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mineral resources branch
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FOREWORD

Geological Fieldwork, 1979 (Paper 1980-1) marks the sixth year of this annual publication which is intended to acquaint the interested public with the preliminary results of fieldwork of the Geological Division as soon as possible after completion. Most reports in this publication were written without benefit of extensive laboratory or office studies and to speed publication; most of the figures have been draughted by the authors.

In order to make results of programs more readily available, the Geological Division will continue the preliminary map series and will place more emphasis on publication of a Paper series, which will be issued on completion of individual programs.

The three major sections making up *Geological Fieldwork, 1979* are similar to previous years. Other Investigations section includes mainly reports by graduate students and professors of the University of British Columbia. These reports deal with studies relating to ongoing Geological Division programs and were funded, in part, by the Division.

Figure 1 (page following) shows the geographic distribution of reports contained in this publication and is keyed by report number to the Table of Contents.

The cover photograph depicts stream sediment sampling in the Nass River area during the 1978 Accelerated Geochemical Survey.

Technical editing of this publication was done by N. C. Carter and production editing and layout by Rosalyn J. Moir with the assistance of Geological Division draughting office under the supervision of J. Armitage.

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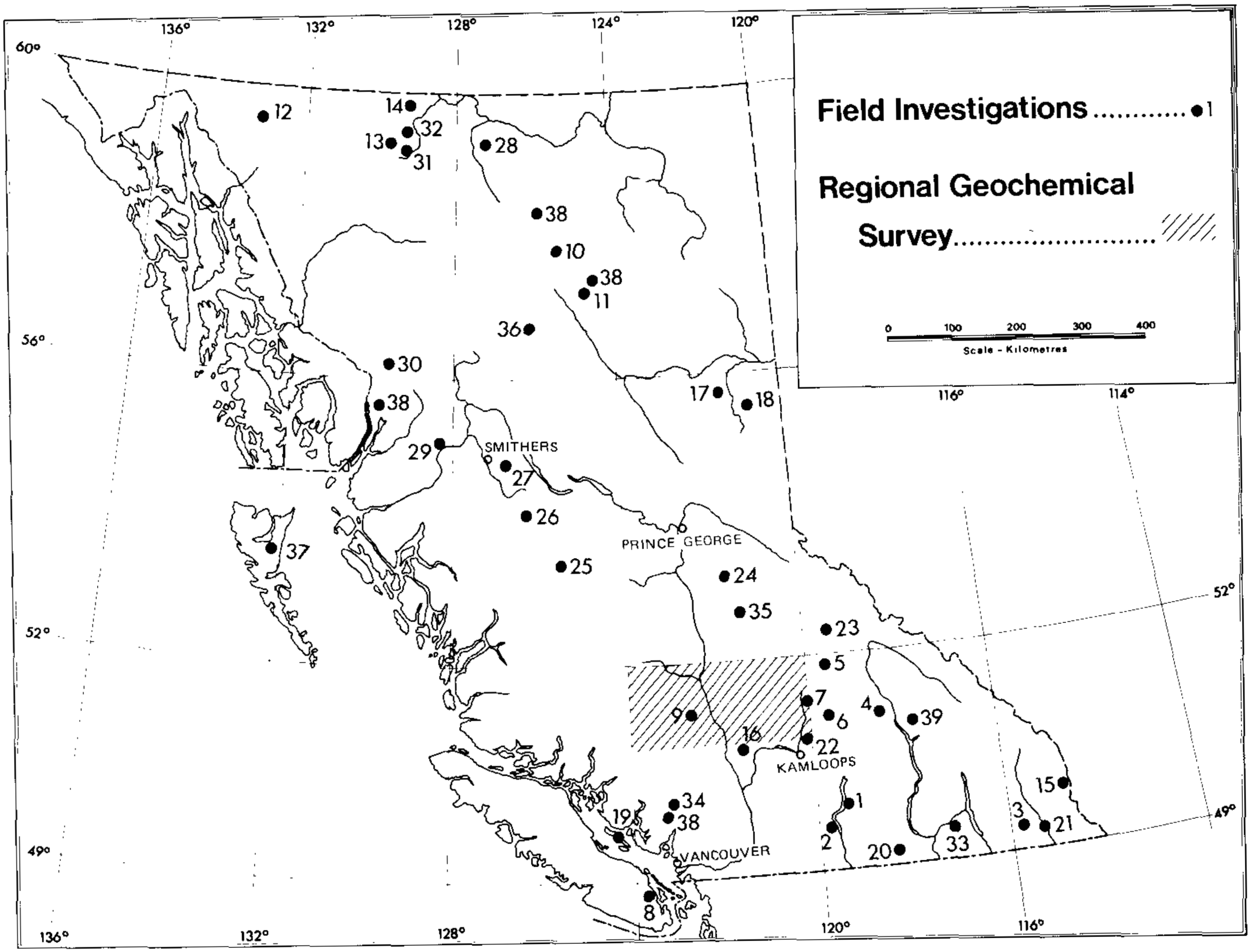

Figure 1. Distribution of programs, Geological Fieldwork, 1979.

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METALLIC INVESTIGATIONS

SOUTHEAST BRITISH COLUMBIA

A SURVEY OF CENOZOIC MAGNETOSTRATIGRAPHY IN SOUTH-CENTRAL BRITISH COLUMBIA (82E, 92I)

By B. N. Church

INTRODUCTION

A detailed knowledge of changes in the earth's magnetic field through geological time affords an opportunity to explore the problem of stratigraphic correlation between the many unconnected Cenozoic volcanic basins that characterize the southern interior of British Columbia.

The utility of paleomagnetic methods stems from the fact that the earth's magnetic field undergoes periodic inversions which affect the orientation of magnetic minerals in newly formed rocks. An alternating sequence consisting of several dozen normal and reversed polarities has been established for Cenozoic rocks using radiometric dates for control (Tarling and Mitchell, 1976).

This report presents some preliminary results on polarity measurements from a type section of Eocene rocks near Penticton and a suite of Miocene to Pleistocene Plateau and Valley basalts from Hat Creek, Merritt, and the Kelowna area (*see* accompanying table).

The procedure for collecting samples and performing measurements is straightforward. In most cases horizontal or near-horizontal bedded lava flows were selected for sampling, each rock specimen being marked prior to removal to show a horizontal azimuth line and the vertical direction. Determinations were carried out using a portable fluxgate magnetometer, sensitive to less than 20 gamma variations.

RESULTS

The most continuous and readily accessible Eocene section available for polarity measurements is the White Lake basin southwest of Penticton. These rocks, comprising a diversified assemblage of lava flows and sedimentary rocks, attained a thickness of about 2 400 metres in the period 53.1 to approximately 48 Ma. Testing of the five principal members of the Marron Formation at 11 localities in this area and the Marama Formation at Summerland shows uniformly normal polarities.

The so-called Plateau and Valley basalts range widely in age and occur in isolated outliers. Normal polarity seems to be a common characteristic of these rocks as exhibited by the Miocene olivine basalt at Hat Creek (14.1±0.5 Ma) west of Cache Creek, on Carrot Mountain (11.8±0.4 Ma) west of Kelowna, and by the

Pliocene basalt (2.8±1.5 Ma*) exposed immediately northwest of Hydraulic Lake southeast of Kelowna. It is interesting to note, however, that similar basalt exposed at Swalwell Lake north of Kelowna and in road cuts east of Hydraulic Lake yield reverse or transitional polarities.

Two relatively recent Valley basalts included in the current study are the Quilchena basalt (0.5 Ma*) exposed south of the west end of Nicola Lake and the Lambly Creek basalt (0.76±0.11 Ma) found north of Westbank near Kelowna. In keeping with the known recent magnetostratigraphic record, the Quilchena basalt exhibits normal polarity and is assigned to the Brunes normal epoch. The Lambly Creek basalt, on the other hand, is anomalous having transitional or negative polarity and apparently belongs to the Matuyama reversed epoch.

MAGNETIC POLARITY OF SOME CENOZOIC LAVAS FROM SOUTH–CENTRAL BRITISH COLUMBIA

Unit	Polarity	Location	
		Latitude	Longitude
Quilchena basalt	normal	50° 08.2′	120° 41.3′
Lambly Creek basalt	reversal ?	49° 57′	119° 33′
Hydraulic Lake basalt	normal	49° 49.2′	119° 13′
Hydraulic Lake basalt	normal	49° 48.8′	119° 12.3′
Plateau basalt (east of Hydraulic Lake)	transitional ?	49° 47.2′	119° 03.7′
Plateau basalt (east of Hydraulic Lake)	transitional ?	49° 47.0′	119° 04.5′
Plateau basalt (east of Hydraulic Lake)	transitional ?	49° 45.8′	119° 07.2′
Plateau basalt (east of Hydraulic Lake)	reversal	49° 44.8′	119° 08′
Plateau basalt (east of Hydraulic Lake)	reversal	49° 43.9′	119° 07.1′
Swalwell Lake basalt	reversal	50° 03.5′	119° 14.7′
Carrot Mountain basalt	normal	49° 55.5′	119° 39′
Hat Creek basalt	normal	50° 42′	121° 35′
Marama dacite	normal	49° 35′	119° 40′
Marron Formation			
Park Rill member	normal	49° 19.2′	119° 41.2′
Nimpit Lake member	normal	49° 21.0′	119° 42.3′
Nimpit Lake member	normal	49° 20.8′	119° 42.6′
Kearns Creek member	normal	49° 20.5′	119° 43.8′
Kearns Creek member	normal	49° 22.4′	119° 45.1′
Kitley Lake member	normal	49° 20.3′	119° 44.8′
Yellow Lake member	normal	49° 20.3′	119° 44.9′
Yellow Lake member	normal	49° 20.2′	119° 45.9′
Yellow Lake member	normal	49° 22.2′	119° 46.7′
Yellow Lake member	normal	49° 14.8′	119° 47.2′
Yellow Lake member	normal	49° 22.3′	119° 38.9′

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*Ages for the Hydraulic Lake and Quilchena basalts were provided by P. A. Christopher and W. J. McMillan, respectively.

ANOMALOUS URANIUM IN THE SUMMERLAND CALDERA

(82E/12)

By B. N. Church

INTRODUCTION

Anomalous uranium values in streams in the southern part of the Okanagan Valley were detected by the 1976 Federal/Provincial Uranium Reconnaissance Program and delineated further during the course of exploration by private individuals and mining companies. The principal zone of uranium concentration, as shown on Figure 6.4a of the Ministry's recent Brief to the Uranium Commission, is on the west side of the Okanagan Valley between Summerland and Oliver. Some very high values in the range 2.3 to 17.5 ppm* uranium were previously reported in pond waters from this area (*Geological Fieldwork, 1977*, p. 10). In the light of these discoveries the Ministry has initiated a water monitoring program focus in part on the Summerland district (*see* Brief, pp. 57-67).

GEOLOGICAL SETTING

An association of uranium deposits with volcanic calderas has been established in the American southwest. Well-known examples are Valles caldera, New Mexico, the McDermitt caldera in Nevada, and the Silverton—Lake City cauldron complex of Colorado. At Valles, uranium has apparently been derived from late hydrothermal activity associated with ring fracturing. Here the mineralizing solutions are trapped along the numerous angular unconformity surfaces formed during caldera collapse. Intracaldera lake sediments with carbonaceous trash horizons are favoured targets for mineralization in the McDermitt caldera. At the Silverton caldera, uranium is concentrated in cracks in the basement rock below the volcanic pile.

Ash deposits associated with calderas may provide both source material and suitable traps for uranium. The Nopal deposit of Peño Blanco in Chihuahua province of Mexico is an example. Devitrification of acidic tuffs by hydrothermal solutions is thought to be important in mobilizing the uranium. The characteristic stacking of alternate permeable and impermeable, nonwelded and welded ash flow members in the Nopal Formation provides suitable trap and cap rock structures for the deposition and preservation of orebodies.

The general structure, stratigraphy, and lithology of the Summerland basin seems to conform to the caldera model although only the central and western segments of this small Tertiary outlier have survived major faulting and erosion. The basin is obscured on the east by Okanagan Lake and truncated on the southeast by the Summerland fault (Fig. 2). Nevertheless, it retains a subcircular plan with beds dipping inward toward Giants Head which is a centrally located hill of relatively young Marama dacite lava, dated 48 Ma by K/Ar whole rock analysis. Other Eocene units form the basal and intermediate layers in the basin below the dacite. Granite boulder conglomerate and breccias assigned to the Kettle River Formation are exposed over a small area at the base of the section on the western margin of the Tertiary outlier. This is overlain by a local deposit of feldspathic lava belonging to the Kitley Lake member of the Marron Formation. The Nimpit Lake member of the Marron Formation lies above this and consists of a thick and widespread sequence of trachyandesite ash flows and some intercalated lava. The youngest units are well exposed along Highway 97 north of Summerland where Marama lava overlies Nimpit Lake ash flows. Uppermost in the Eocene succession is a clastic assemblage of conglomerate, sandstone, and shales correlated with the sedimentary member of the White Lake Formation (Church, 1973).

*ppm — parts per million; ppb — parts per billion.

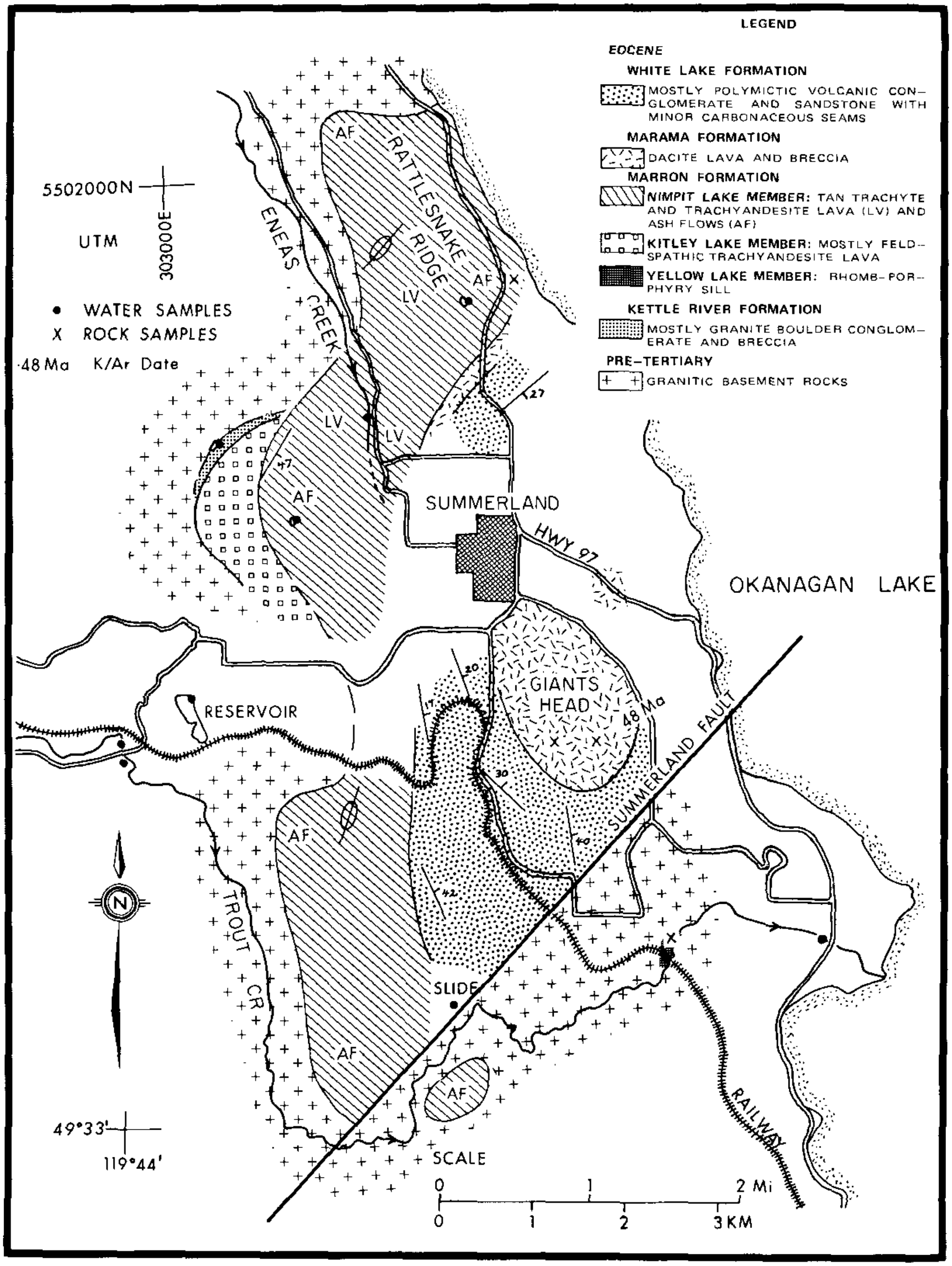

Figure 2. Geology of the Summerland caldera.

The prime source of the ash flows is believed to lie within the Summerland basin, this facies of the Nimpit Lake unit being absent in adjacent Eocene sections. The consequence of emplacement of ash flows, in keeping with current theory, is caldera collapse, the suspected origin of the Summerland basin. Similarly, the Marama dacite forming Giants Head is viewed as a resurgent volcanic dome completing the caldera cycle of eruption.

CHEMICAL RESULTS

The results of water analyses in the Summerland area are given in the following table. The data show a wide range of uranium values and a positive, although not rigorous, correlation between U, F, and pH levels.

ANALYSES OF WATERS IN THE SUMMERLAND AREA

		U *ppb*	F *ppb*	pH
(1)	Spring, slide area south of Summerland			
	SUM 008, July 12, 1977	43.00	930	8.0
(2)	Spring near bridge by Trout Creek, west of Summerland			
	MAG 078, June 22, 1979	0.66	80	7.3
	SMD 003, August 27, 1979	0.44	140	7.3
(3)	Pond, north Summerland			
	SUM 007, July 12, 1977	2 500.00	1 170	9.8
(4)	Pond, northwest Summerland			
	SUM 006, July 12, 1977	11.00	555	8.1
(5)	Pond, northwest Summerland			
	SUM 005, July 12, 1977	5.60	1 210	9.2
(6)	Summerland reservoir			
	MAG 075, June 22, 1979	1.11	72	7.4
	SMD 002, August 27, 1979	1.10	120	7.8
(7)	Eneas Creek, Summerland			
	SMD 001, August 27, 1979	23.00	480	8.0
	SUM 009, July 12, 1977	23.00	410	8.2
(8)	Domestic well, near mouth of Darke Creek			
	MAG 077, June 22, 1979	18.00	385	7.6
(9)	Upper section of Trout Creek			
	MAG 082, July 14, 1979	1.19	107	7.4
(10)	Lower section of Trout Creek			
	MAG 087, July 14, 1979	5.60	305	8.5

LOCATIONS

UTM coordinates	Easting	Northing
No. 1	305850	5493150
No. 2	302700	5496000
No. 3	306150	5500800
No. 4	303400	5499200
No. 5	304300	5498300
No. 6	303100	5496500
No. 7	305100	5499400
No. 8	299100	5499300
No. 9	302500	5496010
No. 10	309800	5493800

The highest reading for uranium (2.5 ppm) was obtained on alkaline water (pH 9.8) from a small pond in an area underlain by ash flows near Highway 97 north of Summerland. Similar anomalous results were previously reported from the 'Oliver ponds' in *Geological Fieldwork, 1978,* page 10. According to Culbert and Leighton (1978, p. 104), the combination of unusual source rocks and climatic conditions is responsible for these anomalies. In the Okanagan region, rapid evaporation rates from ponds in closed depressions can lead to super-enrichment of uranium.

Relatively high uranium concentrations in flowing water, such as shown by analyses of Eneas Creek (23 ppb), are not readily explained. The seepage of uraniferous groundwater into the drainage system from mineral-enriched strata or fault zones is a possibility.

Trout Creek partly encircles the Summerland caldera on the south on its course to Okanagan Lake. The upper section of this stream and tributaries, immediately west of Summerland and the source of water for municipal use, is relatively pure having less than 1.2 ppb uranium at the time of sampling. However, a several-fold increase in uranium is observed downstream near the mouth of Trout Creek. This increase appears to be due to the seepage of uranium-charged groundwater into the creek from the Summerland basin. The spring containing 43 ppb uranium south of Summerland is an example of such seepage (Fig. 2).

A probable primary source of uranium is believed to be the Tertiary volcanic and effusive rocks. It has been shown that the Yellow Lake member of the Marron Formation having above-average uranium levels could yield important amounts of this element under suitable leaching or weathering conditions (*Geological Fieldwork, 1978,* pp. 12-14; *Western Miner,* 1978, No. 5, pp. 33, 34). An example of these rocks in the Summerland basin is the rhomb porphyry intrusion near Trout Creek which assays highest in uranium (13 ppm) when compared with other major rock types (*see* the following table). The apparent limited occurrence, however, would seem to preclude the Yellow Lake rocks as a likely source in this instance, unless of course, such rocks in fact subcrop extensively.

CHEMICAL ANALYSES OF VOLCANIC AND EFFUSIVE ROCKS

	1	2	3	4
Oxides recalculated to 100				
SiO_2	55.72	58.27	65.58	68.28
TiO_2	0.99	1.10	0.72	0.56
Al_2O_3	18.23	16.73	16.19	15.49
Fe_2O_3	2.98	3.27	1.85	3.76
FeO	2.88	2.68	2.72	0.18
MnO	0.11	0.10	0.09	0.04
MgO	3.54	3.08	2.00	1.03
CaO	5.88	4.11	4.17	2.93
Na_2O	4.12	3.73	3.72	3.68
K_2O	5.55	6.93	2.96	4.05
	100.00	100.00	100.00	100.00
Oxides as determined				
H_2O+	1.72	1.02	2.90	0.50
H_2O-	0.20	0.90	1.31	0.83
CO_2	0.25	2.32	0.25	0.25
S	0.01	0.01	0.003	0.01
P_2O_5	0.37	0.21	0.14	0.10
BaO	0.21	0.17	0.13	0.13
SrO	0.28	0.09	0.07	0.05
U (ppm)	13	6	4	3
Th (ppm)	62	20	9	10
RI	1.548	1.538	1.524	1.515

KEY TO CHEMICAL ANALYSES

1 — Rhomb porphyry sill, Trout Creek canyon.

2 — Partly welded trachyandesite ash flow, Nimpit member of Marron Formation, rock cut on Highway 97.

3 — Columnar dacite dyke, feeder to Marama lavas, quarry on west side of Giants Head.

4 — Banded dacite lava, Marama Formation, peak of Giants Head.

NOTE: Analyses have been provided courtesy of Dr. W. M. Johnson, Analytical Laboratory, British Columbia Ministry of Energy, Mines and Petroleum Resources.

An alternative source is the Nimpit Lake member which is a widely exposed unit containing 6 ppm uranium. Much uranium could be released to groundwater by devitrification of unstable potassium-rich glass in these partly welded rocks by process of lithification or hydrothermal alteration.

The possibility of formation of secondary deposits from uranium-enriched waters in the Okanagan area has been discussed by Culbert and Leighton (1978, p. 109). This could be achieved by absorption of uranium on clay, zeolites, or organic sediments with the aid of reducing conditions produced by carbonaceous material, sulphide mineralization, or bacterial action. It is shown that the degree of concentration and rate of accumulation of uranium under natural conditions can be significant in creating deposits of economic potential in young sediments.

The White Lake beds may offer favourable exploration targets for secondary deposits. At Summerland these are mostly wedging coarse clastic intracaldera sedimentary rocks with some carbonaceous mudstones and thin coaly seams. Silicification viewed at several points in Marama dacite indicates a period of late hydrothermal activity that may also have introduced mineralization in the White Lake rocks in the form of uranium-fixing sulphides or uranium directly.

An important factor to be balanced against the search for ore deposits here is the reality that much of the area is either residential or farm land, and therefore precluded from location of mineral claims.

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PURCELL PROJECT

(82G/5)

By T. Höy

Regional mapping at a scale of 1:25 000 of an area centred on Moyie Lake in the Purcell Mountains in southeastern British Columbia was initiated in 1979. The area is underlain primarily by rocks of the Purcell Supergroup of Helikian/Hadrynian age. The project is a continuation of a regional study of the Purcell Supergroup that is emphasizing the depositional environment of these rocks in order to determine the relationships between sedimentation, tectonics, and stratiform sulphide deposits. Two recently published preliminary maps with reports have been released describing the structure, stratigraphy, and depositional environment of Purcell rocks in the Hughes and Lizard Ranges on the east side of the Rocky Mountain Trench. The first, by McMechan (1979), includes the area south of the Wild Horse River; the second (Höy, 1979), located north of Wild Horse River, is an extension of a previously released map (Höy, 1978).

The Moyie Lake project will continue in 1980 and will extend mapping north to Cranbrook, east to Gold Creek, and south to approximately 49 degrees 10 minutes north. It will concentrate on subdivision of the Aldridge Formation, location of the Lower–Middle Aldridge contact, and the relationship of the Moyie fault to Precambrian and younger tectonics. Detailed stratigraphic section measurements and studies of lead-zinc deposits (such as the St. Eugene deposit) will augment the project.

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GEOLOGY OF THE BEWS CREEK AREA
SOUTHWEST MARGIN OF FRENCHMAN CAP GNEISS DOME
(82M/2E)

By T. Höy

INTRODUCTION

The Bews Creek area (Fig. 3) is located southeast of the confluence of Bews Creek and Perry River, 25 kilometres west-northwest of Revelstoke. Access to the western part of the area is provided by a logging road that follows the Perry River, while the southern part is reached by a logging road along Crazy Creek. The area was mapped in eight days; two days of logging road geology and a six-day fly-camp.

The area was investigated in order: (1) to attempt to tie together, both stratigraphically and structurally, the Jordan River area (Fyles, 1970) with the Perry River area (McMillan, 1973); (2) to attempt to confirm the structural and stratigraphic interpretation of the Jordan River area by Höy and McMillan (1979); and (3) to assess the potential for stratabound lead-zinc and carbonatite occurrences which occur elsewhere along the margins of Frenchman Cap gneiss dome.

The Bews Creek area is underlain by gneissic rock which correlates with core gneisses of Frenchman Cap gneiss dome (units A and B of Wheeler, 1965), and an overlying succession constituting a basal quartzite, a calc-silicate gneiss unit, a second quartzite, and finally a mixed pelitic and calcareous sequence. This succession correlates reasonably well with those established elsewhere in the mantling rocks of the dome.

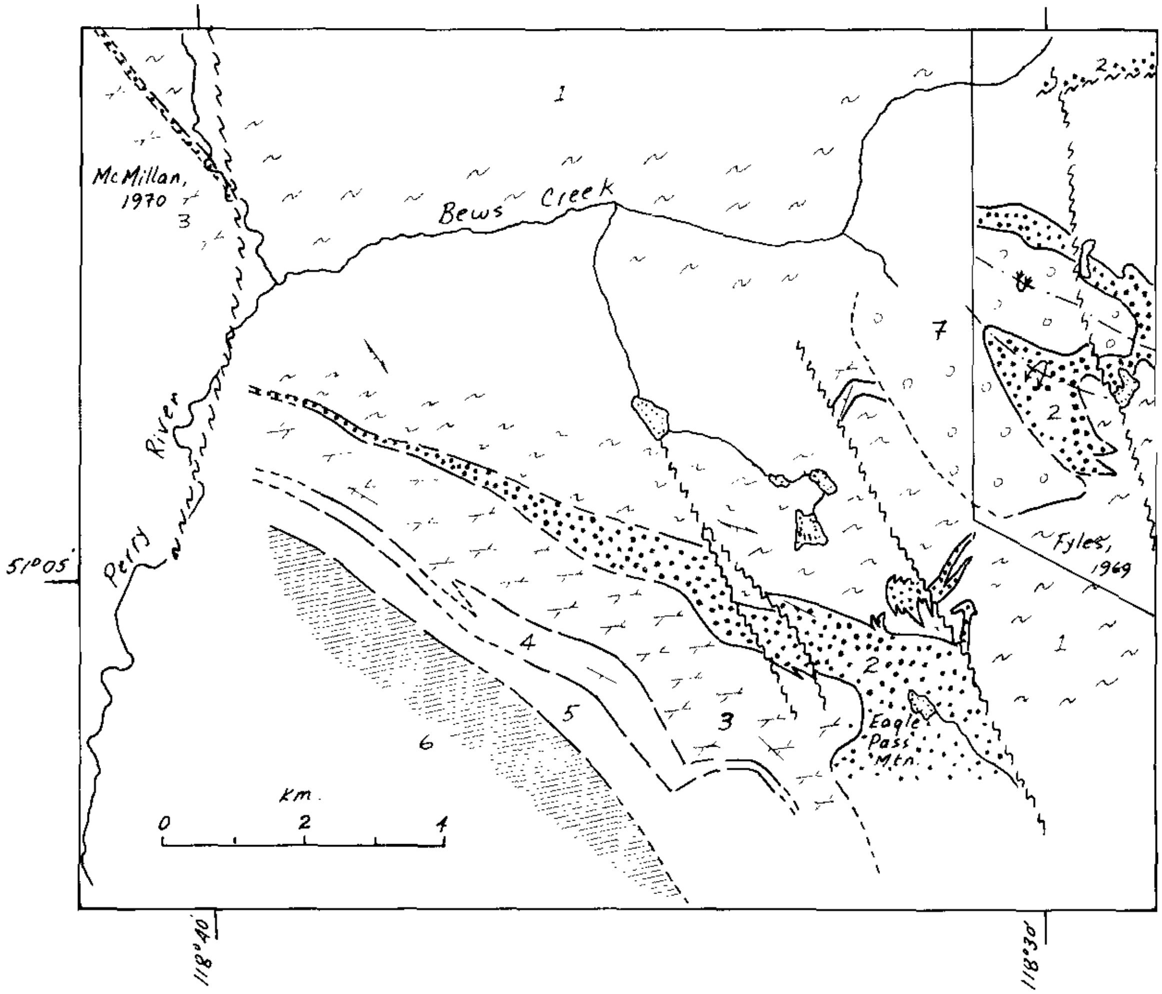
STRATIGRAPHY

Unit 1 comprises well-layered hornblende gneiss, minor amounts of amphibolite and biotite gneiss, and rare calc-silicate gneiss. A granitic orthogneiss occurs in the vicinity of the interference fold structure shown on Figure 4. Unit 1 is continuous in the southeast part of the map-area with unit 10 of Fyles (1970). Unit 10 of Fyles was tentatively correlated with core gneisses (Höy and McMillan, 1979, Fig. 8) and this correlation is in accord with the present study.

A white, relatively pure quartzite (unit 2) overlies unit 1. It is several hundred metres thick north of Eagle Pass Mountain (Fig. 3) but thins to only a few metres near Bews Creek, 8 kilometres to the northwest. A prominent quartz pebble conglomerate occurs near its base and micaceous quartzite layers are common in the Eagle Pass Mountain area.

Diopside-rich calc-silicate gneiss, biotite gneiss, impure marble, and a granular, calcite-cemented quartzite (unit 3) overlie the basal quartzite. Unit 3 is overlain by a second quartzite (unit 4), that is lithologically similar to unit 2, then by a heterogeneous succession comprising quartz feldspar gneiss and pelitic schist with minor amounts of calc-silicate gneiss and quartzite (unit 5).

Overlying pegmatite-laced rocks (unit 6; unit E of Wheeler, 1965) consist of well-layered biotite-hornblende gneiss, pelitic gneiss, quartz feldspar gneiss, and minor quartzite, calc-silicate gneiss, and marble. Unit 6 rocks are tectonically separated from the underlying metasedimentary rocks by a southwest-dipping fault (as predicted by R. L. Brown, personal communication, 1979).



LEGEND

PALEOZOIC – MESOZOIC (?)

7 ORTHOGNEISS, PORPHYRITIC GRANITE GNEISS, GRANITE

PROTEROZOIC – PALEOZOIC (?)

6 GNEISS, SCHIST, ABUNDANT PEGMATITE

5 PELITIC SCHIST, CALCAREOUS SCHIST, QUARTZITE

4 QUARTZITE

3 CALC-SILICATE GNEISS, MINOR MARBLE, BIOTITE SCHIST, GNEISS

2 QUARTZITE, MINOR SCHIST, QUARTZ-PEBBLE CONGLOMERATE

PROTEROZOIC – APHEBIAN

1 MIXED CORE GNEISS· BIOTITE HORNBLENDE PARAGNEISS, ORTHOGNEISS

SYMBOLS

FAULT APPROXIMATE, DEFINED . . . .

FOLIATION . . . .

LAYERING . . . .

OVERTURNED ANTIFORM, SYNFORM . . . .

Figure 3. Regional geology of an area southeast of Bews Creek and Perry River, along the southern margin of Frenchman Cap gneiss dome (northeast corner after Fyles, 1970).

Unit 7, described as a porphyritic granite gneiss by Fyles (1970), was not visited. Its eastern contact is taken from Fyles (1970) and its southwestern contact from Wheeler (1965).

Correlation of the Bews Creek succession with sequences established elsewhere along the margin of Frenchman Cap dome is relatively straightforward. The succession, consisting of basal quartzite, calc-silicate gneiss and biotite gneiss, a second quartzite, and an overlying somewhat pelitic and calcareous sequence, is recognized on the northwestern margin (Höy, 1979a), western margin (McMillan, 1973), and eastern margin (Brown and Psutka, 1979). A similar stratigraphic succession is inferred (Höy and McMillan, 1979) in the more complex Jordan River area (Fyles, 1970).

The core gneisses may represent Lower Proterozoic Aphebian crystalline basement. Samples of both core paragneiss and orthogneiss from the eastern side of Frenchman Cap, collected by R. L. Brown, have yielded dates of approximately 2.1 Ga (R. L. Armstrong, personal communication, 1979). A basal quartzite, locally containing quartz pebble conglomerate, overlies core gneisses around the entire margin of the dome. Furthermore, in one locality fragments of gneissic rocks believed to be core gneiss clasts lie in the quartzite near its base (Fig. 5). The margins of these fragments are diffuse and the only recognizable structure within them, the penetrative mineral foliation, parallels that of both the surrounding quartzite and underlying gneiss. The fragments are inferred to have a sedimentary origin, but it is possible that they have a structural origin. They could represent a fragmented impure sedimentary layer near the base of the quartzite or perhaps a fragmented early fold nose. There are no features typical of boudinaging adjacent to the fragments and it is suggested that they are clasts of basement gneiss incorporated in the quartzite during its deposition.

The age of basal quartzite and overlying metasedimentary succession is not known. They may be correlative with the Middle and Upper Proterozoic Purcell Supergroup as suggested by Read (1979), or with the Upper Proterozoic Windermere Group or the Lower Paleozoic platformal succession exposed to the east as suggested by a number of authors including Wheeler (1965), Fyles (1970), and Höy and McMillan (1979). They do not closely resemble any of these successions. Based on the platformal nature of the Frenchman Cap succession, correlation with the Upper Purcell Supergroup or the Lower Paleozoic seems most likely.

STRUCTURE

The axial surface of an anticlinal fold trends west-northwest through the area. It is the western extension of an early fold described by Höy and McMillan (1979) that opens in the south and closes to the north in the Jordan River area. Unit 1, correlated with core gneisses, occurs in its core and the overlying succession is, in part, repeated on its limbs.

Minor structures are common in all outcrops. Mineral lineations plunge at varying angles to the southwest throughout the area. They are interpreted to parallel fold axes of the earliest recognized folds and in the instances where early folds can be clearly documented by interference structures mineral lineations lie parallel to the early fold axes. The prominent foliation is axial planar to these early (phase 1 ?) minor folds. Relatively open to very tight (phase 2 ?) minor folds that deform the foliation are present in most outcrops. Their axes generally trend southwesterly subparallel to the phase 1 (?) mineral lineations and their axial surfaces are upright to west dipping. Interference patterns between phase 1 and phase 2 folds, which are common on outcrop scale (Fig. 5), may also occur at map scale (Fig. 4).

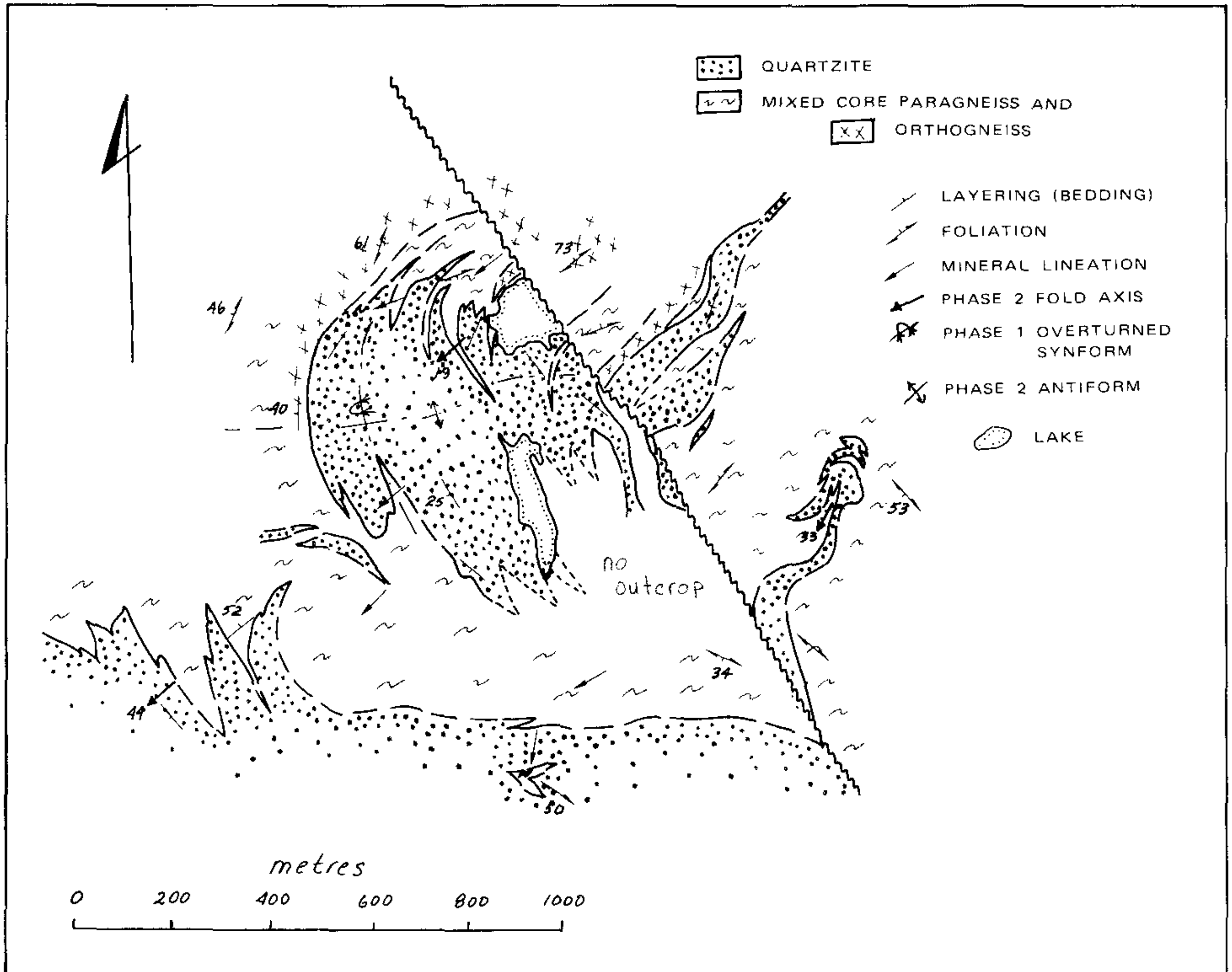


Figure 4. Detailed geological map showing complex interfolding of core gneiss and basal quartzite; map centre is located *approximately* 2 *kilometres north-northeast* of Eagle Pass Mountain.

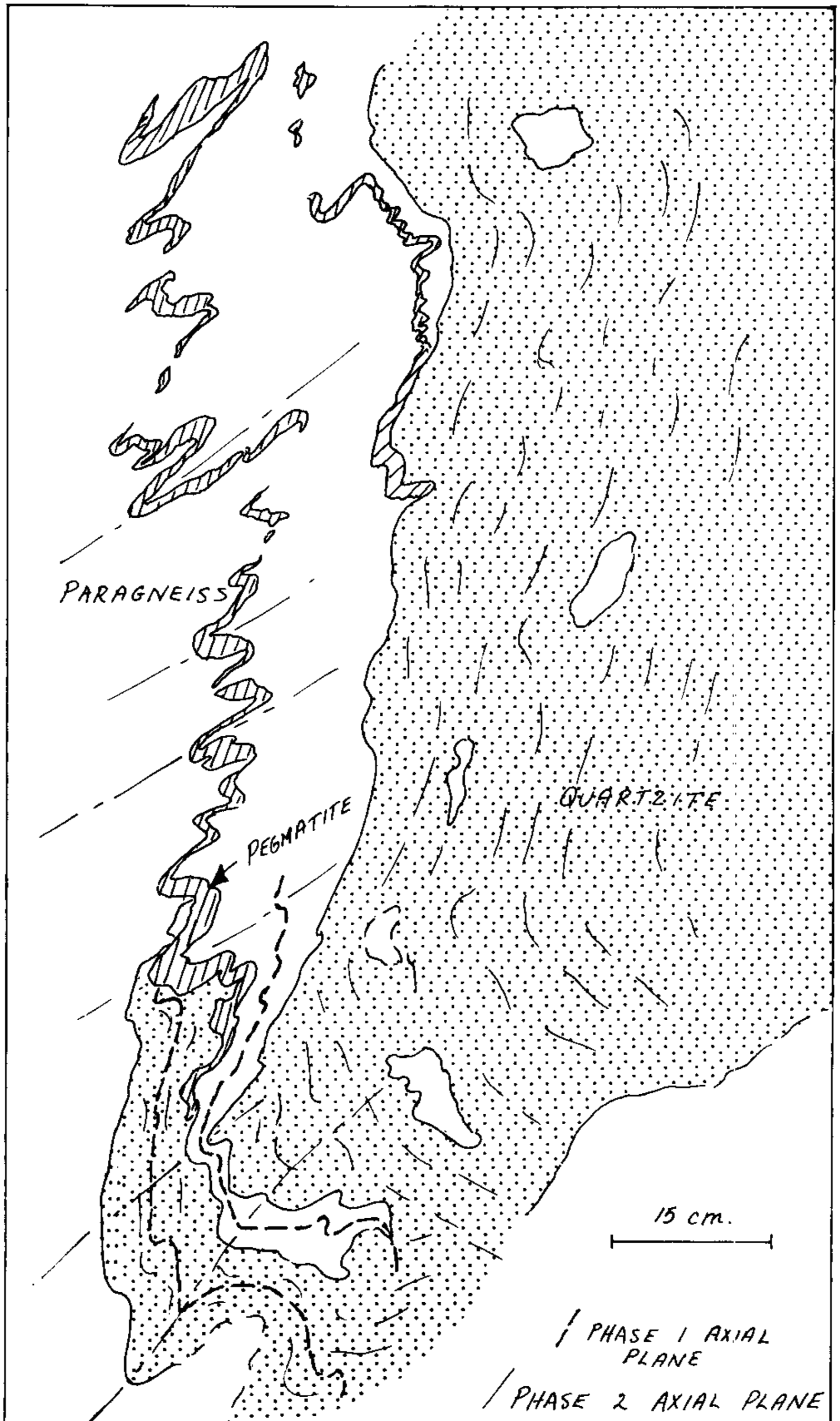


Figure 5. Detail of interference of Phase 1 and Phase 2 minor folds involving core gneiss (no pattern) and basal quartzite (unit 2). Note sharp contact between core and quartzite and clasts (?) of core gneiss near base of quartzite (*see* discussion in text).

SUMMARY

A succession of metasedimentary rocks overlies with apparent conformity gneissic rocks correlative with core gneisses of Frenchman Cap dome. Both core gneisses and the overlying succession are complexly interfolded by at least two phases of deformation. An early (?) northwest-trending anticlinal fold dominates the structure of the area, repeating the stratigraphic succession in the south, but phase 2 minor folds are the most conspicuous folds on outcrop scale.

Stratabound lead-zinc deposits and showings occur elsewhere at a number of horizons within the metasedimentary cover rocks (Höy and McMillan, 1979; Höy, 1979b). The calcareous succession immediately above the basal quartzite (unit 3) hosts the Cottonbelt (Höy, 1979a) and King Fissure (Boronowski, 1976) deposits further north, but no lead-zinc mineralization was seen in this succession in the Bews Creek area. A stratiform carbonatite layer containing anomalous concentrations of niobium and other rare earths occurs in the Perry River (McMillan and Moore, 1974) and Cottonbelt (Höy, 1979b) areas within rocks correlative with unit 3. Nepheline syenite and syenite intrusions occur in Perry River and Jordan River areas. Neither the carbonatites nor the nepheline syenites were seen in the Bews Creek area.

ACKNOWLEDGMENTS

I was ably and cheerfully assisted in the field by Peter Mustard. W. J. McMillan spent several days in the field with me, and many ideas presented in this note developed through discussion with him, and as a consequence of our joint paper in *Geological Fieldwork, 1978.*

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CK PROSPECT
SHUSWAP METAMORPHIC COMPLEX
(82M/13E)

By T. Höy

INTRODUCTION

The CK property includes a number of lead-zinc showings apparently confined to one stratigraphic layer. It is located between Ritchie Creek and Raft River, 37 kilometres north of Vavenby. The area is accessible by a well-maintained logging road branching north from Highway 5, 3 kilometres east of Clearwater and following Raft River.

The Main Boulder and part of the New showings were discovered by Andy Horne, the present owner, in 1973 and optioned by Rio Tinto Canadian Exploration Limited in 1974. A regional soil sampling program by Rio Tinto in 1974 led to the discovery of a massive sulphide exposure, the North showing, and outlined an anomalous zone in the New showing and Main Boulder area. The North showing was explored by geophysical methods and subsequently drilled. Four short holes in the Main Boulder area and one in the New showing failed to intersect significant massive sulphide mineralization (Assessment Report 5192). Two additional holes in the North showing intersected some lead-zinc mineralization; the better assayed intersection returned 3.98 per cent zinc, 0.71 per cent lead, 0.01 per cent copper, 0.18 ounce per tonne silver, and 0.007 ounce per tonne gold over an approximate 1-metre thickness (Assessment Report 5631).

Cominco Ltd. optioned the property in 1978 and carried out geochemical and geophysical surveys and trenching which led to the discovery of mineralized exposures in the Main Boulder, New, and Mist areas. The company drilled 20 holes in 1978 and an additional 18 in 1979. This drill program concentrated on the New showing and to a lesser extent on the Main Boulder showing.

Five days were spent on the property in August 1979, visiting the showings and logging the core drilled to that time (drill hole 79-12). During this time I was cheerfully assisted by Peter Mustard. The co-operation and hospitality of Cominco Ltd. is gratefully appreciated. Access to its maps and reports proved most useful, and discussions with Mike Murrel, G. Benvenuto, and Fred Gill were both stimulating and informative.

GEOLOGY

The area is underlain by metasedimentary rocks of the Shuswap Metamorphic Complex (Campbell, 1963). These include quartz feldspar-hornblende gneiss, amphibolite, calc-silicate gneiss and minor quartzite, and marble of unknown but probable Paleozoic age. Pegmatite is abundant. A fine to medium-grained granitic intrusive rock is present in the west part of the area (Fig. 6, personal communication, G. White).

The general succession in the area includes well-layered hornblende gneiss and amphibolite exposed in canyons in the creek west of Raft River (Fig. 6) which are structurally overlain by a calcareous succession that includes the sulphide layer, and then by a quartz feldspar gneiss and pelitic schist succession exposed in scattered outcrops on the hills east of the New showing (personal communications with Cominco geologists). The Main Boulder showing is assumed to be the same sulphide layer that occurs in the New showing, inferring the presence of a fault in the creek separating them.

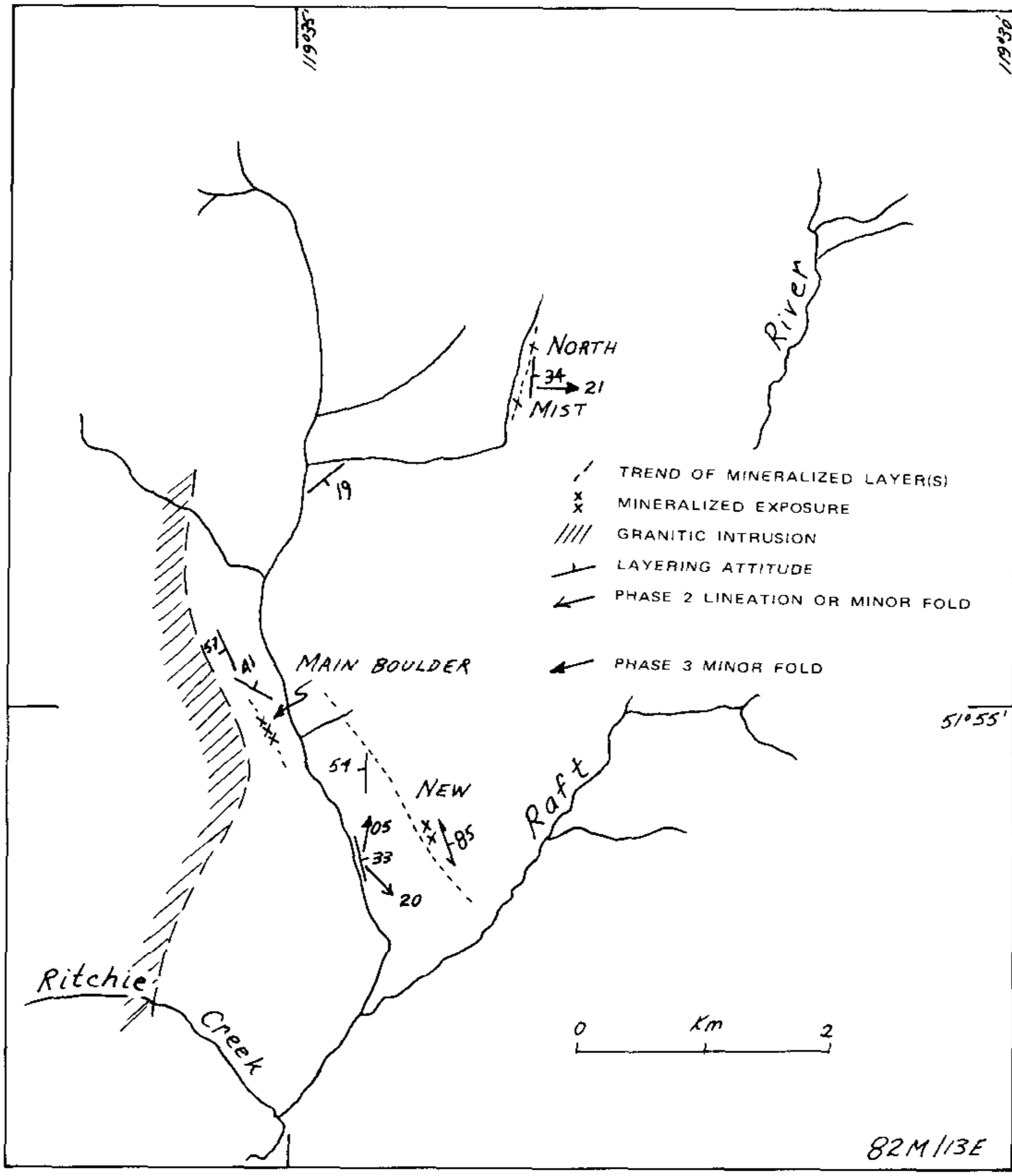

Figure 6. Location map showing mineralized exposures and trends of CK mineralization (after Cominco Ltd.), and some structural data (this report and unpublished data from G. White).

The general structure of the area appears to be relatively simple with an east-facing succession folded into a broad open, east-plunging (phase 3 ?) synformal structure with the New showing trending southeast on the southern limb and the North and Mist trending northeasterly on the northern limb. However, at outcrop scale and drill-section scale structures are very complex resulting in local dip reversals and repetition and omission of lithologies. These complexities are due primarily to relatively late (phase 2 and phase 3) folding and late faulting. Minor folds related to the late (phase 3 ?) structure have upright axial planes and plunge variably to the east and west. Earlier, southeast-plunging (phase 2 ?) folds are noticeable at outcrop scale. They have a pronounced lineation parallel to their fold axes, are relatively open to quite tight, and postdate the regional metamorphism. These folds are responsible for the flattening and apparent thickening of the sulphide layer at the New showing (*see* drill section, Fig. 7) and may be important elsewhere in locally thickening the sulphide layer. An earlier syn-metamorphic deformation (phase 1) is indicated by the parallelism of a regional foliation with bedding. Its effect on the distribution of lithologies is not known.

The calcareous succession structurally above the sulphide layer consists primarily of quartz-diopside calc-silicate gneiss invaded by abundant pegmatite (Fig. 7). In some drill sections, several relatively pure white marble layers up to several tens of metres thick, but generally considerably thinner, occur within this overlying succession. Micaceous schist and quartz feldspar gneiss are also common. Beneath the sulphide layers these schists and gneisses predominate and calc-silicate gneiss is relatively less important.

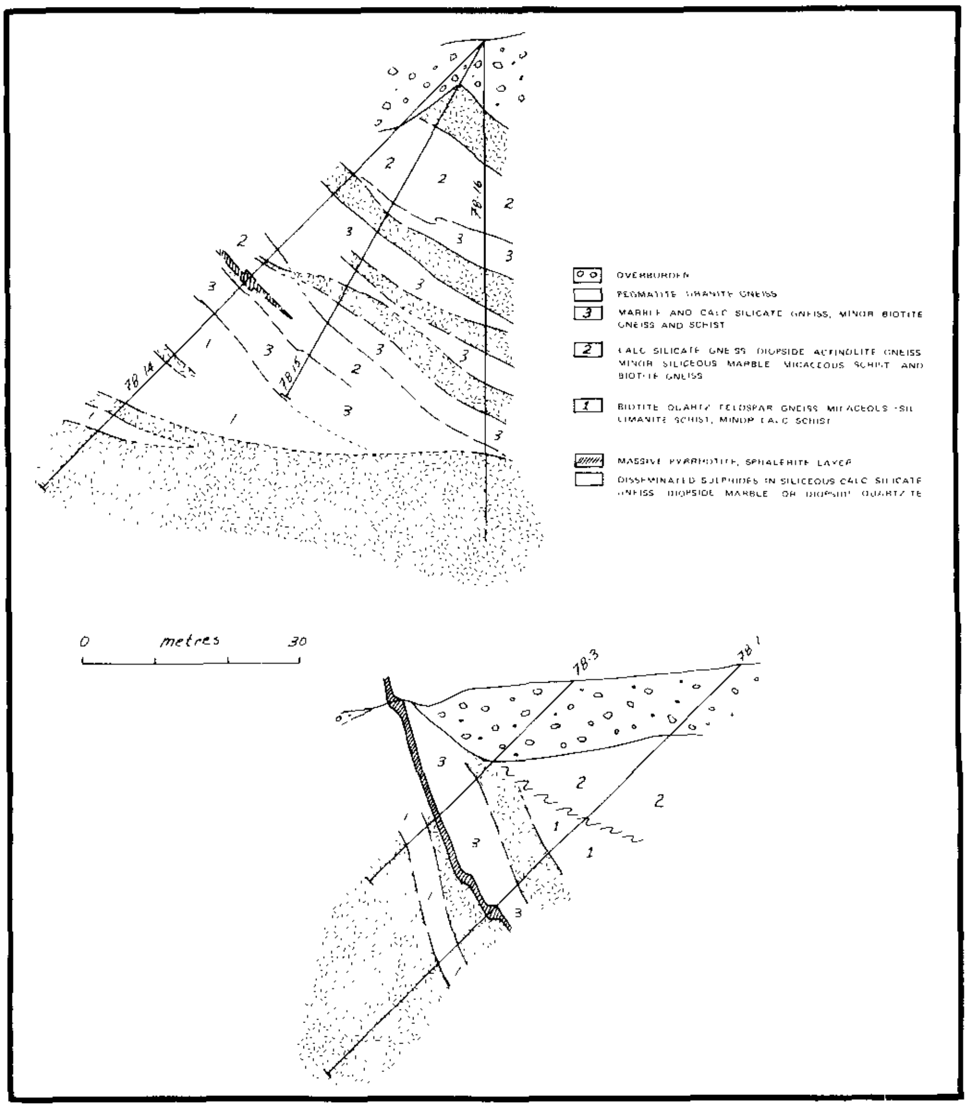

Figure 7. Vertical sections through drill holes CK 78-1, 78-3, 78-14, 78-15, and 78-16, New showing area, viewed to north. For location, *see* Figure 8.

The sulphide layer in the New showing is generally less than 1 metre thick and appears to be continuous, with perhaps minor structural breaks and offsets, for a distance of at least 1 300 metres from drill holes 78-8 to 78-19 (Fig. 8). It is also intersected in holes 79-11, 78-14, and 78-15, a further 800 metres to the north. It consists of massive sphalerite and pyrrhotite, minor galena, and trace chalcopyrite. Gangue quartz, diopside, calcite, amphibole, and plagioclase are common. Fluorite and vesuvianite occur locally. The contacts of the sulphide layer may be sharp or gradational through several metres of siliceous marble containing disseminated sphalerite and pyrrhotite. In a few holes a thin, well-layered diopside-bearing quartzite occurs structurally beneath the sulphide layer.

A 20 to 30-centimetre-thick sulphide layer at the North showing is on strike with a similar layer at the Mist showing several hundred metres to the southwest. Structural complexities at the Boulder showing hinder tracing a small trenched outcrop of massive sulphides for more than a few metres. It was not intersected in any of the holes drilled here.

Assays of both chip and grab samples of the sulphide layer and of a sample of mineralized marble from the Boulder showing are presented in the accompanying table. Average grades of the massive sulphide layer and immediate wallrocks reported by Cominco Ltd. range between 1 to 3 per cent lead and <5 to 15 per cent zinc. The lead/lead + zinc ratio varies from 0.1 to 0.2. Silver and gold are present in only trace amounts, copper varies from 0.02 to 0.057 per cent and cadmium from <0.01 to 0.025 per cent.

ASSAYS, CK PROPERTY

Showing	Sample Type	Pb *per cent*	Zn *per cent*	Fe *per cent*	Cu *ppm*	Cd *ppm*
Main Boulder	grab sample (1974)	1.45	5.8	------	<0.001	------
Main Boulder	grab sample (1974)	4.50	27.1	------	0.045	------
Main Boulder	grab sample	6.31	23.37	7.76	247	252
Main Boulder	0.6 metre chip	4.88	23.45	14.34	423	260
New	0.6 metre chip	4.19	25.20	12.24	408	255
New	0.6 metre chip	4.41	21.85	20.84	568	203
North	0.6 metre chip	0.81	8.95	19.44	515	87
Mist	0.6 metre chip	2.66	20.70	11.33	512	230

SUMMARY

Sphalerite, pyrrhotite, and minor galena occur in a massive sulphide layer generally less than 1 metre thick but locally may be several metres in thickness. This layer appears to be continuous for at least 1 300 metres and probably considerably further. Local structural complexities and lack of outcrop hinder tracing the layer between showings. Surrounding rocks include a dominantly calc-silicate gneiss, micaceous schist, and quartz feldspar gneiss succession, laced by pegmatite.

The CK showings are similar in many aspects to other Shuswap lead-zinc deposits. They are thin layers but commonly very continuous and occur in a calcareous and pelitic succession. Quartzite and marble, common associated lithologies in the Cottonbelt, Jordan River, and Big Ledge successions, are less common at CK and Ruddock Creek.

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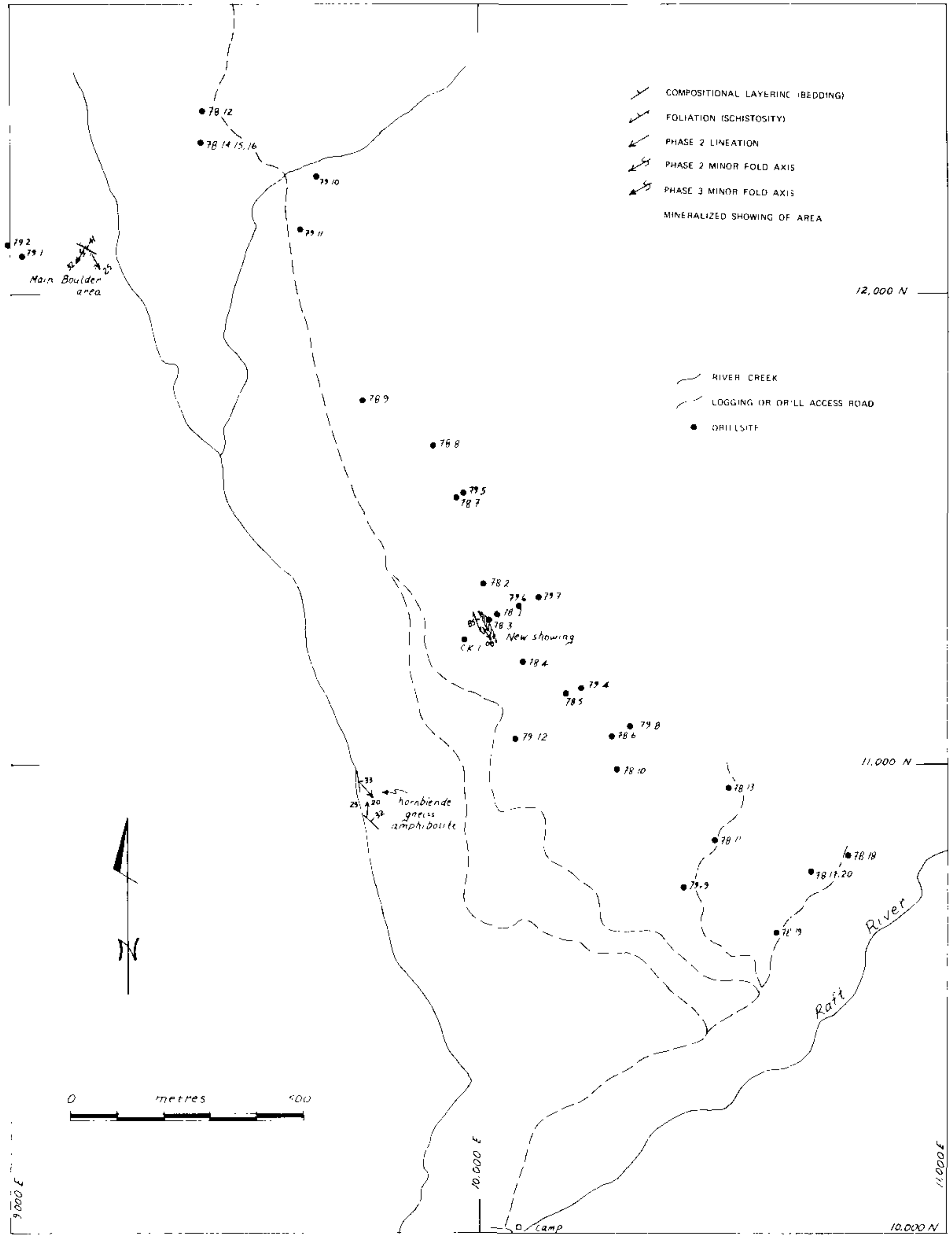

Figure 8. Drillsites in New showing and Main Boulder area (based after Cominco Ltd. data).

BARRIERE LAKES – ADAMS PLATEAU AREA

(82L/13E; 82M/4, 5W; 92P/1E, 8E)

By V. A. Preto, G. P. McLaren, and P. A. Schiarizza

INTRODUCTION

Mapping during the 1979 season was continued in the Barriere Lakes – Adams Plateau area by G. P. McLaren and P. A. Schiarizza, under the supervision of W. J. McMillan. The main effort for the season was devoted to refining the mapping done in 1978, and only a modest area north of Chu Chua Creek and northeast of Brennan Creek was added to that covered in 1978. Much attention was directed to rocks of the Fennell Formation, both in their internal relationships and in their contact relationships with Eagle Bay rocks. A study of the massive sulphide CC deposit on Chu Chua Mountain was carried out by W. J. McMillan and is reported separately. Several fill-in traverses were done in the area of Barriere Mountain, Mount Dixon, and Mount Fraser. Further work on Adams Plateau succeeded in outlining an early synformal fold in the vicinity of Nikwikwaia Lakes.

STRATIGRAPHY

The early indications of stratigraphic relationships between main rock packages that were advanced in *Geological Fieldwork, 1978* were refined and generally confirmed by the current season's fieldwork. These are shown on Figure 9 and can be summarized briefly as follows.

(1) Unit 1 – Devonian and Older (?)

A complex sequence of garnet, biotite, and, occasionally, sillimanite-bearing schists and paragneiss, amphibolite, and orthogneiss is crudely outlined in the northeast corner of the map-area. Mapping in this package is still very crude, in part because some work remains to be done and because exposures are poor. In the area between the east end of East Barriere Lake and Spapilem Creek metasedimentary rocks of this unit are complexly intruded (?) by an orthogneiss which has yielded zircons of Late Devonian age (Okulitch, *et al.*, 1975; Okulitch, 1979). The intruded metasedimentary rocks are therefore considered to be Late Devonian or older. The contact between this higher grade sequence and the considerably lower grade rocks of the Eagle Bay Formation trends uniformly in a northwesterly direction from Adams Lake to North Barriere Lake. The nature of this contact is poorly understood, partly because of poor exposures and partly because of incomplete mapping. The transition, however, is sharp suggesting that it might be due to a structural discontinuity.

(2) Unit 2 – Fennell Formation

Basaltic and related rocks of unit 2 crop out in the northwestern corner of the map-area. Although dips are rare, facing directions in the central and western parts of the Fennell Formation are to the west; dips and 'tops' along the eastern part are consistently steep and to the east, indicating that Fennell rocks underlie Eagle Bay sedimentary rocks. 'Tops' in this area are indicated not only by pillow basalt units but also by graded bedding in sedimentary units and by abundant clasts of units 2a, 2b, and 2c in conglomerate of unit 2d. Eagle Bay rocks crop out a short distance to the east but no Eagle Bay clasts occur in conglomerate of unit 2d. North of Chu Chua Creek, and a short distance to the east of the Chu Chua massive sulphide deposit, conglomerate of unit 2d lies immediately east of quartz feldspar porphyry of unit 2c and contains numerous clasts of this porphyry. The same conglomerate also contains some clasts of massive sulphide mineralization identical to that of the Chu Chua deposit to the west. Pillow basalt units in this area also indicate tops to the east. The eastern, and apparently upper part of the Fennell Formation, therefore, is a transition zone from 2 to 4 kilometres wide which is characterized by abundant massive basalt with interbedded ribbon chert, cherty argillite, quartz feldspar porphyry dykes, sills, and their extrusive equivalents, and in its upper part by several units of intraformational conglomerate crowded with clasts of underlying units. This entire sequence dips steeply, faces east, and underlies black phyllite and related sedimentary rocks of unit 6.

(3) **Eagle Bay Formation (Units 3 to 12)**

Rocks of the Eagle Bay Formation are designated as units 3 to 12 on Figure 9. The arrangement of these units in the map legend is not an exact stratigraphic succession, although in most cases units of lower number are generally thought to underlie units of higher number. The following notes summarize briefly the lithology of these units and their distribution within the map-area.

Unit 3 – A complex package of interlayered grit, impure quartzite, phyllite, impure limestone, and minor greenschist has been mapped in two separate areas between Barriere River and Sinmax Creek and northeast of Johnson Lake (Fig. 9). Although at first glance one might correlate these two packages of broadly similar lithologies and thus infer significant repetitions of stratigraphy, caution in this respect is warranted for several reasons. The unit includes a great variety of lithologies which have been grouped together merely because there are few marker horizons. Between Barriere River and Sinmax Creek several lithologies of units 5, 6, 10, and 12 could be distinguished and mapped separately from rocks of unit 3. These include a prominent quartzite, several carbonate units, and three units of greenschist which was clearly derived from pillow lavas. These features do not appear in the area of unit 3 northeast of Johnson Lake. Smaller packages of unit 3, in part grading laterally into purer quartzite, have also been recognized in the central part of the map-area and on Adams Plateau.

Unit 4 – A thin unit of rusty yellow-weathering, tan to light grey, highly pyritic chloritoid-sericite-quartz and sericite-quartz schist was mapped within rocks of unit 3 west of Forest Lake. Although this unit is of modest thickness and lateral extent, it locally provides a marker horizon and is of interest to exploration geologists. Its high content of silica and pyrite strongly suggests a volcanic, probably exhalative, origin.

Unit 5 – Relatively pure, generally massive, light grey to white micaceous quartzite occurs near and north of Forest Lake, from South Barriere Lake to west of East Barriere Lake, and near Nikwikwaia Lake on Adams Plateau. This rock provides an easily recognizable, reliable marker horizon and is very useful in outlining early folds, such as the tight northeasterly plunging synform near Nikwikwaia Lake.

Unit 6 – The largest part of unit 6, a turbidite-like sequence of black phyllite and interbedded grit, sandstone, siltstone, and argillite, has recently been correlated with the Mississippian Milford Group (Okulitch, 1979). Discontinuous lenses of impure limestone occasionally occur within this sequence. One of these, a short distance south of Barriere River, has yielded an abundant and diverse collection of macrofauna and conodonts of Early Mississippian (Osagian to Early Meramecian) age (Okulitch

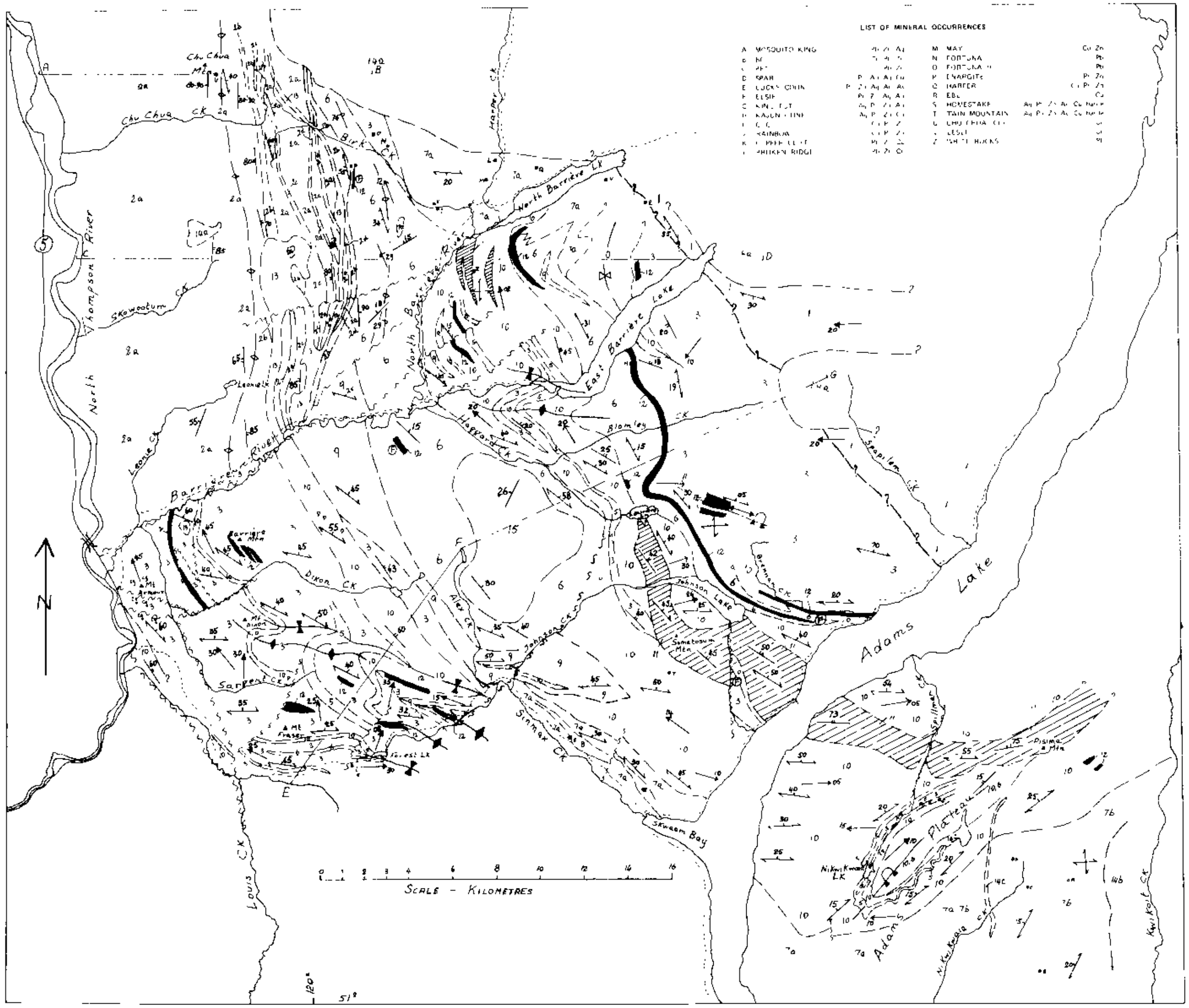

Figure 9. Generalized geological map of the Barriere Lakes—Adams Plateau area.

LEGEND

PLEISTOCENE AND/OR EARLIER

OLIVINE BASALT FLOWS, MINOR INTERBEDDED MUDSTONE

CRETACEOUS

(a) BALDY BATHOLITH: BIOTITE QUARTZ MONZONITE AND GRANITE
(b) KWIKOIT CREEK PLUTON: BIOTITE QUARTZ MONZONITE
(c) QUARTZ FELDSPAR PORPHYRY (ADAMS PLATEAU)

JURASSIC OR TRIASSIC (?)

DIORITE AND QUARTZ DIORITE

PRE–UPPER TRIASSIC (PROBABLY CARBONIFEROUS)

EAGLE BAY FORMATION

LIMESTONE: DARK TO LIGHT GREY, BANDED, MINOR DOLOMITE

TSHINAKIN LIMESTONE: MASSIVE, LIGHT GREY TO WHITE, FINELY CRYSTALLINE

GREENSCHIST DERIVED FROM MAFIC MASSIVE AND PILLOWED (p) FLOWS, BRECCIAS, AND TUFFS

DACITIC TO RHYODACITIC LITHIC TUFF AND VOLCANIC BRECCIA

HOMESTAKE SCHIST: PLATY, LIGHT RUSTY YELLOW–WEATHERING SERICITE–PYRITE–QUARTZ SCHIST
(a) INTERMEDIATE TO FELSIC SCHIST DERIVED MOSTLY FROM FELSIC TUFFS AND QUARTZ FELDSPAR PORPHYRY
(b) INTERLAYERED CHERTY TUFF, CHERT, CALC–SILICATE, AND THIN LAYERS OF IMPURE LIMESTONE

EAGLE BAY FORMATION *(CONTINUED)*

DARK GREY TO BLACK PHYLLITE; INTERBEDDED GRIT, SANDSTONE, SILTSTONE, AND ARGILLITE

RELATIVELY PURE, LIGHT GREY TO WHITE, MICACEOUS QUARTZITE

PYRITIC CHLORITOID–SERICITE–QUARTZ SCHIST AND SERICITE–QUARTZ SCHIST

INTERLAYERED GRIT, MICACEOUS QUARTZITE, PHYLLITE, CALCAREOUS QUARTZITE, IMPURE LIMESTONE, CALCAREOUS PHYLLITE AND MINOR GREENSCHIST (FOR EXAMPLE, CONGLOMERATE ON MOUNT ARMOUR)

MISSISSIPPIAN (?)

SLIDE MOUNTAIN GROUP (?)

FENNELL FORMATION

(a) MASSIVE AND PILLOW BASALT WITH MINOR INTERBEDDED CHERT AND CHERTY ARGILLITE
(b) CHERT AND RIBBON CHERT, LOCALLY BRECCIATED
(c) QUARTZ FELDSPAR PORPHYRY (SPRAGUE CREEK – BIRK CREEK AREA)
(d) CONGLOMERATE WITH PEBBLES AND COBBLES OF CHERT, ARGILLITE, QUARTZ FELDSPAR PORPHYRY AND BASALT

DEVONIAN AND OLDER (?)

ORTHOGNEISS, AMPHIBOLITE, MICACEOUS QUARTZITE, GARNET–BIOTITE SCHIST, IMPURE FINE–GRAINED MARBLE

SYMBOLS

BEDDING: TOPS KNOWN, OVERTURNED

BEDDING: TOPS NOT KNOWN

EARLY SCHISTOSITY: INCLINED, HORIZONTAL

PHASE 1 FOLD AXES

PHASE 2 FOLD AXES

INFERRED FAULT

GEOLOGICAL CONTACT

FOSSIL LOCALITY

MINERAL OCCURRENCE

EARLY AXIAL TRACE:
SYNFORM UPRIGHT, OVERTURNED
ANTIFORM UPRIGHT, OVERTURNED

LATE AXIAL TRACE:
SYNFORM UPRIGHT, OVERTURNED
ANTIFORM UPRIGHT, OVERTURNED

NOTE: The order of superposition between the Fennell Formation and the Eagle Bay Formation has been established. Units within the Eagle Bay Formation, however, are lithologic units and not lithostratigraphic units. For instance, every unit of greenschist within the Eagle Bay has been designated 10 regardless of its stratigraphic position.

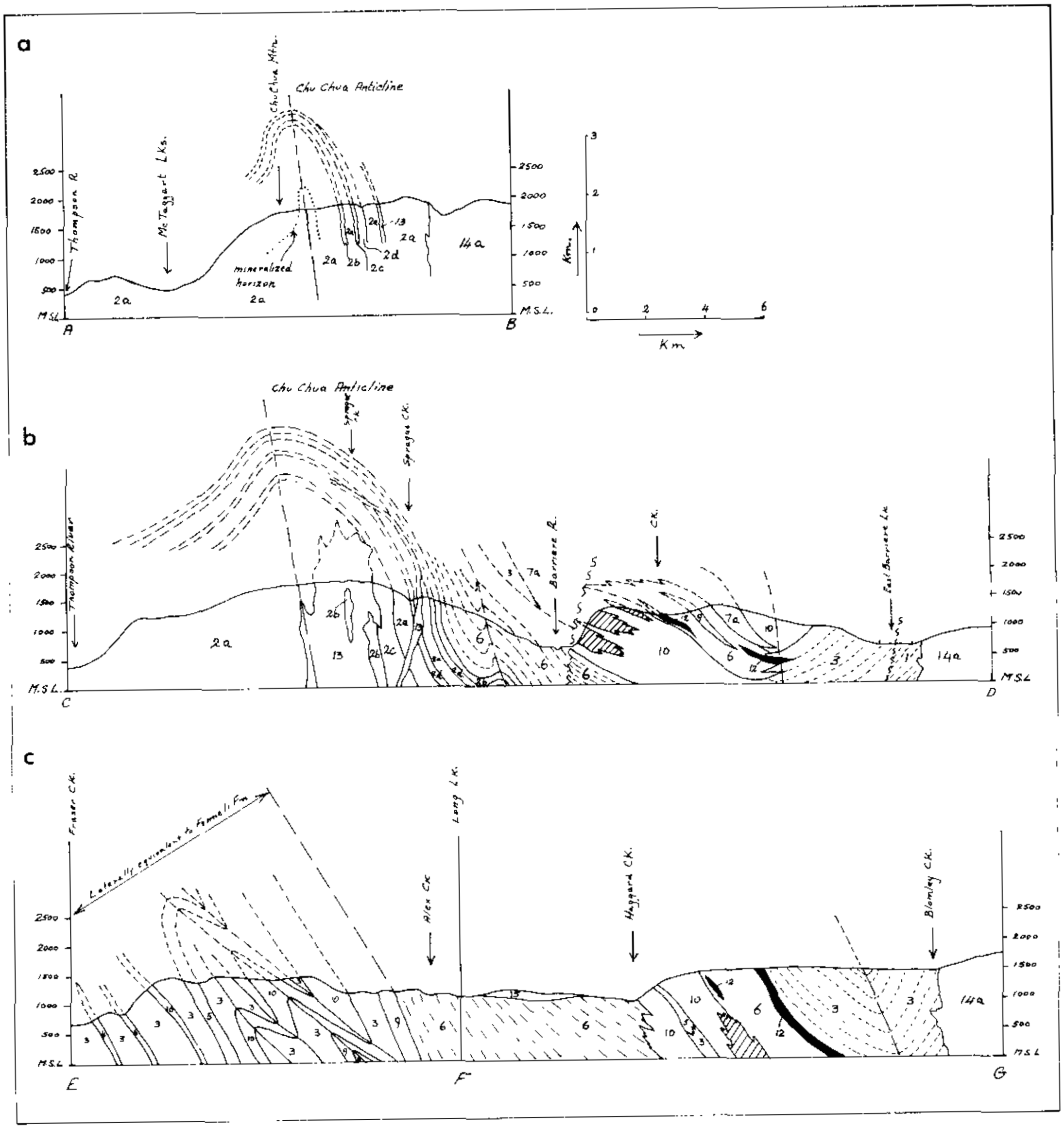

Figure 9 a, b, c: Cross-sections to accompany Figure 9.

and Cameron, 1976; Okulitch, 1979). Another limestone clearly interbedded with argillite and siltstone, a short distance south of Birk Creek and very close to the base of the sequence has also yielded conodonts of Early Mississippian age (mid-Kinderhookian; R. B. Campbell, oral communication, November 16, 1979).

A predominantly black phyllite member of unit 6 occurs between North Barriere Lake and Johnson Lake. At its southeastern end this phyllite grades into, or is infolded with, greenschist of unit 10. Near North Barriere Lake the phyllite displays a similar relationship with felsic schist of unit 7a. A thin but laterally continuous grey to dark grey impure limestone is interlayered with the phyllite and separates it from rocks of unit 3 in the central part of the map-area.

Unit 7 — Generally pyritic, grey to rusty yellow sericite-quartz schists, commonly with eyes of bluish grey quartz occur at North Barriere Lake and near Skwaam Bay. A very extensive package of similar rocks was also mapped east of Adams Lake. East of Nikwikwaia Creek on Adams Plateau these appear to grade laterally into a rather monotonous but apparently not very thick sequence of very fine-grained cherty tuff, calc-silicate, thin layers of impure limestone, and minor argillaceous sediments (unit 7a). Although most schist of unit 7 has been pervasively recrystallized and sheared, volcanic quartz phenocrysts with deeply embayed, resorbed borders have been observed in specimens from the Birk Creek — North Barriere Lake sequence, and clearly fragmental members with numerous flattened felsic clasts crop out southeast of Nikwikwaia Lake on Adams Plateau. These features, together with the generally pyritic and felsic nature of the schist, suggest an acid volcanic origin for at least a good part of this unit. Accordingly, the distribution of the unit indicates the existence of at least two felsic volcanic centres, one near North Barriere Lake and one near, or southeast of, Skwaam Bay.

Unit 8 — Highly foliated, light rusty yellow-weathering, light grey to nearly white sericite-pyrite-quartz schist, commonly with a honeycombed aspect due to the weathering of pyrite was mapped along the north side of Sinmax Creek, near the Homestake mine. It is locally useful as a marker horizon within less pyritic schist of unit 7a. This rock is very similar in aspect, and probably in origin, to the pyritic schist of unit 4.

Unit 9 — Generally rusty grey-weathering, strongly foliated and fine-grained schist to weakly foliated coarsely fragmental volcanic breccia of dacitic to rhyodacitic composition occurs in a continuous band from Johnson Creek to Barriere River. Similar rock is found as interlayers in greenschist and black phyllite west and northwest of East Barriere Lake. Except where it is fine grained and highly foliated, this unit is generally fragmental, commonly coarsely so, and probably represents a sequence of volcanic breccia, lithic tuff, and tuff of intermediate to felsic composition.

Unit 10 — Greenschist of this unit, clearly derived from mafic massive and pillowed flows, breccias, and tuffs, is one of the more common rock types in the area, and is one of the most easily mapped. Locally, as for example in the southwest corner of the map-area, pillow structures are still beautifully preserved. Elsewhere, such as along Adams Lake, the greenschists contain abundant and widespread, flattened clasts of mafic volcanic rocks. Some greenschist units are strongly magnetic and contain clearly visible octahedra of magnetite. One such unit faithfully outlines the Nikwikwaia Lake fold in low-level aeromagnetic maps of that area.

Unit 11 — The Tshinakin limestone is a prominent, light grey to nearly white, finely crystalline limestone. It is overlain and underlain by greenschist, is several hundred metres thick, and provides an excellent marker horizon that can be very easily followed from the vicinity of Pisima Mountain on the Adams Plateau to South Barriere Lake where it terminates abruptly. Careful searching in the greenschist and phyllite beyond this point produced only sparse discontinuous lenses of impure limestone, but a good deal of carbonate is widely disseminated throughout the greenschist and phyllite. Because the formations that overlie and underlie the Tshinakin limestone south of South Barriere Lake continue beyond this point, it is concluded that the sudden termination of this prominent carbonate unit marks an original interruption or termination in the carbonate bank or reef complex that produced the limestone. A very similar limestone, also interlayered with greenschist, is found at Whiterocks Mountain southwest of North Barriere Lake at about the same horizon. This carbonate is considered correlative to the Tshinakin limestone and probably represents another reef complex. Despite its great extent and abundant outcrop, the Tshinakin limestone so far has yielded no fossils.

Unit 12 – Dark to light grey, banded limestone, and, to a lesser extent, orange-weathering dolomite occur interlayered with rocks of units 3, 6, and 10. Some of these lesser carbonate units are of very limited extent and of little use as marker horizons, but others could be traced for considerable distances and locally help in outlining folds. Fossil collections have been made from two carbonate lenses in unit 6. The southern of these has yielded a rich macro and microfauna of Osagian to Early Meramecian age (Okulitch and Cameron, 1976; Okulitch, 1979. The northern lens has yielded conodonts of mid-Kinderhookian age (R. B. Campbell, oral communication, November 16, 1979). Four other collections were made from two carbonate units at Brennan Creek. Reports from these are not yet available.

(4) Unit 13 – Diorite and Quartz Diorite

An irregularly shaped body of diorite and quartz diorite, considered to be possibly of Jurassic or Triassic age, cuts Fennell Formation rocks between the headwaters of Sprague Creek and Leonie Lake. A long, narrow, dyke-like extension of this body has been traced from upper Sprague Creek to the headwaters of Chu Chua Creek, a distance of nearly 15 kilometres. Although this intrusion clearly cuts Fennell rocks and contains many large inclusions or roof pendants of chert and quartz feldspar porphyry, it is irregularly shaped with many protrusions and re-entrants, and markedly elongated parallel to the bedding and main schistosity of the country rocks. In hand specimen and outcrop, the rock is massive, medium to coarse grained, and generally displays a considerable degree of saussuritic alteration.

A smaller body, finer grained but of similar composition, has been mapped northwest of Barriere Mountain.

(5) Unit 14

Post-tectonic porphyritic quartz monzonite of the Cretaceous Baldy batholith cuts Fennell and Eagle Bay rocks from Chu Chua Creek to Spapilem Creek. A smaller body of similar rock was also mapped on upper Skowootum Creek. A similar pluton and numerous related northeast-trending dykes, all probably also of Cretaceous age, cut Eagle Bay rocks along the west of Kwikoit Creek.

(6) Unit 15

A succession of gently dipping basaltic flows with some interbedded poorly indurated mudstone unconformably overlies Eagle Bay rocks between Haggard Creek and Alex Creek. These strata probably are of Pleistocene or Late Tertiary age (Campbell, 1963).

STRUCTURE

The general remarks on the structure of the map-area made in *Geological Fieldwork, 1978* were confirmed in 1979. In addition, fill-in traverses in several parts of the map-area were helpful in outlining a number of fold structures which are briefly discussed below.

(1) Early Folds

These structures deform the bedding and have axial surfaces that are parallel to the main schistosity. Mesoscopic structures of this generation are plentiful throughout the map-area but only a few medium to large structures could be outlined.

(a) *Nikwikwaia Lake Fold*

A synform was traced on upper Spillman Creek and in the vicinity of Nikwikwaia Lake for a strike length of at least 6 kilometres by careful mapping of a thin micaceous quartzite. The fold plunges gently to the northeast parallel to the early lineations and mesoscopic early fold axes in the area. The axial plane dips moderately to the northwest, parallel to the main schistosity. The Nikwikwaia synform is cored by a mixture of argillaceous, locally calcareous sediments and greenschist. The southeast limb is paralleled and locally truncated by a sill-like mass of quartz feldspar porphyry probably of Cretaceous age. The marker quartzite is flanked to the west, south, and east by a thick succession of greenschist which contains a strongly magnetic member along the outward perimeter of the quartzite. The magnetite-rich greenschist faithfully outlines the fold on low-level aeromagnetic maps of the area.

(b) *Mount Dixon and East Barriere Lake – Haggard Creek Areas*

Units of pillowed greenschist and quartzite outline relatively open, west to northwest-trending folds with axial surfaces parallel to the main schistosity and axes plunging north to northwest, roughly parallel to the axes of early mesocopic folds. These structures are only outlined approximately because exposures are generally poor and widely scattered. In the vicinity of Barriere Mountain graded bedding in some members of map unit 3 indicates that the strata here are upright and face northeast. If the same relationship can be applied to the Mount Dixon area, then the structures shown on the map become a syncline-anticline pair, overturned to the southwest.

(2) Late Folds

A late generation of mesoscopic folds clearly warps the main schistosity, has axes parallel to a pronounced and widespread crenulation lineation, and generally upright axial planes parallel to a pronounced crenulation cleavage. These folds, though widespread, are not evenly distributed but tend to occur in clusters that are of generally limited lateral extent but are fairly continuous along strike. One such cluster with a general anticlinal configuration runs in a northerly direction through the middle of map unit 6 west of North Barriere River and south of Birk Creek. Axial planes are upright or only slightly overturned to the west, and fold axes plunge gently north.

A similar fold, or package of folds, probably accounts for the opposing dips and facing directions near the Chu Chua massive sulphide deposit, and might provide for a repetition of the mineralized horizon.

MINERAL DEPOSITS

Numerous base metal occurrences, many of which clearly are stratabound massive sulphide deposits syngenetic with their host rocks, are found in the map-area (Fig. 9), especially in the Birk Creek – North Barriere Lake region, along Sinmax Creek near Skwaam Bay, and on the Adams Plateau. All of these deposits, which are briefly referred to in *Geological Fieldwork, 1978,* are polymetallic deposits, commonly with associated barite and with precious metal values. They are also invariably associated with schists that were derived from acid volcanic and/or high-level intrusive rocks.

The Chu Chua deposit, which was explored by drilling in late 1978 – early 1979, represents a different type of massive sulphide mineralization and is reported on separately (McMillan, 1979). This mineralization consists essentially of massive pyrite and chalcopyrite in basic pillow basalts of the Fennell Formation. The mineralization occurs near the top of the basaltic pile just below the zone of transition between the Fennell and Eagle Bay Formations. Opposing dips and facing directions near the Chu Chua deposit may be due to a late phase anticline.

ACKNOWLEDGMENTS

The able assistance of L. J. Diakow is acknowledged.

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CC PROSPECT, CHU CHUA MOUNTAIN
(92P/8W)

By W. J. McMillan

INTRODUCTION

Interest in the Chu Chua area initially centred on a large anomalous copper gossan outlined in 1977 by Vestor Explorations Ltd. on the south slope of Chu Chua Mountain. The gossan was subsequently interpreted to be transported and prospecting up the slope eventually located a small gossan with lower but anomalous copper values adjacent to a northerly striking massive magnetite body. In 1978 Craigmont Mines Limited optioned the property, which is jointly owned by Vestor Explorations Ltd., Pacific Cassiar Limited, and Seaforth Mines Ltd., and discovered massive sulphide mineralization. In 1978 Craigmont did 2 843 metres of BQ diamond drilling in 23 holes and announced geological reserves of approximately 2 million tonnes of 2 per cent copper, 0.4 per cent zinc, 0.4 gram per tonne gold, and 8 grams per tonne silver. In 1979 an additional 2 932.6 metres of drilling was done in 17 holes to further delineate the deposit (Fig. 10).

ACCESS

The CC property lies about 20 kilometres north-northeast of Barriere on the ridge east of Chu Chua Mountain at 1 800 metres elevation. Access is via paved and logging roads from Barriere along Barriere River, North Barriere River, and Birk Creek. The last few kilometres require a four-wheel-drive vehicle, especially in wet weather.

REGIONAL GEOLOGY

A thick pile of massive to pillowed basalts with local pods and layers of cherty tuff and greywacke comprise the lower part of the Fennell Formation in the Chu Chua area. Stratigraphically upward these give way to massive basalt, then through a transitional zone of basalt, chert, phyllite, quartz feldspar porphyry, and intraformational chert conglomerate (Preto, 1979, this report) into overlying phyllites and turbiditic sandstones of the Eagle Bay Formation. Mississippian (Osagian to Early Meramecian) megafossils and conodonts occur in limestone lenses in Eagle Bay rocks south of Barriere River (Okulitch and Cameron, 1976).

Ministry of Energy, Mines and Petroleum Resources mapping has not yet extended north to Chu Chua Mountain but the deposit lies within the Fennell Formation, apparently just below the base of the transition zone. The exact position is uncertain because although the deposit and nearby basalts have a subvertical dip and apparently face west, interbedded pillow lavas, chert, and conglomerate a kilometre to the east apparently face eastward. If the sequence is actually folded, the CC mineralized horizon could be structurally repeated a short distance east of the known mineralization (Preto, this report).

On the Bonaparte map sheet (Campbell and Tipper, 1971), Fennell Formation rocks continue northward for approximately 35 kilometres. Whether the transition zone curves around or is cut off by the Baldy batholith is not known. It reappears, however, west of Foghorn Mountain and should continue northward to Clearwater where it is cut off by the Raft batholith. Although they are all reported to be veins, there

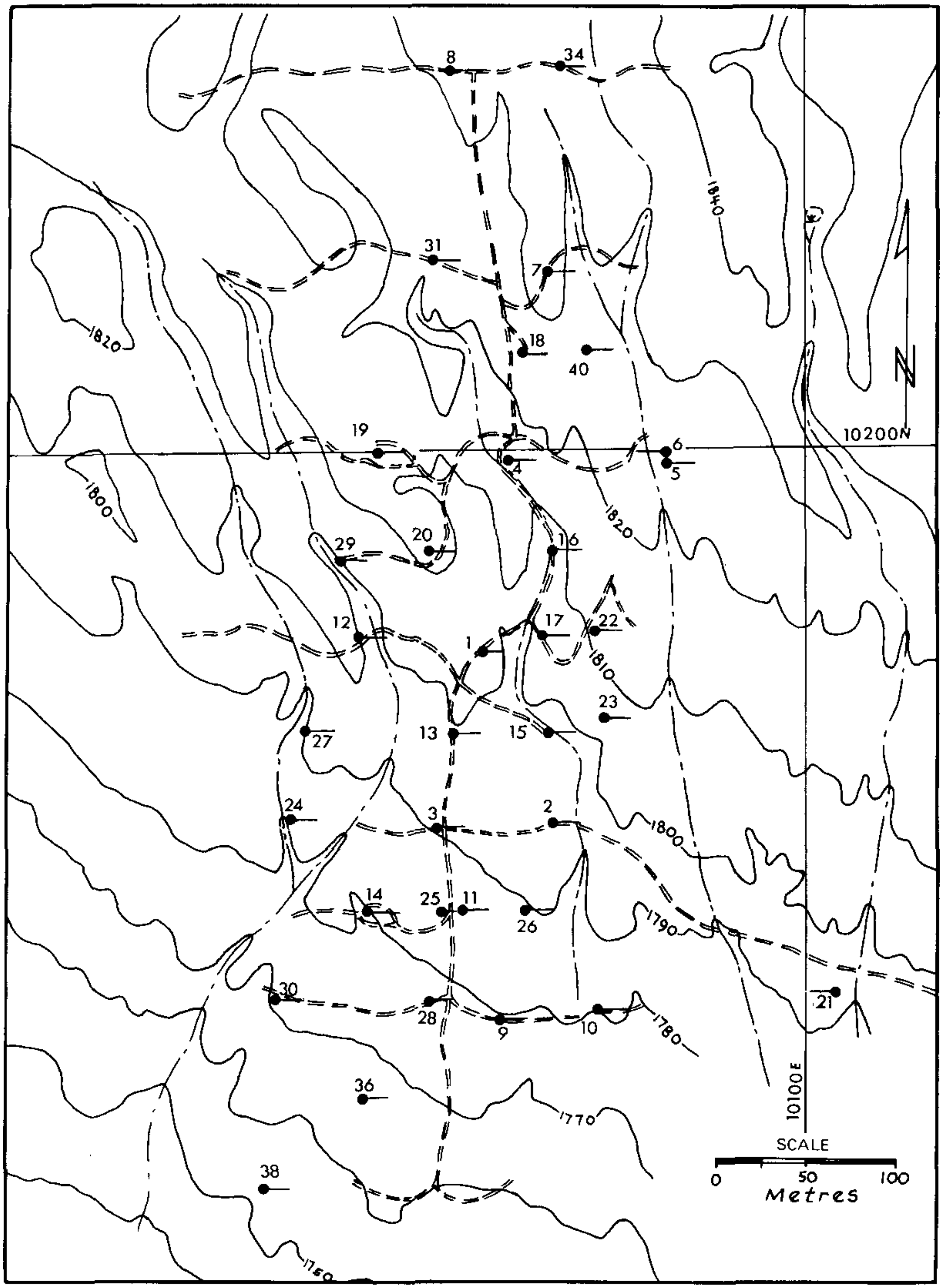

Figure 10. CC property, topography and diamond-drill hole locations (based on company maps); all drill holes are inclined.

are several lead-zinc occurrences between Chu Chua deposit and Clearwater. The area warrants investigation.

LOCAL GEOLOGY

Surface exposures at CC are not abundant and were not mapped in detail. The preliminary geological interpretations presented here are based on examination of core from diamond drilling with no laboratory backup.

Dark green to grey-green pillow basalts and basalts are the dominant country rock of the CC deposit. Although primary volcanic textures are easily recognized, Fennell Formation rocks have been regionally metamorphosed to lower greenschist facies. Primary pyroxene in the basalt has been replaced by hornblende needles and plagioclase has been saussuritized. Scattered epidote and zoisite, patches of carbonate, and some chlorite replace the matrix (Campbell and Tipper, 1971, p. 15). The effect of this regional metamorphism on the Chu Chua massive sulphides and hydrothermally altered country rock appear minimal. On the other hand, 'unaltered' country rock has been recrystallized to lower greenschist assemblages (G. White, personal communication, 1979). In areas between pillows, where minerals are most easily recognized, typical components are chalcedonic quartz, quartz, chlorite, and pyrrhotite with local epidote; other common constituents are pyrite and calcite. Interpillow zones are cut by chlorite±epidote fractures and veinlets of pyrite and calcite.

Pillows in the basalts are generally 1 to 3 metres across in drill core. Pillow rinds are chilled slightly and are chloritized or bleached. Bleaching also occurs adjacent to some of the fractures and veinlets which cut the basalt. Typical fracture fillings are chlorite with or without pyrrhotite, pyrite, or calcite; calcite (often with bleached halos); epidote-quartz with bleached halos; and epidote-calcite.

Generally, primary textures are preserved. Locally, however, alteration and dissemination of chlorite-pyrite give the rock a spotted texture. Elsewhere, where pillows are poorly developed, the rock is often finely crystalline and feldspathic. Areas of monomictic fragmental volcanic rock occur; these appear to be flow breccias.

MINERALIZED ZONES

The mineralized zone is best described as mixed chert or cherty tuff (?) and cupriferous pyrite or magnetite lenses. The cherty rocks will be described first, then the copper-bearing zones.

The cherty rocks are variably grey to pale grey-green or white, siliceous, fine-grained rocks. They are generally massive and usually closely fractured and often brecciated. Pyrite is abundant as disseminations, streaks, veins, and cement in breccia zones. In breccia zones it may be joined by a dark grey very soft mineral (talc ?). Locally the rock is finely laminated and may resemble ribbon chert. Overall, these cherty rocks appear to be chemical precipitates contaminated by volcanic debris and may be of volcanic exhalative (Ridler and Shilts, 1973) origin. In Archean deposits, similar rocks are termed cherty tuffs or tuffites.

Volcanic flows interlayered in the cherty rocks are prevasively bleached or altered to chlorite, carbonate, or talc. They resemble altered volcanic rocks along the eastern border of the cherty zone.

Locally the cherty rocks are cut by pyritic fractures and veinlets carrying chalcopyrite, carbonate-sphalerite-chalcopyrite veinlets, quartz-chalcopyrite-galena veins, and carbonate veins with pockets of pyrrhotite, pyrite, and sphalerite. Bleached pale grey to white siliceous rock is associated with abundant disseminated pyrite and also occurs adjacent to some pyrite veins. Pervasively bleached, pyritized, and silicified volcanic rocks occur locally and are difficult to distinguish from these bleached pyritic cherty rocks.

Copper with minor zinc mineralization occurs in massive pyrite and massive magnetite bodies. Massive mineralization apparently forms two large and several small lenses. Because the deposit is now subvertical, plan views at 1 800, 1 750, and 1 700 metres (Fig. 11a, b, c) are actually cross-sections while vertical sections along 9900N, 10050N, and 10200N (Fig. 12a, b, c) are longitudinal sections of the original deposit.

Metalliferous lenses are enclosed both in chert and in volcanic rocks. A rind of altered volcanic rocks lies along the eastern boundary of the ore 'system.' That is, the rind formed not only adjacent to the metal-rich lenses but also adjacent to the chert. Chert adjacent to massive sulphide zones on the east differs slightly from that on the west. Chert on the east has much black, carbonate (?) as fracture coatings and cementing breccia zones. Similarly, volcanic rocks adjacent to massive sulphides on the east are hydrothermally altered whereas those on the west are virtually unaltered. In the zone of hydrothermal alteration, primary textures of the volcanic rocks are masked by talc or carbonate alteration and black carbonate veining, by bleaching with local silicification, and by pervasive chlorite alteration. Thickness of the alteration zone ranges from 5 to 25 metres and its eastern border is gradational. Outside it are basalts, pillow basalts, and breccias similar to rocks seen west of the mineralizing system.

MASSIVE SULPHIDE BODIES

Pyritic massive sulphide bodies consist of pyrite with several per cent chalcopyrite and minor amounts of sphalerite. Banding of sulphides is uncommon but where it occurs consists of either chalcopyrite-rich layers or alternating bands of very finely crystalline and coarser pyrite. In many areas the pyrite looks clastic but fragmentation could be of either primary or tectonic origin. Chalcopyrite is interstitial, cements brecciated pyrite, and occurs in veins with quartz, calcite, pyrite, and sphalerite. The massive sulphide is also cut by quartz-talc (?) veins and, in one hole, by molybdenite stringers.

COPPER–ZINC DISTRIBUTION PATTERN

Copper-zinc distribution patterns are poorly developed in the deposit. From holes CC 1 to CC 21, the only ones for which both copper and zinc assays are available, an attempt was made to define a zoning pattern for the south massive sulphide zone. There is a relatively zinc-poor zone in the middle area and along its east side to the north. The west side in the northern area is relatively zinc enriched. Holes which penetrated the massive sulphide at greater depth also tend to be relatively zinc rich. The zoning scheme, though poorly developed, is in accord with the interpretation that the deposit faces west and the east side is its base. Zinc deficiencies suggest that the central area was close to the source of hydrothermal fluids. In many massive sulphide deposits, zoning from base to top is from zinc poor to zinc rich. Fringing mineralization also tends to be zinc rich. Therefore, zoning at Chu Chua, though poorly developed, suggests that the deposit faces west and that deeper mineralization is further from the feeder vent(s).

MAGNETITE LODES

A magnetite lode occurs near the base of the south massive sulphide zone and there is a magnetite-pyrite lode at the northern tip of the north zone. Near the contacts with pyritic lodes and where pyrite and magnetite are mixed, copper grades are like or better than those in pyritic lodes; in massive magnetite zones grades are poor.

Magnetite lodes typically contain pyrite and chalcopyrite with lesser amounts of chlorite, carbonate, and talc (?). Pyrite occurs as disseminations and forms veins in magnetite. However, magnetite-pyrite layers with both sharp and gradational contacts are found in pyritic massive sulphides and quartz-magnetite veins cut massive sulphides. Evidently pyrite post-dates magnetite in part but in part they overlap. In many instances contacts between pyrite and magnetite lodes are copper rich. In magnetite lodes there are pockets of carbonate, pyrite, and chlorite. Magnetite is veined by chlorite-feldspar (?)-pyrite, chalcopyrite-talc (?), chlorite-pyrite±chalcopyrite, carbonate (dolomite ?), magnetite-chlorite-quartz-pyrrhotite±chalcopyrite, and chlorite-pyrrhotite. Magnetite breccias are cemented by talc (?) or chlorite-pyrite±chalcopyrite.

GEOMETRY OF THE MASSIVE SULPHIDE ZONES

Plans and sections show that there are two major and several minor massive sulphide zones. Apparently the massive sulphides are lenticular and stratabound. On the 1 800 and 1 750-metre level plans the extent of the bodies is defined. They strike north and have subvertical to steep west dips. Below 1 750 metres, the north zone apparently pinches out but the south zone continues southward. There is a single magnetite lode at the south end of the south zone on 1 800-metre level. By elevation 1 750 metres there is a second magnetite lode near the east-central part of the south zone. This second lode has several metres of massive sulphide east of it and the main massive sulphide layer lies to the west. By elevation 1 700 metres, this magnetite lode has pinched out and cherty rocks separate the main and eastern massive sulphide layers; that is, at depth the south zone apparently splits into two discrete lenses.

DISCUSSION

Massive sulphide and magnetite lodes of the CC deposit are generally closely associated with pyritic, fine-grained, siliceous, often brecciated and locally laminated, cherty rocks. These rocks are over and underlain by basaltic, often pillowed, locally brecciated volcanic rocks. On the east side, the volcanic rocks are hydrothermally altered and the alteration fades to the east. It is interpreted that the alteration took place in the footwall lavas and therefore the deposit is proximal and faces westward.

The massive sulphides form lenticular layers which appear to be stratabound. Some pyrite appears to be clastic but relationships are not definitive. Chalcopyrite deposition usually slightly postdates that of pyrite. Banding in the zones is local and poorly developed. Zoning of copper and zinc is rudimentary but where best developed is in accord with tops to the west.

In several sections massive sulphides lens out down dip into cherty rocks. Similarly, on the level plans cherty rocks are seen to be closely associated with and along strike from massive sulphides. The cherty rocks are thought to be distal equivalents of the proximal massive sulphides.

Along the eastern margins of the south zone, hence early in the mineralizing episode, magnetite lodes were deposited. Magnetite-pyrite-rich areas also occur at the north edge of the north zone. As described by Large (1977), hydrothermal solutions of copper-pyrite ores are initially relatively highly oxidized. Mixing with seawater decreases temperature and oxygen fugacity. The deposition of massive sulphide, then magnetite, early in the mineralizing event suggests that mixing of seawater caused fO_2 to drop and the mixing curve to move into the magnetite field. In spite of further lowering fO_2, continued cooling would move the mixing curve back into the pyrite field (Fig. 13, curve A–B, following the method of Large, 1977). Magnetite-pyrite-chalcopyrite assemblages would develop where mixing paths followed stability field boundaries in fO_2-T space.

In summary, the CC deposit is a proximal massive cupriferous pyrite deposit that appears to be of the Besshi type. It is underlain by massive to pillowed basalts. Apparently the hydrothermal solutions which fed the proximal massive sulphide and magnetite lodes also caused deposition of more distal pyritic cherty exhalites. Ore deposition was either rapid or took place during a period of volcanic quiescence. Later, renewed activity covered the deposit with a thick pile of massive to pillowed basalts.

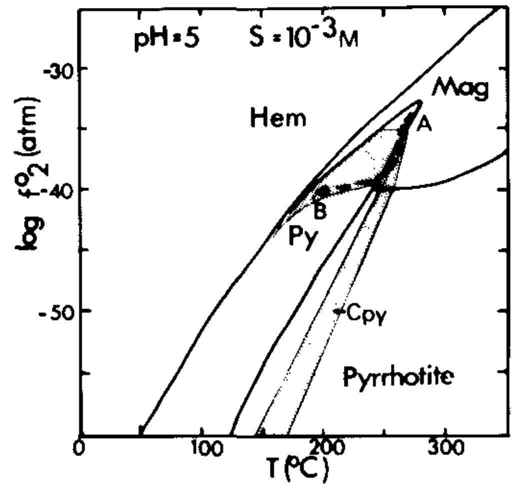

Figure 13. CC property, stability fields of Fe-S-O minerals in fO_2-T space for conditions assumed to be typical for cupriferous pyrite (Besshi)-type massive sulphide deposits (after Large, 1977). Line A—B represents theoretical mixing path to explain deposition of pyritic massive sulphide, then magnetite-rich lodes, then pyritic massive sulphide again from a cooling hydrothermal fluid. Note that nearly the total length of the path is in the chalcopyrite stability field.

ACKNOWLEDGMENTS

Discussions with and the cooperation of Nels Vollo of Craigmont Mines Limited and Michael Kenyon of Vestor Explorations Ltd. are gratefully acknowledged. Peter Mustard provided cheerful and able assistance in logging the drill core. Thanks are extended to V. A. Preto for information on the regional geological setting of the deposit.

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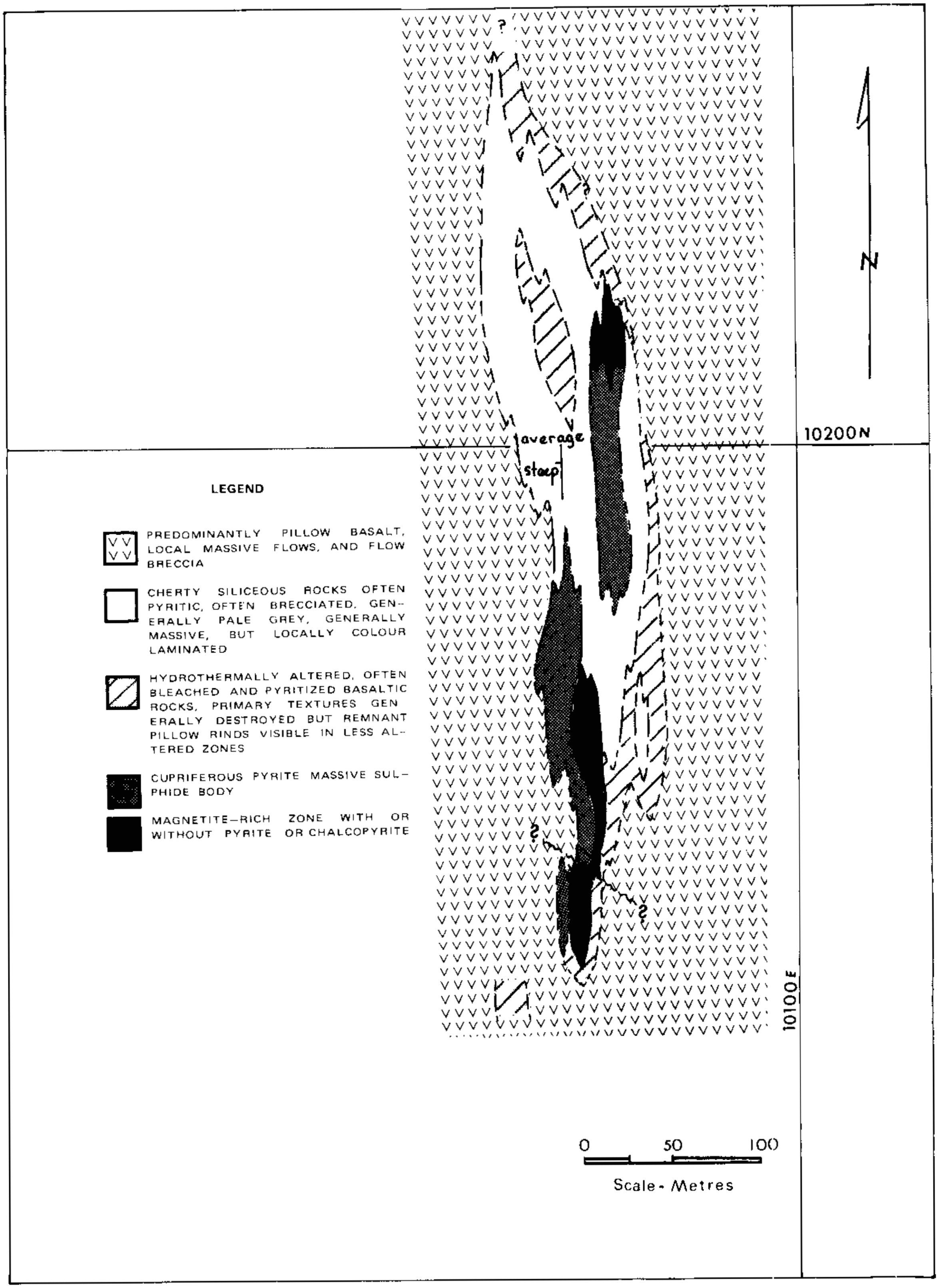

Figure 11a. CC property, plan view of geology and mineralization at elevation 1 800 metres (based on projections from drill-hole information).

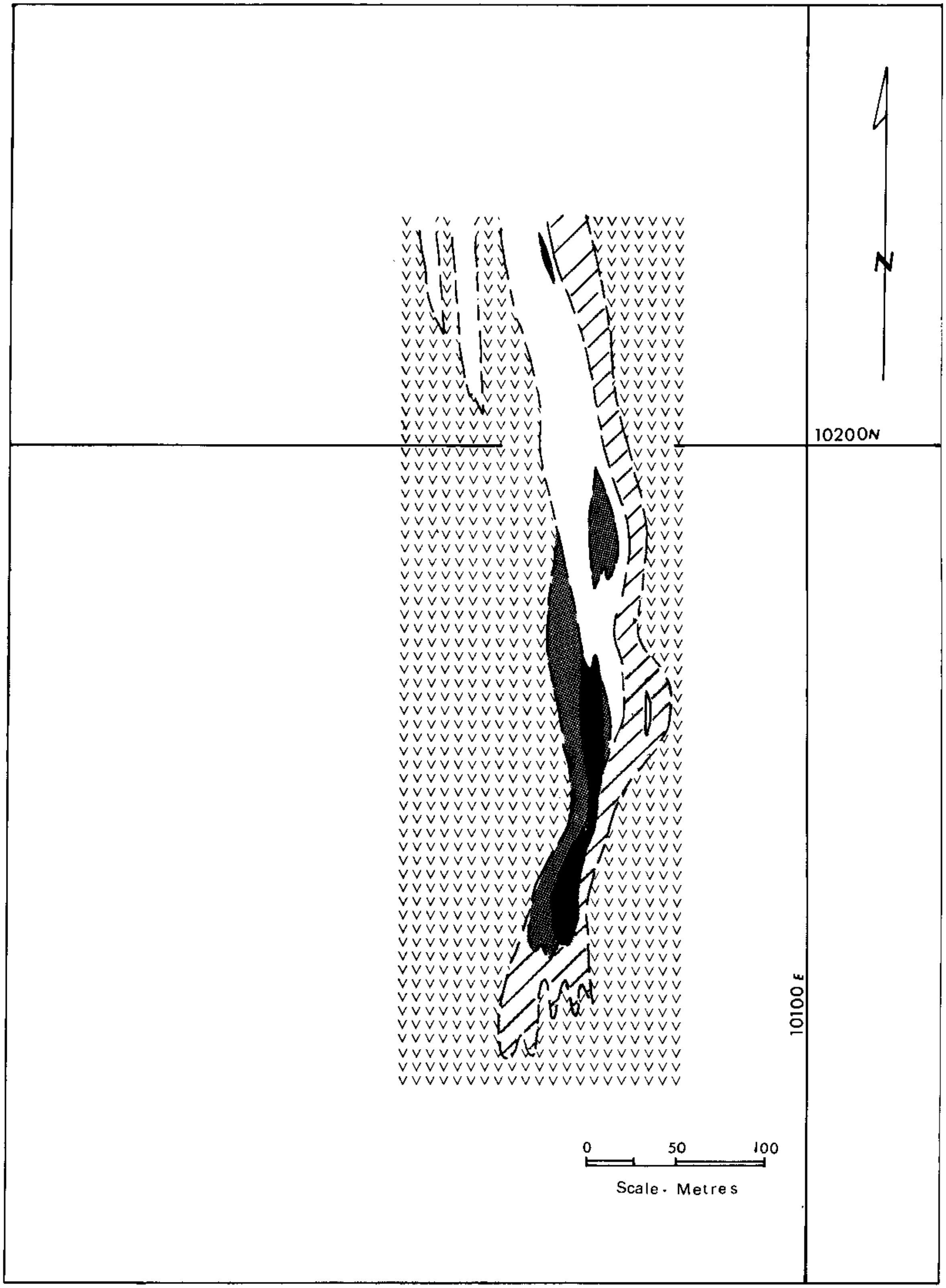

Figure 11b. CC property, plan view of geology and alteration at elevation 1 750 metres (based on projections from drill-hole information). For legend, *see* Figure 11a.

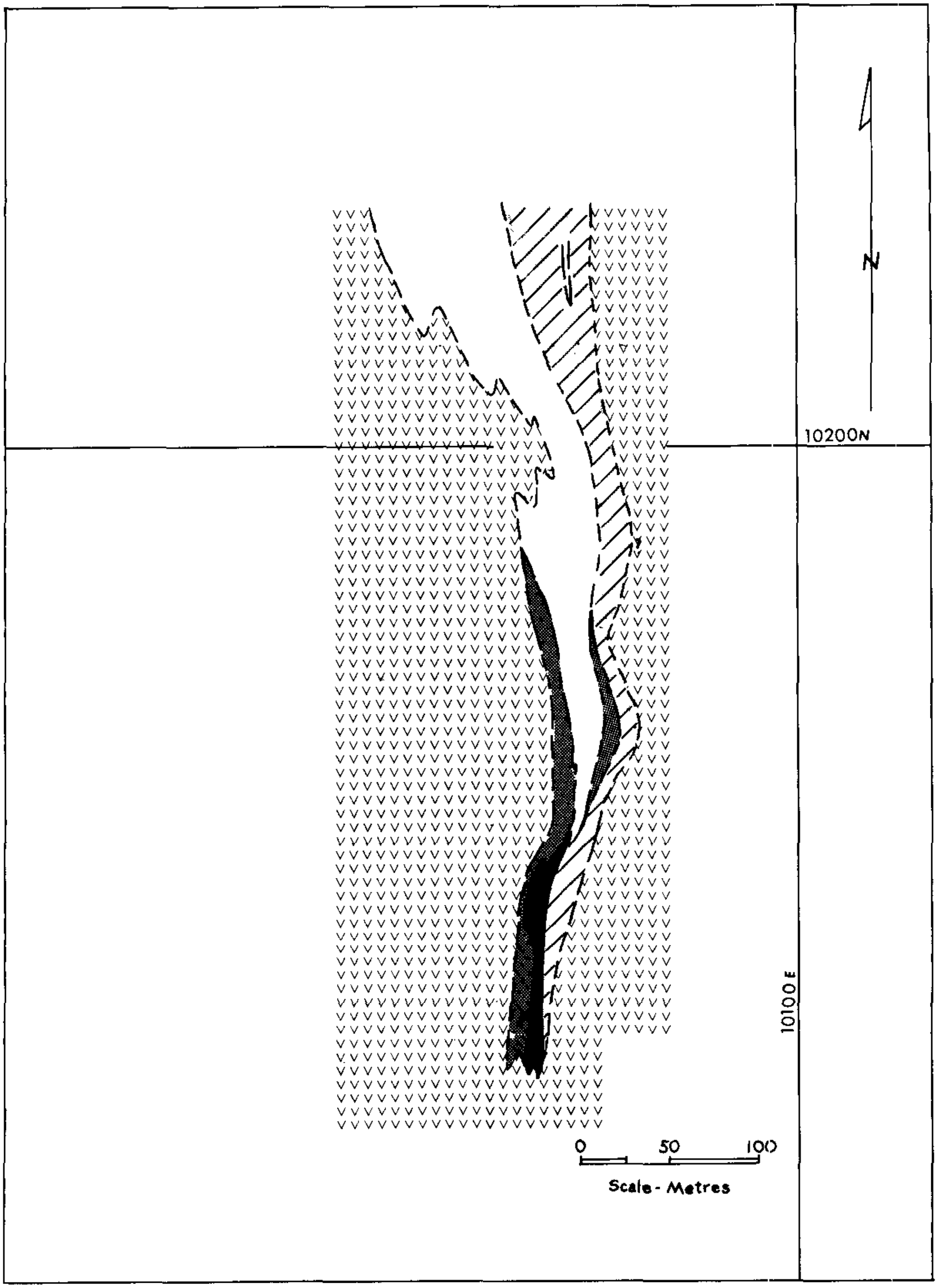

Figure 11c. CC property, plan view of geology and mineralization at elevation 1 700 metres (based on projections from drill-hole information). For legend, *see* Figure 11a.

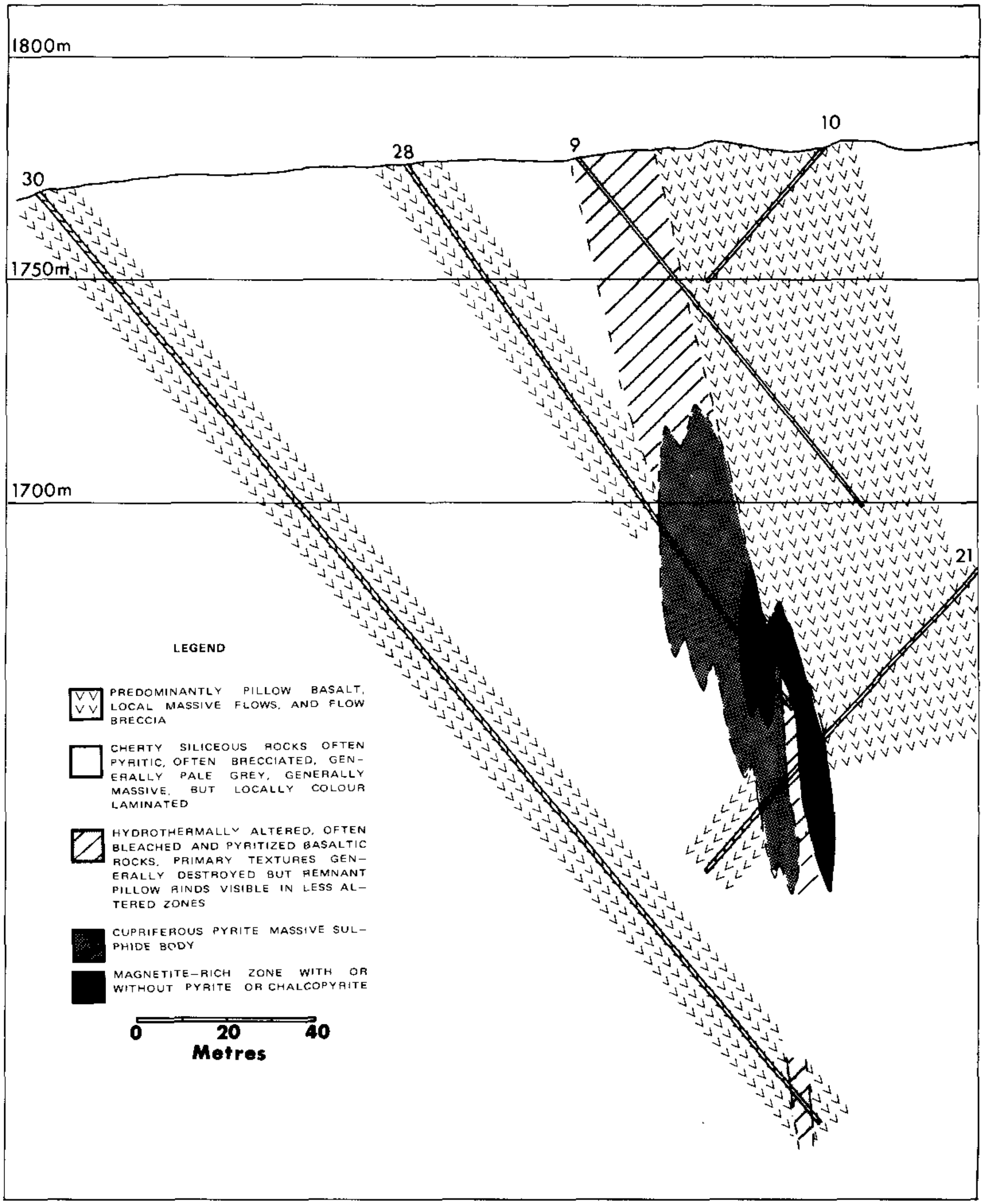

Figure 12a. CC property, geological section 9900N (looking north).

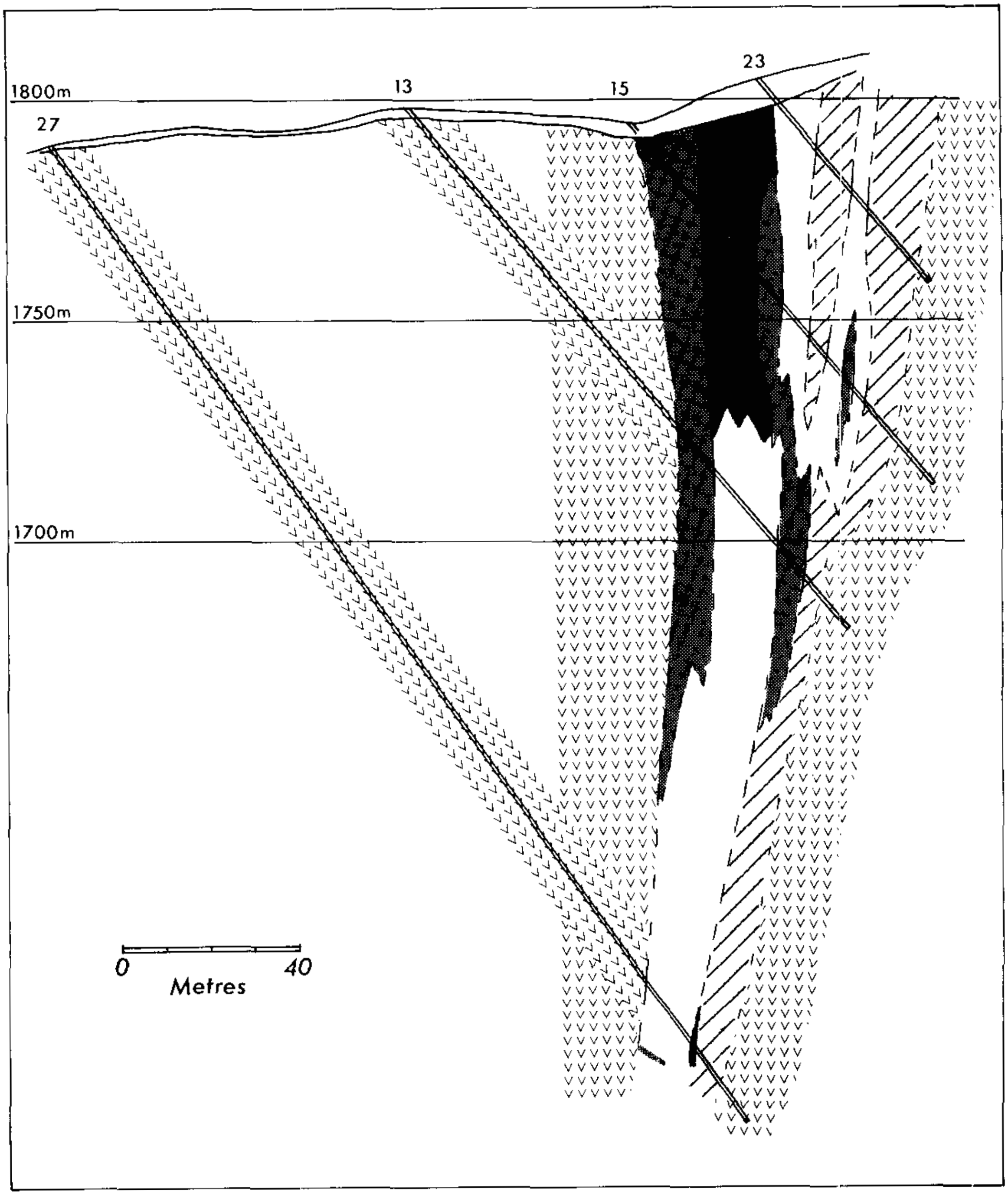

Figure 12b. CC property, geological section 10050N (looking north). For legend, *see* Figure 12a.

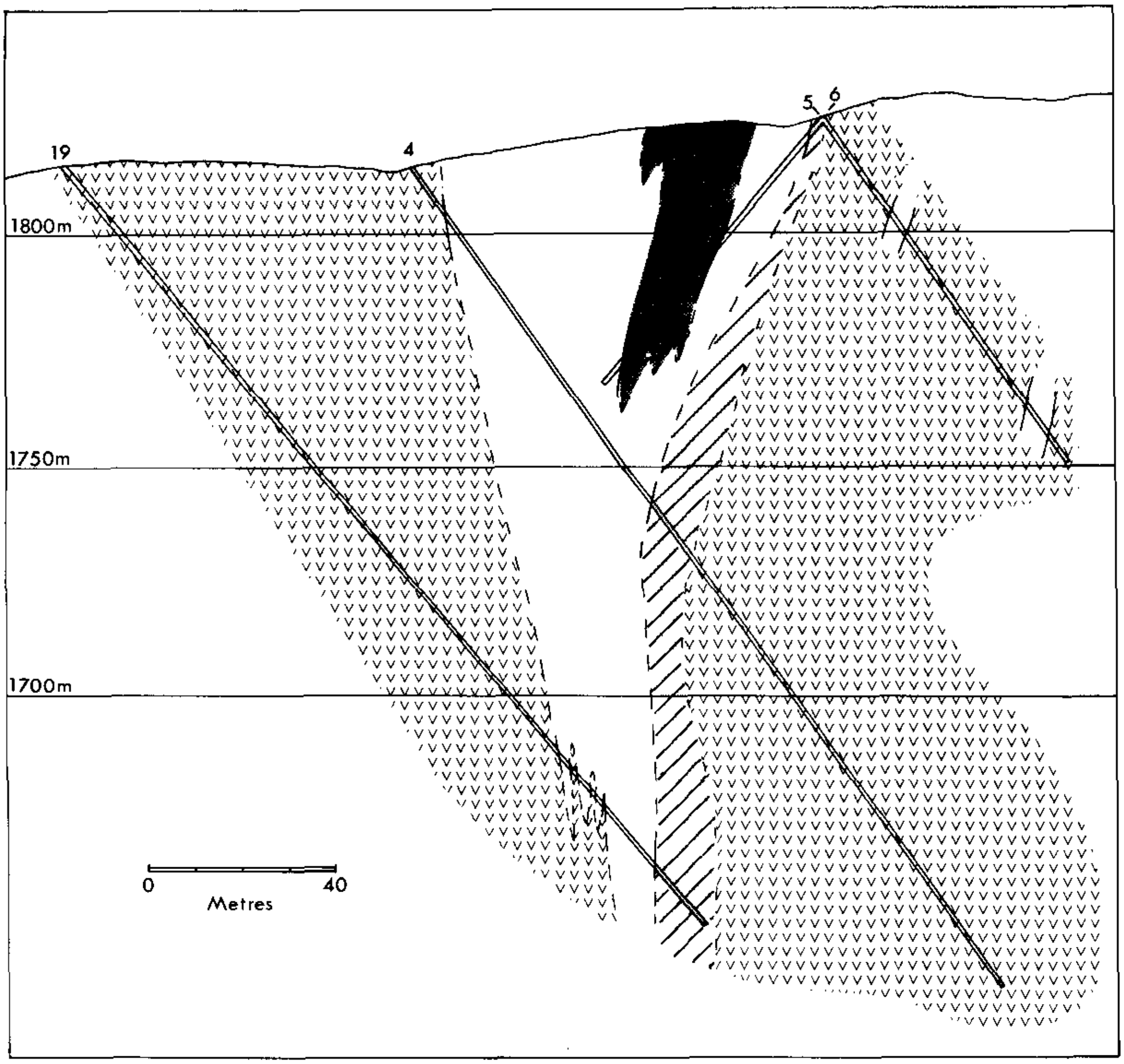

Figure 12c. CC property, geological section 10200N (looking north). For legend, *see* Figure 12a.

SICKER PROJECT – MOUNT RICHARDS AREA
(92B/13E)

By G.E.P. Eastwood

In 1979 the Stratford-Westholme mapping was extended over the Mount Richards Group to Crofton and Osborn Bay Road. Reports of pre-Cretaceous rocks in the Chemainus River at a place known locally as Hells Gate led to traverses up-river from the road bridge at Osborn Bay to the vicinity of Fuller Lake. A drift-covered area between the river and Mount Sicker Road was cruised west to Range 4, and the area between Mount Sicker Road and the main high-tension transmission line was mapped.

The oldest rocks of the area are sedimentary and volcanic rocks of the Sicker Group, which have been intruded by dykes and small stocks of porphyry and gabbro. These rocks are unconformably overlain by clastic sedimentary rocks of the Nanaimo Group. The Sicker rocks and porphyry are extensively and intensely sheared and pyritized along the north side of the belt, on the two northerly ridges of Mount Richards and westward across the Island Highway. The gabbro is less affected, and in one exposure was seen to truncate schistosity in the intruded rock. The intensity of shearing decreases sharply southward across strike and more gradually eastward along strike. Small local shear zones are present in the central and south parts of the belt.

The pre-gabbro rocks in the north part of the belt are sericite-quartz schists containing sporadic rounded, clear quartz eyes, and were thought by Clapp to represent a large stock of quartz porphyry. However, these rocks pass southward in the east part of the north and middle ridges to lightly sheared, banded, chert-like rocks, and in the most northerly exposure contain intercalated black argillite. It would appear that the sporadic quartz eyes may represent small porphyry dykes in a siliceous sedimentary sequence, or possibly a small amount of coarser detritus within an area of fine-grained or cherty deposition.

Across the middle ridge there is a transition to felsic rocks, which are both siliceous and feldspathic. This transition is oscillatory in that intercalated siliceous bands occur at least as far south as Breen Lake. The felsic rocks are felsic tuffs and derived volcanogenic sediments. A more mafic band is exposed on the north side and to the west of Breen Lake, and is in sharp contrast with siliceous rocks on the north. It is characterized by epidote clots, which are seen elsewhere to be altered volcanic clasts. Felsic rocks are again exposed on the south side of Breen Lake and in scattered road cuts up to the crest of a northerly spur of the main ridge of Mount Richards. Here there is an irregular transition to more mafic rocks.

The summit area and south slope of the main ridge of Mount Richards is underlain by intermediate to mafic volcanic rocks. In a few small outcrops these rocks appear featureless, but they are generally characterized by volcanic clasts, medium to large hornblende grains, or by both. The clasts range from pea to football size, and the larger ones may be broken or even whole pillows. They exhibit varying stages of alteration to epidote, and commonly weather in relief. They may be sporadic or so abundant as to render the rock a volcanic breccia. The hornblendes are euhedral plates or rounded grains which appear to float in a granular light grey matrix. In mapping it was found useful to distinguish rocks in which hornblendes were readily apparent to the unaided eye from rocks in which a lens showed minor fine-grained hornblende to be part of the groundmass. The obviously hornblendic rock forms at least two bands, one through the centre of the main ridge and the other low on the south slope above Richards Trail. More may have been present, since much of the section on the south slope has been obliterated by gabbro intrusion. At Richards Trail three small outcrops of felsic and siliceous rocks south of the hornblendic band could indicate a repetition, with the two hornblendic bands lying on the flanks of a major fold, but they could also represent a minor intercalation in the intermediate to mafic sequence. A thin cherty band is intercalated in hornblendic fragmental volcanic rocks 350 metres south of the summit of Mount Richards.

No indications of tops were found in this sequence. From comparison with the sequence in the Cowichan Lake area the black argillite and the siliceous rocks should be at the top.

The intermediate to mafic volcanic rocks are intruded by many small dykes of quartz and quartz feldspar porphyry. They are commonly 6 metres wide, but a few are as much as 15 metres. The groundmass is generally highly siliceous, and where sheared the dykes are commonly pyritized. They are probably equally common in the felsic and siliceous rocks but are less readily recognized, particularly where the rocks have been strongly sheared.

The two northerly gabbro dykes are regular in form and persistent along strike. Both show a regular increase in grain size toward the centre, with chilling to a porphyritic and ultimately a fine-grained phase at the margins. Both lack xenoliths. The most northerly dyke is generally concordant with the schistosity, but at the Crofton high-tension transmission line and Bonsall Road the central part is roofed with schist which has been injected by apophyses. The second dyke transgresses the transition from siliceous to felsic rocks at a small angle.

The other gabbro bodies are less regular in several respects. The grain size may increase and decrease repeatedly across the body, and chilled margins may be lacking. Xenoliths may be present, and one body near Osborn Bay Road contains so many that it is in fact an intrusive breccia. Volcanic clasts are preferentially preserved as xenoliths, and this can lead to misidentification of the rock if the matrix is fine grained. One dyke passes through the north end of Eves Park and the bluff face west of Breen Lake, where it transgresses the fragmental volcanic band in both strike and dip, and appears to pinch out under drift on the north slope of the main ridge. Three smaller bodies southwest and southeast of Crofton Lake terminate abruptly and are really small elongate stocks. Another body is dyke-like where it underlies the north spur of the main ridge, but it terminates in an irregular protuberance at the summit of Mount Richards. The remaining body is one large bifurcating body which underlies a large part of the south slope of the main ridge. A narrow dyke-like arm parallels Richards Trail and crosses the highway to the east slope of Little Sicker Mountain. The larger part continues along and south of Jackson Valley Road, crosses the highway south of the railway overpass, and widens on the southeast face of Little Sicker Mountain. Around Jackson Valley Road it contains large inclusions of porphyry and volcanic rock.

At Hells Gate on the Chemainus River, 1.4 kilometres above the highway bridge, a north-dipping basal grit of the Nanaimo Group overlies sheared dark hornblendic rock. Two hundred and fifty metres downstream, this unit is abruptly succeeded by Nanaimo sandstone. Apparently a fault striking between northwest and west has dropped the Nanaimo beds down a considerable distance on the southwest or south side. The rocks are thickly drift-covered outside the river canyon and the lateral extent of this inlier is unknown.

A longitudinal fault is inferred to underlie the draw between the north and middle ridges, because the siliceous rocks to the south of it are successively truncated toward the east. Clapp's Maple Bay fault should pass to the south of Mount Richards, but no definite evidence of it was found within the Mount Richards area. Several transverse faults are suggested by topographic lineaments, but movement is difficult to demonstrate because of the irregular forms of most of the gabbro bodies and the general lack of sharp boundaries within the Sicker Group.

Most of the larger gabbro bodies have numerous quartz-filled tension fractures toward their margins. Several adits and shafts and more open cuts have been made in these veins, but the best of them contains only a few grains of chalcopyrite. Further adits and cuts have been made in porphyry dykes, but appear to have found only pyrite. Many irregular quartz veins occur in the fragmental volcanic rocks, but they appear essentially barren. Near the summit of Mount Richards the hornblendic volcanic rock is sheared at the contact with a larger porphyry dyke and contains pyrite and some malachite. About 800 metres east-southeast of the summit a shear zone in fragmental volcanic rock contains a lens of thickly disseminated magnetite 45 centimetres wide.

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EXPLORATION FOR GOLD IN THE BLACK DOME MOUNTAIN AREA

(92O/7E, 8W)

By B. N. Church

INTRODUCTION

The Black Dome gold prospect, 70 kilometres northwest of the town of Clinton, is accessible by motor vehicle on dirt road from the suspension bridge crossing the Fraser River near Gang Ranch.

The history of prospecting in this area began with the discovery of gold-bearing quartz veins close to the summit of Black Dome Mountain in 1947 by L. Frenier. Empire Valley Gold Mines Ltd. gained control of the property in 1952 and completed underground testing of the vein system. In 1953 Silver Standard Mines Limited secured an option and continued exploraton by drilling and bulldozer stripping. Following marked increases in the price of gold in 1977, another period of activity was initiated by Barrier Reef Resources Ltd. and this continues to date under the consolidated ownership of Blackdome Exploration Ltd.

GEOLOGY

The rocks underlying Black Dome Mountain are almost entirely volcanic in origin and range in age from Eocene to Pliocene according to Tipper (1978). Host rocks for the mineralization are mainly hornblende andesite in the central and northern sections of the property and flow-banded rhyolite and breccias in the south Ridge zone (Fig. 14). Aphyric andesite and dacite lavas are peripheral to the map-area and form a thick base to the local Tertiary volcanic pile. Dacitic andesite lavas and dykes postdate the principal mineralized units in the southern part of the property. The youngest rocks are olivine basalt dykes, lavas, and agglomerate forming the summit of Black Dome Mountain.

MINERALIZATION

Exploration to date has centred on three veins or vein systems known as the Giant vein, Red Bird vein, and Ridge zone—No. 1 vein. These are steeply dipping quartz and carbonate-filled fractures striking northeast between 030 to 040 degrees.

Empire Valley Gold Mines Ltd. has conducted much of its work in former years on the Giant vein and Red Bird vein which occur *en echelon* on the northwest shoulder of Black Dome Mountain. Giant vein, which has been exposed over a length of 800 metres, is mostly less than 1 metre wide and consists of quartz stringers, quartz and carbonate lenses, and breccia with minor amounts of auriferous pyrite. For the most part low values have been obtained on this vein, however, A. J. Skiber (Assessment Report 4549) quotes an assay result showing 5.8 ppm gold and 10.2 ppm silver from a narrow quartz lead which appears to be a continuation of Giant vein to the southwest. The Red Bird vein, located southeast of Giant vein, has a length of only a few hundred metres and is intersected by dykes at its northern and southern extremities. Red Bird vein is characterized by jasper accompanying milk quartz and carbonates in fillings and a small amount of visible gold.

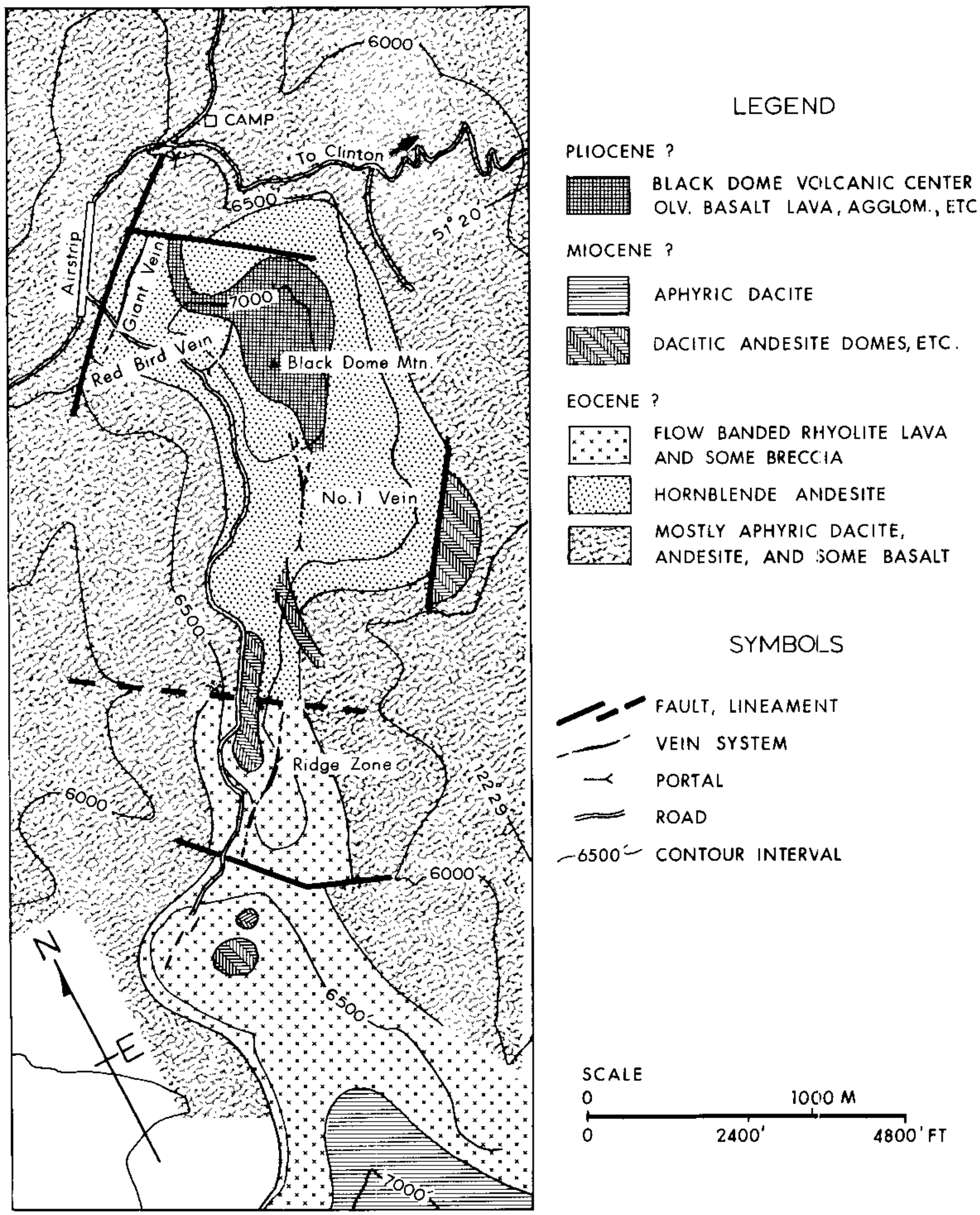

Figure 14. Geology of Back Dome Mountain.

Silver Standard Mines Limited has focused its attention in previous years primarily on No. 1 vein which is located on the southeast shoulder of Black Dome Mountain. This so-called vein is actually an assemblage of splayed quartz stringer, lenses, and silicified breccia which carry promising precious metal values. According to company reports, a section of the southern tail of No. 1 vein assays on the average 9.0 ppm gold and 64 ppm silver over an average width of 2.3 metres and a length of 130 metres.

At present the Ridge zone is the main target of Blackdome Exploration Ltd. This zone follows the southwest spur of Black Dome Mountain aligned more or less with No. 1 vein but separated from it by several hundred metres of rather barren andesite and crosscutting dacite dykes. The section of the Ridge zone of apparent economic potential and current prime interest lies within a pod of silicified breccia in rhyolite measuring 400 metres in strike length and from 1 to 30 metres wide. According to company reports 15 drill intersections here give an average grade of 18 ppm gold and 138 ppm silver across 2.3 metres.

It is anticipated that to define an ore deposit in this area, underground drifts may be required from a point lower on the flank of the Ridge zone to test the vertical continuity of higher grades, with the knowledge that previous work on the property has shown the veins to be of low economic potential beyond the rhyolite formation.

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NORTHEAST BRITISH COLUMBIA

DRIFTPILE CREEK – AKIE RIVER PROJECT

(94 F, K, L)

By D. G. MacIntyre

INTRODUCTION

A regional mapping project was initiated in the Driftpile Creek–Akie River area of northeastern British Columbia in response to increased levels of base metal exploration in this area during 1978. The main purpose of the initial phase of this project was to obtain additional information on the stratigraphic and structural setting of recently discovered shale-hosted barite-lead-zinc-silver occurrences. These occurrences are Devonian in age and are comparable to those of the Selwyn Basin in the Yukon.

The 1979 program involved a two-man helicopter-supported field crew operating out of exploration camps at Driftpile Creek and Pretzel Lake (21 kilometres southeast of Ware). Mapping was done at a scale of 1:125 000 and was restricted to that part of the belt containing Devonian black clastics with known mineral occurrences. This included the area from Gataga Lakes north to Through Creek (Driftpile Creek district) and the area from the Warneford River south to the Ospika River (Akie River district), a total area of approximately 1 350 square kilometres. Samples for future petrographic, paleontological, and geochemical studies were collected at 413 geologic stations. A 1:250 000 geological compilation map is currently in preparation. More detailed mapping, concentrating on delineation of sedimentary facies within the Devonian succession, is planned for the 1980 field season.

EXPLORATION HISTORY

Geologic mapping and stratigraphic studies have been done in the Ware (94F), Tuchodi Lakes (94K), and Kechika (94L) map-areas by Gabrielse (1962, 1977), Taylor and Stott (1973), Taylor (1979), Taylor, *et al.* (1979), and Cecile and Norford (1979), all of the Geological Survey of Canada. In addition, the Gataga Joint Venture has carried out detailed mapping in the Driftpile Creek area (for example, Carne, 1978) and the Cyprus Anvil/Hudson's Bay Oil and Gas joint venture has mapped the Akie River district (W. Roberts, D. Kilby, personal communication).

The first major regional exploration program in the Gataga Lakes area was done by Geophoto Consultants in 1970 on behalf of a syndicate. Follow-up work was done in 1973 by Placer Development Limited (through Canex Placer Limited) on behalf of their joint venture partners, Pembina Pipe Line Ltd., Sur Oil Company Limited, and General Crude Oil Company, Northern Ltd. Subsequent work resulted in the discovery of several shale-hosted barite-sulphide occurrences including Driftpile Creek. In 1976, Castlemaine Explorations Ltd. conducted a regional geochemical program in the Driftpile Creek area and in 1977, Aquitaine Company of Canada Ltd., Chevron Canada Limited, Getty Mining Pacific, Limited, and Welcome North Mines Ltd. formed the Gataga Joint Venture to do follow-up work in geochemically anomalous areas. This work, contracted to Archer, Cathro and Associates, Limited resulted in the staking of

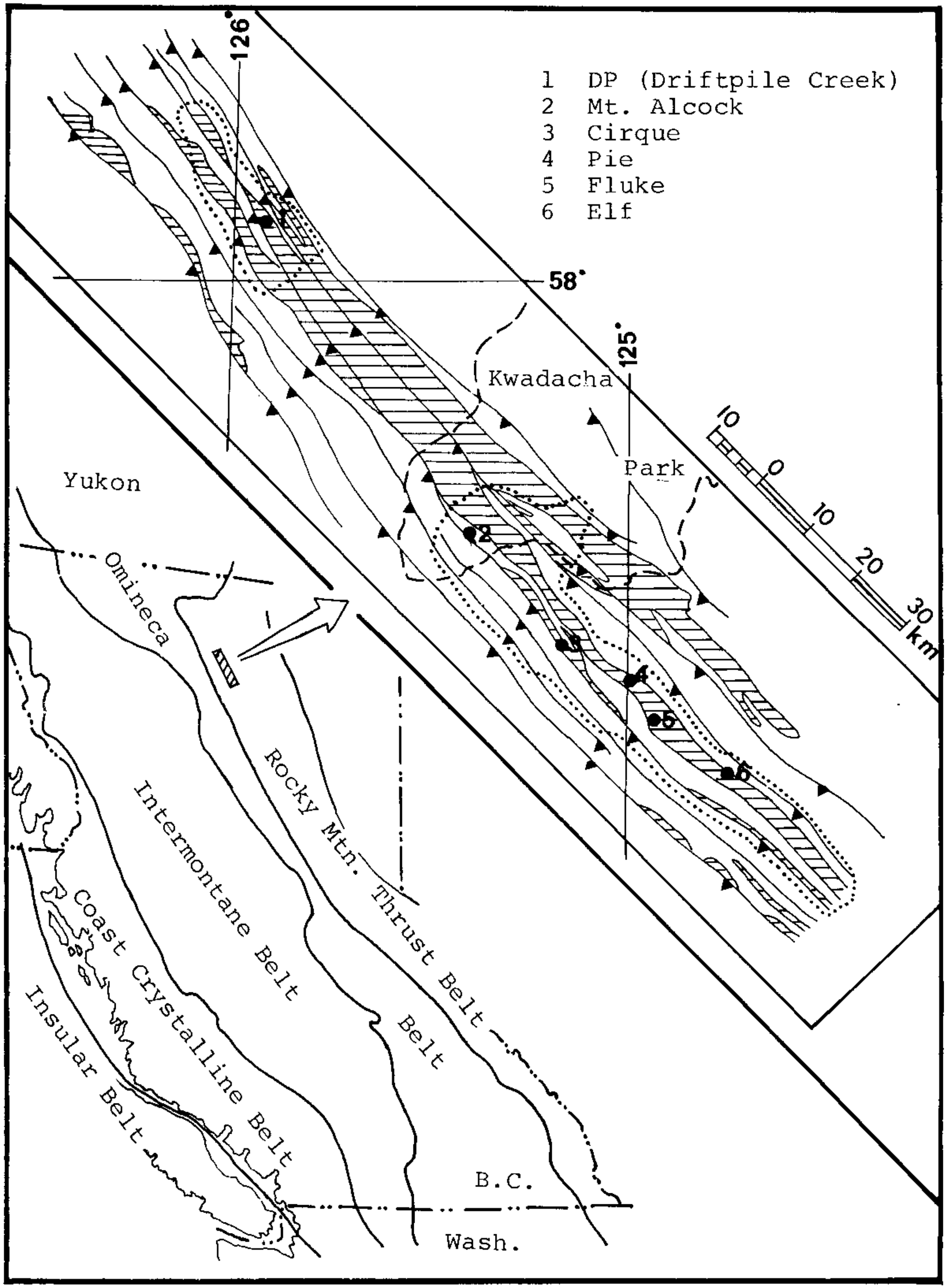

Figure 15. Location and tectonic setting of the 1979 Driftpile Creek—Akie River project area. Inset shows limit of mapping (dotted line), major thrust faults, distribution of Devonian black clastics (lined), and location of major shale-hosted Ba-Pb-Zn occurrences.

several new claim blocks northwest and southeast of Driftpile Creek. Other companies active in the area at that time were Texasgulf Inc., Granby Mining Corporation, S.E.R.E.M. Ltd., Cominco Ltd., and United Mineral Services Ltd. Further south, Cyprus Anvil Mining Corporation and Hudson's Bay Oil and Gas Company Limited were involved in a joint regional exploration program in the Akie River district which resulted in the discovery of three new showings – the Cirque, Elf, and Fluke. In the following year Rio Tinto Canadian Exploration Limited (Riocanex) staked the area between the new showings. During 1978 and 1979 diamond-drilling programs were conducted on the DP (Driftpile) claims, currently under option to the Gataga Joint Venture, and on the Cirque and Elf claims.

PHYSIOGRAPHY

The physiography of the map-area is characterized by northwest-trending ridges, locally rising to 2 200 metres elevation, truncated by broad northeast-trending drainage corridors. The most prominent ridges are generally capped by resistant strata, whereas valleys and low ridges are usually underlain by recessive formations. Alpine glaciation has carved numerous cirque valleys into the most resistant ridges thus producing excellent exposures of the stratigraphic succession, particularly on the steeper northeast-facing slopes. By contrast, valleys are filled with fluvioglacial and lacustrine deposits and, with the exception of downcutting creeks, contain very little outcrop.

TECTONIC SETTING

The project area (Fig. 15) is located within the Rocky Mountain (Foreland) thrust and fold belt of the Columbian Orogen and is centred approximately 35 kilometres east of the Rocky Mountain Trench. This part of the thrust belt is underlain by Early Paleozoic miogeoclinal strata. These rocks are part of the northwest-trending Kechika Trough which may represent a southeasterly extension of the larger Selwyn Basin. The trough is bounded by platformal carbonates and uplifted Proterozoic rocks to the east forming the Muskwa anticlinorium (Taylor, *et al.,* 1979) and is truncated to the west by transcurrent faults of the Rocky Mountain Trench system.

GEOLOGY

The project area is underlain by sedimentary strata ranging in age from Proterozoic to Early Triassic. The various formations are arranged in narrow discontinuous belts bounded by northwest-trending thrust faults. Mapping was done by traversing ridges and creeks oriented perpendicular to the structural trend and interpolating between traverses. The results of this work are summarized on Figures 16, 17, and 18. Idealized stratigraphic sections are shown on Figure 19.

PROTEROZOIC–CAMBRIAN (UNIT P€)

The oldest rocks exposed in the project area are Hadrynian to Early Cambrian in age. This part of the stratigraphic succession is comprised of a structurally complex assemblage of metasedimentary rocks which are well exposed in the Gataga River valley and ranges to the east (Taylor, *et al.,* 1979). No work was done on these rocks in 1979.

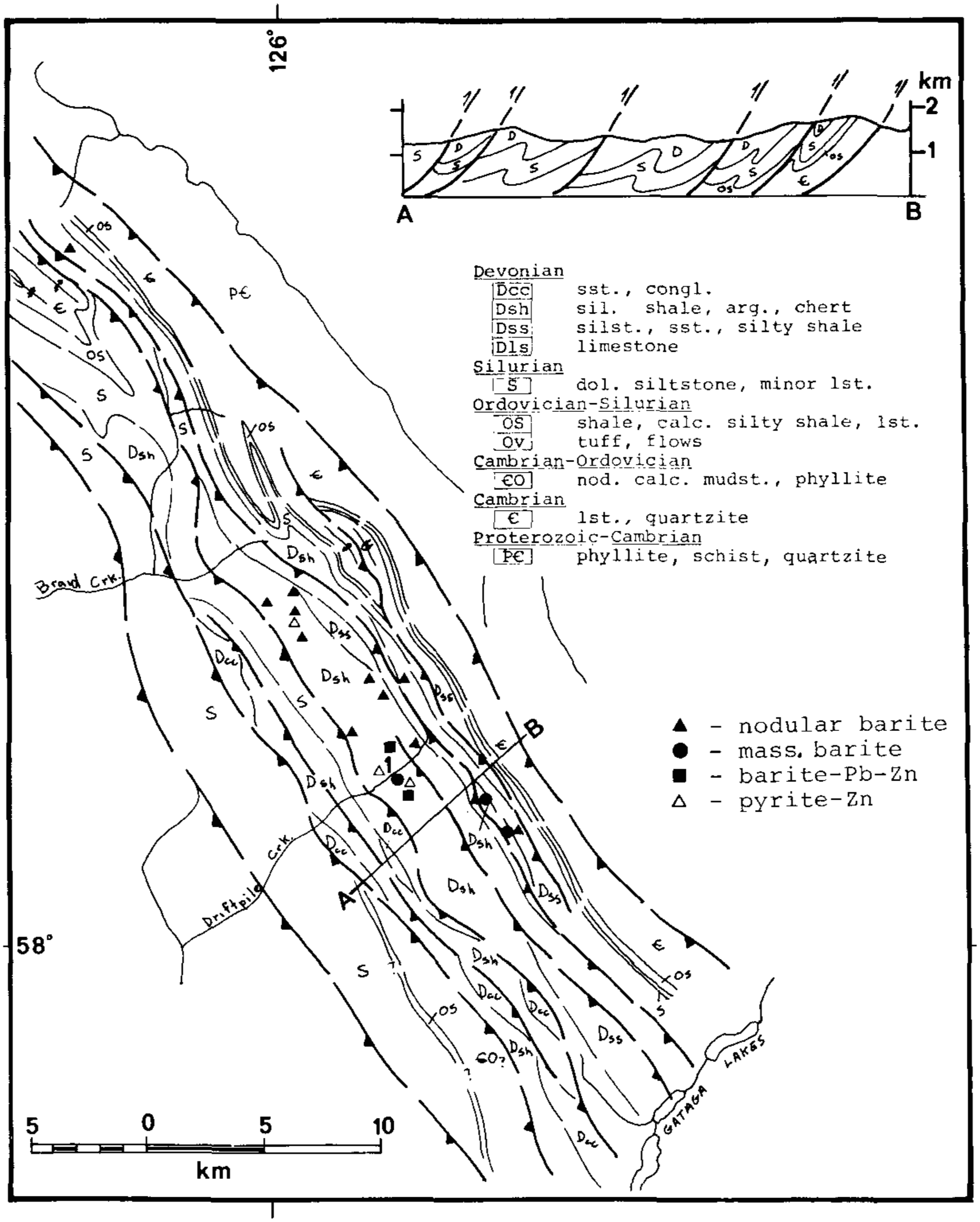

Figure 16. Geology of the Driftpile Creek district. [1 = Driftpile Creek occurrence.]

LOWER TO MIDDLE CAMBRIAN (UNIT €)

Hadrynian to earliest Cambrian rocks are unconformably overlain by quartzite and massive limestone believed to be correlative with the Lower to Middle Cambrian Atan Group. These rocks are very resistant and form prominent cliffs, particularly where they have been thrust over younger, less resistant strata. The upper limestone unit is well exposed in the Driftpile Creek district (Fig. 16) where it consists of massive grey micritic limestone, possibly representing archeocyathid 'patch reefs' and biostromes (Carne, 1978). Rusty weathering, dolomitized channel or reef front breccia deposits and interbedded quartzite and quartzite pebble conglomerate locally occur at the top of the limestone unit and may represent a pre-Ordovician erosion surface. Taylor, *et al.* (1979) have described several periods of block faulting, uplift, dyke emplacement, and erosion in Cambrian and older rocks exposed east of the Driftpile Creek area.

CAMBRIAN TO ORDOVICIAN (UNIT €O)

In the Akie River district (Fig. 17) the Atan limestone is apparently unconformably overlain by up to 1 500 metres of cream to light grey-weathering, wavy banded, nodular calcareous mudstone or phyllite, believed to be part of the Kechika Group. These rocks are well exposed in the core of several large overturned anticlinal structures. Lithologically similar rocks are absent in the Driftpile Creek area, where Atan limestone is apparently overlain by Ordovician to Silurian age rocks. Several thin tuff horizons were noted in the upper part of the Kechika Group suggesting periodic Late Cambrian to Early Ordovician volcanism. The stratigraphy of the Kechika Group has recently been described in detail by Cecile and Norford (1979).

ORDOVICIAN TO SILURIAN (UNIT OS)

In the Akie River district, Kechika rocks are unconformably overlain by a succession of calcareous siltstone, shale, limestone, and volcanic rocks which have been assigned to the Middle Ordovician to Upper Silurian Road River Formation (Taylor, *et al.*, 1979). These rocks reflect the establishment of an abrupt, well-defined basin-platform transition zone along the eastern margin of the project area that persisted from Early Ordovician to Late Devonian time. Three major cycles of platformal or near-platformal deposition followed by marine transgression and progressively more distal basinal deposition are recognized in the stratigraphic record, roughly corresponding to the Ordovician, Silurian, and Devonian periods.

The stratigraphy of the Road River Formation in the Ware map-area has been described by Cecile and Norford (1979). Within the project area this formation includes a lower unit of cream, beige, and reddish brown-weathering, laminated calcareous siltstone and shale with limestone turbidite interbeds. The latter are probably related to the Skoki shale-out as described by Cecile and Norford (1979). A much thinner succession of lithologically similar rocks overlie the Atan limestone in the Driftpile Creek area and are also tentatively assigned to the Road River Formation. In both areas these rocks are conformably overlain by black carbonaceous basinal shales containing Middle Ordovician to Upper Silurian graptolite assemblages. Black chert horizons are locally interbedded with the shales. This part of the stratigraphic succession is very incompetent relative to underlying and overlying strata and consequently the shales are intensely sheared and folded and have a well-developed axial plane cleavage. Upon weathering these rocks decompose to a black carbonaceous mud.

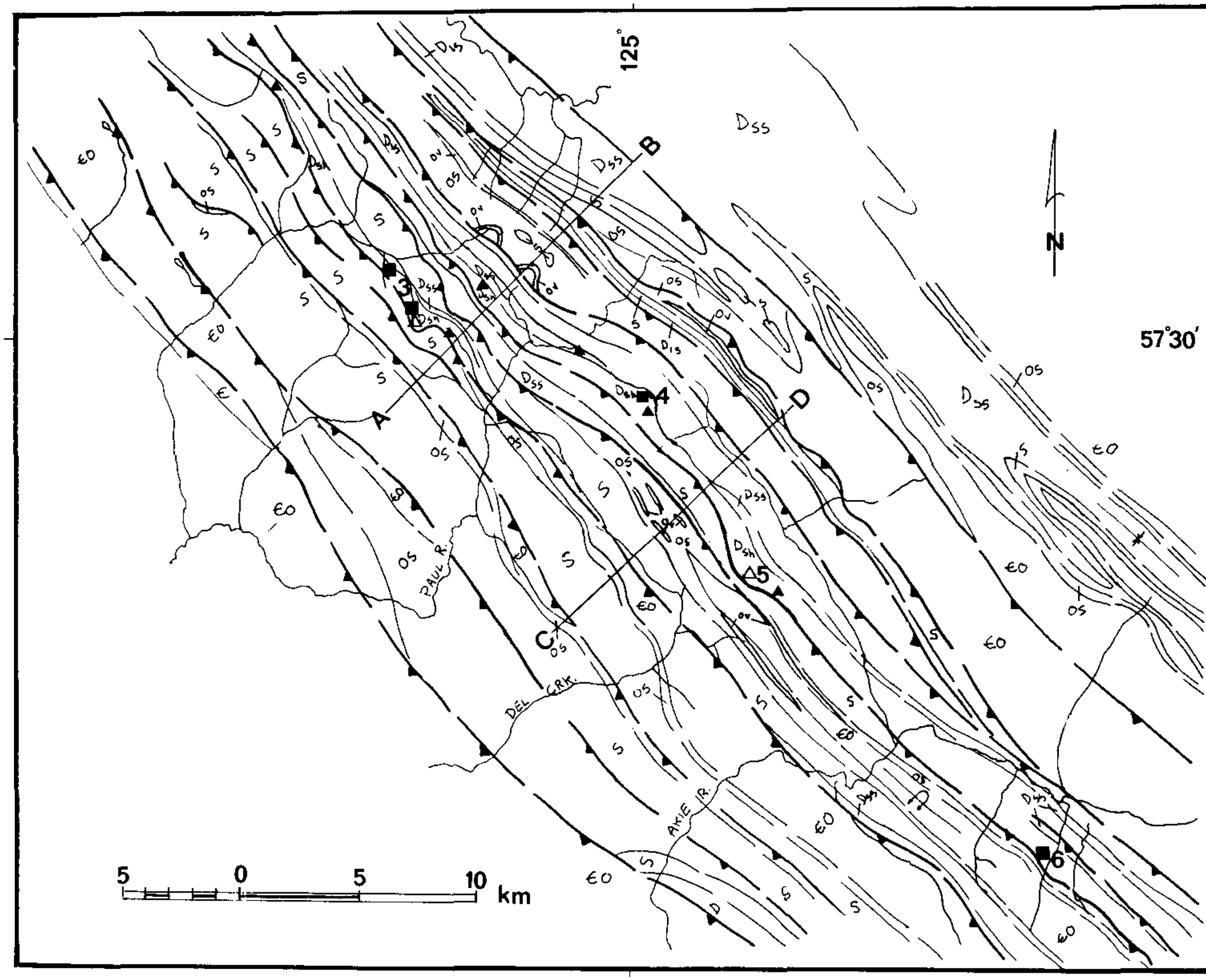

Figure 17. Geology of the Akie River district (*see* Figure 16 for legend and explanation of symbols; 3 = Cirque, 4 = Pie, 5 = Fluke, 6 = Elf.)

In the Akie River district discontinuous volcanic horizons occur near the base of the black shale unit. The best exposures of these rocks occur east of the Pie claims (Fig. 17) where a greenish grey-weathering massive micro-dioritic flow, up to 50 metres thick, overlies graptolitic black shale and chert and in turn is overlain by interbedded shale and orange to brown-weathering vitric crystal and lapilli-tuff with high carbonate content. These rocks are probably related to periodic volcanic activity along a deep-seated rift zone.

SILURIAN (UNIT S)

Road River shales are unconformably overlain by up to 800 metres of orange to brown-weathering siltstone and minor limestone of apparent Silurian age. This unit is relatively competent and resistant and is found capping peaks and ridges throughout the project area, particularly where it has been thrust over younger rocks.

In the Driftpile Creek area the Silurian section is less than 200 metres thick, but becomes progressively thicker to the west. The main lithologies are interbedded platy, thin laminar-bedded and blocky thick flaser-bedded dolomitic siltstone with minor orange-weathering limestone interbeds. Overall, the succession is strongly bioturbated and contains spiral feeding trails, siliceous sponge spicules, and poorly preserved graptolites. Similar rocks constitute a much thicker Silurian section in the Akie River district. However, in this area the base of the section is marked by a 10 to 20-metre-thick unit of grey, blocky weathering, massive limestone or dolostone, overlain by 5 to 10 metres of interbedded black chert, laminated silty shale, and limestone turbidites [SL unit of Cecile and Norford (1979) ?]. The stratigraphic succession suggests *an eastward migration of the basin-platform transition zone during Middle Silurian time. Limited* paleocurrent data and the composition of the dolomitic siltstone turbidites suggest these rocks are derived from the carbonate platform. As such, they may be basinal equivalents of the Nonda Formation.

DEVONIAN

Within the project area the Silurian siltstone unit is conformably to disconformably overlain by shale, siltstone, and limestone of Devonian age. With the exception of limestone and the more siliceous shale facies, these rocks are very recessive and are usually poorly exposed. In many areas the Devonian succession has been completely removed by erosion. The most complete Devonian stratigraphic sections occur in overturned synclinoria which have been overridden by thrust plates containing older, more resistant strata. Unfortunately, under such a stress regime the Devonian rocks, because of their incompetence, tend to coalesce into tight isoclinal folds and develop a pervasive axial plane cleavage. These features make definition of original stratigraphic thicknesses and recognition of lateral and vertical facies changes extremely difficult. In spite of the structural complexity of the Devonian section, an attempt has been made to divide the succession into different units. These units are largely based on gross lithological characteristics. Four major subdivisions have been used in the current mapping project.

(1) D_{ls} – limestone, minor chert, shale (Dunedin Formation equivalent);
(2) D_{ss} – silty shale, siltstone, minor sandstone, limestone (Besa River Formation equivalent);
(3) D_{sh} – Siliceous shale, argillite, chert (Gunsteel shale);
(4) D_{cc} – sandstone, siltstone, conglomerate (Warneford coarse clastics).

These unit names conform to those currently being used informally by workers in the area, for example, Carne (1978), Roberts (1977), and Gabrielse (1977).

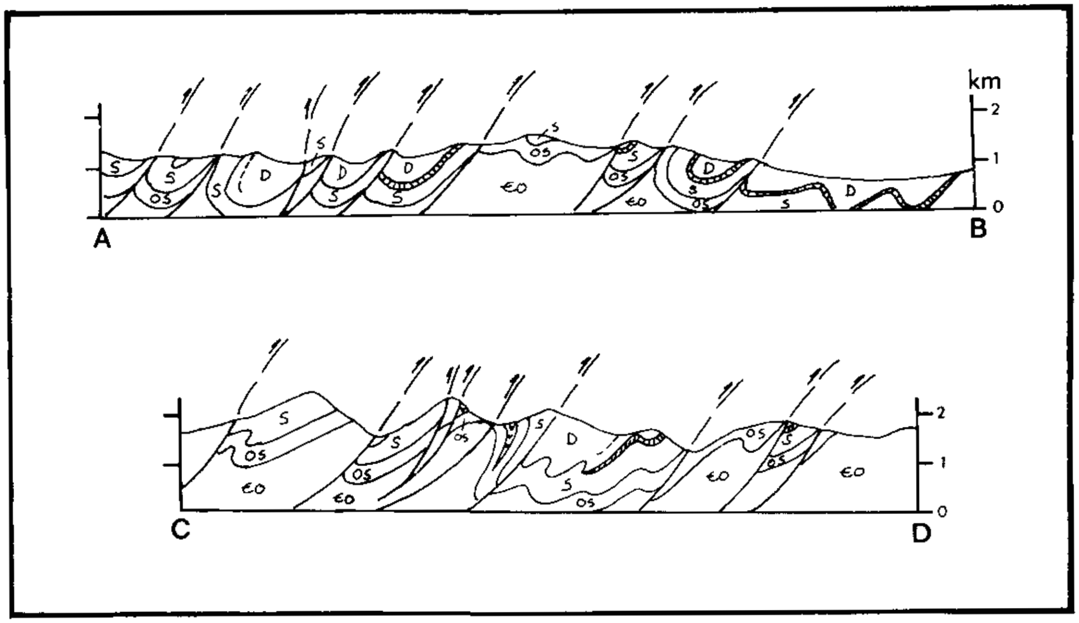

Figure 18. Structural sections, Akie River district (*see* Figure 17 for location of section).

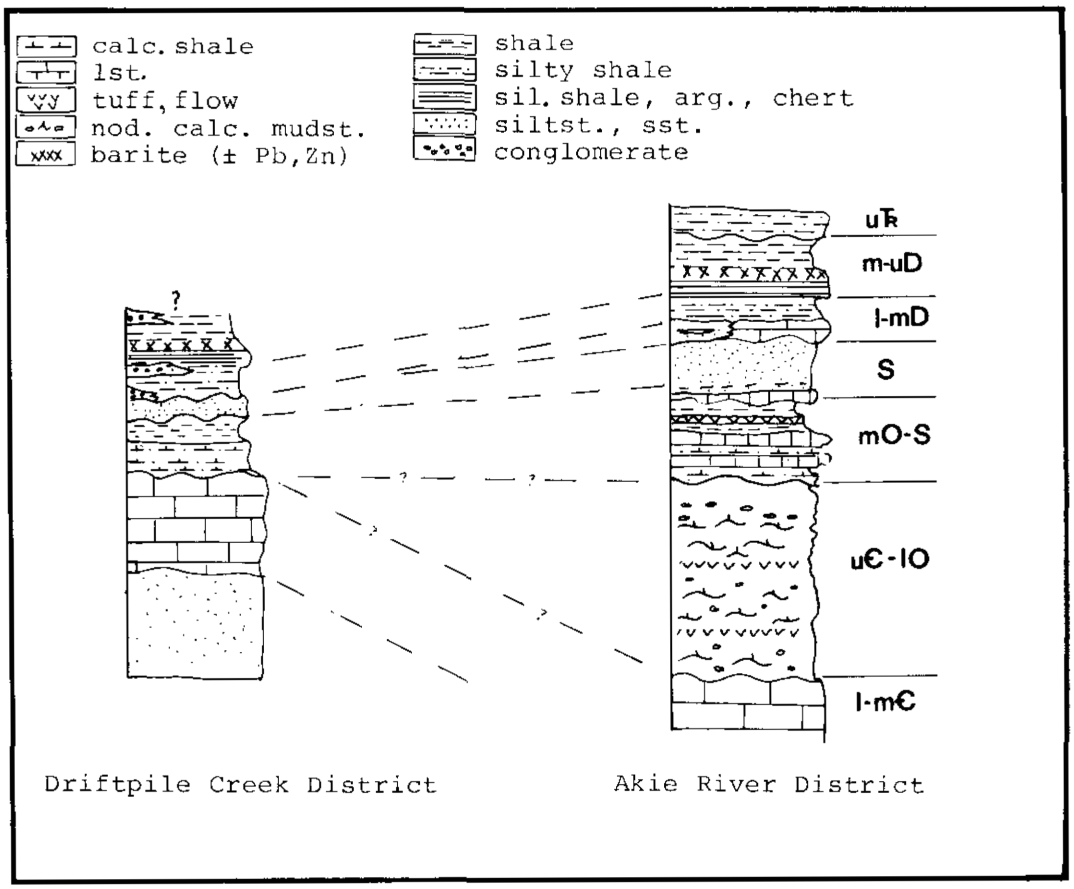

Figure 19. Idealized stratigraphic section, Akie River and Driftpile Creek districts.

UNIT D_{ls}

East of the Cirque claims (Fig. 17) Silurian siltstone is unconformably to disconformably overlain by up to 100 metres of grey fossiliferous limestone believed to be correlative with platformal carbonates of the Dunedin Formation (Morrow, 1978). Here the limestone is thick bedded and massive with alternating fossil-rich and fossil-poor beds. Elsewhere in the area the limestone is thin and discontinuous and shales-out into the basinal Besa River Formation. Limestone turbidites and coarse debris flows with interbedded quartz siltstone, siliceous argillite, calcareous siltstone, and black graptolitic shale are characteristic of this shale-out. The shale-out appears to be very abrupt, suggesting a relatively sharp well-defined platform margin with a steep basinward slope.

The Dunedin Formation or its equivalent is apparently absent in the Driftpile Creek area although it occurs to the east in the Tuchodi Lakes map-area (Taylor and Stott, 1973).

UNIT D_{ss}

Unit D_{ss} is interpreted to be the basinal equivalent of the Dunedin limestone and is tentatively correlated with the Besa River Formation (Kidd, 1963; Pelzer, 1966). Immediately east of the Fluke and Elf showings up to 200 metres of brownish grey-weathering, poorly sorted, slightly calcareous siltstone and minor sandstone with interbedded siliceous argillite appears to overlie Silurian siltstone and interfinger with Devonian limestone. Further to the west these rocks grade into laminated silty shale with occasional thin siltstone and sandstone interbeds. These interbeds carry white calcareous detritus which may be shell fragments. At the Cirque property laminated silty shales overlie Silurian siltstone but here this unit is less than 50 metres thick. It is suggested that unit D_{ss} represents a clastic wedge thinning and fining westward away from the platform margin.

UNIT D_{sh}

Unit D_{sh} includes bluish grey-weathering, siliceous black laminated silty shale, blocky thick-bedded siliceous argillite or chert, and rusty weathering pyritic carbonaceous black shale. These rocks have been given the informal name Gunsteel Formation. Although stratigraphic relationships are not well defined it appears that Gunsteel rocks unconformably overlie both the Besa River and Dunedin Formations and may in places lie directly on Silurian siltstone. The Gunsteel Formation appears to thicken locally, suggesting development of small isolated basins or troughs within the larger basin of deposition. Gunsteel rocks apparently represent a major marine transgression which marks the change from a well-defined basin-platform regime to a more flyschoid-type deposition during Late Devonian time. This event is roughly coincident with the Antler orogeny recognized elsewhere in the Cordillera.

UNIT D_{cc}

Unit D_{cc} is restricted to the western half of the Driftpile Creek map-area and to the area between Mount Alcock and Gataga Lakes. This unit includes grey-weathering, poorly sorted sandstone and siltstone, polymictic pebble conglomerate, and minor shale and has been given the informal name Warneford Formation

(Roberts, 1977). Well-defined, proximal to distal turbidite sequences are characteristic of the Warneford Formation and define a series of westerly derived submarine fans (Carne, 1978) that are interfingered with and in places overlie Gunsteel shales. This type of flysch deposition probably reflects rapid uplift to the west during latest Devonian to earliest Mississippian time.

TRIASSIC

Gunsteel shale is disconformably overlain by dolomitic siltstone which has been preserved within an overturned synclinal structure east of Mount Luke. Although these rocks are lithologically similar to the Silurian siltstone unit, they are easily distinguished by containing shelly fauna of Early Triassic age (Gabrielse, 1977).

MINERAL OCCURRENCES

Cecile and Norford (1979) have described stratiform barite occurrences in Kechika, Road River, and Silurian siltstone units in the Ware map-area. Within the current project area the most significant concentration of barium is associated with siliceous argillite and shale of the Devonian Gunsteel Formation. Six major shale-hosted barite-lead-zinc occurrences with or without associated laminar banded pyrite-zinc mineralization are known. These are Driftpile Creek, Mount Alcock, Cirque, Pie, Fluke, and Elf. Location of these occurrences is shown on Figures 15, 16, and 17. In addition, numerous occurrences of stratiform blebby or nodular barite and locally massive white crystalline barite are known in Gunsteel shale of the Driftpile Creek and Akie River districts. This suggests the barite-bearing horizons are present on a regional scale and locally thicken to form significant deposits of potential economic value.

Prospecting in the Driftpile Creek and Akie River districts has been enhanced by the fact that the baritic horizons often produce prominent kill zones. In addition, extensive orange to red ferricrete deposits occur where groundwater emanates from faults cutting pyritic shale horizons.

DP (DRIFTPILE CREEK) (94K/4)

The Driftpile Creek occurrence was discovered by Canex Placer in 1973 while following up anomalous stream sediment data. The paucity of outcrop and presence of deep surface oxidation necessitated extensive geochemical and geophysical surveys (Wise, 1974; Kowalchuk and Rivera, 1976) during the early stages of exploration. The property was subsequently optioned to the Gataga Joint Venture and in 1978 nine drill holes totalling 1 016 metres were drilled. An additional 21 drill holes totalling 2 417 metres were drilled in 1979. This work has defined several southwest-dipping, finely laminated pyrite and bedded barite horizons within siliceous shales of the Gunsteel Formation. The Devonian section is extensively folded and faulted in this area and some of the mineralized horizons may represent fault repeats.

The main massive sulphide horizons are characterized by very finely laminated pyrite which locally has soft sediment deformation and graded bedding. Bedding is locally disrupted by the diagenetic growth of small calcium carbonate nodules. Barite and sphalerite are present in variable amounts.

The best mineralization exposed on the property is located in trenches 1 400 metres north of Driftpile Creek. Here thin parallel bands composed of discrete irregular grains of galena and sphalerite occur in a dark grey-bedded barite host. The best drill intersection during the 1978 program was from this horizon and graded 9.05 per cent lead and 3.53 per cent zinc over 8.1 metres. What appears to be the same horizon was intersected in drill holes immediately south of Driftpile Creek but here finely laminated pyrite predominates and galena and barite are present in very minor amounts.

MOUNT ALCOCK (94F/11)

A prominent white barite kill zone occurs on the ridge northeast of Mount Alcock, in Kwadacha Wilderness Park. This showing is contained within a fault-bounded wedge of Gunsteel shale surrounded by Silurian siltstone. The barite horizon is apparently 25 to 30 metres thick and dips from 45 degrees to 75 degrees to the southwest. Within the barite horizon is a 2 to 3-metre-thick zone containing fine diffuse bands of galena and sphalerite. Assays of grab samples collected from this zone follow.

Sample No.	**Ag** *ppm*	**Ba** *per cent*	**Cu** *per cent*	**Pb** *per cent*	**Zn** *per cent*
AL–1	24	50.5	0.002	13.0	0.11
AL–2	17	49.3	0.002	10.8	1.41
AL–3	15	50.3	0.001	8.4	2.41
AL–4	20	50.8	0.001	10.0	4.81
AL–5	15	51.8	0.002	6.8	1.07

CIRQUE (94F/6, 11)

The most significant barite-lead-zinc deposit in the project area is the Cirque. This deposit is described in detail in the following report.

PIE (94F/6, 7)

The Pie claims were staked by Rio Tinto in 1978 to cover an area of Gunsteel shale southeast of the Cirque claims. An extensive soil sampling and hand trenching program was done in 1979. Several showings of stratiform nodular and massive barite with varying amounts of galena, sphalerite, and minor chalcopyrite occur in Gunsteel shales exposed on the southwest limb of an anticline cored by Devonian limestone. Minor amounts of sphalerite also occur within the limestone.

FLUKE (94F/7)

The Fluke claims were staked by Cyprus Anvil Mining Corporation/Hudson's Bay Oil and Gas in 1978 to cover a panel of Gunsteel shale sandwiched between Silurian siltstone to the west and Besa River rocks to the east. Several thin bands of pyrite with coarse-grained galena and sphalerite have been exposed by trenching. Outcrop is very limited within the area of interest and extent of the mineralized horizon is not known at this time. Blebby barite occurs in siliceous argillite exposed southeast of the main showings.

ELF (94F/7)

The Elf claims were staked by Cyprus Anvil in June 1978 to cover an area of moderately anomalous silt sediment samples and an occurrence of massive barite-lead-zinc float. The claims straddle a northwest-trending belt of Gunsteel shale southwest of the Akie River. Subsequent work on the property resulted in the discovery of a new barite-lead-zinc showing on the heavily timbered southeast-facing slope above one of the anomalous creeks. Hand trenching has exposed a zone of siliceous pyritic argillite and shale containing 10 to 20-centimetre-thick beds of dark grey bedded barite with diffuse bands of galena. Some thin, very fine-grained bands of galena are also present. The mineralized zone is apparently 4 to 5 metres thick at this point, with a moderate dip to the southwest. An extensive soil geochemical anomaly is coincident with the apparent trend of the mineralized horizon. Boulders of white crystalline barite containing medium to coarse-grained galena and sphalerite occur downstream from the main showing, but appear to be derived from a different source. Several occurrences of laminated pyrite and nodular barite were noted upstream from the main showing. These occurrences are apparently contained within wedges of Gunsteel shale trapped beneath overthrust plates of Silurian siltstone. Assay results of four grab samples are listed as follows:

Sample No.	Ag *ppm*	Ba *per cent*	Cu *ppm*	Pb *per cent*	Zn *ppm*
ELF–1	15	51.5	35	3.0	37
ELF–2	33	30.1	88	32.0	1 408
ELF–3	43	47.1	70	16.8	687
ELF–4	93	12.1	383	15.0	115

Sample Descriptions

ELF–1 — white crystalline barite with interstitial galena float in creek.
ELF–2, 3 — dark grey-bedded barite with diffuse galena bands, from trenches.
ELF–4 — thin, very fine-grained band of galena and interstitial barite, from trenches.

DISCUSSION

The nature and stratigraphic setting of shale-hosted barite-lead-zinc deposits in the Driftpile Creek and Akie River districts are strikingly similar to those in the MacMillan Pass area of the Yukon (Carne, 1979). In both areas the mineral occurrences, which are clearly syngenetic to early diagenetic, are associated with a siliceous carbonaceous black argillite or shale facies overlying or interfingered with a proximal to distal turbidite assemblage. A synsedimentary graben structure and a stockwork feeder zone have been defined at MacMillan Pass (Carne, 1979) but are still unrecognized in the Driftpile Creek–Akie River project area. However, in this area the platform margin does appear to have been very sharp and tectonically active at the time of mineralization and may have been located along a northwest-trending rift system. The distribution of mineral occurrences and volcanic rocks in the Akie River district is parallel to such a trend, suggesting the inferred rift system was the site of volcanic and hydrothermal activity from Ordovician to Late Devonian time. If these relationships are correct, then the timing of rifting and associated mineralization coincided with the early stages of marine transgression (crustal downwarping ?) and was followed by prograding flysch-type sedimentation from an uprising terrane to the west. It is hoped that future work on the Devonian section will provide a more refined model for the genesis of the shale-hosted barite-lead-zinc occurrences in the Akie River and Driftpile Creek districts.

ACKNOWLEDGMENTS

The author would like to thank Archer, Cathro and Associates and Cyprus Anvil Mining Corporation for their hospitality and logistical support during the current program. In addition, discussions with Wayne Roberts, Rob Carne, Charlie Jefferson, Dan Kilby, Mike Cecile, Bob Thompson, Gordon Taylor, and Hugh Gabrielse provided a useful and informative introduction to the area. Kevin Heather ably assisted in the field.

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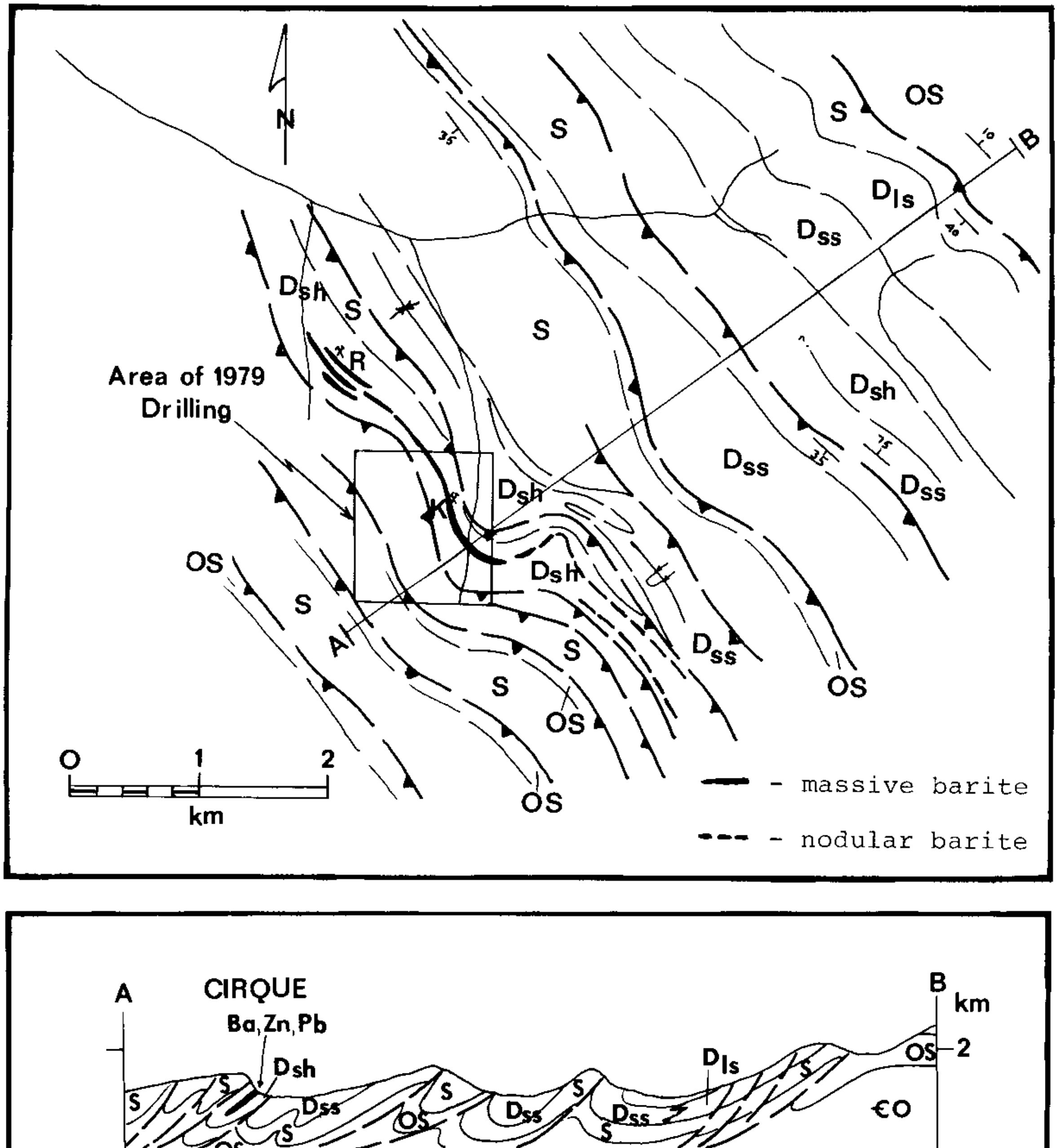

Figure 20. Geology of the Cirque claims (*see* Figure 16, page 58, for legend).

CIRQUE BARITE–ZINC–LEAD–SILVER DEPOSIT

(94F/6, 11)

By D. G. MacIntyre

INTRODUCTION

The Cirque claims were staked by the Cyprus Anvil/Hudson's Bay Oil and Gas joint venture in July 1977 to cover a northwest-trending belt of lead-zinc-bearing barite kill zones and gossans near the headwaters of the Paul River. Subsequent work outlined a coincident lead-zinc soil anomaly over 2 kilometres in length. In 1978 additional soil sampling and an electromagnetic survey were done followed by 882 metres of diamond drilling in six holes. Diamond-drill holes 78-1, 78-2, and 78-3 tested the R float showing and 78-4, 78-5, and 78-6 tested the K showing (Fig. 19). In 1979 the K showing was further explored by an additional 24 drill holes, totalling 7 928 metres. This work resulted in the discovery of a major stratiform barite-zinc-lead-silver deposit. To date drill indicated reserves of 18 million tonnes containing 2.3 per cent lead, 7.9 per cent zinc, and 49 grams per tonne silver with an additional down-dip geological reserve of approximately 15 million tonnes of similar grade have been announced. Extension of the deposit along strike is, as yet, untested.

STRUCTURAL AND STRATIGRAPHIC SETTING

The Cirque deposit is contained within a thrust panel of Devonian 'black clastics' which has been segmented by a series of southwest-dipping imbricate thrust faults (Fig. 20). The Devonian rocks define the northeast limb of an overturned synclinal structure which has been overridden and preserved beneath thrust plates of Silurian siltstone (unit S). Unit S is up to 400 metres thick in the vicinity of the Cirque deposit. Thrusting has been directed along incompetent black shale horizons of Late Ordovician to Early Silurian age (unit OS) which underlie the more competent limestone, chert, and shale unit (unit S_{ls}) at the base of the Silurian section.

The basal part of the Devonian succession is characterized by laminated silty shale with thin, poorly sorted siltstone, sandstone, conglomerate, and limestone interbeds (unit D_{ss}). These rocks, which are tentatively correlated with the Besa River Formation, are interpreted to be distal turbidites derived from a carbonate platform to the east. On the Cirque property, this unit is less than 50 metres thick and is overlain by more than 100 metres of siliceous argillite, chert, and carbonaceous black shale of the Gunsteel Formation (unit D_{sh}). A major facies change occurs on the eastern fringe of the property where unit D_{ss} passes abruptly into massive bedded limestone of the platformal Dunedin Formation (unit D_{ls}). This unit contains Middle Devonian fossil assemblages (Taylor and MacKenzie, 1970).

GUNSTEEL STRATIGRAPHY

The Cirque deposit occurs within an anomalously thick section of the Gunsteel Formation (Roberts, 1977). It is not certain whether this thickening represents a tectonic or primary depositional feature.

Four major subdivisions of the Gunsteel Formation (unit D_{sh}) are recognized, both on surface (Fig. 21) and in diamond-drill intersections (Fig. 22). These divisions are in ascending stratigraphic order:

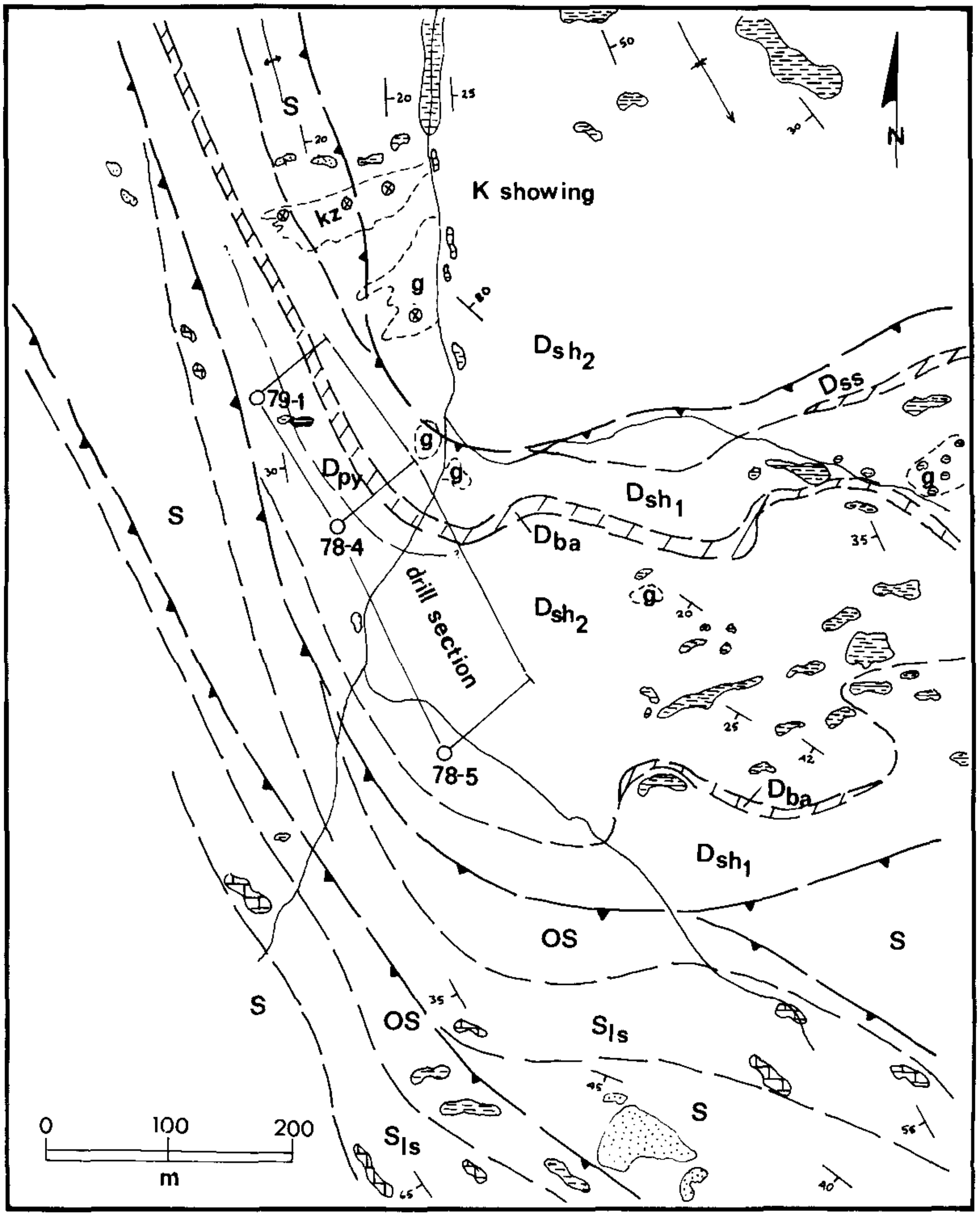

Figure 21. Detailed geology in the vicinity of the K showing as modified from company plans (*see* Figure 20 for location of map-area and Figure 22 for legend). Lithologic units are described in text. [g = gossan, Kz = kill zone, x - barite, Pb, Zn float.]

(1) Banded siliceous argillite and shale (map unit D_{sh_1});
(2) Baritic horizon (map unit D_{ba});
(3) Pyritic horizon (map unit D_{py}); and
(4) Argillite and shale (map unit D_{sh_2}).

UNIT D_{sh_1}

Unit D_{sh_1} forms the footwall of the Cirque deposit and is comprised of banded bluish grey-weathering siliceous argillite or chert with carbonaceous black shale interbeds. This division varies from 20 to 50 metres thick and is relatively resistant and competent. Roberts (personal communication) reports the occurrence of the ammonoid *Ponticeres* at the top of this unit indicating a lower Late Devonian age.

UNIT D_{ba}

Unit D_{ba} which conformably overlies unit D_{sh_1} is present on a regional scale and is characterized by black siliceous argillite or shale with nodular or blebby barite interbeds. This division, which is normally less than 5 metres thick, apparently grades into the much thicker massive barite horizon of the main mineralized zone.

UNIT D_{py}

Unit D_{py} varies from 20 to 30 metres thick and forms the hangingwall of the Cirque deposit. This unit is comprised of silvery grey to black-weathering, moderately siliceous argillite or shale with several 2 to 3-metre-thick zones of laminated, very fine-grained, or massive coarse-grained pyrite. Thin beds of nodular barite are also present. The overall sulphide content of this unit apparently decreases away from the massive barite horizon.

UNIT D_{sh_2}

Unit D_{py} apparently grades both up section and laterally into unit D_{sh_2} which is characterized by weakly to moderately siliceous carbonaceous black shale and argillite. To the east of the K showing this unit appears to be in excess of 200 metres thick.

MINERALIZATION

The K showing, located 2 kilometres southeast of the R float showing, is currently the main exploration target on the Cirque property (Fig. 20). The showing consists of several small outcrops and a prominent white-weathering barite kill zone exposed on the northeast-facing slope of a northwest-trending ridge. Diamond drilling in this area has intersected a massive coarsely crystalline (recrystallized ?) barite horizon containing diffuse bands and interstitial blebs of sphalerite and galena. This horizon varies from less than 5 to greater than 35 metres thick, appears to have a roughly lensoid or dish-like shape, and dips moderately to steeply to the southwest. Thin shaly partings and very fine-grained pyrite laminae occur locally within the massive barite. Average grades of drill intersections from this horizon are in the range of 9 to 15 per cent combined lead-zinc with 50 to 70 grams per tonne silver. The zinc/zinc + lead ratio of the 1978 drill

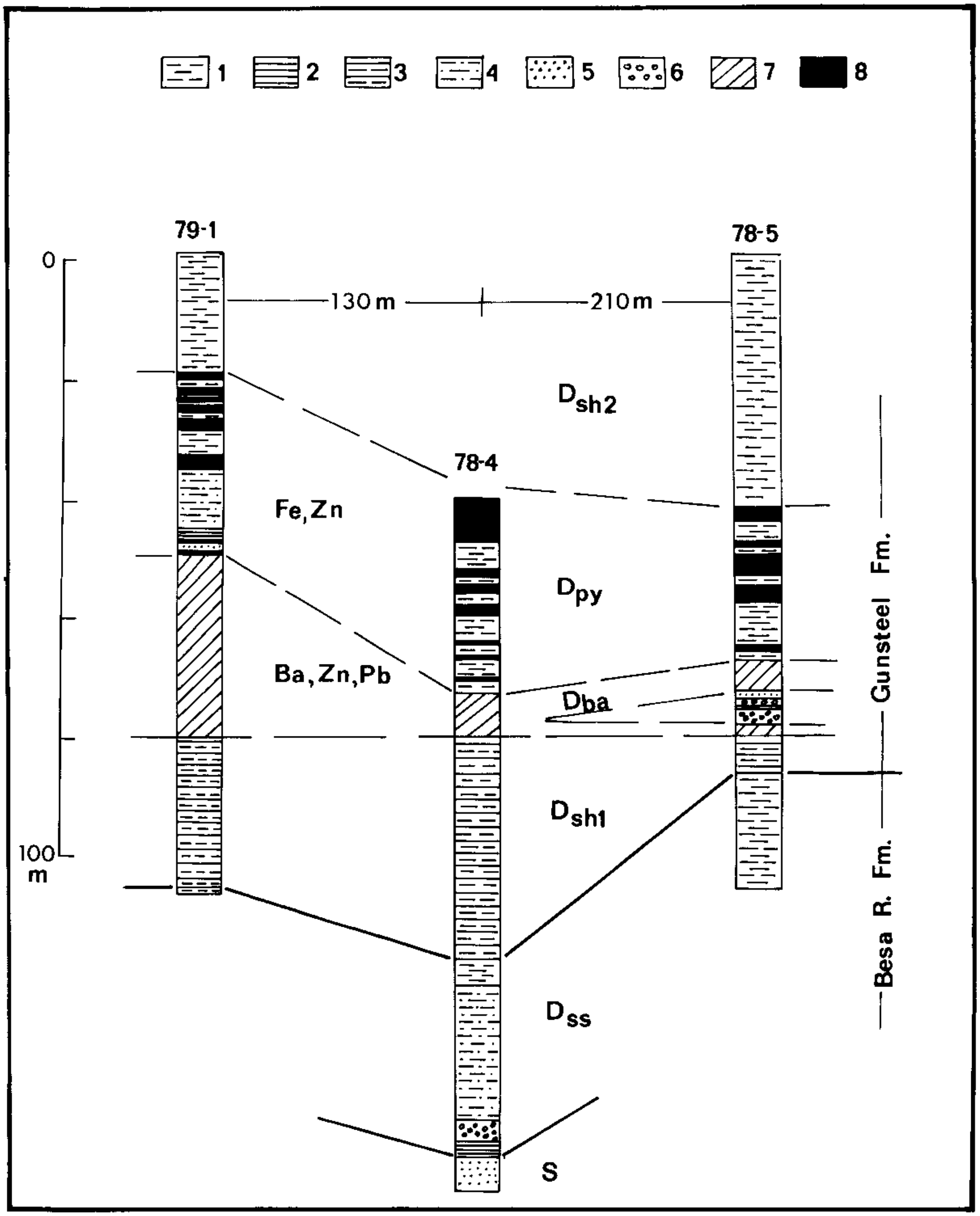

Figure 22. Composite drill section, Cirque claims (*see* Figure 21 for location of drill holes). [1 = weakly to moderately siliceous shale and argillite, 2 = siliceous argillite, chert, 3 = interbedded siliceous argillite, chert, and shale, 4 = silty shale, 5 = siltstone, 6 = conglomerate, 7 = massive barite, 8 = laminated pyrite in shale.]

intersections varied from 0.72 to 0.77. The overall ratio for the reserves defined in the 1979 program is 0.77.

Very fine-grained sphalerite and trace amounts of galena also occur in bands of laminated fine-grained and massive coarse-grained pyrite directly overlying the main barite horizon (unit D_{py}). Assay results from this zone are extremely variable and range from 0.5 to 8 per cent combined lead-zinc. Anomalously high background concentrations of lead and zinc also occur in rocks immediately underlying (unit D_{sh_1}) and overlying (unit D_{sh_2}) the main deposit.

Five selected samples from the Cirque property were analysed by the British Columbia Ministry of Energy, Mines and Petroleum Resources' laboratory. The results are listed as follows:

Sample No.	Ag	Ba	Cu	Pb	Zn
	ppm	*per cent*	*ppm*	*per cent*	*ppm*
Cirque 1	<10	57.03	15	1.7	13
Cirque 2	17	51.34	6	10.4	581
Cirque 3	<10	56.52	5	2.6	133
Cirque 4	18	0.03	155	0.33	1 850
79–CQ–51	*<10*	*19.60*	*45*	*0.013*	*40*

SAMPLE DESCRIPTIONS

Cirque 1-3 – massive coarsely crystalline white barite with blebs of galena; samples from barite kill zone, K showing.
Cirque 4 – laminated pyrite in siliceous black shale; float in creek, southeast of K showing.
79–CQ–51 – nodular barite in carbonaceous black shale; outcrop on ridge, 700 metres east-southeast of K showing.

The low concentrations of zinc in samples from the barite kill zone relative to those intersected in drilling suggests either selective leaching of zinc during weathering of the mineralized float or a possible facies change within the barite horizon going toward the east.

DISCUSSION

Roberts (1977) has suggested that the Cirque deposit formed within a fault-bounded sub-basin or trough which had restricted seawater circulation. This hypothesis is based on the reasonable assumption that the anomalous thickening of the Gunsteel Formtion is a primary depositional feature. Interbeds of coarse, poorly sorted conglomerate or breccia within the southern part of the massive barite horizon suggests the inferred bounding faults were tectonical active during the main pulse of mineralization. The thickness and lensoidal shape of the massive barite horizon and general lack of pelitic interbeds in consistent with Sato's (1972) model of accumulation of dense metalliferous brines in a seafloor depression and subsequent rapid crystallization. The reported occurrence of ammonites within the barite (Roberts, personal communication) further supports a syngenetic origin for the deposit. A period of alternating pelitic sedimentation and syngenetic to early diagenetic crystallization of pyrite followed the main episode of barite precipitation and was apparently restricted to the same basin of deposition. It is suggested that the source fluids for both types of mineralization emanated from rift zones bounding this basin.

ACKNOWLEDGMENTS

The writer would like to acknowledge the excellent work done by Wayne Roberts of Cyprus Anvil and Dan Kilby of Hudson's Bay Oil and Gas on the Cirque property.

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MOUNT LEONARD BOSS – SURPRISE LAKE BATHOLITH (104N)

By P. A. Christopher

Regional mapping of the Surprise Lake batholith was initiated during the 1979 field season. The Mount Leonard boss, the most westerly segment of the Surprise Lake batholith, was mapped during July and August. Continuation of mapping in the batholith is planned for 1980.

The map-area (Fig. 23), within the Atlin Horst tectonic subdivision, is situated east of Atlin Lake in northern British Columbia with the centre of the Surprise Lake batholith at latitude 59 degrees 42 minutes north and longitude 132 degrees 53 minutes west. The area is mountainous with peak elevations of 1 800 to 2 100 metres and the valley containing Surprise Lake at about 942 metres. Access is via the Alaska Highway and Highway 7 to Atlin. A good gravel road exists between Atlin and Surprise Lake and various mining roads provide access to most of the batholith situated northwest of Surprise Lake. Several mining companies actively explored the area around Ruby Mountain during 1979.

Prospecting and exploration efforts in the Surprise Lake batholith have located interesting molybdenum and/or tungsten properties including Adanac (molybdenum), Gladys Lake (molybdenum), Black Diamond (tungsten), and Weir Mountain (molybdenum, tungsten). Geochemical data obtained from stream silt and water samples collected during the Uranium Reconnaissance Program in 1977 demonstrate that the Surprise Lake batholith is anomalous in uranium, molybdenum, tin, tungsten, and fluorine.

GENERAL GEOLOGY

The Surprise Lake batholith intrudes Permo-Pennsylvanian Cache Creek metamorphic rocks and Atlin ultramafic rocks and Coast Intrusions which have been assigned a Jurassic age (Aitken, 1959). The lenticular batholith, comprising alaskite and quartz monzonite, is bisected by a band of older Cache Creek rocks in the Trout Lake graben. Biotite K/Ar ages of 75.4±5 Ma (N. C. Carter, unpublished data) from pegmatitic alaskite near Trout Lake and 62.0±2.2 Ma (Christopher, *et al.*, 1972) from coarse alaskite on the Adanac property suggest a composite batholith of Cretaceous and Early Tertiary age. In the Ruby Creek drainage, a Tertiary olivine basalt stratovolcano and Quaternary olivine basalt volcanic conelets and flows overlie auriferous gravels and granitic rocks of the batholith.

The presence of grey or smoky quartz is characteristic of both the Mount Leonard boss and the Surprise Lake batholith. The grey colouration of quartz is related to the generally high uranium background of the granitic bodies.

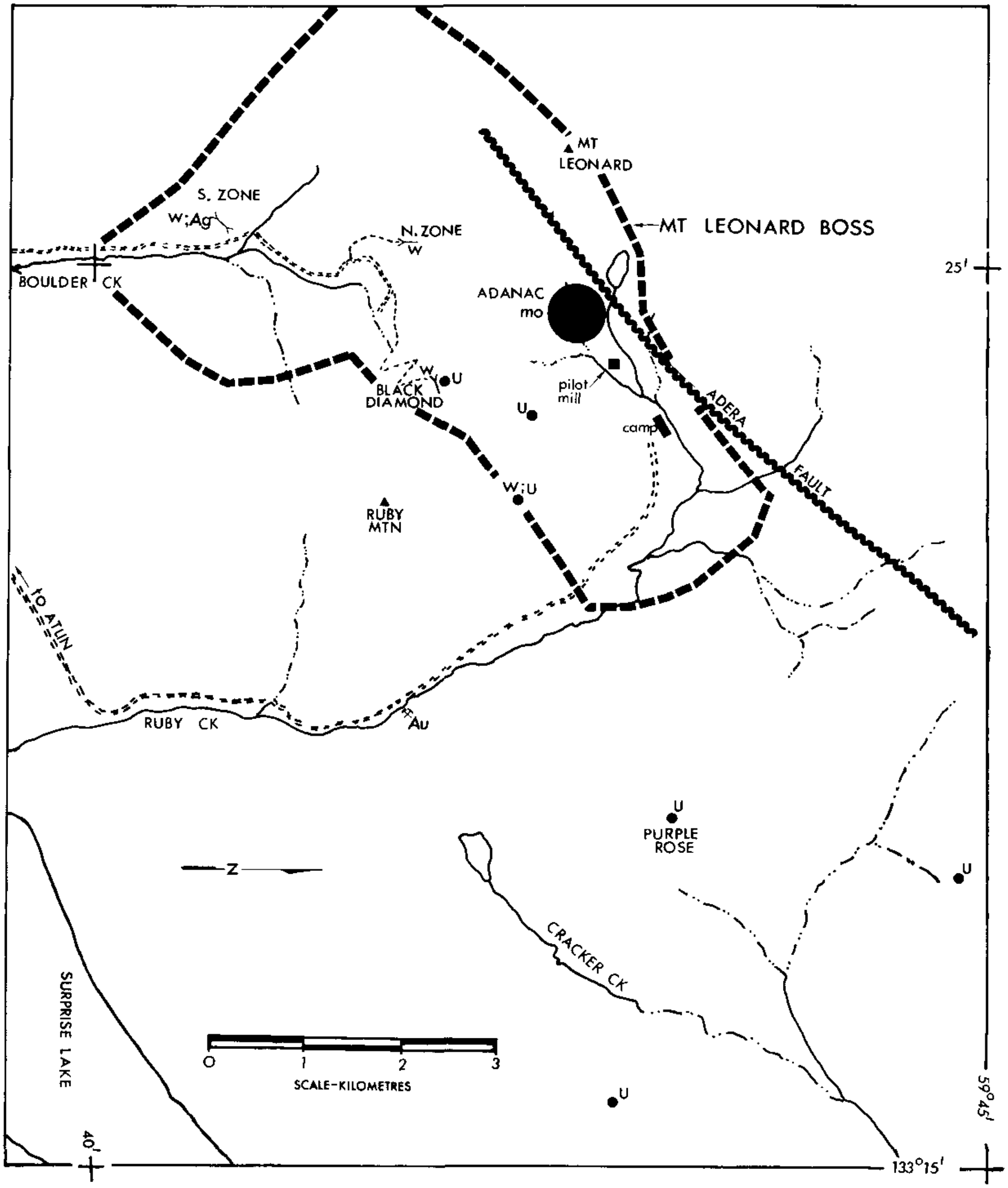

Figure 23. Mount Leonard boss – Surprise Lake batholith.

MINERAL DEPOSITS

ADANAC

The Adanac molybdenum property, owned by Adanac Mining and Exploration Ltd. and under option to Placer Development Limited, is situated at the headwaters of Ruby Creek (Fig. 23). In 1979, 39 NQ diamond-drill holes, totalling 5 351.7 metres, were drilled to further explore the deposit and concurrent environmental impact studies included testing of proposed tailings and plant site areas with eight NQ diamond-drill holes, totalling 457.2 metres, soil test pits and trenches, and geophysical surveys. Surprise Lake and Pine Creek were evaluated for hydroelectric potential.

PROPERTY GEOLOGY

The main mineral showings occur between 1 463 metres and 1 495 metres in the creek valley. Outcrops are generally limited to stream valleys, steeper slopes and ridges with diamond drilling relied upon for geological information. On gentle slopes felsenmeer mapping was attempted.

The Adanac deposit occurs in the northeasterly part of the multiphase Mount Leonard boss (Fig. 23). The geology of this area has been studied by Aitken (1959), Sutherland Brown (1970), Jones (1971), and White, *et al.* (1976). These authors generally agree on distribution of units but not on unit names. The writer and present operators have expanded on Sutherland Brown's nomenclature. The deposit geology is described in terms of six main units: quartz monzonite porphyry, coarse alaskite, crowded quartz-perthite-oligoclase porphyry, sparse quartz-perthite-oligoclase porphyry, fine-grained alaskite, and equigranular granite. The fine-grained alaskite is coincident with the higher grade molybdenite zone in the underground workings and the equigranular granite was encountered at a depth of 402 metres in drill hole 1W-1N. Quartz monzonite porphyry occurs in the eastern part of the property and the coarse alaskite is found in the southern and western areas. Sparse and crowded porphyries occur between the Adera fault and Coast Intrusions and Cache Creek rocks to the north, and at surface near the southeast boundary of the deposit (*see* Sutherland Brown, 1970, Fig. 4). Mafic varieties, textural gradations, aplitic dykes, basic dykes, and hybrid phases complicate the geologic picture but are not mappable units.

STRUCTURE

The Adera fault, which forms the northern boundary of the Adanac deposit, strikes north 65 degrees east and dips 80 degrees north between Molly Lake and Ruby Creek (White, *et al.*, 1976). Geophysical surveys (electromagnetic and magnetic) by Richard Cannon, diamond drilling for a proposed dam site and mapping indicate a strike of about north 45 degrees east for the easterly extension of the Adera fault. About 500 fracture measurements were used by White, *et al.* (1976) to define four principal trends: north 36 degrees east/82 degrees southeast, north 15 degrees to 30 degrees west/70 degrees to 80 degrees southwest, north 38 degrees east/77 degrees northwest, and nearly horizontal with molybdenum veins in the nearly horizontal and north 36 degrees east structures. They suggested that fracture density does not appear to increase in the area of the mineral deposit but that the higher grade zones result from an increase of intensity of mineralization in nearly horizontal veins.

MINERALIZATION

Molybdenum mineralization occurs in all phases of the Mount Leonard boss, with the exception of the post-mineral equigranular granite. The fine-grained alaskite, coarse alaskite, and sparse porphyry host the higher grade mineralization on the Adanac property with molybdenite occurring mainly in quartz veins and as fracture coatings. The modes of occurrence of molybdenite are:

(1) rosettes in smoky quartz veins
(2) fine-grained fracture coatings with quartz envelopes
(3) quartz-pyrite-molybdenite veins with some carbonate
(4) molybdenite gouge on fault surfaces
(5) molybdenite-bearing quartz veins with potassium feldspar and/or biotite envelopes
(6) quartz-molybdenum-fluorite-potassium feldspar±biotite.

Barren veins include:

(1) quartz veins
(2) fracture coatings of pyrite with rare chalcopyrite and copper carbonates
(3) quartz and pyrite with rare chalcopyrite and copper carbonates
(4) quartz, calcite, and chalcopyrite
(5) potassium feldspar and/or biotite
(6) quartz, wolframite, arsenopyrite, scheelite, and fluorite
(7) carbonate.

Chalcopyrite is rare within the deposit and pyrite content of less than 1 per cent is restricted to veins and fractures. Examination of the adit area confirms the existence of pyrite in veins and fractures to the east of the deposit but pyrite appears to be more abundant within the molybdenum deposit. The density of fluorite-bearing veins appears to increase in the fine-grained core of the deposit. Only one quartz-wolframite vein was identified in core from the northern margin of the deposit but quartz, wolframite-arsenopyrite veins, and breccia zones are more common in peripheral areas.

Further evaluation of the 1979 drilling program will be required before the published tonnage and grade of 94 350 000 tonnes of 0.16 per cent molybdenite (established by Kerr Addison Mines Limited and reported in White, *et al.*, 1976) can be refined.

YKR

The YKR tungsten property is situated south and west of Adanac and covers parts of the southerly contact between the Mount Leonard boss and Cache Creek metasedimentary rocks (Fig. 23). The old Black Diamond, Tungsten, Silver Diamond, and Bub properties are included in the present holdings of Yukon Revenue Mines Limited.

Linecutting, soil sampling, bulldozer trenching, geophysical surveys, limited X-ray diamond drilling, and prospecting and mapping of the property were carried out in 1979. Coarse alaskite and porphyritic phases of the Mount Leonard boss intrude calcareous metasedimentary rocks of the Cache Creek Group. Vein, contact skarn, and porphyry potential of the property is presently being examined. Vein mineralization occurs mainly within the granitic rocks but has also been found at the alaskite-metasediment contact. The Black Diamond vein can be traced about 4 kilometres from near the Ruby Creek valley to Boulder Creek with the strike varying from about north 70 degrees east to about north 50 degrees east. A north 40 degrees to 45 degrees east striking quartz vein on the west side of Boulder Creek may be part of the vein system. Veins contain quartz, muscovite, arsenopyrite, wolframite, with minor chalcopyrite, scheelite, molybdenite, cassiterite, fluorite, and gold. Diopside-tremolite-garnet skarn occurs in pendants and contact altered Cache Creek rocks with pyrrhotite, pyrite, chalcopyrite, scheelite, wolframite, tetrahedrite, sphalerite, and fluorite. Bismuthinite ($PbBi_2S_4$) and possible tetradymite ($BiTe_2S$) have been reportec by Schroeter (1979).

URANIUM EXPLORATION

Uranium exploration in the Surprise Lake batholith was continued by Cominco Ltd., Wyoming Minerals, Mattagami Lake Mines Limited, St. Joseph exploration Limited, and E & B Explorations Ltd. The Mount Leonard boss was surveyed during mapping with a McPhar TVI and scintillometer and several anomalous areas were located on the ridge south of the Adanac property. Secondary uranium minerals, generally kasolite or zeunerite, occur in quartz veins or breccia zones with arsenopyrite, fluorite, tetrahedrite, chalcopyrite, and wolframite. Zeunerite has also been reported from the Black Diamond vein. The Purple Rose prospect (Fig. 23), a zeunerite-bearing quartz vein on the Pato claims, and the Cirque prospect, a quartz-fluorite stockwork or vein zone on the IRA claims (on Mount Edmund), are the best known and explored examples of structurally controlled uranium mineralization in the Surprise Lake batholith. The Cirque prospect was tested with limited diamond drilling by Wyoming Minerals.

Eight diamond-drill holes by Cominco Ltd. were used to test for secondary uranium mineralization in paleostream sediments capped by olivine basalt flows on the Vol, Per-Eye, and Dambouleo claim group between Boulder and Ruby Creeks.

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CASSIAR MAP–AREA

(104P)

By A. Panteleyev

INTRODUCTION

Geological mapping at a scale of 1:15 840 (1 inch = ¼ mile) that began in 1978 in the region south and west of Cassiar mine was extended to the west and north. In 1979 an additional 210 square kilometres of mainly granitic terrane was mapped for total map coverage during 1978 and 1979 of 470 square kilometres. *This area encompasses the entire 'Cassiar stock,' a younger (73 Ma) intrusion that forms part of the well-*mineralized eastern margin of the composite Cassiar batholith (Fig. 24).

In addition, 36 stream sediment samples (Fig. 25), 9 assay samples, and 92 rock specimens were collected. The 36 stream sediment samples (minus 80 mesh) were analysed for silver, copper, lead, zinc, cobalt, manganese, nickel, uranium, thorium, tungsten, tin, and molybdenum. Together with the 76 samples reported in *Geological Fieldwork, 1978,* they are intended to provide an orientation survey for use in interpreting results of the 1978 Uranium Reconnaissance Program (URP) in McDame (104P) and Jennings River (104O) map-areas (NGR 41-1978, 42-1978; Geological Survey of Canada, Open File Reports 561 and 562, June 1979).

GEOLOGY

This short report is intended to update and augment the more lengthy description of Cassiar map-area in Geological Fieldwork, 1978, pages 51 to 60.

The 'Cassiar stock' is a north-south elongate intrusion approximately 7 by 30 kilometres in size. The distinction between this younger intrusion and the mid-Cretaceous Cassiar batholith to the west can be emphasized by use of the informal name 'Troutline Creek quartz monzonite or adamellite.' In the south and east it intrudes a bedded sedimentary and metasedimentary sequence made up of rocks of the Good Hope (Ingenika), Atan, Kechika, Sandpile, and McDame Groups. These are a shelf assemblage of clastic and carbonate rocks that are overlain by allochthonous volcanic and sedimentary rocks of the Sylvester Group. The bedded rocks have been described by Gabrielse (1963) and are discussed in *Geological Fieldwork, 1978.*

In the southwest the Troutline Creek quartz monzonite is separated from rocks of the Cassiar batholith by a metamorphosed septum of Good Hope rocks, approximately 1 to 2 kilometres in width (Fig. 24). Along the western extremity of the Troutline Creek quartz monzonite the Good Hope rocks are engulfed by batholithic rocks and form a zone of dissected northwesterly trending pendants. To the north of these pendants (north and northeast of Maria Lake) the contact of the Troutline Creek quartz monzonite and Cassiar batholith is largely buried along a creek valley. Where the contact is exposed it is irregular and is defined arbitrarily as the zone in which there is a preponderance of pink porphyritic quartz monzonite dykes in batholithic granodiorite.

In general, the eastern intrusive contact of the Troutline Creek quartz monzonite is sharp and has extensive hornfels and calc-silicate rocks adjacent to it. Skarn and calc-silicate tactite are especially prevalent where calcareous rocks of the upper Good Hope and Atan map units and the Sandpile–McDame map units are intruded. The western contact is more irregular and consists of a multitude of partially assimilated xenoliths of foliated metasedimentary rocks and numerous leucocratic dykes. These granite dykes commonly trend parallel with schistosity and are noteworthy for their content of small red spessartine garnets. Wall-rocks are mica schist that locally contains abundant black tourmaline (schorlite).

Two small satellitic intrusions of quartz monzonite porphyry are present north of Cassiar along the eastern margin of the Troutline Creek quartz monzonite. A small stock of diorite is found alongside Highway 37 about 8 kilometres southeast of Cassiar. It intrudes Sylvester volcanic rocks as a plug and might have been a feeder zone for overlying Sylvester volcanic flows.

The Troutline Creek quartz monzonite intrusion as shown on Figure 24 consists of three major map units with obvious textural and subtle compositional differences and two dyke types. The major units are megacrystic quartz monzonite porphyry, medium-grained, equigranular to coarse porphyritic quartz monzonite (mantled porphyry), and medium-grained, equigranular border zone quartz monzonite or granite. These three main rock types have gradational relationships. Average composition of the megacrystic and porphyritic quartz monzonite (mantled porphyry) is 34 per cent perthitic K-feldspar, 32 per cent plagioclase, 27 per cent quartz, and 7 per cent mafic minerals with biotite always in excess of hornblende. The equigranular border quartz monzonite forms a chilled contact and grades into megacrystic quartz monzonite porphyry. Along much of the western margin of the intrusion the border zone is leucocratic and is granitic in composition.

The two main dyke types are grey quartz monzonite and quartz feldspar porphyry. They form small bodies within core areas of porphyritic quartz monzonite (mantled porphyry). There appears to be a close genetic relationship between quartz feldspar porphyry and quartz monzonite porphyry in which mantling of K-feldspar phenocrysts by albite is common and well developed. Molybdenite rosettes are present in the quartz feldspar porphyry and molybdenite-bearing fractures and veinlets in the surrounding mantled quartz monzonite. The presence of molybdenite and pyrite as well as micrographic textures in the matrix of both rock types suggest that quartz feldspar porphyry dykes and the enclosing strongly mantled quartz monzonite porphyries are zones of hydrothermal fluid separation and concentration. At Cassiar molybdenum deposit (K/Ar site 1, Fig. 24), quartz feldspar porphyry forms a steeply dipping dyke and a number of smaller dykes and plugs, some with rinds and cappings of quartz-K-feldspar-biotite pegmatite. At Storie molybdenum deposit (K/Ar site 2, Fig. 24), quartz feldspar porphyry forms a number of sheet-like intrusions, each one up to 60 metres in thickness. The dykes have porphyritic borders that grade into quartz porphyry or equigranular, miarolytic pink quartz monzonite in dyke cores.

The coeval and cogenetic relationships of all the quartz monzonite map units and related molybdenum mineralization is suggested by field relations. This is further supported by K/Ar dating (*see* Table 1). The 73.0±2.5 Ma mean age of intrusion/molybdenum mineralization clearly isolates the Troutline Creek quartz monzonite from the approximately 100-million-year-old Cassiar batholith.

Rocks of the Cassiar batholith in the map-area are fine to medium-grained, equigranular to porphyritic granodiorite and quartz monzonite. Average composition is 42 per cent plagioclase, 28 per cent quartz, 21 per cent poikilitic K-feldspar, and 9 per cent mafic minerals, mainly biotite. Porphyritic batholithic rocks are made up of stubby crystals of plagioclase with blocky K-feldspar phenocrysts up to 1.5 centimetres in size in a granular quartz-plagiocase-biotite matrix. Most commonly batholithic rocks are equigranular to slightly porphyritic granular mosaics in which there is a persistent though subtle foliation caused by orientation of biotite grains.

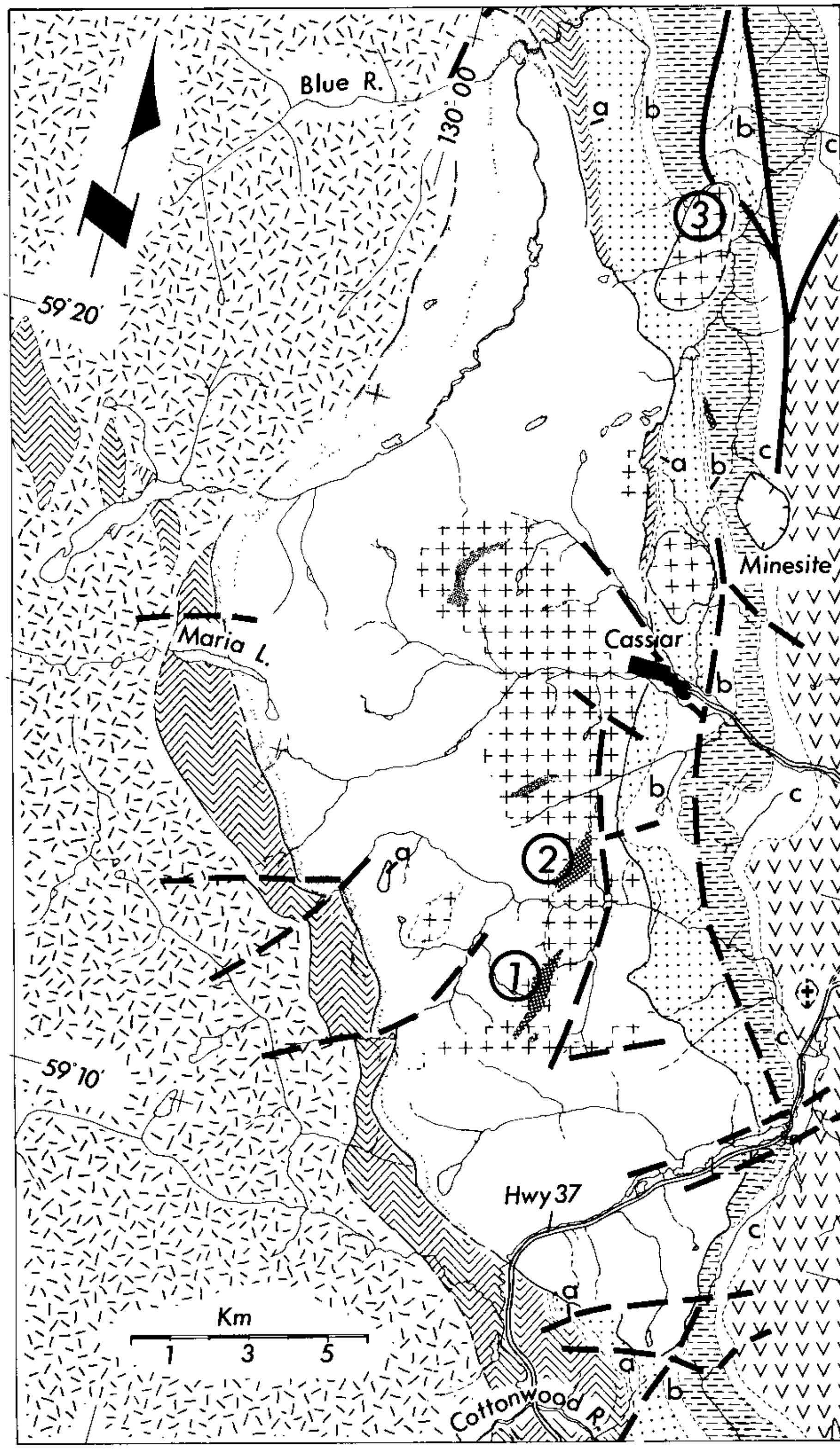

Figure 24. Geology of Cassiar map-area.

LEGEND

BEDDED ROCKS

DEVONIAN AND MISSISSIPPIAN

SYLVESTER GROUP

SILTSTONE, SLATE, BLACK CHERT, GREENSTONE

ORDOVICIAN AND DEVONIAN

SANDPILE AND McDAME GROUPS (UNDIVIDED)

c — **McDAME:** BLACK FETID DOLOMITE AND LIMESTONE, LIMESTONE
SANDPILE: GREY AND BUFF DOLOMITE, SANDY DOLOMITE, GREY AND PURPLE QUARTZITE

CAMBRIAN AND ORDOVICIAN

KECHIKA GROUP

SHALE, CALCAREOUS SHALE, MINOR SLATE AND LOCAL CALC-SILICATE HORNFELS

LOWER CAMBRIAN

ATAN GROUP

b — RUSTY WEATHERING CORDIERITE AND BIOTITE HORNFELS, SPOTTED HORNFELS, SILTSTONE, QUARTZITE; UPPER UNIT 'b': GREY, PINK, AND BUFF DOLOMITE, GREY AND BLACK LIMESTONE, MARBLE, SKARN, MINOR SLATE

PROTEROZOIC

GOOD HOPE (INGENIKA) GROUP

a — LAYERED CALC-SILICATE HORNFELS, CORDIERITE AND BIOTITE HORNFELS, MICACEOUS QUARTZITE, PHYLLITE, MICA SCHIST; UPPER UNIT 'a': MARBLE, GREY LIMESTONE, DOLOMITE, MINOR SKARN

INTRUSIVE ROCKS

CASSIAR STOCK (73±2.5 Ma)

MEGACRYSTIC HORNBLENDE BIOTITE QUARTZ MONZONITE PORPHYRY

EQUIGRANULAR MEDIUM-GRAINED TO PORPHYRITIC QUARTZ MONZONITE AND GRANITE (BORDER ZONE)

BIOTITE QUARTZ MONZONITE PORPHYRY: MANTLED K-FELDSPAR AND PORPHYRITIC TO EQUIGRANULAR MEDIUM-GRAINED QUARTZ MONZONITE, CONTAINS SOME MUSCOVITE (GRADATIONAL WITH MEGACRYSTIC ROCKS)

QUARTZ FELDSPAR PORPHYRY (PINK QUARTZ MONZONITE TO GRANITE DYKES WITH ASSOCIATED *MOLYBDENUM*)

GREY FINE TO MEDIUM-GRAINED QUARTZ MONZONITE (DYKES)

CASSIAR BATHOLITH (~100 Ma)

FINE TO MEDIUM-GRAINED PORPHYRITIC GRANODIORITE AND QUARTZ MONZONITE (MINERAL ALIGNMENT AND FOLIATION EVIDENT)

PALEOZOIC (?)

DIORITE (SYLVESTER INTRUSION)

SYMBOLS

MAJOR ROAD . . . .

FAULT, NORMAL, REVERSE . . . .

INTRUSIVE CONTACT DEFINED, APPROXIMATE . . .

K/Ar SAMPLE SITE (MAIN Mo PROSPECTS) 1

TABLE 1. K/Ar ANALYTICAL DATA, CASSIAR STOCK

Sample No.	Location	Material Analysed	% K	Ar^{*40} (10^{-6} cc STP/g)	$\frac{Ar^{*40}}{\text{Total } Ar^{*40}}$	Apparent Age (Ma)
(1) 78AP–60a	Cassiar Mo (location 1) mineralized greisen	muscovite (hydromuscovite ?)	8.42±0.02 (2)	24.618	97.9	73.7±2.6
(2) 78AP–43	Cassiar Mo (location 1) porphyry dyke	biotite	7.78±0.03 (2)	22.720	93.4	73.6±2.5
(3) 78AP–127	Storie Mo (location 2) mineralized vein	muscovite	8.77±0.02 (3)	25.440	92.7	71.4±2.5
(4) 78AP–126	Storie Mo (location 2) porphyry dyke	biotite	7.69±0.03 (2)	22.110	92.8	72.5±2.5
(5) 78AP–158	Lamb Mtn. (Windy) (location 3) *porphyritic stock*	biotite	7.92±0.03 (2)	23.236	89.7	73.9±2.5

NOTES

% K determined by the Analytical Laboratory, Ministry of Energy, Mines and Petroleum Resources; number in parenthesis refers to number of K analyses.

Ar determination and age calculation by J. E. Harakal, University of British Columbia.

Constants used: $\lambda = 0.584 \times 10^{-10} yr^{-1}$; λ^6 $4.72 \times 10^{-10} yr^{-1}$; $K^{40}/K = 1.19 \times 10^{-4}$ (sample 3)
$\lambda = 0.581 \times 10^{-10} yr^{-1}$; λ^6 $4.96 \times 10^{-10} yr^{-1}$; $K^{40}/K = 1.167 \times 10^{-4}$ (samples 1, 2, 4, 5)

MINERALIZATION

The following discussion can be added to the description of the 15 main mineral deposits and occurrences in the Cassiar map-area reported in *Geological Fieldwork, 1978,* pages 55 to 57.

Molybdenite is the main mineral of current economic interest. The two main porphyry molybdenum deposits are shown on Figure 24 as K/Ar sites 1 (Cassiar molybdenum deposit) and K/Ar site 2 (Storie or New Jersey zinc-molybdenum deposit). K/Ar site 3 is Lamb Mountain (Fort Reliance Star Group) or Windy tungsten-molybdenum skarn deposit.

At Cassiar and Storie molybdenum prospects molybdenite mineralization is related to a single younger quartz feldspar porphyry that forms plugs or sheet-like dykes. The hydrothermal environment indicated is relatively dry and high temperature and produced a molybdenum-tungsten-tin-fluorine-beryllium association related to stockwork greisen and pegmatite development. Molybdenite at the Cassiar molybdenum prospect is widespread but scattered and low grade overall although small greisen pods and fracture zones have spectacular grades. At Storie molybdenum deposit a large low-grade surface deposit has been indicated by diamond drilling. Potential for additional tonnage of better grade material in both deposits is at some considerable depth. These molybdenum prospects might respond to detailed geological and lithogeochemical investigations using models of overlapping ore and alteration 'shells' such as those described at Climax and Henderson deposits, Colorado. Direct comparison can be made with Glacier Gulch deposit near Smithers, British Columbia (Bright and Jonson, 1976) and with Adanac deposit near Atlin, British Columbia (White, *et al.*, 1976) where molybdenum mineralization is related to buried intrusions.

Lamb Mountain tungsten-molybdenum occurrence (K/Ar site 3, Fig. 24) is part of an extensive skarn zone formed in Atan carbonate rocks (map unit b, Fig. 24). Skarn with scheelite and greisen pods with molybdenite are found along the intrusive contact of a small quartz monzonite porphyry stock. Mineralized skarn is close to the northern and western contacts of the small stock but can be traced for at least 2 kilometres to the south of the intrusion where skarn appears to be related to a small porphyry dyke that also carries some molybdenite. Skarn in the Atan carbonate map unit displays lateral zoning. At the intrusive contact of the stock a magnetite-garnet tactite has formed; further from the contact garnet-pyroxene skarn with pyrrhotite lenses is present; and at some distance from the intrusion the skarn contains abundant tremolite. Some scheelite is present in the magnetite tactite and pyrrhotite lenses in garnet-pyroxene skarn. Two chip samples across 3 metres from trenches in tactite contain 0.2 per cent WO_3, 0.07 per cent copper, 0.01 per cent zinc, and 0.01 per cent tin. A sample from pyrrhotite-rich garnet-pyroxene skarn reported in *Geological Fieldwork, 1978,* page 56, has similar values.

Some skarn development with sphalerite and molybdenite is also seen in the upper Good Hope (map unit a) to the west of Cassiar minesite. To the north the same thin Good Hope carbonate unit contains some magnetite tactite and skarn with gold, silver, and bismuth values (location near silt sample sites 93 and 94, Fig. 25).

The tin occurrence discovered in 1978 on the northern bank of Lang Creek (location 4b, *Geological Fieldwork, 1978,* p. 57) has been confirmed to contain at least 1.5 per cent tin, all as cassiterite. It appears to be a vein-like replacement in a fault zone. Where exposed the mineralized zone contains abundant arsenopyrite and marcasite in a fault breccia developed over a width of 3 to 4 metres.

GEOCHEMICAL DATA

Analytical data are shown in Table 2. Locations of the 76 stream sediment samples from 1978 are shown as dots on Figure 24 and the 36 sample sites from 1979 are shown as diamonds with corresponding numbers. Summary statistics for all 112 stream sediment samples are given in Table 3.

Of the total 112 samples, 70 are from granitic source terranes and the remaining 42 are from the thermal aureole and bedded rocks. This distinction in source terranes is readily evident in the data as two fundamental associations can be recognized: molybdenum, tungsten, tin, and uranium related to the Troutline Creek quartz monzonite intrusion and lead, zinc, silver, cobalt, nickel, and copper related to bedded rocks.

When elements are examined individually, molybdenum most clearly defines the areas of quartz feldspar porphyry dyke intrusions and the faulted and fractured zones surrounding them. These are the sites of known porphyry-type molybdenum mineralization in the southern half of the Troutline Creek quartz monzonite intrusion. Uranium and tin are concentrated in drainages throughout the stock and therefore indicate high background values in quartz monzonite. For example, uranium in silts from the Troutline Creek quartz monzonite has a mean concentration of 41 ppm, outside the stock the mean value is 13 ppm. Similarly the average tin content of quartz monzonite is consistently 5 to 10 ppm whereas outside the stock tin content is generally less than 5 ppm. However, unlike uranium which appears to have a homogeneous distribution through the quartz monzonite, tin can also be related to specific mineralized sources such as stanniferous lead-zinc-silver veins and certain skarn zones.

Tungsten in comparison has scattered high values (>10 ppm) in silts derived from quartz monzonite. Maximum concentration (>25 ppm tungsten) can be readily seen to be derived from two mineralized sources: porphyry molybdenum deposits (Cassiar and Storie molybdenum prospects) and skarns in Atan and Good Hope carbonates along the eastern margin of Troutline Creek quartz monzonite.

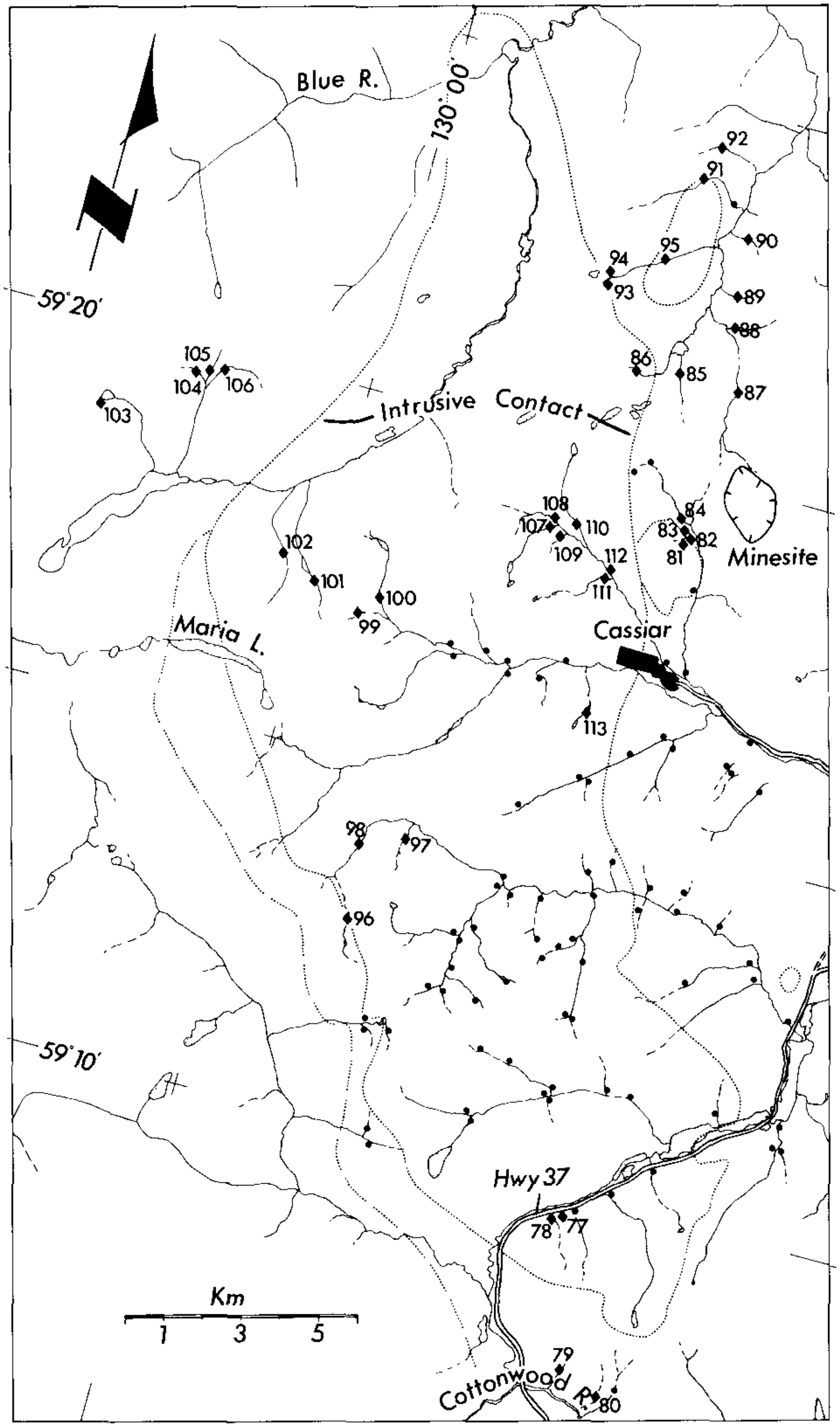

Figure 25. Silt sample location, Cassiar map-area; 1979 sample sites are shown as diamonds, 1978 sites are dots.

TABLE 2. ANALYTICAL DATA, CASSIAR SILT SAMPLES, 1979
(IN PPM)

	Ag	Cu	Pb	Zn	Co	Mn	Ni	U	Th	W	Sn	Mo
S– 77	<0.5	19	10	75	8	432	25	17	17	14	<3	7
78	0.8	13	82	127	6	1 020	13	30	75	13	7	5
79	<0.5	33	19	103	21	577	48	7	21	13	4	<1
80	0.7	26	33	113	17	533	39	5	19	9	<3	<1
81	0.7	28	10	86	13	385	18	5	22	26	5	2
82	<0.5	30	32	164	17	775	26	13	27	11	6	3
83	<0.5	34	15	120	23	672	50	23	26	9	5	5
84	1.5	50	18	368	18	1 830	115	10	16	11	<3	8
85	<0.5	56	12	172	22	1 015	40	8	20	62	8	7
86	<0.5	11	10	54	3	417	11	46	20	12	6	5
87	0.6	61	15	273	30	787	452	10	9	9	<3	3
88	0.6	51	20	270	8	323	70	6	6	11	<3	4
89	0.5	27	21	267	9	307	67	8	25	27	<3	2
90	0.6	29	17	259	8	193	79	9	9	14	<3	10
91	<0.5	29	7	56	18	497	35	14	10	14	<3	6
92	0.5	68	13	98	29	570	58	8	19	22	3	<1
93	<0.5	14	20	125	5	1 470	6	53	33	15	10	5
94*	5.5	400	6	33	2	195	2	N.A.	N.A.	93	7	17
95	<0.5	39	30	165	18	697	37	39	27	11	4	7
96	<0.5	14	18	90	7	301	20	23	26	<6	4	5
97	<0.5	18	22	102	11	856	21	30	25	<6	4	5
98	0.5	15	16	80	7	394	21	32	26	<6	4	8
99	0.6	11	15	81	6	615	13	52	26	7	6	3
100	0.8	9	14	91	8	940	27	237	20	14	4	8
101	0.9	8	9	45	5	334	7	30	19	<6	4	3
102	0.8	11	9	73	6	477	15	73	23	11	4	3
103	<0.5	42	25	139	21	943	44	24	20	<6	7	2
104	<0.5	11	8	40	5	337	8	16	20	<6	3	<1
105	0.7	7	7	49	6	273	6	25	20	<6	4	4
106	<0.5	9	9	50	5	325	6	31	47	<6	5	<1
107	<0.5	8	8	38	5	379	26	103	17	<6	4	3
108	<0.5	8	7	29	2	240	11	34	15	<6	3	3
109	0.6	7	5	10	1	112	2	8	11	<6	<3	<1
110	<0.5	8	17	61	5	479	9	34	20	12	6	2
111	0.6	6	11	36	3	213	17	44	25	12	7	6
112	<0.5	7	8	39	3	292	11	25	24	<6	6	6
113	0.6	27	17	90	8	675	35	152	51	54	7	33
$\bar{x}$ ARITH.	0.4	23.4	16.9	112.2	10.8	574	41.2	35.7	23.3	11.8	4.2	4.9
SD	0.34	17.2	13.2	82.8	7.8	362	74.6	45.4	12.7	13.4	2.4	5.4
MEDIAN	<0.5	16.0	15.0	94.0	7.0	455	25.5	24.5	20.0	<6	4.0	4.0

*All samples have <0.3 ppm Au except sample S - 94; S 94 is a soil sample and is not included in the summary statistics, it contains 0.5 per cent Bi which interferes with U, Th determination, also 5.5 ppm Au.

Analyses by Analytical Laboratory, Ministry of Energy, Mines and Petroleum Resources
Ag, Cu, Pb, Zn, Co, Ni by atomic absorption spectrometry, U, Th, W, Sn, Mo by X ray fluorescence

TABLE 3. SUMMARY STATISTICS, 1978 AND 1979, SILT SAMPLES, N = 112

[1978 Series S–1 to S–76 (*see* Geological Fieldwork, 1978, pp. 58, 59); 1979 Series S–77 to S–113, excluding S–94; samples below detection limit are assigned values of 1 ppm (0.1 ppm for Ag)]

	Ag	Cu	Pb	Zn	Co	Mn	Ni	U	W	Sn	Mo
Mean ($\bar{x}$)	0.34	21.8	23.7	153	8.9	519	32.4	31.5	11.1	5.5	11.5
Standard deviation ($\sigma n-1$)	0.22	35.0	41.0	271	5.7	285	51.4	36.2	15.2	5.8	20.9
Detection limit	0.4	2	2	2	2	10	2	2	6	3	1

It is interesting to compare geochemical patterns around Cassiar molybdenum deposit (K/Ar site 1, Fig. 24) with those at Storie molybdenum deposit (K/Ar site 2, Fig. 24). At Cassiar molybdenum deposit, molybdenum, tungsten, uranium, and to a lesser degree tin (and probably fluorine which was not determined) form a broad anomaly that is coincident with the known molybdenite mineralization and favourable porphyritic rocks. In contrast at Storie molybdenum there is a multi-element association in a more complex, zoned area of mineralization. In the centre and coincident with the sheet-like quartz feldspar porphyry dykes is a tungsten-molybdenum-tin (probably fluorine, beryllium) and lesser uranium anomaly. This is partially overlapped and surrounded by a lead, zinc, silver, copper, and manganese anomaly, probably derived largely from peripheral veins.

The main sources for lead in the map-area are major stanniferous lead-zinc-silver veins and manganiferous magnetite silver-lead veins to the south of Cassiar townsite. A secondary source for lead is rocks from the top of the Kechika succession or basal McDame. Main sources for zinc and silver are Kechika black shales (and possibly also McDame black shales) as well as skarn deposits along the eastern contact of the Troutline Creek quartz monzonite. Cobalt concentration coincides with pyrrhotite development in skarn zones. Nickel has a high concentration (>70 ppm) in Kechika black shales. Maximum cobalt and nickel are found in silts from a creek cutting through ultrabasic rocks north of Cassiar minesite.

Copper is anomalously low throughout the Troutline Creek quartz monzonite but has slight concentration in skarn deposits, Kechika black shale, and in areas with pyrrhotite disseminations and lenses in hornfels of the Good Hope Group. The main source for copper in the Cassiar map-area is Sylvester volcanic rocks.

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The cooperation of Cassiar Asbestos Corporation Limited and Shell Canada Resources Limited is acknowledged. Peter Mustard ably assisted the writer in the field.

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BLUE RIVER GEOCHEMICAL ANOMALIES
(104P/14)

By A. Panteleyev

The 1978 Federal/Provincial Uranium Reconnaissance Program (URP) geochemical survey in McDame map-area, NTS 104P (Geological Survey of Canada, Open File Report 562) identified a significant stream sediment molybdenum-silver-zinc-(lead) anomaly near Blue River, approximately 5 kilometres west of Highway 37.

The area is covered extensively by glacial and fluvioglacial debris. Bedrock is exposed only where the Blue River, some of the larger tributary creeks, and a few meltwater channels have deeply incised the cover. Bedrocks are sedimentary rocks that appear to be part of the Cambro-Ordovician Kechika Group. Some Tertiary outliers (Tv on Fig. 26) are seen as flat-lying columnar flows. Kechika rocks form a folded sequence of calcareous shale, black shale, siltstone, and black chert.

In Blue River area drainage patterns are poorly defined and swamps, ponds, and kettle lakes are abundant. Only a few streams have any persistent length or flow. Carbonate-rich rocks in the area give rise to mildly alkaline waters (pH 8.2 to 8.3). Calcareous deposits in seepage areas and marl deposits in ponds and lakes are common.

Eight representative specimens of outcroppings along the traverse route (locations shown as X along the dashed line on Fig. 26) were found to have no extraordinary metal content other than in two specimens with 3.9 and 2.4 ppm silver and one with 104 ppm zinc. Molybdenum content in all hand specimens was determined to be <2 ppm. Therefore, the highly anomalous molybdenum-silver-zinc-lead concentrations in stream sediments appear on the basis of the abundance of black nonorganic sediment to be related to recessive-weathering Kechika black shales.

The following data illustrate the geochemical response of stream sediments derived from Kechika rocks in Blue River and Cassiar areas.

STREAM SEDIMENT GEOCHEMICAL DATA, KECHIKA SOURCE ROCKS
McDAME MAP–AREA, NTS 104P
(IN PPM)

Sample No.	Ag	Cu	Pb	Zn	Co	Mn	Ni	U	W	Mo
Blue River area, URP 1978 Survey (GSC Open File 562), *see* Figure 26										
781048	0.2*	34	24*	500†	6	215	60	12.2	2	25†
781049	0.8†	42	6	176*	8	480	41	3.0	2	15†
781050	0.1	4	2	38	5	565	15	1.4	2	1
Blue River area, 1979 (this report), *see* Figure 26										
S–114	0.6*	20	4	70	5	2 120*	30	7	<6	1
S–115	<0.5	8	6	43	7	848	24	2	<6	1
S–116	1.7†	46	10	193*	11	573	58	7	14*	20†
Cassiar map-area, mean of 13 samples (this report)										
composite	0.5*	39	29*	496†	12	337	88	7	<6	6*

*>95 percentile and †>99 percentile values of 802 samples in 104P map-area reported by URP.

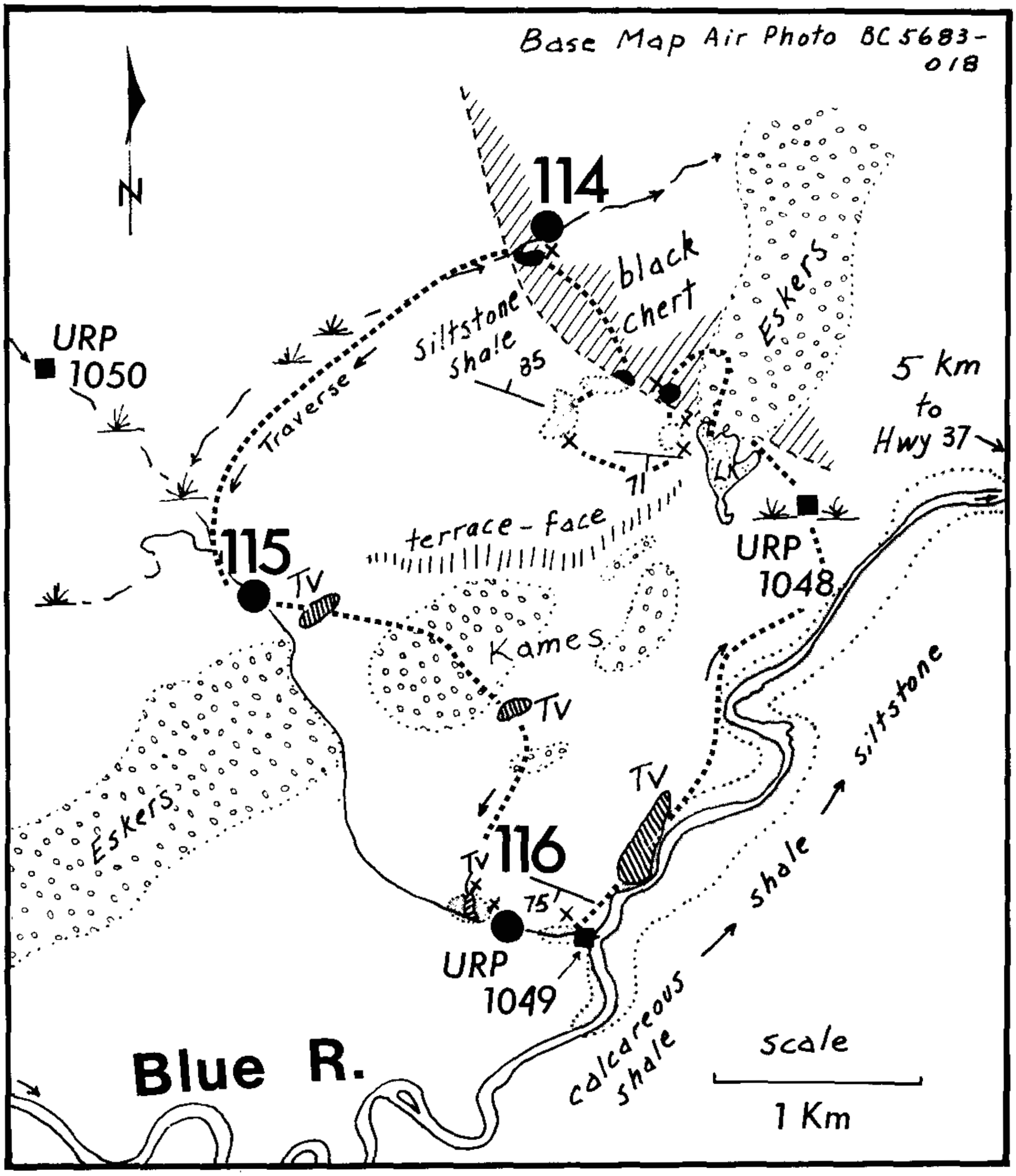

Figure 26. Reconnaissance traverse, Blue River (104P/14), Uranium Reconnaissance Program geochemical anomalies.

COAL INVESTIGATIONS

ELK VALLEY COALFIELD

(82J/2)

By David E. Pearson and D. A. Grieve

INTRODUCTION

Systematic 1:7 000 scale mapping of Elk Valley Coalfield started in the 1979 field season on the Greenhills Range and adjacent areas. Kaiser Resources Ltd. has freehold rights to the southern portion of the area and Fording Coal Limited holds the northern part under licence. During the latter part of the field season coal sampling and 1:50 000 scale mapping of the entire Elk Valley Coalfield was undertaken to produce a preliminary rank map and define major tectonic features of the coalfield.

GREENHILLS RANGE

South Greenhills Range is structurally complicated by gentle folding, thrust faulting, and late gravity (normal) faulting. Despite these complications, thick seams of coal exist in attractive open-pit mining situations.

The basal seam, directly overlying the basal sandstone in this area, has a mean reflectance ($\bar{R}_o$ max.) of 1.14 per cent. All other seams in the area are therefore essentially high-volatile bituminous coals. In the core of the Greenhills syncline the highest exposed coal seams have vitrinite reflectances of 0.88 per cent and 0.66 per cent. The lower seams are inertinite rich and the upper seams are bright and vitrinite rich, as is typical of the East Kootenay Coalfields (Cameron, 1972; Pearson and Grieve, 1978). However, the overlying Elk member is not exposed on South Greenhills.

A late gravity fault, here referred to as the Greenhills fault, downthrows the western part of the coal measures about 100 metres on the Kaiser property. Its sinuous trace is shown on Figure 27. At the south end of the property at 'A,' the fault is essentially vertical; to the east of the triangular-shaped outcrop pattern of the upper seams, the fault surface dips westerly at 25 degrees to 35 degrees, and actually displaces the axial trace of the small syncline about 170 metres. The fault therefore appears to postdate the syncline, rather than being its cause. Further to the north the fault again steepens and appears to join the Fording fault, which also downthrows to the west.

Between the Greenhills Forest Service lookout and the Fording–Kaiser property boundary approximately 100 metres of overlying Elk member is exposed.

ELK VALLEY COALFIELD

During the latter part of the field season 1:50 000 scale reconnaissance mapping and sampling were done to provide data for a coal rank distribution map of the Elk Valley Coalfield (Fig. 28). Despite this considerable

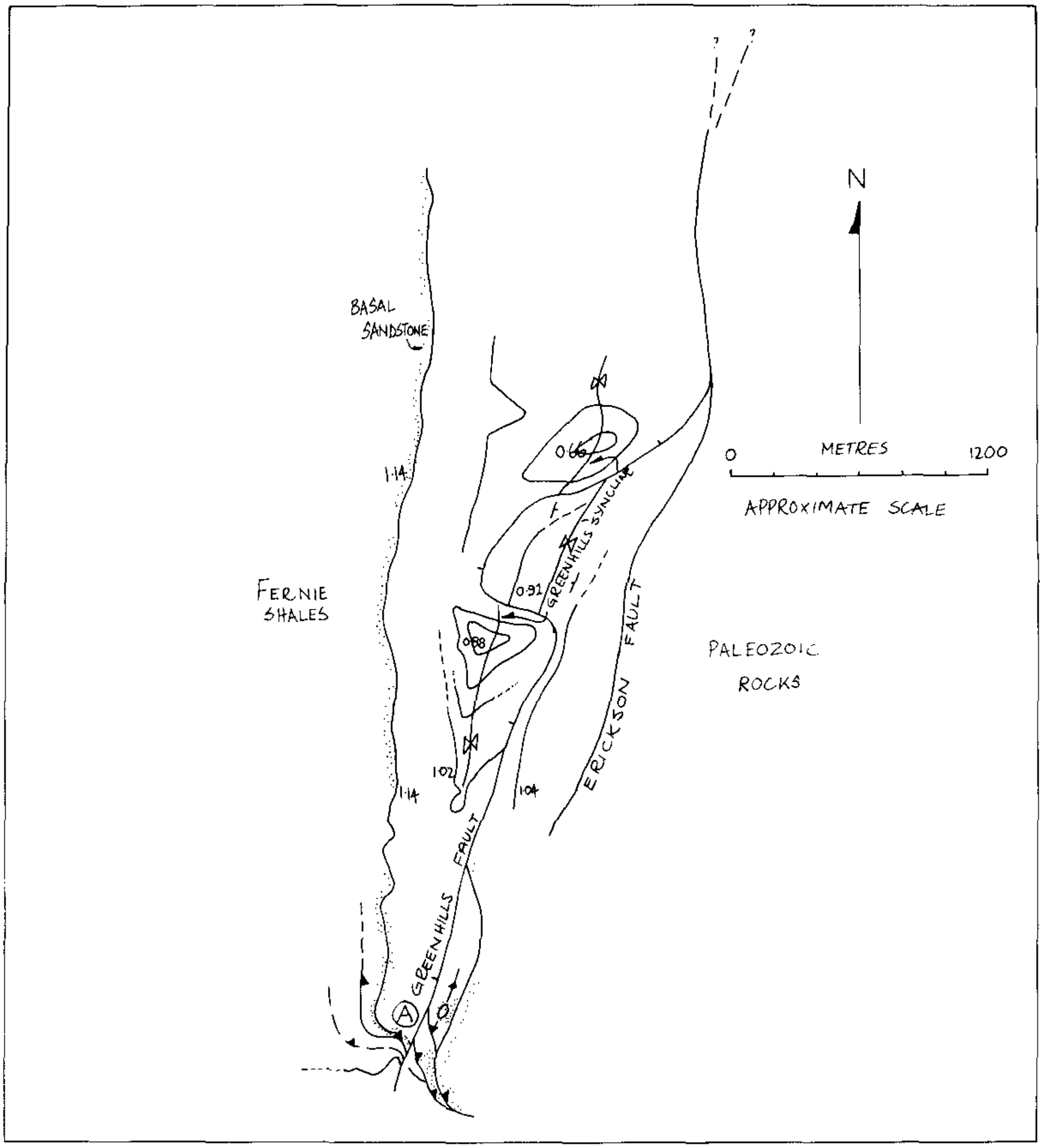

Figure 27. Geological sketch map of south Greenhills (Kaiser Resources') property, showing main structural elements and some rank data.

field effort and subsequent rank analysis on over 100 coal samples some major structural problems remain unresolved. The rank distribution shown on Figure 28 is nevertheless reasonably accurate.

Analysis of the rank map reveals that considerable resources of high-volatile coal ($\bar{R}_o$ max. <1.12 per cent) are present in this coalfield, with only a small amount of low-volatile coal ($\bar{R}_o$ max. >1.5 per cent).

A description of some of the main structures of the coalfield follows.

ALEXANDER CREEK SYNCLINE

This syncline, which is also known locally as the Fording syncline, is named for a south-flowing creek in the Crowsnest Pass (Dahlstrom, *et al.*, 1962). The fold appears to be continuous along the length of the coalfield. Careful mapping of the base of the Elk member and occurrences of the overlying quartzite cobble-bearing Cadomin Formation conglomerate reveals a number of plunge depressions and culminations along the axis of this structure, as shown on Figures 28 and 29. In this paper we define the base of the Elk member as the *first appearance* of needle coal, a coal type actually rich in the liptite maceral alginite. Inasmuch as algal coal deposition was probably dependent on specific environmental conditions, this definition of the base of the Elk member will probably prove to be generally applicable.

The east limb of the syncline is structurally thickened between Eagle Mountain and Ewin Pass by the Ewin Pass fault. Since the fault repeats and thickens the succession it is interpreted as a thrust fault. Between Line Creek and Ewin Pass, coals with a rank of $\bar{R}_o$ max. = 1.05 per cent overlie Elk coals with a rank of 0.71 per cent $\bar{R}_o$ max. Further north, however, at 2 440 metres on Ewin Pass Ridge (section D on Fig. 28), the rank of the base of the Elk member is 0.83 per cent. This contrasts with rank of the base of the Elk on Burnt Ridge, north Line Creek, and east of the Cadomin conglomerate in the Fording Bridge depression, which have vitrinite reflectances of about 0.70 per cent despite a lower elevation of 2 070 metres. We interpret this as evidence of normal movement on the Ewin Pass thrust, as normal faulting in the East Kootenay Coalfields occurred after coal ranks had been achieved (Pearson and Grieve, 1979). The differences in rank between the west and east sides of the syncline are very small in the vicinity of Eagle Mountain and we interpret this to imply aggregate movement approaching zero. Despite this sag effect, produced by the relative amounts of normal movement on the fault, we believe the Fording Bridge depression is primarily related to the syncline and was later emphasized by the normal movement.

In general, there is a northward increase in the rank of the basal seam exposed along the east side of the Alexander Creek syncline, from 1.2 per cent in the vicinity of Ewin Pass to 1.3 per cent in the Chauncey-Todhunter; 1.4 per cent at Henretta Creek to 1.5 per cent in the Mount Veits–Weary Ridge area. It is therefore anomalous to find only high-volatile coal ($\bar{R}_o$ <1.12 per cent) in the area north of Cadorna Creek. [Graham, *et al.* (1977) report only two of 66 reflectance analyses in this area greater than 1.12 per cent.] For this reason we speculate that a normal fault with about 400 to 500 metres of downthrow to the west separates these areas at the north end of the coalfield.

FORDING MOUNTAIN ANTICLINE

The prominent scarp slope of Greenhills Range defines the east limb of the Fording Mountain anticline. In the vicinity of the Greenhills lookout a pronounced change in strike occurs in the lower portions of the succession, so that individual beds dip shallowly to the north which corresponds with the fold hinge. The west limb crops out between Bingay Creek and Forsyth Creek on the west bank of the Elk River, where

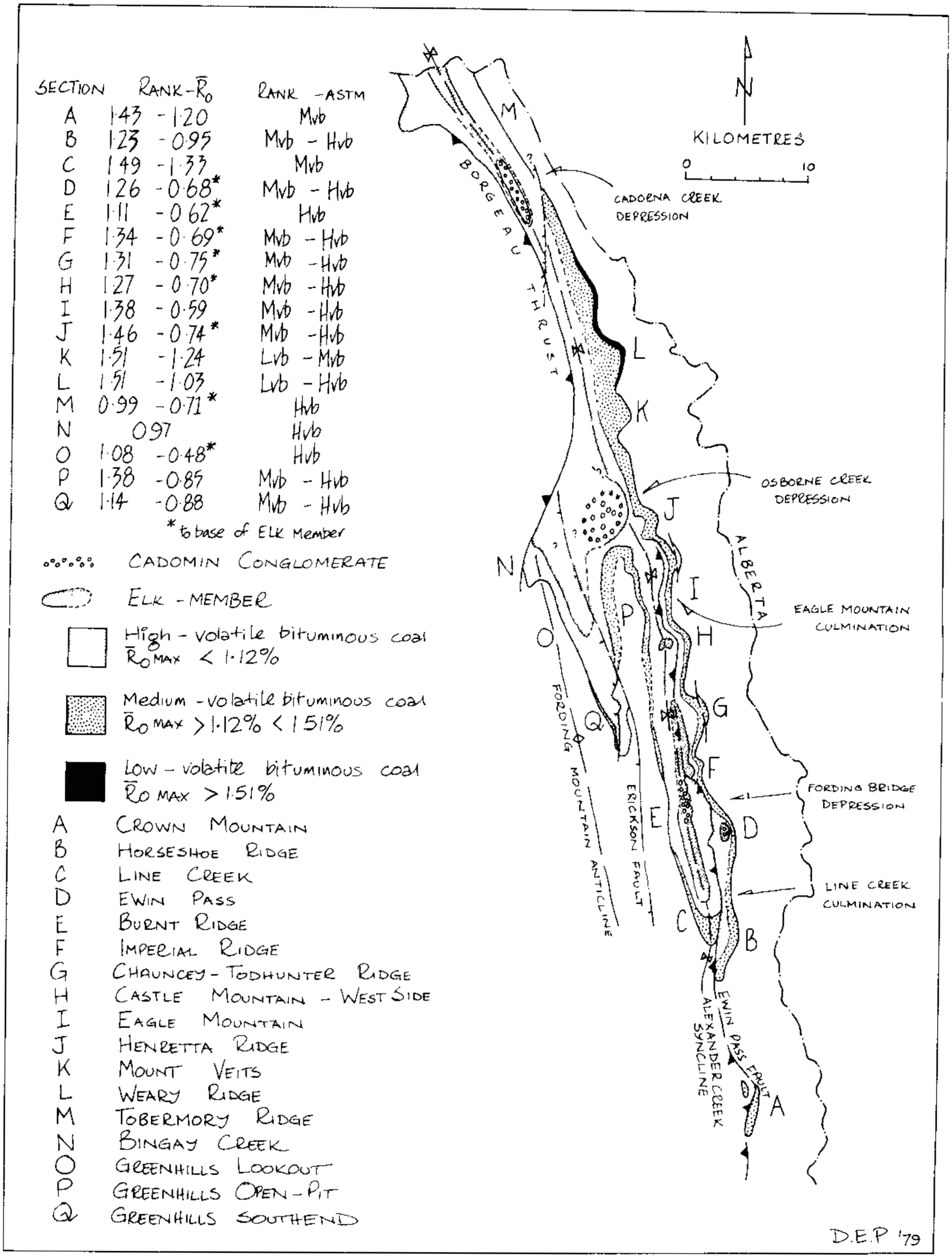

Figure 28. Distribution of low, medium, and high-volatile bituminous coals over Elk Valley Coalfield. Ranges in vitrinite reflectance data at specific locations represent coals overlying the basal sandstone to either the highest exposed coal in that section or to the first Elk member coal in that section.

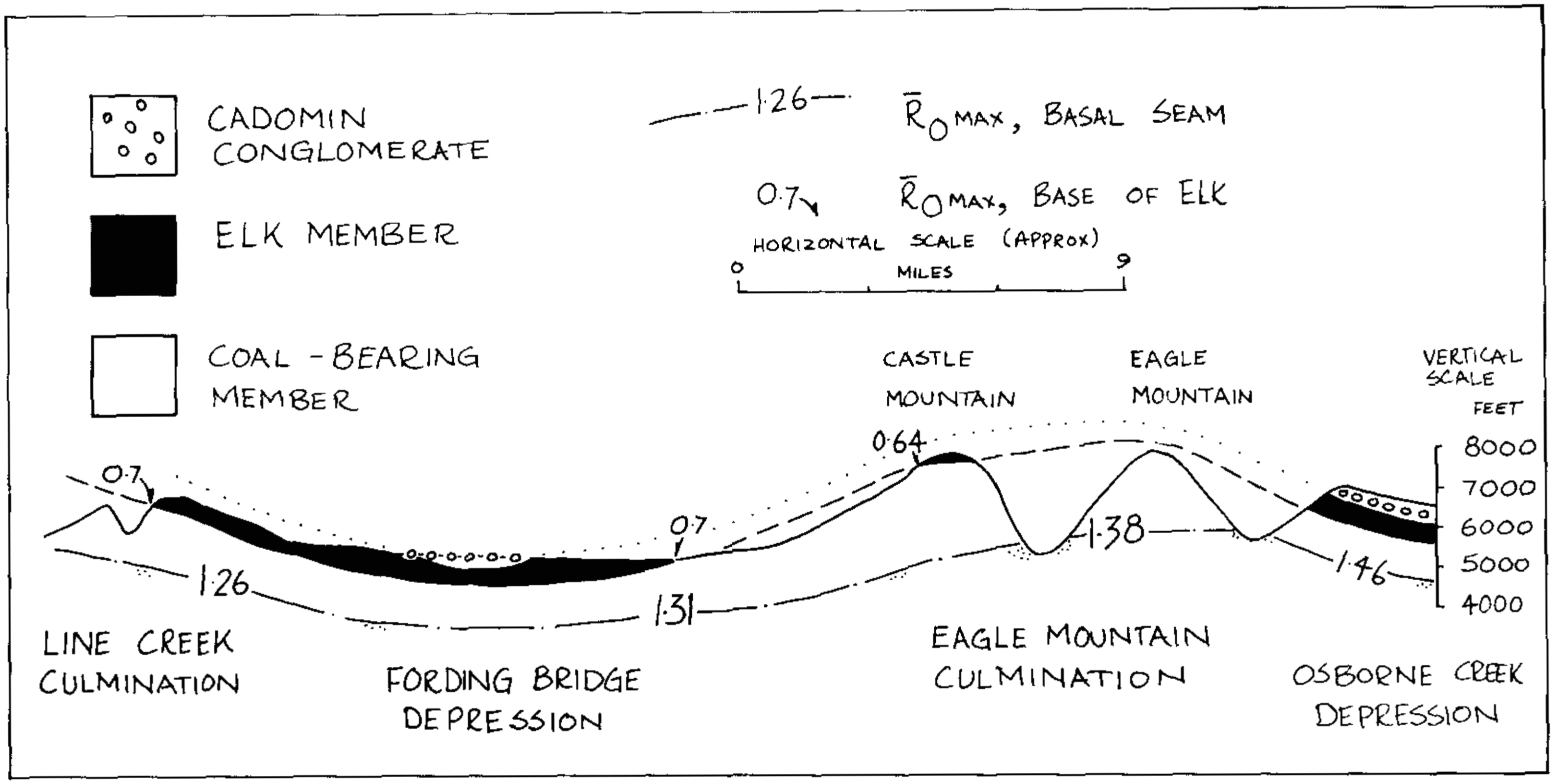

Figure 29. Geological cross-section along the axis of the Alexander Creek syncline, showing in diagrammatic form, plunge depression and culminations and some rank data.

coal measures are exposed in a tight northerly plunging syncline. The numerous resistance sandstone units exposed at this locale represent the lower part of the succession. The single coal sample taken from an old exploration trench here is of high-volatile rank ($\bar{R}_o$ max. = 0.97 per cent).

ERICKSON FAULT

The trace of the Erickson fault, which juxtaposes coal-bearing Kootenay Formation with Paleozoic carbonates along the east margin of Kaiser Resources' Greenhills property, is difficult to follow northward because of poor exposure. The rank of the basal seam in the Fording Greenhills open pit is, however, 1.38 per cent $\bar{R}_o$, similar to the highest rank from Eagle Mountain (Clode pit). Both are distinctly higher than the 1.08 per cent $\bar{R}_o$ recorded from the basal seam on the scarp face of Greenhills, 4 000 metres west of the Greenhills open pit. With an average rank gradient for this area of 0.09 per cent R_o per 100 metres, such a reflectance disparity suggests that 330 metres downthrow to the west for this fault. Its trace is apparently west of the Greenhills pit, but east of the ridge crest.

ACKNOWLEDGMENTS

It is a pleasure to record our thanks to Mickey Welder and Bob Janowicz, our co-workers during the summer. Company geologists working in the area during the summer are thanked for their counsel and hospitality.

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HAT CREEK BOCANNE–BUCHITE

(92I/2E, 13E)

By B. N. Church

The term bocanne-buchite has been aptly applied to high temperature metamorphic rocks and pseudovolcanic rocks above No. 1 Coal Reserve at Hat Creek. According to Crickmay (1967) bocanne is the process of autogenous combustion of carbonaceous shale or coal-bearing strata, and buchite, by glossary definition, is a partly fused shale or clay resulting from intense thermal metamorphism.

It was noted by Church (1975, p. G110) that some of the coal at Hat Creek appeared to be burnt, evidence of this being yellow and reddish altered rocks and soil overlying the Hat Creek Coal Formation. This observation was subsequently confirmed by British Columbia Hydro and Power Authority during excavation of a large trench for bulk sampling purposes.

At the beginning of excavations hard clinker-like material was encountered. The layered structure of this material, although somewhat rumpled and deformed, proved to be continuous with bedd ng planes in the adjacent coal. A sharp line visible on the walls of the trench cuts sinuously across the strata marking the boundary of the burnt zone.

The extent of the burnt zone has been established by drilling. The thickest section, about 75 metres deep, underlies the Dry Lake gulch near the base of the coal measures. Other profiles of the burnt zone give an average thickness of about 25 metres, although thinning and some discontinuity is apparent. The present area of the burnt zone amounting to about 3.5 square kilometres is evidently only an erosional remnant of a once much broader area of altered rocks. Similar reddish rocks and soils can also be seen 8.5 kilometres to the south near the No. 2 Coal Reserve.

A rock described as a volcanic dyke by MacKay (1925, plate opposite p. A320) on the south slope of Dry Lake gulch was re-examined and found to be metamorphic in origin, reconstituted by fusion and recrystallization. In thin section a typical sample resembles volcanic agglomerate consisting of welded scoriaceous clasts composed of numerous microlites of calcic plagioclase, mostly 0.2 to 0.6 millimetres in length, and interstitial opaque oxides and glass. However, chemical analysis shows this to be unlike normal volcanic rock displaying unusual alumina and iron oxide enrichment with overall composition more like the ash residue obtained from burn tests on Hat Creek coal (*see* Table 1, Church, *et al.*, 1979, p. 1886). Norm calculations indicating an abundance of anorthite, cordierite, hematite, and quartz agree with X-ray diffraction results.

Exposed locally on the walls of the bulk sample trench are peculiar lenses of vesicular hematite and magnetite interlayered with baked shales resembling accumulations characteristic of volcanic spatter. In particular, the rootless lava lenses of hematite and magnetite, which were probably derived from fused siderite-rich stumps and logs in the bocanne, bear striking similarity to the iron ore lavas of the Laco Volcano, Chile. Among the numerous exotic minerals identified in the baked shales are tridymite, cristobalite, cordierite, corundum, mullite, clinopyroxene, anorthite, pseudobrookite, siderite, barite, ferroan dolomite, hoegbomite or spinel, and woodhouseitte-hinsdalite±goyozite or gorceixite.

The thermal effect is also manifest in the physical characteristics of the coal. For example, fresh samples taken from the bulk sample trench near the burnt zone have a peculiar appearance, displaying a hard clean

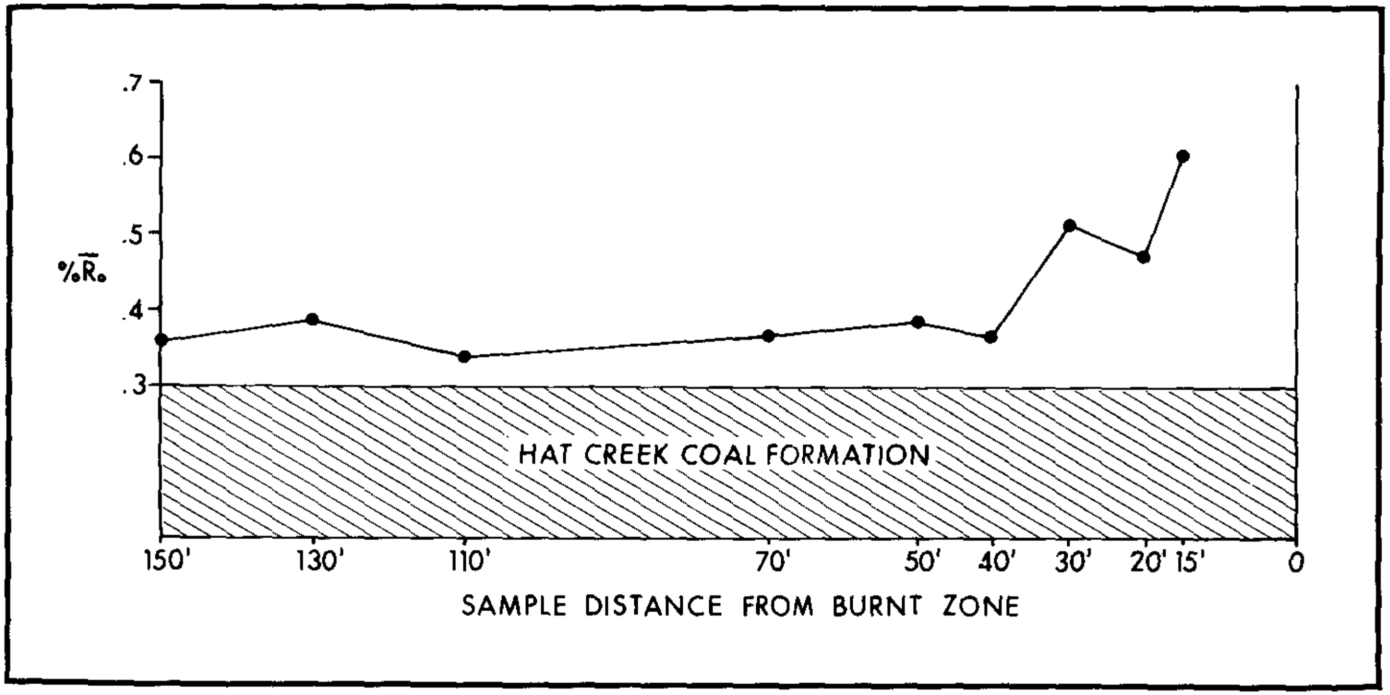

Figure 30. Plot showing increase in vitrinite reflectance in *Hat Creek Coal Formation* approaching burnt zone contact.

surface with a waxy lustre and conchoidal fracture not typical of low rank coal from this area. Determination of the coalification level of this material gives an $\bar{R}_o$ value of 0.42 per cent. A more representative collection of coal samples, taken at intervals across gently dipping strata up to the burnt zone, shows significant increase in $\bar{R}_o$ values from an average level of approximately 0.36 per cent to 0.61 per cent (Fig. 30).

The temperature of the bocanne estimated from combustion tests was probably in the range 1 330 to 1 400 degrees celcius and possibly higher (*see* Table 1, Church, *et al.*, 1979, p. 1886). Owing to the insulating properties of coal and the anticipated short duration of the combustion episode, temperature in adjacent unburnt coal beds probably did not exceed a few hundred degrees. Indeed it appears that the thermal effect did not penetrate the coal measures laterally more than about 12 metres (40 feet) from the combustion interface as viewed in the bulk sample trench.

The age of the bocanne appears to be interglacial. The burnt zone is covered by till and glacial alluvium, proving a minimum age of at least 10 000 years, the time of retreat of last glaciation. Maximum age, shown by a polarity test of magnetite-rich lenses in the burnt zone, is evidently less than 700 000 years, the time of the last major magnetic reversal.

The phenomena of spontaneous combustion of low rank coal is widely known and it is suspected to be the ultimate cause of the Hat Creek bocanne. Tests have demonstrated that loose stacking of the coal promotes oxidation. Within several days temperatures can rise sharply causing ignition. It seems most likely that the original fire at Hat Creek may have begun in this manner in talus accumulations adjacent the coal measures.

ACKNOWLEDGMENTS

Much appreciation is extended to A. Matheson and C. Kenyon for assistance in collecting samples and J. Munaro for performing reflectance measurements. Thanks are also owing J. Kwong for mineral identification by X-ray diffraction.

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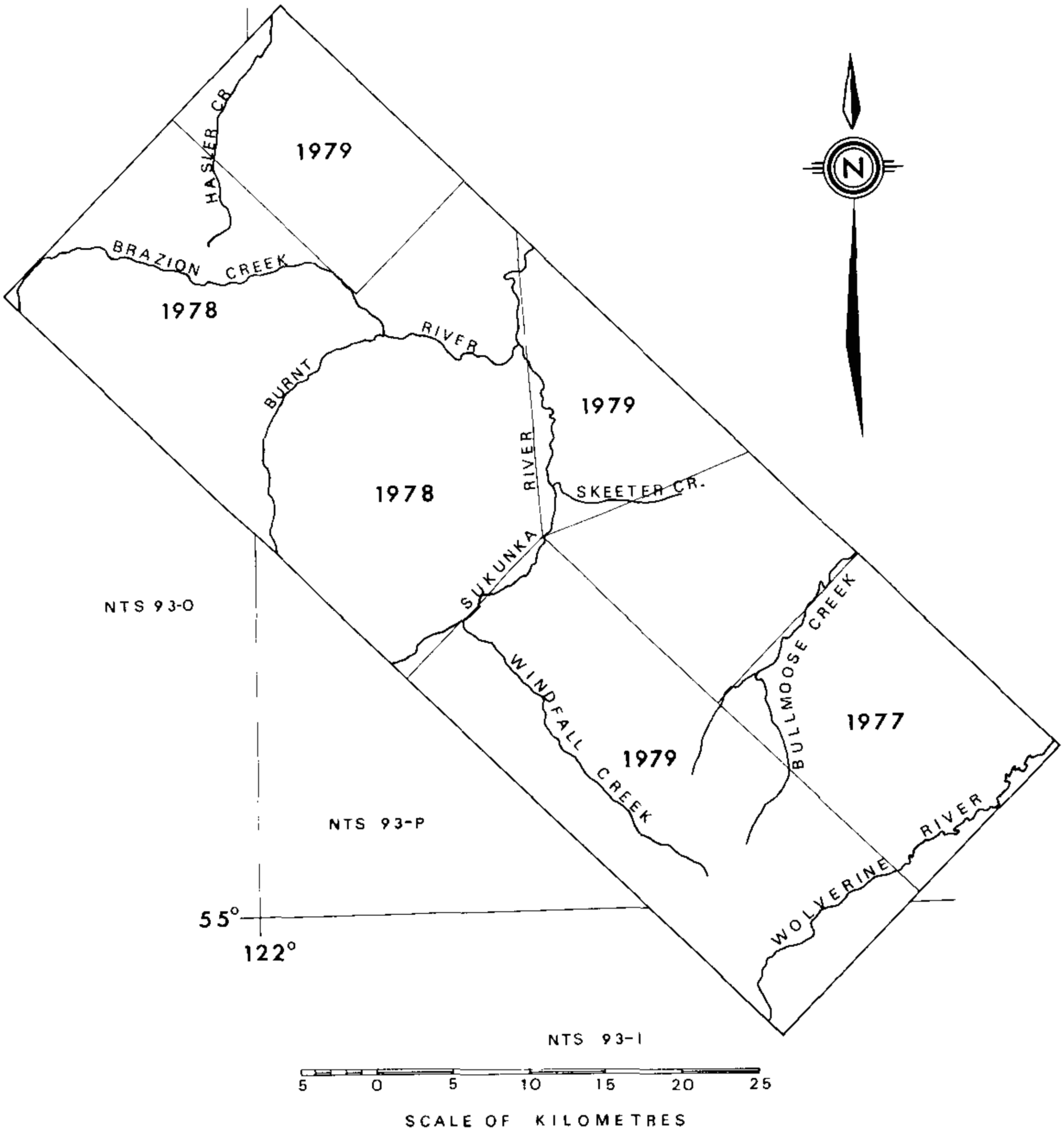

Figure 31. Wolverine—Hasler map-area, showing areas by year mapped.

WOLVERINE–HASLER MAP–AREA

(93I/14; 93O/8; 93P/3, 4, 5)

By R. D. Gilchrist

1979 was the final year of a three-year mapping project to define the coal measures of the central portion of the Peace River Coalfield. Originally only the Bullhead and Fort St. John Groups were intended to be mapped, but discovery of the development of clean, thick coal seams below the Bullhead encouraged the author to include beds of the Upper Minnes Group in this study.

The total map-area is rectangular, 26 by 70 kilometres oriented northwest-southeast, approximating the regional strike. A major thrust bringing up older rocks over the Minnes Group forms the southwest boundary; the Fort St. John/Smoky Group contact is the northeast boundary. Geographically the southeast boundary is the Wolverine River while a line bearing northeast-southwest and lying 5 kilometres southeast of Mount Le Hudette forms the northwest boundary. Areas and the year they were mapped are shown on the accompanying map (Fig. 31).

A preliminary map at a scale of 1:50 000 is in preparation and will be available in early 1980.

MINNES GROUP

The very thick resistant sandstone unit outcropping on the Sukunka road just west of Windfall Creek and extending approximately 10 kilometres south is believed to belong to the Lower Minnes Group (perhaps equivalent to the Monteith Formation), not the Cadomin as some workers had previously concluded.

The thick coals found on the north salient of Mount Merrick are in strata believed to be equivalent to Hughes' Dresser Formation, not his Brenot Formation as previously stated (*Geological Fieldwork, 1978*). A complete description of sections measured in the Upper Minnes Group, their correlation and nomenclature is in preparation.

CADOMIN FORMATION

Outcrops examined on the Manalta property west of Mount Suprenant showed considerable variation in the character of the formation. Composition and texture vary rapidly over short distances and are often quite unlike the rather uniform character the formation displays in the rest of the map-area.

At the most southerly part of the Hasler Forestry Road, two thick conglomeratic units outcrop within a stratigraphic interval of approximately 50 metres. Both resemble the Cadomin in character but unfortunately outcrop is not extensive enough to see if one or both of the beds have lateral continuity.

A sequence of Cadomin-Gething strata outcropping on the northeast side of Mount Merrick illustrates a similar case. Again there are two thick (6 to 7 metres) conglomerates approximately 175 metres stratigraphically apart. The exception is that here lateral exposure exists and the upper conglomerate is shown to change lithology rapidly to a medium-grained sandy unit, whereas the lower unit outcrops as a conglomerate over the several kilometres it is exposed. Numerous other examples of large conglomerates in the Lower Gething are found further south.

GETHING FORMATION

Generally the Gething thickens somewhat northward from Bullmoose Mountain (350 metres) to the headwaters of Hasler Creek where a composite section has established a thickness of 400 metres. The character changes to the north as well; local facies changes are far more rapid than in the Bullmoose area, making correlations difficult over relatively short distances. Although good coal seam development exists in places they do not have significant lateral continuity. Also, no evidence has been found of the marine tongues that exist in the Upper Gething in the Bullmoose area.

MOOSEBAR FORMATION

North of Bullmoose Mountain a new facies unit appears between the nonmarine coal-bearing Gething strata and the rather uniform fissile mudstones that typify the basal Moosebar elsewhere. This new unit consists mainly of sandstones and siltstones and appears to be a shallow marine sequence; perhaps representing small regressive stages in the major Moosebar transgression. It is known to reach a thickness of 230 metres in the vicinity of the headwaters of Goodrich Creek but thins southward and disappears at Bullmoose Mountain.

COMMOTION FORMATION, GATES MEMBER

Although the total thickness of the Gates member remains relatively constant over the map-area, the major coals known south of Bullmoose Mountain are represented by a few thin, poorly developed seams northward. However, major conglomerate and sand units are still common in the northern part of the map-area, especially in the lower part of the member. In the area just south of Mount Linklater an especially clean sand and conglomeratic unit was noted in the basal Gates although a few minor coal seams lie stratigraphically below it.

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COAL RANK DISTRIBUTION WITHIN THE BLUESKY–GETHING STRATIGRAPHIC HORIZON OF NORTHEASTERN BRITISH COLUMBIA

(93 I, O, and P)

By R. H. Karst and G. V. White

The top of the Gething Formation is one of the more important formational picks routinely performed by the oil and gas industry during their exploratory and development drilling as this horizon is very continuous through northeastern British Columbia and much of northern Alberta. The name Bluesky is given to the rock unit which occupies this stratigraphic level, namely a sandstone-conglomerate unit of marine origin which separates the continental coal measures of the Gething Formation from the overlying marine shales of the Moosebar Formation (*see* Fig. 32). The Bluesky is commonly glauconitic and has a variable thickness (0 to 50 metres) over relatively short distances and most likely represents shoreline deposition of the rapidly transgressing Clearwater Sea from the north. The Bluesky-Gething is an important petroleum producer in the Fort St. John area.

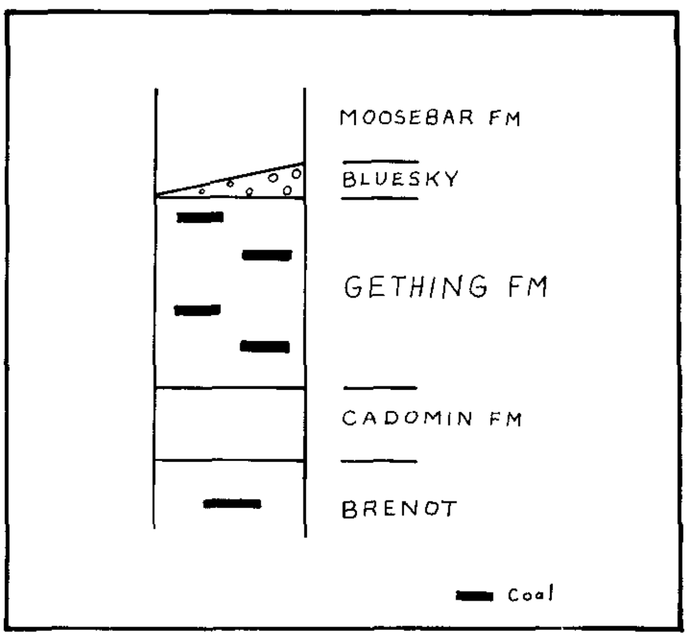

Figure 32. Columnar section, northeast British Columbia.

Coalification is mainly a result of temperature to which the host sedimentary rocks are exposed. In turn, this temperature is determined by the geothermal gradient and the depth of subsidence. Coal rank is therefore a very sensitive indicator of these temperatures. A coal rank map of a specific stratigraphic horizon is particularly useful in portraying regional variations in geothermal heat-flow, tectonism, and post-depositional basin history. Any coal rank variation due to differences in the stratigraphic level of the coal occurrences is eliminated because only one stratigraphic horizon is sampled. This effectively screens out the back-

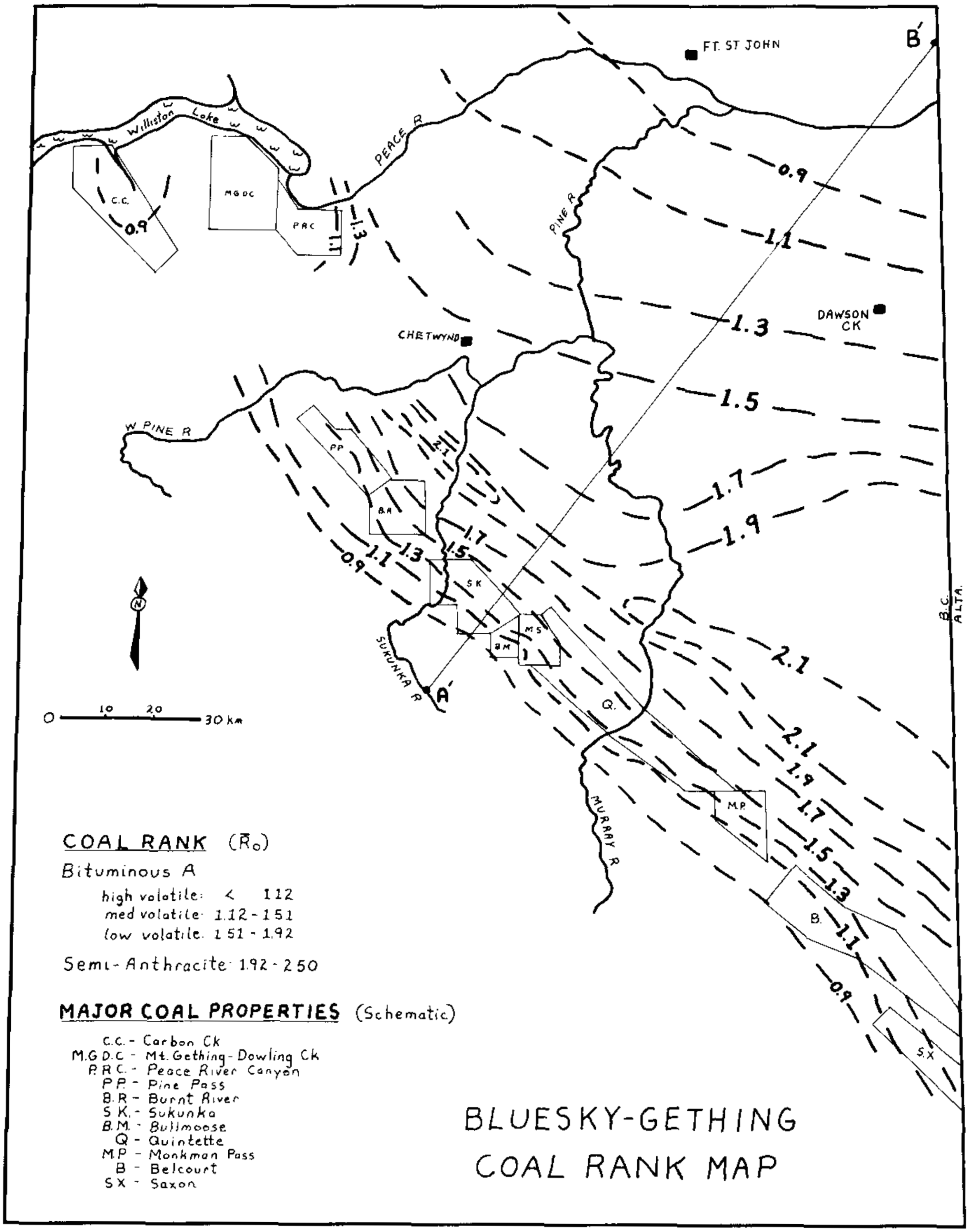

Figure 33. Preliminary coal rank map, northeast British Columbia.

ground noise when interpreting the resulting coal rank map. The top of the Gething Formation was chosen as the specific stratigraphic horizon of this study because of its widespread occurrence and relative ease of identification on oil and gas geophysical logs.

The coal samples collected for this study come from three sources: petroleum well dril bit cuttings; coal industry diamond-drill core; and surface outcrop samples. The first coal below the Bluesky-Gething horizon was sampled in most instances. In a few locations there was no recognizable Gething-Moosebar contact (that is, Carbon Creek and Burnt River areas) and in these cases the stratigraphically highest Gething coal seam was used. All samples had their coal rank determined by petrographic means using the mean-maximum reflectance of vitrinite technique. This method enabled rank determinations to be made on relatively small samples such as the drill bit cuttings. It also had the advantage of not being affected by oxidation of coal from outcrop samples. The values obtained were plotted on a map and contoured at an interval of 0.20 per cent $\bar{R}_o$.

RESULTS

Figure 33 is a preliminary rank map resulting from the 90 coal samples examined to date. No contouring was done between Williston Lake and the West Pine River because of inadequate sample control, but will be added as soon as petroleum drilling for this area is performed.

There are three observations which can be made from the preliminary rank map. They are:

(1) Coal rank increases slowly but steadily from the undisturbed plains region of northeastern British Columbia to the structural margin of the foothills belt (*see* Fig. 34).

This phenomena is due to the geometry of the sedimentary basin and its resultant increase in depth of cover encountered by a specific stratigraphic horizon. This increase in coal rank westward has been well documented in the Alberta portion of the western Canada sedimentary basin.

(2) The increase in coal rank accelerates at the first sign of tectonism and quickly peaks in the deep subsurface of the northeastern boundary of the foothills belt.

The increase in coal rank caused by tectonism can be seen on Figure 34 by the upward steepening of the coal rank profile. The maximum rank increase due to tectonism along this particular cross-section is indicated by the graph to be approximately 0.20 per cent $\bar{R}_o$.

Coal rank reaches a maximum at the very front of the structural margin. The piling-on effect of crustal shortening (stacked thrusts), the frictional heat of rock deformation and failure, and the relative deep position within the sedimentary wedge (before tectonism) would all contribute to these high coal rank values.

(3) After reaching its peak at the structural front, coal rank decreases sharply in a southwesterly direction within the foothills belt itself.

The immediate implication is that much of the coalification undergone by these coals is post-orogenic, or in other words, after tectonism has placed them at their present position. However, this does not explain the severeness of the rank decrease into the foothills belt. This phenomenon was not expected and its reasons can only be hypothesized at this time.

One possible explanation would be that part of the Cordilleran Orogeny (Columbian) had raised the western area of the present foothills belt to a relatively high position at the end of the Early Cretaceous. As a consequence it was not subject to Upper Cretaceous sedimentation and may have actually been the source for some of the Upper Cretaceous sedimentary rocks located to the north-east. This would keep the extreme southwestern Gething coals from being as deeply buried as their northeastern counterparts.

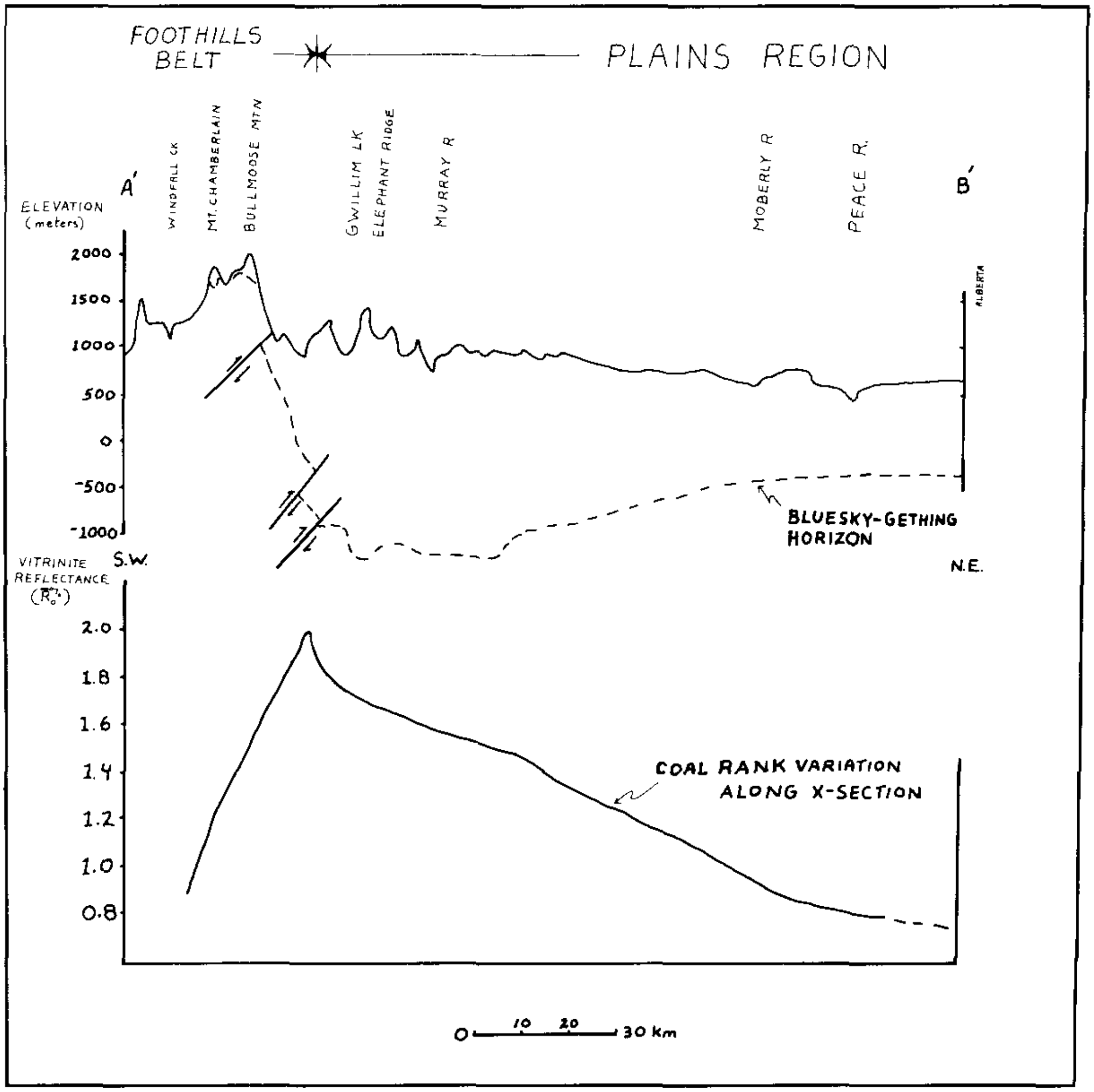

Figure 34. Coal rank variation along cross-section.

Another possible explanation would be that normal faulting is responsible for the rapid subsidence which created the tremendous thickening of Cretaceous sedimentary rocks in a westerly direction. This thickening of Cretaceous strata is observed along the entire western margin of the western Canada sedimentary basin. The sudden drop in coal rank westward would signify that the normal fault zone has been crossed.

Doubtless there are other possible explanations for the rapid drop in coal rank but the preliminary nature of this study does not lend itself to further discussion.

ECONOMIC IMPLICATIONS

The rank map can be used to delineate areas of semi-anthracite and bituminous coal of low, medium, and high-volatile rank within the Upper Gething Formation. Commotion Formation coals will have correspondingly lower ranks than the indicated Gething coals because of their higher stratigraphic position.

A $\bar{R}_o$ of 1.3 per cent is generally regarded as being too high for oil occurrence. That means that any oil which was present in a reservoir rock subjected to these temperatures and pressures would be volatilized into natural gas. Therefore the rank map can be used to delineate those areas where oil can occur within the Bluesky-Gething zone from a viewpoint of organic metamorphism. Predictions of suitability regarding other potential oil reservoir horizons can be made if allowances are made for higher or lower stratigraphic effects. It is apparent that most of the Elmworth-Deep Basin extension into British Columbia exceeds the 1.3 per cent $\bar{R}_o$ rank line and therefore could only contain natural gas, with the oil potential being limited to the northeastern fringe of the Elmworth play and at stratigraphic levels higher than the Bluesky-Gething.

The observation that coal rank declines once into the foothills belt enhances the likelihood that pre-Cadomin coals (that is, Minnes Group) will have coal ranks which are within acceptable coking limits. It also makes it technically possible (at least from a coal rank point of view) that oil could exist within some Lower Cretaceous rocks of the foothills belt.

ACKNOWLEDGMENTS

We wish to thank Heidi Schwab for measuring some of the $\bar{R}_o$ values reported here.

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STRUCTURAL MATERIAL INVESTIGATION

TEXADA ISLAND LIMESTONE

By Z. D. Hora and K. J. Sharman

Detailed geological mapping of limestone deposits near Davie Bay and Anderson Bay on Texada Island was carried on during June, July, and August of 1979.

The Davie Bay deposit is an elongate northwest-southeast trending body of grey fine to cryptocrystalline limestone with minor dolomite and is exposed on the southwestern slopes of Texada Island above Davie and Mouat Bays. In 1955 and 1956 British Columbia Cement Company Limited (now owned by Genstar Limited) did some exploration work on its land holdings covering the southeastern part of the deposit. Land in the central part of the limestone body has been held by Lafarge Canada Ltd.'s claims since 1970 and an extensive drilling program was carried out between 1972 and 1976.

Areas with best bedrock exposures are mainly in the southeastern end and along the northeastern edge of the deposit, mainly on the steeper slopes. The middle of the limestone body has small ridges (or ribs) of limestone separated by overburden while the southwest side and the northwest part are extensively covered. Most of the overburden is a silty clayey till with rounded cobbles and boulders of volcanic and granitic rocks. Small areas indicate the presence of Quadra sand on the surface.

The limestones of Davie Bay have been correlated by McConnell (1914) with similar limestones of the Marble Bay Formation on the north end of the island. In both areas the limestones conformably overlie amygdaloidal and pillow andesites and basalts of the Texada Formation. The age of both Marble Bay and Texada Formations is considered to be Triassic. The limestone is generally medium grey in colour with local areas being light grey. Outcrops weather a distinctive blue-grey colour and show extensive solution scalloping along irregular fractures and joints. Karst features are evident along the northeast contact with the volcanic rocks, where a small cave can be viewed and a series of six conical depressions some 35 metres in diameter and up to 15 metres deep are present.

Calcite veinlets less than 1 millimetre wide are present in most samples and a few up to 5 millimetres wide were found. General observations indicate that coarser grained limestones occur in areas with a high density of secondary veinlets which stand out on weathered surfaces.

No stratification has been observed in the limestone belt and the only evidence of structure are contacts with underlying volcanic rocks and limestone lenses embedded in the volcanic rocks. It is expected that chemical compositions and particularly the magnesium contents from samples collected during fieldwork will help to outline a more detailed stratigraphic subdivision, similar to the Marble Bay Formation in the northern part of the island. While the northeastern contact of limestones is a stratigraphic one, there are indications that an entirely obscured contact to the southwest is tectonic, perhaps due to a northwest-southeast fault.

The Anderson Bay marble deposit is a layer of crinoidal limestone embedded in volcanic rocks and volcanogenic sedimentary rocks of the Anderson Bay Formation (stratigraphically below Texada Formation) at the southern end of Texada Island. Two small quarries were operated near Anderson Bay at the beginning of the century, and the stone has been used for interior decoration of some of the public buildings in Victoria, Vancouver, and Nanaimo.

The exposed width of the limestone varies from 20 metres to 71 metres and, in part, the limestone bed in the southern half of the island is entirely missing. This band of limestone extends for about 1.5 kilometres south of Anderson Bay, then pinches out to reappear for a short distance near the southwest coast. It strikes north to northeast and dips between 30 degrees and 60 degrees to the west. Although the principal rock type, coarse-grained crinoidal limestone, is much the same along its length viewed in the northen exposures, it exhibits a variety of colours from white to deep red. These colour variations, represented by lenticular bands, cannot be correlated from section to section. The limestone outcrops on the western coast are fine to medium-grained uniformly grey rock lacking the colour variations of the northern exposures. The limestone bed is underlain by volcanic breccias, slightly metamorphosed grey argillites, and aphanitic grey volcanic rocks. This contact is sharp where exposed and the abrupt change from massive lava and volcaniclastics to relatively pure carbonates indicates a sudden change in depositional environment. Five sections with measured true thickness have been described in the northern segment of the limestone band and one section on the west coast of the island. They are numbered from north to south and numbers 1 to 5 are approximately between 200 and 400 metres apart.

Section 1

Base	grey fine-grained argillite
0– 6.7 metres	massive whitish coarse crinoidal limestone, joint spacing 20 to 50 centimetres
6.7– 9.2 metres	pinkish coarse crinoidal limestone with argillaceous laminae, joint spacing 10 to 20 centimetres
9.2–16.0 metres	yellowish white coarse crinoidal limestone, joint spacing 20 centimetres
16.0–20.0 metres	white to very light grey coarse crinodial limestone, joint spacing 20 to 30 centimetres
20.0–23.0 metres	light pinkish coarse crinoidal limestone, joint spacing 20 to 30 centimetres
23.0–30.8 metres	whitish to pale orange coarse crinoidal limestone, joint spacing 30 centimetres
Top	medium grey calcareous argillite

Section 2

Base	volcanic breccia
0– 6.7 metres	banded red coarse crinoidal limestone with argillaceous partings and white calcite veining, joint spacing 30 to 40 centimetres
6.7–11.0 metres	orange-white coarse crinoidal limestone, stylolites, joint spacing 5 to 20 centimetres
11.0–26.0 metres	light pink coarse crinoidal limestone, styolites, joint spacing 20 to 30 centimetres
26.0–35.0 metres	pink, orange, and white coarse crinoidal limestone, joint spacing 20 centimetres
Top	grey argillite

Section 3

Base	volcanic breccias
0– 6.2 metres	light pink and red limestone, argillaceous partings, joint spacing 25 centimetres
6.2–11.8 metres	white to orange-white crinoidal limestone, joint spacing 30 centimetres
11.8–15.5 metres	grey white to pinkish limestone, quartz veins locally, joint spacing 20 centimetres
15.5–20.0 metres	covered interval – road
Top	grey argillite

Section 4

Base	volcanic breccia
0– 6.0 metres	reddish crinoidal limestone, white calcite patches and veins, argillaceous laminae, joint spacing 20 centimetres

Section 4 *(continued)*

6.0–13.4 metres	white to greyish white coarse limestone, joint spacing 20 centimetres
13.4–21.6 metres	pinkish banded limestone, argillaceous laminae, joint spacing 20 centimetres
21.6–31.8 metres	whitish orange limestone, joint spacing 30 centimetres
31.8–59.6 metres	greyish white coarse crinoidal limestone, joint spacing 30 centimetres, lens-like body of argillite breccia from 45.0 to 49.0 metres
59.6–71.0 metres	white and white-orange coarse crinoidal limestone, joint spacing 10 to 30 centimetres, jasper lenses up to 15 centimetres thick
Top	rusty weathering grey argillite

Section 5

Base	grey argillite
0– 1.5 metres	pinkish argillaceous limestone, joint spacing 20 centimetres
1.5–16.4 metres	orange-white coarse limestone, joint spacing 20 to 30 centimetres
Top	covered interval – road

Section 6

Base	medium grey aphanitic volcanic rocks
0–15.0 metres	medium grey, medium-grained crinoidal limestone, joint spacing 5 to 20 centimetres
15.0–21.0 metres	medium grey, medium to fine-grained crinoidal limestone, bands and patches of calcite and jasper replacing fossils, joint spacing 10 to 20 centimetres
21.0–43.4 metres	light grey, coarse to medium-grained crinoidal limestone, joint spacing 10 to 30 centimetres
Top	grey aphanitic volcanic rocks (Texada Formation)

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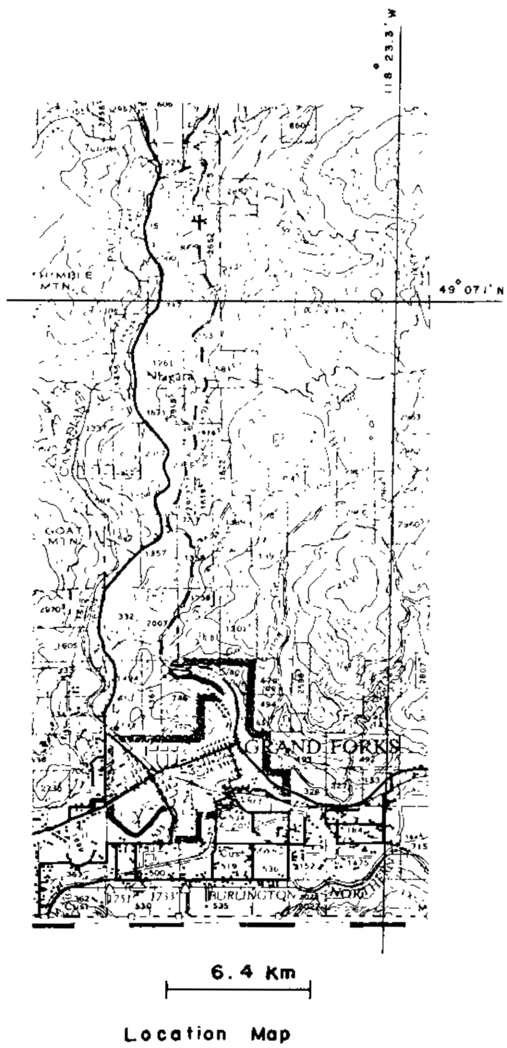
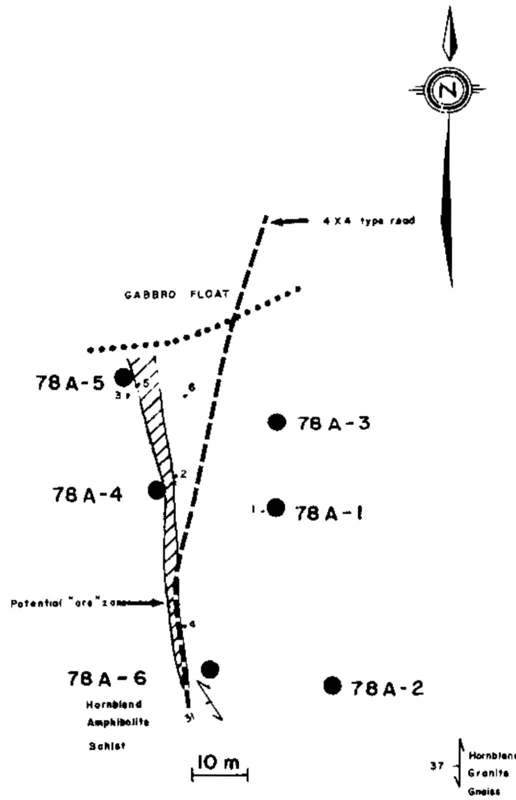


SD 18 - DEB Claims

(Geological sketch map- chain and compass)



Percussion Hole collar	Tc	T2	T3
78 A-1	3,750	200	60
2	2,750	150	45
3	3,600	200	50
4	24,000	1,000	160
5	40,000	1,800	225
6	3,750	200	60

MC PHAR TV-1 Readings – 3 π

Sta	Tc (C.P.M.)	T2	T3
1	1,000	625	225
2	90,000	5,000	1,100
3.	47,500	2,000	225
4.	>100,000	6,700	900
5	95,000	2,000	160
6.	60,000	2,000	150

Figure 35. Geological sketch map, DEB (SD 18) claim.

APPLIED GEOLOGY

MINERAL PROPERTY EXAMINATIONS

SOUTHEAST BRITISH COLUMBIA

By G. G. Addie

DEB (SD 18) (82E/1W)

The SD 18 claim is located approximately 15 kilometres north of Grand Forks east of the Granby River, between Toronto and Snowball Creeks (Fig. 35). The claim is owned by Consolidated Boundary Exploration Limited and is part of the DEB group.

Uranium mineralization is found in a biotite-garnet-quartz feldspar pegmatite identical to that on the Radar claim to the east (*Geological Fieldwork, 1978,* pp. 89, 90). K/Ar dating on biotite from the Radar claim yielded an age of 51.7±1.8 Ma.

A preliminary statistical study (*see* table) indicates again that the Log U (cpm)/Log K (cpm) and Log Th (cpm)/Log K (cpm) have a high correlation and can be used for mapping purposes. In this case (the SD 18 claim) there is a systematic increase in the thorium count from east to west. The mineralized zone is terminated on the north by a gabbro outcrop and on the south by overburden (Fig. 35). The claim to the north (SD 20) has similar pegmatites suggesting that gabbro intrusion is small.

Uranium was encountered with assays between 0.02 per cent and 0.034 per cent U_3O_8 in 78A–4 over 4.5 metres; and 0.017 per cent and 0.036 per cent U_3O_8 over 6 metres for percussion hole 78A–5. The assay data were provided by the owners.

McPHAR TV–1 SCINTILLOMETER RESULTS IN COUNTS PER MINUTE

Location	Tc	T2	Tc–T2	Log K Log (Tc–T2)	Th T3	U T2–3.5 x T3	Log U Log (T2–3.5 x T3)	Log Th Log T3	$\frac{\text{Log U}}{\text{Log K}}$	$\frac{\text{Log Th}}{\text{Log K}}$
Percussion hole										
PH78–1	3 750	200	3 550	3.55	60	0	------	1.78	------	.50
PH78–2	2 750	150	2 600	3.41	45	0	------	1.65	------	.48
PH78–3	3 600	200	3 400	3.53	50	25	1.40	1.70	.40	.48
PH78–4	24 000	1 000	23 000	4.36	160	440	2.64	2.20	.61	.50
PH78–5	40 000	1 000	38 400	4.58	225	812.5	2.91	2.35	.64	.51
PH78–6	3 750	200	3 550	3.55	60	0	------	1.28	------	.50
Station										
STA–1	1 000	625	375	2.57	225	0	------	2.35	------	.91
STA–2	90 000	5 000	85 000	4.93	1 100	1 150	3.06	3.04	.62	.62
STA–3	41 500	2 000	45 500	4.66	225	1 212.5	3.08	2.35	.66	.50
STA–4	100 000	6 700	93 300	4.97	900	3 550	3.55	2.95	.71	.59
STA–5	95 000	2 000	93 300	4.97	150	1 475	3.17	2.18	.64	.44
STA–6	50 000	2 000	48 000	4.68	150	1 475	3.17	2.18	.68	.47

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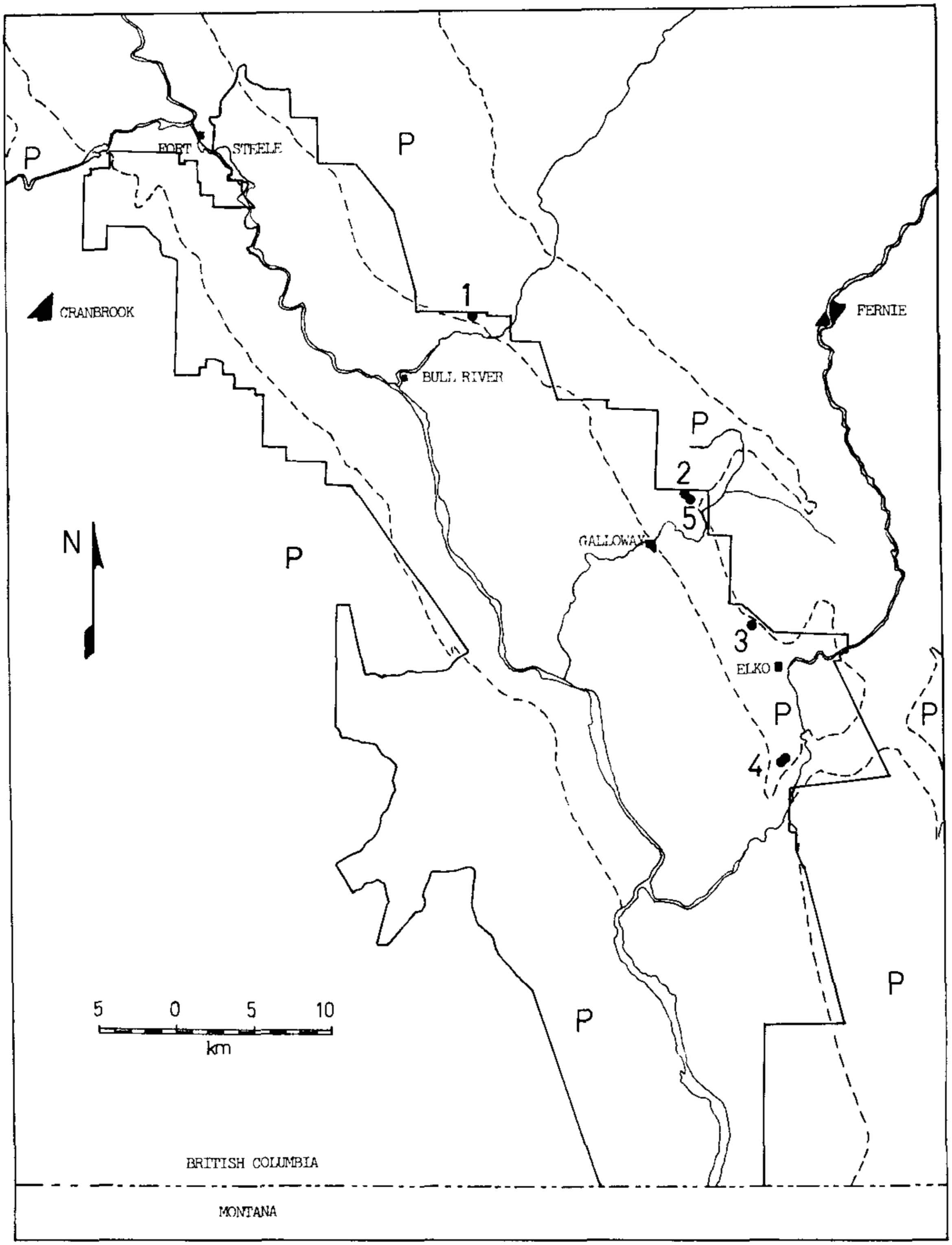

Figure 36. Outline of Libby Reserve planning study area, with locations of mineral deposits and showings described in report, and approximate boundaries of areas underlain by Purcell sedimentary rocks (P) (Leech, 1960; Price, 1961). [1 = Bull River mine, 2 = Empire-Strathcona, 3 = Burton, 4 = Sweet May and Jennie, 5 = Burt.]

BASE METAL DEPOSITS IN THE LIBBY PONDAGE RESERVE AREA
(82G/SW, NW)

By D. A. Grieve

INTRODUCTION

A land-use study of the Rocky Mountain Trench between Fort Steele and the United States border (Fig. 36) is underway. The goal of the study is effective management of Crown land in the Libby Pondage Reserve following removal of the reserve. As part of the resource evaluation of the region the author investigated several mineral deposits and showings in the study area. All are small vein-type sulphide deposits hosted by Helikian sedimentary rocks of the Purcell Supergroup. Two (Burton and Empire-Strathcona) were small producers earlier this century, while one (Bull River mine) was operated recently.

BULL RIVER MINE

Bull River mine, which was operated by Placid Oil Company between October 1971 and June 1974, is located 7 kilometres upstream from the settlement of Bull River. Over 524 000 tonnes of ore was mined, grading 1.46 per cent copper, 0.232 gram per tonne gold, and 11.7 grams per tonne silver. Two pits were excavated, each on a different vein. Several other mineralized zones are also reported on the property.

Chalcopyrite occurs as irregular blebs and fracture fillings along with disseminated pyrite and pyrrhotite in quartz-siderite veins and veinlets. Malachite and azurite coat fractures in both vein material and country rock. These veins are concentrated in highly fractured and sheared zones in dark grey laminated argillites and quartzites of the Aldridge Formation. The sedimentary rocks are characterized by bands rich in fine, well-crystallized pyrite. The mine area is intersected by basic dykes, which are spatially related to the mineralization (McMechan, 1979a). Host rocks dip roughly 25 degrees to the northeast, although structural deformation is prevalent in the pit areas. Mineralized zones dip steeply to the south.

EMPIRE–STRATHCONA

This deposit, located north of Sand Creek 6 kilometres from Galloway, was developed between 1898 and 1900, and again in 1929 and 1930. Small quantities of high-grade ore were shipped in 1937.

In common with Bull River mine, the Empire-Strathcona deposit is a siderite-quartz vein (in this case with hematite) in dark grey, well-laminated Aldridge Formation argillites. Strata here dip 45 degrees to the northeast, and the vein itself dips 50 degrees to the southwest. The vein, as viewed in two open cuts, is 1.5 to 2 metres in thickness and contains a pure siderite band up to 1 metre thick. It occupies a prominent shear zone which includes 1-metre zones of schistose rock on both walls of the vein. Mineralization consists of sparse irregular blebs and fracture fillings of chalcopyrite and disseminated pyrite. Empire-Strathcona ore also contained significant quantities of silver.

BURTON

The Burton, located 4 kilometres north of Elko, is a vein deposit hosted by argillites and quartzites of the Roosville Formation, the youngest Purcell strata in the region. Roosville rocks have pronounced red and green colourations and include dark stromatolitic dolomite bands. The Burton vein is predominantly composed of quartz, with small amounts of calcite and siderite, and is vertical and trends northeast. Mineralization, which is sparse in outcrop, consists of small disseminated patches of chalcopyrite. Malachite staining is common on fracture surfaces within and adjacent to the vein.

Two adits were developed at the turn of the century, the uppermost of which intersected high-grade material. Ore was shipped to Trail in 1916 and 1917. Silver values were apparently low.

SWEET MAY AND JENNIE

These showings are within a few hundred metres of each other on Sheep Mountain, 6 kilometres south of Elko. Development took place at the turn of the century, but was not long lived.

The showings occur in shear zones adjacent to both contacts of a 10-metre-thick K-feldspar porphyry sill. Bedding in Purcell-age Gateway Formation carbonates is vertical and trends north-south. Both showings consist of scattered blebs of chalcopyrite in thin quartz veins. In general Sheep Mountain is host to many small quartz veins, some of which contain sulphide minerals.

BURT

The Burt showing is less than 1 kilometre south of the Empire-Strathcona. Two adits and several trenches were excavated in the 1930's, but very little outcrop is visible now. Float found consists of vein quartz with small stringers of galena, which apparently contained appreciable silver. The vein is reportedly 0.7 metre thick and can be traced for 600 metres. Basic dyke material and Aldridge Formation sedimentary rocks are the host rocks (*Minister of Mines, B.C.,* Ann. Rept., 1937, p. 41).

CONCLUSIONS

Small vein-type base metal deposits are common in Helikian Purcell Supergroup sedimentary rocks in the vicinity of the southern Rocky Mountain Trench (*see* Mineral Inventory Maps 82G/SW and 82G/NW, *B.C. Ministry of Energy, Mines & Pet. Res.*; Höy, 1978; Grieve and Höy, 1979; McMechan, 1979b). In some cases they are spatially related to small intrusive bodies.

In view of the potential for economic mineral deposits, areas underlain by Purcell Supergroup sedimentary rocks within the Libby Pondage Reserve should remain accessible for exploration and development.

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CENTRAL BRITISH COLUMBIA

F & S

(82L/13W)

By G.P.E. White

The F & S claims, owned by John Filek, are under option to Interior Stone & Marble Ltd. and are operated as a source of quartz for stucco dash. The claims are located near the headwaters of Niskonlith Creek, northeast of Pritchard.

During the quarrying operation scheelite and tungstenite (WS_2) in dolomite have been uncovered along the contact of the quartz body and the schistose country rocks. The tungsten minerals have been found in patches measuring up to 10 by 30 centimentres.

Soil samples collected below a scant A horizon between the quartz quarry and a coarse-grained granite about 0.8 kilometre to the east showed anomalous concentrations of scheelite using a gold pan and an ultraviolet lamp. Glacial clays and gravels are present in the area in variable thicknesses and it is possible that the anomalous scheelite has been transported from the northwest.

POTENTIAL CARBONATITE LOCALITIES

By G.P.E. White

Two properties containing carbonatite-like bodies were examined in 1979. These include the JTM claims (83D/3E) and the Sandy Victor (82L/16W) properties.

The JTM property, owned by John Morton, is located along the Mud River logging road 14 kilometres northeast of Blue River. Limited study has indicated a possible metabeforsite (metamorphosed dolomitic carbonatite) with enveloping ferroaugite-albite-perthite fenitization replacing granulite schists of quartz-albite-biotite or biotite-sillimanite-garnet composition. This carbonatite-like unit has been traced at one outcrop locality for 150 metres along strike and is greater than 4 metres in thickness. In its present form the unit is composed of a reddish brown residual soil containing elongate, oval fragments of metabeforsite up to 30 centimetres in diameter. Forsterite and chondrodite have been determined by X-ray analysis of the soil. Other minerals identified megascopically in the soil are phlogopite, limonite, a pyroxene, and magnetite. Coarse banding of the soil is exhibited by varying quantities of phlogopite.

Preliminary thin section study of the metabeforsite has identified dolomite, augite, phlogopite, calcite, probably ankerite, magnetite, pyrrhotite, and minor secondary chlorite and sericite. Variations in the composition of the metabeforsite are indicated by the percentage of dolomite to mafic minerals, with some samples containing about 70 per cent mafic minerals.

Fenitization marginal to the metabeforsite extends 1 metre into country rock schists and the fenite is also coarsely banded. Often a 5-centimetre band of ferroaugite-rich rock with interstitial albite and perthite separates the fenite and metabeforsite. This contact is usually sharp with the metabeforsite intrusive showing embayed and intersecting relations with the fenite. The fenite/schist contact is gradational.

Although the outcrops are limited, the metabeforsite/fenite appears to be sill-like and concordant with the regional schistosity. These criteria may at a later date indicate that these bodies are not true metasomatic replacements but may be limestone beds containing abnormally high rare earths. However, Rb-Sr dating at the University of British Columbia yielded an age of 370 Ma in this area for these carbonatite-like units

(R. L. Armstrong and W. J. McMillan, personal communication, August 1979) which would suggest a younger age than the country rock schists.

A carbonatite-like unit has been discovered by Francis Jenkins and partners near the intersection of the Victor Lake main logging road and the British Columbia Hydro and Power Authority right-of-way at an elevation of 476 metres, 14 kilometres west of Revelstoke.

The field relations and petrography are similar to the metabeforsite/fenite at the JTM claims near Blue River situated 148 kilometres to the northwest.

At some localities the metabeforsite measures 3.5 metres in width and has been traced by intermittent outcrop for 1.5 kilometres along strike in a northwest-southeast direction. Possibly due to better rock exposures than at the JTM claims, the embayed and intersecting nature of the metabeforsite/fenite contact is more obvious at this site. Further, fragments of altered schist are present in the metabeforsite.

A mineralogical variance from the JTM site is that the ferroaugite in the fenite is partially altered to hornblende.

A partial semiquantitative spectrographic analysis of soil and rock specimens from both properties is shown in the following table.

PARTIAL ELEMENT COMPARISON OF CARBONATITE–LIKE UNITS IN CENTRAL BRITISH COLUMBIA AND CARBONATITES IN SOUTH WEST AND SOUTH AFRICA

	JTM Claims – Blue River			Sandy Victor Claims – Three Valley Gap			South African
	Soil	Metabeforsite	Metabeforsite	Soil	Metabeforsite	Metabeforsite	Average Carbonatite Content
Sr (ppm)	trace	3 500	2 000	200	3 000	2 000	4 735
Nb (per cent)	0.02	0.4	-----	0.015	0.01	0.01	-----
P (per cent)	-----	2.0	-----	2.5	2.5	1.0	-----
Th (ppm)	29	254	<7	29	<7	<7	-----
U (ppm)	19	<3	<3	31	<3	<3	-----

Studies in South West and South Africa on carbonatites showed a clear distinction between carbonatites, metacarbonatites, and limestones based on strontium content. Usually beforsite has a corresponding lower strontium content than sovite at similar localities in South Africa. Transvaal carbonatites range from 620 ppm strontium to 9 975 ppm strontium. Metacarbonatites in South Africa are generally regarded to have greater than 1 000 ppm strontium. Using these criteria, the Blue River and Three Valley Gap metabeforsite units with 3 500 ppm, 2 000 ppm, 3 000 ppm, and 2 000 ppm would have to be accepted as metabeforsites.

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MOSQUITO CREEK

(93H/4E)

By G. H. Klein

The Mosquito Creek gold property is located 3 kilometres north of the town of Wells, 88 kilometres east of Quesnel. The Mosquito Creek Gold Mining Company Limited was formed in 1971 to explore 29 Crown-granted mineral claims and two placer leases. The claims encompass Mosquito and Red Gulch Creeks, which have been sites of placer gold mining since the 1860's. The property is on strike northwesterly from Island Mountain (Aurum) and Cariboo Gold Quartz, both former producing mines. The property partially overlaps the lower workings of the Island Mountain mine.

Bulldozer trenching and geological mapping in 1971 led to a surface percussion and diamond drilling program in 1972 and 1973. The drilling indicated gold mineralization similar to that of the former producers and a three compartment shaft was sunk to 157 metres in 1974. Four levels were established, the lowest of which is the 4100, which is 240 metres above the former workings. The property lay dormant from April 1975 until July 1977, when underground exploration and diamond drilling resumed.

Late in 1979, the construction of a 100-tonne-per-day mill, crusher, and cyanidation plant was in progress. A tailings pond has been completed and production is scheduled for early 1980.

Lower Cambrian (or earlier) phyllites, quartzites, and limestone host the gold mineralization. These rocks have been intensely deformed by folding, and the mineralization lies in the overturned limb of an anticlinorium which strikes northwest and plunges 22 degrees to the northwest.

Crossfaulting does occur on the property but its relationship to the mineralized zone is not yet known. No igneous intrusions are known.

Exploration has been concentrated near the contact between dark quartzites and phyllites of the Rainbow member, and the lighter, calcareous Baker member, as this contact was known from the Island Mountain mine as being the zone of best mineralization.

Gold is associated with medium to coarse-grained pyrite, both in quartz veins and as replacement lenses. No visible gold has been found to date. The quartz veins are gash veins found mainly in the more brittle Rainbow member while replacement lenses are found in the softer, calcareous Baker rocks. The quartz veins tend to be of limited extent, and have not been fully explored. The one replacement lens found to date has been explored between the 4100 and 4200 levels. This lens, consisting of pyrite which is locally massive in a quartz and calcite matrix, plunges 22 degrees to the northwest, parallel to the plunge of the anticlinorium. Contacts of the lens are erratic, suggesting selective replacement. Three grab samples of this mineralization returned 88, 35, and 102 grams gold per tonne. This limited sampling indicated no correlation between gold and iron content.

The mineralization found to date is similar to that mined previously at the Island Mountain mine (*see* Sutherland Brown, 1957). Stated mining reserves from exploration and development are 19 400 tonnes at 26 grams gold and 8 grams silver per tonne.

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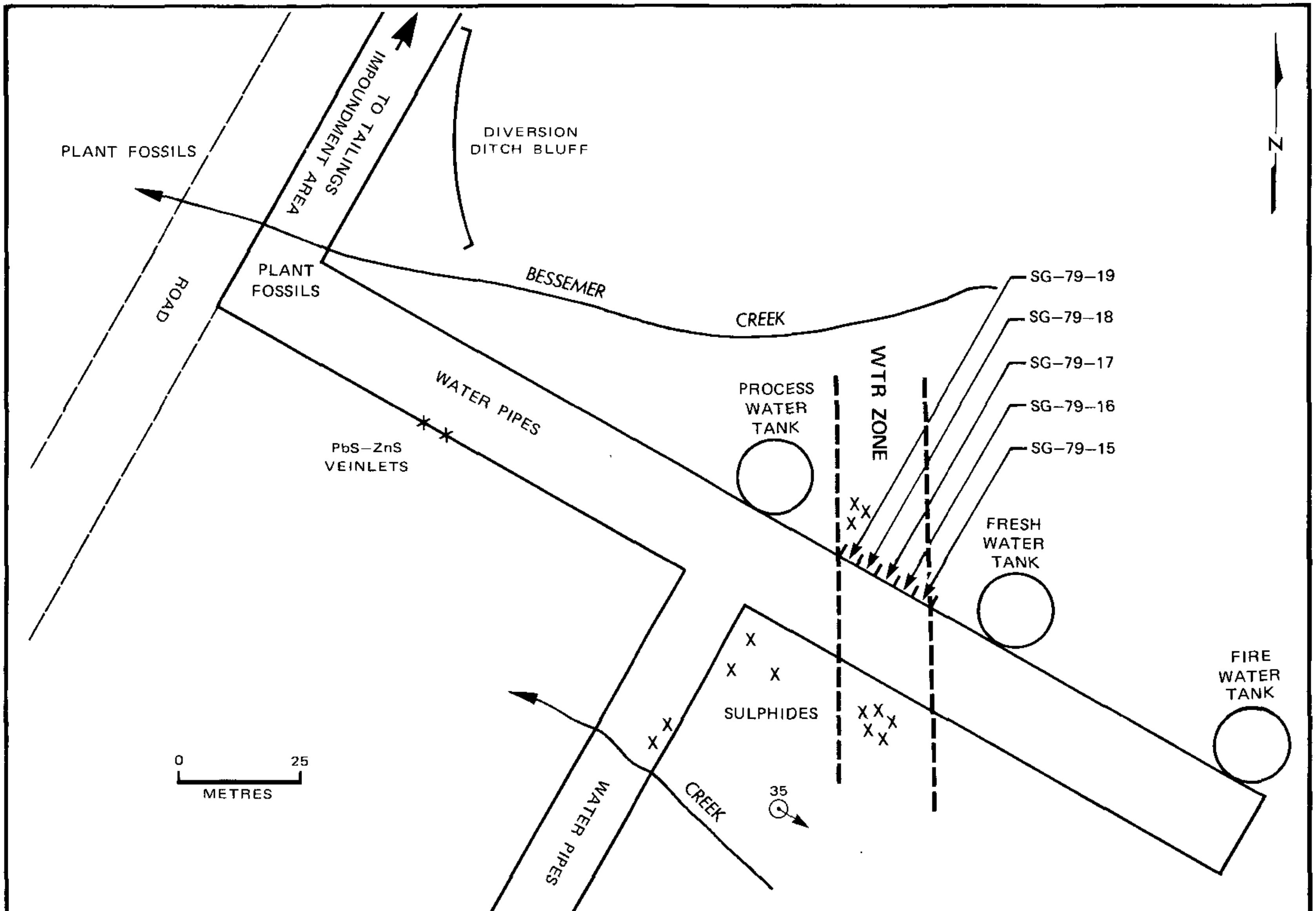

Figure 37. Sketch map of W-T-R zone, Sam Goosly.

WEST–CENTRAL AND NORTHWEST BRITISH COLUMBIA

SELECTED MINERAL PROPERTY EXAMINATIONS

By T. G. Schroeter

CAPOOSE LAKE (93F/6)

During 1979 Granges Exploration Aktiebolag, as operators, carried out drilling programs on its Ned molybdenum prospect and its E zone silver prospect, both situated near Fawnie Nose, approximately 110 kilometres south of Burns Lake.

Traces of molybdenite coating dry fractures in quartz monzonite were encountered in three diamond-drill holes totalling 352.7 metres on the Ned claims.

On the D and E claims, approximately 6 kilometres east of the Ned claim, the company drilled 25 percussion holes and nine diamond-drill holes totalling 1 434.4 metres. Galena, pyrite, pyrrhotite, chalcopyrite, and sphalerite occur as disseminations and as fracture fillings in fine-grained rhyolite tuffs and flows. Tetrahedrite, pyrargyrite, electrum, and trace amounts of arsenopyrite have also been identified. Within the host rhyolites, pisolitic bands occur with pisolites up to 8 centimetres in diameter, and garnet is locally disseminated and/or banded. Significant jointing has an attitude of north 70 degrees east/85 degrees east. Flow banding in rhyolite strikes north 56 degrees east and dips 35 degrees west. Fairly consistent low grades of silver and minor gold assays have been obtained over a large area. Steel grey to black hematite is a common accessory.

The following character samples were collected:

Sample No. Location	Description	Au ppm	Ag ppm	Cu ppm	Pb ppm	Zn ppm
CAP–1 (east pit)	rhyolite	0.7	130	153	250	30
79–CAP–4 (237 ft.)	rhyolite	1	10	260	0.21%	348
79–CAP–3 (221 ft.)	rhyolite, highly oxidized	9	747	295	1.73%	348
79–CAP–2 (325 ft.)	rhyolite	0.7	1	0.23%	500	233
79–CAP–4 (502 ft.)	rhyolite	*	368	0.35%	0.26%	1.06%
79–CAP–5 (350 ft.)	rhyolite	trace	trace	0.03%	0.25%	0.3%
					Plus Mo	0.03%
					W	0.03%

*A small speck of gold was observed, but was lost during sample splitting.

SAM GOOSLY (93L/1E)

The Sam Goosly silver-copper-gold-antimony deposit is situated approximately 35 kilometres southeast of Houston. Exploration work to date included numerous geochemical and geophysical surveys, mapping, 3 500 metres of trenching, 32 000 metres of diamond drilling [Kennco Explorations, (Western) Limited, 1 to 62; Equity Mining Corporation, 63 to 207; Placer Development Limited, 208 to 229], and 177 metres of underground workings. Mineable reserves are 27 970 000 tonnes grading 106.3 grams silver, 0.384 per cent copper, 0.96 gram gold per tonne, and 0.084 per cent antimony. The property is being prepared for production by Equity Mining, controlled by Placer Development.

During January and February 1979, Placer Development completed six diamond-drill holes totalling approximately 1 067 metres in the proposed tailings impoundment basin, northwest of the Main ore zone. All holes encountered a hangingwall sequence of intermixed pyroclastics (ash, lapilli, dust tuffs), and volcanic conglomerate and dacite porphyry flows with abundant pyrite plus tourmaline alteration. Only minor veinlets of sphalerite and galena were noted.

During the summer of 1979 Placer Development drilled a further 10 short holes in the area of the tailings dam. Most of the holes encountered unmineralized Goosly Lake volcanic rocks.

The copper-silver-gold-antimony deposits occur within a window of rocks thought to be Cretaceous in age which are surrounded by younger flat-lying Tertiary andesitic to basaltic flows (Goosly Lake volcanic rocks and Buck Flats volcanic rocks). The Cretaceous rocks are intruded by two stocks along the flanks of the host units. The stratigraphy strikes about 015 degrees and dips about 45 degrees to the west. The mineral deposits are grossly conformable to the pyroclastic host horizon.

Four major stratigraphic units have been recognized: Upper volcanic flow division; sedimentary-volcanic division; pyroclastic division; and clastic division.

The clastic division, composed of a lower polymictic conglomerate and an upper chert pebble conglomerate, is lowermost and is thought to be correlative with the Skeena Group. The overlying pyroclastic division consists of a heterogeneous sequence of tuff (dust, ash, lapilli), breccia, and reworked pyroclastic debris. This unit hosts the Main zone and Southern Tail zone deposits and may be correlative with the Kasalka Group (Cretaceous). The sedimentary-volcanic division consists of tuff, sandstone, and conglomerate with well-defined bedding. The uppermost unit, the volcanic flow division, is composed of andesitic and dacitic flows.

Principal ore minerals, which include pyrite, chalcopyrite, tetrahedrite, arsenopyrite, sphalerite, and galena, are associated with tourmaline, andalusite, scorzalite, and corundum (only in the Main zone). Ore zones occur within the pyroclastic division and are controlled mainly by structure and to a lesser extent by stratigraphy. Other zones of mineralization at Sam Goosly include a zone of copper-molybdenum mineralization in a quartz stockwork in and adjacent to the quartz monzonite stock to the west of the ore zones, and a large zone of tourmaline-pyrite breccia located to the west and northwest of the Main zone.

During mill construction in the summer of 1979, a new zone (WTR zone, Fig. 37) was located on the water tower right-of-way, approximately 300 metres to the north and on strike with the Main zone. This zone consists of massive to brecciated stringer sulphide ore in the pyroclastic division and was exposed in a trench over a width of 23 metres. The mineralization has been traced on the surface for over a 60-metre length and other occurrences were noted in the adjacent hangingwall. The location of the zone is approximately 60 metres north of diamond-drill hole 35. The zone trends north-south and appears to dip steeply to the west. Mineralization consists of chalcopyrite, sphalerite, pyrite, plus minor galena, molybdenite, and an unidentified tungsten mineral. Scorzalite alteration was noted. The following chip samples were taken across intervals of 4.5 metres by the writer (*see* Fig. 37).

Sample No.	**Au**	**Ag**	**Cu**	**Pb**	**Zn**	**MoS_2**	**WO_3**	**Sn**
	ppm	*ppm*	*per cent*	*per cent*	*per cent*	*ppm*	*per cent*	*per cent*
SG–79–15	3.6	68	.73	.03	2.77	10 - 30	.02	trace
SG–79–16	4.3	267	1.16	.15	1.24	10	.04	trace
SG–79–17	4.8	210	2.05	.05	.72	12	.03	.015
SG–79–18	0.5	27	.28	0.01	.1	10	------	------
SG–79–19	7	380	6.37	0.07	1.28	10	.04	.02

Plant fossils (reeds) were located in the area of the junction of the water tower right-of-way (western end) and the Bessemer Creek diversion ditch within the sedimentary-volcanic division (Fig. 37). In the Bessemer Creek diversion ditch, quartz veinlets with pyrite, sphalerite, and minor chalcopyrite occur within pyroclastic rocks and pyritized sedimentary rocks.

The diversion dam on Lu Creek (west end) is underlain by pyritized volcanic sedimentary rocks and tuffs. The starter dam on Lu Creek (east end) is underlain by grey to maroon-coloured andesitic Goosly Lake rocks.

Construction of the millsite exposed numerous sub-outcrops of well-bedded intermixed pyroclastics and welded tuffs with abundant tourmaline-pyrite alteration and later dykes. Dumortierite was observed in the foundation for the coarse ore storage. A 7.6-centimetre vein of massive chalcopyrite and tetrahedrite was observed in the same foundation.

Three new K/Ar age determinations were obtained during a thesis study completed during the summer of 1978 and winter of 1979 by Dennis Wetherell at the University of British Columbia and are reported as follows:

Location	Minerals	Type	Age (Ma)
Tourmaline-breccia alteration, DDH 54 (250 m)	sericite-tourmaline-pyrite-chlorite	whole rock	58.5±2.0
Southern Tail alteration, DDH 61 (19.2 m)	sericite-quartz	whole rock	58.1±2.0
Main zone alteration, DDH 28 (77.4 m)	sericite-quartz-chlorite	whole rock	48.3±1.7

These dates point to a correlative mineralizing event with the quartz monzonite stock (57.2±2.3 Ma). The apparent age of alteration in the Main zone is identical to that of the gabbroic pluton and suggests that the age has been reset by contact metamorphism.

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LUCKY GOLD (93L/10E)

The Lucky Gold (Free Gold) property is approximately 40 kilometres east of Smithers. During 1979 Kryco Mines Ltd. constructed a 2.5-kilometre access road from the Fulton Lake main logging road south to the property and the old workings were rehabilitated. The company continued drifting along vein 3 to hook up with the workings below shaft 2. Approximately 45 tonnes of ore mined in the 1930's are stockpiled outside the portal (main dump) and another 45 tonnes of newly broken ore has been stockpiled (new dump) from a surface exposure located approximately 55 metres south of the portal. Another 45 to 91 tonnes of ore exists in a number of small dumps along the surface expression of the vein system which has been traced by trenches and shafts over a length of over 180 metres.

The property is underlain by altered andesitic rocks of the Hazelton Group which have been intruded in the vicinity of the showings by an irregular mass of quartz porphyry. The showings consist of a series of several quartz veins and quartzose shear zones, ranging in width from a few centimetres to 0.75 metre. These are exposed in a section about 180 metres long and 137 metres wide. The veins strike generally northwest and dip steeply northeast. The veins are irregular in both strike and dip, and pinch and swell and locally split into stringers. Mineralization consists of pyrite, sphalerite, galena, tetrahedrite, chalcopyrite, and native gold within the quartz veins.

The following samples were collected by the writer.

Sample No.	Description and Location	Au *ppm*	Ag *ppm*	Zn *per cent*	Cu *per cent*	Pb *per cent*
LG– 3	ZnS+py+tetrahedrite in 15-cm quartz vein, main dump	116.4	248	>5	0.4	0.5 - 1
LG– 6	Py-ZnS+tetrahedrite in 7.6-cm quartz vein, main dump	71	187	2 - 3	0.6	.25
LG– 9	Py-PbS+ZnS+tetrahedrite in 10-cm quartz vein, main dump	41	263	>10	0.6	>5
LG–12	Py-ZnS+PbS in 10-cm quartz vein, main dump	48	212	>10	0.6	.25
LG–15	Py-PbS-cpy in 15-cm quartz vein, 'new' dump	57	126	>10	0.4	>2
LG–16	Py in 13-cm quartz vein, surface dump near shaft 3	11	>10	0.3	0.05	0.2
LG–18	Fine-grained PbS+ZnS in 8-cm quartz vein, surface dump near shaft 3	105	235	>15	0.2	>5

REFERENCE

Minister of Mines, B.C., Ann. Rept., 1938, pp. 15-20.

BOYA (94M/3W, 4E, 5E, 6W)

The Boya molybdenum-tungsten prospect, being explored by Texasgulf Inc., is located 125 kilometres southeast of Watson Lake, approximately 10 kilometres northeast of the confluence of the Kechika and Turnagain Rivers. During 1979, a 15-person camp was set up on the north shore of Graveyard Lake. Geochemical, geophysical, and geological surveys were conducted, and six diamond-drill holes totalling approximately 1 380 metres were completed.

Several zones of mineralization are exposed over a northwesterly trending ridge for a length of over 2 500 metres. Molybdenite is best observed in the Main Face showing. Other (dominantly tungsten) showings include West Hill, Nighthawk Hill, and Paint Can Hill.

A complex stock of quartz-biotite-feldspar porphyry has intruded a sequence of probable Lower Paleozoic metasedimentary rocks which include in apparent stratigraphic sequence (oldest to youngest) porcellanite (thinly banded skarnified siltstones), skarn (diopside-quartz-garnet-pyrrhotite-scheelite-molybdenite), volcanic tuffs, and massive limestone. An intense quartz stockwork has developed both within the intrusive rock and the hornfels. Alteration includes intense sericitization and biotitization. Mineralization occurs as two distinct types:

(1) ribbon-banded molybdenite-bearing quartz veins (no rosettes) with minor scheelite and chalcopyrite and trace bismuthinite, galena, and sphalerite in quartz-biotite-feldspar porphyry and adjacent hornfels, and
(2) stratigraphically controlled skarn with disseminated and semi-massive pyrrhotite and lesser chalcopyrite in pods. Scheelite and minor amounts of molybdenite also occur within the skarnified beds.

STAR 9 (103P/1W)

The Star 9 (Morning Star) molybdenum prospect is located north of the Skeena River approximately 3.5 kilometres northeast of Woodcock. The property was explored during 1927 and 1931 for its vein lead-zinc-silver potential. Several old trenches and test pits and a couple of old adits were located between 450 and 570 metres elevation. A granodiorite stock contains disseminated and fracture-filling molybdenite and intrudes sandstone, argillites, and conglomerates.

Geochemical, geophysical, and geological surveys were to be carried out in the fall by Newmont Exploration of Canada Limited under an option agreement with Earl Sargent.

The following samples were taken by the writer.

Sample No.	Description Location	Au	Ag	Cu	Pb	Zn	Mo	Sn
		ppm	*ppm*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
M–S– 1	high grade, 1490 adit	1.7	45	0.073	5.0	4.07	*	------
M–S– 3	high grade, 1490 adit	1.4	120	0.12	9.4	6.37	*	0.01
M–S– 9	west trench, 1740 level	<1	150	0.11	3.6	9.41	*	0.015
M–S– 7	west trench, 1740 level	------	------	------	------	------	0.54	------
M–S–12	west trench, 1740 level	------	------	------	------	------	0.07	------
M–S–15	east pit, 1880 level						trace	

*No determination.

REFERENCES

Minister of Mines, B.C., 1927, p. 127; 1929, pp. 154, 155; 1930, p. 138; 1931, p. 72.

SURPRISE CREEK (104A/4E, 5E)

The Surprise Creek molybdenum prospect is located approximately 25 kilometres northwest of Meziadin Lake, immediately to the east of Mount Patullo. In 1979 Falconbridge Nickel Mines Limited set up a base camp on the Nordore road, approximately 5 kilometres from the Stewart-Cassiar Highway. From there, access to the property was via helicopter.

Over the last decade, glaciers and snow have retreated considerably in the area exposing a highly altered (sericite-saussurite) granodiorite at lower elevations intrusive into Bowser Assemblage shales and conglomerates. Molybdenite occurs as disseminations, as smears, and in quartz veins within the granodiorite and to a lesser extent in quartz stringers in hornfelsed and pyrrhotized Bowser Assemblage sedimentary rocks. Pyrite is common in the granodiorite and purple fluorite was also seen. A few massive pods of pyrrhotite occur within the hornfelsed Bowser sedimentary rocks.

TABLE MOUNTAIN (104P/4E)

The Table Mountain gold prospects are located approximately 25 kilometres east of Cassiar and include the *Vollaug vein (Table Mountain Mines Limited), the Erickson Creek gold mine (Nu-Energy Development* Corp.), and properties of Cusac Industries Ltd. and Plaza Mines.

On the Table Mountain Mines Limited's property, work during 1979 included 707 metres of underground development comprising 281.3 metres of drifting, 294.4 metres of raising and 132.2 metres of subdrifts, diamond drilling of 13 holes totalling 966.4 metres, and surface stripping of the quartz vein in eight new trenches. The Vollaug vein has now been traced on the surface for over 900 metres and may well extend over a strike length of 2 200 metres. Gold in free form as well as that with tetrahedrite and/or chalcopyrite occurs in a quartz structure which occurs along the contact, dipping approximately 15 degrees to the north, between andesite (footwall) and argillite (hangingwall). Local steepening of the dip to 40 degrees does occur. The width of the quartz structure varies from 0.5 metre to 3 metres. Company reports indicate that development work this year has proven 17 418 tonnes in the A ore shoot grading 16.78 grams gold per tonne and 9.92 grams silver per tonne plus additional lower grade material.

The Erickson gold mine is located approximately 20 kilometres east of Cassiar. A trailer camp with 35 people has been set up and the mill operated at between 45 and 91 tonnes per day. The Jennie quartz vein crops out in only one place on the property, in Erickson Creek at 1 450 metres elevation. The haulage level at 1 375 metres intersects the vein at approximately 183 metres and drifting has been carried out both east and west along the vein. The vein has been stoped to 60 metres above the main drift. The thickness of the vein varies from 0.5 metre to 1.8 metres. During the summer of 1979 development work progressed on the 39 level, a subdrift above the main drift. Gold occurs in the free form and also with tetrahedrite and/or chalcopyrite. An andesite dyke averaging 0.3 metre in thickness occurs both adjacent to or within the quartz vein. Better values of gold and silver appear to occur in rusty coloured sections.

MOUNT REED (104P/6W)

The Mount Reed tungsten prospect is located approximately 17 kilometres east of Cassiar. During 1979 Canadian Superior Exploration Limited, by option agreement, diamond drilled four holes totalling approximately 405 metres to test for skarn mineralization.

In 1979, Brettland Mines Ltd. (now Valez Resource Industries Ltd.) and Glen Copper Mines Ltd. (now Cusac Industries Ltd.) conducted geological, geochemical, and geophysical surveys on the property. In 1970 and 1971, Pacific Petroleums Ltd., Brettland Mines, and Glen Copper Mines diamond drilled 18 holes totalling 1 820 metres. In 1978, Canadian Superior Exploration diamond drilled three holes totalling approximately 162 metres in the eastern skarn zone.

The property is underlain by Lower Cambrian Atan Group metasedimentary rocks (limy and argillaceous units) which have been hornfelsed to garnet, epidote, wollastonite, or magnetite skarn. The host rocks include (oldest to youngest) hornfels, limestone with argillaceous bands, banded limestone, massive limestone, and siliceous ferruginous chert. Compositional layering has been preserved locally. Previous drilling and outcrops suggest that there may be a skarn shell around the Mount Reed quartz monzonite stock of Eocene age. Atan rocks are overlain by Kechika phyllites.

Mineralization consists of the following:

(1) molybdenite on widely spaced fractures within hairline quartz fractures in hornfels and rarely in quartz monzonite,

(2) powellite, occurring as variable fine disseminations and as fracture coatings, associated with molybdenite in highly silicified skarn.

The 1979 drill program was designed to test for tungsten skarn mineralization on the southeast side of the stock and also in an area between the main stock and a smaller body of quartz monzonite located to the east.

REFERENCE

B.C. Ministry of Energy, Mines & Pet. Res., Assessment Report 7069.

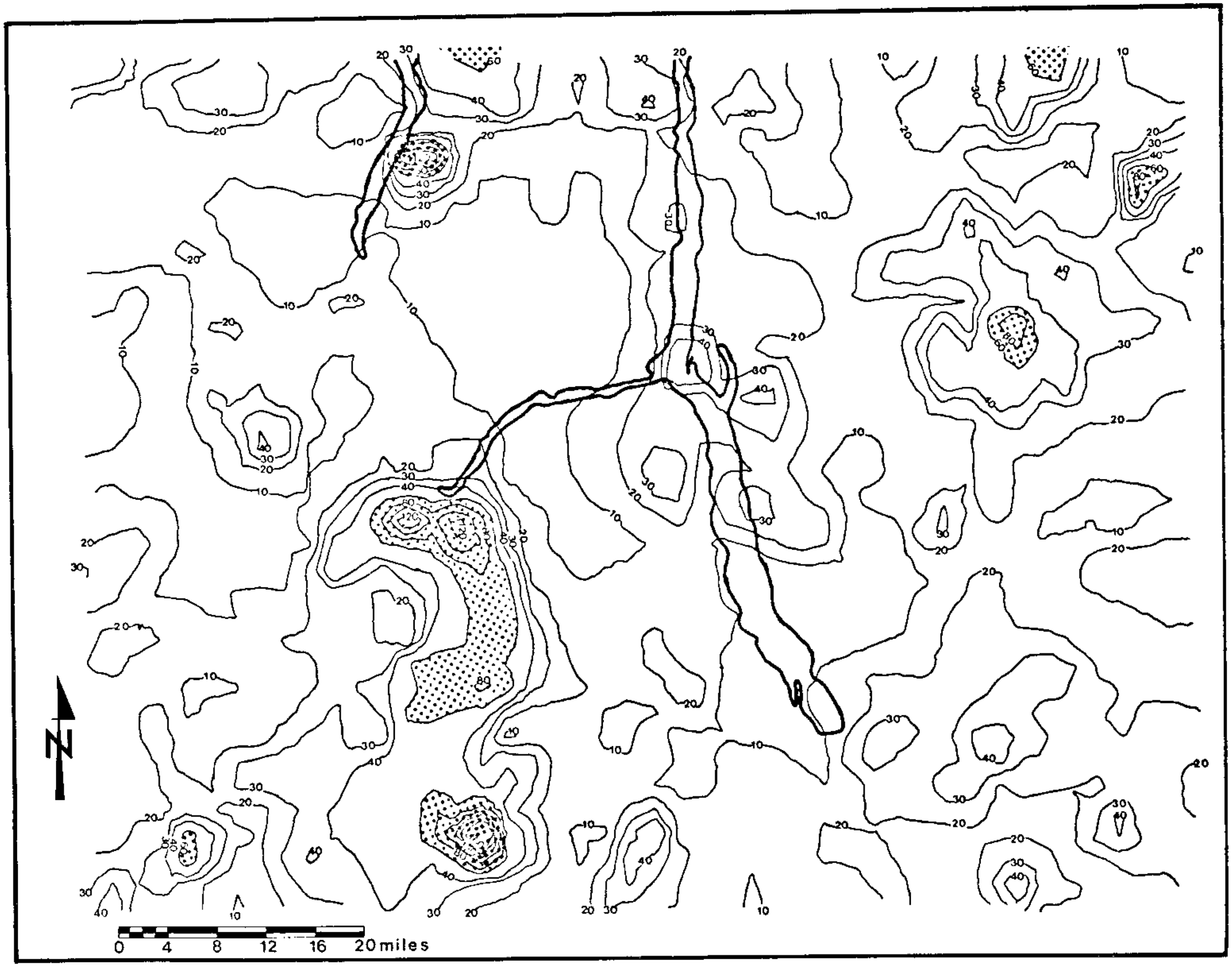

Figure 38. Redraughted rolling mean map for Cu in stream sediments, NTS map-area 82F high areas (>60 ppm are shaded). Heavy lines in centre outline Kootenay Lake, and in the northwest, Slocan Lake.

OTHER INVESTIGATIONS

EVALUATION PROCEDURE FOR GEOCHEMICAL DATA URANIUM RECONNAISSANCE PROGRAM (82F)

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ABSTRACT

Our preliminary studies indicate that a useful procedure for evaluating regional multi-element geochemical data, such as those obtained during the joint Federal-Provincial Uranium Reconnaissance Program, is a systematic application of readily available standard procedures as follows:

(1) Sorting of data into provenance groups based on predominant rock type of the provenance region of each sample;
(2) Evaluation of log probability graphs of each element and pH in each provenance group;
(3) Qualitative evaluation of a correlation matrix for data in each provenance group;
(4) Multiple regression studies for each provenance group of data using as successive dependent variables those elements of particular interest.

In addition, moving average maps have proved useful in making regional comparisons of element distribution patterns and general geology.

Additional studies will involve more widespread application of these procedures, the use of multivariate statistical methods, and further subdivision of the data base in terms of field parameters.

INTRODUCTION

We are in the process of conducting an examination of regional stream geochemical data obtained during a joint Federal-Provincial Uranium Reconnaissance Program of NTS areas 82 F and K released in 1978. The purposes of our study are to evaluate the usefulness of individual variables coded in the course of these surveys, to develop a statistical procedure for extracting useful information from the data, and to ultilize the data base as an effective means of defining problems of geological interest that warrant further investigation. Our work is developmental in nature and is confined to data for NTS map-area 82F. Initial work has emphasized a routine approach to both subjective and statistical evaluation of the data. A brief outline of initial procedures and typical results obtained form the basis of this report.

Geochemical data from the Uranium Reconnaissance Program were made available to us on magnetic tapes by the British Columbia Ministry of Energy, Mines and Petroleum Resources. Examination of various published compilations of these data (for example, Uranium Reconnaissance Program, open file data) led to

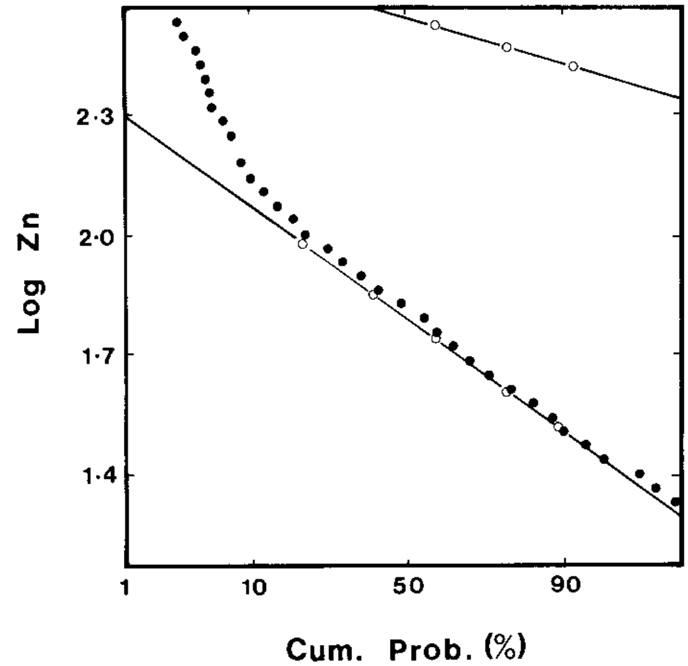

Figure 39. Log probability plot of 515 Zn values for steam sediments from areas underlain by granitic rocks (GRNT-35) in NTS map-area 82F. Black dots are original data, open circles are construction points for partitioning, and sloping straight lines are assumed lognormal populations comprising data set. To a first approximation the lower population can be thought of as background and the upper population can be considered anomalous. The two populations are separated effectively by a threshold of 210 ppm Zn.

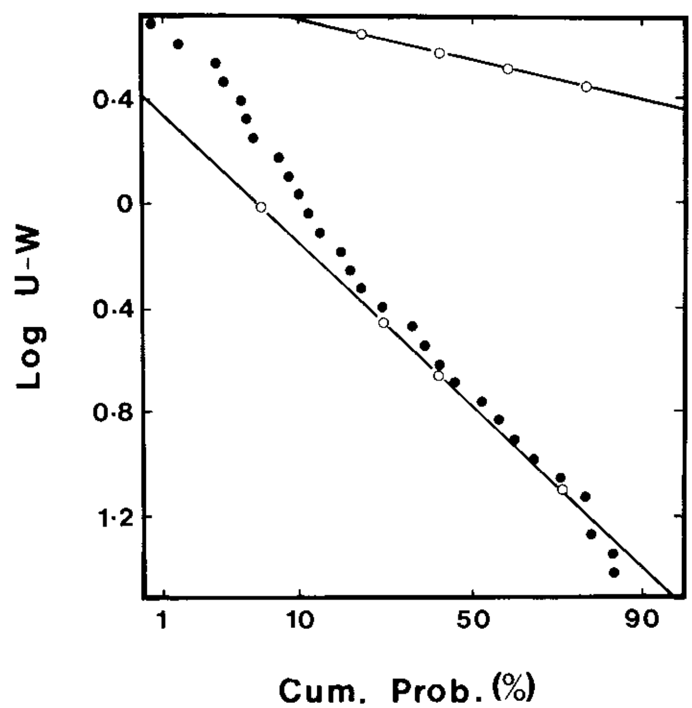

Figure 40. Log probability plot of uranium in water (U-W) for 515 sample sites underlain predominantly by granitic rocks (GRNT-35) in NTS map-area 82F. Black dots are original data, open circles are construction points for partitioning, and sloping lines are assumed lognormal populations comprising the data set. To a first approximation the lower population can be considered background and the upper population can be considered anomalous. A threshold of 2 ppb U separates the two populations.

the selection of data from map-area 82F as the basis for most of our studies. Our preliminary evaluation procedure then developed as follows:

(1) Production of machine-contoured moving average maps;
(2) Sorting of data on the basis of dominant rock type in the provenance region of each water or stream sediment sample;
(3) Interpretation of probability graphs obtained separately for each continuous variable for each provenance group of data;
(4) Linear correlation studies within each provenance group of data;
(5) Multiple regression analysis for specific dependent variables within each provenance group of data.

Additional multivariate statistical studies will be done in the future.

MOVING AVERAGE MAPS

We have examined moving average maps for all variables for which data are available. A moving average map is generally obtained from weighted averages of all values in a window or cell, assigning this average to the cell centre, and repeating the procedure for a network of cells over the data field. Purpose is two-fold: (1) to smooth some of the local variability in the data, and (2) to produce a regular grid of smoothed data that is amenable to straightforward contouring procedures. In constructing such maps three parameters can be varied: averaging procedure (weighting), the size and shape of the window in which data are averaged, and the amount of overlap of adjoining windows. There are no set rules in defining these variables but an important control is the mean spatial sample density and the uniformity of geographic distribution of sample sites. Uranium Reconnaissance Program samples have, in general, been collected to a uniform sample density of close to 1 per 12.5 square kilometres; consequently, 12.5 square kilometres is a minimum window size that would produce little in the way of smoothed data. On the other hand, with too large a window extreme smoothing is obtained with substantial loss of information. After several trials we settled on a 7-kilometre by 7-kilometre cell with 50 per cent overlap. Moving average maps were prepared for all elements. Examination of these maps (Fig. 38) led to the following general conclusions for map-area 82F (west half):

(1) Ni and Co highs correlate generally with volcanic terranes such as the Rossland Formation and to a lesser extent fine-grained clastic sequences such as the Slocan Group;
(2) U and Mo highs are mostly confined to local areas underlain by plutonic rocks of Mesozoic and Tertiary ages;
(3) Zn, Ag, and Pb have comparable distribution patterns with highs that correlate closely with known mineralized areas such as Slocan camp, Salmo area, Rossland camp, etc.;
(4) Cu highs correlate closely with the Rossland Formation and to a lesser extent with Slocan Group;
(5) Mn highs clearly are mostly related to known areas of Zn-Ag-Pb mineralization;
(6) High concentrations of U in water and F in water are similar and occur sporadically in acid to intermediate plutonic rocks, especially the western and southwestern parts of the Nelson batholith;
(7) Large areas of high Fe values correspond to terrane underlain by volcanic rocks such as the Rossland Formation.

Of course, there are local departures from these generalizations that warrant more detailed study. Compared to the original open file NTS map-area, the rolling mean maps permit rapid assessment of regional

TABLE 1. MEANS AND STANDARDS

Variable	$\bar{x}$	s
Zn	92.33	118.9
Cu	14.34	19.89
Pb	24.51	44.05
Ni	13.75	18.40
Co	6.20	3.41
Ag	0.21	0.501
Mn	439.1	254.6
Fe	1.62	0.538
Mo	1.59	1.32
U	23.8	40.3
U–W	0.47	0.921
F–W	92.6	12.18
pH	7.31	0.409

TABLE 2. MEANS AND STANDARD DEVIATIONS FOR TWO MAIN pH GROUPS LOG TRANSFORMED DATA, GRNT–35, 82F

Variable	Original Units*	Slightly Alkaline (n = 405)		Slightly Acidic (n = 101)	
		$\bar{x}$	s	$\bar{x}$	s
Zn	ppm	1.873	0.272	1.709	0.252
Cu	ppm	1.042	0.312	0.937	0.308
Pb	ppm	1.189	0.396	1.053	0.349
Ni	ppm	0.954	0.419	0.792	0.458
Co	ppm	0.742	0.229	0.686	0.274
Ag	ppm	–0.837	0.312	–0.944	0.168
Mn	ppm	2.605	0.201	2.508	0.245
Fe	per cent	0.194	0.150	0.141	0.175
Mo	ppm	0.116	0.210	0.189	0.235
U	ppm	1.147	1.417	1.094	0.433
U–W	ppb	–0.704	0.567	–0.841	0.609
F–W	ppm	1.791	0.402	1.561	0.456
pH	pH	7.44	0.28	6.72	0.18

*All variables except pH have been $\log_{10}$ transformed.

patterns and interelement comparisons. Loss of detail through smoothing is a disadvantage that can be offset by the use of residual maps that we have not yet produced.

SIMPLE STATISTICS

For all Uranium Reconnaissance Program geochemical samples the predominant rock type in the provenance areas of samples has been coded. Data were first sorted on the basis of these provenance groups and in subsequent statistical evaluation these groups were treated separately. The basic assumption here is that for most samples the abundant rock type in the provenance area will exert a dominant control on the chemical character of derivative stream sediments and that different chemical characteristics will result from different chemical variables for provenance group GRNT-35 for map-area NTS 82F.

Means and standard deviations of continuous variables for data set GRNT-35 are listed in Table 1. For the most part standard deviations are as large or larger than their corresponding means indicating highly skewed distributions. Such distributions commonly arise from a lognormal form or from a combination of populations. Consequently, the forms of density distributions must be examined individually for each element. The methodology we have adopted is a subjective approach involving use of probability plots (Sinclair, 1976).

PROBABILITY PLOTS

Three examples illustrate the types of graphs that are common and some of the apparently straightforward interpretations that result.

The probability graph for Zn (Fig. 39) is typical of those obtained for many elements. A centrally positioned sinuous cumulative curve has been partitioned into two lognormal populations that are distinguished effectively with a threshold of 210 ppm Zn (Sinclair, 1974). The large, lower population can be interpreted as normal background and the smaller, upper population can be considered anomalous.

Figure 40 is a somewhat comparable probability plot for uranium in water, also for areas underlain predominantly by rock type GRNT-35, and it shows two populations separated by a threshold of 2 ppb uranium. In both these examples possible explanations of the high or anomalous populations include:

(1) Mineralization in the sample provenance area;
(2) Incorrect designation of principal rock type (that is, some high values for GRNT-35 might be low for another provenance group);
(3) Peculiar local chemical conditions favouring a higher than normal dissolution rate for the metal(s) in question;
(4) Contamination by man in the form of industrial waste, sewage, fertilizers;
(5) Biased sampling of stream sediments (for example, an over-abundances of heavy minerals in the sample selected).

Despite the various conditions that might give rise to high values, the methodology leads to recognition of a significant threshold above which values require an explanation and therefore demand further investigation. A useful procedure is to colour-code the relatively small group (about 25 sample sites in the above two cases) of high values on a map and interpret them individually and collectively in the light of known geology.

TABLE 3. CORRELATION MATRIX FOR ORIGINAL DATA, GRNT–35, 82F

	Zn	Cu	Pb	Ni	Co	Ag	Mn	Fe	Mo	U	U–W	F–W
Cu	0.220											
Pb	0.534	0.173										
Ni	0.104	0.182	0.082									
Co	0.198	0.506	0.090	0.675								
Ag	0.366	0.207	0.615	0.020	0.073							
Mn	0.368	0.219	0.264	0.084	0.339	0.321						
Fe	0.274	0.321	0.164	0.331	0.683	0.196	0.510					
Mo	0.185	0.106	0.124	0.044	0.140	0.069	0.206	0.162				
U	0.084	−0.030	0.068	−0.025	−0.134	0.044	0.126	−0.111	0.259			
U–W	−0.011	−0.071	−0.037	−0.083	−0.215	−0.029	−0.048	−0.223	0.033	0.509		
F–W	0.089	0.004	0.002	−0.008	−0.135	0.021	−0.002	−0.134	0.116	0.246	0.453	
pH	0.220	0.135	0.081	0.081	0.101	0.108	0.196	0.221	−0.068	0.076	0.212	0.269

A third example is shown to illustrate a somewhat more complex situation of data interpretation. In the case of pH (Fig. 41) three populations seem to be present. The high pH population represents only 1.4 per cent of the data (about seven values greater than pH 8.1). The other two abundant populations overlap somewhat but can be separated reasonably well at a threshold of 7.0. We can therefore designate these two abundant populations as weakly acid and weakly alkaline. Because acid and alkaline conditions represent fundamentally different controls for some metals we subdivided data for GRNT-35 into pH subgroups using the thresholds determined from our probability graph analysis, and examined metal distributions within each of the two major pH groups (weakly acidic and weakly alkaline). Means and standard deviations of all variables in each group are given in Table 2. A systematic difference is apparent for most means; stream sediments and waters from the weakly alkaline group contain higher metal values in most cases than do those from the weakly acidic group. The most obvious exception is molybdenum which shows the opposite relationship. These results are as might be expected and indicate that different background element abundances are to be expected even within a single provenance group of data, depending on the pH category of individual samples.

A further evaluation of these data involved examination of probability graphs for each metal in each of the two principal pH groups. These plots indicated that only rare anomalous samples occur within the weakly acidic pH population, or, in other words, nearly all the anomalous samples recognized in evaluating the total data set for provenance group GRNT-35 are for samples from a weakly alkaline environment.

These three examples illustrate clearly the practical advantages of systematic utilization of probability graphs for interpretations of geochemical data such as those obtained from the Uranium Reconnaissance Program. Of course, the intercorrelations among variables are obscured, considered only in a cursory or subjective manner, or are ignored by such methods. Furthermore, this type of analysis does not lead readily to the recognition of anomalous values that occur below the selected thresholds. More sophisticated analysis is required to achieve these ends.

Our probability plots differ from those on maps published by the Geological Survey of Canada because we divided data into provenance groups whereas they did not. It is also important to realize that probability graph analysis is not possible for some provenance groups because of too few data. At least 50 data values, and preferably 100 or more, are desirable for probability graph analysis.

CORRELATION

A correlation matrix was obtained for chemical data for sediments and water and is reproduced in Table 3. All significant correlations in this case are positive.

Molybdenum and pH are either uncorrelated with, or weakly correlated with other elements. Strong correlations, defined arbitrarily as those with a correlation coefficient of 0.5 or greater can be used to define four groups of inter-related elements as follows:

(1) Pb-Zn-Ag
(2) Co-Cu-Ni
(3) Co-Fe-Mn
(4) U-U_w

These are expected element groupings from the point of view of common geochemical associations.

Stream width and stream depth have been omitted from the correlation table because they have such low correlation coefficients with the elements represented. Both of these variables have very weak negative

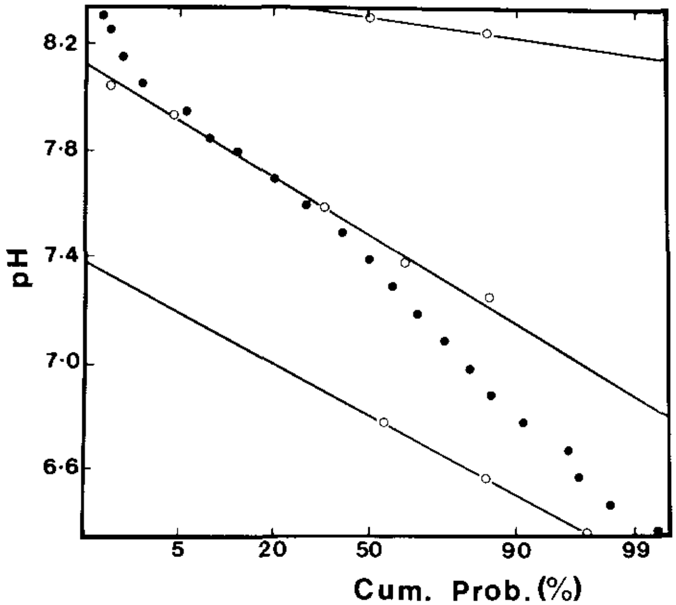

Figure 41. Probability plot of pH values for 515 stream sediment sites from drainage basins underlain by GRNT-35 (Mesozoic granitic rocks) in NTS map-area 82F. Filled circles are original data, open circles are construction points for partitioning, and the three sloping straight lines represent three interpreted normal populations of pH values.

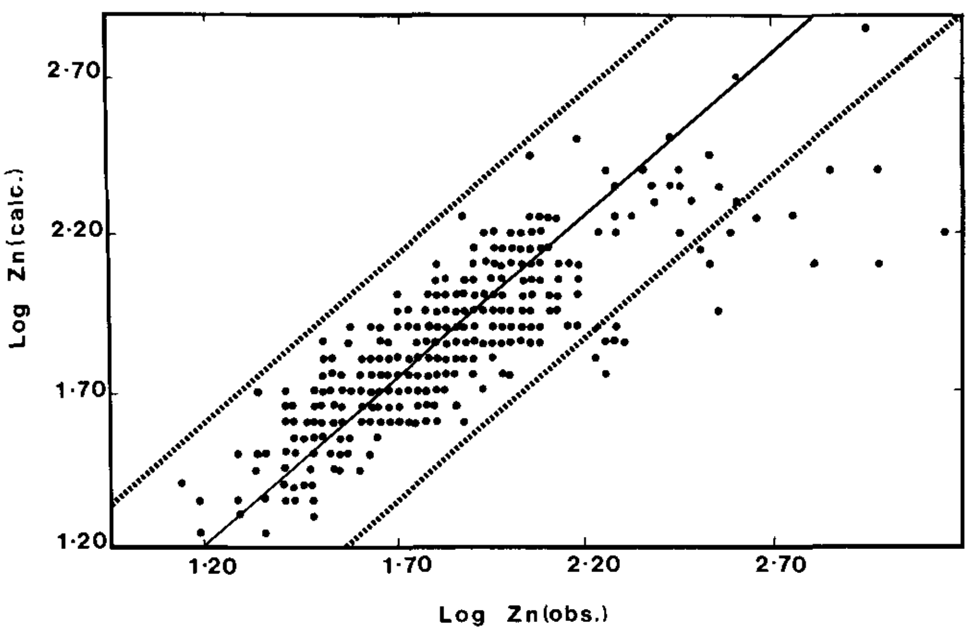

Figure 42. Plot of calculated log (Zn), using multiple regression equation of Table 4 versus observed value of log (Zn). Traced from computer print-out, thus abscissa and ordinate are slightly different scales. Plotted values scatter about the central line representing the 'expected relationship.' Fringing lines contain 95 per cent of the values. Points outside the 95-per-cent confidence zone are arbitrarily taken to be anomalous.

correlations with U-W and F-W and pH (maximum r = 0.196) but correlate strongly with each other (r = 0.461).

False correlation is a common problem in treating geostatistical data, commonly arising from a few outlying values that are not representative of the bulk of data (for example, Chapman, 1976). To guard against such a likelihood scatter diagrams are useful.

MULTIPLE REGRESSION

Multiple regression is used to find a systematic relationship between a single (dependent) variable and a combination of other (independent) variables. The method has been applied with apparent success to a wide variety of types of multivariate geochemical data (for example, Spilsbury and Fletcher, 1974). A procedure that we have found particularly useful is backwards stepwise regression (Le and Tenisci, 1978) in which a multivariate relationship is established as above, and individual variables are dropped successively if their coefficients are not significantly different from zero as some preset level of significance (we used 0.05). The method does not include redundant variables, that is, those that are linear combinations of other variables. All variables except pH have been log transformed for this analysis. Results for several dependent variables are given in Table 4. By far the best statistical relationship of all those listed is that for Co as the dependent variable. If data for other elements are used to calculate the expected Co content and a log (Co) value of 0.779 (that is, about 6 ppm Co) is obtained, the true value has a 68-per-cent chance of lying in the range 0.681 to 0.877 (that is, from 4.8 to 7.5 ppm Co).

The relationship for log (Zn) as a dependent variable will serve to illustrate the practical applications of the multiple regression approach to data analysis. For each sample the raw data can be used in the log (Zn) equation to **calculate** a value of the independent variable (Y_c) which can be compared with the **observed** value (Y_o). The difference between a calculated and observed values for a single sample represents a residual (d):

$$d = Y_o - Y_c$$

If one can assume that the calculated values represent an average background relationship, then high positive residuals are anomalous in Zn. Similarly, high negative residuals indicate abnormally high amounts of independent variables with positive coefficients and/or abnormally low amounts of independent variables with negative coefficients. Consequently, all samples that depart markedly from the general multivariate background model are unusual and warrant detailed study. Figure 42 is a plot of calculated versus observed log (Zn) values based on the relationship of Table 4. Ideally the observed and calculated values would plot on the central line; in fact, they scatter such that about 95 per cent of samples should plot in the field between the two bounding curves. Points outside this 95-per-cent confidence field represent anomalous samples based on an arbitrary definition. Although we have not done so here, it is convenient in practice to show on diagrams such as Figure 42 the thresholds determined for univariate data from probability graphs for example.

CONCLUSIONS

Our evaluation of geochemical data from the Uranium Reconnaissance Program in British Columbia is in its early stages but already a useful systematic procedure for analysing the data has emerged. Future work will involve applications of multivariate statistical procedures to the data, an evaluation of the usefulness of individual discrete variables, and an evaluation of problems arising from the study and warranting further investigation.

TABLE 4. EXAMPLES OF MULTIPLE REGRESSION
GRNT–35, 82F

Dependent Variable: log (Zn)
$R^2 = 0.684$
Standard Error = 0.1598
log (Zn) = 0.3040 + 0.0414 pH + 0.1007 log (F–W) + 0.2334 log (Fe)
+ 0.2629 log (Mn) + 0.1428 log (Ag) + 0.3122 log (Pb)
+ 0.0939 log (Cu)
Rejected variables are: Ni, Mo, U, U–W, Co

Dependent Variable: log (Cu)
$R^2 = 0.593$
Standard Error = 0.2020
log (Cu) = 0.0020 + 0.0651 log (F–W) – 0.0807 log (U) + 0.0927 log (Mo)
– 0.3816 log (Fe) + 0.0770 log (Ag) + 0.8098 log (Co)
+ 0.1252 log (Ni) + 0.2245 log (Zn)
Rejected variables are: Pb, Mn, U–W, pH

Dependent Variable: log (Co)
$R^2 = 0.834$
Standard Error = 0.0983
log (Co) = 0.2078 – 0.0708 log (F–W) – 0.0274 log (U) + 0.6707 log (Fe)
+ 0.0983 log (Mn) + 0.2080 log (Ni) – 0.0718 log (Pb)
+ 0.1886 log (Cu)
Rejected variables are: Zn, Ag, Mo, U–W, pH

Dependent Variable: log (Mn)
$R^2 = 0.577$
Standard Error = 0.1411
515 observations
log (Mn) = 1.3557 + 0.0541 pH – 0.0483 log (U–W) + 0.1229 log (U)
+ 0.4004 log (Fe) + 0.2688 log (Co) – 0.1125 log (Ni)
+ 0.0649 log (Pb) + 0.2280 log (Zn)
Rejected variables are: Ag, Mo, F–W

Dependent Variable: log (U)
$R^2 = 0.556$
Standard Error = 0.2840
515 observations
log (U) = 1.1140 – 0.1277 pH + 0.0767 log (F–W) + 0.4331 log (U–W)
+ 0.3733 log (Mo) + 0.5089 log (Mn) – 0.3404 log (Co)
+ 0.1171 log (Ni) + 0.1169 log (Pb) – 0.2232 log (Cu)
Rejected variables are: Ag, Zn, Fe

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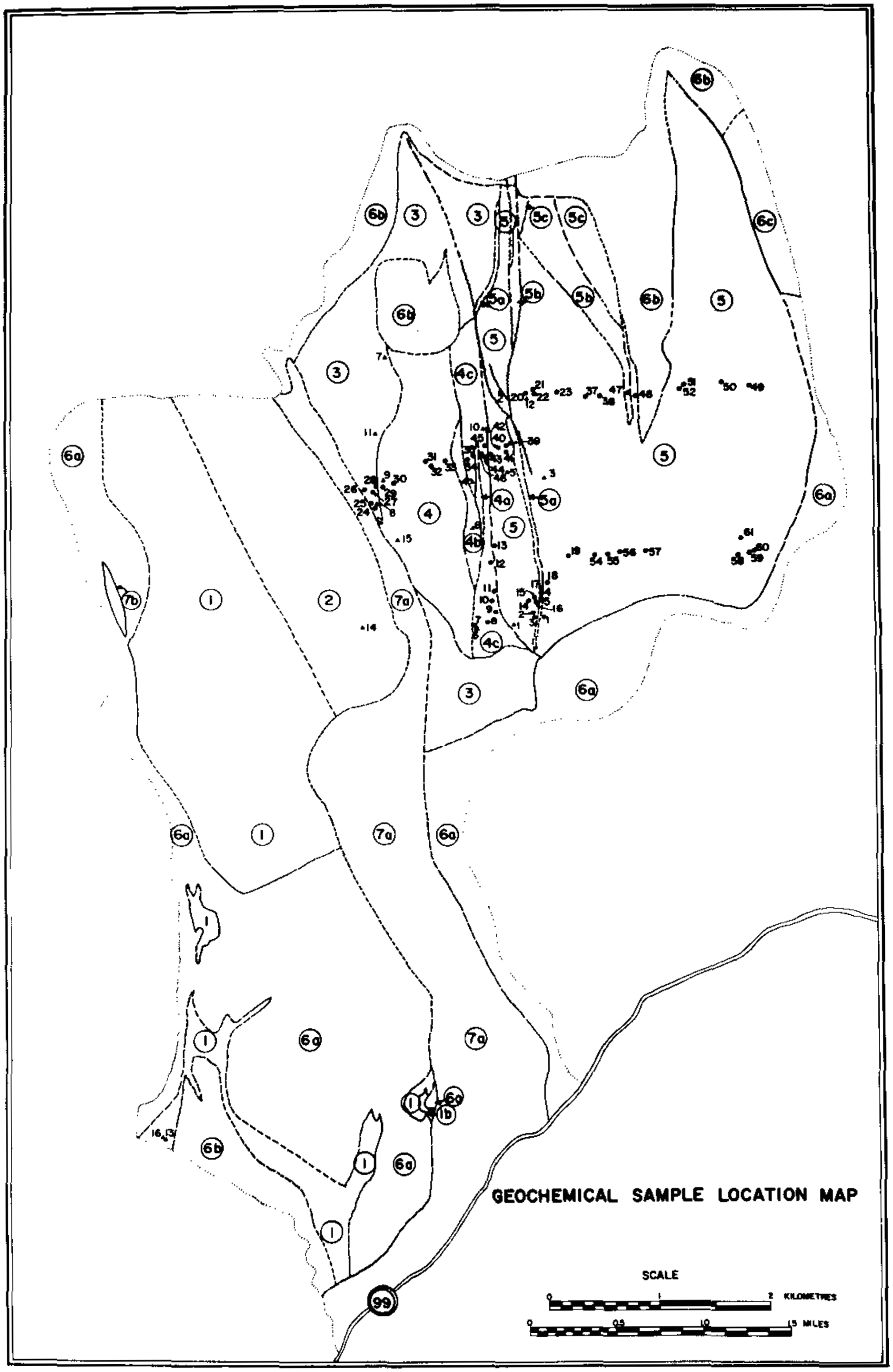

Figure 43. General location of geochemical samples. Circled numbers represent geological units of Miller and Sinclair (1978); filled triangles are 'whole rock' sample sites; and filled circles are 'minor metal' or lithogeochemistry sample sites.

SURFACE LITHOGEOCHEMISTRY, NORTHAIR MINE

(92J/3W)

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INTRODUCTION

A lithogeochemical study in the vicinity of Northair Mines Ltd.'s Callaghan Creek property was undertaken concomittently with a geological mapping program in the area (Miller and Sinclair, 1978 and 1979). Several recent works indicate that readily identifiable geochemical signatures exist in comparable volcanic rock sequences containing polymetallic sulphide deposits (Nicol, *et al.,* 1977; Cagatay, *et al.,* 1977). The apparently layered nature of the Northair deposits and their overall similarity to exhalite deposits suggested that a surface lithogeochemical study of the area was warranted. Consequently, the orientation survey reported here was undertaken to provide some insight into the exploration potential of the method as well as to outline general geochemical characteristics of the mineralized volcanic sequence.

General geology of the Callaghan Creek area is described by Miller and Sinclair (1978) who recognize two principal fragmental volcanic units underlying the Northair property. These rocks are thought to correlate with the Lower Cretaceous Gambier Group to the south (Roddick and Woodsworth, 1975).

SAMPLING PROGRAM

A sampling program was undertaken in the summer of 1978 along two traverse lines confined to lithological units 3 and 5 inclusive as shown on Figure 43. The two traverse lines were selected so that one crossed an ore zone (the Warman zone) approximately at right angles and the second crossed much the same lithological section but in an apparently barren area south of the southernmost extension of known ore in the Manifold zone. Exploration drilling in this latter area confirmed the apparent absence of sulphides of economic interest. Consequently, the two traverses represent a mineralized section and an apparently unmineralized section.

Sample spacing and location depended critically on locations of outcrops. Thus, spacing as indicated on Figure 43 was irregular and samples had to be taken as much as 200 metres off the profile location.

Sampling procedure involved taking three large fist-sized specimens at 1-metre intervals across the regional strike of the units. These samples were submitted to the Analytical Laboratory of the Geological Division, Mineral Resources Branch, Ministry of Energy, Mines and Petroleum Resources where they were crushed, mixed, and reduced in volume for analysis. In this way we hoped to introduce some rigor into the sampling procedure and to reduce an anticipated high local sampling variability.

Samples were analysed for Ag, Pb, Zn, Cu, Mn, Fe, Ba, Ca, Rb, Sr, and K by routine atomic absorption techniques. Samples were taken in a comparable manner from all five rock units of Miller and Sinclair (1979) for whole rock chemical analysis.

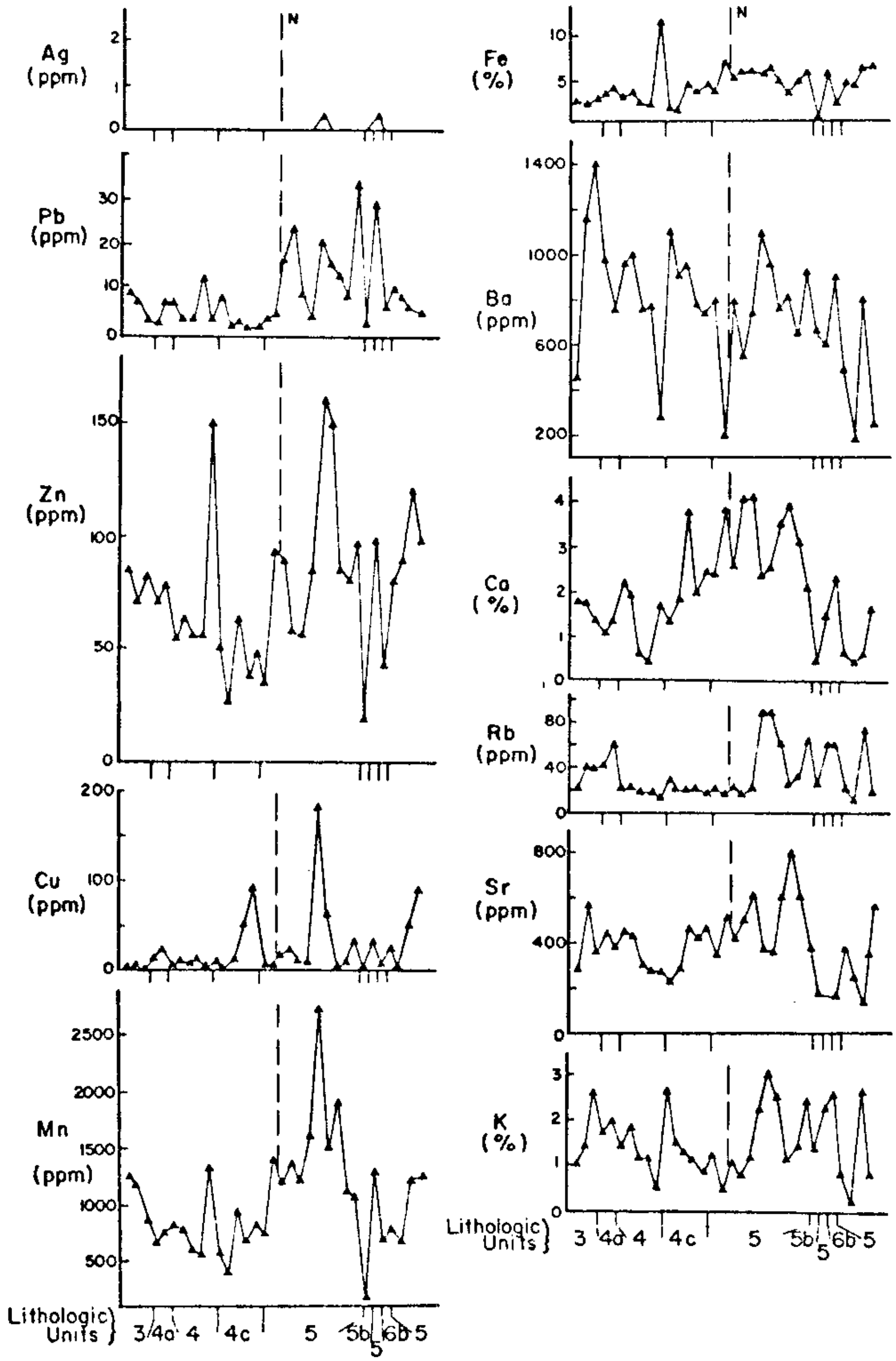

Figure 44. Metal profiles (west on left) for northern traverse through Warman zone whose location is shown by a dashed line marked N. Numbers along the abscissa refer to lithological units of Miller and Sinclair (1978, 1979).

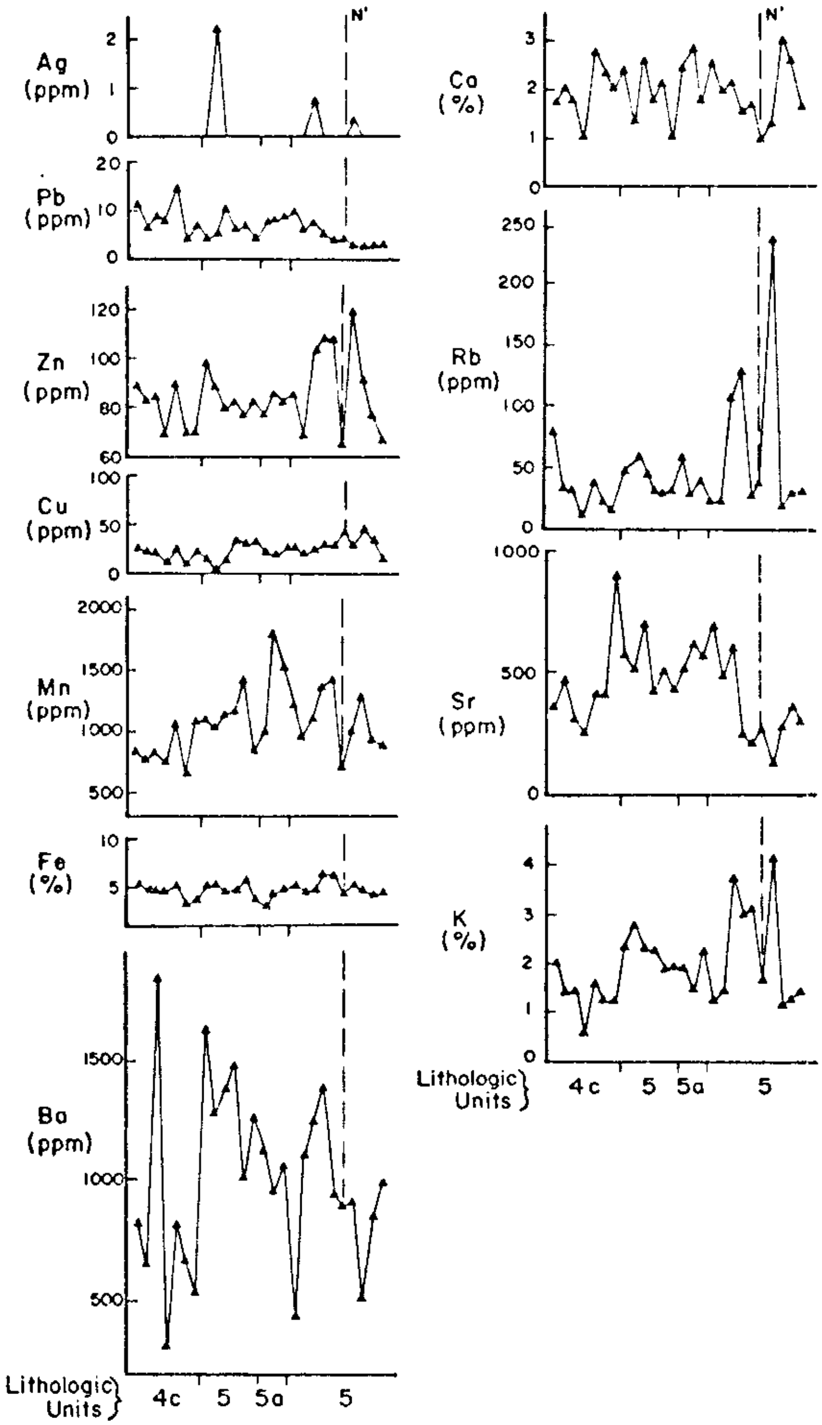

Figure 45. Metal profiles for southern (unmineralized ?) traverse. The projected position of the Manifold zone is shown by a dashed line marked N'.

TABLE 1. WHOLE ROCK GEOCHEMISTRY

Sample No.	SiO_2 per cent	Al_2O_3 per cent	Fe_2O_3 per cent	MgO per cent	CaO per cent	Na_2O per cent	K_2O per cent	TiO_2 per cent	MnO per cent	L.O.I.* per cent	Total per cent
1	54.04	19.20	7.33	4.18	7.33	3.977	1.983	0.790	0.170	1.38	100.38
2	53.19	18.58	7.61	4.48	5.69	3.779	2.886	0.845	0.168	2.11	99.34
3	58.89	17.58	6.71	2.50	4.28	2.514	2.450	0.643	0.199	2.74	98.50
4	63.76	16.30	4.30	1.92	3.39	5.484	0.842	0.426	0.160	2.51	99.09
5	55.92	17.96	5.81	3.06	5.33	6.018	0.791	0.574	0.137	3.56	99.16
6	52.95	18.07	7.46	3.75	5.55	5.212	1.073	0.754	0.248	3.73	98.80
7	53.23	18.41	7.79	5.20	5.08	4.033	2.159	0.776	0.123	2.18	98.99
8	59.35	16.59	6.04	3.22	2.28	5.533	0.898	0.703	0.149	3.07	97.83
9	63.90	16.74	4.59	2.57	1.47	5.119	1.905	0.504	0.108	2.29	99.20
10	56.67	20.25	5.06	2.75	4.37	4.373	1.336	0.610	0.091	2.68	98.19
11	56.25	20.28	8.53	1.55	6.51	2.631	0.283	0.663	0.215	2.23	99.14
12	55.16	19.07	8.11	2.71	4.45	4.104	1.612	0.792	0.161	2.92	99.10
13	41.54	18.74	10.22	7.26	5.58	0.566	2.889	1.083	1.026	9.06	97.96
14	51.38	21.41	7.46	3.57	5.56	2.951	2.843	0.796	0.137	3.36	99.47
15	63.23	16.42	4.06	2.31	4.44	3.463	1.685	0.457	0.075	3.22	99.36
16	70.64	14.71	1.75	0.56	2.40	0.334	4.225	0.275	0.136	3.82	98.85

*Loss on ignition.

TABLE 3. MEANS AND STANDARD DEVIATIONS LITHOGEOCHEMICAL DATA
(n = 59)

Name	Arithmetic $\bar{x}$	Arithmetic s	Logarithmic $\bar{x}$	Logarithmic s
Ba	868.8	346.1	2.897	0.2108
Ca	2.012	0.9250	0.2479	0.2419
Cu	25.29	28.26	1.204	0.4396
Fe	4.836	1.616	0.6601	0.1535
K	1.744	0.8486	0.1836	0.2452
Mn	1 047	407.6	2.986	0.1873
Pb	8.407	6.693	0.8243	0.2876
Rb	40.92	35.76	1.509	0.2821
Sr	413.5	168.0	2.578	0.1923
Zn	81.14	27.13	1.883	0.1606

RESULTS

Analytical data are listed in Table1 for whole rock analyses and in Table 2 for lithogeochemical analyses. The lithogeochemical data are plotted as profiles on Figures 44 and 45. Where sample sites are off the traverse line they have been projected along the regional strike to the line of profile, a procedure that adds to the apparent local variability but which should not cloud any significant trends that exist in the sequence. A few systematic patterns exist which will be discussed with reference to profile I (Fig. 44).

Lead shows a sharp increase in mean value and variability in Unit 5 compared with the underlying Unit 4. Rubidium has a pattern not unlike lead but the division between low and high values is slightly higher in the section than is the case for lead. The pattern for potassium follows those of lead and rubidium but is somewhat more vague. Iron also has a pattern comparable to that of lead. Both manganese and zinc have low values in the upper part of Unit 4 that contrast with higher values in the lower part of Unit 5. Their patterns are both more erratic and more gradational than those of lead, iron, and so on. Despite the local variability shown in all these profiles it is apparent that a significant change in rock chemistry occurs roughly at the contact between Unit 4 (dacitic agglomerate) and Unit 5 (andesitic agglomerate). This result is not so clearly demonstrated in the second profile (Fig. 45).

STATISTICAL ANALYSIS

A correlation matrix of the lithogeochemistry data of Table 2 can be used to classify the elements into groups of correlated variables as follows:

Rb-K-Ba
Sr-Ca-Mn
Zn-Cu-Mn-Fe-(Pb)
Pb-Mn-Fe

These metal associations do not differ greatly for the two principal stratigraphic units underlying the property (Unit 4 and Unit 5 of Miller and Sinclair, 1978) and probably relate to specific minerals such as feldspars and mafic minerals.

Probability graphs (not shown) indicate that all minor elements except calcium and potassium can be considered mixtures of lognormal populations. Calcium and potassium appear to be mixtures of either two normal populations or a combination of normal and lognormal populations. Means and standard deviations for raw data and log transformed data are given in Table 3.

DISCUSSION

Major element analyses indicate the calc-alkaline nature of the mineralized volcaniclastic sequence at Northair Mines Ltd.'s Callaghan Creek property.

The main result of the minor element lithogeochemical study has been to quantify metal abundances in a volcanic rocks sequence that contains polymetallic sulphides in a now disjointed tabular zone parallel to bedding. The rocks do not seem to be abnormal chemically. This orientation survey did not identify particular geochemical signatures near the mineralized zone, perhaps because (1) sample spacing was too wide along traverse lines and (2) there were insufficient sample traverses.

However, the chemical data were successful in pointing to a marked chemical difference between the upper part of Unit 4 and the lower part of Unit 5.

TABLE 2. SURFACE LITHOGEOCHEMICAL DATA, NORTHAIR MINES

		Ag	Ba	Ca	Cu	Fe	K	Mn	Pb	Rb	Sr	Zn
1	+5	<0.3	425	2.62	27	5.07	1.11	1 200	10	24	700	86
2	−5	<0.3	1 500	1.73	35	4.94	2.27	1 144	6	32	415	82
3	−5	<0.3	1 000	2.18	31	5.93	1.92	1 434	7	33	520	59
4	5A	<0.3	1 125	2.41	21	3.29	1.93	1 000	8	60	520	76
5	5A	<0.3	940	2.75	19	4.31	1.43	1 840	8	35	615	86
6	4C	<0.3	660	2.03	23	4.84	1.34	767	7	32	470	83
7	4C	<0.3	825	1.71	26	5.46	2.02	806	12	80	350	88
8	4C	<0.3	1 840	1.80	21	4.69	1.46	800	9	30	300	84
9	4C	<0.3	825	2.79	24	5.32	1.66	1 080	15	40	415	90
10	4C	<0.3	300	0.92	10	4.20	0.55	720	8	10	250	68
11	4C	<0.3	670	2.31	8	3.24	1.25	680	4	20	400	68
12	4C	<0.3	525	1.94	24	3.62	1.20	1 090	7	15	920	70
13	−5	<0.3	1 650	2.40	16	5.04	2.36	1 086	4	46	570	98
14	−5	2.2	1 250	1.26	2	5.28	2.81	1 046	5	52	500	88
15	−5	<0.3	1 365	2.63	16	4.64	2.30	1 128	11	58	700	78
16	−5	<0.3	1 275	0.96	34	3.62	1.90	776	4	36	410	82
17	5A	<0.3	1 075	1.72	25	4.75	2.31	1 514	9	42	560	82
18	+5	<0.3	1 100	1.94	20	4.57	1.46	915	6	26	470	67
19	+5	0.8	1 250	2.19	26	4.90	3.80	1 100	8	108	615	104
20	+5	<0.3	1 100	2.38	9	6.11	2.45	1 616	4	92	365	88
21	+5	0.3	950	2.66	187	6.36	3.13	2 726	22	88	350	164
22	+5	<0.3	770	3.43	60	5.24	2.60	1 452	17	60	590	150
23	+5	<0.3	815	3.97	2	3.97	1.13	1 924	14	22	800	89
24	4A	<0.3	975	1.02	15	4.01	1.71	682	3	40	440	74
25	4A	<0.3	750	1.33	23	4.51	2.03	768	8	64	380	82
26	3	<0.3	460	1.80	2	3.32	1.01	1 268	10	19	275	88
27	3	<0.3	1 150	1.73	5	3.10	1.42	1 172	8	42	570	74
28	3	<0.3	1 400	1.35	3	3.43	2.74	872	4	38	350	86
29	4	<0.3	950	2.22	3	3.65	1.42	814	8	20	450	56
30	4	<0.3	1 000	1.84	11	4.12	1.93	770	4	23	420	68
31	4	<0.3	750	0.57	9	3.26	1.26	620	4	17	300	58
32	4	<0.3	765	0.49	12	2.79	1.18	546	14	18	270	58
33	4	<0.3	280	1.71	41	2.02	0.53	1 362	4	13	270	154
34	4C	<0.3	1 200	1.36	10	2.41	2.75	560	10	31	220	52
35	4C	<0.3	900	1.82	2	2.22	1.49	392	2	20	280	28
37	+5	<0.3	650	3.11	9	5.64	1.38	1 100	9	32	590	83
38	+5	<0.3	925	2.03	35	6.64	2.49	1 040	35	67	380	100
39	−5	<0.3	725	4.11	10	6.36	1.24	1 184	10	23	615	58
40	−5	<0.3	550	4.09	25	6.22	0.72	1 360	25	14	500	60
41	−5	<0.3	790	2.53	19	5.89	1.13	1 140	19	24	405	92
42	−5	<0.3	200	3.94	8	7.93	0.41	1 423	5	17	520	97
43	−5	<0.3	800	2.38	7	4.10	1.32	746	4	21	335	36
44	4C	<0.3	950	3.82	15	5.10	1.29	1 004	4	19	460	68
45	4C	<0.3	775	1.94	55	4.23	1.11	674	2	22	420	40
46	4C	<0.3	740	2.46	94	5.03	0.81	836	2	16	570	52
47	5B	<0.3	650	0.36	5	1.06	1.40	138	2	22	170	20
48	+5	0.3	600	1.47	38	6.55	2.33	1 314	31	62	164	102
49	*5	<0.3	250	1.70	90	6.82	0.82	1 240	5	16	560	98
50	*5	<0.3	800	0.57	52	6.99	3.06	1 214	6	80	125	122
51	*5	<0.3	175	0.47	4	4.91	0.18	670	8	12	230	92
52	*5	<0.3	475	0.60	28	5.12	0.80	780	11	18	380	84
53	6B	<0.3	900	2.44	8	2.96	2.71	680	6	60	160	44
54	+5	<0.3	1 400	1.54	29	6.33	2.93	1 360	5	133	240	108
55	+5	<0.3	950	1.71	29	6.38	3.11	1 430	4	24	205	108
56	+5	<0.3	890	0.96	45	4.56	1.60	684	4	43	275	63
57	+5	0.4	900	1.29	29	5.24	4.31	1 006	3	230	125	120
58	*5	<0.3	500	3.05	46	4.51	1.14	1 310	4	18	275	90
60	*5	<0.3	1 000	1.68	13	4.20	1.47	874	4	27	290	66
61	*5	<0.3	850	2.51	34	4.33	1.28	920	4	28	370	76

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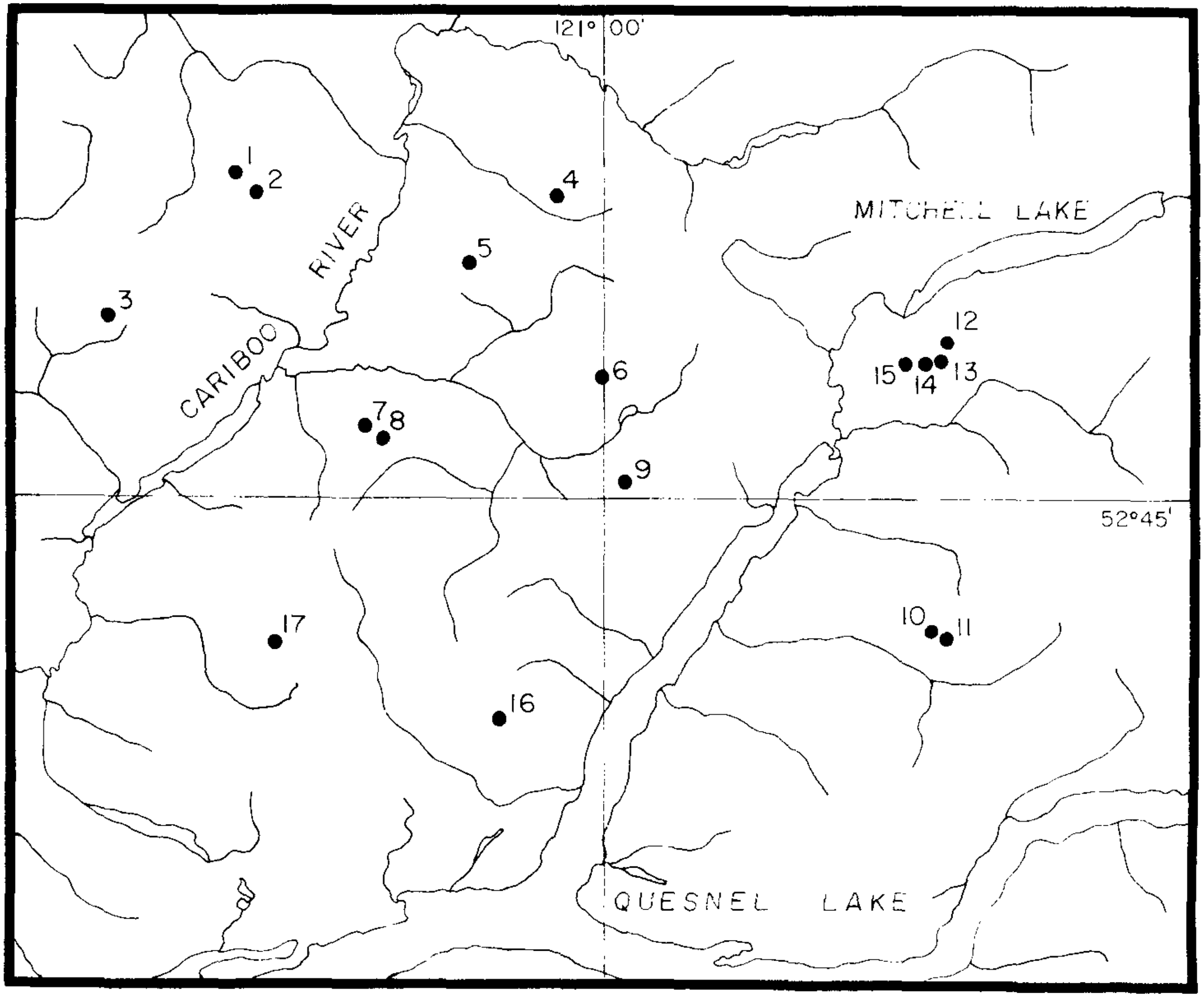

Figure 46. Geographic distribution of specimen locations for the study of fluid inclusions, Cariboo Mountains.

CARIBOO MOUNTAINS PROJECT

(93A/10, 11, 14, 15)

By H. J. Greenwood, J. V. Ross, D. Klepacki, and J. Getsinger
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In 1978 the British Columbia Ministry of Energy, Mines and Petroleum Resources funded reconnaissance work by H. J. Greenwood and J. V. Ross in the Cariboo Mountains, and in 1979 funded the first full season of fieldwork. The goal of the work is to refine the metamorphic, structural, and stratigraphic framework of the northern Cariboo Mountains. The area is of interest because of several unresolved problems in the stratigraphy of the Cariboo Group, the base-metal content of some of the stratigraphic units, and because of the existence of numerous interesting metamorphic problems. None of these features can be adequately studied without reference to each of the others. This report takes the form of three short summaries of work completed and in progress, deriving from field seasons 1978 and 1979.

FLUID INCLUSIONS IN THE CARIBOO MOUNTAINS

In the summer of 1979 during reconnaissance and planning work 27 specimens were collected from 16 localities in the Cariboo Mountains (Fig. 46). Of these 27 specimens, 17 were taken from large and small quartz veins folded with and crosscutting the metamorphic and sedimentary structures. The remaining specimens have been studied petrographically and broadly confirm results of Campbell, Mountjoy, and Young (1973), *who indicate a steadily increasing metamorphic grade from chlorite and biotite schists* in the northwest to staurolite, kyanite, sillimanite schists in the southeast. The quartz veins have been examined for fluid inclusions and without exception all specimens are rich in fluid inclusions. The inclusions are small, ranging from 10 to 60 microns in diameter, and all have at least two fluid phases. Most inclusions consist of two fluids, a water-rich liquid and a carbon dioxide-rich gas, the gas amounting to 5 to 10 per cent by volume of the inclusion. One specimen from locality 9 (Fig. 46) contains three fluids, a water-rich liquid, a carbon dioxide-rich liquid, and a carbon dioxide-rich gas. This inclusion is approximately 60 per cent carbon dioxide overall, while the others range up to a maximum of 10 per cent. No inclusion was seen to contain solid daughter minerals and to date it has not been possible to determine homogenization temperatures due to the small size of the inclusions. The present limited sampling gives no clear indication of gradient in proportions of CO_2/H_2O in the metamorphic fluid, but it is hoped that more extensive sampling coupled with measurements on the heating/cooling stage will show good correlation between the properties of the fluids and the conditions indicated by the metamorphic mineral assemblages.

MAEFORD LAKE AREA (93A/14, 15)

A study of the stratigraphy and structure of the Cariboo Group in the vicinity of Maeford Lake was undertaken *during the summer of 1979 by D. Klepacki (Fig. 47). Detailed mapping of 85 square kilometres at* a scale of 1:25 000 and later petrologic and structural analysis will form the basis of an M.Sc. thesis at the University of British Columbia.

Previous regional mapping of the area was done by A. Sutherland Brown (1963) and later by R. B. Campbell (1978). More detailed work immediately to the north has been done by Mansy (1970) and Struik (1979). The work reported here extends detailed coverage south toward Quesnel Lake.

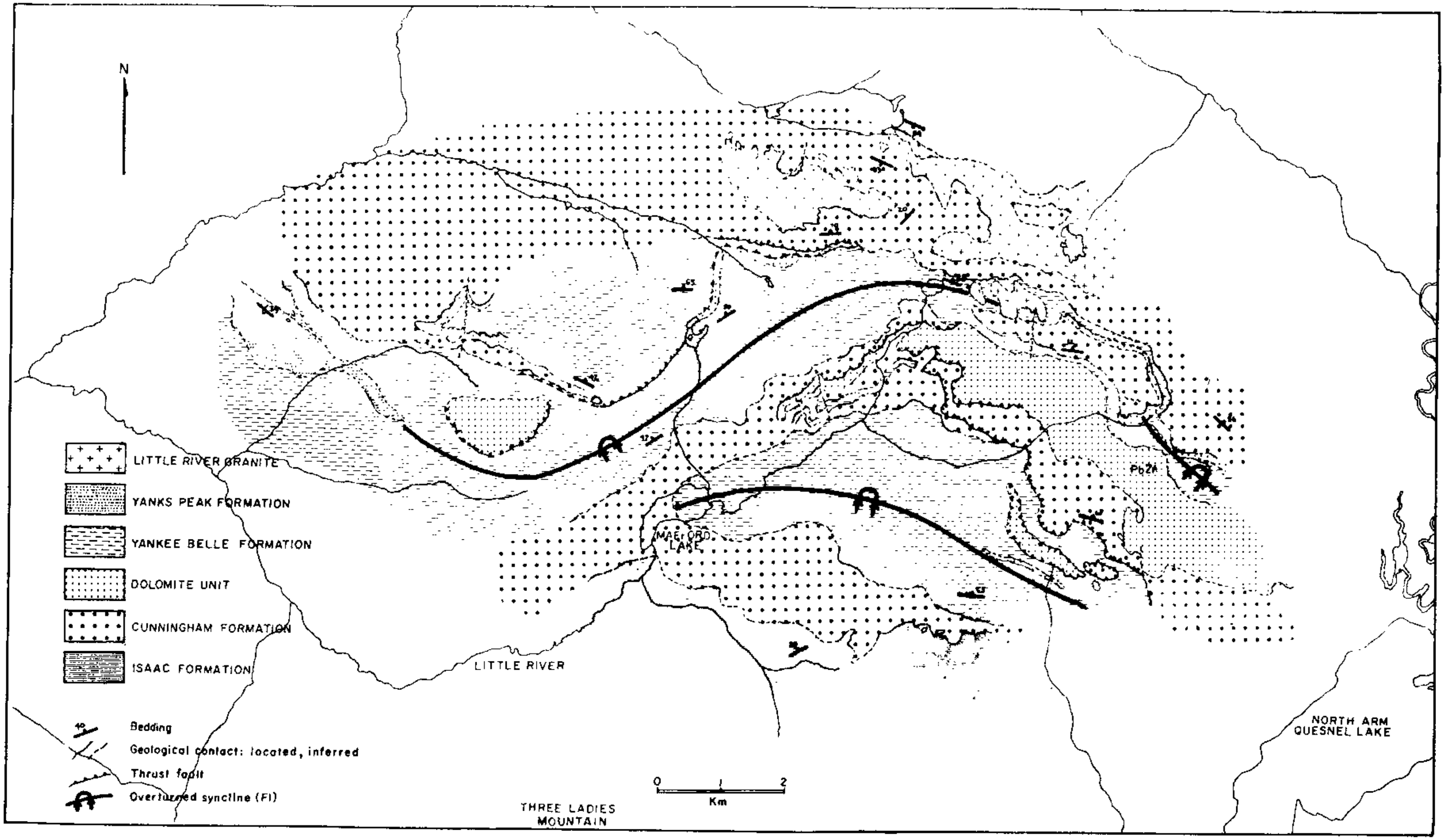

Figure 47. Geology of the Maeford Lake area.

The Cariboo Group and equivalent rocks along the Cordillera are host to lead/zinc and, farther north, gold mineralization. Lead/zinc showings in the Maeford Lake area have been examined by exploration companies using geophysical techniques and diamond drilling. The program reported on here is intended to elucidate the structural history of this area which lies between intensely metamorphosed terrain to the south and metalliferous sediments to the north. Such clarification should assist in the rational planning of mineral exploration.

STRATIGRAPHY

Rocks of the Cariboo Group comprise a sequence of schists, marbles, dolomites, calcareous phyllites, and cherts and quartzites. The stratigraphic sequence was established by correlation with named units farther north and by local determinations of 'tops' by means of graded bedding. The oldest rocks mapped in the area are grey to dark grey, slightly rusty weathering garnet schists overlying a sequence of bedded feldspathic grits and micaceous quartzites. The schists are correlated with the Hadrynian Isaac Formation of Campbell, *et al.* (1972).

Above the schists lie coarsely crystalline, white calcitic marbles with local tremolite horizons. In the northern and eastern parts of the area, this unit is much less recrystallized and is a fine to medium-grained grey marble with thin micritic laminae and easily visible stylolites. The unit is resistant, weathers light grey to white, and underlies the northwest-trending ridges of the area. This unit is correlatec with the Cunningham Formation. Near the top of the Cunningham Formation lies a cream to light grey-weathering, fine-grained dolomite horizon. The dolomite is in most places brecciated, with a matrix of coarse-grained, sparry calcite or fine-grained calcite and hematite.

Stratigraphically above the Cunningham Formation is a heterogeneous unit of calcareous phyllite, calcareous biotite schist, intercalated marbles and phyllites, marbles, garnet schist, quartzites, and greenish phyllites. Locally present are thin green amphibolite horizons and dark sulphidic graphitic marbles. These various lithologies weather recessively and are collectively correlated with the Yankee Belle Formation.

The youngest unit is exposed only in the northwest part of the map-area and consists of green to white, clean quartzites. The base of the unit is interbedded with green mica phyllites. The phyllitic layers decrease in number toward the top of the unit. This unit is correlated with the Lower Cambrian to Hadrynian Yanks Peak Formation.

The 'Little River Stock' (Sutherland Brown, 1963) intrudes all stratified rocks in the map-area. The rock is a slightly porphyritic quartz monzonite to granodiorite that has been altered and in places weakly mineralized with iron and copper sulphides. It weathers light grey to greenish grey. The stock contains leucocratic veins and dykes, which are locally garnetiferous. There is local contact metamorphism, seen as a coarsening of grain sizes near the intrusion and development of skarn minerals in the marbles. The stock postdates the Yankee Belle Formation and is presumed to be of Mesozoic age similar to other granitic intrusions near Quesnel Lake.

STRUCTURE

The rocks of the Maeford Lake area are complexly deformed and faulted. The area is traversed by two early recumbent synclines trending northwest-southeast. This is evident from the map pattern, with a belt of Yankee Belle Formation in the core of each syncline, Cunningham Formation on either side, and Isaac Formation exposed in the extreme northeast and southwest of the map-area.

First stage structures control the map pattern and are seen on both macroscopic and mesoscopic scale. Isoclinal folds with northeast-dipping axial surfaces and generally northwest-plunging axes characterize Phase 1 structures. Foliation is parallel to the axial planes of these Phase 1 structures and minor structures and lineations are common. In most places foliation is parallel to bedding. Micritic layers in the marble units commonly show isoclinal folds and transposed layering associated with this event.

Second stage structures are somewhat more open with axial surfaces dipping steeply southwest and axes plunging northwest. Phase 2 minor structures deform Phase 1 foliation and have an associated lineation. In lower grade zones to the north and northwest, Phase 2 deformation is accompanied by a crenulation cleavage having west-dipping axial surfaces. Phase 2 minor structures in the micritic marble are locally isoclinal and can be separated from Phase 1 structures by means of a generally northeast sense of vergence in the Phase 2 structures. The near colinearity of Phase 1 and Phase 2 produces a 'fish hook' interference pattern which is common in outcrops of the bedded marbles. This is not readily apparent in the map pattern because of the moderate to shallow plunge of both structures. The Little River granite is involved in Phase 2 deformation and appears to cut Phase 1 structures. The granitic rocks are unfoliated in the centre of the bodies, but show some foliation near the contacts.

Third phase structures are open folds trending northeasterly with gently plunging axes and upright axial surfaces. They are better developed in the higher grade rocks in the southwestern part of the area, where kink banding exhibits Phase 3 orientations. Thin conjugate veins and fractures and several joint sets in the area are associated with brittle and extensional episodes of Phase 3 deformation. Interference of Phase 3 with Phases 1 and 2 produces an elongate dome and basin pattern seen as topographic highs of resistant marble units aligned with the north-northeast-trending antiforms of Phase 3.

Thrust surfaces dipping gently northeast and striking northwest can be seen in the field and truncated contacts and incomplete stratigraphic sequences have been confirmed by mapping. Thrusts have been folded and were probably operative during the first and second stages of deformation. High-angle reverse faults with strikes subparallel to the thrusts and southwest sides downthrown are later, as these are not folded. Some small, steep normal faults with a conjugate sense (northeast side downthrown) are probably related to this set. Displacement along these faults is measured in tens of metres. The final phase of faulting consists of north to northwest-trending, steep faults with a small right lateral displacement.

METAMORPHISM

The map-area bridges an area where metamorphic zones change from phyllitic (biotite ?) rocks in the northwest to kyanite-staurolite-garnet-biotite schists near Three Ladies Mountain. The garnet isograd seems to have a complex trace, and further work on mineral assemblages will attempt to define its position. Metamorphism seems to have been most intense following the main pulse of Phase 2 deformation as porphyroblastic micas with weak preferred orientation are common and staurolite porphyroblasts appear to be randomly oriented.

MINERALIZATION

Lead/zinc mineralization occurs in the form of coarse-grained galena and amber sphalerite, locally with minor barite and scheelite, in veins in the dolomite breccia of the Cunningham Formation. The only substantial showing consists of a vein system 15 metres long and up to 10 centimetres wide in the southeastern part of the area. Sphalerite is far less abundant than galena. Some disseminated chalcopyrite occurs in minor amounts in sulphidic, graphitic marbles of the Yankee Belle Formation.

THREE LADIES MOUNTAIN

During the period August 12 to 30, 1979, preliminary geological mapping in the Isaac Formation was started by J. Getsinger in the area near Three Ladies Mountain (52 degrees 45 minutes north; 121 degrees 00 minutes west). The purpose of this study was to investigate the Isaac Formation as a subject for a Ph.D. project concentrating on metamorphism and structure. Previous work by Campbell (1978) shows the Isaac Formation as an undivided unit of metamorphosed pelites, with minor carbonate and some grit, underlying the Lower Cambrian Cunningham limestone.

During two weeks of mapping of a 10-square-kilometre area, it was found that the Isaac Formation is divisible into at least four mappable lithologies, including pelitic schist (garnet-kyanite-staurolite, two-mica schist), 'quartzite' (micaceous quartz-rich layers and some schist), carbonate (calcite marble with pelitic and calc-silicate layers), and 'hornblende-bearing rocks' (amphibolite, carbonate/pelite reaction zone rocks, and possible local meta-intrusive rocks.

The distinction of some of the lithologies in the Isaac Formation led to the recognition of large-scale folds (on the order of 1 kilometre) and it is presumed that others occur in the area. At least two periods of penetrative deformation are indicated by minor folds and strong pervasive foliations and lineations were noted in all rock types except pegmatites and quartz veins. Refolded folds are common in rocks that retain visible lithologic layering and in some places two foliations and/or lineations were observed. Detailed structural analyses of superimposed folds are expected to reveal much about the phases and style of deformation throughout the area.

All metamorphic assemblages observed in the field appear to be consistent with kyanite-staurolite grade of amphibolite facies metamorphism as mapped by Campbell (1978), although there is also some evidence for later retrograde metamorphism.

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K/Ar ANALYTICAL DATA FROM THE WREDE CREEK ULTRAMAFIC COMPLEX

Sample No.	Location Lat. (N); Long. (W)	Rock Unit	Mineral Dated	% K + S	$\frac{^{40}Ar^*}{^{40}Ar\ Total}$	$^{40}Ar^*$ (10^{-5} cm^3 STP/g)	Apparent Age (Ma)	Time
G77RW1	56° 40'; 126° 08'	hornblende diorite dyke cutting ultramafic complex	hornblende	0.959±0.007	0.790	6.740	172±6	Middle Jurassic
G77RW2	56° 40'; 126° 08'	hornblende pegmatite segregation within dunite	biotite (secondary)	8.98±0.18	0.967	57.258	157±5	Middle Jurassic
G77RW4a	56° 40'; 126° 08'	hornblende pegmatite segregation within dunite	hornblende	1.224±0.063	0.881	11.078	219±10	Late Triassic
G77RW4b	56° 40'; 126° 08'	hornblende pegmatite segregation within dunite	hornblende	1.188±0.088	0.881	11.078	225±8	Late Triassic

NOTES

All analyses done in the Geochronology Laboratory, Department of Geological Sciences, the University of British Columbia.

S is the range of the duplicate analyses from the mean value.

Ar* indicates radiogenic argon.

Constants used are: $\lambda_e = 0.581 \times 10^{-10} yr^{-1}$; $\lambda_\beta = 4.962 \times 10^{-10} yr^{-1}$; $^{40}K/K = 1.167 \times 10^{-4} yr^{-1}$; error is one standard deviation.

K/Ar AGE DETERMINATIONS
WREDE CREEK ZONED ULTRAMAFIC COMPLEX
(94D/9E)

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The Wrede Creek ultramafic complex is one of several zoned or Alaskan-type ultramafic bodies in the McConnell Creek and Aiken Lake map-areas of north-central British Columbia. The ultramafic body, composed of a dunite core with a pyroxenitic margin, occurs within volcanic rocks of the Upper Triassic Takla Group. K/Ar dating of hornblende from pegmatitic segregations within the dunite gave ages of 219±10 Ma and 225±8 Ma, suggesting a possible genetic relationship between the ultramafic and volcanic rocks. Secondary biotite developed in similar hornblende pegmatite yielded a K/Ar date of 175±5 Ma, while hornblende from a diorite dyke cutting the ultramafic complex gave an age of 172±6 Ma. The latter two ages are correlative with Middle Jurassic plutonism represented in the area by the Hogem batholith. *Analytical data are listed in the accompanying table, page 156.*

BP Minerals Limited, Vancouver, supported fieldwork for this project. The British Columbia Ministry of Energy, Mines and Petroleum Resources provided funding for microprobe analyses and K/Ar dating. An M.Sc. thesis on the study is in preparation.

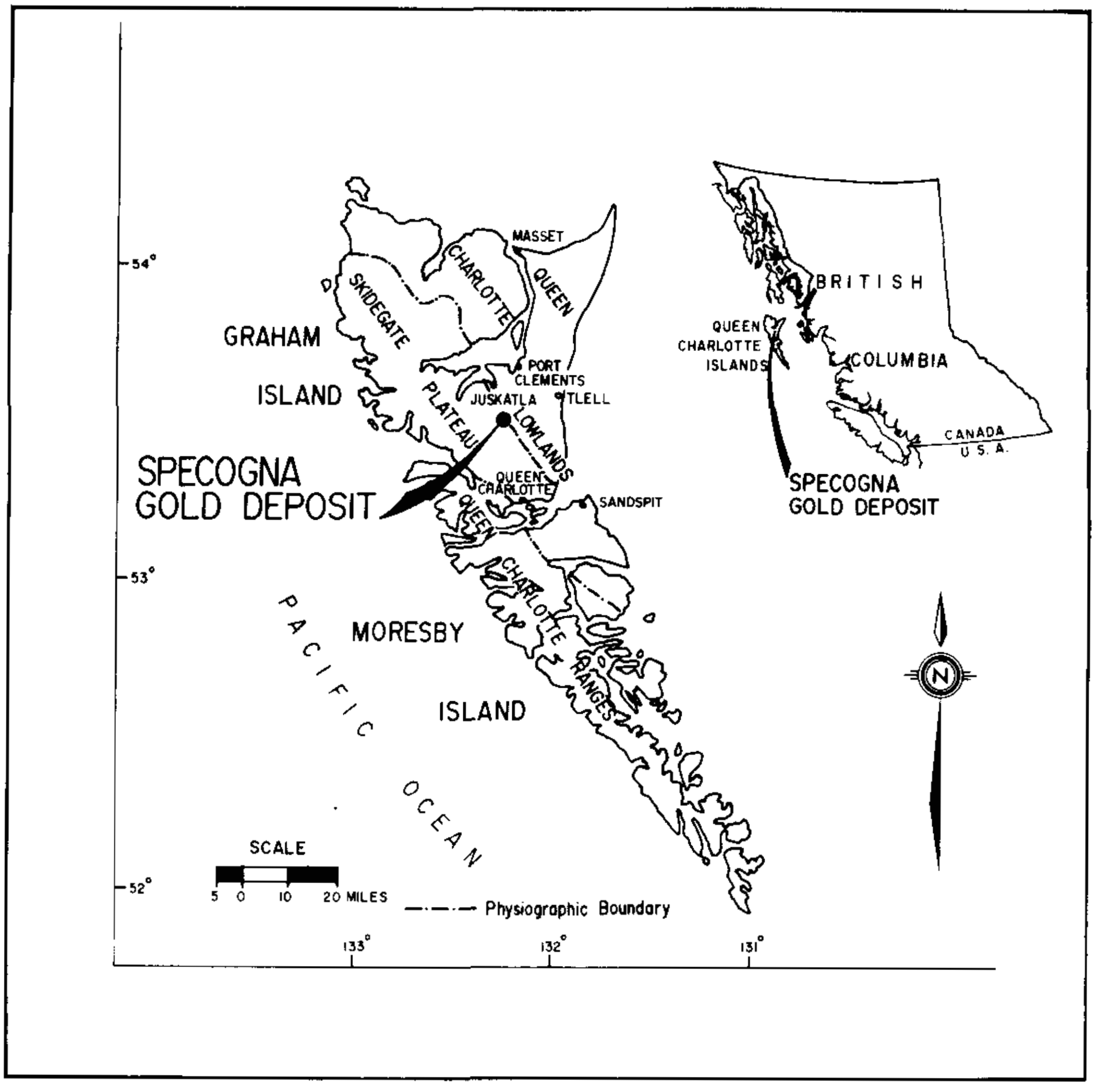

Figure 48. Location of Specogna gold deposit.

PROGRESS REPORT ON THE GEOLOGY OF THE SPECOGNA (BABE) GOLD DEPOSIT (103F/9E)

By N. Champigny and A. J. Sinclair
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INTRODUCTION

Specogna (Babe) gold property consisting of 41 full claims and seven fractions is 17.6 kilometres south of the town of Port Clements on Graham Island (Fig. 48). The showing is a prospecting discovery, found in late 1970 by Efrem Specogna and Johnny Trico. Five companies optioned the property successively from 1971 to 1975 during which time geochemical sampling, trenching, and diamond drilling were conducted. Consolidated Cinola Mines Ltd., the present owner, bought the claims in 1977 and diamond drilled a total of 708 metres the same year. Another 1 254 metres of diamond drilling in 1978 and 3 041 metres in the first eight months of 1979 have been completed. Sutherland Brown and Schroeter (1975) were the first to describe the showings formally and produced a generalized geological cross-section of the deposit. A more detailed description was given by Richards, *et al.* (1975) who emphasized the fine-grained character of the siliceous ore and the general geochemical expression. Our study is based on detailed geological examination of 5 506 metres of diamond-drill core and limited surface exposure during the summer of 1979. Computerized logging techniques (GEOLOG System) were used as a basis for the work (Blanchet and Godwin, 1972; Godwin, Hindson, and Blanchet, 1977). The GEOLOG System proved to be a useful tool for rigorous description of such a large amount of drill core.

REGIONAL GEOLOGY

The general area about the Specogna gold deposit includes a major fault system and four main rock formations (Sutherland Brown, 1968). These include Sandspit fault system, the Haida and Honna Formations of Cretaceous age, the Masset Formation of Early Tertiary age, and the Skonun Formation of Mio-Pliocene age (Fig. 49).

Sandspit fault system separates the two main physiographic provinces of the area, Queen Charlotte Lowlands on the east and the Skidegate Plateau to the west. The fault zone strikes about 143 degrees and seems to have involved large vertical movement. Southwest of the deposit, the Haida Formation is divided into a lower sandstone member and an upper shale member (Sutherland Brown, 1968). The overlying Honna Formation was mapped originally as an extension of the Haida Formation. Identified lithologies are conglomerate with coarse pebbles to small cobbles, coarse sandstone, and minor siltstone or shale. Sutherland Brown and Schroeter (1975) remapped these sedimentary rocks as part of the Skonun Formation. West of the gold prospect the Masset Formation marks the beginning of the Skidegate Plateau. It is composed exclusively of volcanic rocks ranging from mafic to felsic in composition. East of the Sandspit fault system, the Queen Charlotte Lowlands are underlain by the Skonun Formation consisting of poorly lithified sands, shale, and conglomerate (Sutherland Brown, 1968).

STRATIGRAPHY

The deposit is situated on two small hills (210 metres above sea level) between the Skidegate Plateau and the Queen Charlotte Lowlands. A shale sequence representing the Haida Formation and an overlying interbedded sequence of pebble conglomerate and coarse sandstone of Skonun age are both intruded by a stock of rhyolite porphyry (Fig. 50). A thin cover of glacial till and sand overlies all rocks.

SHALE SEQUENCE – HAIDA FORMATION

This formation extends from the Masset volcanic rocks on the west side of the property to the overlying coarse clastic sequence on the east. The thickness of the shale sequence on the property is unknown although Sutherland Brown (1968) reported that the upper shale member of the Haida Formation is 320 metres thick at the type locality. A maximum thickness of 34 metres was penetrated in drill hole 79-5. The sequence is composed of dark grey to black, poorly consolidated and thinly bedded calcareous shale. Minor sandy layers have been observed. Near the contact with the rhyolite porphyry, the shale sequence becomes an argillite or hornfels due to intense silicification. On the basis of lithology this shale sequence appears to correlate with the upper member of the Haida Formation.

CONGLOMERATE – SANDSTONE SEQUENCE

A coarse sedimentary sequence overlies the Haida Formation to the west and extends to the Sandspit fault system on the east (Fig. 50). The contact between the two sequences has not been observed clearly in drill core because of pervasive silicification and intrusion of the rhyolite porphyry (Figs. 50, 51, and 52). Thickness of the sequence throughout the drilled area varies from 0 to 300 metres. Strike changes from northwesterly to northeasterly with most of the values around 015 degrees. Strata consistently dip 15 degrees to 25 degrees to the east. Thicknesses of mappable units range from 0.1 to 30 metres, with a 2-metre average. The sequence contains about 62 per cent conglomerate, 31 per cent coarse sandstone, and 7 per cent interbedded sandstone and siltstone with minor shale interbeds. Contacts between adjacent units in the sequence are generally sharp but transitional contacts are also observed. Mafic volcanic pebble-rich conglomerate, interbedded sandstone, and shaly siltstones and some sandstone units have been used successfully for stratigraphic correlation between drill holes (Figs. 51 and 52).

The principal rock type is a medium grey to pale brown polymictic conglomerate with well-rounded to *subangular large pebbles and small cobbles. Graded bedding and load cast structures are abundant.* The coarse fraction totals 70 per cent of the rock with an average fragment diameter of 3 centimetres. Particles are moderately poorly sorted and sphericity is low to intermediate. Most of the conglomerate units are pebble supported. Pebble and cobble lithologies are 60 per cent felsic volcanic rock, 20 per cent mafic volcanic rock, 10 per cent granite, 5 per cent argillite and shale, and 5 per cent conglomerate, sandstone, and siltstone. Acid volcanic clasts include massive and banded rhyolite, rhyolite porphyry, quartz, and rare pyroclastics, chert, and hematitic rhyolite porphyry. Mafic volcanic pebbles are mostly dark green porphyritic andesite with feldspar and hornblende phenocrysts. Granitic fragments consist of a quartz feldspar mosaic with about 10 per cent disseminated mica. Commonly 1 to 3 per cent of wood fragments are intermixed with the coarse and fine fraction. The matrix of these conglomerates occupies 30 per cent of the volume of the rock, and grains are a medium to coarse-grained sand size.

Sandstone units are medium grey to dark brown, medium to coarse grained with bedding and graded bedding commonly apparent. Two to 15 per cent wood fragments are present with rare occurrences of leaves and shells.

Minor but persistent medium to pale grey interbedded sandstone and siltstone-shale units are found locally. They show bedding, graded bedding, crossbedding, ripple marks, and rare convolute bedding and flame structures. Local soft sediment slumping is indicated by conglomerate lenses in sandstone units, disrupted bedding, and matrix replacement.

The coarse nature of the sediments, their polymictic character, and rapid changes from conglomerate to sandstone units suggest a marine near shore environment of deposition for the clastic sequence. The sequence appears to correlate with the Skonun Formation based on lithologic similarity (Sutherland Brown and Schroeter, 1977).

RHYOLITE PORPHYRY

A stock of rhyolite porphyry crops out sparsely east and west of the footwall fault. Dykes of the same composition crop out within the shale sequence west of the footwall fault. In drill hole 77-5 the porphyritic rhyolite crosscuts the shale sequence at four intervals of a few metres each. These dykes or sills contain up to 20 per cent fragments of black silicified shale. In drill hole 79-4, from 144 to 147 metres, a series of shale lenses are intermixed with the porphyritic rock. Sandstone and conglomerate fragments are found in the quartz feldspar porphyry in drill hole 78-3 from 102 to 103 metres. A porphyritic dyke intersects a conglomerate unit from 44.3 to 44.7 metres in drill hole 78-4. These field relations indicate that the rhyolite porphyry is younger than both the shale and conglomerate-sandstone sequence. Locally the contact with the coarse clastic sequence is sharp but in many places a transition zone exists. The contact zone is composed of a mixture of highly deformed conglomerate, sandstone, and rhyolite fragments in an aphanitic bluish grey siliceous matrix.

The thickness of the main rhyolite porphyry mass decreases to the east (Figs. 51 and 52). Drill hole 75-4 intersected 155 metres of intermized rhyolite porphyry and shale after penetrating the footwall fault.

The rock is pale grey and contains 2 to 3 per cent bluish grey subrounded quartz eyes 1 to 4 millimetres in diameter and 5 to 10 per cent white subhedral to euhedral feldspar phenocrysts. The rhyolite is brecciated in many places with the fragments contained in a dark grey to black siliceous matrix. Aphanitic fragments of rhyolite in a white glassy matrix and streaky banding with preferential orientation of the phenocrysts are observed. These two features are possibly characteristic of an extrusive phase of the porphyry.

STRUCTURE

The major structural feature of the Specogna gold deposit is the footwall fault, which strikes 157 degrees and dips 40 to 60 degrees to the east (Figs. 51 and 52). The footwall fault parallels the Sandspit fault system and is probably a part of that system. In the drill core the footwall fault is recognized by an abrupt change from silicified shale to soft, relatively fresh shale. Slickensides have been found in drill hole 79-4 at 153.5 metres in altered rhyolite porphyry. On surface the fault is visible as a scarp near the southwest boundary of the deposit (Fig. 50). Northwest of the present drilling area, an outcrop called the Marino showing exposes the fault contact. At the base of the exposure a gouge zone, 20 centimetres wide, separates the rhyolite porphyry from a black homogeneous shale. Slickensides are abundant in the shale. There the footwall fault strikes 150 degrees and dips 55 degrees to the east.

In drill hole 75-4, located 250 metres northwest of the Marino showing, the rhyolite porphyry is observed both beneath and above the footwall fault. Thus, faulting occurred at least in part after the intrusion of the rhyolite porphyry. Displaced gold geochemical anomalies, drainage patterns, and topography suggest a dextral fault with a downward movement of the east block. This is the same movement picture observed for the Sandspit fault system (Sutherland Brown, 1968).

DISTRIBUTION, FORM, AND SETTING OF THE DEPOSIT

The gold-silver deposit terminates abruptly against the footwall fault to the west and dies out gradually to the north and east (Fig. 50). The rocks are highly anomalous in mercury and arsenic and less anomalous in antimony, copper, and zinc. Gold and silver values are plotted on Figures 53 and 54. Two distinct populations are recognized: a first population of low-grade gold and silver values with a wide range of gold/silver ratios, and a second population of high-grade gold values with gold/silver ratios of about 2:1. Gold values range between 0.01 and 2.50 ounces per ton. High-grade gold values (that is, greater than 5.7 ppm) are found in quartz veins and at the contact zone between the rhyolite porphyry and the coarse sediments (Fig. 55).

Intense silicification characterizes the host rocks. Leached rims of pebbles and cementation of the matrix in pebble conglomerate units by very fine-grained silica is common. The degree of silicification of the host rocks increases toward the rhyolite porphyry body.

Several generations of veins and stringers crosscut the host rock. Larger veins strike 020 ± 20 degrees and dip 60 to 90 degrees in either direction. Their widths range up to several metres. Increased quartz veining toward the rhyolite porphyry has been measured quantitatively in most drill holes (Fig. 55). Individual veins present clear accretionary features such as crustification, chalcedonic quartz, and development of well-formed quartz and calcite crystals reaching 2 centimetres in size. Wallrock silicification is common. Some veins contain numerous angular fragments of host rock. Banding in the veins is common; several coloured bands of quartz show the different episodes of veining. Microveins and stringers commonly pervade wood fragments, producing a chessboard texture on a hand specimen scale. Crosscutting relationships support the following sequence of veining in order of decreasing age: (1) massive sulphide veins; (2) dark grey to black quartz veins, (3) bluish grey quartz veins, (4) white and cherty quartz veins, and (5) calcite veins.

MINERALOGY

Opaque minerals identified in drill cores and hand specimens include in decreasing order of abundance: pyrite, marcasite, limonite, hematite, native gold, and cinnabar. Chalcopyrite and sphalerite have been identified in polished sections of rhyolite porphyry from 157 to 173 metres in drill hole 78-6.

Limonite staining (a pale yellow to reddish brown fine-grained mixture) is present on surface exposures and up to a depth of 20 metres in drill holes. Hematite occurs as finely disseminated grains in quartz veins and massive veinlets in brecciated rhyolite porphyry.

Iron sulphides are encountered throughout the gold-bearing rocks. Sulphide content ranges from 0.5 to 10 per cent, with an average of about 3 per cent. No definite correlation can be obtained between sulphide contents and gold values (Fig. 55). Pyrite and marcasite are the most common sulphides. Pyrite is found as rims, disseminations, blebs, veins, and euhedral crystals. Rims of pyrite consist of dark brown very fine-grained coatings on pebbles in conglomerate units. These rims are thought by some geologists to be melnikovite, but verification is required. Needles, rosettes, veins, and rarely crystals are the forms observed for marcasite. Both pyrite and marcasite are present in petrified wood.

Native gold was recognized in quartz veins, with most occurrences in dark grey and bluish grey quartz veins. The gold apparently exists in a very fine form in varying amounts in most of the rock types that have undergone silicification. At the Marino showing abundant fine free gold is visible in white cherty quartz veins. Cinnabar is rare and was noticed only in a few drill holes.

Two general mineral associations are present in high-grade gold-bearing rhyolite porphyry: (1) pyrite-marcasite and (2) pyrite-marcasite-sphalerite-chalcopyrite-native gold. Sphalerite and chalcopyrite have an average grain size of about 0.2 millimetres in the six polished sections examined. Native gold was observed as monomineralic grains in quartz and in places as inclusions in chalcopyrite. Several soft, white unidentified minerals have been observed associated with sphalerite, chalcopyrite, and native gold. Sphalerite is not readily apparent in hand specimen, and minute grains of chalcopyrite can be confused megascopically with native gold. Paragenesis is summarized on Figure 56.

ALTERATION

Three alteration minerals have been identified in the gold-bearing host rock: a clay mineral (species unidentified), sericite, and chlorite. Clay and sericite alteration are the most extensive. Clay occurs in gouge zones with a white to greyish matrix and containing isolated pebbles. Feldspar phenocrysts in porphyritic pebbles and in the rhyolite poprhyry are also commonly altered to a very fine mixture of clay and sericite. Sericitic alteration is also found as disseminated grains in conglomerate pebbles and matrix and in fine-grained units. Chlorite occurrences seem to be limited to within 20 metres of the contact zone with the rhyolite porphyry where it occurs as stringers or finely disseminated grains.

GENESIS

Sutherland Brown and Schroeter (1975) suggested that the Specogna gold mineralization occurred in a vein system in the rhyolite porphyry which is onlapped by sedimentary rocks of the Skonun Formation. Richards, *et al.* (1976) consider the deposit to be of the Carlin type, and indicate that the rhyolite porphyry is mineralized and is younger than or equivalent to unmineralized Skonun conglomerates, suggestions accepted by Sutherland Brown and Schroeter (1977).

After careful examination of new information available from diamond drilling from 1977 to 1979, there is little doubt that the rhyolite porphyry crosscuts the conglomerate-sandstone sequence. The gold mineralization is superimposed in part on the rhyolite porphyry and appears to be spatially related to the intrusion. Intrusion of the porphyry probably created a hydrothermal system in which ascending fluids rich in gold, silver, mercury, arsenic, and antimony percolated through the porous clastic sequence. Deposition of the gold occurred in an early stage of fluid circulation and was followed by later stages of quartz veining.

ACKNOWLEDGMENTS

The pleasant assistance of K. G. Sanders and A. McKillop of Consolidated Cinola Mines Ltd. is acknowledged with thanks. H. J. Mah and P. H. Blanchet (International Geosystems Corporation) advised on the use of the GEOLOG System. Mr. John Gardiner provided technical assistance in the field.

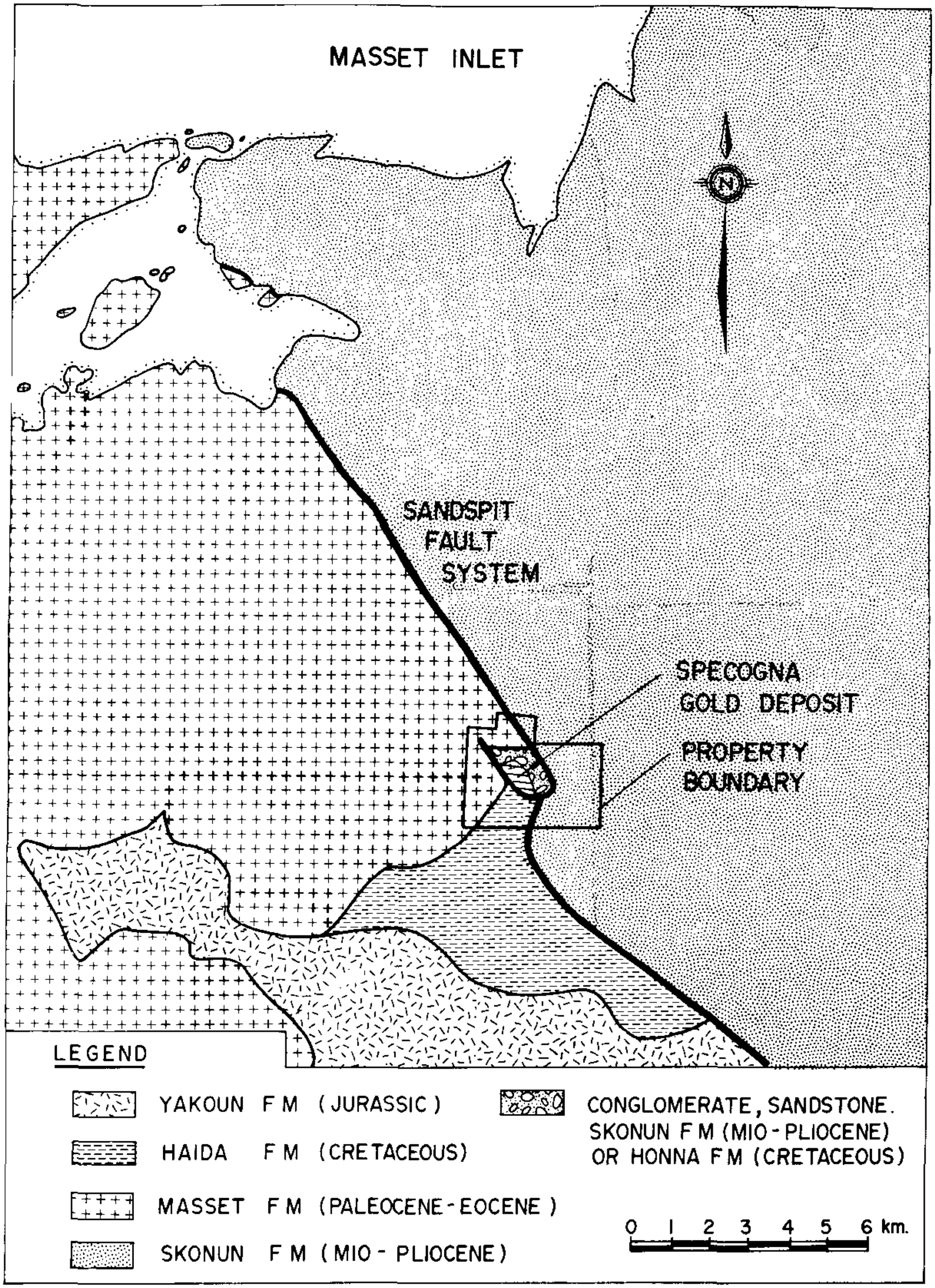

Figure 49. Regional geology, Specogna gold deposit (after Sutherland Brown, 1968).

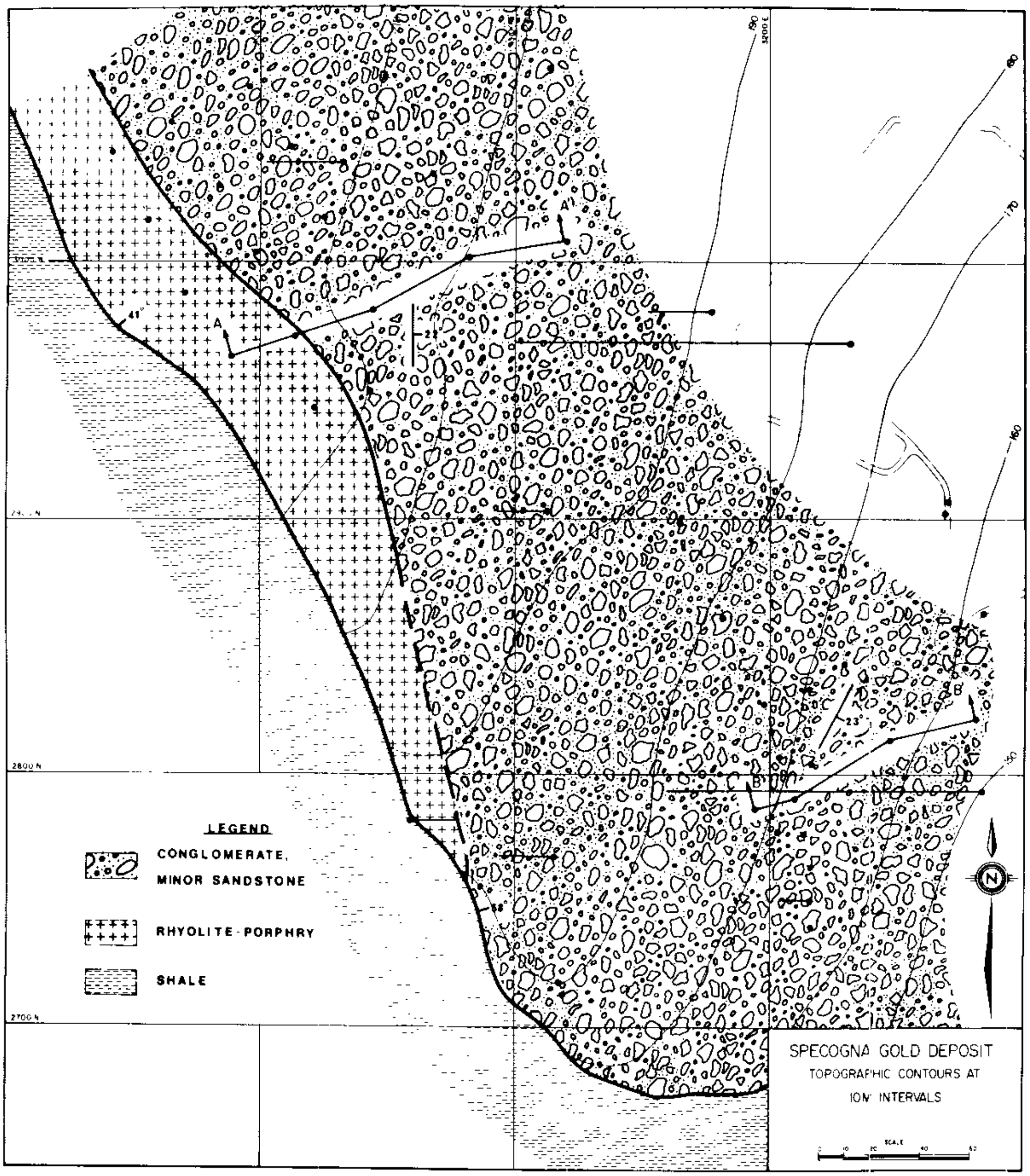

Figure 50. Property geology, Specogna gold deposit.

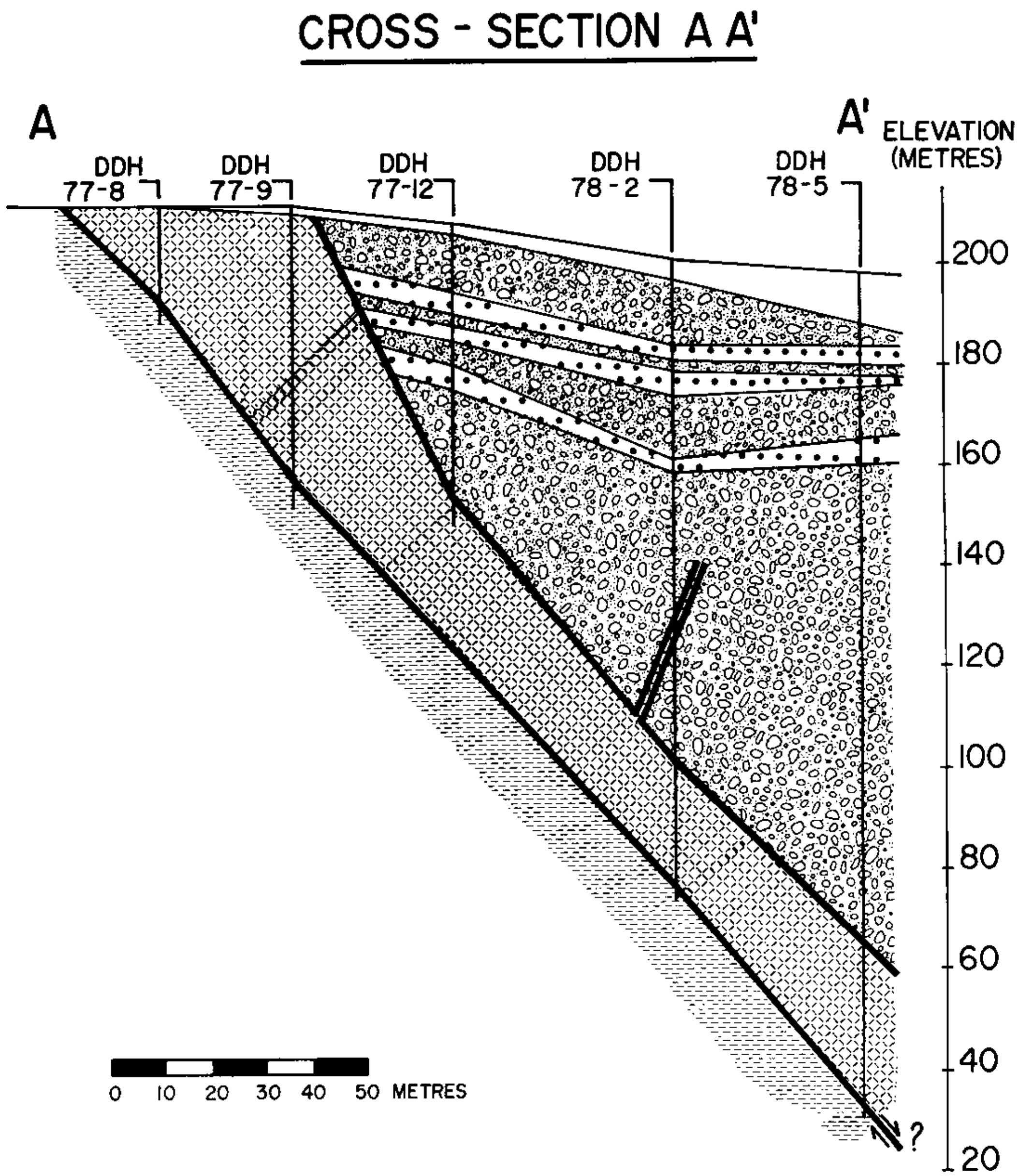

Figure 51. Cross-section A-A' (location shown on Figure 50; *see* Figure 52 for legend).

CROSS - SECTION B B'

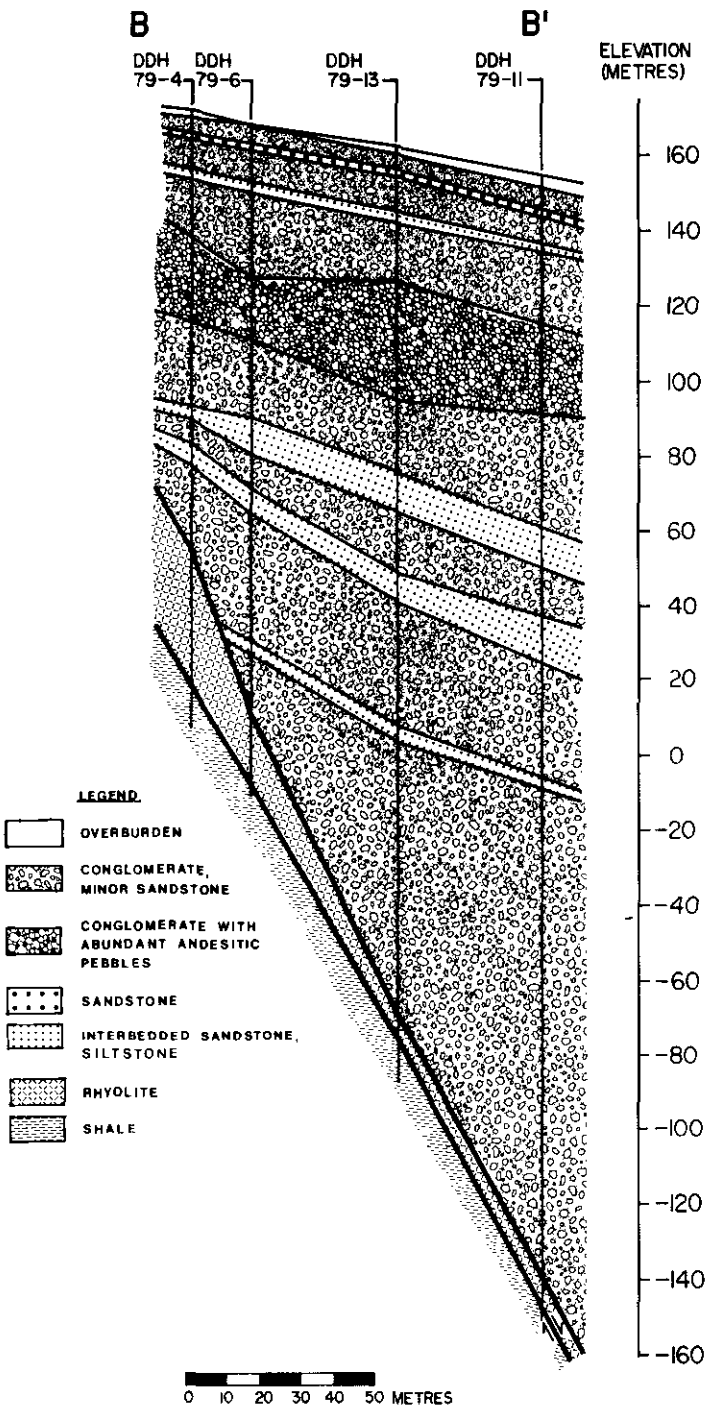

Figure 52. Cross-section B-B' (location shown on Figure 50).

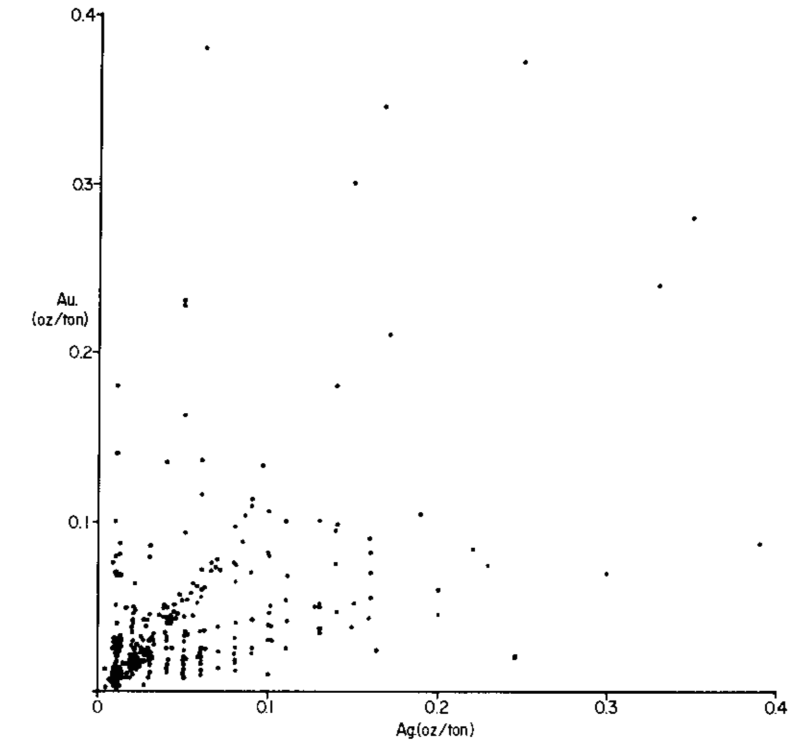

Figure 53. Gold-silver scatter diagram for low-grade assays from drill core, based largely on 2-metre core lengths.

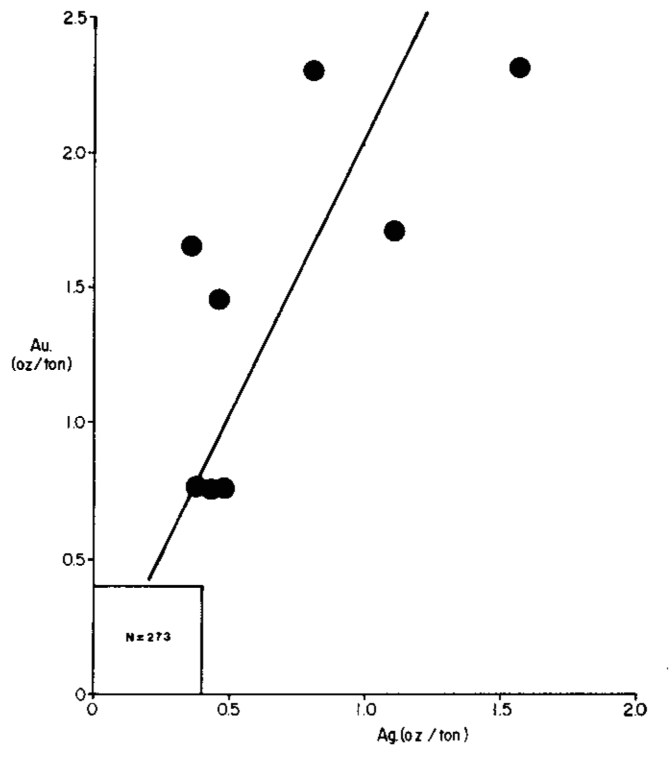

Figure 54. Gold-silver scatter diagram for high-grade assays (>10 grams gold per tonne), based on 2-metre core lengths. The straight line represents a gold/silver ratio of 2:1.

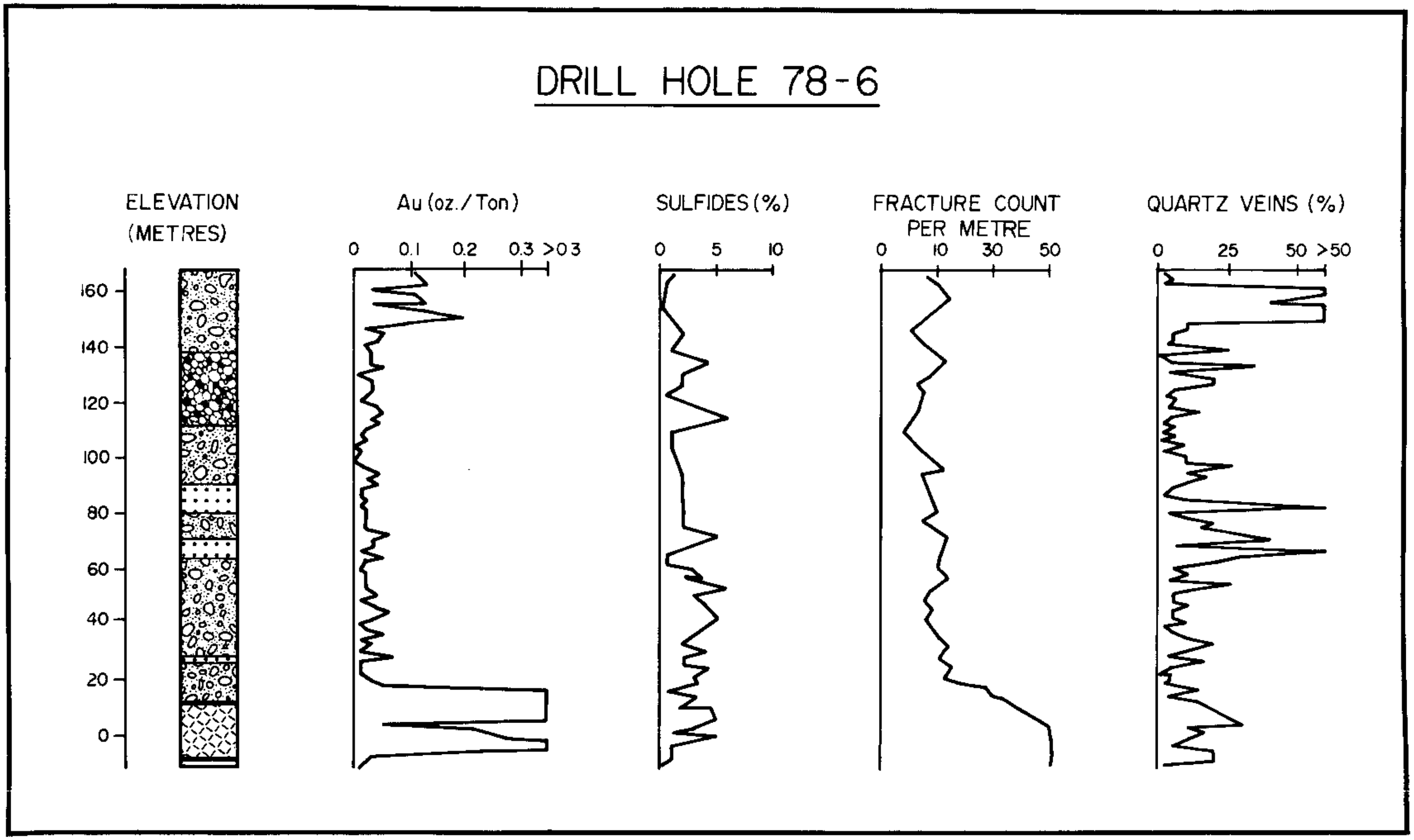

Figure 55. Graphic log of diamond-drill hole 78-6 showing geology, gold assays, percentage sulphides, fracture density, and volume per cent of quartz vein in core. Quantitative data are based on core lengths of 2 metres (*see* Figure 52 for legend).

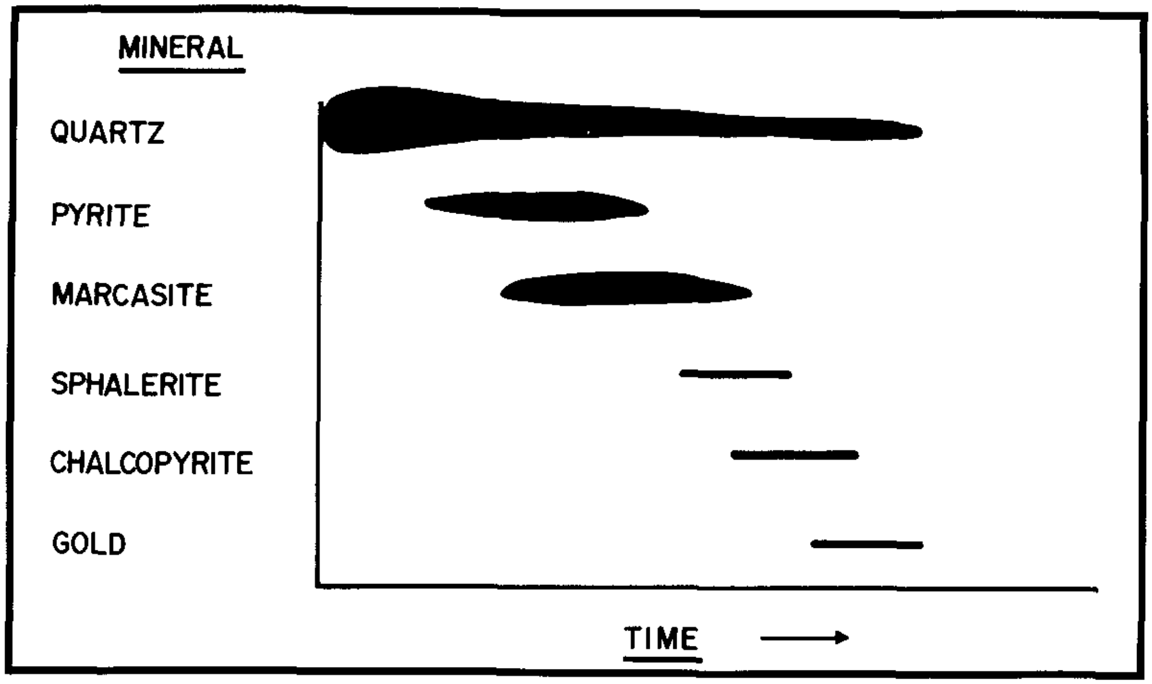

Figure 56. Paragenetic line diagram for high-grade gold occurrences in drill hole 78-6.

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PRELIMINARY INTERPRETATION OF LEAD ISOTOPES IN GALENA–LEAD FROM BRITISH COLUMBIA MINERAL DEPOSITS

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INTRODUCTION

Analysis of lead isotopes from mineral deposits in British Columbia is part of an ongoing lead isotope-oriented metallogenic study of the Canadian Cordillera. A total of 80 new analyses from 48 deposits, reported in Tables 1 to 5 (*see* pp. 178-182), have been completed since early 1979 in the Geology-Geophysics Laboratory at the University of British Columbia.

Data are discussed in terms of major tectonic belts (Sutherland Brown, *et al.*, 1971), and data presentation (Tables 1 to 5) is organized in the same fashion. Table 1, Insular Belts, lists 12 analyses from 7 deposits; Table 2, Central Coast Crystalline Belt, reports 23 analyses from 17 deposits; Table 3, Southern Coast Crystalline Belt, contains 26 analyses from 10 deposits; Table 4, Intermontane Belt, shows 11 analyses from 8 deposits; and Table 5, Eastern Fold Belt, reports 8 analyses from 6 deposits. Locations of deposits analysed are on Figure 57. Averaged values for age categories within each belt or table are shown on Figure 58. This is an interim report since some tectonic belts are not represented in Tables 1 to 5, many more analyses are in progress, and analyses completed prior to this study are not considered here. Our comments are restricted entirely to preliminary evaluation of the new data reported and will be updated as additional analyses are compiled.

SAMPLE PREPARATION AND ANALYSIS

All analyses were done on samples of pure galena or, in the case of very fine-grained sulphides, on samples of mixed sulphides containing galena. Sulphide samples were dissolved using HCl and HNO_3, and the resulting solution was filtered and evaporated until a precipitate of $PbCl_2$ crystals was obtained. Following washing of these crystals in H_2O and ethyl alcohol, they were redissolved in H_2O to provide a concentrated $PbCl_2$ solution which was further purified by passing it through anion exchange columns.

Electroplating of lead from this solution followed by dissolving in HNO_3 and by evaporation provided about 50 grams of $Pb(NO_3)_2$ for each sample. About 1μ gm of lead was then loaded onto single rhenium filaments, using the standard silica gel technique.

Isotopic analyses were done using a 90-degree, 12-inch mass spectrometer. Samples and standards were analysed at temperatures of 1100 degrees to ±100 degrees centigrade. Runs on samples were interspersed with runs of the Broken Hill No. 1 standard. Reproducibility of individual analyses of this standard is generally about 0.1 per cent at 1 sigma and this is considered to be the reproducibility of the sample analyses. All isotopic ratios reported in the tables have been normalized to their absolute values by intercomparison with the Broken Hill No. 1 standard. The absolute value of this standard was taken to be: $^{206}Pb/^{204}Pb = 16.003$, $^{207}Pb/^{204}Pb = 15.389$, and $^{208}Pb/^{204}Pb = 35.657$ (Cooper, *et al.*, 1969).

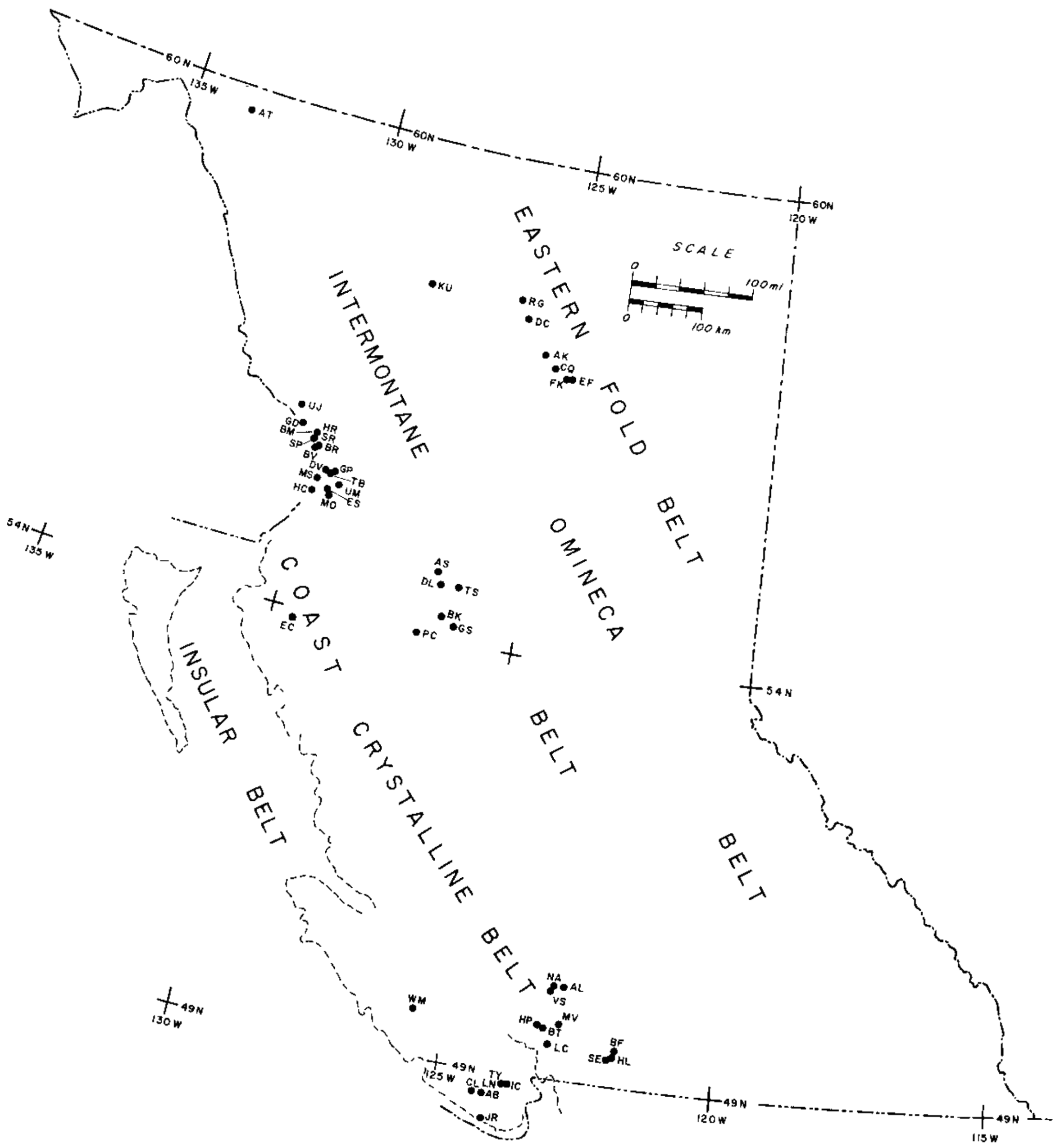

Figure 57. Location of deposits for lead isotope analyses.

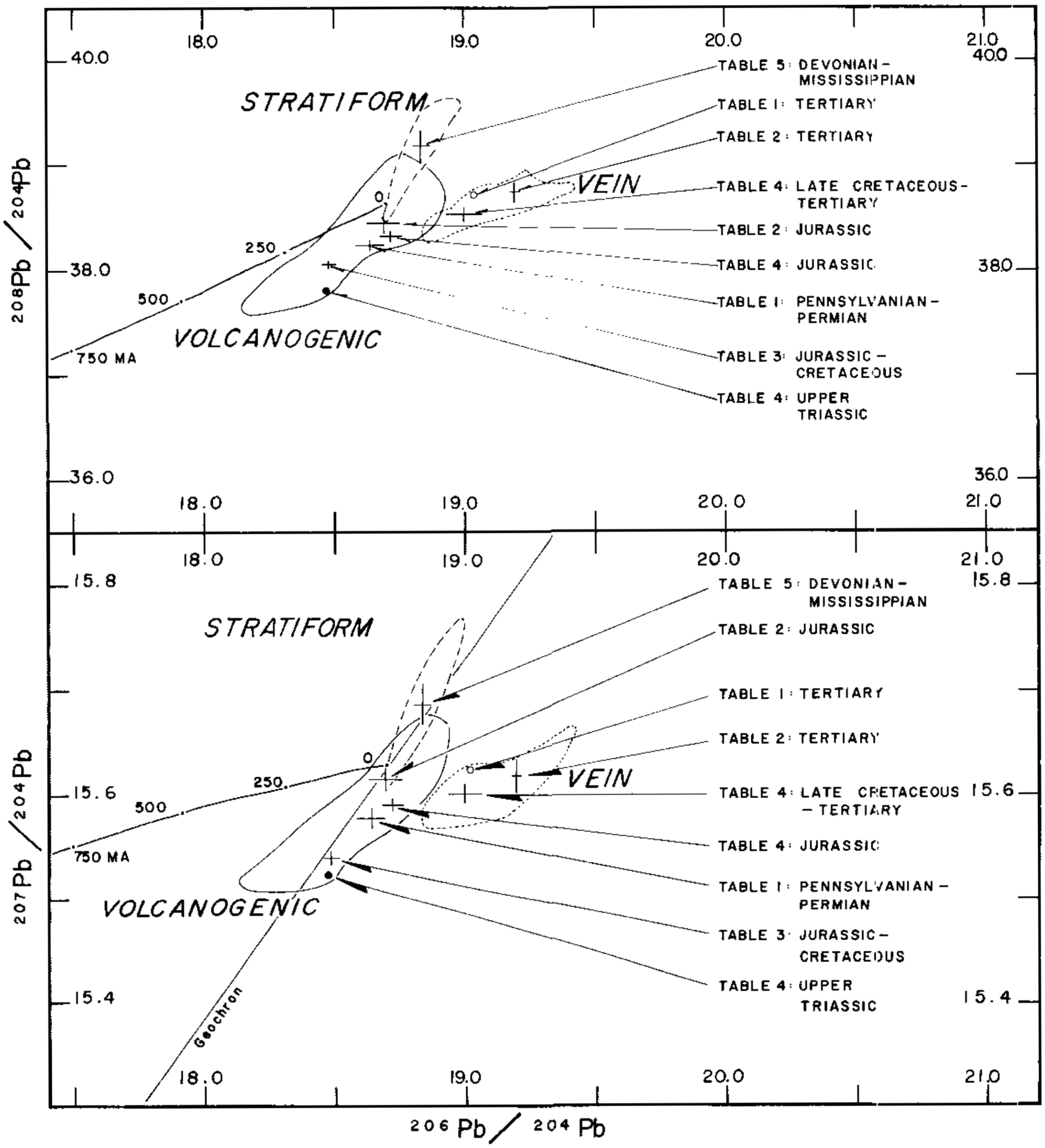

Figure 58. Lead isotope analyses — averaged values.

INSULAR BELT

Data, listed in Table 1, are generalized on Figure 58. Most deposits are demonstrably volcanogenic in origin (for example, Western Mines, Tyee, etc.), however, the origin is uncertain for some showings.

Results for those deposits hosted by the Sicker volcanic rocks of Pennsylvanian/Permian age cluster roughly about a point centred near the geochron (zero isochron) but significantly below the normal crustal growth curve of Stacey and Kramers (1974). These features indicate a multistage evolution, part of which was in a low U/Pb and Th/Pb environment. A linear trend in the $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ data can be defined by a York II cubic regression line. This trend, if real, and if interpreted as a two-stage model with final mineralization about 250 Ma ago, indicates a source rock (basement complex ?) about 2000 Ma in age. More work is required to examine this possibility.

The Tertiary Sunro deposit, in Metchosin volcanic rocks, also developed in a low U/Pb and Th/Pb environment. However, the lead is more radiogenic than that from lead in Sicker volcanic rocks, presumably because of the younger, Tertiary age for Sunro.

COAST CRYSTALLINE BELT

Lead isotope data for deposits in the central part of the Coast Crystalline Belt are in Table 2. Most results are from deposits in metamorphosed Hazelton volcanic rocks of Jurassic age, and many are of volcanogenic origin. Because of the complex geological history in this area, the origin is uncertain for some showings described as veins. Some vein deposits, however, are demonstrably Tertiary in age (for example, late-stage veins at British Columbia Molybdenum), because of their association with Tertiary intrusive rocks.

Data from most deposits contained in Jurassic volcanic rocks cluster closely to the composition of average modern-day lead (Fig. 58). Consequently, they are abnormally enriched in radiogenic lead because their true age is *circa* 200 Ma. This anomaly requires a multi-stage origin which to a first approximation is estimated by a two-stage model based on a York II cubic regression line through the $^{207}Pb/^{204}Pb$ data. This model requires a source for radiogenic lead of about 2400 Ma, although there is a large uncertainty attached to this model age. Obviously, more high quality analyses are required to investigate this problem adequately. Lead from the Ecstall and Big Missouri deposits is the least radiogenic and lies significantly to the left of the geochron on Figure 58; thus, single stage ages based on the model of Stacey and Kramers (1974) can be calculated and are 134 Ma and 173 Ma respectively. These ages are in reasonable agreement with the age of host rocks. Several authors (for example, Cannon, *et al.*, 1972) have suggested that the greatest economic potential for lead-zinc deposits, in a constant geological setting in a given area, is for those with the least radiogenic isotopic ratio of lead. According to this empirical relationship, the lead from the Ecstall and Big Missouri indicates areas of significant potential for large lead-bearing deposits, a possibility in accord with the origin and known reserves at the Ecstall deposit.

Tertiary deposits sampled in the central part of the Coast Crystalline Belt contain more radiogenic lead than do older deposits, perhaps in part due to their young age. In general, however, they are too highly radiogenic to attribute their greater content of radiogenic lead only to decreased age. A more complex history of evolution is necessary; more data are required.

Lead isotope data for deposits in the southern part of the Coast Crystalline Belt are in Table 3. Analyses are either from volcanogenic deposits or from veins which are probably closely related spatially to volcanogenic deposits. Volcanic host rocks are Jurassic in the Seneca—Harrison Lake area, but might be as young as Early Cretaceous in the Britannia—Northair area.

Isotopic ratios plot on the geochron and are substantially below the normal crustal evolutionary growth curve. Thus lead from these deposits evolved in an environment with significantly lower U/Pb and Th/Pb ratios than that of deposits from the central part of the Coast Crystalline Belt.

Some data for galena from the Van Silver deposits represent veinlets cutting intrusive rocks of the Garibaldi Volcanic Suite (for example, TUN. and MILL). The young vein leads have similar isotopic compositions to older, volcanogenic leads (for example, Tedi), indicating that Late Tertiary mineralization has occurred without significant contamination by a radiogenic component. This uniformity of lead isotope composition points to a close genetic relationship between lead deposits in and near the Callaghan Creek pendant depsite the several ages of mineralization (Miller and Sinclair, 1978, 1979).

INTERMONTANE BELT

The relatively few new lead isotope dates for deposits in the Intermontane Belt are mainly from the Smithers area and are given in Table 4. Deposits hosted by Hazelton volcanic rocks of Jurassic age are probably volcanogenic unless closely related spatially to stocks as young as Tertiary. The Kutcho volcanogenic deposit occurs in volcanic rocks which are probably Triassic in age. Lead isotope data from deposits *in Jurassic rocks are relatively uniform in composition and cluster close to the geochron only slightly below* the normal crustal growth curve. Isotopic values are comparable to those found in volcanogenic deposits of the neighbouring central Coast Crystalline Belt. The Kutcho deposit is an obvious anomaly, but is separated widely geographically from the other deposits and occurs in older Triassic rocks.

OMINECA BELT

No new data have been obtained for the Omineca Belt.

EASTERN MARGINAL BELT

Lead isotope data for the Eastern Marginal Belt, given in Table 5, are for shale-hosted, stratiform zinc-lead-silver deposits in the Driftpile–Gataga area of northeastern British Columbia. These data cluster near the geochron but are significantly above the general growth curve for crustal leads for both thorium-derived ^{208}Pb and ^{206}Pb and ^{207}Pb. On fossil evidence, the deposits formed very near the Devonian/Mississippian boundary (W. Roberts, 1979, personal communication). Earlier lead isotope studies (Godwin, *et al.*, 1979) indicate a basement source of 1500 Ma for this area.

CONCLUSIONS

The comparatively few new lead isotope analyses on galena from mineral deposits in British Columbia show that lead isotopes provide a useful means of investigating different ages and geochemistries of basement rocks throughout the Canadian Cordillera. More data obviously are desirable and will result in refined interpretations. A number of specific conclusions can be drawn from data presented.

(1) Insular Belt lead isotope ratios from deposits hosted by Sicker volcanic rocks suggest the possible existence of an approximately 2000-Ma-old basement complex.

(2) Central Coast Crystalline Belt lead isotope data from Jurassic volcanogenic or related deposits suggest the possibility that basement rocks *circa* 2500 Ma old underlie this area.

(3) Southern Coast Crystalline Belt lead isotope ratios from volcanogenic or related deposits developed in a significantly different Pb-U-Th environment than did lead in comparable deposits in the central Coast Crystalline Belt.

(4) Tertiary mineralization at Van Silver deposits have lead isotope ratios indistinguishable from volcanogenic deposits in Lower Cretaceous Gambier Group rocks, indicating that a close genetic relationship is likely. In other cases lead may be mobilized and contaminated with a radiogenic component to produce, for example, Tertiary lead highly enriched in a radiogenic component. Examples of this may include Tertiary porphyry and related deposits.

(5) Most lead ratios from *circa* Mesozoic volcanogenic and related deposits appear to have developed in a relatively low U/Pb and low Th/Pb environment relative to the normal crustal evolution curve defined by Stacey and Kramers (1975) and implies growth in a more primitive environment. This characteristic is common to such deposits in the Insular, Coast Crystalline, and Intermontane Belts. Data are not yet available for the Omineca Belt.

(6) Leads from several volcanogenic deposits with 'least radiogenic' isotopic ratios allow calculation of reasonable single stage ages, and may specify areas of high mineral potential.

(7) Eastern Fold Belt lead isotope ratios from Devonian/Mississippian stratiform lead-zinc-barite deposits evolved in a high U/Pb and Th/Pb environment relative to normal crustal evolution. Evolution of the lead in the Selwyn shale basin is an acceptable explanation of the pattern found.

Our comparatively few, new lead isotope analyses on galena from mineral deposits in British Columbia show that such studies provide important restrictions on ore genesis, age of mineralization, and age and geochemical attributes of the source rocks (*see* Sinclair, 1965). Much more data are desirable and will provide a useful means of studying metallogeny of the Canadian Cordillera.

ACKNOWLEDGMENTS

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TABLE 1: LEAD ISOTOPE ANALYSES[1] ON GALENA[2] FROM MINERAL DEPOSITS

Insular Belt

Sample Number	Deposit Name	Map Name	Lat.° North	Long.° West	Lead Isotope Data (Relative 1S Error as %) $^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	Remarks
Tertiary								
G679JR-001	Sunro (Jordan R.)	JR	48.44	124.04	19.018 (.06)	15.624 (.10)	38.714 (.13)	
Number of deposits (n) = 1	arith. average = $\bar{X}$				[19.018 (.06)]	[15.624 (.10)]	[38.714 (.13)]	
Number of analyses = 1	std. error mean $=S \cdot n^{-1/2}$				-----	-----	-----	
Pennsylvanian - Permian								
G79AB-001	Alpha and Beta	AB	48.73	124.09	18.882 (.07)	15.617 (.10)	38.406 (.07)	massive
G79CL-001	Cowichan Lake	CL	48.7A	124.3A	18.646 (.03)	15.581 (.05)	38.276 (.10)	massive
G49CL-002	Cowichan Lake	CL	48.7A	124.3A	18.666 (.02)	15.589 (.07)	38.396 (.10)	massive
G79CL-003	Cowichan Lake	CL	48.7A	124.3A	18.702 (.07)	15.546 (.10)	38.086 (.30)	massive
Average for Cowichan Lake		CL	48.7A	124.3A	[18.671 (.04)]	[15.572 (.07)]	[38.252 (.16)]	
G79IC-001	Iron Clad	IC	48.85	123.68	18.682 (.08)	15.581 (.09)	38.304 (.12)	disseminated[3]
G79LN-001	Lenora	LN	48.87	123.78	18.534 (.04)	15.538 (.09)	38.216 (.04)	massive
G79LN-002	Lenora	LN	48.87	123.78	18.562 (.08)	15.572 (.08)	38.230 (.09)	massive
Average for Lenora		LN	48.87	123.78	[18.548 (.06)]	[15.555 (.08)]	[38.223 (.06)]	
G79TY-001	Tyee	TY	48.87	123.78	18.558 (.08)	15.577 (.07)	38.123 (.11)	massive
G79Wh-001	Western: Myra	WM	49.57	125.59	18.506 (.06)	15.579 (.04)	38.186 (.07)	massive
G79WM-002	Western: Myra Z	WM	49.57	125.59	18.488 (.07)	15.554 (.07)	38.089 (.06)	massive
G79WM-003	Western	WM	49.57	125.59	18.484 (.06)	15.551 (.09)	38.115 (.03)	massive
Average for Western		WM	49.57	125.59	[18.493 (.06)]	[15.561 (.07)]	[38.130 (.05)]	
Number of deposits (n) = 6	arith. average = $\bar{X}$				[18.639 (.06)]	[15.577 (.08)]	[38.240 (.10)]	
Number of analyses = 11	std. error mean $=S \cdot n^{-1/2}$				0.057	0.009	0.044	

1. All analyses done in the Geology - Geophysics Laboratory, The University of British Columbia.

2. All analyses done on galena samples unless otherwise noted.

3. Sample is galena poor and mainly pyrite and chalcopyrite.

TABLE 2: LEAD ISOTOPE ANALYSES[1] ON GALENA[2] FROM MINERAL DEPOSITS

Central Coast Crystalline Belt

Sample Number	Deposit Name	Map Name	Lat.° North	Long.° West	Lead Isotope Data (Relative 1S Error as %) $^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	Remarks
Tertiary								
G79BR-001[3]	RAF: Bear R. area	BR	55.98	129.89	19.231 (.05)	15.629 (.04)	38.712 (.07)	age uncertain
G78NC4155[4]	B.C. Molybdenum	MO	55.42	129.42	19.203 (.14)	15.537 (.10)	38.893 (.13)	K-Ar: 51 Ma
G79SB-001[3]	Packer Fraction	SB	56.11	130.02	19.155 (.08)	15.585 (.05)	38.602 (.06)	age uncertain
Number of deposits (n) = 3	arith. average = $\bar{X}$				[19.196 (.09)]	[15.617 (.06)]	[38.736 (.09)]	
Number of analyses = 3	std. error mean = $S \cdot n^{-1/2}$				0.022	0.016	0.085	
Jurassic								
G78BV-001	Bayview	BV	55.96	129.98	18.501 (.14)	15.592 (.08)	38.213 (.08)	
G78BM-001	Big Missouri	BM	56.11	130.03	18.175 (.06)	15.521 (.06)	37.634 (.09)	
G78DV-001	Dolly Varden	DV	55.74	129.63	18.948 (.09)	15.673 (.03)	38.779 (.11)	
G78DV-002	Dolly Varden	DV	55.74	129.63	18.866 (.08)	15.628 (.11)	38.432 (.16)	
Average for Dolly Varden		DV	55.74	129.63	[18.907 (.08)]	[15.651 (.07)]	[38.605 (.14)]	
G78EC-001	Ecstall River	EC	53.87	129.51	18.303 (.04)	15.549 (.02)	37.788 (.04)	
G78ES-001[3]	Esperanza	ES	55.49	129.49	18.791 (.14)	15.617 (.05)	38.620 (.10)	
G78NC8136[4]	Galena Property	GP	55.72	129.52	18.912 (.11)	15.668 (.06)	38.784 (.20)	
G79GD-001[3]	Granduc	GD	56.21	130.33	18.722 (.11)	15.600 (.10)	38.428 (.11)	
G79HR-001[3]	Hercules (Dumas)	HR	56.16	130.05	18.753 (.07)	15.634 (.06)	39.057 (.10)	
G78HC-001	Hidden Creek	HC	55.44	129.81	18.489 (.13)	15.590 (.09)	38.380 (.11)	
G78MS-001	Mastadon	MS	55.59	129.76	18.758 (.10)	15.654 (.06)	38.546 (.10)	
G78SP-001	Silbak-Premier	SP	56.05	130.02	18.825 (.06)	15.577 (.06)	38.357 (.07)	
G78SP-002	Silbak-Premier	SP	56.05	130.02	18.849 (.06)	15.639 (.04)	38.551 (.10)	
G78SP-003	Silbak-Premier	SP	56.05	130.02	18.839 (.05)	15.632 (.06)	38.475 (.07)	
G79Pr-001[3]	Silbak-Premier	SP	56.05	130.02	18.767 (.06)	15.594 (.13)	38.494 (.08)	
Average for Silbak-Premier		SP	56.05	130.02	[18.820 (.06)]	[15.605 (.07)]	[38.469 (.08)]	
G78TB-001	Torbit	TB	55.69	129.49	18.844 (.11)	15.580 (.03)	38.295 (.05)	
G78TB-002	Torbit	TB	55.69	129.49	18.856 (.10)	15.610 (.05)	38.287 (.20)	
G78NC6995	Torbit	TB	55.69	129.49	18.918 (.05)	15.642 (.08)	38.546 (.05)	
Average for Torbit		TB	55.69	129.49	[18.872 (.09)]	[15.611 (.05)]	[38.376 (.10)]	
G78NC198[4]	United Metals	UM	55.55	129.28	18.858 (.07)	15.671 (.07)	38.503 (.18)	
G78UJ-001	Unuk River	UJ	56.41	130.49	18.861 (.08)	15.629 (.08)	38.373 (.15)	
Number of deposits (n) = 14	arith. average = $\bar{X}$				[18.694 (.09)]	[15.614 (.06)]	[38.456 (.11)]	
Number of analyses = 20	std. error mean = $S \cdot n^{-1/2}$				0.063	0.011	0.103	

1. All analyses done in the Geology - Geophysics Laboratory, The University of British Columbia.

2. All analyses done on galena samples unless otherwise noted.

3. Sample submitted by T. Grove, BCMOM.

4. Sample submitted by N. Carter, BCMOM.

TABLE 1: LEAD ISOTOPE ANALYSES[1] ON GALENA[2] FROM MINERAL DEPOSITS

Southern Coast Crystalline Belt

Sample Number	Deposit Name	Map Name	Lat.° North	Long.° West	Lead Isotope Data (Relative 1S Error as %) $^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	Remarks
Jurassic - Lower Cretaceous								
G78AL-001	Fitzsimmons Creek	AL	50.12	122.93	18.466 (.05)	15.525 (.05)	38.047 (.07)	massive
G79BF-001	Big Foot	BF	49.44	121.84	18.494 (.07)	15.525 (.04)	38.030 (.07)	stockwork
G79BF-002	Big Foot	BF	49.44	121.84	18.496 (.04)	15.550 (.10)	38.077 (.14)	stockwork
Average for Big Foot		BF	49.44	121.84	[18.495 (.06)]	[15.538 (.07)]	[38.054 (.11)]	
BRITN-493	Britannia: E Blf.	BT	49.61	123.14	18.53. (.10)	15.573 (.08)	38.097 (.08)	massive
BRITN-494	Britannia: Vict	BT	49.61	123.14	18 .59 (.09)	15.556 (.08)	37.952 (.13)	massive
BRITN-495	Britannia: Vict	BT	49.61	123.14	18.524 (.05)	15.579 (.06)	38.221 (.06)	massive
BRITN-496	Britannia: Vane	BT	49.61	123.14	18.502 (.07)	15.548 (.03)	38.054 (.11)	massive
G78BT-001	Britannia: Bluff	BT	49.61	123.14	18.484 (.07)	15.521 (.07)	38.035 (.06)	massive
G78BT-002	Britannia: No 5	BT	49.61	123.14	18.544 (.08)	15.591 (.09)	38.145 (.05)	massive
G78BT-003	Britannia: No 8	BT	49.61	123.14	18.502 (.09)	15.568 (.07)	38.092 (.08)	massive
Average for Britannia		BT	49.61	123.14	[18.507 (.08)]	[15.562 (.07)]	[38.085 (.08)]	
G79HL-001	Harrison Lake	HL	49.35	121.83	18.482 (.07)	15.563 (.07)	38.043 (.10)	stockwork
G79HP-001	Hopkins	HP	49.64	123.29	18.532 (.05)	15.599 (.08)	38.093 (.12)	massive
G78LC-001	Lynn Creek	LC	49.42	123.06	18.474 (.04)	15.529 (.03)	38.028 (.15)	massive (skarn?)
G79MV-001	McVicar: Ruth	MV	49.66	123.02	18.408 (.08)	15.545 (.02)	37.976 (.09)	massive
G79MV-002	McVicar: Whistler	MV	49.66	123.02	18.467 (.07)	15.549 (.10)	38.058 (.08)	massive
Average for McVicar		MV	49.66	123.02	[18.438 (.08)]	[15.547 (.06)]	[38.017 (.09)]	
G79NA-001	Northair: Manif.	NA	50.13	123.10	18.378 (.10)	15.511 (.06)	38.960 (.07)	massive
G78NA-002	Northair: Discov.	NA	50.13	123.10	18.472 (.06)	15.537 (.05)	38.101 (.11)	massive
G78NA-003	Northair: Warman	NA	50.13	123.10	18.441 (.10)	15.517 (.08)	38.034 (.10)	massive
G78NA-004	Northair: Warman	NA	50.13	123.10	18.429 (.05)	15.527 (.07)	38.012 (.04)	vein
Average for Northair		NA	50.13	123.10	[18.430 (.08)]	[15.523 (.06)]	[38.026 (.08)]	
G78SE-003	Seneca	SE	49.32	121.95	18.312 (.10)	15.516 (.08)	37.895 (.07)	massive
G78SE-005	Seneca	SE	49.32	121.95	18.319 (.10)	15.516 (.09)	37.914 (.08)	stockwork
Average for Seneca		SE	49.32	121.95	[18.316 (.10)]	[15.516 (.08)]	[37.905 (.08)]	
G78VS-001	Van Silver: Tedi	VS	50.06	123.14	18.427 (.09)	15.556 (.07)	38.079 (.09)	disseminated
G78VS-002	Van Silver: Mill	VS	50.06	123.14	18.664 (.06)	15.552 (.08)	38.190 (.05)	vein in tert. intr.
G78VS-005	Van Silver: Tun.	VS	50.06	123.14	18.712 (.04)	15.583 (.09)	38.223 (.12)	veinlet
G78VS-006	Van Silver: Tun.	VS	50.06	123.14	18.462 (.07)	15.519 (.08)	38.002 (.07)	disseminated
average for Van Silver		VS	50.06	123.14	[18.553 (.06)]	[15.552 (.08)]	[38.124 (.08)]	
Number of deposits (n) = 10	arith. average = $\overline{X}$				[18.481 (.07)]	[15.541 (.06)]	[38.055 (.10)]	
Number of analyses = 26	std. error mean = $S \cdot n^{-1/2}$				0.028	0.007	0.027	

1. All analyses done in the Geology - Geophysics Laboratory, The University of British Columbia.

2. All analyses done on galena samples unless otherwise noted.

TABLE 4: LEAD ISOTOPE ANALYSES[1] ON GALENA[2] FROM MINERAL DEPOSITS

Intermontane Belt

Sample Number	Deposit Name	Map Name	Lat.° North	Long.° West	Lead Isotope Data (Relative 1S Error as) $^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	Remarks
Cretaceous - Tertiary								
G79AT-001	Atlin Ruffner	AT	59.73	133.53	19.066 (.05)	15.599 (.09)	38.580 (.11)	
G79AT-002	Atlin Ruffner	AT	59.73	133.53	19.101 (.05)	15.637 (.08)	38.718 (.09)	
Average for Atlin Ruffner		AT	59.73	133.53	[19.084 (.05)]	[15.618 (.08)]	[38.649 (.10)]	
S78GS-003	Goosley: Galena	GS	54.18	126.25	18.863 (.06)	15.577 (.07)	38.387 (.20)	K-Ar: 50MA
G78SG-002	Goosley: Main	GS	54.18	126.25	19.402 (.06)	15.661 (.06)	38.772 (.12)	
G78SG-003	Goosley: S. Tail	GS	54.18	126.25	18.860 (.05)	15.553 (.04)	38.301 (.05)	
Average for Goosley		GS	54.18	126.25	[19.042 (.06)]	[15.597 (.06)]	[38.487 (.12)]	
G79PC-036	Poplar Porphyry	PC	54.02	126.98	18.861 (.10)	15.588 (.07)	38.438 (.08)	
Number of deposits (n) = 3		arith. average = $\bar{X}$			[18.995 (.07)]	[15.601 (.07)]	[38.524 (.10)]	
Number of analyses = 6		std. error mean = $S \cdot n^{-1/2}$			0.068	0.009	0.064	
Jurassic								
G78AS-001	Ascott	AS	54.79	126.72	18.666 (.09)	15.592 (.07)	38.349 (.10)	
G78BK-001	Bob Creek	BK	54.30	126.60	18.834 (.09)	15.608 (.07)	38.444 (.04)	
G78DL-002	Del Santo	DL	54.65	126.70	18.643 (.08)	15.586 (.08)	38.219 (.04)	
G78TS-001	Topley Silver	TS	54.60	126.26	18.735 (.07)	15.578 (.08)	38.346 (.05)	
Number of deposits (n) = 4		arith. average = $\bar{X}$			[18.720 (.08)]	[15.591 (.08)]	[38.340 (.06)]	
Number of analyses = 4		std. error mean = $S \cdot n^{-1/2}$			0.043	0.006	0.046	
Upper Triassic								
G78KU-001	Kutcho Ck.	KU	58.20	128.37	18.469 (.07)	15.524 (.13)	37.815 (.09)	
Number of deposits (n) = 1		arith. average = $\bar{X}$			[18.469 (.07)]	[15.524 (.13)]	[37.815 (.09)]	
Number of analyses = 1		std. error mean = $S \cdot n^{-1/2}$			----	----	----	

1. All analyses done in the Geology - Geophysics Laboratory, The University of British Columbia.
2. All analyses done on galena samples unless otherwise noted.

TABLE 5: LEAD ISOTOPE ANALYSES[1] ON GALENA[2] FROM MINERAL DEPOSITS

Eastern Fold Belt

Sample Number	Deposit Name	Map Name	Lat.° North	Long.° West	Lead Isotope Data (Relative 1S Error as %) $^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	Remarks
Devonian - Mississippian								
G78AK-001	Alcock	AK	57.67	125.42	18.984 (.09)	15.764 (.08)	39.561 (.09)	
G78CQ-001	Cirque	CQ	57.52	125.12	18.795 (.08)	15.689 (.08)	39.166 (.08)	
G78DC-001	Driftpile Creek	DC	58.07	125.92	18.864 (.07)	15.666 (.07)	39.093 (.05)	
G78DC-002	Driftpile Creek	DC	58.07	125.92	18.860 (.09)	15.686 (.06)	39.202 (.10)	
G78DC-003	Driftpile Creek	DC	58.07	125.92	18.852 (.08)	15.655 (.06)	39.043 (.13)	
Average for Driftpile Creek		DC	58.07	125.92	[18.859 (.08)]	[15.669 (.06)]	[39.113 (.09)]	
G78EF-001	Elf	EF	57.42	124.72	18.834 (.09)	15.661 (.09)	39.310 (.04)	
G78FK-001	Fluke	FK	57.42	124.87	18.846 (.08)	15.714 (.04)	39.477 (.06)	
G79RG-001	Rough	RG	58.27	126.17	18.709 (.03)	15.617 (.07)	38.548 (.11)	
Number of deposits (n) = 6	arith. average = $\bar{X}$				[18.838 (.08)]	[15.686 (.07)]	[39.196 (.08)]	
Number of analyses = 8	std. error mean $= S \cdot n^{-1/2}$				0.037	0.020	0.148	

1. All analyses done in the Geology - Geophysics Laboratory, The University of British Columbia.

2. All analyses done on galena samples unless otherwise noted.

BULLETIN 60 – GEOLOGY OF THE AKOLKOLEX RIVER AREA AN ADDENDUM

By P. B. Read
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and
R. I. Thompson
The Institute of Sedimentary and Petroleum Geology, Calgary, Alberta

In the interval between submission of the manuscript and maps for Bulletin 60, Geology of the Akolkolex River Area, and its publication, mapping in the northern part of the Kootenay Arc and Clachnacudainn Salient permits an alternative interpretation for stratigraphic correlations and regional structural associations to that proposed by Thompson for the Akolkolex River area.

Thompson (1978) subdivided rocks of the Akolkolex River area into two fundamental tectono-stratigraphic assemblages: an upper structural level composed of Lower Paleozoic units of the Kootenay Arc and a lower structural level, called the Clachnacudainn Salient (Wheeler, 1965), consisting of schist, micaceous quartzite, quartzite, marble, and minor amphibolite. Rocks of the lower structural level were correlated on the basis of gross lithology with the Hamill Group. Separating the two levels is the gentle southeasterly dipping Standfast Creek fault or slide that cuts down structurally from northeast to southwest. This fault should be extended beneath the klippe of unit Ꞓbd on Ghost Peak as on Figure 60.

It is proposed here that the stratified metamorphic rocks of the lower structural level or Clachnacudainn Salient may represent an inverted sequence comprising the Lardeau Group, Badshot Formation, and the upper part of the Hamill Group. This interpretation hinges on correlation of a 10 to 30-metre-thick amphibolite layer (unit B4c) of the Clachnacudainn Salient with the Jowett Formation of the Kootenay Arc. As the Jowett Formation is traced northwestward along Kootenay Arc, it thins rapidly from about 400 metres of amphibolite, biotite-chlorite-calcite schist, and spatially associated marble near Comaplix Mountain to 30 metres south of Akolkolex River (Fig. 59). The thickness and lithology agree well with those of the amphibolite unit B4c beneath Sandfast Creek slide and lead to the interpretation that unit B4c is the northerly extension of the Jowett Formation. Recent mapping (Read, 1980) has defined an additional amphibolite layer with similar characteristics that is approximately 300 metres structurally below amphibolite B4c shown on Figure 59 (Thompson, 1978). At present, uncertainty exists as to whether the new amphibolite is a structural repetition of Thompson's amphibolite; however, the distribution of map units shown on Figure 60 is based on the assumption of a single, folded amphibolite layer as with the Jowett Formation of the arc. Rock units adjacent to amphibolite B4c comprise mica and quartz-rich mica schist and some micaceous quartzite. These lithologies are similar to those found on either side of the Jowett Formation in the arc where quartz grit occurs in the upper part of the Index Formation as well as in the overlying Broadview Formation (Read, 1975; Read and Wheeler, 1976). The dominant grey mica schist of unit B4 and marble of unit C are lithologically similar to the lower part of the Index Formation and Badshot Formation respectively of the arc. In the northeastern part of the map-area, grey mica schist of unit D and a structurally overlying, thick quartzite of unit Da form the footwall of Standfast Creek slide. The quartzite thickens eastward into the Albert Peak area where Sears (1979, p. 27) tentatively correlated it with the Hamill Group. Using only the quartzite (unit Da), Sears correlated the stratigraphic succession structurally below the quartzite with the Horsethief Creek Group (see accompanying table, column B). If the quartzite is overturned, the succession in Clachnacudainn Salient would represent

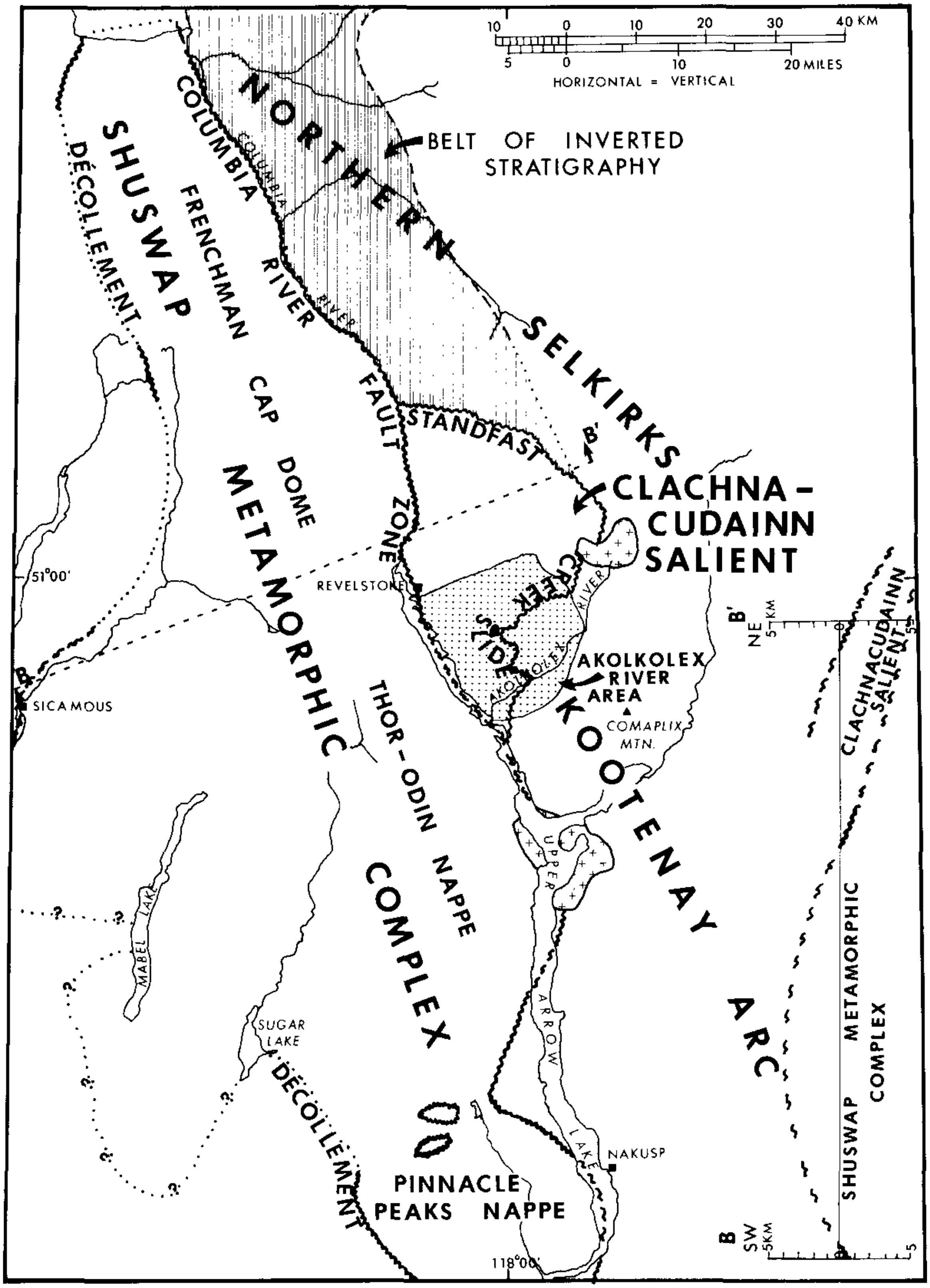

Figure 59. Regional map showing Kootenay Arc and northern Selkirk Mountains, Shuswap Metamorphic Complex, Clachnacudainn Salient, and location of the Akolkolex River area. Position of the decollement northwest of Revelstoke modified from Brown (1980) and southwest of Revelstoke taken from Okulitch (1979).

of the salient where a belt of inverted stratigraphy up to 20 kilometres wide underlies the northern Selkirk Mountains on their western side against the Shuswap Metamorphic Complex (Read and Brown, 1979 and Fig 59). Unfinished work and some problems still remain: (1) amphibolite B4c is incompletely mapped southwest of Ghost Peak and may be missing northwest of the peak (Fig. 60); (2) a unique equivalent to the Badshot Formation does not exist among the marble layers which comprise unit C; and (3) Sears (1979, p. 23) noted that one graded bed within the quartzite of unit Da is upright, but in these structurally complicated rocks more facing data are needed.

CORRELATION SCHEMES FOR THE STRATIFIED METAMORPHIC ROCKS OF CLACHNACUDAINN SALIENT

STRATIGRAPHY OF KOOTENAY ARC AND SELKIRK MOUNTAINS	A AKOLKOLEX RIVER AREA (Thompson, 1978)	B ALBERT PEAKS AREA (Sears, 1979)
LARDEAU GROUP		
Broadview Formation	A3, part of A1, B1, B3, and B4	
Jowett Formation	unit B4c	
Index Formation	B4a, B4b, and part of B4	
Badshot Formation	unit C	
HAMILL GROUP		
Mohican Formation	unit D	unit Da (Єh ?)*
Marsh Adams Formation Mount Gainer Formation	unit Da	
HORSETHIEF CREEK GROUP		
Upper pelite		absent
Middle carbonate		units C and D (m, s, and p)*
Lower pelite		absent
Quartzofeldspathic grit		units A1, A2, A3, B1, B2, B3, B4, B4a, B4b, and B4c (qs, sc, qt)*

*Map unit symbols within brackets are those used by Sears, 1979.

Although Clachnacudainn Salient has been considered a part of the Shuswap Metamorphic Complex by workers such as Wheeler (1965), Ross (1968), and Read (1977a and 1977b), recent data indicate that it is an eastward dipping allochthon lying on the eastern side of the complex (Read, 1979a and 1979b; Brown and Read, 1979). Standfast Creek slide confines the salient on its north, east, and southern sides, but its amount and direction of displacement are unknown. The recognition that the stratigraphy within the salient is probably correlative with that of the arc suggests that displacement relative to the arc is not major. Movement on the fault is after Middle Jurassic deformation but prior to or synchronous with metamorphism because the movement does not disrupt the simple westward increase in metamorphic grade toward the Shuswap Metamorphic Complex (Fig. 60). The major structural break is the post-metamorphic decollement lying along the Columbia River fault zone which separates the arc and salient from the stratigraphically dissimilar rocks of the Shuswap Metamorphic Complex. It dips gently eastward for over 150 kilometres along the eastern side of the complex and may warp up over Thor-Odin and Pinnacle Peaks nappes (formerly capped domes, *see* Read, 1980) and Frenchman Cap dome. If the gneiss 'dome' terrain of the Shuswap Metamorphic Complex is arbitrarily considered autochthonous, the decollement is the break with an allochthonous cover which includes Clachnacudainn Salient, the northern Selkirk Mountains, and Kootenay Arc (Fig. 59).

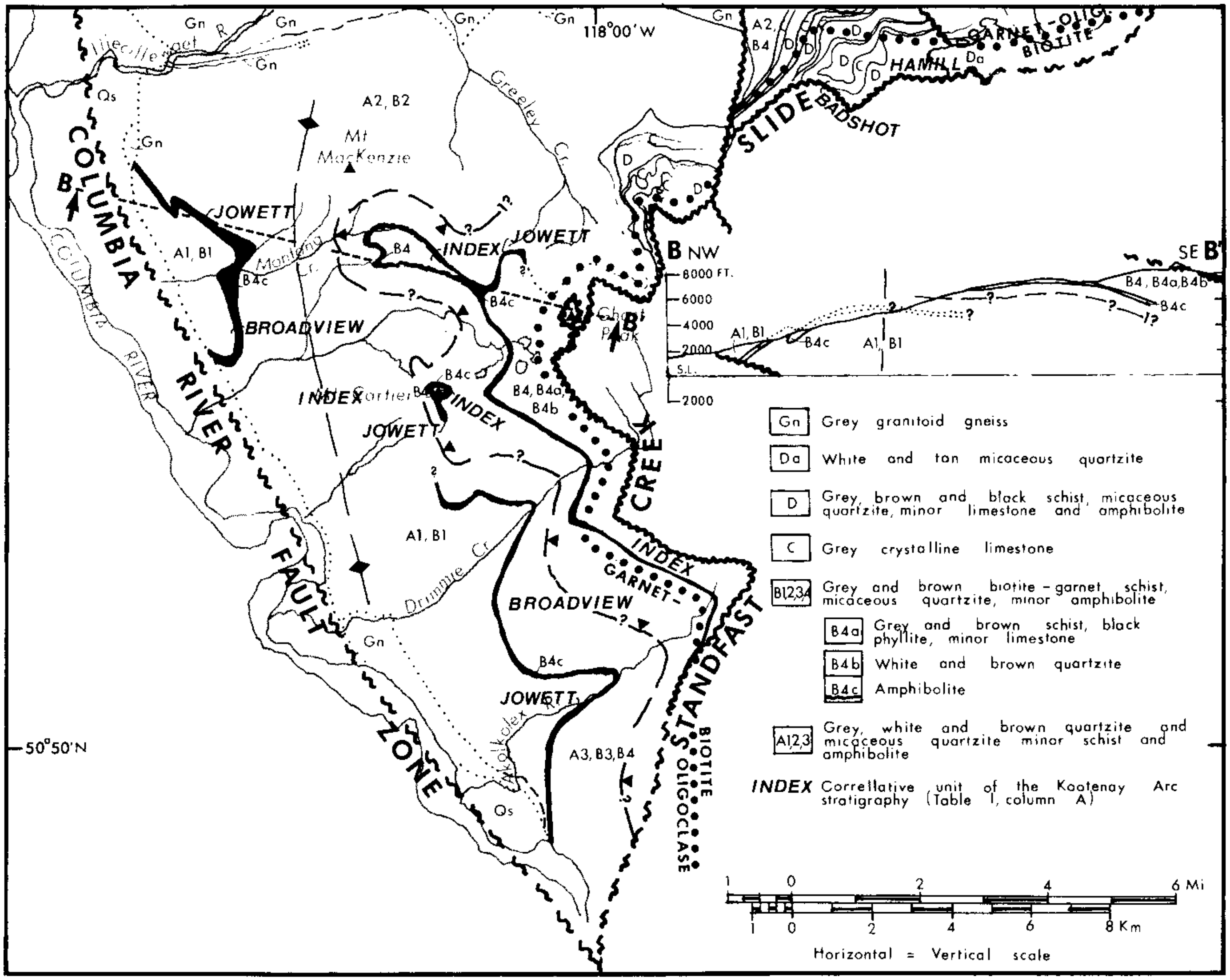

Figure 60. Simplified geological map of the southern part of Clachnacudainn Salient showing the distribution of rock units and their correlation with units of the Kootenay Arc.

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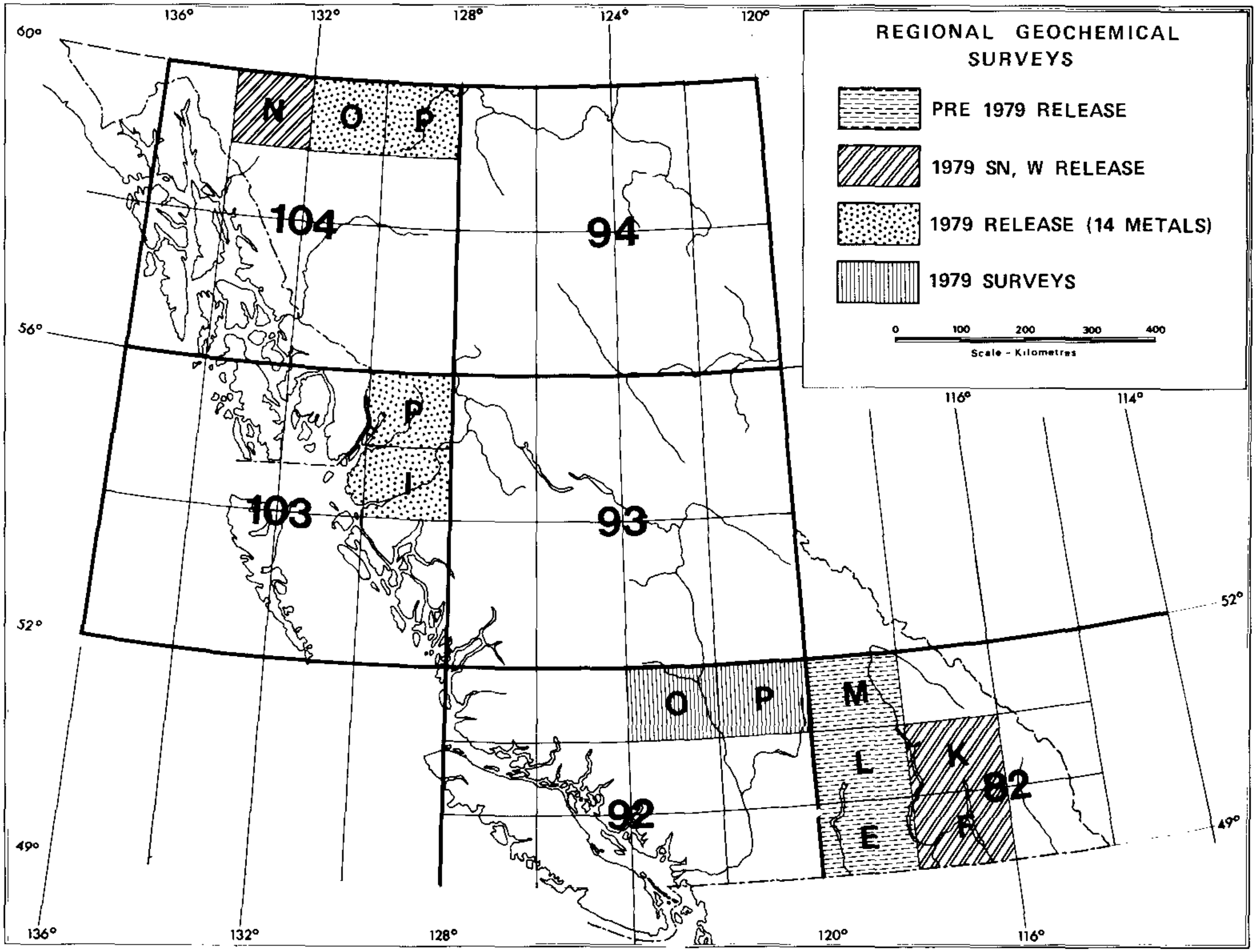

Figure 61. Index map – regional geochemical surveys.

REGIONAL GEOCHEMICAL SURVEY

(92 O, P)

By N. C. Carter and T. E. Kalnins

The Ministry of Energy, Mines and Petroleum Resources conducted a regional geochemical survey of NTS map-areas 92O (Taseko Lakes) and 92P (Bonaparte River) during the 1979 field season.

The Regional Geochemical Survey, an ongoing program of the Geological Division, is patterned after the Uranium Reconnaissance Program. Previous areas covered by these programs and the 1979 sampling area are shown on Figure 61.

Stream sediment and water samples were collected from 1 747 sites in the Taseko Lakes and Bonaparte River map-areas for an average sample site density of one per 14 square kilometres. Excluded from the survey was an area of 5 800 square kilometres near the mutual boundaries of the two map-areas where poorly developed drainage is due to extensive overburden and plateau basalt cover. About half the sites were accessible by road, the remainder were sampled using helicopter support. A six-person sampling crew was provided by Bema Industries Ltd. of Langley and was under the supervision of T. E. Kalnins, Ministry representative.

Sample preparation was done by Kamloops Research and Assay Laboratory Ltd. Stream waters were analysed for uranium, fluorine, and pH by Min-En Laboratories, while stream sediment analyses were performed by Chemex Labs Ltd. and included the determination of zinc, copper, lead, nickel, cobalt, silver, manganese, iron, molybdenum, tungsten, mercury, and arsenic. Uranium analyses of stream sediments will be carried out by Novatrack Analysts Ltd.

Data processing will be done by Resource Geophysics and Geochemistry Division of the Geological Survey of Canada. Release of analytical results is scheduled for late May 1980.

Figure 61 shows map-areas for which data were released in 1979. Two releases in June included the Jennings River–McDame (104 O and P) map-areas, covered by the Uranium Reconnaissance Program, and the Terrace–Nass River (103 I–J, O–P) areas, representing the Accelerated Geochemical Survey of 1978. Stream sediments collected during 1977 Uranium Reconnaissance Program surveys in 82 F and K (Nelson and Lardeau) were re-analysed for tin and tungsten and sediments from 104N (Atlin) were analysed for tin. The results were released in mid-September.