitous but is probably not very thick, that is, in the order of 1 millimetre. The primary mineral is probably uraninite, as at China Creek, and best values seem to be associated with biotite.

Highest grades found so far are in the order of 0.03 per cent U_3O_8.

ALEXANDRIA NO. 2 MINE (CHIEF) (82F/11W)

The CHIEF claim is accessible by a good logging road up Lemon Creek and Crusader Creek for 20 kilometres, thence by an old logging road on Branch 5 for 3.5 kilometres to an elevation of 1 600 metres on Tagart (Tiger) Creek and a foot trail for 2 kilometres to the mine on the south slope of Mount Rappel at an elevation of 2 100 metres.

The host rock for the mineralization is granite to granodiorite of the Nelson batholith. In the mine the vein is generally measured in centimeteres, but in several locations widths of 0.6 metre were seen. Economic mineralization consists of galena, argentite, and chalcopyrite. The owner also reports native silver.

Massive galena occurs on the eastern side of the first stope. The shaft probably was raised on the vein and galena is present on the west wall. Here the galena forms the matrix of a breccia as compared to the rest of the vein which is normal vein filling. The production from the last two years has all come from a surface cut at an elevation of 2 100 metres.

CENTRAL BRITISH COLUMBIA

BOWRON BASIN
(93H/12, 13)

By G. H. Klein

Coal has been known on the Bowron River for over a hundred years. Since the early nineteen hundreds the coal has received intermittent attention with shafts sunk, adits and declines driven, and diamond drilling done. The most recent work was done by Norco Resources Ltd., who drilled 20 holes in 1977 on Coal Licences 148, 163, and 164.

GENERAL SETTING

The coal, considered to be Cretaceous or Tertiary in age, is found mainly in one location on the Bowron River where it occurs as a number of seams on the west bank of the river in the vicinity of the workings. The coal, classified as a 'high-volatile B bituminous' is found in the lower portion of a series of shale, sandstone, and conglomerate beds, which diamond drilling has indicated to be up to 700 metres thick. Glacial deposits limit exposure of the sedimentary sequence to a very few known locations, and that the coal is exposed at all appears to be fortuitous.

Associated with the coal is resin, which is a constituent of the coal and enclosing sediments.

Radioactivity is noted in the coal outcrop in thin shale bands, with two narrow bands yielding about four times background. Uranium in the form of thucolite has been identified from this location.

The sedimentary sequence, which occupies a trough, is bounded by Mississippian and older volcanic and metasedimentary rocks. Contacts are hidden by glacial drift.

The 1977 field season work consisted of geological mapping of the Bowron River from Haggen Creek to Highway 16 and mapping of the older rocks in the northern portion of the study area.

The objectives of this work are to outline the area of sedimentary rocks in which coal and economic minerals may occur, and to indicate the structural setting of the deposit.

REFERENCES

B.C. Ministry of Mines & Pet. Res., GEM, 1969, p. 422; 1970, p. 528.

Geol. Surv., Canada, Radioactivity in Western Canadian Coals, Paper 70-52, pp. 14, 16.

Minister of Mines, B.C., Ann. Rept., 1948, pp. 233-240; 1960, p. 238; 1967, p. 459; 1968, p. 468.

WEST–CENTRAL AND NORTHWEST BRITISH COLUMBIA

By T. G. Schroeter

SAM GOOSLY (93L/1E)

The Sam Goosly silver-copper-gold-antimony property is located approximately 40 kilometres southeast of Houston. Several short visits to the property were made during 1977. In January and February, Placer Development Limited entered into a preliminary agreement with Equity Mining Capital Limited regarding development of the property and conducted a diamond-drill program; however, the program was cut short and Placer withdrew from the agreement. Granby Mining Corporation and Boliden of Sweden then came to a preliminary agreement with Equity and have become participating partners pending formal agreement.

Under the Placer-Equity agreement, 25 short (at most 45 metres) NQ diamond-drill holes totalling approximately 1 295.4 metres were completed on the Southern Tail zone. This brings the number of drill holes completed on the property to 207. The 1977 core was logged, photographed, and crushed for metallurgical testing. Some interesting textures were exhibited in the core including rounded 'fragments' of nearly massive tetrahedrite enclosing small angular fragments of host-rock dust tuff and disseminated pyrite. Fragments of dust tuff contained in the breccia are crackled and healed and rimmed by tetrahedrite. Brecciation and veining are conspicuous throughout.

The four test pits from the Southern Tail zone used to supply ore for the pilot mill in 1976 were used again this year to supply approximately 59 tonnes of ore for metallurgical testing to be carried out by Boliden. The pits (Nos. A, B, C, and D) are located basically along the north-south line for a distance of approximately 275 metres. Another pit was dug immediately south of the northernmost pit, pit C. A highly fractured and sulphide-healed dust tuff is the host rock in all five pits, cut by postmineral dykes of quartz feldspar porphyry with apparent widths up to 10 metres (pit B) and andesite with widths up to 1.8 metres (pit C). Shearing attitudes in pits A and D strike 010 degrees and dip 55 degrees southwest which happens to parallel the assumed general attitude of the orebodies on the property.

A small program of backhoe trenching in the northeast section of the cleared millsite was tested for massive galena-sphalerite float that was found last year. Although no direct source was discovered, more pieces of float were encountered. Bedrock, in this area 2 metres and 3 metres deep, consisted of a dust tuff similar to that of the Southern Tail zone with varying amounts of chalcopyrite, pyrite, tetrahedrite, and tourmaline-filled fractures.

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

POPLAR (93L/2W; 93E/15W)

The POPLAR copper-molybdenum prospect is situated on the north side of Tagetochlain Lake approximately 50 kilometres southwest of Houston.

During 1977 Utah Mines Ltd. tested the Main zone with four diamond-drill holes and the Eastern zone with two diamond-drill holes. Drilling on the Main zone confirmed the presence of previously known copper-molybdenum mineralization in a highly altered biotite feldspar porphyry. The outline of mineralization appears to have been delineated on the Main zone.

The Eastern zone is situated approximately 3 kilometres east of the Main zone and consists of pyrite and chalcopyrite in a biotite granodiorite to quartz monzonite host. Chloritic alteration is locally very strong. Host andesitic volcanic rocks contain only pyrite as does a younger intrusive quartz-eye porphyry.

References: *B.C. Ministry of Mines & Pet. Res.,* GEM, 1972, p. 373; 1974, pp. 256, 257; 1975, pp. 138, 139; *B.C. Ministry of Mines & Pet. Res.,* Geological Fieldwork, 1976, pp. 56, 57; Assessment Reports 5360, 5586, 5679, 6065, 6136.

SILVER QUEEN (93L/2E)

The SILVER QUEEN gold-silver-copper-lead-zinc mine is located 45 kilometres south of Houston. New Frontier Exploration Inc. acquired an option on the property and during 1977 carried out exploration work aimed at increasing known reserves which have been estimated to be in the order of 362 800 tonnes, grading gold, 34.28 ppm; silver, 342.8 ppm; copper, 0.76 per cent; lead, 2.1 per cent; and zinc, 6 per cent. The ore occurs in eight subparallel veins which occupy fracture zones in gently dipping acid volcanic rocks. To date all the veins have been exposed on the surface, but only one, the Main vein, has been developed by underground workings.

During 1977 a trailer camp was set up and two wedge holes were diamond drilled to test for an extension of the main mine vein from a point 396.2 metres southeast of the furthest drift face (old NG-3 set-up). Two deep holes were drilled from Bralorne 74-3 set-up at angles of −60 degrees and −75 degrees to test for ore at depth. These holes intersected a structural zone with gouge but nothing which could be considered as a definite continuation of the Main vein. Weak vein mineralization only was encountered.

Most of the previous core had been laid out and was very briefly examined. Two points of interest were the abundance of gypsum veining and the presence of purple fluorite. The rocks have some similar appearances to rocks at the Sam Goosly silver prospect located 30 kilometres to the east (especially the abundance of pyrite), but they lack significant fracturing and sulphide healing.

References: *B.C. Ministry of Mines & Pet. Res.,* GEM, 1969, pp. 126-139; 1970, pp. 134-137; 1973, pp. 338, 339; 1974, p. 256; *B.C. Ministry of Mines & Pet. Res.,* Geological Fieldwork, 1974, p. 79.

GROUSE (93L/7E)

The GROUSE claims are located 5 kilometres north of Houston on Mount Harry Davis. Recent road building to a new VOR communciations tower on a knob immediately north of the microwave tower has exposed a sequence of rhyolite breccia which hosts some galena-sphalerite-chalcopyrite mineralization. Two showings exist: a 'main' showing and a 'southwest' showing located 45 metres to the southwest. The main showing consists of galena, sphalerite, and chalcopyrite in veins, in interstices, and as disseminations within a 'bleached' pale green to dark grey-coloured acid pyroclastic over a length of 18 metres. Purple fluorite veining also occurs. Unmineralized and unaltered acid pyroclastic rocks are massive black to dark green 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.

LAKEVIEW (93L/7E)

The LAKEVIEW copper prospect is located 10 kilometres north of Houston. During 1977 John Bot of Smithers restaked the old property which was examined by numerous mining companies. 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. The length of the mineralized zone is greater than 400 metres and appears to follow the contact between footwall pink acid pyroclastic rocks and hangingwall green acid pyroclastic rocks. Beds are up to 3 metres in width including 1.8 metres of solid specular hematite, chalcopyrite, and pyrite trending 040 degrees with a nearly vertical dip. Unmineralized basic volcanic dykes averaging 1.3 metres in width cut the volcanic sequence and the mineralization.

Approximately 180 tonnes of copper ore remains on the property in old dumps.

References: *Minister of Mines, B.C.,* Ann. Rept., 1926, p. 122; 1966, p. 102; 1967, p. 108; 1968, p. 138; *B.C. Ministry of Mines & Pet. Res.,* GEM, 1969, p. 121; 1970, p. 151; 1971, p. 173; Assessment Report 2145.

ASCOT (93L/10E)

The ASCOT zinc-lead property is located 20 kilometres east of Smithers. Geological mapping and a geochemical survey were conducted by Petra Gem Exploration Limited on the ex-Texasgulf (1966-68) property. Several small stratigraphically controlled lead-zinc-barite showings have been discovered in a sequence of complexly folded volcanic and sedimentary rocks of probable Hazelton Group. Galena, sphalerite, and occasionally pyrite occur as disseminations in acid tuffs, and along bedding planes in impure limestone. Irregular veins or lenses of coarsely crystalline barite and calcite containing sphalerite and some galena are also present. Two grab samples of mineralized impure limestone assayed: lead, 6.50 per cent and zinc, 7.50 per cent.

References: *Minister of Mines, B.C.,* Ann. Rept., 1968, p. 121; *B.C. Ministry of Mines & Pet. Res.,* GEM, 1969, p. 100; Assessment Reports 1702, 2139, 2140, 2141.

SUMMIT (93L/10W)

The SUMMIT copper prospect is located near Burbridge Lake approximately 30 kilometres east-southeast of Smithers. Asarco, under an option agreement with M. H. Chapman of Smithers, diamond drilled six holes totalling approximately 344.5 metres. Pyrite, chalcopyrite, and minor molybdenite occur within an altered 180-metre sill (?) of diorite composition intrusive into a volcanic package of Hazelton Group acid and basic pyroclastic rocks on the south and mainly highly epidotized and chloritized andesite to the north. Rocks have a general strike of 310 degrees with relatively flat dips to the southwest (for example, 35 degrees). Mineralization appears to exist in the upper part of the diorite sill which is highly altered (saussurite + chlorite + quartz stockwork) very fine-grained pyrite and chalcopyrite with minor molybdenite. The lower part of the sill is much less altered (mainly chloritization) and contains only traces of mineralization.

References: *B.C. Ministry of Mines & Pet. Res.*, GEM, 1973, p. 345; *B.C. Ministry of Mines & Pet. Res.*, Geological Fieldwork, 1974, p. 82; Assessment Report 5422; Mineral Inventory 93L-223.

SNOWSHOE (93L/14W)

The Snowshoe (Empire) vein prospect is located on the east flank of Hudson Bay Mountain approximately 5 kilometres west of Smithers. During December 1976 and January 1977, a 76.2-metre crosscut adit was driven to intersect sulphide ore which is exposed on surface as replacement vein(s) varying in width from 15 centimetres to 60 centimetres. The ore consists of galena, sphalerite, tetrahedrite, arsenopyrite, chalcopyrite, and pyrite in shear zones within hydrothermally altered rhyolitic and andesitic rocks of the Hazelton Group which strike north to north 16 degrees west and dip east to northeast at steep angles.

During the past winter three men worked on the driving of a tunnel. At a point approximately 64 metres in from the portal, a 10-centimetre vein dipping at 60 degrees to the east was encountered and drifted on to the southeast for approximately 4 metres where much of the vein had been crushed into a gouge material. The massive vein consisted of banded tetrahedrite, galena, pyrite, and arsenopyrite in a quartz gangue. Assays of a grab specimen yielded: gold, 21 ppm; silver, 3 064 ppm; copper, 0.3 per cent; lead, 9.85 per cent; and zinc, 3.38 per cent.

At the face of the crosscut a bleached 'pink' rhyolite is highly fractured and veined with chalcopyrite, bornite, and pyrite. Disseminations of this mineralization also occur. The principal rock type encountered in the adit is a 'grey' rhyolite and the 'pink' rhyolite is probably an altered variety. Alteration is primarily weak sericitization, chloritization (after biotite when present), and carbonatization. Late calcite veining is prominent in the mineralized 'pink' rhyolite. An assay of a grab sample of typical chalcopyrite-bornite mineralization in the 'pink' rhyolite yielded 0.274 per cent copper.

No further work was carried out during 1977.

References: *Minister of Mines, B.C.*, Ann. Rept., 1937, pp. 19, 20; 1966, pp. 90, 91; 1968, pp. 120, 121.

MOLLY BLUE (93M/13E)

The MOLLY BLUE molybdenum prospect is located on the west flank of Kisgegas Peak, 56 kilometres north of Hazelton. The ex-Amax Exploration, Inc. property (1963-66) was restaked by John Bot of Smithers who has prospected and sampled the prospect this summer.

A granodiorite to quartz monzonite stock of probable Eocene age intrudes interbedded argillites and greywackes with minor conglomerate and limestone belonging to the Bowser Assemblage. The rocks have been only slightly regionally metamorphosed but adjacent to the stock a good hornfels zone has been developed with some secondary biotite in pelitic sedimentary rocks and skarn with epidote and red garnet in limy sedimentary rocks. In the vicinity of the stock the sedimentary rocks are warped so that they conform roughly to the attitude of the contact.

The pear-shaped granodiorite stock, trending east-west with a length of 1 524 metres and a width of 610 metres, is cut by a quartz vein stockwork of varying intensity. An aureole of pyrite and pyrrhotite extends outward for about 60 metres into the sedimentary rocks. The stock is cut by four types of dykes: aplite, mafic granodiorite, granodiorite, and basalt.

Alteration includes potash feldspathization associated with an early random quartz vein stockwork containing minor amounts of disseminated molybdenite and sericitization and argillization up to 10 metres in width associated with shear zones and quartz vein stockwork within the core of the stock.

Veining appears to be the most important control for both mineralization and alteration. All dyke rocks except the basalt contain different stages and types of veins.

Mineralization consists of molybdenite, chalcopyrite, pyrite, and minor sphalerite and stibnite in mainly quartz veins varying in width from 1 centimetre to 60 centimetres. Gypsum and fluorite have been observed. The most regular set of veins trends 055 degrees with a dip of 70 degrees northwest. Mineralized veins also extend into the hornfels.

References: *Minister of Mines, B.C.*, Ann. Rept., 1966, p. 81; Mineral Inventory 93M-82.

SPUR (94D/2W)

The SPUR prospect belonging to Canadian Nickel Company Limited is located approximately 145 kilometres north of Smithers on Tsaytut Spur at the southwest end of Bear Lake. The property is underlain by a sequence of easterly dipping Takla Group (?) volcanic units (intercalated basalt-andesite and volcaniclastic rocks). Mineralization occurs mainly within or near a contact zone between basic lava flows and a volcaniclastic series and consists of chalcocite, bornite, chalcopyrite, and malachite-azurite in fracture fillings, irregular vein systems, and possibly along bedding planes. Pyrite is conspicuously absent. Mineralization appears to be controlled by a major north-northeast-trending fault and a series of numerous crosscutting faults. High-grade pods of massive sulphide occur locally. Canadian Nickel diamond drilled four holes during the summer.

References: Assessment Report 5681; Mineral Inventory 94D-103.

IN (94D/3W, 6W)

The IN porphyry copper prospect, under option by Cities Service Minerals Corporation from Canadian Superior Exploration Limited, is located 30 kilometres west-northwest from the north end of Bear Lake, approximately 320 kilometres north of Smithers.

Cities Service diamond drilled two holes totalling approximately 440 metres in a previously untested zone. Typical altered biotite feldspar porphyry and quartz feldspar porphyry with varying amounts of chalcopyrite, molybdenite, and pyrite on fractures, in quartz veins, and as disseminations were encountered. A large area of the prominent rust-stained mountain underlain by the complex of apparent dyke-like intrusions remains to be tested.

References: *Minister of Mines, B.C.,* Ann. Rept., 1966, p. 81; *B.C. Ministry of Mines & Pet. Res.,* GEM, 1972, p. 479; 1973, p. 405; *B.C. Ministry of Mines & Pet. Res.,* Geological Fieldwork, 1976, pp. 65, 66; Assessment Report 3868, 4563.

BELL MOLYBDENUM (103P/6W)

The Bell Molybdenum property is located 10 kilometres southeast of Alice Arm. During 1977 Climax Molybdenum Corporation of British Columbia Limited drilled nine vertical holes totalling approximately 2 678 metres to test for more molybdenum ore outside the main known mineralized zone, and in the Southwest zone. Three holes, that were drilled on the Southwest zone, intersected mineralization at depth; three holes were drilled north-northwest of the Main zone; one hole was drilled to the northwest; and two holes were drilled between the Main zone and the Southwest zone. A sequence of Quaternary basalt capping unconsolidated gravels, hornfelsed sedimentary rocks, and intrusive quartz monzonite was encountered on the Southwest zone. The remaining holes intersected weakly mineralized hornfels. The geometry of the intrusive rocks is not known but may be in the form of apophyses from a deeply buried stock. A medium to dark grey-coloured diorite feldspar porphyry was intersected at depth (500 metres) in the one hole located approximately 675 metres northwest of the Main zone. Minor amounts of molybdenite mineralization in the form of selvages in quartz veinlets occur in both the quartz monzonite and biotite hornfels. Significant amounts of pyrite and pyrrhotite occur as disseminations and as fracture fillings.

References: *Minister of Mines, B.C.,* Ann. Rept., 1967, pp. 44-47; *B.C. Ministry of Mines & Pet. Res.,* Geological Fieldwork, 1976, p. 58.

STAR (104J/4E)

The STAR porphyry copper prospect owned by United Cambridge Mines Limited is located 55 kilometres northwest of Telegraph Creek. Road building and trenching during 1977 on the east and west sides of Dick Creek (first creek west of Copper Creek on the north side of Hackett River) have exposed disseminated and fracture-filled chalcopyrite, pyrite, malachite, azurite, and minor bornite mineralization in an altered hornblende diorite to granodiorite near the contact with Upper Triassic tuffs and andesite. Magnetite is also a prominent constituent in areas of mineralization and chalcopyrite replaces mafic minerals. Major lineaments appear to trend northwesterly, consistent with regional trends. A skarn zone containing fine-grained magnetite and chalcopyrite is situated on the east side of Dick Creek.

Grab samples of typical mineralized intrusive rock from trenches on the west side of Dick Creek returned values of 0.33 to 0.87 per cent copper. One grab sample of fine-grained skarn from outcrop on the east side of Dick Creek assayed 0.72 per cent copper.

An access road was constructed from the base camp near the head of Dick Creek eastward to Copper Creek.

References: *B.C. Ministry of Mines & Pet. Res.,* GEM, 1971, pp. 48, 49; 1972, pp. 547-549; Assessment Reports 3514, 3515, 3516.

LOGTUNG (104O/13E)

The Logtung tungsten-molybdenum prospect is located on the British Columbia-Yukon border 66 kilometres southeast of Teslin (turnoff Kilometre 1213, Alaska Highway). It was discovered by Cordilleran Engineering Ltd. (managers of the program for the 1976 Bath Uranium Partnership Limited, 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.

Late Paleozoic (?) metasedimentary rocks flanked to the east and west by northerly elongate diroite bodies underlie the headwaters of West Logjam Creek. A younger quartz monzonite stock forms the southeastern boundary of the showings; several quartz monzonite porphyry dykes occur as off-shoots. The metasedimentary rocks are variously altered to brown hornfels or light to dark green garnet-diopside skarn in the vicinity of the mineralized zones.

Three mineralized zones are recognized: the southernmost, the B.C. zone; the Central zone, and the Yukon zone. The latter two are probably a single continuous 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. 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.

During 1977, Amax reconstructed a 13-kilometre road to the property from the Alaska Highway, set up a trailer camp, and completed over 2 840 metres of diamond drilling in 14 holes.

HUM BIRD (114P/10W)

The HUM BIRD silver prospect, owned by Yukanda Mines Ltd., is located approximately 32 kilometres southwest of Milepost 87 on the Haines Road near Bear Camp. The property is underlain by a sequence of sedimentary rocks including limestone, shale, and sandstone, and volcanic rocks which strike generally north-south and dip 40 degrees to the west.

Replacement and vein-type occurrences of tetrahedrite, galena, sphalerite, chalcopyrite, and pyrite mineralization are contained in silicified and carbonatized limestone and sericite schist. These rocks have been folded, faulted, and locally intruded by diorite.

Six mineralized zones basically along a strike length of 3 500 metres are known: the Creek showing, Camp showing, Discovery showing, Cliff showiing, Ridge showing, and Southeast showing. The showings were explored by Ronex Explorations Ltd. in 1968 who completed a good deal of bulldozer trenching, established a grid, and conducted geophysical and geochemical surveys. In 1975 Asarco Ltd. conducted geological mapping.

No systematic sampling or diamond drilling has been done on the property. This summer a 32-kilometre access road to the property was upgraded but remained virtually impassable. A permanent camp was erected and mill equipment and a diamond drill were brought to the property but were not used.

References: *B.C. Ministry of Mines & Pet. Res.*, GEM, 1975, p. G 196; Mineral Inventory 114P-18, 24, 25, 26.

OTHER INVESTIGATIONS

GEOLOGY OF THE PRECAMBRIAN PURCELL SUPERGROUP CRANBROOK–FORT STEELE AREA (82G/11, 12)

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INTRODUCTION

During the summer of 1977, approximately 120 square kilometres of Purcell strata in a northwest-trending strip along the eastern edge of the Rocky Mountain Trench between the Bull and Wild Horse Rivers (Fig. 15) was mapped at a scale of 1:25 000. The main objects of the study were to examine the stratigraphy of the Helikian Purcell succession; determine lateral and vertical sedimentary environment associations; outline major structures; and investigate the relationship of faulting to sedimentation, with particular emphasis on evidence for or against syn-depositional faulting. This study forms part of a Ph.D. thesis being completed at Queen's University and has been supported, in part, by the British Columbia Ministry of Mines and Petroleum Resources.

STRATIGRAPHY

The formation names used in this report are those proposed by Leech (1958), and the subdivision of the Aldridge Formation follows the criteria outlined by Edmunds (1973). The stratigraphy of the Aldridge through Gateway Formations was studied north of the Dibble Creek fault, whereas south of the fault only the Creston and Kitchener-Siyeh Formations were examined during the 1977 field season. Estimates of formation thicknesses, their spatial variability, and a comprehensive interpretation of sedimentary environments will not be made until mapping of Purcell strata between the Boulder Creek fault and Sand Creek and section measurement has been completed. The following discussion summarizes the stratigraphic characteristics of the field mapping units chosen.

Aldridge Formation: The oldest rocks (Paleo-Helikian) exposed in the map-area belong to the Middle Aldridge Formation. Three distinct sedimentary packages characterized by abundant thin to thick-bedded laterally continuous, pyritic, fine to medium-grained quartzite are recognized. Each quartzite bed generally displays graded bedding in the top few centimetres, may contain black argillaceous rip-up clasts, and usually has flute or load casts along its base. Thus, the quartzites resemble the A unit of the Bouma turbidite sequence (*see* Walker, 1976). A preliminary study of flute cast orientations indicates a south to southwest source direction for these quartzites. Between successive thin to thick quartzite beds, pyritic, crossbedded, or laminated, very fine-grained quartzite or siltite, up to a few metres thick, may occur.

Separating these quartzite units are thick sequences of grey pyritic slate with rare darker laminae and occasional abundant limestone nodules, laminated very thin-bedded, light and dark grey, pyritic slate, minor brown-weathering, light grey siltite very thinly interbedded with grey-weathering, dark grey siltite, and rare very thin-bedded, crossbedded siltites or quartzites.

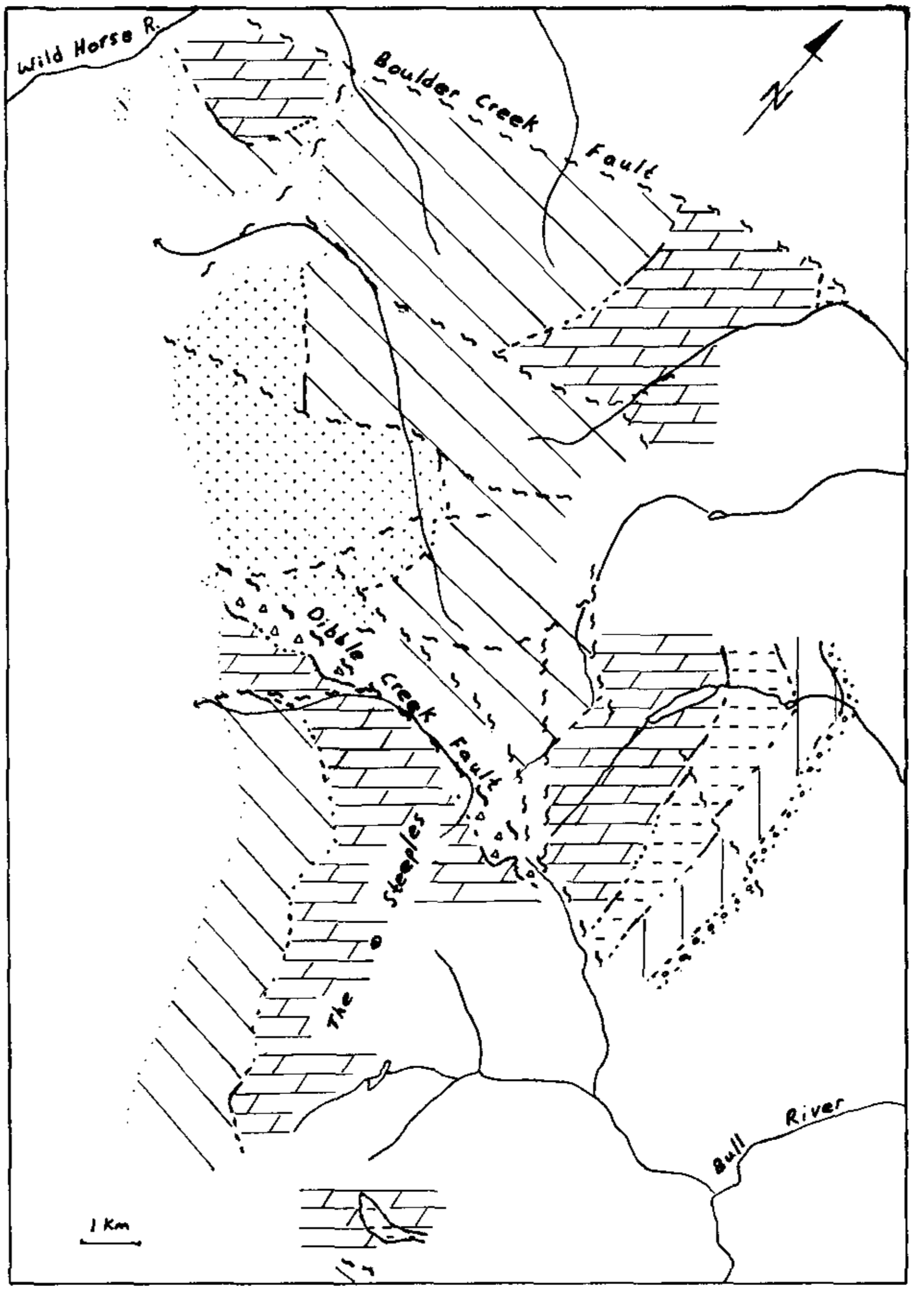

Figure 15. Generalized geology of the Purcell Supergroup between the Bull and Wild Horse Rivers, Cranbrook-Fort Steele area.

LEGEND

DEVONIAN

BASAL UNIT: DOLOMITE BRECCIA, SANDY DOLOMITE, QUARTZITE; OVERLAIN BY LIMESTONE, SHALY LIMESTONE, AND SHALE

CAMBRIAN

CRANBROOK FORMATION: QUARTZITE, CONGLOMERATE, AND SANDSTONE

PRECAMBRIAN

PURCELL SUPERGROUP

GATEWAY FORMATION: MICACEOUS SILTITE, DOLOMITE, WITH MINOR SANDSTONE

KITCHENER-SIYEH FORMATION – UPPER PART: SILTITE, PURCELL LAVA AT TOP

KITCHENER-SIYEH FORMATION – LOWER PART: DOLOMITE, SILTY DOLOMITE, ARGILLACEOUS DOLOMITE, AND DOLOMITIC ARGILLITE

CRESTON FORMATION: SILTITE, WITH LENTICULAR QUARTZITE LENSES

ALDRIDGE FORMATION: QUARTZITE, SILTITE, AND PHYLLITIC ARGILLITE

SYMBOLS

GEOLOGIC CONTACT: KNOWN, APPROXIMATE, ASSUMED . . . . .

FAULT . . . .

Above the uppermost quartzite sequence are the rusty weathering, pyritic, medium and dark grey, interlaminated phyllitic argillites of the Upper Aldridge Formation. Abundant crossbedded or laminated, light grey siltite occurs in zones at both the base and top of the unit.

Creston Formation: Rocks of the Upper Aldridge Formation grade into those of the Creston Formation over a distance of a few hundred metres. A distinctive irregularly interlaminated to very thinly interbedded, light green or grey and black siltite forms the basal Creston Formation throughout the map-area. Mud cracks, cut and fill, load-casting, and rusty weathering blotches are common. This unit always grades upward into discontinuously interlaminated to very thinly interbedded, light and darker green siltites with occasional thin-bedded, lenticular, fine-grained quartzites that are frequently crossbedded and often contain rip-up clasts. Mud cracks, ripple marks, cut and fill, and load casts are common sedimentary structures. A number of mappable units of variable thicknesses, order of succession, and lateral continuity occur above this. These include:

(1) Rocks with similar sedimentary structures and lithologies, but with green-purple, green-green, or less commonly purple-purple-coloured siltite couplets. This unit has not yet been recognized south of the Dibble Creek fault.

(2) Rocks with similar sedimentary structures and lithologies, but with quartzites comprising 15 to 35 per cent of the section, and occurring as tabular lenses up to 20 metres thick. The siltites are green or purple in colour and dolomitic interbeds are common in both lithologies, especially near the top of the unit. This unit occurs only near the top of the Creston Formation and is found on both sides of the Dibble Creek fault.

(3) Very thin-bedded purple siltite, with minor discontinuously laminated green siltite couplets and thin-bedded, lenticular, fine-grained quartzite that is often crossbedded and contains rip-up clasts. Mud cracks and load casts are locally abundant. Although this lithologic unit is recognized on both sides of the Dibble Creek fault, its stratigraphic position is different on either side of the fault.

(4) A unit characterized by abundant thin-bedded grey-purple or purple-mottled grey, coarse siltite, with minor green or purple discontinuously laminated siltite couplets and thin-bedded, lenticular, fine-grained quartzite that often contains rip-up clasts, mud cracks, load casts, and cut and fill structures that are associated with the laminated siltites and quartzite beds. This unit has not yet been recognized south of the Boulder Creek fault.

(5) Parallel-bedded, thin-bedded, very fine-grained quartzites, with some very thin siltite interbeds. This unit is only recognized near Lone Peak.

Kitchener-Siyeh Formation: Almost everywhere rocks of the Kitchener-Siyeh Formation transitionally overlie those of the Creston Formation. The change to dolomitic argillites from green siltites usually occurs over a distance in the order of a hundred metres, while the transition from Creston map unit 2 occurs over a much shorter interval.

The lower (dolomitic or Kitchener) part of the Kitchener-Siyeh Formation shows pronounced changes in general stratigraphy and thickness across the Dibble Creek fault. To the south of Sunken Creek, a few tens of metres of dolomitic siltite and argillite, locally containing white crossbedded quartzite lenses, occur above the contact with the Creston Formation. The remainder of the Lower Kitchener-Siyeh Formation is interbedded thin to thick-bedded dolomite or silty dolomite with well-developed molar-tooth structures or limestone pods, very thin-bedded grey or green siltite, lesser dolomite with discontinuous thin black argillite laminae with or without molar-tooth structures, minor very thin lenses of dolomitic, fine-grained sandstone; and occasional thin algal stromatolite beds. A zone of well-developed algal head stromatolites, approximately 20 metres thick, occurs near the top of the unit, and is only found to the south of the Dibble Creek fault. This zone is in a similar stratigraphic position to an algal stromatolite zone found in the eastern Rocky Mountains. The latter stromatolite zone extends from Marias Pass, Montana to North Kootenay Pass, British Columbia (*see* Price, 1964), and the zone found on the steeples may be a continuation of it.

To the north of the Dibble Creek fault a relatively thick sequence of dolomitic argillites, argillites, argillaceous dolomite, minor dolomite, and rare dolomitic quartzite lenses occurs at the base of the Kitchener-Siyeh Formation. Mud cracks and pyrite are locally abundant in the argillaceous rocks. Above this is a unit of interbedded thin to thick-bedded dolomite, containing discontinuous chaotic black argillite partings, with or without molar-tooth structures, dolomite or silty dolomite with molar-tooth structures or limestone pods, very thin-bedded grey siltite, and minor very thin lenticular dolomitic or calcareous quartzites.

In most areas, the transition to siltites of the upper (non-dolomitic or Siyeh) part of the Kitchener-Siyeh Formation occurs over a very short interval. However, near Cliff Lake the transition takes place over a thickness of a few hundred metres and is a mappable unit. Green, or locally purple, very thin-bedded to discontinuously laminated siltites, and minor thin-bedded fine to medium-grained dolomitic sandstone lenses comprise the siltite unit. Sedimentary structures such as mud cracks, ripples, crossbedding, cut and fill, and rip-up breccias are extremely abundant throughout. South of the Dibble Creek fault this unit has the same characteristics. Its top was not observed in the area mapped since sandy dolomitic breccias, sandy dolomites, and granule to fine sand-sized quartz arenites of the basal Devonian unconformably overlie the Kitchener-Siyeh Formation in this region.

Purcell Lava: North of the Dibble Creek fault, the lowermost flow or associated crystal tuff of the Purcell lava overlies the upper siltite unit with a sharp contact. These green or purple-weathering flows are chloritized or sericitized plagioclase porphyries and most contain quartz, calcite, or specularite-filled amygdules. Sedimentary sequences up to 25 metres thick, consisting of laminated green or purple siltite, with thin lenses of dolomitic sandstone and minor very thin-bedded dolomite or bedded crystal tuff, occur between some of the flows. Immediately east of Cliff Lake, the sedimentary interbeds are thickest and most numerous. The number of interbeds and their thicknesses decrease markedly along strike to the north and south from there. The uppermost lava flow has at least 2 metres of local relief on its upper surface. Parallel laminated siltites and dolomitic sandstones of the Gateway Formation overlap this surface.

Gateway Formation: The Gateway Formation is divisible into three general units. The Lower Gateway Formation consists of tan-weathering, light-coloured dolomite, stromatolitic dolomite, and dolomitic siltite, green or purple discontinuously laminated siltites, thin-bedded red micaceous fine-grained sandstone, and locally, purple thin-bedded fine to coarse-grained quartz arenites in tabular lenses 3 to 4 metres thick. Mud cracks and ripples are locally abundant. Purple or green thin-bedded to discontinuously laminated, micaceous siltites and minor lenticular very fine-grained quartzite comprise the middle part of the Gateway Formation. Mud chip breccias, mud cracks, and salt casts occur locally. The presence of dolomitic siltites and thin dolomitic lenses and layers interbedded with the green or purple siltites characterizes the Upper Gateway Formation. Mud cracks, salt casts, and ripple marks are present in siltite layers. In most areas, this formation is truncated with slight angularity by the white, pink, or grey quartzites and quartz-rich grits and conglomerates of the Lower Cambrian Cranbrook Formation. A transition to micaceous, maroon, fine-grained sandstones, that may belong to the Phillips Formation, was observed below this unconformity on the ridge immediately north of Dibble Creek.

Intrusive Rocks: Although numerous hornblende-plagioclase sills and dykes were observed in the Lower Purcell formations, none were seen in the Upper Purcell formations. Narrow contact metamorphic zones border the larger 'sills' in the Aldridge and Creston Formations, while wide zones of 'bleached' dolomitic rock occur around the 'sills' in the Kitchener-Siyeh Formation.

STRUCTURE

The Dibble Creek fault is the dominant structural feature, dividing the map-area into two stratigraphic and structural regions. South of the fault Devonian rocks unconformably overlie the Kitchener-Siyeh Formation, while the Upper Purcell formations have been removed. Strata are in open folds that plunge gently to the northeast and significant faults are apparently rare. Between the Boulder Creek and Dibble Creek faults, a more complete section of Purcell stratigraphy from the Aldridge to the Gateway Formation is found beneath the Cambrian unconformity. Numerous faults cut the area. In the region around Maus Creek, the strata are deformed into mesoscopic to megascopic asymmetric folds, with one limb striking northwest and dipping northeast and the other limb striking north and dipping steeply east or overturned to the west. To the east of this area, around Cliff Lake, strata are dominantly north striking, steep easterly dipping, or slightly overturned to the west; to the northeast toward the Boulder Creek fault, strata strike northwesterly and dip steeply to moderately northeast. Locally strata are overturned to the west by northwesterly plunging folds.

MINERALIZATION

Chalcopyrite and pyrite, and less commonly galena, are found associated with quartz veins. These occurrences are restricted to the Aldridge, Creston, and Lower Kitchener-Siyeh Formations, and most of those observed have already been mined or explored by adits.

ACKNOWLEDGMENTS

I would like to thank Wendy Comfort for her cheerful accompaniment in the field; Mr. and Mrs. A. Comfort for their encouragement and use of accommodation on their ranch; and Dr. R. Edmunds of Cominco Ltd. and Dr. T. Hoy of the British Columbia Ministry of Mines and Petroleum Resources for an introduction to Aldridge stratigraphy in neighbouring areas.

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STRUCTURAL GEOLOGY OF THE BIG LEDGE AREA (82L/8E)

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INTRODUCTION

James T. Fyles (1966) reviewed the geology and economic potential of lead-zinc mineralization in the Kootenay Arc and the Shuswap Complex. Polyphase deformation and high-grade metamorphism of Shuswap deposits necessitates detailed structural mapping for evaluating their economic potential.

Mapping around the margins of the Frenchman Cap gneiss dome by Fyles (1970) represents the first significant study of the structural geometry of stratabound lead-zinc mineralization in the Shuswap Complex. Mapping around the Big Ledge and Mount Symonds prospects on the southern margin of the Thor-Odin gneiss dome by Reesor and Moore (1970) and Höy (1977) indicated considerable structural complexity. The present study was initiated to complete a detailed structural analysis of the southern margin of the Thor-Odin dome.

The project has involved three summers' field work supported in part by the British Columbia Ministry of Mines and Petroleum Resources, the Penrose Fund of the Geological Society of America, and National Research Council Grant No. 4222 to H. J. Greenwood. Tony Hodge, Dita Runkle, Joan Grette, Randy Parrish, Mark and Sue Harrison, and Graeme Nixon acted as field assistants at various times. Each contributed greatly to the completion of the fieldwork. The project was supervised by Hugh Greenwood who has been a constant source of ideas and suggestions. Peter Read and Trygve Höy discussed aspects of the project at various times, and made useful comments.

GENERAL GEOLOGY

The general geology of the Thor-Odin gneiss dome has been described by Reesor and Moore (1970) and in part by Höy (1977). The area can be divided into three domains:

(1) the 'Core zone,' an autochthonous core domain, dominated by massive and layered 'granitic' gneisses of Hudsonian age (at least in part);

(2) the 'Mantling zone,' an imbricate domain, consisting of infolds of quartzite, calc-silicate, and schist cover rocks, sandwiched between thrust sheets of core gneisses; and

(3) the 'Fringe zone,' an allochthonous domain consisting of a complexly folded and imbricated sequence of cover rocks: quartzites, marbles, calc-silicates, schists, gneisses, and amphibolites possibly correlative with the Hamill quartzite-Badshot marble sequence of the Kootenay Arc.

Lead-zinc mineralization occurs in rocks of the Mantling zone as sporadic massive sulphide lenses and disseminations within thin units of quartzofeldspathic graphitic rocks and/or arenaceous marble. The mineralization occurs near, but not in, the massive white marble units that Reesor and Moore (1970) and Höy (1977) suggest could be equivalent to the Badshot Formation. The lead-zinc mineralization is stratabound and appears to have been involved in most, if not all, of the deformational and metamorphic events imposed on the cover rock sequence.

GENERAL STRUCTURAL GEOLOGY

Detailed structural mapping and careful observation of refolded folds and geometrical patterns of lineations have enabled identification of the following sequence of distinct phases of deformation:

Phase 1 structures occur as rootless isoclinal folds with generally north-south-oriented fold axes. Interference with later phases of deformation has produced complex, elongate dome and basin structures. Phase 1 structures are typically isolated outcrop-scale folds; however, a few folds on a scale of kilometres have been mapped.

Phase 2 structures are tight to isoclinal recumbent folds with generally east-west-oriented fold axes. Detailed mapping has revealed that phase 2 was a multiple event, composed of two distinct generations of co-axial folding. Both generations, labelled F2A and F2B, refold phase 1 folds and lineations. All three folds can be identified superimposed on one another in a single outcrop.

Phase 3 folds are northwest-trending flexural slip folds with upright axial planes. These folds are rarely developed on an outcrop scale.

Phase 4 folds are southwest-trending flexural slip folds with upright axial planes. Large-scale (chevron style) phase 4 folds are conspicuous on the western margin of the dome.

Phase 5 folds are broad, open flexures with upright north-south-trending axial planes and a nonpenetrative axial-plane fracture cleavage.

STRUCTURE OF THE BIG LEDGE AREA

Preliminary mapping by Höy (1977) suggested that the distribution of lithologies in the Big Ledge area is controlled by large-scale isoclinal folds overturned to the north. Höy further suggested that the mineralized zone occurred in the hinge of an antiform. Detailed mapping has confirmed the essential features of Höy's interpretation.

Mesoscopic structures in the area are dominated by open to isoclinal F2B folds with axial planes dipping 15 to 25 degrees to the south. These structures refold co-axial, isoclinal F2A folds with more upright axial planes that are the same generation as the large-scale structures outlined by lithological repeats. As the large-scale folds are isoclinal and plunge subhorizontally, mainly parallel to the topography, it is rarely possible to trace units around their hinges. Hence, careful observation of the vergence of rare F2A mesoscopic folds is necessary. The existence of an F2A antiformal structure cored by the Big Ledge-Mount

Symonds mineralized zone is suggested by: (a) lithological repeats of the mineralized unit, a distinctive sillimanite-garnet rock and an arenaceous marble and (b) by a systematic reversal of F2A fold vergences. The hinge of this structure and clear overprinting by F2B structures can be seen on the eastern face of Mount Symonds.

To the west of Mount Symonds graphitic rocks in the same structural position as the Big Ledge horizon have been traced for 7 kilometres toward Mount Fosthall. At this point the sequence is doubled back on itself by a large-scale phase 1 antiformal closure, plunging steeply to the southwest and outlined by arenaceous marbles.

Structurally above the Big Ledge horizon, a mineralized unit has been mapped along the northern flank of Fosthall Ridge. This unit, which is on the shallow-dipping northern limb of the Mount Fosthall syncline (an F2B structure), is within a sequence of rocks lithologically similar to that in the Big Ledge area. It is possible that the two mineralized units are correlative and repeated by a high-angle normal fault, subparallel to the layering that has been mapped along the side of Fosthall Ridge. Movement along this fault could be coincident with the formation of the gneiss dome as has been suggested for the Standfast Creek slide by P. B. Read (personal communication).

CONCLUSIONS

The superficially simple outcrop pattern in the Big Ledge area reflects firstly, the intensity of F2A deformation and secondly, the co-axial nature of F2A and F2B. An understanding of the state of finite strain in these rocks, developed during this study, should be useful in interpreting drill-hole data and re-evaluating the economic potential of the area.

In a regional sense it is interesting to compare the Big Ledge structural sequence with that described by Fyles (1970) on the southern flank of the Frenchman Cap dome. The two generations of generally east-west-trending folds (F2A and F2B) at Big Ledge are similar in style and orientation to Fyles' F1 and F2. It is not possible, however, to correlate these structures until structural studies by other workers in the intervening area are completed.

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TULAMEEN COAL BASIN
(92H/7)

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INTRODUCTION

The Tulameen coal basin is situated about 20 kilometres northwest of Princeton and is elliptical in plan being about 5 kilometres long by 3 kilometres wide. The long axis trends northwest to southeast, and the basin forms a plateau at about 1 200 metres elevation. On its northeast, north, and southwest sides, the basin is rimmed by ridges of more resistant volcanic and metavolcanic rocks. In the south, the sedimentary rocks are protected from erosion by a younger basalt cap rock. The major portion of the basin is drained by Collins Gulch, which flows northeast through a pronounced watergap in the volcanic rocks (*see* Fig. 16).

Field mapping was carried out in the Tulameen coal basin for the British Columbia Ministry of Mines and Petroleum Resources during May, June, and July. Mapping was done at a scale of 1:7920 on airphoto enlargements provided by Cyprus Anvil Mining Corporation. The data collected is being plotted on a 1:5000-scale orthophoto map, and will update and extend previous work done in the area. Periodic visits were made to the area throughout the summer and fall to check the progress of the exploratory trenching and drilling being done by Cyprus Anvil on coal licences optioned from Imperial Metals and Power Ltd.

STRATIGRAPHY

The oldest rocks in the area are Upper Triassic metavolcanic rocks of the Nicola Group which are mainly greenstones and greenschists. In the south, near Blakeburn, this rock unit is contact metamorphosed to hornfels and contains pyrrhotite mineralization where cut by hornblende porphyry dykes.

All other rocks in the area are of Tertiary age. The oldest Tertiary units are lavas and volcaniclastic rocks of andesitic composition. The volcanic rocks are well exposed along the southwest and north perimeters of the basin. They conformably underlie basinal sedimentary rocks in both these areas; elsewhere the sedimentary rocks are directly underlain by Nicola rocks.

The sedimentary succession consists of three units. The basal unit is predominantly arkosic sandstone with clayey matrix, poor cementation, and interbeds of siltstone and Tertiary andesitic volcanic rocks. It is up to 100 metres thick, but may not be present everywhere. The second unit is predominantly fissile shale, up to 200 metres thick, with interbeds of coal, ash, and sandstone. The uppermost unit is mostly arkosic sandstone and pebble conglomerate with interbedded shale, ash, and coal in the lower sections. It is up to 700 metres thick, and poorly exposed, as are all the sedimentary rocks.

The sedimentary units are unconformably overlain by a succession of at least five flat-lying basalt flows. There are two possible source areas for these flows. One is just northwest of the main cap, and the other is

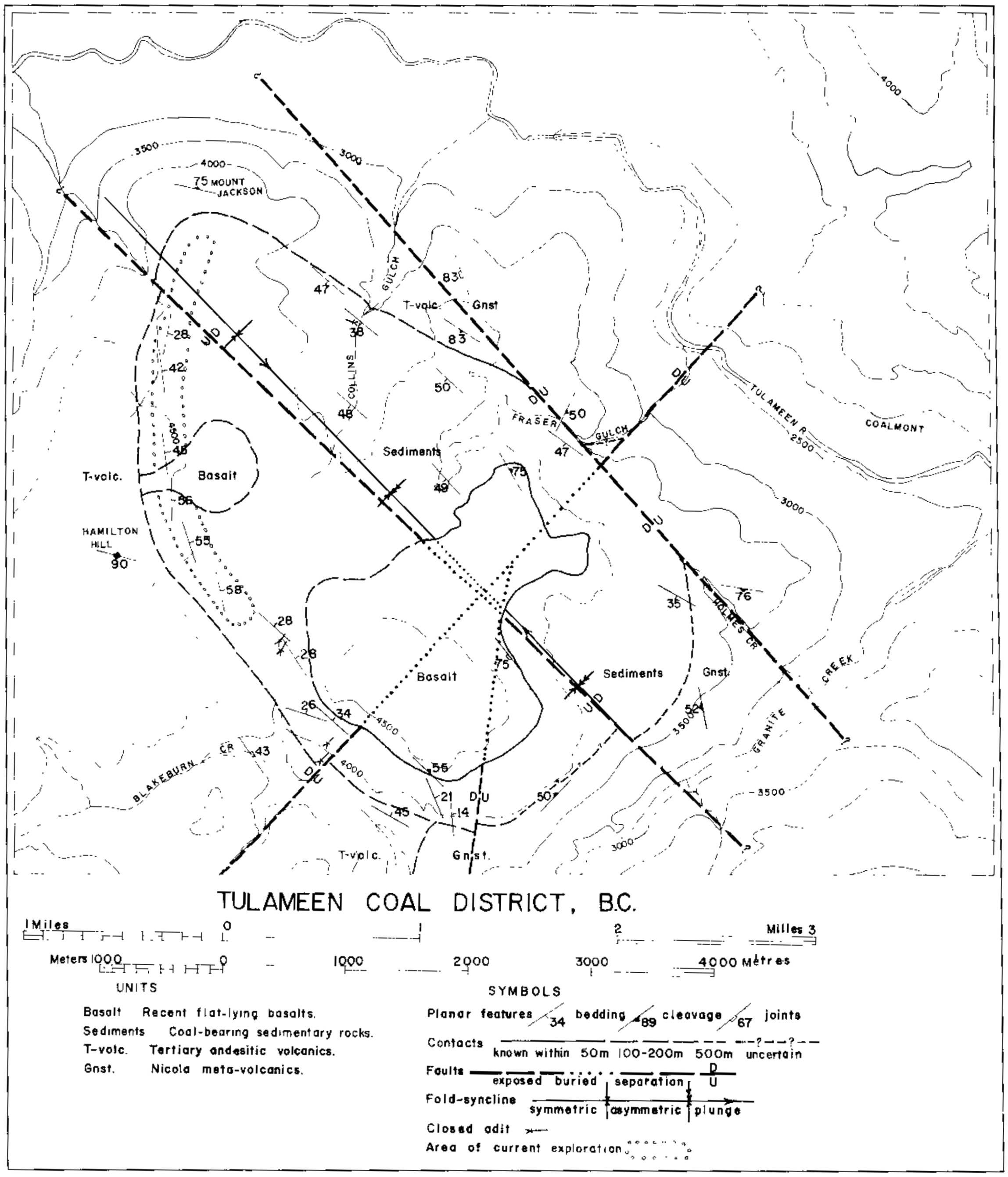

Figure 16. Tulameen Coal District.

in the northwest corner of the basin (*see* Fig. 16). The basalt forms extensive outcrops and has shed talus slopes which obscure the underlying strata.

STRUCTURE

The structure of the sedimentary rocks is a relatively simple syncline. In the northwest the fold is open, with both limbs dipping about 45 degrees. In the southeast, the syncline becomes asymmetric, with the northeast limb dipping 45 degrees, and the southwest limb dipping about 20 degrees. The fold trends northwest, and is doubly plunging toward the centre of the basin.

The basin is believed to be dissected by high-angle faults. At least two sets of lineations can be seen, one trending northwest and one trending northeast. Field data to substantiate these faults is sparse, but if correlation between coal seams proves feasible, offsets along these faults will be more accurately known.

COAL

Drilling by Cyprus Anvil has revealed at least three thick coal seams south of the northwest basalt occurrence. The main seam averages 15 to 20 metres. North of the basalt, volcanic layers are more abundant, and the seams can no longer be correlated. It is therefore not presently known if the seams are continuous.

ACKNOWLEDGMENTS

I would like to acknowledge the assistance of Cyprus Anvil Mining Corporation and their coal geologists Tom Adamson who have made available the results of the current exploration, sampling, and drilling program to the author. The assistance of Diane MacFarlane is also appreciated.

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GENESIS OF MAGNETITE DEPOSITS IN THE IRON MASK BATHOLITH (92I/9W, 10E)

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INTRODUCTION

The Iron Mask batholith, near Kamloops, contains several magnetite-rich rock units and a number of dyke-like magnetite lodes. Genesis of the magnetite lodes is not understood, and possible petrogenetic interrelations between the lodes and the batholithic rocks are being investigated by studying trace element patterns in magnetite from several localities and from different types of occurrences.

This study, under the direction of Professor Colin Godwin, is being supported financially by the British Columbia Ministry of Mines and Petroleum Resources and the University of British Columbia.

PURPOSE

Significant magnetite, in the form of dyke-like lodes (Cockfield, 1948), occurs in close spatial relationship to copper deposits such as the Afton mine. The genetic relationship of these massive magnetite lodes to the copper deposits of the Iron Mask is unknown, as is the origin of the magnetite deposits. However, the proximity of these deposits to magnetite-rich intrusive units of the Iron Mask batholith suggests that they might be magmatic injection deposits. The three main objectives of this study, therefore, are to:

(1) determine the origin of the magnetite lodes,
(2) determine which intrusive unit they originated from if they are magmatic,
(3) determine if relationships exist between magnetite deposits and copper mineralization.

FIELDWORK

Fieldwork in the area was completed in 1977. Magnetite lodes exposed in three pits 1.2 kilometres southeast of Afton (Fig. 17) were mapped at a scale of 1:120 (1 centimetre = 1.2 metres) and a large amount of core from the Afton property was examined for possible relationships between magnetite lodes and copper mineralization. More than 40 samples were collected (Fig. 17) for separation and analysis of the magnetite. Sampling was carried out on units defined by Northcote (1977). In addition to the samples shown on Figure 17, massive, disseminated and vein-like magnetite was sampled at Cherry Bluffs (approximately 11 kilometres west of Afton), and disseminated magnetite was sampled in fresh picrite on Watching Creek (Cockfield, 1948) on the north side of Kamloops Lake.

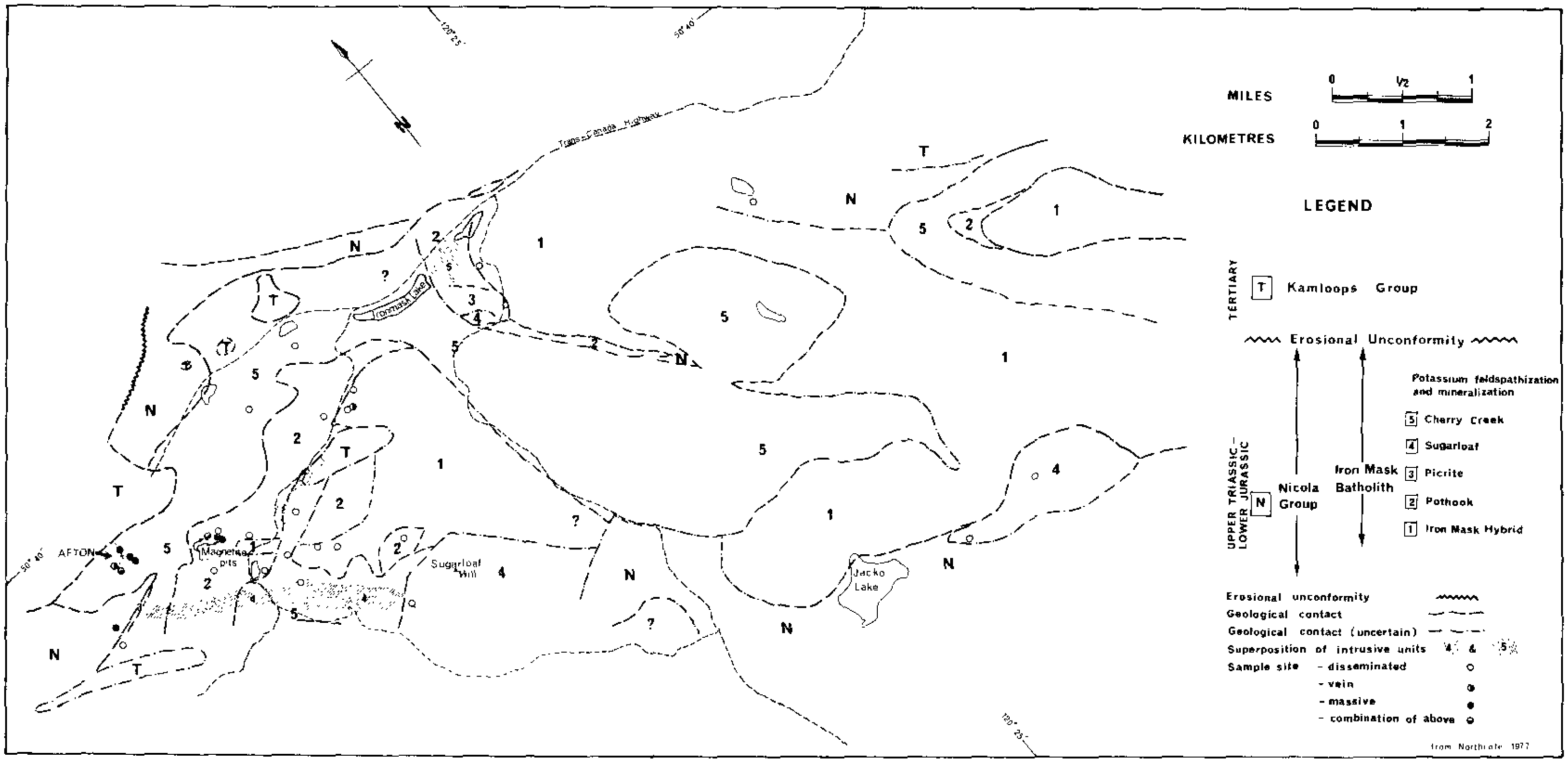

Figure 17. General geology and sample sites for magnetite study, Iron Mask batholith.

LABORATORY WORK

The principal method to be used in this study will be analysis of the magnetite for trace elements Ti, Cr, V, Cu, Pb, Zn, Mg, Mn, Ag, Ni, Co, and Cd. Distributions of these trace elements will allow correlations to be made that might indicate the unit which is the source of the magnetite in the lodes, and shed light on the genesis of these deposits. In addition, the stages of differentiation of units in the Iron Mask batholith might be reflected by the abundance of certain trace elements. Analyses will be conducted during the winter of 1977-78 by the atomic absorption methods.

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CACHE CREEK–NICOLA CONTACT ASHCROFT AREA (92I/11W)

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ABSTRACT

Mapping southwest of Ashcroft has revealed Paleozoic Cache Creek Group rocks which are both undeformed and structurally complex and which have a wide variation in metamorphism and rock type. Triassic Nicola Group rocks are generally hydrothermally altered volcanic rocks and volcanogenic sedimentary rocks which dip steeply to the southwest, and the Jurassic Ashcroft Formation consists of gently dipping conglomerate and folded shales. The Cache Creek-Nicola and the Cache Creek-Ashcroft contacts are thrust faults, while the Nicola-Ashcroft contact is probably an unconformity. The Nicola Group was deposited, hydrothermally altered, and tilted before deposition of the Ashcroft Formation. The Cache Creek Group was thrust over both the Nicola and Ashcroft rocks. Copper showings are found in greenstone, in contact with a quartz diorite and microdiorite intrusion on Red Hill and in quartz syenitic bodies within the Cache Creek Group.

INTRODUCTION

Detailed mapping on a scale of 1:15 840 was completed during 1977 in an 80-square-kilometre area southwest of Ashcroft. This mapping fills a gap between areas recently mapped by McMillan (1975), Travers (in press), and Grette (unpublished map). The area was previously mapped by Duffel and McTaggart (1952) and Carr (1962) did detailed mapping in the southeastern portion. The rocks underlying most of the area are primarily Nicola and Cache Creek with lesser amounts of Ashcroft Formation and Tertiary (?) basalt. The Trans-Canada Highway bisects the region, and additional access is provided by the Cornwall Lookout road and a number of ranch roads.

STRATIGRAPHY

Nicola and Cache Creek Group rocks have been metamorphosed and sheared; consequently fossils are rare and cannot be used as a basis for correlation. Rocks were correlated by lithologic similarity to those mapped by workers in adjoining areas. Structural style and metamorphic grade aid in classification. In general, Ashcroft rocks are unmetamorphosed and gently folded; Nicola rocks are hydrothermally metamorphosed, tilted, and sheared; and Cache Creek rocks, while they show a wide range in structural complexity and degree of metamorphism, lack any indication of hydrothermal metamorphism. Cache Creek rocks are often intensely folded or chaotically deformed.

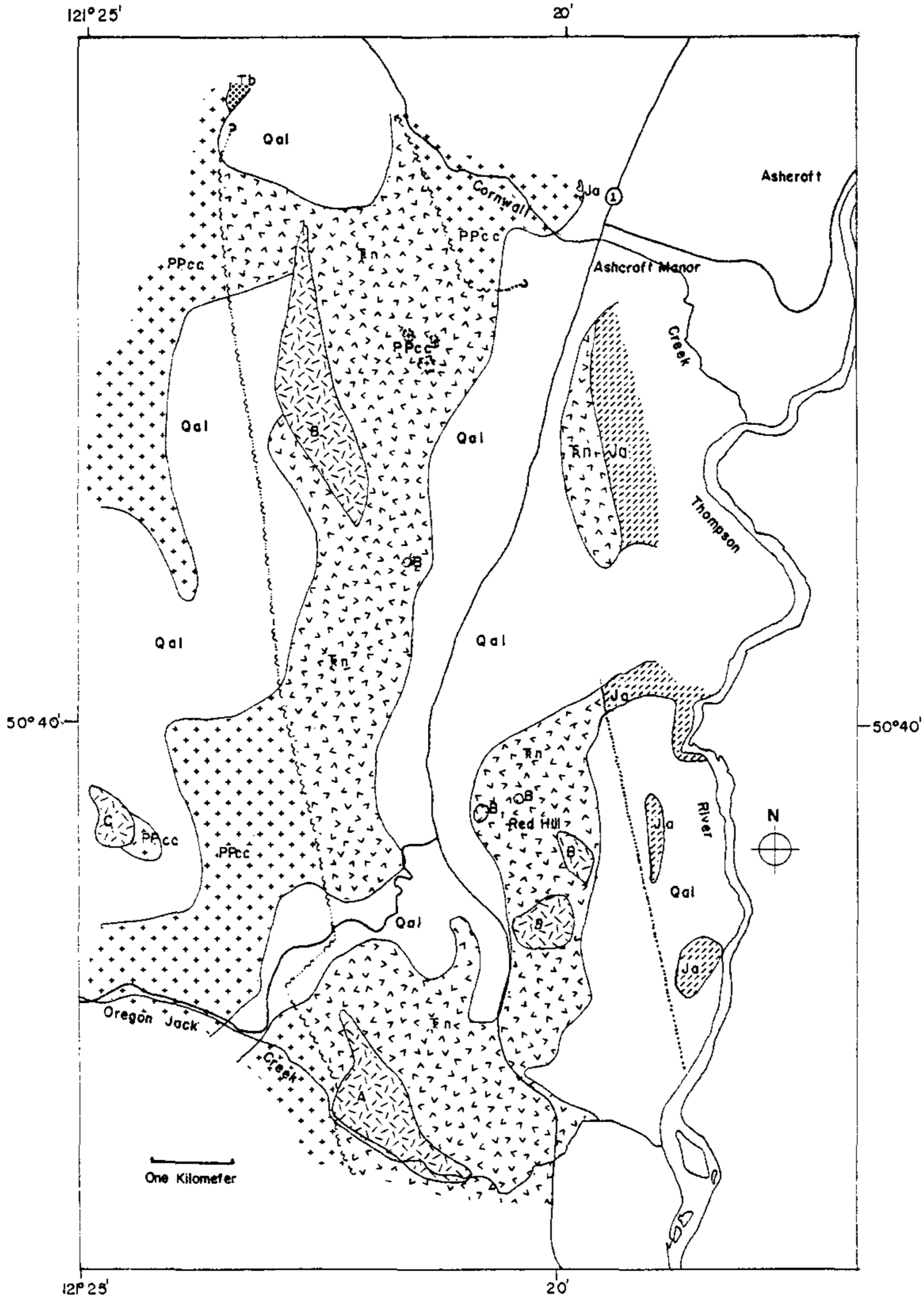
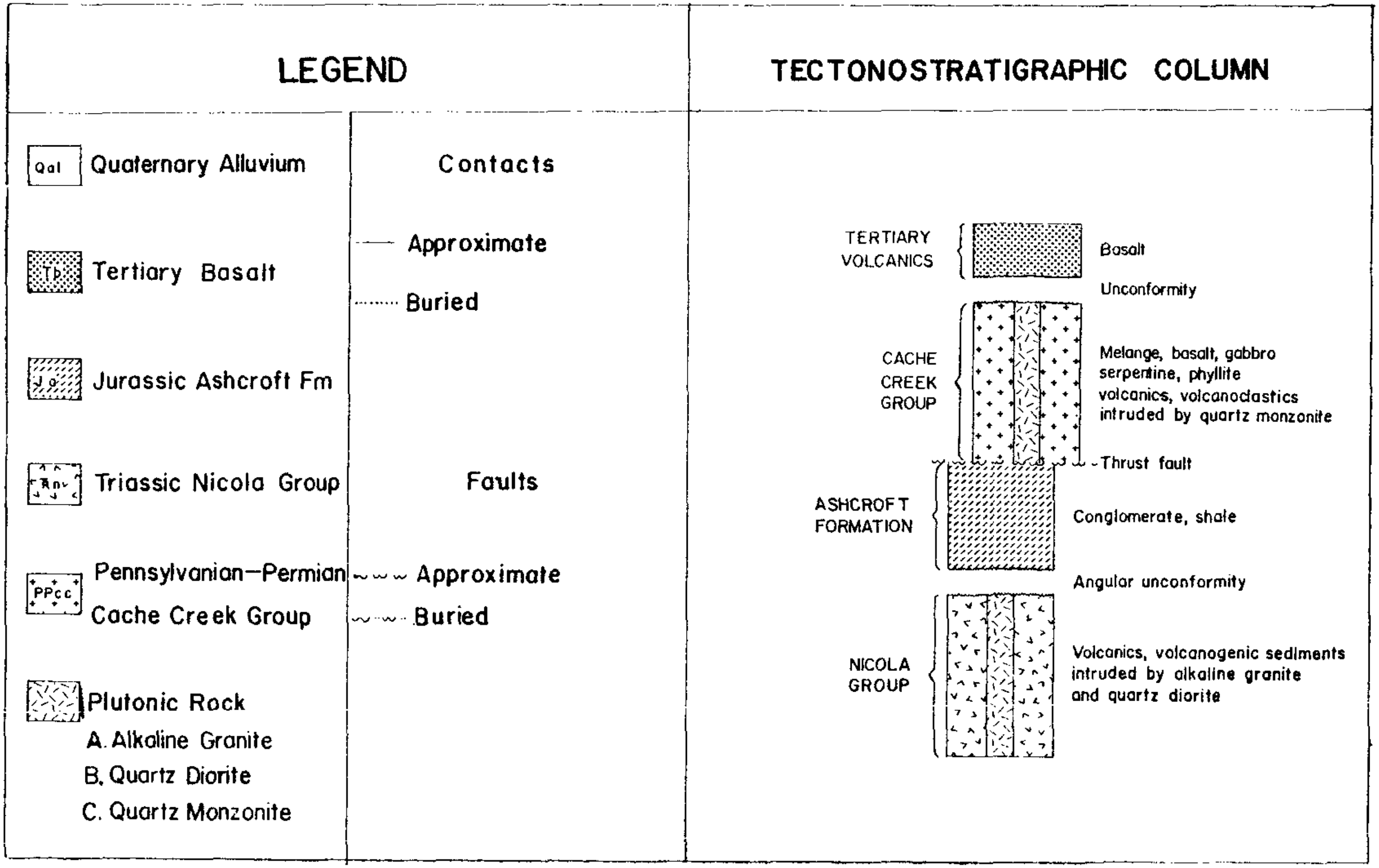


Figure 18. Geology of the Ashcroft-Red Hill area.


LEGEND
Qal
Quaternary Alluvium
Tb
Tertiary Basalt
Jа
Jurassic Ashcroft Fm
Ꞧnv
Triassic Nicola Group
PPcc
Pennsylvanian—Permian
Cache Creek Group
Plutonic Rock
A. Alkaline Granite
B. Quartz Diorite
C. Quartz Monzonite
Contacts
Approximate
Buried
Faults
Approximate
Buried
TECTONOSTRATIGRAPHIC COLUMN
TERTIARY VOLCANICS
Basalt
Unconformity
CACHE CREEK GROUP
Melange, basalt, gabbro
serpentine, phyllite
volcanics, volcanoclastics
intruded by quartz monzonite
Thrust fault
ASHCROFT FORMATION
Conglomerate, shale
Angular unconformity
NICOLA GROUP
Volcanics, volcanogenic sediments
intruded by alkaline granite
and quartz diorite

Cache Creek Group: The most extensive rock unit within the Cache Creek Group is a melange. Outcrops along Oregon Jack Creek (Fig. 18) consist mainly of highly deformed phyllite or black chert with blocks of mafic rocks up to 5 metres across. Melange near Cornwall Creek (Fig. 18) consists of large blocks (up to 100 metres by 500 metres) of massive basalt, clean limestone, and grey pure chert in a matrix of highly deformed and poorly indurated black argillite. The Cache Creek Group also contains large areas of massive mafic rocks, including fine-grained green or pale blue basalt and layered black and white metagabbro. These rocks are generally highly fractured, with two sets of fracture planes. Calcite veins in the fractures are offset and folded. Numerous outcrops of serpentinite occur in the northwestern section of the map-area. Between areas of mafic rocks and melange are bands of relatively undeformed grey phyllite and volcanic and volcaniclastic rocks.

Nicola Group: The Nicola Group here consists mainly of volcanic flows and volcanogenic sedimentary rocks. Stratigraphic complexities and the widely varying intensities of hydrothermal alteration make it impossible to draw a precise stratigraphic section. Numerous rock types are found within a small area and possible marker beds are rare and discontinuous. A workable stratigraphic sequence can be developed by grouping rocks which are commonly found in close proximity and then determining at what stratigraphic level these units usually occur. It should be stressed that units grouped in this manner both interfinger and grade into one another. The lowest unit in the section is comprised of grey mafic volcaniclastic rock that lacks epidote and is overlain by a thick sequence of greenstone. The greenstone includes altered, fine-grained volcanic flows, green chert, plagioclase andesite and basalt, schist, and minor limestone. Above this is a thick sequence of felsic to intermediate quartz-bearing tuff and quartz sericite schist. This unit is distinguished by the large number of subangular to subrounded quartz fragments. Within both the greenstone and the quartz-bearing tuff units, several areas of massive epidotized basalt are found. Interfingered with, and above the tuff units, are layers of green phyllite and semischist, and a unit of grey semischist which appears to be of a clastic, nonvolcanic origin.

Ashcroft Formation: The Jurassic Ashcroft Formation outcrops in several localities near the Thompson River and Ashcroft Manor (Fig. 18). Conglomerate is the most common rock type. In the southeastern section of the map-area it is well indurated with well-rounded clasts of a wide compositional range including greenstone, porphyritic rock, intrusive rock, sharpstone conglomerate, and limestone. These clasts are generally about 5 centimetres in diameter, but range upward to 18 centimetres. In contrast, near Ashcroft Manor, the matrix is grey and the conglomerate is poorly indurated. Outcrops of shale are located northeast of Red Hill (Fig. 18) where they are poorly indurated, fine grained, black, and apparently unmetamorphosed.

An outcrop area, tentatively identified as Tertiary basalt (Kamloops Group ?) is situated on a hilltop in the northwest corner of the map-area. On fresh surface the rock has a fine-grained, black matrix with numerous plagioclase phenocrysts and lacks epidote and chlorite alteration.

INTRUSIVE ROCKS

Three major types of intrusive rocks are found within the map-area. One, which forms a pluton centred on a hill immediately north of Oregon Jack Creek, about 2 kilometres west of the Trans-Canada Highway (Fig. 18), is composed of large subangular quartz crystals in a highly sheared and altered matrix. The matrix is primarily recrystallized sodic feldspar with a minor amount of muscovite as is typical of alkaline granites.

Altered but not sheared medium to coarse-grained quartz diorite and microdiorite crop out in several small bodies on Red Hill and form an elongate pluton southwest of Ashcroft Manor. It has a greenish colour due to the alteration of mafic minerals to chlorite and green staining of feldspars. Numerous mafic inclusions in these intrusive bodies consist of fine-grained crystals altered to chlorite. The borders of these inclusions in the quartz diorite are sharp and irregular. The microdiorite is very fine grained with little quartz and mafic minerals are completely altered to chlorite. A pluton of quartz monzonite is located 2 kilometres north of Oregon Jack Creek and 4 kilometres west of the Trans-Canada Highway. This rock is medium grained, appears fresh, and contains unaltered biotite. It is intruded by a coarse-grained quartz feldspar rock at several localities. There are numerous small gabbroic sills within the Nicola Group between Red Hill and Oregon Jack Creek. A quartz siderite body and several dykes outcrop within the Cache Creek Group.

METAMORPHISM, STRUCTURE, AND TECTONIC RELATIONSHIP BETWEEN UNITS

The wide variety of metamorphic and structural styles exhibited within the Cache Creek Group makes it difficult to generalize the tectonic history. The rocks can be subdivided into zones showing complex deformation and those showing little internal deformation. The melange matrix, whether it is phyllite, chert, or argillite, is tightly folded and faulted. Blocks within the matrix often show little deformation, but basalt, clean limestone, and chert are in close proximity to one another in the sheared matrix indicating that they have been tectonically juxtaposed. In contrast, the phyllite and the volcanic and volcaniclastic rocks show little deformation despite being surrounded by deformed rocks. The phyllite has a well-developed foliation and crops out in long linear bands as seen in Grette's area to the south. The volcanic and volcaniclastic rocks occur as large massive outcrops with no apparent internal deformation. Some basalt and chert appear to be unmetamorphosed while some of the layered metagabbros are amphibolites. Metamorphism within the phyllite has not destroyed graded bedding. There is no field evidence of hydrothermal alteration.

The Nicola Group, in contrast to the Cache Creek Group, shows only minor deformation but has been intensely hydrothermally altered. The rocks form a single upturned block which strikes between north 20 degrees west and north 40 degrees west and dips 50 to 80 degrees southwest. No major fo ds were observed and no evidence was found to show whether the rocks are overturned. A well-developed but discontinuous foliation is parallel or subparallel to bedding throughout most of the area. Occasionally, within the space of tens of metres, outcrops grade from schist into massive, poorly foliated rock. Sericitization along planes of foliation is common, and foliation surfaces often have a micaceous luster. Kink bands in the foliation are common and generally display a counter-clockwise rotation. These rocks have been subjected to several kinds of alteration, the most widespread being epidotization and chloritization which have produced the characteristic green colour of Nicola Group rocks. Silicification is also important and chert is common in both the greenstone and quartz-bearing tuff units, and its close association with volcanogenic sedimentary and volcanic rocks suggests that it is a secondary alteration product. Gossan zones located on the north and south ends of Red Hill, and along Oregon Jack Creek adjacent to the alkaline granitic intrusion, appear to be due to the breakdown of pyrite. Sulphuric acid associated with this breakdown has bleached some of the rock so that a few greenstone and tuff beds are pure white. The effect of this alteration rock varies greatly within single outcrops and suggests that the processes are extremely localized.

The Ashcroft Formation is distinguished by its lack of metamorphism and alteration and its poor induration. Several clasts within the conglomerate appear to be Nicola greenstone suggesting that Nicola rocks had already been deposited and were being eroded at the time of Ashcroft deposition. The conglomerate generally strikes north 10 degrees west and dips 25 to 35 degrees southwest. Shales found northeast of Red Hill also strike north 10 degrees west but are folded and exhibit a well-developed slaty cleavage.

Undeformed rocks of the Cache Creek Group are found between outcrops of highly deformed Cache Creek rock suggesting that the undeformed rocks are either in fault contact with the deformed rocks, or that they were deposited after the melange was emplaced. Also, the degree of metamorphism within the Cache Creek Group varies widely, which supports the idea that many of these rocks are in fault contact.

Cache Creek and Nicola Group rocks are found in direct contact in two localities. Approximately 4 kilometres west of Ashcroft Manor, Cache Creek argillite overlies Nicola greenstone in an apparent reverse fault contact which dips 55 degrees southwest. The argillite is thoroughly sheared while the greenstone shows only a characteristic foliation. Several outcrops of nearly pure limestone, identical in appearance to fossiliferous Cache Creek limestones found nearby, sit directly on top of Nicola plagioclase andesite along a gully 2.5 kilometres southwest of Ashcroft Manor. Some of the plagioclase andesite has been closely fractured, the only location where intense deformation was observed within the Nicola rocks. A similar, but much larger, limestone block is found directly overlying poorly indurated and unmetamorphosed conglomerate which is considered to belong the Ashcroft Formation. Although the limestone block is unfossiliferous, W. R. Danner (personal communication, 1977) has found Permian fossils in a limestone block approximately 1 kilometre to the north. Another block of Cache Creek rock has been found surrounded by Ashcroft rock further to the east in Cornwall Creek (Travers, in press). It appears, therefore, that Cache Creek rocks were transported eastward over both Nicola and Ashcroft rocks probably in post-Early Jurassic time.

Nicola Group rocks on the east side of Red Hill dip steeply westward, away from their contact with the Ashcroft Formation. The Ashcroft Formation also dips westward, toward the contact, but more gently. The contact is not exposed but must either be an angular unconformity or a fault. On a hill 2 kilometres southeast of Ashcroft Manor the contact is an angular unconformity. However, north of Cornwall Creek rocks of the Nicola Group are thrust over the rocks of the Ashcroft Formation (Travers, in press).

The contact between the Tertiary (?) basalt and the Cache Creek Group is not exposed but is presumably an unconformity.

The alkaline granitic intrusion along Oregon Jack Creek shows a variety of contact relationships with the surrounding country rock. Along the southern and eastern margins, it appears to grade into Nicola felsic tuff, suggesting that the two rock types are genetically related. The intrusive rock is in fault contact with Nicola green phyllite and semischist at the northern end of the intrusion. While the granitic rock is always somewhat sheared, it is mylonitized at this contact. The foliation within the granite is parallel to that of the surrounding Nicola rocks, therefore the granite predates this foliation and possibly unfoliated quartz diorite intrusions as well. Along the southwestern edge of the pluton, the alkaline granite intrudes both Nicola green phyllite and a layered algal limestone that is tentatively included in the Cache Creek Group.

The quartz diorite and microdiorite appear to be in intrusive contact with the country rocks which are metamorphosed to fine-grained schist which commonly forms slivers in the intrusive rock. The elongate pluton west of Ashcroft Manor lies on strike with a small outcrop of quartz diorite, the plutons on Red

Hill, and the Spatsum pluton at the west edge of the Guichon batholith. Gossan zones on the north and south ends of Red Hill and east of the Trans-Canada Highway, south of Oregon Jack Creek (Carr, 1962), also fall along this trend. The quartz diorite is similar in appearance to the plutonic rock near Spatsum (W. J. McMillan, personal communication, 1977). The trend is approximately north 25 degrees west and is approximately parallel to the country rock foliation. These plutons, therefore, may be related and represent the outcropping of a larger pluton which has intruded along the plane of foliation in the Nicola Group rocks. In this interpretation, the gossan zones occur in roof rocks immediately above the pluton.

The contact between the quartz monzonite and the country rock was not observed. Its fresh appearance and undeformed state suggests that it is younger than the other intrusive rocks.

MINERALIZATION

Numerous small showings of copper were found throughout the map-area. Almost all of the showings are associated with one of two types of rock. Copper showings on Red Hill occur in Nicola greenstone near or within gossan zones. As mentioned previously, this rock is presumably underlain by the quartz diorite and microdiorite pluton. The main showings occur in or near a pit located approximately at the 'e' in Red Hill on Figure 18. A minor showing occurs at the base of the hill immediately northwest of the southernmost outcrop of the plutonic rock. Copper mineralization consists of chalcopyrite mainly altered to malachite and lesser amounts of azurite. Abundant pyrite is associated with the copper mineralization.

Copper showings within the Cache Creek Group occur in a quartz siderite body and in two veins. The massive quartz-siderite body is contained in altered limestone. It is more resistant than the limestone and forms a small hill about 50 metres high, located about 2 kilometres east of the quartz monzonite intrusion. Two thick veins of identical rock, one striking north 2 degrees west, the other striking north 26 degrees west, are located in a creek valley about 4.5 kilometres west of Ashcroft Minor. Within these quartz-sericite bodies, minor amounts of chalcopyrite remain but most of it has been altered to malachite which is evenly disseminated throughout the rock. Two minor showings of malachite are located in Nicola felsic tuff east of the alkaline granitic pluton.

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GEOLOGY OF PART OF THE CALLAGHAN CREEK ROOF PENDANT (92J/3W)

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INTRODUCTION

Callaghan Creek roof pendant, located approximately 100 kilometres north of Vancouver, is within Vancouver Mining Division. The map-area is approximately 26 square kilometres (10 square miles) centred on latitude 50 degrees 07 minutes north and longitude 123 degrees 06 minutes west. It is bounded on the south by Highway 99, approximately 50 kilometres north of Squamish. 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 (Fig. 19). Northair Mines Ltd. has its minesite 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.

GENERAL GEOLOGY

Callaghan Creek roof pendant is one of many northwesterly trending volcanic and volcanic-sedimentary pendants within the southern part of the Coast Plutonic Complex. The pendant rocks are variably metamorphosed and commonly are 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 and commonly are narrow shear zones whose orientations are subparallel to the main foliation of the roof pendant (Woodsworth, personal communication, 1977). Several centres of Tertiary volcanic rocks form a north by northwesterly trending belt containing local flow and pyroclastic accumulations from basalt to rhyolite in composition (Mathews, 1958; Green, 1977).

Geology of the map-area is shown on Figure 19 and lithologic types are grouped into seven main divisions. No effort has been made to define separate bodies of the Coast Plutonic Complex – mapping extended only a short distance outward from the septum. Similarly, little effort has been expended on Tertiary volcanic rocks which have been the subject of a recent detailed study (Green, 1977). Our work has been directed principally to an understanding of the extensive volcaniclastic assemblage forming the bulk of the Callaghan Creek roof pendant in this area. Five main units of volcaniclastic rocks can be recognized, each of which is further divisible into less continuous members whose geometry generally is unclear due principally to the absence of outcrops in critical areas. A final definition of these members must await extended laboratory work.

Stratigraphy: A generalized structural (possibly stratigraphic) section shown on Figure 20 is based on the assumption that no significant repetitions occur in the sequence. In a number of places we have been able to determine direction of 'tops' in tuffaceous rocks, principally using graded bedding. In all cases tops were indicated to the east in a rock sequence that strikes northerly.

Total apparent thickness of the section of volcaniclastic rocks is in excess of 5 000 metres (16,000 feet). Some units vary drastically in thickness over short distances. The crystal tuff unit for example shows an extreme variability in apparent thickness from 100 to about 1 000 metres over a strike length of 1 000 metres. On the other hand, the volcanic breccia (unit 5a) is remarkably uniform in thickness over a distance of 3 000 metres. These volcanic units may represent parts of three volcanic cycles, each dominated by products of explosive volcanism, and here referred to as cycles I, II, and III from oldest to youngest respectively. According to this suggestion unit 1 is the uppermost expression of cycle I, units 2, 3, and 4 are cycle II, and unit 5 is the lowermost part of cycle III.

Structure: Rocks in the map-area appear to have the form of a simple homoclinal sequence striking northerly to northwesterly and dipping steeply to the east with tops to the east. No evidence of significant large-scale repetitions by folding or faulting has been found during the mapping although rare minor folds were observed in some well-bedded exposures. The apparent homoclinal nature of the volcaniclastic rocks may be a too simplistic geometric form for the sequence considering the complex history of intrusion, deformation, and metamorphism that the area has undergone.

Faulting has been extensive. Numerous faults with apparent horizontal movement of a few centimetres to a few metres are apparent in the underground workings of Northair Mines Ltd. Most of these faults are steeply dipping and cut across bedding and the ore zones. Vertical components of movement are not known.

Numerous northerly trending gullies occur in the area and can be identified readily on aerial photographs as extending in straight linear fashion for hundreds of metres in some cases. These linear elements are almost certainly ground traces of steeply dipping faults that are subparallel to layering in the volcaniclastic sequence and have a significant strike-slip component. The movement picture is not everywhere clear; however, in the area immediately west of Northair mine the base of the tuffaceous agglomerate (unit 5) has been offset with right-hand displacement.

A major 'break' of uncertain nature exists at the south end of unit 4, in the vicinity of the mine access raod and coincides closely with an area of possible crystal tuff feeder channels. In this zone an acid volcanic sequence (unit 4) is replaced abruptly along strike to the south by crystal tuff (unit 3). Whether or not this represents a structural break of a facies change remains uncertain due to absence of outcrop in the critical area.

Age: Age of the volcaniclastic sequence is somewhat uncertain. Lithologies and textures show a remarkable similarity to the lower volcanic member of the Gambier Group as exposed near the type area along Howe Sound where Cretaceous fossils have been found in an upper sedimentary member. Similarly, Cretaceous fossils have been found near Black Tusk Mountain in a sedimentary sequence, one member of which contains granitic cobbles and which seems to overlie the volcaniclastic sequence unconformably (Mathews, 1958). Furthermore, mapping to date has not located any granitic fragments within the volcaniclastic rocks of the Callaghan Creek pendant. Consequently, it seems fairly certain that the volcaniclastic sequence is Early Cretaceous or older. A K-Ar model age of 124±4 Ma has been obtained for a hornblendite 'dyke' cutting crystal tuff (unit 4) and assumed to represent a feeder to the crystal tuff. The true age may be older if partial release of argon occurred during metamorphism accompanying emplacement of the Coast Plutonic Complex.

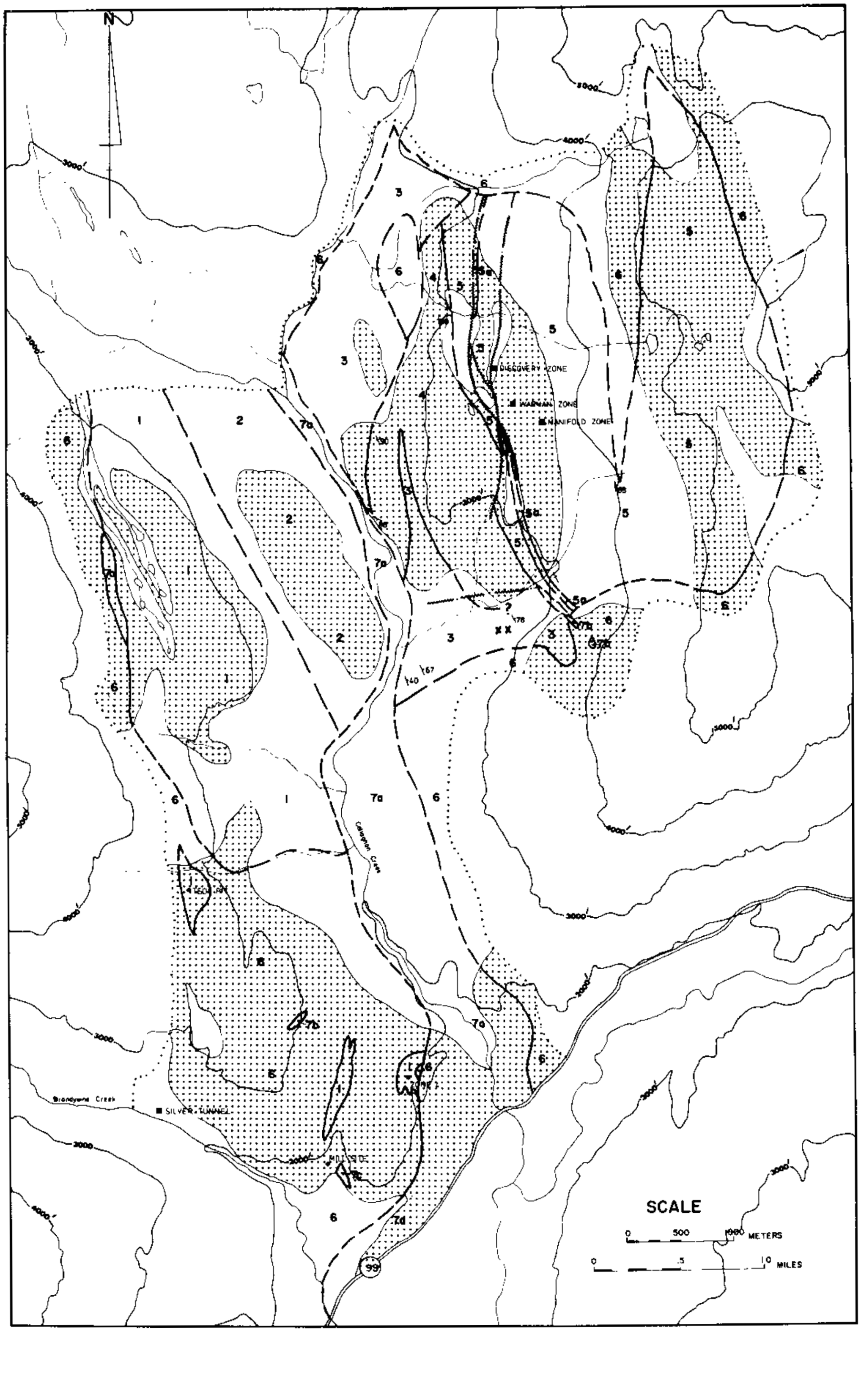

Figure 19. General geology of part of the Callaghan Creek roof pendant.

LEGEND

TERTIARY

- [7] VOLCANICS a) BASALT
  - b) ACIDIC TUFF
  - c) RHYOLITE

CRETACEOUS (or earlier)

- [6] COAST PLUTONIC COMPLEX
- [5] AGGLOMERATE; 5a) VOLCANIC BRECCIA
- [4] ACIDIC VOLCANIC ROCKS
- [3] CRYSTAL TUFF
- [2] AGGLOMERATE
- [1] GREENSTONE

HORNBLENDITE CENTRES	X
BEDDING AND DIP	40
CONTACT (APPROXIMATE; ASSUMED)	
ABUNDANT OUTCROP	
FAULT (APPROXIMATE; ASSUMED)	
MINE ADIT	■
MINERAL OCCURRENCE	●
LIMIT OF FIELD MAPPING	

BRIEF DESCRIPTION OF ROCK UNITS

These descriptions are not meant to be complete, but are intended to indicate the dominant characteristics of the principal rock units. The reader should recognize that considerable variability exists within each of the units described. Names are those used in the field. Reference should be made to Figure 19 for field locations and to Figure 20 for a rough guide to estimated thickness.

Greenstone (unit 1):	'Acidic,' fine-grained volcaniclastic rock, commonly extensively sheared, generally pale green in colour.
Aggomerate (unit 2):	Massive volcanic fragmental rock with fragments up to 50 centimetres in diameter in a tuffaceous matrix that is 5 to 40 per cent of the rock.
Crystal tuff (unit 3):	Medium-grained pyroclastic rock containing abundant plagioclase fragments and less abundant hornblende fragments. Locally well layered.
Acidic volcanic rock (unit 4):	Principally dacitic and rhyolitic tuffaceous rocks with rare large fragments. Locally contains up to 5 per cent pyrite.
Tuffaceous aggomerate (unit 5):	Massive pyroclastic unit, principally tuffaceous material near the base and predominantly rounded volcanic fragments higher in the section. Near the base this unit contains a 60-metre-thick marker bed of volcanic breccia with abundant fragments mostly 3 to 5 centimetres in diameter.
Coast Plutonic Complex (unit 6):	Includes quartz monzonite, quartz diorite, and hornblende diorite.
Tertiary volcanic rocks (unit 7):	Fresh, blocky basalt for the major flow in the map-area, and elsewhere much smaller amounts of more acidic composition. Correlations with Garibaldi calc-alkalic volcanic suites.

Two zones of small hornblendite intrusions cutting crystal tuff are shown by X's on Figure 19. These intrusions are thought to represent parent material for the crystal tuff.

MINERAL DEPOSITS

Seven mineral occurrences of apparent importance are known in the map-area. All are held by two mining companies as follows:

Northair Mines Ltd.:
- Discovery zone — massive
- Warman zone — veins, massive and disseminated
- Manifold zone — veins and disseminated

Van Silver Explorations Ltd.:
- Silver tunnel — veins and disseminated
- Millsite — veins and disseminated
- Tedi pit — massive
- Zone 4 — massive skarn

These mineral occurrences are confined to units 1 and 5. Locations are shown on Figure 19.

Zone 4 is a skarn deposit containing sphalerite, pyrite, and minor amounts of chalcopyrite. This occurrence seems to be genetically distinct relative to other known deposits. All the other deposits are polymetallic containing galena, sphalerite, and pyrite as the principal sulphide minerals with significant amounts of several silver minerals and native gold, and minor amounts of chalcopyrite and pyrrhotite. Two general forms of mineral deposits exist: (i) veins and (ii) massive and disseminated sulphide bodies. Veins contain abundant quartz and/or calcite gangue and undeformed sulphides. Massive and disseminated mineralized zones occur in lenticular, variously layered masses that are generally parallel to bedding and show superimposed deformation features, the most obvious of which is a pronounced gneissic structure. Some

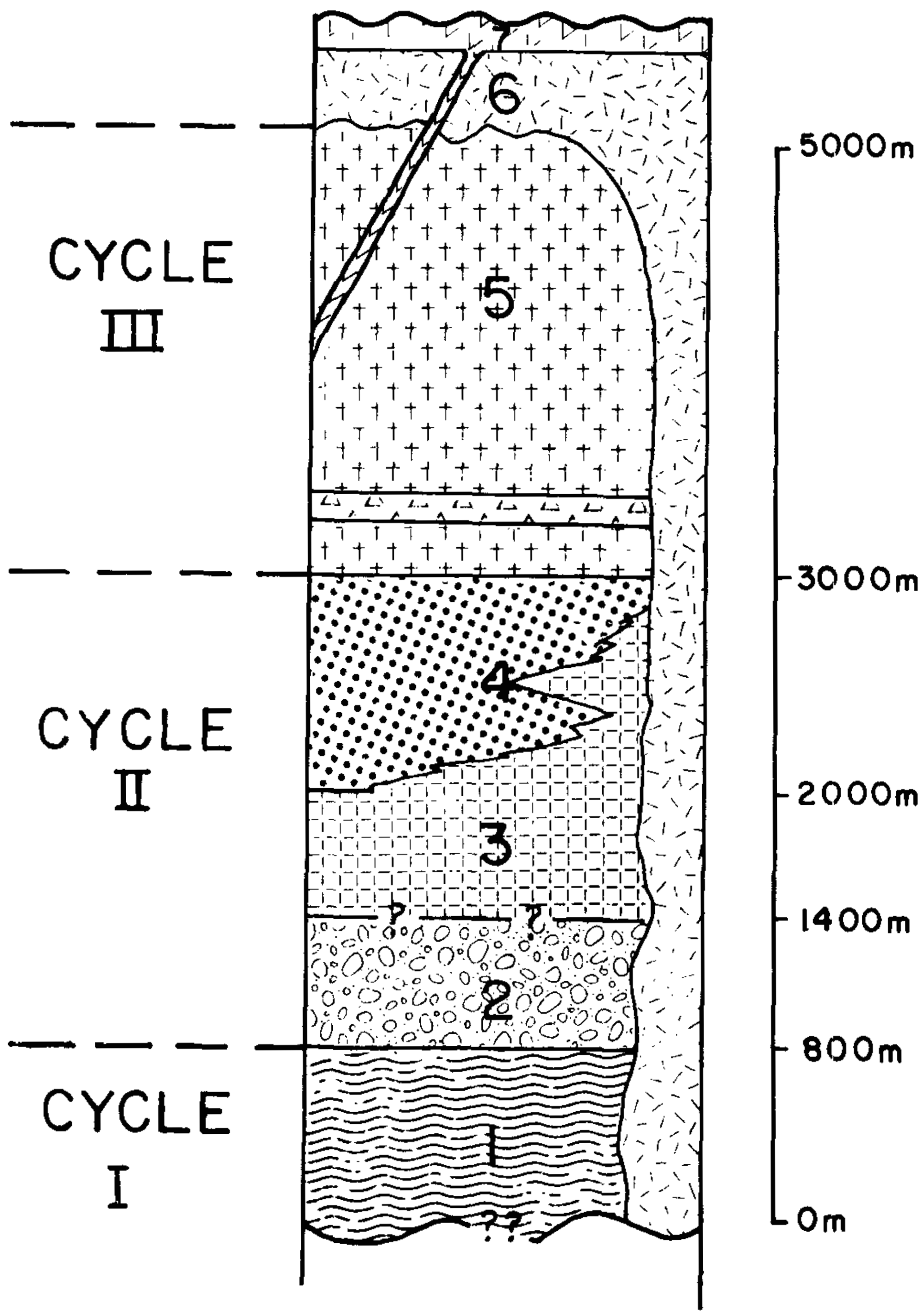

Figure 20. General structural succession in the Callaghan Creek roof pendant. The pre-Tertiary volcaniclastic rocks (units 1 to 5 inclusive) may represent as many as three volcanic cyles as shown.

disseminated ore in the Manifold zone occurs in a metamorphosed, bedded, siliceous limestone. Our impression is that sulphide-bearing veins have been derived locally during metamorphism from pre-existing concentrations of massive and disseminated sulphides that seem to be related in age and origin to the volcaniclastic rock sequence in which they occur. Veins remote from the massive and disseminated sulphides are sulphide-free (*see* Woodsworth, *et al.*, 1977).

ACKNOWLEDGMENTS

The management of Northair Mines Ltd. has aided the project measurably, particularly Mr. M. P. Dickson and Mr. Wayne Ash. Discussions and field visits with Dr. G. J. Woodsworth are appreciated. Mr. M. H. Levasseur kindly provided access to the workings of Van Silver Explorations Ltd. This project has been funded in part by the British Columbia Ministry of Mines and Petroleum Resources.

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SEARCH FOR HYDROTHERMAL DEPOSITS ON JUAN DE FUCA AND EXPLORER RIDGES NORTHEAST PACIFIC OCEAN

By R. L. Chase*, J. W. Murray*, E. V. Grill†, Guy Beland*, and Ray Cook*

INTRODUCTION

A three-week cruise to the crestal areas of Juan de Fuca and Explorer Ridges in the northeastern Pacific Ocean (June 16 to July 8, 1977) aboard the Canadian Forces Auxiliary Vessel *Endeavour* resulted in the mapping of bathymetry of two areas of 2 900 square kilometres and 2 100 square kilometres respectively, and the raising of 66 sediment cores, two dredge hauls, and 23 hydrographic casts. The areas surveyed are shown on Figure 21. The purpose was to investigate the effect of hydrothermal processes in young volcanic oceanic crust on the heavy-metal content of overlying oceanic sediments.

Forty-three bathymetric profiles were recorded, totalling 2 053 kilometres in length. A sound frequency of 3.5 kilohertz was used, in order to reveal fine structure in thin discontinuous sedimentary sequences overlying the young volcanic and tectonic features at spreading ridges. Profiles were spaced about 5 kilometres apart in each area. Navigation, by Loran A, gave position with accuracy of 1 mile.

Cores were taken with gravity corers (lowered on wires) and with Benthos Boomerang corers (independent pop-up). The top of each core was sampled immediately after it was brought aboard, and monitored for copper, lead, and zinc by a dithizone test (Bloom, 1955).

The near-bottom water column was sampled by Niskin samplers equipped with reversing thermometers at many core sites in order to detect anomalous temperature or chemistry which might be caused by emission of hot brines from fissures near the ridge crest. Lister (1974) developed the theory of heat loss from hydrothermal circulation through fissures to explain anomalously low heat flow on the western flank of Juan de Fuca ridge. The east flank, blanketed with sediment from Cascadia plain, has a heat flow distribution closer to the theoretical.

The cores recovered in 1977 all contained olive-grey mud, in places graded, and, in many cores, overlain by red-brown mud, up to 10 centimetres thick. The dithizone test for copper, lead, and zinc suggested that manganese and iron oxides in the red-brown mud are variably enriched in copper, lead, and zinc. The first area surveyed (area 1 on Fig. 21), at the northern end of Explorer Ridge, includes two short ridge segments with well-defined rift valleys bounded by transform faults. The topography protected the valleys from inundation by Pleistocene turbidity currents. Enriched red-brown mud occurs within and on the sides of the valleys, along the transform faults, and away from the valleys on the northwest flank of the ridge. The second area, near the northern end of Juan de Fuca Ridge (area 2 on Fig. 21), includes several valleys and intervening horsts parallel to the ridge. The western valley is the present locus of spreading (McManus, *et al.*, 1972; Barr and Chase, 1974; Davis and Lister, 1977). In contrast to the first area, the second area was

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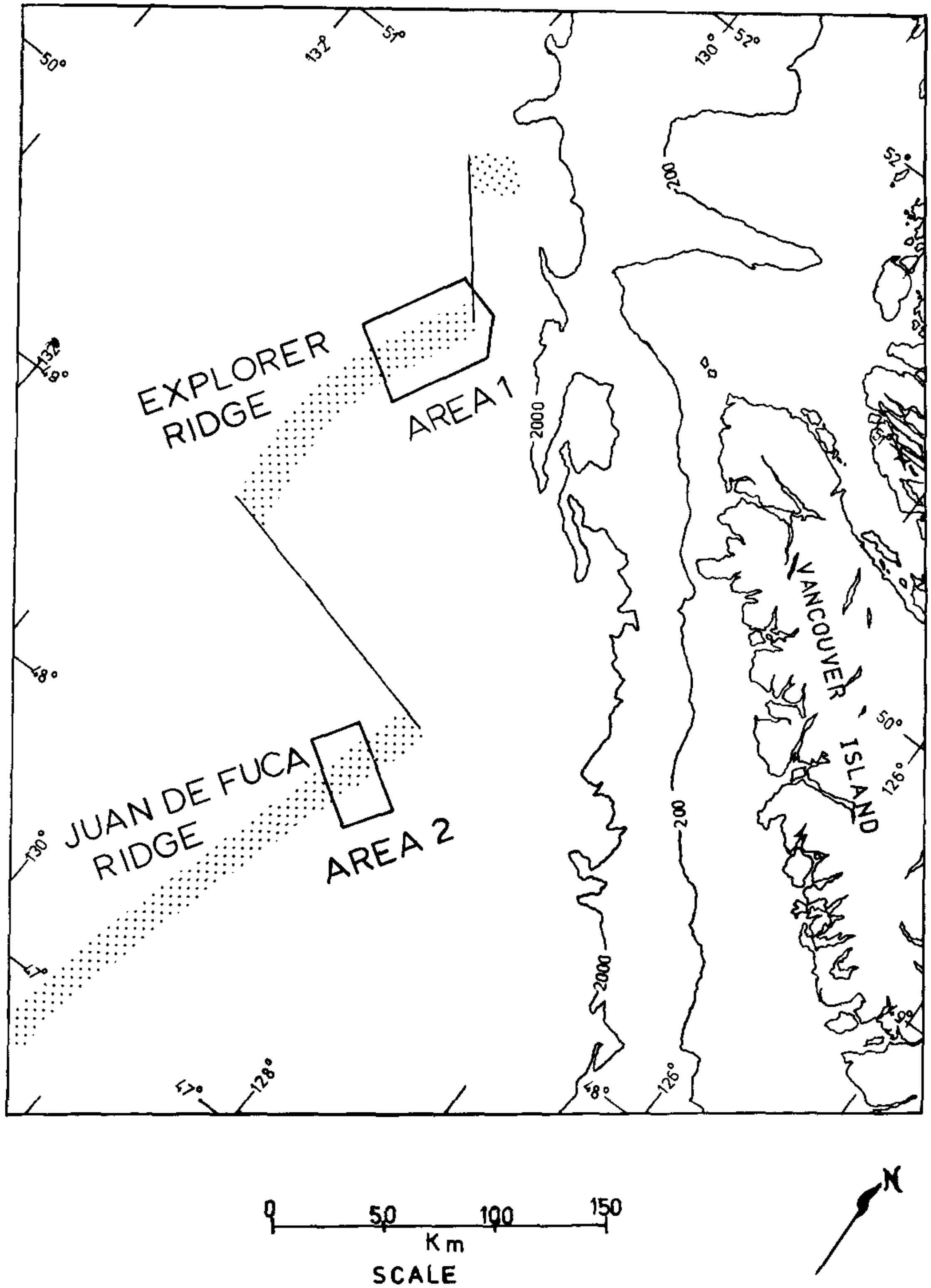

Figure 21. Juan de Fuca and Explorer Ridges.

flooded by turbidites during the Pleisotcene. Enriched red-brown mud several centimetres thick overlies turbidites and, in places, basalt, fragments of which were recovered in some cores. Outside the area, eastward toward the continental margin, upon the distal end of Nitinat deep-sea fan, however, the red muds were not encountered in cores. Several cores raised on a single traverse west of area 1, on the northwestern slope of Explorer Ridge, also showed enrichment. Thus it appears that enrichment is present at the active ridge crests but also occurs on the western flank of the ridges. One hypothesis to explain the existence of the contrasting red-brown and olive-grey layers is that the latter are Pleistocene, and the former Holocene, their difference being caused by differing sedimentational regimes, a result of the post-Pleistocene flooding of the continental shelf. Another hypothesis has the red-brown layer as the normal product of upward diffusion of porewater in deep-sea muds, with oxidation and precipitation of iron and manganese near the sediment-water interface. Selk (M.Sc. dissertation, Oregon State University, 1977) concluded that hydrothermal activity led to the formation of manganese-rich sediments in a trough in the active Blanco Fracture Zone south of the areas investigated. Metalliferous sediments occur along thousands of kilometres of crestal areas of spreading rises (Bonatti, 1975; Heath and Dymond, 1977). Cronan (1976) found metalliferous sediments widely distributed at the volcanic-sediment interface on the western flank of the East Pacific Rise. Hydrothermal activity has been observed directly on the Galapogos and Mid-Atlantic Ridge (Von Herzen, *et al.,* 1977; Rona, 1977).

Since the cruise, cores have been split, logged, photographed, and samples taken for heavy metal analysis. The cores and data from the cruise will form the basis of M.Sc. projects for R. Cook and G. Beland.

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URANIUM RECONNAISSANCE PROGRAM
(82F, K, 104N)

By N. C. Carter

The Uranium Reconnaissance Program in British Columbia is a regional geochemical program managed and funded jointly by the Ministry of Mines and Petroleum Resources and the Department of Energy, Mines and Resources. 1977 marks the second year of the three-year program for which total costs of $600 000 are being shared equally by the Provincial and Federal Governments.

The Uranium Reconnaissance Program on a Canada-wide basis has been developed by joint Federal-Provincial Agreements in all Provinces except Alberta and Quebec. The main objectives of the program are to provide the mineral industry with high-quality reconnaissance data to assist in the search for new uranium deposits and to provide both levels of Government with nationally consistent systematic data to serve as a basis for uranium resource appraisal.

The mode of operation has been for Energy, Mines and Resources, through the Geological Survey of Canada, to carry out geochemical orientation surveys and to issue tenders for contracts for sample collection, preparation, and analysis. All phases of the program to date have been conducted in close consultation with the Mineral Resources Branch of this Ministry. The Geological Division has been involved in designating areas for orientation and regional surveys, suggesting analysis for elements in addition to uranium, and providing source lists of potential British Columbia-based contractors for sample collection and analysis.

To date, over 90 000 square kilometres in British Columbia have been sampled at a density of one sample site per 12.5 square kilometres in Penticton, Vernon, Seymour Arm, Nelson, Lardeau, and Atlin map-areas. Selection of these areas was in response to widespread exploration for uranium in southeastern British Columbia and near Atlin.

Field sampling in 1976 was carried out by a thirteen-man crew provided by Stokes Engineering and Management Company of Vancouver. The crew was supervised by a Geological Survey of Canada geochemist and a Ministry of Mines and Petroleum Resources geologist. Stream sediment and water samples were collected from 3 563 sample sites. Sample preparation and analysis were contracted out to separate commercial firms. Determination of uranium in stream sediments was done by the Atomic Energy of Canada Laboratory in Ottawa. Water samples were analysed for uranium, fluorine, and pH while stream sediments were analysed for zinc, copper, lead, nickel, cobalt, silver, manganese, iron, and molybdenum in addition to uranium.

Results of the 1976 program were released May 4 of 1977 by way of sample location maps for each of the three map-areas covered, accompanied by computer print-outs of analytical data for all elements. Separate symbol plot maps for each element were also made available.

The 1977 survey was carried out in the Nelson (82F), Lardeau (82K), and Atlin (104N) map-areas. Samples were collected from over 3 600 sites and helicopter-supported fill-in work in the Seymour Arm (82M) map-area was also completed. As in 1976, Stokes Engineering and Management Company was again awarded a contract to provide sampling crews while Chemex Laboratories of Vancouver performed the major part of the analytical work, also under contract.

Analytical results of this year's program are expected to be released in May of 1978.

Orientation work in the Atlin area, in addition to the regional survey, has led to the proposal that the adjacent Jennings River (104O) and Cassiar (104P) map-areas be covered by the regional program in 1978.

Uranium-related studies by the Geological Division include those of Addie, Christopher, Church, and Preto. Descriptions of these projects are contained elsewhere in this publication.