Geological Setting and Mineralization in the Mount Attwood – Phoenix Area of the Greenwood Mining Camp

By B.N.Church

Ministry of
Energy, Mines and
Petroleum Resources
Hon. Jack Davis, Minister

PAPER 1986–2

GEOLOGICAL SURVEY BRANCH
MINERAL RESOURCES DIVISION

FRONT COVER

Courtesy of G. O. M. Stewart of Dentonia Resources Ltd., from a painting by W. Smith of Osoyoos of the Denoro Grande headframe (1973) near Jewel Lake.

ADDENDUM:

To accompany Geological Setting and Mineralization in the Mount Attwood – Phoenix area of the Greenwood Mining Camp; Ministry of Energy, Mines and Petroleum Resources Geological Survey Branch Paper 1986–2, page 29.

TABLE 7B
URANIUM–LEAD ZIRCON DATA FOR LEXINGTON QUARTZ PORPHYRY

Sample No.	Location	Sample Properties	Concentration Observed: Weight (mg)	Concentration Observed (ppm): U	Concentration Observed (ppm): Pb	Concentration Observed: $^{206}Pb/^{204}Pb$	$^{206}Pb/^{238}U$	Atomic Ratios[3,4]: $^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$	Model Ages (Ma)[4]: $^{206}Pb/^{238}U$	Model Ages (Ma)[4]: $^{207}Pb/^{235}U$	Model Ages (Ma)[4]: $^{207}Pb/^{206}Pb$	Concordia Intercepts: low	Concordia Intercepts: high
FLY 86-1	49°0.5' 118°36.5'	nm,<100μm	0.8	130.6	4.0	1438	0.03141±0.00023	0.2177±0.0028	0.05027±0.0050	199.4±1.4	200.0±2.3	207.5±23.1	200	2445
		m, 100-200μm	4.6	166.7	5.4	1555	0.03219±0.00024	0.2302±0.0033	0.05187±0.0061	204.3±1.5	210.4±2.7	279.6±26.5		
		m,>200μm	2.4	197.5	6.3	2808	0.03175±0.00023	0.2286±0.0020	0.05223±0.0024	201.5±1.4	209.1±1.6	295.5±10.2		

Note. Sample submitted by B.N. Church, analysis performed by P. Van der Heyden.

GEOLOGICAL SETTING AND MINERALIZATION IN THE MOUNT ATTWOOD-PHOENIX AREA OF THE GREENWOOD MINING CAMP

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Canadian Cataloguing in Publication Data

Church, B. N.
Geological setting and mineralization in the Mount Attwood-Phoenix area of the Greenwood mining camp, British Columbia

(Paper, ISSN 0226-9430 ; 1986-2)

ISBN 0-7718-8511-3

1. Geology, Economic - British Columbia - Greenwood Region. 2. Geology - British Columbia - Greenwood Region. 3. Mines and mineral resources - British Columbia - Greenwood Region. I. British Columbia. Ministry of Energy, Mines and Petroleum Resources. II. Title. III. Series: Paper (British Columbia. Ministry of Energy, Mines and Petroleum Resources) ; 1986-2.

QE187.C58 1986 557.11'41 C86-092070-4

VICTORIA
BRITISH COLUMBIA
CANADA

AUGUST 1986

The Phoenix mine at close of operations, October 1976.

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GEOLOGICAL SETTING AND MINERALIZATION IN THE MOUNT ATTWOOD-PHOENIX AREA OF THE GREENWOOD MINING CAMP

INTRODUCTION

The Mount Attwood-Phoenix area is centred around the old mining town of Greenwood on transprovincial Highway 3 in south-central British Columbia. Regional mapping of this 250-square-kilometre quadrangle was prompted by continuing mining exploration and ore production. This report gives the results of recent geological work and summarizes previous investigations including some property examinations.

Successive studies show that the area is underlain by a variety of sedimentary, volcanic, and metamorphic rocks and igneous intrusions of Paleozoic, Mesozoic, and Tertiary ages. The first definitive geological contributions were by Brock (1902) and LeRoy (1912). Other significant reports based on further mapping were completed by McNaughton (1945), Seraphim (1956), Carswell (1957), and Little (1983).

The present study is a result of mapping completed in 1984 utilizing the 1:2 000-scale topographic base of The Granby Mining Co. Ltd. and information from previous property evaluations including the Lexington mine (Church, 1970), Jewel mine (Church and Winsby, 1974), Oro Denoro mine (Church, 1976b), Sappho (Church and Robertson, 1983), Sylvester K prospect (Church, 1984), and Skomac mine (Church, 1985c).

PHYSIOGRAPHY

The Mount Attwood-Phoenix map sheet extends 16 kilometres north of the International Boundary covering much of the highland terrain comprising the northern part of the Tenas Mary Creek horst between the towns of Midway and Grand Forks.

The area is characterized by smooth-topped hills and low mountains having a maximum topographic relief of approximately 900 metres (3,000 feet). Five peaks rising above 1 500 metres m.s.l. elevation (5,000 feet) are aligned forming a divide projecting north from the International Boundary, midway on the sheet. These peaks are Mount McLaren, Rusty Mountain, Mount Wright, Mount Attwood, and Knob Hill. Drainage on the east side of this divide flows to July Creek and thence to the Granby River beyond the southeast margin of the map-area. On the west and northwest, streams flow to Boundary Creek which joins the Kettle River near the International Boundary at the town of Midway.

The terrain has been broadly corregated by southerly and southeasterly moving Pleistocene glaciers. Generally the best bedrock exposures are at high elevations, the valleys being filled with glacial sand, gravel, and clay deposits.

HISTORY

Lode mineralization was first recorded in the Greenwood area near Boundary Falls in 1884 and by 1900 most of the important deposits had been found. Mining began on the Skylark property in 1893, on the Providence claim in 1896, and in the Phoenix area in 1900. Development was stimulated by completion of the railway in the period 1898 to 1904 and construction of a major smelter at Grand Forks in 1900. Production from the mines at Phoenix attained a peak delivery in 1913 of more than a million tonnes of ore. Labour unrest in the Crowsnest Coalfield indirectly forced closure of the Grand Forks smelter and many of the mines in 1919.

An increase in the price of precious metals in 1933 led to a revival of operations at the Providence, Dentonia, and North Star mines where concentrators were built. However, it was not until 1957 and 1959 that an increase in copper prices combined with new mining technology resulted in large-scale open-pit production from the Mother Lode and Phoenix orebodies. Production at Phoenix attained 2 750 tonnes per day in 1972 and remained at this scale until exhaustion of the ore in 1976 (*see* frontispiece).

Small-scale production of precious metals from the Greenwood area has sustained since closure of the copper operations. Robert Mines Ltd. achieved some ore production in 1975 and 1976 and installed a mill in 1981. Also, intermittent production has been recorded by Colt Resources Ltd. and Dentonia Resources Ltd. from 1974 to present from the Denero Grande claim at Jewel Lake.

ACKNOWLEDGMENTS

Assistance rendered by mining and mining exploration personnel of Greenwood is gratefully acknowledged. Special thanks are owing G.O.M. Stewart and H. H. Shear of Dentonia Resources Ltd., James T. Fyles and W. Gilmour of Kettle River Resources Ltd., R. Seraphim of Azure Resources Ltd., J. J. McDougall, formerly of Falconbridge Nickel Mines Ltd., K. Schindler of Robert Mines Ltd., F. G. Franchi, formerly of Lexington Mines Ltd., and residents of Greenwood, A. Taylor and J. M. MacLean.

Technical assistance and advice have been supplied by Ministry colleagues, including G. G. Addie, District Geologist based in Nelson and officers of the Analytical Laboratory, including S. W. Metcalfe, former Chief Analyst.

Officers of the Geological Survey of Canada, H. W. Little and K. M. Dawson, provided valuable scientific support in this investigation.

GEOLOGICAL SETTING

Twenty-two geological units are distinguished in the Mount Attwood-Phoenix area (*see* Fig. 1). These include a wide-ranging variety of Paleozoic to Tertiary beds that have been disturbed by multiple episodes of deformation and igneous intrusion.

This report retains, from primary sources, the names of the major stratigraphic divisions such as 'Brooklyn', 'Attwood', and 'Knob Hill' applied to the Triassic, Permo-Carboniferous, and older Paleozoic formations respectively. The name 'Penticton Group' is adopted from nomenclature used in the Okanagan area for the collective reference to the Early Tertiary formations of that region (Church, 1982).

The relative stratigraphic position and age of these rocks are generally interpreted according to the rules of superposition of beds, degree of regional metamorphism, and the sequential cutting relationships of igneous intrusions; fossils, and a few radiometric dates, provide some specific control. Interpolation of geological contacts was guided by detailed mapping in vicinity of the principal mines and establishment of more than 2 400 outcrop control stations throughout the area.

KNOB HILL GROUP

The Knob Hill Group is the oldest of the four major unconformable stratigraphic assemblages. LeRoy (1912) first described these 'pre-Carboniferous' rocks in the Phoenix area and noted a predominance of cherts (rock unit 2), lesser amounts of greenish chloritic rocks (2a), and a minor carbonate facies (1). These units have now been traced to Deadman Hill to the northeast, along the valley of Boundary Creek to the west, and to Stacey Creek near the south margin of the map-area.

According to LeRoy (1912, p. 32) "The whole group is a massive [basement] complex in which there is no apparent structure to assist in establishing a stratigraphic sequence. The rocks are much broken by a complicated system of faulting and shearing, . . ."

The chert beds (2), estimated by Seraphim (1956) to be a few hundred metres thick on Deadman Hill, are at least 700 metres thick in the area north of Boundary Falls. Characteristically these rocks are dark grey or light cream coloured and highly competent. They range from massive units to thinly bedded ribbon cherts. In thin section the chert is found to be recrystallized and silicified. The resulting finely granular quartz is invaded by a reticulate pattern of veinlets of coarser quartz and calcite. Concentrations of recrystallized, small, radiolarian-like spherical bodies, viewed in a few samples from Mount Attwood, are the only suggestions of fossil remains (Plate I).

The pelitic rocks of the Knob Hill assemblage, being relatively incompetent and compositionally more reactive than the chert beds, show the sum effects of metamorphism. These ductile units have been transformed to quartz-chlorite and mica schists in a 2-kilometre-wide belt trending southeast from Boundary Falls to Stacey Creek, Mount Wright, and the southwest slopes of Mount Attwood. A pronounced southeast-trending foliation, subparallel to bedding planes, is evidently the result of gliding, cataclasis, and some recrystallization. Interfoliated quartz and carbonate sweats, which commonly characterize these schists, are deformed into many small well-delineated sharp-crested northerly plunging folds (Fig. 2; Plate II).

The maximum effect of thermal metamorphism appears to post-date the principal dynamic events. This is proved by the growth of fresh mica across the early penetrative fabrics (Plate III). Recrystallization is commonly best developed near the contacts of the major granodiorite bodies. Gneissic rocks adjacent to the eastern limits of the Wallace Creek stock (E) are converted to hornfels consisting of small grains of quartz (25 per cent) and biotite (35 per cent) in a matrix of muscovite, feldspar, quartz, and accessory magnetite. Potassium-argon determination on a biotite-muscovite concentrate from this hornfels gives an apparent age of 150 ± 5 Ma (Table 7, No. 3).

Dark schistose rocks (2a) of possible igneous and volcanic origin assigned to the Knob Hill Group are exposed in small areas south and west of Phoenix, north of Providence Lake, and on the south slope of Mount Wright. These rocks are generally more massive in appearance than the metasedimentary units and are relatively enriched in amphibole, feldspar, and epidote. Chemical analyses of this rock type (Table 2a, No. 3) demonstrate higher alumina and total alkalies content than the chloritic schists (No. 2) and quartz-rich schists (No. 1) of the metasedimentary assemblage.

The only good marker formation in the Knob Hill Group is a 2 to 4-metre-wide grey and white marble band (1) within the metacherts (2). This band is exposed opposite the provincial campground in a highway cut 2.8 kilometres north of Boundary Falls. It can be traced, with minor fault offset, 1.5 kilometres westerly to the east-bounding fault of the Toroda Creek graben and thence 4.6 kilometres easterly onto the central ridge of Mount Attwood. Smaller exposures are found north of Haas Creek in the Phoenix area and on the Great Laxey claim 14 kilometres northeast of Boundary Falls.

Intense deformation and recrystallization of the marble (1) has destroyed most primary structural features including any fossil remains. On the upper slopes of Mount Attwood the band is discontinuous and forms *en echelon* marble pods (Plate IV).

Rocks of the Knob Hill Group were a significant exploration target for early prospectors. This led to discovery of the Providence mine at Greenwood which has yielded 42 552 kilograms of silver since the beginning of operations in 1896 (Table 5). Source of the ore was a 300-metre-long quartz vein in altered Knob Hill schists (2) near the northern contact of the Greenwood granodiorite pluton (E). A smaller production was obtained in a similar geological setting from the Gold Bug mine immediately to the west.

The only other known mineral prospects in the Knob Hill Group are a large 200-metre-long quartz lens in schists on the VAL and SIL claims on the south slope of Mount Attwood

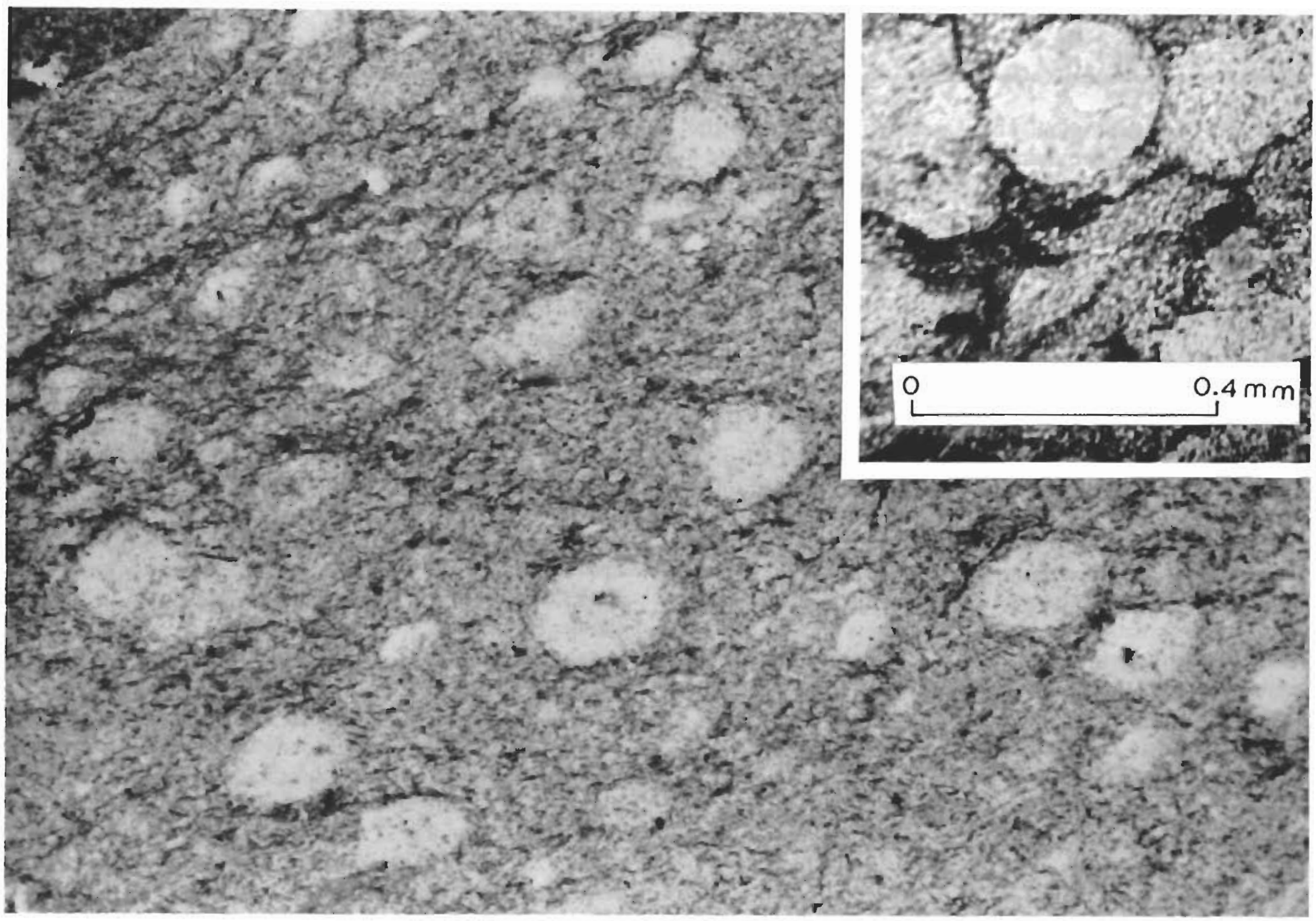

Plate I. Photomicrograph of radiolarian chert, Knob Hill Group.

and sulphide-bearing skarn deposits associated with the marble band (1). The skarn prospects occur both at the contact of a Tertiary diorite dyke (G) cutting the marble on the Combination claim north of Boundary Falls, and along the intrusive contact of the Wallace Creek granodiorite where it intercepts the marble on the Great Laxey claim northeast of Phoenix. There has been no significant production from these deposits.

ATTWOOD GROUP

The Permo-Carboniferous Attwood Group underlies much of the central and southern part of the map-area and, in the type locality on Mount Attwood, it rests unconformably on the Knob Hill Group. The Attwood assemblage consists of chert pebble conglomerate (3), limestone (4), argillite (5), and volcanic rocks (6).

The original description by Brock (1902), reaffirmed by Daly (1912, p. 382), remains essentially correct: "The limestones, argillites and quartzites, cut by serpentines, form a series which closely resemble the Cache Creek series (Carboniferous) of the Kamloops district. They occur in areas of greater or less extent in almost all parts of the district. They are always more or less metamorphosed; the limestone is generally white and crystalline, although occasionally a core of black or drab limestone is to be seen; the argillites are or were somewhat carbonaceous but are frequently altered. A hornblende or mica schist found in the Long Lake [Jewel Lake] region seems to be an alteration form."

The argillites (5) are the most distinctive and widespread rocks of the Attwood sedimentary sequence. In the type area on the north slope of Mount Attwood, the formation is about 250 metres thick and comprises mainly dark grey phyllitic argillite intercalated with thinly bedded greywacke, siltstones, and few chert layers. Similar rocks are found on the slopes overlooking Gibbs Creek, on the Skylark claim west of Phoenix, on Rusty Mountain and Mount McLaren, and in the vicinity of the Skomac mine north of Boundary Falls.

At the Skomac mine the argillites are laminar bedded and accompanied by siliceous siltstones and chert pebble conglomerates. Chemical analysis of a sample of typical black argillite gives 74 per cent normative quartz (Table 2a, No. 8). The age of these rocks has been determined to be Permo-Carboniferous from a small lens of fossiliferous grey limestone, 0.5 kilometre west of the mine, which provided molluscan shells including *Warthia* sp., *Atomodesma* sp., *Bitaunioceras* forms, and crinoid stems. Little (1983) reports six additional fossil localities on Mount Attwood that yield a similar age.

The conglomerate beds (3) predominate near the base of the black argillite formation at the west summit of Mount Attwood. These are chert pebble conglomerates clearly derived from the immediately underlying recrystallized Knob

Plate II. Highly deformed schistose rocks, Knob Hill Group on Mount Attwood.

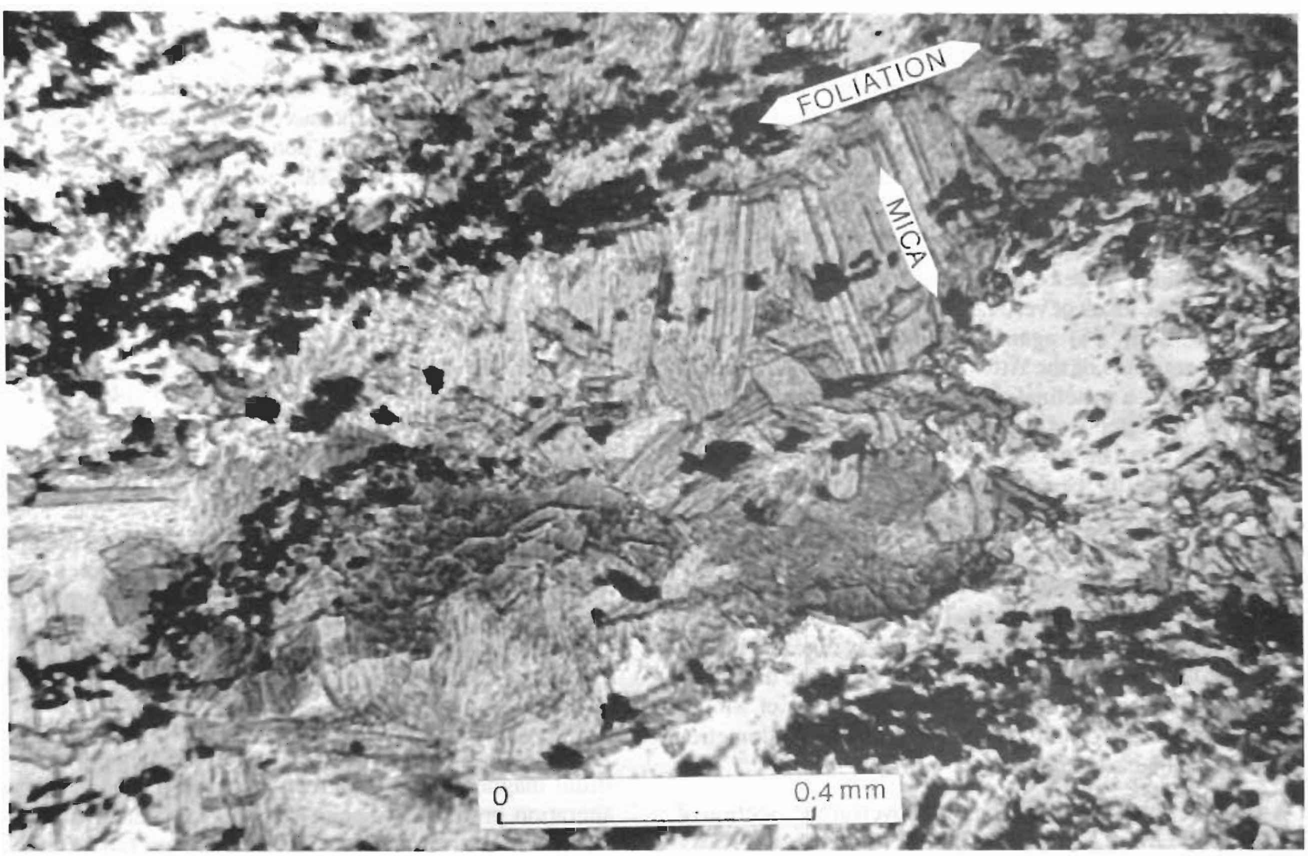

Plate III. Late growth of biotite and muscovite across early penetrative fabric (indicated by streaks of opaque ore granules).

Plate IV. *En echelon* marble lenses in Knob Hill schist.

Hill chert terrain (Plate V). 'Sharpstone' conglomerates of similar association are also found east of the Skylark claim in the central part of the map-area and on the hill 2 kilometres northwest of the Skomac mine. At this latter locality, a large volume of northerly dipping quartz-rich sandstone and conglomerate rests directly on Knob Hill metachert and breccia.

Deformation of these beds in vicinity of the Skomac mine appears to be the result of vertical and lateral movement of the Old Diorite body (A) against the relatively incompetent shales and argillites of the Attwood Group. Such appears to be the origin of a synclinal structure west of the minesite. Elsewhere, the effects of this deformation are imprinted on underlying Knob Hill rocks. This is manifested by crinkle lineations plunging 18 degrees northwest, trending subparallel to the axis of the Skomac syncline (Fig. 2).

A volcanic unit of mostly andesite breccia (6) overlies the argillite (5) in the area west of Boundary Creek 0.5 kilometre northeast of the Skomac mine. These volcanic rocks are intruded by diorite (A) which contains partly digested blocks of the surrounding country rock. Similar rocks are displayed again in a small area midway up the west slope of Mount Attwood and in the vicinity of the Keno claim, 2 kilometres northeast of the east summit of Mount Attwood.

An almost complete, but apparently overturned, section of the Attwood Group is found on Mount McLaren and Rusty Mountain, where three of the main formations are identified: these are a lower zone of basalt and andesite lava (6), an intermediate zone of carbonaceous phyllite (5), and an upper zone of quartz wacke and conglomerate (3); the total sequence being more than 300 metres thick. These units are mostly horizontal, although locally some beds are steeply inclined on the limbs of minor folds. The phyllite is generally wrinkled, with crenulations plunging gently to the east and west.

Amphibolitized metabasalt (6), assigned to the Attwood Group, forms numerous scattered outcrops on Mount Attwood, in the vicinity of Haas Creek and Lind Creek, on the Winnipeg and Golden Crown claims, on the old railway grade east and west of Glenside Creek and Montezuma Ridge, and along the course of Snowshoe Creek. Although these lavas are generally massive, small limestone and argillite lenses (4) are found within the pile at several localities. These provide bedding attitudes suggesting an overall formational thickness of at least 100 metres. According to Little (1983), fossils secured from a lens of sedimentary rock north of the Athelstan mine yielded a Permo-Carboniferous age similar to collections from Mount Attwood.

Petrographic examination of the metabasalt generally shows a felted mixture of feldspar and amphibole with interstitial magnetite and some epidote, chlorite, and carbonate alteration products. Chemical analyses of three samples of this rock type from Glenside Creek and Jewel Lake (Table 2a, Nos. 4, 5, and 6) are similar proving a basalt composition.

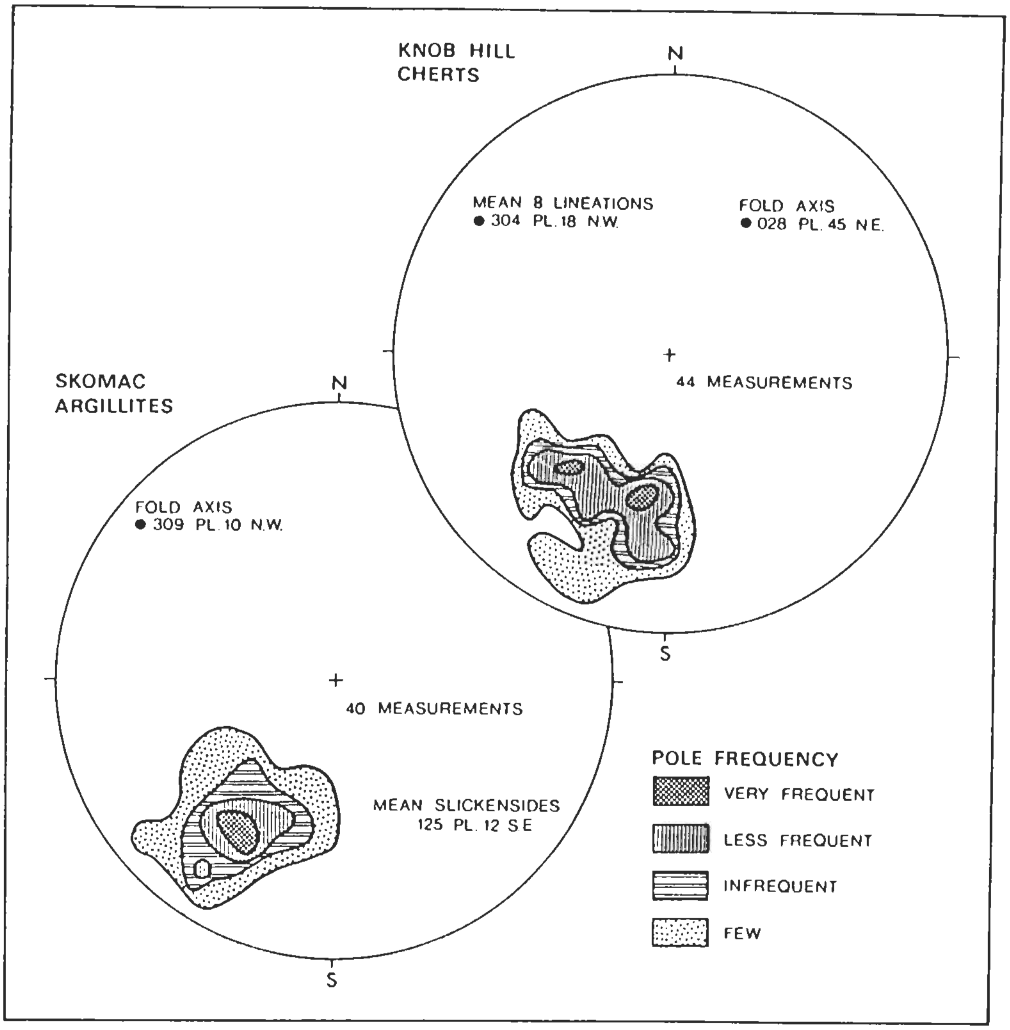

Figure 2. Equal area plot of bedding and lineation attitudes.

The metabasalt unit (6) appears to rest disconformably on eroded basal sharpstones (3) east of the Skylark claim and onlaps unconformably onto Knob Hill rocks in the area 1 kilometre north of Providence Lake.

The main body of limestone (4) occurs within the argillites (5) and is exposed discontinuously along the 9-kilometre faulted length of Mount Attwood ridge. The limestone is a conformable, mostly light grey unit dipping 25 to 60 degrees northeast. It has a maximum thickness of about 100 metres in the area east and northeast of the summit. The formation thins westerly to less than 10 metres on the Croesus claim, 1.5 kilometres west of Boundary Creek. An abundance of recognizable fossils such as coral, crinoid plates, gastropods, and bryozoan fragments, etc., is usually sufficient to distinguish this limestone from other carbonate beds in the region.

The effects of metamorphism on rocks of the Attwood Group are variable throughout the map-area. It is rarely sufficient to be destructive of internal structures. Penetrative cleavage slip deformation is locally well developed and apparently related to elongation of conglomerate clasts and the development of small chevron folds (Plate VI). The thermal effects are manifested in the argillites (5) by development of incipient biotite such as exhibited by the rocks on Rusty Mountain and at the Skomac mine, and the secondary growth of blue-green laths of amphibole in the metabasalts (6).

Significant mineral production has been realized from deposits in the argillite (5) and volcanic (6) formations of the Attwood Group. This production is mostly from precious-metal vein systems related to faults and fractures satellitic to plutonic intrusions. For example, the Skylark mine, operating from 1893 to 1940, produced 5 283 kilograms of silver from a quartz vein in argillite (5) near the east boundary of the Greenwood granodiorite stock (E). Also, the Skomac mine (Republic property) has yielded 3 709 kilograms of silver from quartz veins in argillite (5) adjacent to large diorite (A) and serpentine (F) intrusions. The combined mining operations on the Golden Crown and Winnipeg claims yielded 1 207 kilograms of silver and 402 kilograms of gold from sulphide-bearing quartz veins in metavolcanic rocks (6) and diorite (A). Unlike the above, the Croesus prospect is in a skarn where a granitic apophysis cuts limestone (4); there is no record of production from this property.

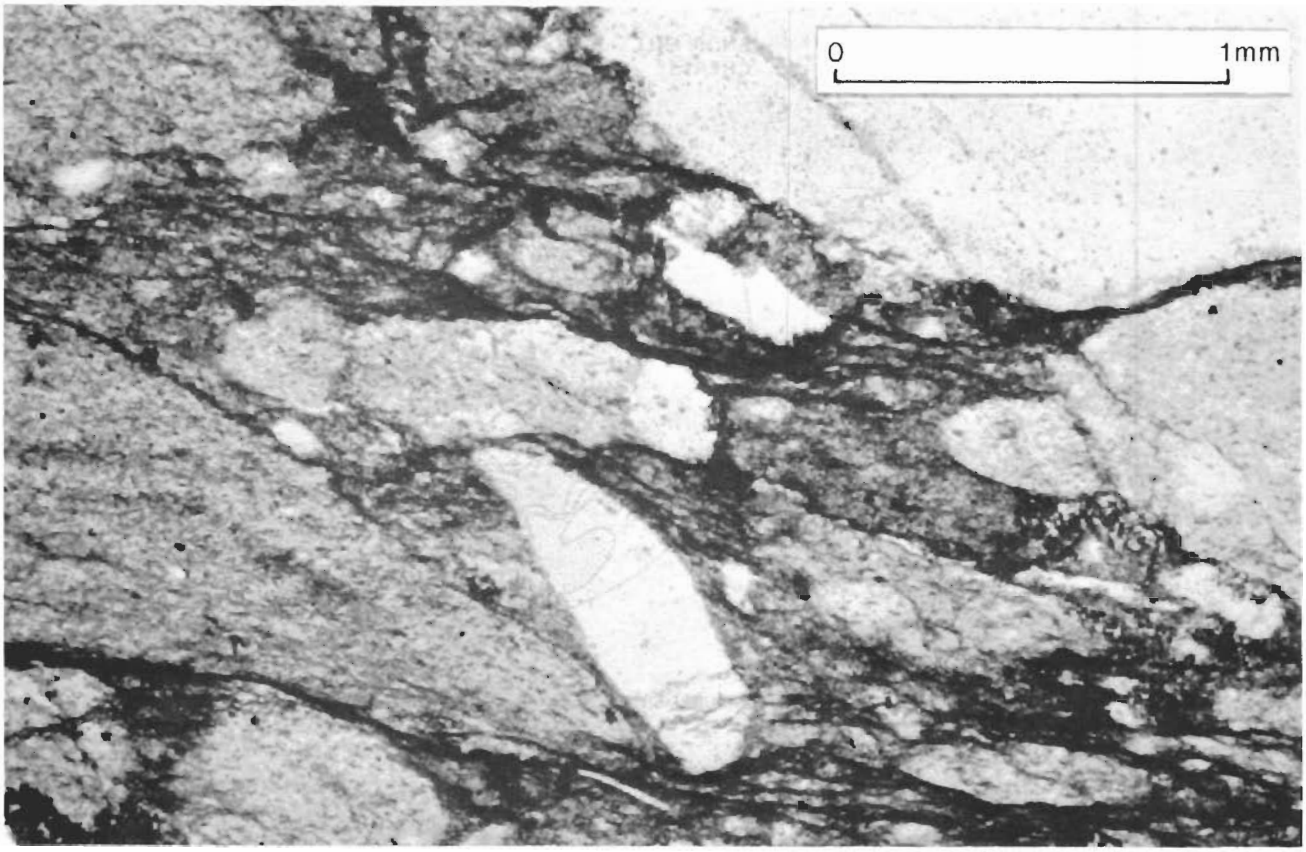

Plate V. Photomicrograph of immature chert pebble conglomerate, Attwood Group.

Plate VI. Small chevron folds in black argillite of the Attwood Group, Skomac mine area.

BROOKLYN GROUP

The Brooklyn Group is a Triassic sequence of conglomerate, shale, limestone, and volcanic rocks. It is comparable in total distribution and volume to the older stratigraphic assemblages. The principal outliers are between Phoenix and the Oro Denoro mine in the northeast part of the map-area, around the Mother Lode and Sunset mines north of Deadwood Creek, underlying much of the drainage basin of May Creek between Mount Attwood and July Creek, and forming a small area in vicinity of the Ruby claim northeast of Boundary Falls.

Mapping of the Brooklyn Group was initiated by Brock in 1902 and the study of these rocks has continued to the present time. LeRoy (1912) was the first to apply the name Brooklyn to the strata near the Brooklyn mine in the Phoenix area. Seraphim (1956) recognized a three-fold division consisting of sharpstone conglomerate (7), limestone (8), and volcanic formations (9). Little (1983) collected several fossil suites which proved a Middle and Late Triassic age for these rocks.

The sharpstone conglomerate (7) consists of immature polymictic conglomerate 450 to 600 metres thick. It is characterized by an abundance of purple and grey, pebble-sized angular chert clasts intermixed with greenstone fragments and lesser amounts of jasper, diorite, limestone, and other rocks derived from the diverse lithologies of the underlying metamorphosed Paleozoic terrain (Plate VII). Modal analyses of the sandy matrix of this rock give an average of 40 per cent chert and quartz, 15 per cent amphibole and chlorite hash, 15 per cent carbonates, and minor feldspar and opaque iron oxides.

These conglomerate beds are intercalated with green sandstones and siltstones, limestone lenses, and discontinuous shale layers. The 'Rawhide shale', named by LeRoy (1912), is an example of a thick shale lens near the base of the sharpstone conglomerate (7). It is well displayed on the haulage road southeast of the Phoenix mine. Chemical analysis of the Rawhide shale (Table 2b, No. 11) resembles dacitic andesite, which suggests derivation of the constituent particles from a volcanic provenance. In comparison, the conglomerate facies is much higher in silica and lower in alumina (Table 2b, Nos. 9 and 10) reflecting the abundance of 'Knob Hill chert' clasts. Calculations based on analysis No. 9 give 47 per cent normative quartz.

The contact relations of the sharpstone conglomerate (7) are displayed on the slopes of Deadman Hill. At the lower contact, the conglomerates directly overlie the Knob Hill chert and, at one point, a thin zone of felsic tuff breccia. The upper contact, exposed further east on the main ridge, passes transitionally into the limestone formation through a few hundred metres of intercalated sandstones and shale.

The limestone (8), estimated to be approximately 600 metres thick, is exposed extensively in the east part of the map-area. This limestone is a light grey rock consisting of relatively pure calcium carbonate layers alternating with thin beds enriched in siliceous sand grains and clay impurities. Above the contact with the sharpstone conglomerate, southwest of Wilgress Lake and the Oro Denoro mine, the limestone is commonly massive and locally brecciated. To the east the upper half of the limestone section is generally well bedded with frequent shale partings. Cherty sand is concentrated at several horizons within calcarenite zones. In thin section these rocks display rounded 55 per cent carbonate clasts in a carbonate mud matrix; 35 per cent subangular to well-rounded chert grains; and minor quartz, feldspar, and porphyritic rock fragments.

The Eholt Formation (9) was named by Carswell (1957) for volcanic breccias and volcaniclastic rocks in the northeast part of the map-area near the Phoenix road turn-off on Highway 3. The unit includes a peculiar 'pudding stone' facies composed of chert, greenstone, and limestone blocks within basaltic andesite tephra (Table 2b, No. 12; Plate VIII). Brock's original description of these rocks, quoted by Carswell (1957, p. 21), is remarkably accurate: "This series of rocks consists of green tuffs and volcanic conglomerates and breccias, fine ash and mud beds, flows of green porphyrite and probably some interbedded limestones and argillites. The tuffs, conglomerates and breccias consist of a mixture of pebbles and boulders of porphyrite material with a great many fragments (probably a large proportion) of the rocks through which the volcanics burst. Pebbles and boulders of limestone, argillite, jasper, and chert are common."

The age of these rocks is shown to be Late Triassic by Little (1983, p. 19) who collected the diagnostic coral *Thecosmilia suttonensis* from a limestone lens immediately north of the Phoenix road junction on Highway 3.

According to Carswell there is a 'nonconformable' relationship between Eholt volcanic rocks (9) and the underlying Brooklyn beds (7 and 8). South of the Phoenix road, the Eholt Formation rests mainly on sharpstone conglomerate (7); to the north the same rocks overlie limestone (8).

Recent work by James T. Fyles (personal communication) shows that volcanic breccias east of the Stemwinder claim in the Phoenix area overlie an upper facies of the sharpstone conglomerate unit (7). These volcanics are tentatively correlated with the Eholt Formation (9). It is noted that two lenses of 'Stemwinder' limestone breccia, occurring near the contact of the sharpstones (7) and volcanic rocks (9), resemble the 'pudding stone' deposits exposed on Highway 3 to the east.

A relatively complete, but apparently inverted and down-faulted Triassic section is viewed on the upper slopes of Mount Attwood 1 kilometre southwest of the east summit. At this location a wedge of Brooklyn limestone (8), about 50 metres thick and dipping westerly, is sandwiched between Eholt volcanics (9) below and a 110-metre-thick cap of sharpstone conglomerate (7) above. The sharpstone unit displays overturned graded beds and scour structures and a general structurally upward increase in clast size throughout the section. At the top of Attwood ridge, blocks of Knob Hill quartzose schist, as large as 1 metre in diameter, are embedded in the conglomerate (7). At the base of the ridge the limestone beds (8) pass abruptly, but apparently conformably, into a thin zone of well-bedded volcaniclastic rocks and then into massive greenstone breccias (9). The thickness of Eholt volcanic rocks is estimated to be at least several hundred metres.

Structurally the Triassic rocks on Mount Attwood form a recumbent fold, plunging about 20 degrees northwest. This fold has a gently inclined northerly dipping limb, that underlies May Creek and the lower slopes of Mount Attwood, and a more steeply inclined and inverted west-dipping limb exposed on the upper slopes of Mount Attwood. A penetrative cleavage, extensively developed on the inverted limb, appears to coincide with an important easterly trending fault which transects the structure. These structures arise apparently as a result of thrusting from a northerly direction which has carried segments of the Knob Hill and Attwood terrains southward over the Brooklyn rocks.

In the Phoenix and Oro Denoro areas structures are more diverse. East of Deadman Hill the Brooklyn Formation is monoclinal and dips east at about 50 degrees on average. Local reversals and deflections of beds give evidence of minor folds plunging about 30 degrees toward northeast (Fig. 3). In the area north of Phoenix the Brooklyn limestone (8) and sharpstone conglomerate (7) are generally steeply inclined and strike northerly. These beds are intercepted at shallow depth by a thrust fault that is exposed north of the mine tailings pond on the Cimeron claim and by drilling on the Sylvester K claim. The drilling penetrated the thrust fault at a depth of 150 metres where fault gouge separates sharpstone conglomerate (7) above from crushed dark grey cherts of the Knob Hill Group (2) below.

Mineralization in the Brooklyn rocks is the source of most of the ore produced from the Greenwood area. A total of 31 788 743 tonnes of ore (Table 5) has been processed from skarn rocks (0) of the Phoenix, Oro Denoro, Mother Lode, Greyhound, and Marshall mines. This has yielded 35 976 kilograms of gold, 117 216 kilograms of silver, and 269 604 tonnes of copper, which ranks this mining camp in the category of a significant world producer.

The target for mineral exploration is commonly the Brooklyn limestone (8), although the sharpstone conglomerate and associated argillites (7) have also undergone some local skarnification. In places movement along the incompetent shaly beds that form the transitional zone between units (7) and (8) has resulted in fracturing and allowed the entry of mineral-bearing solutions.

The Oro Denoro mine presents a classical model for skarnification which sheds light on ore emplacement in other skarn deposits of the area. The geology of the Oro Denoro mine is relatively straightforward; mineralization consists of pockets of pyrite, chalcopyrite, and magnetite in a garnetite skarn. This skarn is mostly a replacement of limestone (8) caused by intrusion of the Lion Creek granodiorite, the most easterly lobe of the Wallace Creek pluton (E).

The mine workings cover about 4 hectares in the central part of the Oro Denoro Crown-granted claim. In the early period of mining between 1903 and 1910 ore was drawn from five quarries and a number of open stopes which were serviced by two underground levels. This mine and the Phoenix operation several kilometres to the southwest were among the earliest attempts at open-pit mining in the province.

Mineralization and the development of skarn rocks at Oro Denoro evidently resulted from intrusion of the granodiorite body. An exchange of chemical components between the Brooklyn limestone (8) and the granodiorite (E) is apparent. A determination of the mineralogy of the skarn is provided by Carswell (1957, p. 61); it is 85 per cent garnet (grossularite, 10 per cent; andradite, 90 per cent) and 5 per cent each of clinozoisite, diopside, and quartz. In terms of estimated chemical composition this mineralogy reduces to SiO_2, 39.6 per cent; Al_2O_3, 3.9 per cent; Fe_2O_3, 24.7 per cent; MgO, 0.9 per cent; and CaO, 30.9 per cent on an anhydrous base. This determination compares closely to the actual chemistry of a sample of the Oro Denoro skarn (Table 1, No. 1). The gain of large amounts of iron oxide and silica by the limestone (8) is matched by an equally large loss of lime to the granodiorite (E). Source of the iron oxide and silica appears to result from calcification of iron-bearing silicates and plagioclase feldspar in the granodiorite.

Formation of the skarn and emplacement of the sulphide and magnetite ores involved medium to high-temperature interaction between the limestone and the granodiorite. The intensity of this exchange is reflected in the extensive development of coarse, essentially monomineralllic garnetite. Marked irregularities and variations in the width of the skarn zone, from a few metres to many tens of metres, suggest that the reactions occurred only at places where ascending solutions were active. These solutions, enriched in carbon dioxide, silica, and iron oxide, rose along formational contacts and the local fissure systems. At first the invading solutions formed metasomatic veins, and, with further infiltration of the limestone mass, wholesale replacement occurred.

TABLE 1
ANALYSES OF SKARNS

	1	2	3
Oxides recalculated to 100:			
SiO_2	36.71	50.88	67.38
TiO_2	0.11	0.11	0.56
Al_2O_3	5.69	0.70	14.38
Fe_2O_3	23.09	5.30	2.25
FeO	1.16	8.69	1.66
MnO	0.39	0.28	0.08
MgO	0.64	8.94	1.42
CaO	32.20	25.08	5.87
Na_2O	0.01	0.01	5.54
K_2O	—	0.01	0.86
	100.00	100.00	100.00
Oxides as determined:			
H_2O^+	0.28	1.53	2.18
H_2O^-	0.11	0.13	0.28
CO_2	1.67	16.20	3.52
P_2O_5	0.48	0.62	0.25
S	0.11	3.44	1.72
Molecular norms:			
QZ	—	4.90	19.30
OR	—	0.10	5.10
AB	—	0.10	49.70
NE	2.50	—	—
AN	16.10	1.90	11.80
WO	61.00	51.20	6.90
EN	—	25.80	3.90
FS	—	10.00	0.20
FO	1.50	—	—
FA	—	—	—
IL	0.20	0.20	0.80
MG	2.70	5.80	2.30
HE	16.00	—	—
CR	—	—	—

Key to Analyses
1. Skarnified impure limestone (Brooklyn Group), Oro Denoro pit — *see* Church (1976), No. 4, p. 3.
2. Skarnified carbonate beds (Brooklyn Group), Phoenix pit.
3. Skarnified sharpstone conglomerate (Brooklyn Group), Phoenix pit.

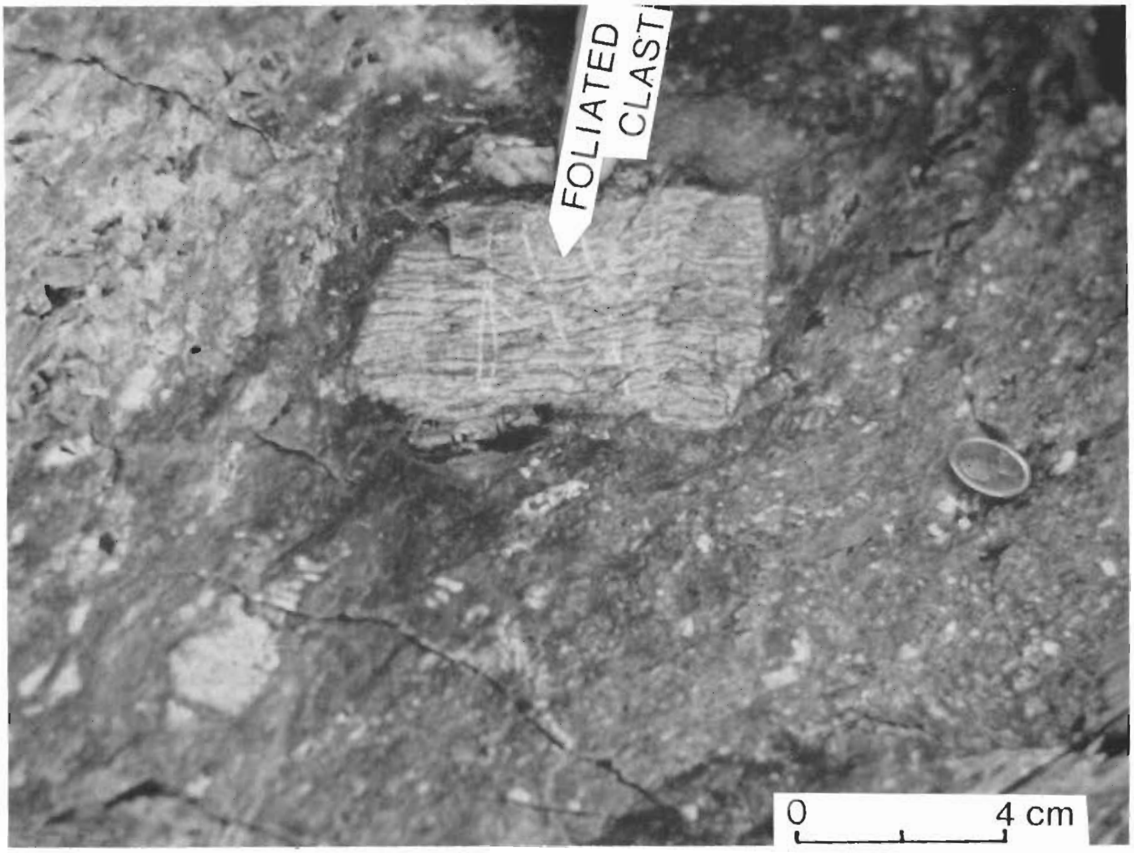

Plate VII. Foliated clast of Knob Hill schist in Brooklyn conglomerate.

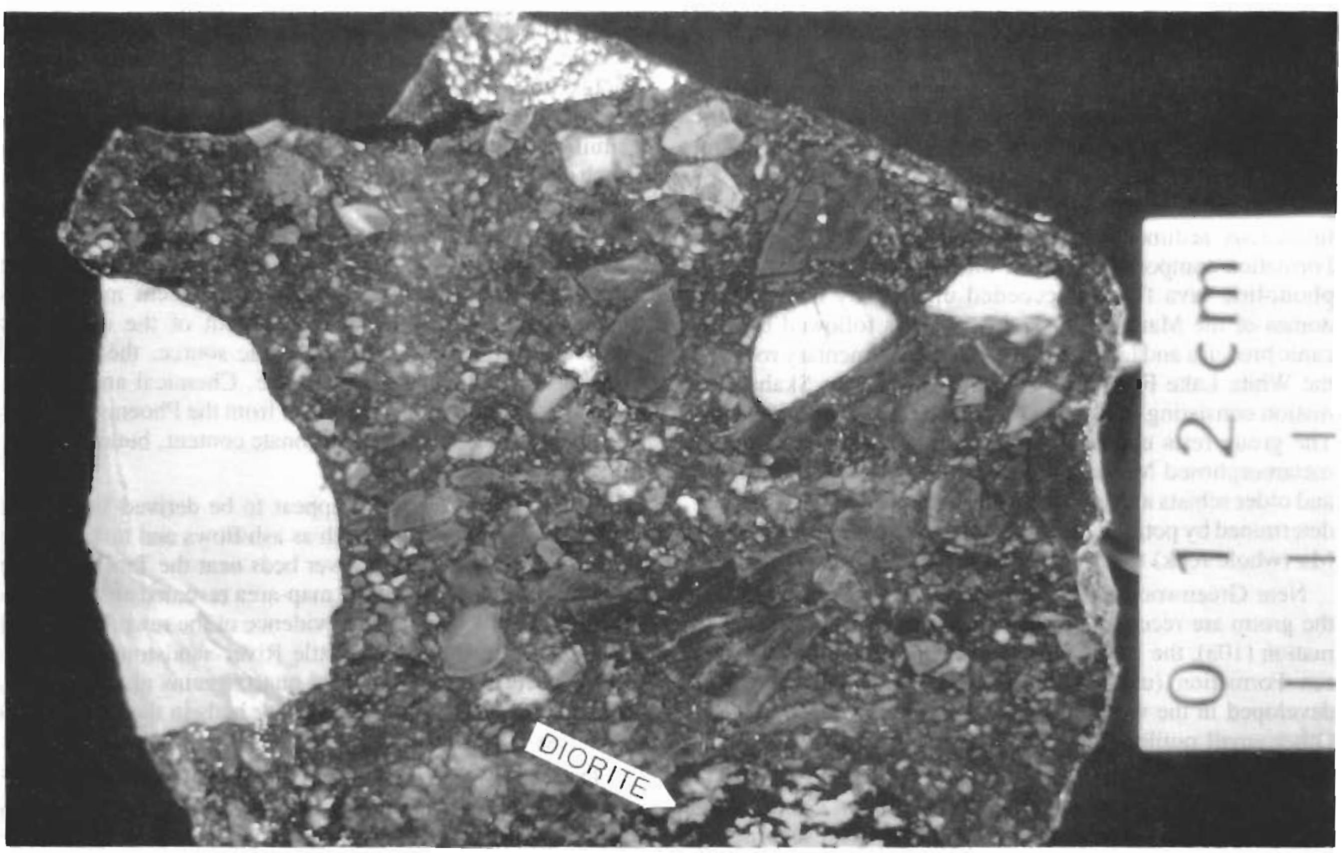

Plate VIII. 'Pudding stone' facies of Eholt Formation with limestone, chert, Old Diorite, and volcanic clasts.

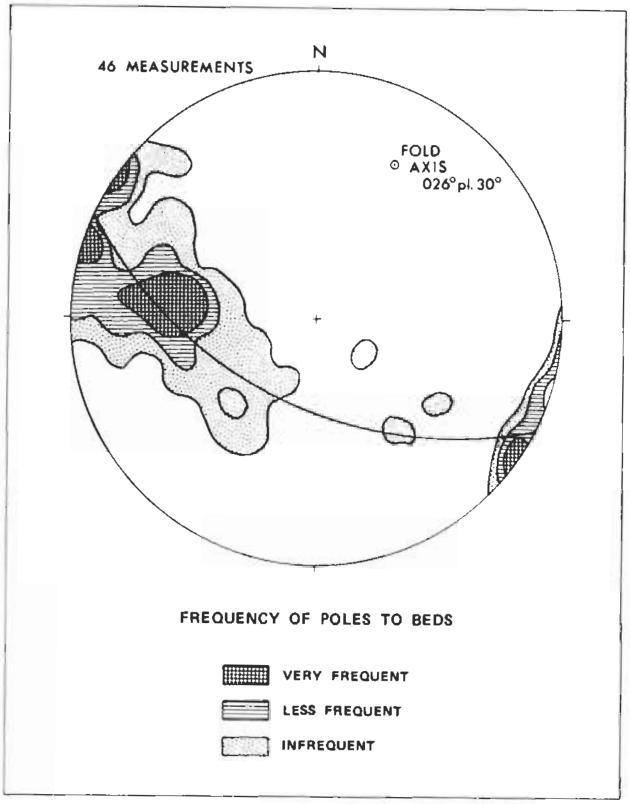

Figure 3. Equal area plot of Brooklyn beds, Oro Denoro area.

PENTICTON GROUP

The Tertiary Penticton Group, as described in the type area 90 kilometres northwest of Greenwood (Church, 1982), consists of six well-defined formations having an aggregate thickness of 2 500 metres. At the base are polymictic conglomerates and breccias of the Springbrook Formation and coeval beds of the Kettle River Formation consisting of granite boulder conglomerate, rhyolite breccia, and tuffaceous sedimentary rocks. Above this is the Marron Formation composed mainly of thick andesite, trachyte, and phonolitic lava flows succeeded upward by dacitic lava domes of the Marama Formation. This is followed by volcanic breccias and lacustrine and fluvial sedimentary rocks of the White Lake Formation and, uppermost, the Skaha Formation consisting of a slide complex and fanglomerate beds. The group rests unconformably on pre-Tertiary granitoids, metamorphosed Mesozoic sedimentary and volcanic rocks, and older schists and gneisses. The age range of the group, as determined by potassium-argon radiometric methods, is 48.4 Ma (whole rock) to 51.3 Ma (biotite) ± 1.8 Ma.

Near Greenwood only the three lowermost formations of the group are recognized, these being the Springbrook Formation (10a), the Kettle River Formation (10), and the Marron Formation (units 11 to 13). The assemblage is best developed in the west part of the map-area and at Phoenix. Other small outliers are found 2 kilometres east of Mount Wright and north of Wilgress Lake.

The most complete section of the Penticton Group is on Deadwood Ridge which projects into the northwest corner of the map-area. Here the Kettle River sedimentary rocks, approximately 200 metres thick, and the Marron volcanics, approximately 1 500 metres thick, are inclined 35 degrees southeast in a graben structure.

The Springbrook Formation (10a) occurs as a very small conglomeratic outlier on a low ridge crest 2 kilometres east of Mount Wright. This remnant paleochannel deposit is polymictic with clasts of diorite, greenstone, felsite, limestone, chert, and a large number of other varieties representing the older units of the map-area including fragments of serpentine from the immediately underlying ultrabasic terrain (F).

The Kettle River Formation (10) is the most widely distributed of the basal Tertiary sedimentary units. It is characterized by flaggy and thick-bedded, light-coloured sandstones with shaly or silty partings containing carbonaceous trash.

At Phoenix the Kettle River rocks are well exposed on the east side of the main pit where they rest unconformably on Brooklyn rocks. From here the Kettle River Formation extends northerly for a total strike length of 2 kilometres to the headwater basin of Glenside Creek on the north slope of Deadman Hill. The beds attain a maximum thickness of 80 metres and dip about 45 degrees easterly below the Yellow Lake volcanic rocks of the Marron Formation. A coal-bearing marker bed developed near the base of the sandstones in the pit area is believed to be a paleosol unconformably overlying skarnified Brooklyn sharpstone conglomerate (7). Locally, contact relations are obscured by intrusion of pulaskite (12) sills and dykes along joints and bedding planes; these connect as feeders to the overlying volcanic rocks of the Penticton Group.

Petrographic examination of typical Kettle River sandstone shows this rock to be an immature quartz feldspar wacke. Thin sections display clasts of broken plagioclase and potassium feldspar crystals, angular unstrained quartz grains, and a few deformed biotite plates in a matrix of similar but more comminuted material and clay. Exotic clasts such as skarn, chert, and carbonates are generally only minor constituents. Modal analysis of a sandstone sample from the Wilgress Lake area shows 15 per cent quartz, 5 per cent chert, 40 per cent feldspar, 10 per cent volcanic rock, minor mica and opaque minerals, and 30 per cent matrix. It is estimated that more than 75 per cent of the clasts were derived from a fresh felsic volcanic source, the remainder having a metamorphic provenance. Chemical analysis of a sample of Kettle River sandstone from the Phoenix pit (Table 2b, No. 13) reveals some carbonate content, but otherwise a resemblance to rhyolite.

The Kettle River rocks appear to be derived from widespread volcanic sources such as ash flows and tuff deposits. Recent drilling of Kettle River beds near the Tam O'Shanter claim in the west part of the map-area revealed an abundance of rhyolite tuff breccia and evidence of the reworking of this material to form typical Kettle River sandstones. The frequent occurrence of embayed quartz grains also supports a volcanic origin for the Kettle River beds in the Phoenix and Wilgress Lake areas.

The Marron Formation exposed near Greenwood corresponds remarkably well with that in the Penticton type locality. It is evident that throughout the region the Marron volcanic cycle began with the eruption of phonolitic volcanics of the Yellow Lake Member (11) followed by trachyte and trachyandesite lavas of the Kitley Lake and Nimpit Lake Members (12), and finally, extrusion of Park Rill andesite (13); the Kearns Creek andesite, in the middle of the Marron type section, is the only member not found in the Greenwood area and Boundary district.

The Yellow Lake Member (11) rests with minor disconformity on Kettle River sandstones (10) as viewed in the main exposures at Phoenix in the Wilgress Lake area west of the Tam O'Shanter claim and on Deadwood Ridge immediately west of the map-area. The Yellow Lake rocks are located east of the Kettle River Formation on Deadman Hill and the Phoenix pit where the unit is rotated downward against a major northerly trending fault. The estimated thickness of this faulted remnant is approximately half that of the full section of 320 metres of Yellow Lake volcanics exposed on Deadwood Ridge.

The Yellow Lake volcanic rocks are medium to dark grey lavas and breccias characterized by scattered tabular or rhomb-shaped anorthoclase phenocrysts and interstitial anhedral pyroxene grains. In thin section the matrix is commonly charged with randomly arranged feldspar plates, small equant analcite crystals, and interstitial pyroxene, magnetite, and apatite. Chemical analyses of representative rock samples from Deadman Hill and the Wilgress Lake area are relatively enriched in alumina and alkalies, indicating phonolitic composition (Table 2b, Nos. 14 and 15).

The Kitley Lake Member forms part of the Deadwood Ridge section west of the map-area. These rocks consist of buff-coloured, porphyritic effusives approximately 160 metres thick, but within the map-area only subvolcanic porphyritic dykes and small stocks (G) are represented.

Petrographically the Kitley Lake rocks are characterized by an abundance of glomerophenocrysts of feldspar commonly measuring 0.5 centimetre in diameter. These clots are intermixed with smaller biotite and pyroxene crystals set in a fine-grained feldspathic matrix. Chemical analyses of typical porphyritic pulaskite dykes (Table 4, Nos. 1 and 2) are similar to Marron trachyte lavas (these rocks resemble some of the younger units in the Penticton succession, especially the White Lake porphyritic lavas and associated feeder intrusions).

The Nimpit Lake Member (12) is widely distributed near the west margin of the map-area within the Toroda Creek graben. The rocks are best developed on Deadwood Ridge where the unit is estimated to be more than 700 metres thick. The typical tan trachytes comprising this member form tiered 'wedding cake' flow sequences, suggesting high fluidity for the original source magma.

The Nimpit Lake lavas are mostly finely grained, feldspathic, and quartz free. Phenocrysts are small and commonly consist of plagioclase rosettes with sanidine jackets accompanied by a few scattered biotite and pyroxene crystals. Fine-grained pulaskite feeder dykes are scattered throughout the map-area but are difficult to delineate at 1:25 000 scale, which is the mapping base for this study.

The Park Rill andesite (13) is recognized as the uppermost member of the Marron Formation. This is a medium brown lava sequence which is best exposed on the knolls and ridges overlooking Boundary Falls on the northwest and south where the member is displaced downward and tilted easterly against the east-bounding fault of the Toroda Creek graben.

Petrographically the andesite is merocrystalline consisting of crowded, small crystals of plagioclase, pyroxene and biotite, and minor apatite and magnetite in brown glass. The chemical composition of these rocks (Table 2b, No. 16) corresponds well with the composition of fresh microdiorite dykes in the map-area (Table 4, Nos. 7 and 8). Analysis No. 7 is for a microdiorite dyke that intrudes Knob Hill rocks (1) and (2) north of Boundary Falls on the Combination claim where a small adjacent sulphide deposit has been explored.

The most important structural overprinting is block faulting which is coincident with, and continued after, the Marron volcanic events. The result is preservation of great thicknesses of the Tertiary cover rocks such as are found in the segment of the Toroda Creek graben in the west part of the map-area, and unroofing of the older stratigraphic assemblage, now exposed to the east in the main part of the map-area.

The same structural pattern prevails on a smaller scale at Phoenix. The Tertiary outlier, and to some extent the underlying Brooklyn rocks, are downfaulted and tilted in a half graben structure. This movement rotated the Tertiary beds about 35 degrees easterly and displaced them downward several hundred metres, in the area immediately east of the Phoenix pit, effectively severing the skarn zone which originally connected the Phoenix and Snowshoe orebodies. Subsequent to this trap-door rotation pulaskite dykes feeding the local Marron volcanics intruded and sealed the fault system south and east of the Phoenix pit.

IGNEOUS INTRUSIONS

Igneous intrusions, consisting mostly of Mesozoic granodiorite plutons, underlie approximately one quarter of the map-area. The lesser intrusive masses include a variety of diapiric granitoid stocks, irregular ultrabasic bodies, and dyke-like felsic porphyries of Mesozoic and Tertiary ages.

DIORITE (A): The principal outcrops of what appear to be the oldest intrusions in the area, termed 'Old Diorite', lie in a belt coincident with the course of Lind Creek. The intrusions extend across the map-area from a point near Snowshoe Creek on the east to Haas Creek on the west. Similar small bodies occur in the vicinity of Gibbs Creek and on the west end of Montezuma Ridge.

The diorite is a mottled greenish grey rock of variable texture with numerous crisscrossing, light-coloured veinlets of felsic minerals, calcite, and epidote. In thin section a typical sample is found to consist of 50 to 60 per cent subhedral calcic plagioclase and 25 to 40 per cent green amphibole, with a small amount of interstitial quartz and opaque minerals. Commonly the amphibole is partly chloritized and much of the feldspar is altered to clay and carbonates. Chemical analyses of this rock indicate silica undersaturation of the dark amphibolitic phases and alumina enrichment of the feldspathic phases (Table 3, Nos. 1 and 2).

The age of the diorite is estimated to be Late Paleozoic based on cutting relationships and the superposition of sedimentary rocks. For example, partly digested xenoliths of Attwood volcanics (6) and sedimentary rocks (5) found in the diorite suggest a post-Permian age. Clasts of the same diorite occur in Brooklyn conglomeratic facies (9) proving a pre-Late Triassic age for the intrusion. (J. Harakal newly reports K/Ar whole rock date of 258 ± 10 Ma, Winnipeg mine area.)

TABLE 2a

ANALYSES OF BEDDED ROCKS

	1	2	3	4	5	6	7	8
Oxides recalculated to 100:								
SiO_2	73.09	58.02	63.13	49.66	50.74	51.01	54.82	85.56
TiO_2	0.89	0.92	0.91	1.05	1.06	2.38	0.56	0.33
Al_2O_3	11.81	11.21	15.43	17.21	14.36	14.67	16.22	6.79
Fe_2O_3	0.66	5.72	2.37	3.11	1.89	1.65	2.94	1.55
FeO	5.26	1.33	2.73	8.83	8.57	10.47	6.40	2.25
MnO	0.17	0.21	0.08	0.22	0.22	0.21	0.17	0.01
MgO	2.89	7.88	3.30	7.07	6.77	9.46	4.72	1.37
CaO	1.44	11.20	4.67	8.51	13.75	6.34	10.71	0.56
Na_2O	1.18	2.15	3.33	2.17	2.14	2.79	3.40	0.04
K_2O	2.61	1.36	4.05	2.17	0.47	1.02	0.06	1.54
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as determined:								
H_2O^+	1.76	3.66	1.78	2.11	1.36	3.71	3.06	—
H_2O^-	0.30	—	0.29	0.24	1.18	0.13	0.10	0.09
CO_2	1.65	7.44	1.80	0.60	0.13	0.42	0.52	3.19
P_2O_5	0.47	0.08	0.28	0.18	0.20	0.21	0.20	0.21
S	0.03	0.01	0.01	0.01	0.03	0.06	0.01	1.38
Molecular norms:								
QZ	43.60	12.10	13.40	—	—	—	5.90	73.90
OR	16.00	8.10	24.00	12.90	2.80	6.00	0.40	9.70
AB	11.00	19.50	30.00	19.60	19.40	25.20	30.80	0.40
NE	—	—	—	—	—	—	—	—
AN	7.40	17.10	15.20	31.00	28.60	24.60	29.00	3.00
WO	—	15.60	3.20	4.60	16.20	2.80	9.80	—
EN	8.30	21.90	9.10	12.50	18.90	22.10	13.10	4.00
FS	6.70	—	1.30	6.40	10.60	10.00	7.10	2.10
FO	—	—	—	5.40	—	3.00	—	—
FA	—	—	—	2.80	—	1.30	—	—
IL	1.30	1.30	1.30	1.50	1.50	3.30	0.80	0.50
MG	0.70	1.20	2.50	3.30	2.00	1.70	3.10	1.70
HE	—	3.20	—	—	—	—	—	—
CR	5.00	—	—	—	—	—	—	4.70

Key to Analyses

1. Metaquartzite (Knob Hill Group), Jewel Lake area — *see* Church and Winsby (1974), No. 1, p. 44.
2. Chloritic segregation in schist (Knob Hill Group), northeast slope of Mount Wright.
3. Greenstone unit (Knob Hill Group), northwest slope of Knob Hill.
4. Amphibolite (Attwood Group ?), Glenside Creek area — *see* Church (1976), No. 1, p. 3.
5. Metabasalt (Attwood Group), Jewel Lake area — *see* Church and Winsby (1974), No. 7, p. 44.
6. Metabasalt (Attwood Group), on abandoned railway grade west of Glenside Creek.
7. Metavolcanics (Attwood Group), northeast of Snowshoe Creek.
8. Skomac argillite (Attwood Group), Skomac mine — *see* Church (1985), No. 1, p. 5.

MICRODIORITE (B): Several consanguineous stocks of fine, evenly grained microdiorite are found across the map-area. The most readily accessible of these are on the south side of Providence Lake, at Hartford Junction on the haulage road southeast of Phoenix, on the Sappho claim in the southwest part of the map-area, and west of Boundary Creek in the Buckhorn Creek area.

In thin section, the Providence Lake microdiorite displays an abundance of rectangular plagioclase crystals, 0.5 to 1.5 millimetres in diameter, intermixed with a scattering of amphibole laths set in a matrix of clay-altered feldspar, chloritized mafic minerals, and a minor amount of quartz. Major oxides from analyses of this rock are comparable to those of the Hartford Junction microdiorite (Table 1, Nos. 3 and 4).

The age of the Providence Lake microdiorite, based on potassium-argon analysis of the constituent amphibole, is Late Triassic (206 ± 8 Ma) according to new determinations for this report by J. Harakal of The University of British Columbia (Table 7, No. 4). Thermal overprinting by younger Mesozoic and Tertiary igneous events evidently has not affected this amphibole.

QUARTZ FELDSPAR PORPHYRY (C): A group of related hypabyssal felsic intrusions, found in the south-central part of the map-area, has been mapped variously as quartz feldspar porphyry, quartz porphyry, felsite, and schistose felsite. The largest and best preserved of these bodies is a wedge-shaped quartz feldspar porphyry stock located south and east of the confluence of McCarren and Gidon Creeks.

TABLE 2b
ANALYSES OF BEDDED ROCKS

	9	10	11	12	13	14	15	16
Oxides recalculated to 100:								
SiO_2	75.60	74.81	68.04	52.28	67.61	53.91	56.21	59.37
TiO_2	0.52	0.89	0.81	0.96	0.39	1.12	0.97	1.00
Al_2O_3	9.98	9.55	13.82	17.83	14.66	19.02	19.41	15.67
Fe_2O_3	1.33	0.83	0.43	9.31	0.64	4.90	4.85	3.59
FeO	3.30	4.91	6.81	1.36	1.53	2.32	1.94	2.40
MnO	0.12	0.06	0.06	0.15	0.04	0.11	0.08	0.19
MgO	2.94	3.69	4.30	8.17	2.30	3.56	2.24	3.60
CaO	3.86	2.40	1.07	4.85	6.05	5.39	4.37	7.23
Na_2O	1.42	1.71	1.37	4.80	3.71	4.02	5.61	3.35
K_2O	0.93	1.15	3.29	0.29	3.07	5.65	4.32	3.60
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as determined:								
H_2O^+	1.14	2.74	2.39	3.49	1.97	3.22	2.79	1.28
H_2O^-	0.27	0.16	0.20	0.35	0.61	1.05	1.25	1.16
CO_2	0.15	0.89	1.60	0.87	3.91	2.05	1.35	1.12
P_2O_5	0.32	0.25	0.21	0.39	0.20	0.78	0.71	0.24
S	0.02	0.07	0.29	0.01	0.01	0.01	0.01	0.01
Molecular norms:								
QZ	47.70	44.80	32.10	0.70	19.10	—	—	8.70
OR	5.70	7.00	19.90	1.70	18.10	33.20	25.20	21.30
AB	13.20	15.90	12.60	42.60	33.30	28.50	44.00	30.20
NE	—	—	—	—	—	4.30	3.40	—
AN	18.80	12.30	5.40	23.80	14.30	17.00	14.80	17.20
WO	0.40	—	—	—	6.30	3.80	2.60	7.50
EN	8.40	10.50	12.20	22.30	6.30	—	—	10.00
FS	3.60	6.00	9.30	—	1.40	—	—	—
FO	—	—	—	—	—	7.30	4.60	—
FA	—	—	—	—	—	—	—	—
IL	0.80	1.30	1.20	1.30	0.50	1.50	1.30	1.40
MG	1.40	0.90	0.50	1.10	0.70	3.00	2.40	3.50
HE	—	—	—	5.60	—	1.40	1.70	0.20
CR	—	1.30	6.80	0.90	—	—	—	—

Key to Analyses

9. Sharpstone conglomerate (Brooklyn Group), Deadman Hill — *see* Church (1976), No. 2, p. 3.
10. Sharpstone conglomerate (Brooklyn Group), north slope of Knob Hill — *see* Church (1984), No. 1, p. 8.
11. Rawhide shale (Brooklyn Group), south of Snowshoe pit on haulage — *see* Church (1984), No. 2, p. 8.
12. Eholt volcanics (Brooklyn Group), near Highway 3 east of Phoenix — *see* Church (1976), No. 3, p. 3.
13. Kettle River sandstone (Pentincton Group), east side of Phoenix pit.
14. Yellow Lake mafic phonolite (Penticton Group), near water reservoir east of Phoenix pit.
15. Yellow Lake mafic phonolite (Penticton Group), Deadman Hill area — *see* Church (1976), No. 5, p. 3.
16. Park Rill andesite (Penticton Group), north of Boundary Falls — *see* Church (1985), No. 2, p. 5.

Petrographically, the rock consists of large tabular phenocrysts of orthoclase, 3 to 10 millimetres in diameter, surrounded by smaller plagioclase plates and subhedral quartz crystals, 1 to 4 millimetres in diameter, suspended in a fine-grained matrix. Modal analyses of four samples show the following average composition: quartz, 5 per cent; perthitic orthoclase, 15 per cent; plagioclase, 45 per cent; quartz and feldspar matrix, 25 per cent; and epidote, calcite, sphene, and magnetite, 10 per cent.

The north edge of this intrusion is deflected to the east parallel to the south (faulted) contact of the Knob Hill assemblage (2) following the margin of a large ultrabasic intrusive tongue (F). In the vicinity of the No. 7 mine a cataclastic phase of the rock, referred to as schistose felsite, is cut by the ultrabasic tongue.

An elongated quartz porphyry intrusion, exposed along the course of Goosmus Creek, appears to be the easterly extension of the quartz feldspar porphyry stock. Petrographically, the intrusion displays a number of facies, including a fine-grained phase resulting from cataclasis, and a chilled selvage phase. The typical porphyry contains subhedral quartz phenocrysts and composite quartz eyes, 2 to 7 millimetres in diameter, set in a matrix of small rectangular plagioclase crystals, chloritized biotite, and interstitial fine-grained quartz and feldspar. Quartz phenocrysts rarely exceed 10 per cent of the rock, however, according to calculations based on a chemical analysis (Table 3, No. 5), normative quartz is about 35 per cent. Presumably about 25 per cent of the quartz is in the matrix. Characteristically, potassium feldspar is scarce and occurs as thin mantles on plagioclase grains and discrete grains in the matrix. Where the rock is badly sheared, quartz and especially feldspar are reduced to small fragments; the comminuted feldspar is readily altered to sericite and clay minerals.

The age of this porphyry is estimated to be Early Mesozoic on the basis of the sheared condition of unit and cutting relationships. The porphyry intrudes Attwood argillites (5) and volcanic rocks (6) and is itself invaded by the younger ultrabasic rocks (F).

GABBRO (D): A relatively small gabbro body occurs south of the Cyclops prospect and on the east part of the Lancashire Lass claim in the northeast part of the map-area. The rock is commonly dark greenish grey and uniformly fine grained. It consists of approximately 55 per cent subhedral plagioclase plates, interspersed with 20 per cent equant pyroxene grains (averaging 1.5 millimetres in diameter), set in a matrix of chlorite and disseminated magnetite. Local conversion of some of the pyroxene to blue-green amphibole is viewed as younger metamorphic overprinting.

The gabbro post-dates the Triassic Brooklyn limestone host rocks (8) and pre-dates crosscutting Tertiary dykes.

GRANODIORITE (E): Three compositionally similar granodiorite plutons are prominent in the map-area, the largest is the Wallace Creek intrusion. Smaller satellitic stocks are centred around the town of Greenwood and in the Skeff Creek area.

The Wallace Creek granodiorite body is well exposed at Jewel Lake and at the Oro Denoro mine near the northeast boundary of the map-area. Characteristically the rock is massive, light grey, and ranges from equigranular to porphyritic. Its average modal composition is 25 per cent quartz, 65 per cent microcline and plagioclase feldspar, 10 per cent amphibole, and accessory biotite, apatite, sphene, and magnetite. The plagioclase occurs as rectangular zoned plates, 2 to 4 millimetres across, intermixed with smaller subhedral microcline and quartz grains and accompanied by interstitial quartz and feldspar associated with scattered prisms of green amphibole and biotite books. Where altered, the feldspar is replaced by sericite, clay, and carbonates and the amphibole and biotite are transformed to chlorite. Chemical analyses of the granodiorite from the Jewel Lake and Oro Denoro areas are essentially the same (Table 3, Nos. 7 and 8). The age of these rocks, determined from potassium-argon analyses of the contained biotite, falls into the Lower Cretaceous in the 128 to 143 ± 5 Ma range (Table 7, Nos. 1 and 2). A recent determination of adjacent biotite-muscovite hornfels gives 150 ± 5 Ma (Table 7, No. 3).

ULTRABASIC ROCKS (F): Serpentinized ultrabasic rocks are widely distributed throughout the map-area. The largest bodies occur on Mount Wright, the northwest slope of Mount Attwood, and along the upper section of July Creek between the tributaries Skeff Creek and Neff Creek. These bodies have been emplaced as sills and irregular dyke-like masses, probably in a semisolid state at modest temperatures, along unconformity surfaces, and in fault zones. Elliptical shapes resembling pillows, found in some sheared phases of the ultrabasic rocks, are structural in origin and not volcanic manifestations (Plate IX).

The Mount Wright ultrabasic rocks comprise two subparallel summit-straddling bands which strike southeast from McCarren Creek to the International Boundary. The southwest-flanking band is a splayed lensing body intruding quartz feldspar porphyry (C) which occupies a major dislocation between Knob Hill (2) and Attwood Group rocks (5 and 6). The northeast-flanking band is lenticular with a maximum width of approximately 500 metres near the summit of Mount Wright, where it concordantly intrudes quartz mica schist (2).

Separate major ultrabasic masses are enclosed within the Knob Hill Group and Attwood Group on Lind Creek and the adjacent northwest slopes of Mount Attwood. A faulted sinuous ultrabasic band lies along the unconformity between the Knob Hill and Attwood Groups from Boundary Creek to the summit ridge of Mount Attwood. On the summit ridge of Mount Attwood the same ultrabasic band traverses stratigraphic boundaries and intrudes the faulted triple contact zone between major formations of the Knob Hill, Attwood, and Brooklyn Groups.

The large mass of ultrabasic rock north of Skeff Creek has been offset from the main ultrabasic belt at Neff Creek by an important fault trending northerly subparallel to July Creek. These ultrabasic rocks are associated with 'Old Diorite' (A) in a relationship similar to that found in the area south of Gibbs Creek and in the area between Haas Creek and the Skomac mine. At the Skomac mine lenses of ultrabasic rock were intruded advantageously into the pre-existing sheared intrusive contact between the 'Old Diorite' (A) and the Attwood argillites (5).

These ultrabasic rocks consist of both massive and schistose phases. Freshly broken surfaces are brittle and dark green or black, except in shear zones where the rock is often bright green with a greasy lustre. Weathered surfaces are soft and light grey or mottled rusty brown.

The sheared marginal phases of the ultrabasic bodies are commonly altered to talc and talc carbonate schists, the thoroughly carbonated facies being referred to as 'listwanite'. The typical poorly defined borders of the ultrabasic bodies reflect intense shearing in the contact zones and serpentinization of adjacent country rocks.

In thin section a typical sample of ultrabasic rock is composed of a cataclastic aggregation of antigorite, talc, and carbonate minerals interspersed with ragged pyroxene remnants and concentrations of opaque mineral granules. In a few sections where textures are well preserved it is clear that the serpentine minerals are pseudomorphic after subhedral olivine and pyroxene grains, the original rock being a peridotite. Chemical analysis of a sample of the ultrabasic rock (Table 3, No. 8) shows approximately equal amounts of silica and magnesia, suggesting high original olivine content.

The age of these rocks is estimated to be Late Mesozoic and possibly Cretaceous, based mainly on cutting relationships. Ultrabasic rocks are hosted by a wide variety of country rocks including the Brooklyn Group (7) and the Greenwood granodiorite (E). The only known conglomerate proven to contain ultrabasic clasts is assigned to the Tertiary Springbrook Formation (10a).

Plate IX. Serpentine kernels in sheared ultrabasic rocks.

DIORITE AND MONZODIORITE (G): A series of scattered intrusions, petrographically similar to lavas of the Marron Formation, is considered to be among the youngest intrusive rocks in the map-area. These include a wide variety of diorite, monzodiorite, and pulaskite sills and dykes. These rocks are generally fresh and show little sign of fault dislocation or metamorphism. Commonly they have been emplaced on irregular fractures and change orientation abruptly.

An unusually high concentration of diorite dykes is found on Rusty Mountain and Mount McLaren in the south part of the map-area. These trend northerly subparallel to a prominent set of cross joints. North of Goosmus Creek the dykes coalesce to form irregular bodies against the older, southeast-striking serpentine intrusions. Similar young diorite dykes cut the various formations of the old Paleozoic metamorphic complex to the north and the Triassic Brooklyn Group on the Ruby claim northeast of Boundary Falls and in the Phoenix area.

Petrographically, many of these rocks are best defined as microporphyritic alkali-rich monzodiorites. In thin section they consist of 20 per cent plagioclase plates, 5 per cent biotite, and 2 per cent pyroxene subhedra. These microphenocrysts range in grain size from 1 to 4 millimetres. They are set in a fine-grained matrix of randomly oriented laths of 30 per cent plagioclase and 15 per cent potassium feldspar, with interstitial wedges of 15 per cent quartz, 3 per cent scattered biotite, 2 per cent pyroxene, 2 per cent magnetite, 1 per cent apatite, and 5 per cent alteration minerals. Chemical analysis of a sample of this rock from the Mabel claim is very similar to an analysis of monzodiorite from Lookout Hill, immediately north of Phoenix (Table 4, Nos. 4 and 5).

CORYELL INTRUSIONS (H): The Coryell intrusions are exposed most prominently at the west boundary of the Emma claim and on the Sappho claim in the northeast and southwest parts of the map-area respectively. These intrusions include an assemblage of syenite, monzonite, and shonkinite bodies. The most common rock in this suite is a mottled pink and grey feldspar porphyry. It consists of glomerophenocrystic clots of potassium feldspar and plagioclase, measuring to 6 millimetres in diameter, and smaller solitary feldspar crystals suspended in a finer grained matrix of interlocking feldspars and biotite with a minor amount of interstitial quartz, magnetite, and apatite. Clinopyroxene is present in abundance in the more basic phases. A sample of pyroxene monzodiorite obtained from the intrusion northwest of the Emma claim gives the following normative composition: 6.5 per cent quartz, 27.2 per cent potassium feldspar, 41.1 per cent plagioclase, 22.8 per cent clinopyroxene, and 2.4 per cent magnetite (Table 4, No. 3).

TABLE 4
ANALYSES OF TERTIARY INTRUSIONS

	1	2	3	4	5	6	7	8
Oxides recalculated to 100:								
SiO_2	60.23	62.56	59.95	60.27	63.12	60.07	59.78	57.32
TiO_2	1.25	0.44	1.13	1.08	0.91	0.90	0.96	1.06
Al_2O_3	18.17	18.47	14.84	14.70	15.43	15.84	15.51	15.82
Fe_2O_3	0.56	1.65	2.31	2.08	2.38	2.58	2.24	2.15
FeO	4.29	1.84	4.22	4.04	2.73	3.66	3.51	4.33
MnO	0.09	0.11	0.22	0.09	0.08	0.12	0.90	0.12
MgO	1.59	0.67	4.53	4.30	3.30	5.12	4.15	4.27
CaO	1.95	1.48	5.33	5.89	4.67	4.12	5.26	6.03
Na_2O	4.92	6.26	3.03	3.82	3.33	4.73	3.58	3.60
K_2O	6.95	6.52	4.55	3.72	4.05	2.67	4.11	3.30
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as determined:								
H_2O^+	1.86	1.19	1.27	2.92	1.78	1.98	1.66	1.91
H_2O^-	0.54	0.29	0.79	0.07	0.29	0.78	0.20	0.45
CO_2	0.55	0.06	1.21	0.12	1.80	0.91	1.69	1.43
P_2O_5	0.21	0.54	0.41	0.54	0.28	0.28	0.32	0.28
S	0.01	0.05	0.02	0.02	0.01	0.02	0.01	0.02
Molecular norms:								
QZ	—	—	7.30	6.30	13.40	5.40	6.60	5.00
OR	40.40	37.60	26.90	21.90	24.00	15.60	24.40	19.80
AB	41.60	50.90	27.20	34.20	30.00	42.00	32.20	32.90
NE	1.20	2.40	—	—	—	—	—	—
AN	6.90	3.00	13.50	11.90	15.20	14.00	14.20	17.60
WO	1.10	1.70	5.20	6.90	3.20	2.50	4.80	5.10
EN	—	—	12.50	11.80	9.10	14.00	11.50	12.00
FS	—	—	3.40	3.30	1.30	2.60	2.60	3.80
FO	3.20	1.30	—	—	—	—	—	—
FA	3.30	0.80	—	—	—	—	—	—
IL	1.70	0.60	1.60	1.50	1.30	1.20	1.30	1.50
MG	0.60	1.70	2.40	2.20	2.50	2.70	2.40	2.30
HE	—	—	—	—	—	—	—	—
CR	—	—	—	—	—	—	—	—

Key to Analyses

1. Pulaskite porphyry dyke southeast of Phoenix pit — *see* Church (1984), No. 6, p. 8.
2. Biotite-feldspar porphyry dyke, Dentonia mine near Jewel Lake — *see* Church and Winsby (1974), No. 3, p. 44.
3. Coryell monzodiorite, north of Oro Denoro mine — *see* Church (1976), No. 9, p. 3.
4. Biotite monzodiorite dyke, south of Mabel claim — *see* Church (1970), No. 2, p. 419.
5. Pyroxene-feldspar monzodiorite, from Lookout north of Phoenix pit — *see* Church (1984), No. 5, p. 8.
6. Aphanitic dyke at Oro Denoro mine — *see* Church (1976), No. 8, p. 3.
7. Microdiorite dyke on Combination claim north of Boundary Falls — *see* Church (1985), No. 5, p. 5.
8. Microdiorite dyke, Skomac mine — *see* Church (1985), No. 6, p. 5.

Most mineral production in the Greenwood mining camp has come from copper-bearing skarn deposits. To a lesser extent production has been derived from quartz veins with gold, silver, and minor lead and zinc values. Production to date from the 26 principal mines in the area is listed in Table 5. The aggregated total for these mines is 32 044 173 tonnes of ore that yielded 38 278 kilograms of gold, 283 102 kilograms of silver, 270 945 tonnes of copper, 966 tonnes of lead, and 329 tonnes of zinc.

Ancillary information on these deposits is given in Table 6. A breakdown of the types of deposits shows twelve vein settings related to granodiorite stocks, four veins in fault zones, six skarns with significant ore production, two mineralized listwanites with production record, one magmatic orebody, and at least one porphyry copper body. The most common host rocks are the granodiorite stocks (E), ultramafic bodies (F), Knob Hill schists (2 and 2a), skarns (0), Brooklyn limestone (8), Mount Attwood greenstone (6), and Mount Attwood argillite (5).

MINERAL POTENTIAL

The combination of a long geological history and a wide range in types of deposits ensures good potential for new mineral discoveries in this old mining camp. Recent exploration has focused on gold-sulphide mineralization in the Triassic Brooklyn beds on the Sylvester K claim in the Phoenix area, and precious metal-bearing quartz veins peripheral to the Wallace Creek batholith at the Dentonia mine near Jewel Lake. Other mineral occurrences of note that have received attention are the silver-bearing Skylark veins, the Oro Denoro copper skarn deposit, the Lexington porphyry copper and gold deposit, and the Buckhorn microdiorite copper prospect. The Tam O'Shanter prospect is an example of epithermal vein mineralization associated with Tertiary faulting peripheral to the Toroda Creek graben. Sappho is a precious-metal and copper prospect hosted in a small Coryell syenomonzonite-type intrusion. The No. 7 mine and the Skomac mine are examples of former operations and current prospects centred on precious-metal veins in or adjacent to intrusive lenses of ultrabasic rock of possible Cretaceous age.

The classical metallogenic model for the area, supported by LeRoy, McNaughton, Seraphim, and Little, relates mineralization in a wide range of host rocks to the igneous intrusive events, especially the emplacement of the granodiorite plutons (Fig. 4). However, this model in itself does not adequately explain the anomalous coherence of lead isotope results of 10 of a selection of 12 deposits in the area (Fig. 5). This linear lead relationship connects diverse deposits such as skarns (Nos. 1 and 2) with veins of ultrabasic setting (Nos. 5, 6, and 7) and veins satellitic to the granodiorite Nos. 5, 6, and 7. This pattern is characteristic of mixing and tying together diverse hydrothermal plumbing systems.

It is conceivable that the intricate and extensive fissure system of the Mount Attwood-Phoenix area, as shown in part on Figure 1, provided the necessary channelways for metalliferous solutions that formed the ore deposits. In this model the igneous intrusions served principally as heat engines in the process of convection and dispersion of the solutions.

The necessary heat for the mineralization process may have had an ultimate ultrabasic-mantle origin. Evidence suggests that the ultrabasic rocks, which are abundant in the Greenwood area, moved upward on many of the main faults following the injection of the principal Jurassic-Cretaceous stocks. The rise of mantle material appears to coincide with regional uplift which was possibly induced by underplating and stacking of oceanic and mantle slabs beneath an overriding continental plate (Fig. 6).

The Early Tertiary in southern British Columbia records a resurgence of magmatic activity and a renewed cycle of tectonic events such as graben development and thrusting (Fig. 7). The Tenas Mary horst, and east and west flanking Republic and Toroda Creek grabens, are part of this system. Small magmatic derived sulphide deposits, such as exposed on the Sappho claim, and some precious-metal-bearing epithermal veins on the graben faults (Tam O'Shanter) provide evidence of Tertiary mineralization (Fig. 8).

MINERAL DEPOSITS

The principal mines and mineral deposits of the area are listed in Table 5. These are mostly fissure-controlled deposits manifested as simple vein systems or stockwork fillings and replacement of wallrocks along fractures or bedding planes. Many of the deposits are combinations of these forms (Table 6).

The descriptions of the various properties are based on mapping and visits to the Greenwood area by the writer between 1958 and 1984 and previous reports such as those by LeRoy (1912, 1913), Galloway (1913, 1927), Hedley (1936, 1941), McNaughton (1945), and White (1950). Caving and flooding have hampered detailed re-examination of inactive workings necessitating some reliance on the old reports.

ATHELSTAN, JACKPOT

(Lat. 49° 03.8′; Long. 118°, 33.7′; M.I. 082ESE047)

The Athelstan-Jackpot mine is 8.5 kilometres southeast of Greenwood and 1.5 kilometres northwest of the confluence of Skeff Creek and July Creek. Access to the mine is from an abandoned railway grade at an elevation of 1 150 metres (3,750 feet) and connecting roads from the Winnipeg mine and Hartford Junction to the northwest and Highway 3 to the east.

The main production from the property was in the period 1901 to 1930. This operation yielded 33 216 tonnes of ore containing 180 kilograms of gold, 210 kilograms of silver, and 7.2 tonnes of copper. A small operation continued until 1940.

Exploration and mining on the Athelstan and Jackpot claims began independently with no interconnection of workings. In 1900 operations commenced on the Athelstan claim with shaft development, drifting, and the installation of a small plant. Much additional exploration and development were completed between 1909 and 1912. The Jackpot

TABLE 5
ORE PRODUCTION FROM THE GREENWOOD CAMP

Deposit	Easting	Northing	Tonnes	Au Kg	Ag Kg	Cu Tonnes	Pb Tonnes	Zn Tonnes
Athelstan	858	357	33 216	180	210	7	—	—
Bay	793	382	447	17	14	—	—	—
City of Paris	825	296	1 934	27	151	60	373	—
Crescent	798	401	250	2	454	—	3	4
Dynamo	781	376	385	3	59	—	28	7
E Pluribus Unum	788	381	571	45	230	—	8	1
Elkhorn	776	408	179	5	456	—	8	2
Gold Drop	833	469	296	5	29	—	—	—
Gold Finch	784	382	300	18	88	—	8	2
Greyhound	759	400	221 200	16	349	597	—	—
Jewel	825	466	123 294	1 219	7 193	—	163	3
Keno	840	358	294	1	101	—	3	—
Last Chance	792	391	667	23	—	—	—	—
Marshall	829	408	194	15	18	1	2	1
Morrison	739	405	2 647	8	26	11	—	—
Mother Lode	747	412	4 245 875	5 391	21 406	34 915	—	—
No. 7	803	315	13 748	92	3 110	—	97	6
North Star	861	422	6 178	24	475	—	9	12
Oro Denoro	869	425	364 949	329	3 388	4 041	—	—
Phoenix	835	395	26 956 525	30 225	192 055	230 050	1	—
Providence	782	409	10 476	183	42 552	—	183	260
Republic	751	354	2 513	21	3 709	—	50	26
Sappho	753	293	102	—	6	14	—	—
Strathmore	783	399	198	5	533	—	4	—
Skylark	804	386	1 931	22	5 283	4	26	5
Winnipeg	852	367	55 804	402	1 207	1 245	—	—

TABLE 6
ANCILLARY INFORMATION ON DEPOSITS

Deposit	Mineral Inventory No. (082ESE)	Host Rocks	Mineralization Main Type Host	Mineralization Subsidiary
Athelstan	047	F, 6	listwanite	
Bay	005	E	satellitic veins	
City of Paris	041, 042	C, F	porphyry copper	rift vein
Crescent	012	A, F, 3, 5	rift vein ?	
Dynamo	008	E, F, 2	satellitic vein	
E Pluribus Unum	006	E, 2	satellitic vein	
Elkhorn	002	E, 2	satellitic vein	
Gold Drop	153	2	satellitic vein	
Gold Finch	004	E	satellitic vein	
Greyhound	050	O	skarn	
Jewel	055	E, 2(a)	satellitic vein	
Keno	192	6	satellitic vein	
Last Chance	216	F, 6	listwanite	
Marshall	031	B, O, 7, 8	skarn	
Morrison	052	O, 8	skarn	
Mother Lode	034	E, O, 8	skarn	
No. 7	043	C, F, 2(a)	rift vein	
North Star	152	2	satellitic vein	
Oro Denoro	062, 063	E, O, 8	skarn	
Phoenix	020, 021, 025, 026, 014, 013	O, 7, 8	skarn	
Providence	001	E, 2	satellitic vein	
Republic	174	F, 5	rift vein	
Sappho	147	H, 6	magmatic	
Strathmore	215	E	satellitic vein	
Skylark	011	5	satellitic vein	
Winnipeg	032, 033	A, F, 6	rift vein ?	listwanite ?

TABLE 7
RADIOMETRIC DATES

Material	Lat.	Long.	K%	Ar^{40+}	% Ar^{40}	Ma
1. Wallace Creek granodiorite (biotite)	49°07.5′	118°33′	1.12 ± 0.020	6.491×10^{-6} cc/gm	75.5	143 ± 5
2. Wallace Creek granodiorite (amphibole)	49°09.5′	118°36.7′	4.188 ± 0.008	0.3865 ppm	63.2	128 ± 5
3. Knob Hill schist (mica hornfels)	49°07.5′	118°34.3′	4.19 ± 0.010	25.424×10^{-6} cc/gm	97.3	150 ± 5
4. Providence Lake microdiorite (amphibole)	49°06.3′	118°36.3′	0.588 ± 0.014	4.996×10^{-6} cc/gm	90.4	206 ± 8
5. Old Diorite (whole rock)	49°04.4′	118°34.3′	0.462 ± 0.008	4.970×10^{-6} cc/gm	81.2	258 ± 10

Note: Determination of sample No. 2 was completed by Geochron Laboratories, Cambridge, Ma.; samples Nos. 1, 3, 4 and 5 were analysed by J. Harakal at The University of British Columbia.

adit, located 335 metres to the east and 90 metres below the Athelstan mine, is connected to an inclined 17-metre shaft with levels at depths of 10 and 16 metres. By 1942 the combined underground development included 91 metres of shaft sinking and 570 metres of tunnelling.

Ultrabasic intrusions (F) and diorite dykes are the main rocks exposed in these workings. Included in the ultrabasic rocks are light-coloured talc-carbonate lenses, known locally as 'listwanites'.

According to McNaughton (1945, p. 23): "The talc-carbonate rocks weather brown and contain talc and ferromagnesian carbonate in various proportions. Their outcrops are marked by limonitic gossan produced by the oxidation of the carbonate. The rocks show some variation in lithological character from one locality to another. Sheared varieties consisting largely of talc and serpentine with subordinate amounts of carbonate are common near the contacts of the talc-carbonate rocks against serpentine. Massive varieties largely made up of a brown-coloured ferromagnesian carbonate, probably ankerite, and some calcite are well exposed around the Athelstan surface workings. Other varieties containing a conspicuous green mica, probably mariposite, are common in the underground workings of the Jackpot mine. Contacts between the talc-carbonate rocks and serpentine are usually gradational. The total extent of exposed talc-carbonate rock is not known, but they extend from an elevation of 4,200 feet [1 280 metres] at the top of the hill above the Athelstan adit at least as far as the Jackpot adit and outcrop over a maximum width of about 550 feet [168 metres]."

"These rocks are traversed by an irregular system of pre-mineral fissures that have strongly influenced the rising ore-bearing solutions by providing channelways for them, and gouge-filled barriers capable of deflecting them."

The common ore minerals are pyrite and arsenopyrite. These form replacements in the listwanites. Disseminations of chromite occur locally in the sheared listwanite such as on the adjoining Butte claim where 17.1 per cent chromium has been reported from a 3-metre-wide open cut (Galloway, 1927, p. 62). Near surface the ore is oxidized to limonite and a white arsenious oxide which locally attains shipping grade.

McNaughton reports further (1945, p. 24): "The shape and size of several ore bodies that were mined in the early days can be inferred from the accessible mine workings. At the Jackpot mine two of the ore bodies that were mined from the present adit crosscut were crescentric in plan and plunged from 10 to 40 degrees to the east along their longest axis. They ranged in thickness from a few feet to 25 feet [7.6 metres] and probably averaged 10 feet [3 metres]. They were stoped over a length of at least 100 feet [30 metres] and over a width of at least 40 feet [12 metres]. Narrower parts of these same ore bodies have been mined during the past 2 years. At the Athelstan mine the only accessible stope is about 60 feet [18 metres] long, averages about 40 feet [12 metres] wide, and ranges from 3 to 8 feet [1 to 2.4 metres] in height. A winze, which was sunk in the floor of this stope to a depth of 12 feet [3.6 metres] during the summer of 1936, is entirely in ore."

"The foot-and hanging-walls of the ore bodies commonly follow well-defined fissures, and occasionally such fissures also form the lateral limits of the ore bodies. Sulphides may extend for a few inches beyond these fissures, but then are extremely erratic."

"Chemical composition of the wall rock has also had a marked influence on ore deposition. Those rocks containing a high percentage of carbonates were the most susceptible to replacement by the ore-bearing solutions, whereas those containing appreciable amounts of serpentine were apparently the least susceptible."

The orebodies are displaced by several northwesterly dipping normal faults, however, movements are not thought to be large. Locally the faulted-off segments of the ore have been found within the mine workings.

There are no available ore reserve estimates for this mine.

BAY

(Lat. 49°, 05.2′; Long. 118°, 39.2′; M.I. 082ESE005)

The Bay mine is 1.5 kilometres east of Greenwood at an elevation of 1 021 metres (3,350 feet). Access to the mine is from a short side road which joins the main road to Phoenix, 0.4 kilometre to the northwest of the Bay claim.

Production from this claim in the period 1904 to 1941 totalled 17 kilograms of gold and 14 kilograms of silver from 447 tonnes of ore mined. More than half of the mining was completed in 1935. Exploration continued on the property until 1946.

Underground development consists of two inclined shafts and approximately 60 metres of drifting. Evidence of the intensity of surface exploration in past years is provided by the numerous trenches.

ADDENDUM:

To accompany Geological Setting and Mineralization in the Mount Attwood – Phoenix area of the Greenwood Mining Camp; Ministry of Energy, Mines and Petroleum Resources Geological Survey Branch Paper 1986–2, page 29.

TABLE 7B
URANIUM–LEAD ZIRCON DATA FOR LEXINGTON QUARTZ PORPHYRY

Sample No.	Location	Sample Properties	Concentration Observed: Weight (mg)	Concentration Observed: U (ppm)	Concentration Observed: Pb (ppm)	$^{206}Pb/^{204}Pb$	Atomic Ratios[3,4]: $^{206}Pb/^{238}U$	Atomic Ratios[3,4]: $^{207}Pb/^{235}U$	Atomic Ratios[3,4]: $^{207}Pb/^{206}Pb$	Model Ages (Ma)[4]: $^{206}Pb/^{238}U$	Model Ages (Ma)[4]: $^{207}Pb/^{235}U$	Model Ages (Ma)[4]: $^{207}Pb/^{206}Pb$	Concordia Intercepts: low	Concordia Intercepts: high
FLY 86-1	49°0.5′ 118°36.5′	nm,<100μm	0.8	130.6	4.0	1438	0.03141±0.00023	0.2177±0.0028	0.05027±0.0050	199.4±1.4	200.0±2.3	207.5±23.1	200	2445
		m, 100-200μm	4.6	166.7	5.4	1555	0.03219±0.00024	0.2302±0.0033	0.05187±0.0061	204.3±1.5	210.4±2.7	279.6±26.5		
		m,>200μm	2.4	197.5	6.3	2808	0.03175±0.00023	0.2286±0.0020	0.05223±0.0024	201.5±1.4	209.1±1.6	295.5±10.2		

Note. Sample submitted by B.N. Church, analysis performed by P. Van der Heyden.

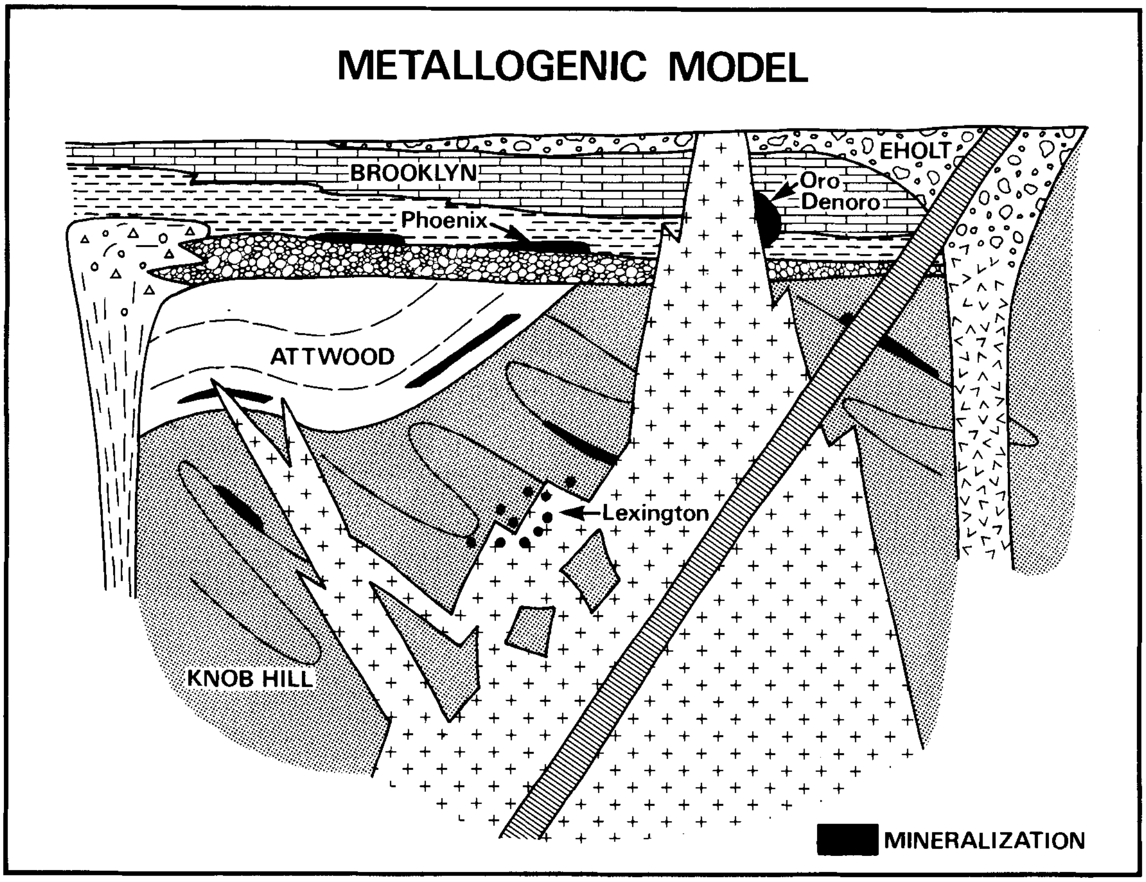

Figure 4. Metallogenic model for the Greenwood area.

The claim is underlain by part of the Greenwood granodiorite stock and fine-grained, dark-coloured Tertiary dykes. The granodiorite is a mesocratic medium-grained rock with shearing and some propylitic alteration adjacent to the mineral-bearing fractures.

The deposit comprises a single quartz vein dipping 35 to 50 degrees east. The vein varies from several centimetres to a metre in width and can be traced for a strike length of 150 metres in the surface workings. North of the shafts the vein is well delineated. Elsewhere it consists of braided quartz veinlets enveloping lenses of mineralized country rock.

McNaughton (1945, p. 17) reports: "Pyrite, galena, sphalerite, chalcopyrite, petzite, and free gold comprise the ore minerals in the quartz-carbonate gangue. Finely crystalline petzite with well-defined cubic cleavage has been mistaken for galena in the Bay vein, but may be distinguished by its lighter colour, finer grain, and common association with free gold. Pyrite and an occasional small piece of free gold are found in the altered granodiorite adjacent to the vein fissures. High-grade ore shoots are characterized by minutely fractured vitreous quartz of greenish blue cast, by the presence of finely crystalline petzite, and by the absence of coarsely crystalline galena and sphalerite."

The main ore production has come from the south shaft. This was sunk to a depth of 20 metres following at first the hangingwall and then the footwall of the vein. In an attempt to locate a faulted segment of the vein a raise was driven to surface from a 12-metre-long tunnel connected on the east to the bottom of the shaft. The north shaft was sunk to a depth of 30 metres and yielded only a small amount of high-grade ore. An important southeasterly dipping fault, located between the shafts, cuts and displaces the vein.

According to McNaughton: "Other faults cut the vein but do not displace it more than a few feet. Broken fragments of vein material in the breccia zones and free gold in fault gouge

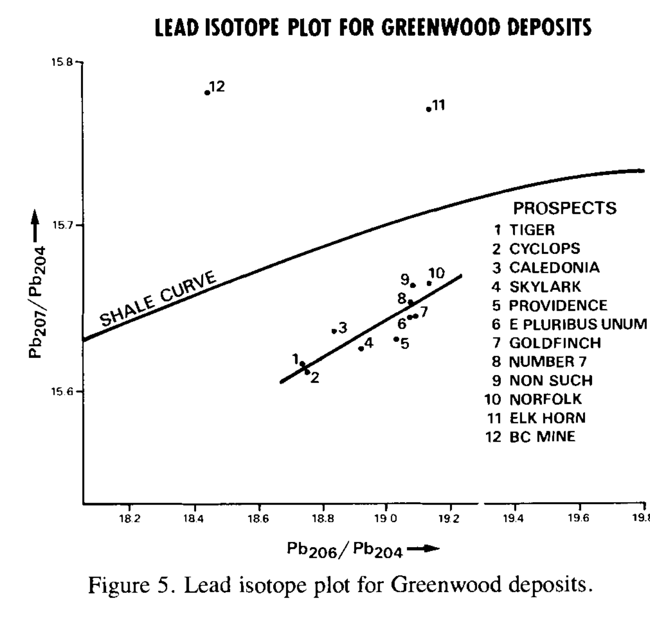

Figure 5. Lead isotope plot for Greenwood deposits.

HYPOTHETICAL CROSS-SECTION

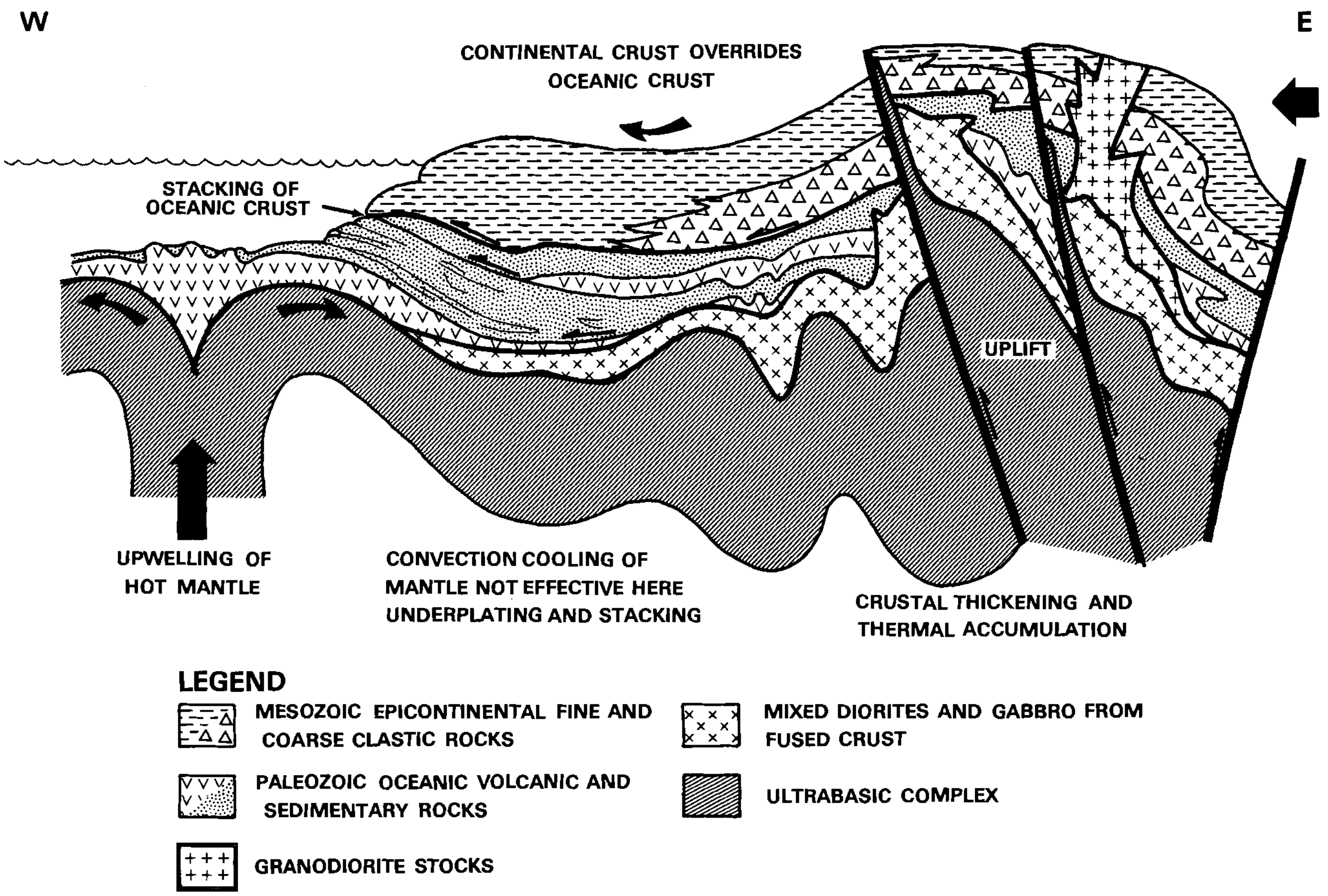

Figure 6. Tectonic model for Early Cretaceous events in southwestern and interior British Columbia.

indicate that there has been some post-mineral movement along most of the cross faults. Shearing parallel with or at an acute angle to the walls of the vein, and along thin septa of altered country rock in the vein, fractured the quartz along closely spaced parallel planes before the close of mineralization. These fracture planes served as channelways for later mineralizing solutions and are now occupied in some places by thin seams of metallic minerals, chlorite, and carbonate, giving the vein quartz a distinctive banded appearance known as ribbon structure."

There are no known published ore reserves for this mine.

CITY OF PARIS, LINCOLN, LEXINGTON

(Lat. 49°, 00.5′; Long. 118°, 36.5′; M.I. 082ESE041 and 042)

The City of Paris mine is 10 kilometres southeast of Greenwood and 1.1 kilometres north of the International Boundary at the elevation of 1 370 metres (4,500 feet) east of Goosmus Creek. Access to the mine is from the Boundary road approximately 1 kilometre west of the haulage road to the Lone Star mine.

Production from the City of Paris mine for the period 1900 to 1940 was 1 926 tonnes of ore containing 27 kilograms of gold, 139 kilograms of silver, 60 tonnes of copper, and a small amount of lead and zinc. About 85 per cent of this production was in 1900. An additional 8 tonnes of ore was produced from the Lincoln claim in 1962-63 yielding about 12 kilograms of silver, 373 kilograms of lead, and a minor amount of gold and zinc.

Development of the City of Paris mine began in 1898. A crosscut adit was driven 250 metres northeast to intersect the main southeasterly trending vein system at approximately 90 metres below the hillside (Fig. 9). From this intersection drifting was extended 180 metres northwest on the vein, connecting with the City of Paris shaft and further drifting of 90 metres to the southeast toward the Lincoln shaft. At the end of the main period of production in 1900 the total mine development consisted of 1 580 metres of drifts and crosscut tunnels, 213 metres of raises, and 113 metres of shafts.

Work began on the Lexington claim in 1899. This property is adjacent to the City of Paris property on the west. A total of 360 metres of underground tunnelling was completed to 1901.

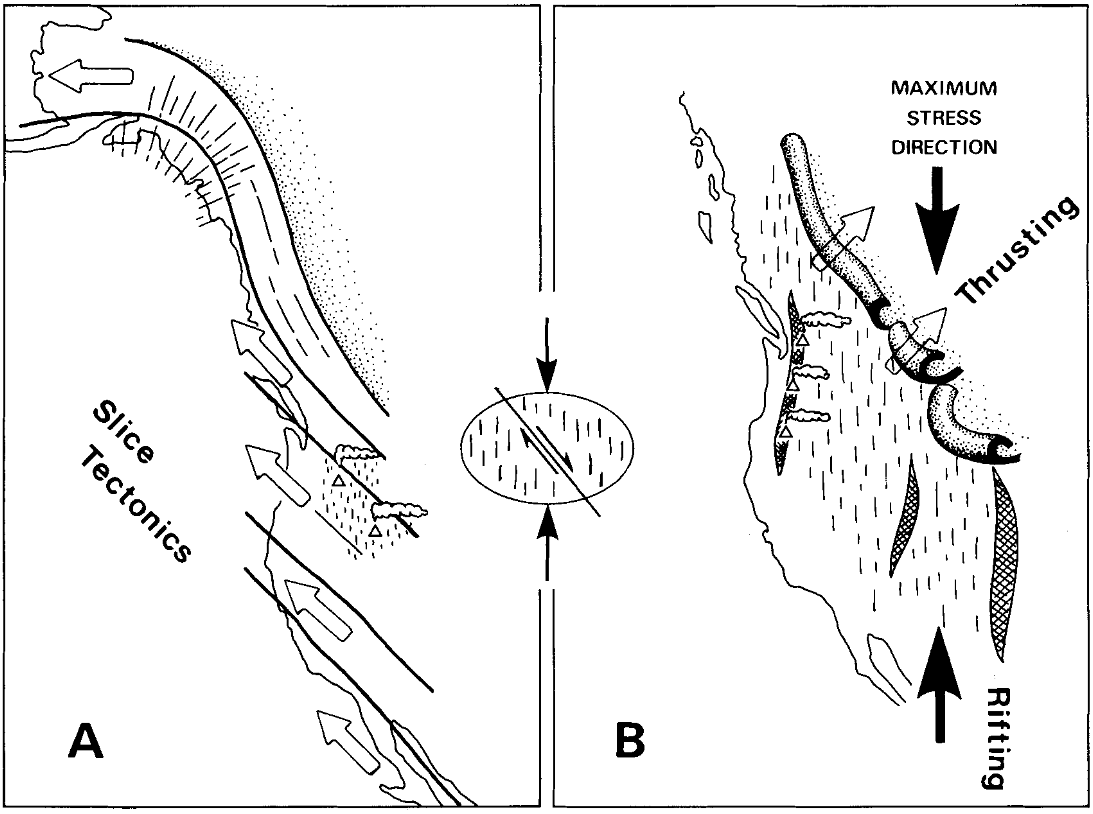

Figure 7. Tectonic model for Cordilleran Tertiary events.

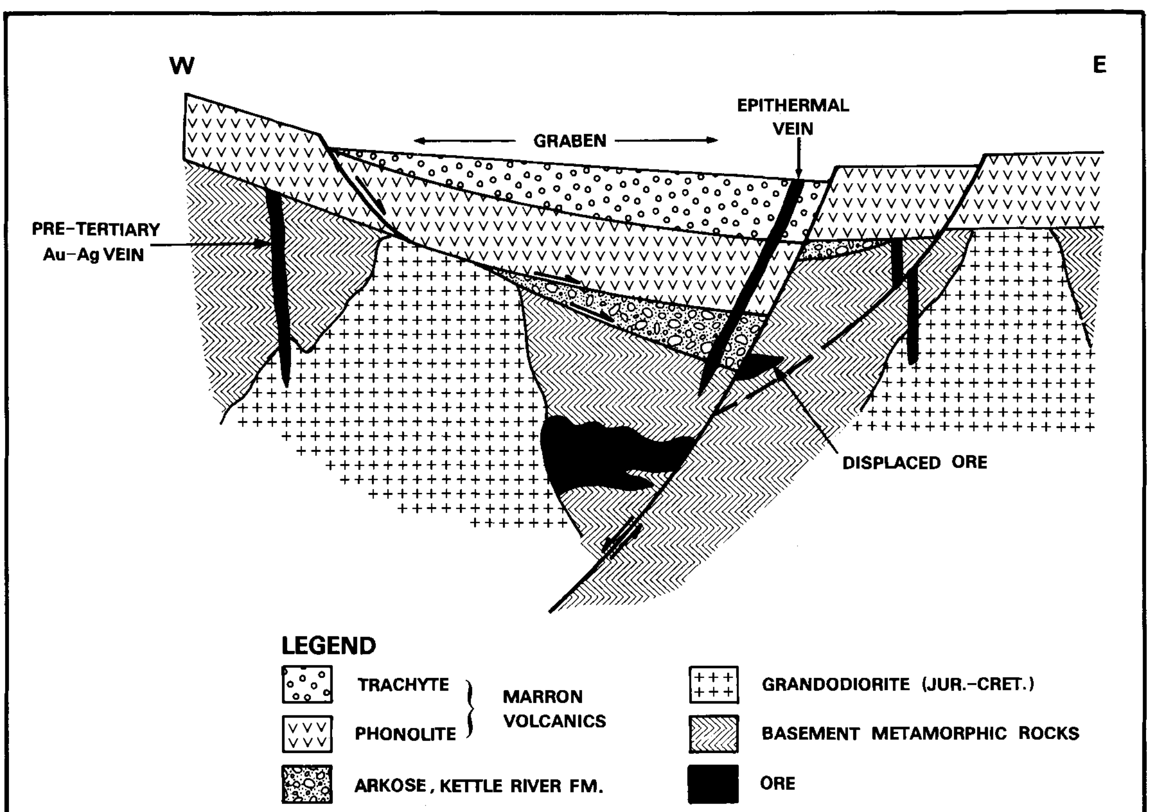

Figure 8. Cross-section of hypothetical Tertiary graben.

In 1962 a short adit was completed near the Lincoln shaft, immediately southeast of the City of Paris workings. This operation produced a small amount of high-grade silver ore.

In the period 1968 to 1981 much additional exploration was completed including trenching and diamond drilling. In 1980 a new adit was driven midway between the City of Paris and Lexington adits. This work included 210 metres of drifting and crosscut tunnelling and 34 metres of raise development.

The City of Paris mine is on a vein system near the south contact of a major ultrabasic intrusion. The vein system consists of two locally discontinuous, subparallel veins developed along the margins of a narrow serpentine appendage flanking the main ultrabasic body. The system dips 55 degrees northeast and has an exposed strike length of 460 metres.

The City of Paris vein, which follows the northeast side of the serpentine appendage, appears to have been the source of much of the ore mined.

The Lincoln vein is exposed on the south side of the serpentine appendage (Plate X). This is the vein followed by the main northwest-trending drift on the bottom level of the mine. In general metal values are intermittent, some of the best assay results being obtained from the Lincoln shaft and portal area.

Much of the recent exploration has focused on the widespread, low-grade copper mineralization associated with the quartz porphyry intrusion on the City of Paris, Lincoln, Lexington, and adjacent claims. This 'porphyry' mineralization is mostly contained within a 900-metre long, 300-metre wide segment of the quartz porphyry exposed between the main ultrabasic intrusion and a smaller subparallel serpentine splay near Goosmus Creek. The principal mode of occurrence of the main ore minerals, pyrite and chalcopyrite, is in fractures and disseminations and, to some extent, in quartz stockworks. The results of an electron microprobe study by G. Anselmo of Can-Ex Resources Ltd. of this area are appended to this report.

Anomalous copper values have also been obtained in the serpentine splay adjacent to the quartz porphyry intrusion (Plate XI) near Goosmus Creek just below the Lexington portal. This sheared serpentine contains interfoliated impregnations of pyrite and chalcopyrite.

Ore reserves for this property, based on the most recent work (1981 estimates) indicate 313 527 tonnes grading 5.44 grams per tonne of gold and 1.96 per cent copper, calculated using a 15-per-cent dilution factor. An additional 110 000 tonnes grading 1.99 grams per tonne gold and 0.92 per cent copper is amenable to possible open-pit mining.

CRESCENT

(Lat. 49°, 06.2′; Long. 118°, 38.7′; M.I. 082ESE012)

The Crescent claim is 2.7 kilometres northeast of the centre of Greenwood at an elevation of 1 280 metres (4,200 feet). Access is on a side road which connects the Phoenix road to the old railway grade on Montezuma Ridge.

Production from this claim was intermittent from 1905 to 1959 with the greatest tonnage recorded in 1905 and 1908. The total mine output was 250 tonnes which contained 1.9 kilograms of gold, 453.8 kilograms of silver, 3 tonnes of lead, and 3.5 tonnes of zinc.

The mine development consists of a shaft and an adit (now mostly collapsed) on a narrow quartz vein. Galloway (1927, p. 39) reports: "The vein strikes north 20 degrees east and stands vertically. It consists of 6 inches [15 centimetres] of quartz mineralized with galena, zinc blende, and grey copper. In vicinity of the vein the country rock has the appearance of an iron cap owing to the oxidation of original pyrite. A sample of this iron cap material only assayed traces of gold and silver. A sample across the vein assayed 0.24 ounces [8.2 grams] of gold; 6 ounces [204 grams] to the ton [tonne] of silver; 0.2 per cent lead. The sorted ore assayed 111 ounces [3 800 grams] in silver to the ton."

The host rocks on the Crescent claim are mostly dark grey argillite (5) and some conglomerate (3) of the Attwood Group accompanied by a minor amount of serpentine (F) and old diorite (A).

No ore reserve data are available for this property.

Plate X. Lincoln vein, City of Paris area.

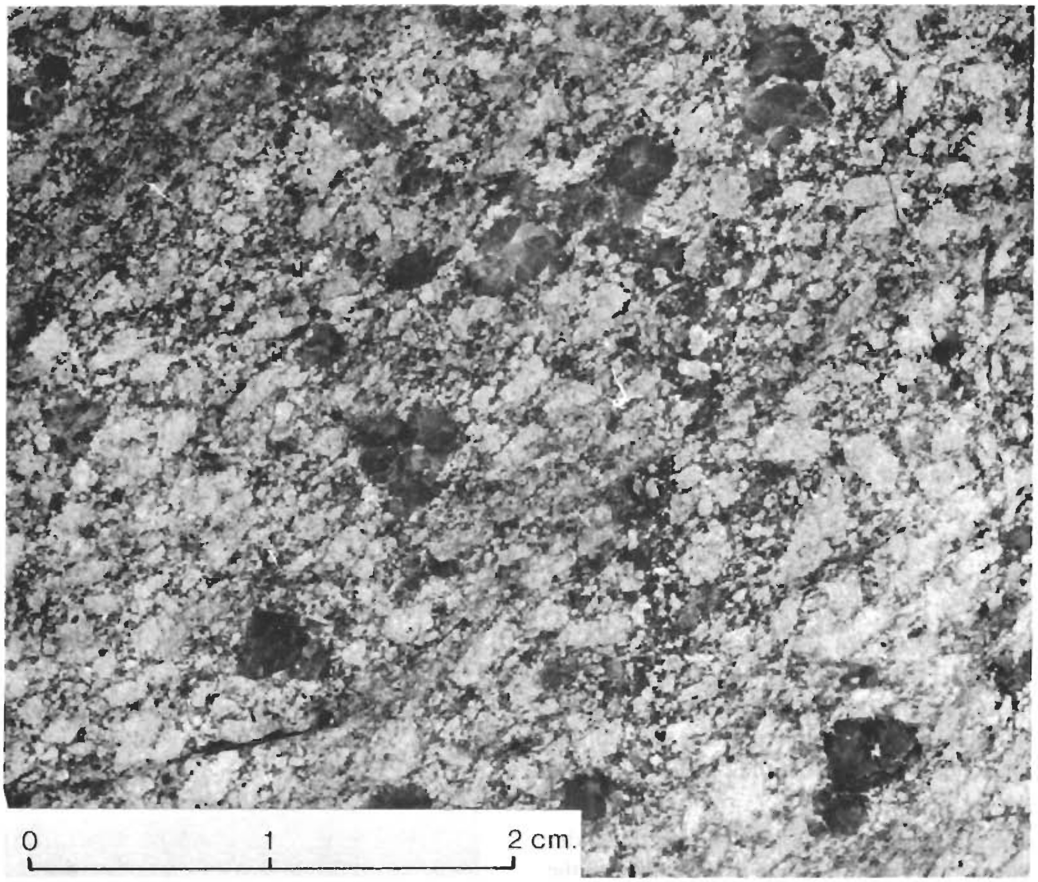

Plate XI. Polished section of Lexington quartz porphyry.

DYNAMO, MAMONT, STARVEOUT

(Lat. 49°, 04.8′; Long. 118°, 40.1′; M.I. 082ESE008)

The Dynamo claim is centred on the transmission line midway between Twin Creek and Lind Creek, 1 kilometre southeast of the post office at Greenwood. The Starveout and Mamont claims lie immediately to the west of Dynamo. The Lind Valley road provides ready access to the property.

Production from this property in the period 1914 to 1955 totalled 385 tonnes of ore which yielded 3 kilograms of gold, 59 kilograms of silver, 27.8 tonnes of lead, and 7.3 tonnes of zinc. In the early years of production, from 1914 to 1942, the ore (201 tonnes) was mined principally from the Dynamo claim. More recently, until 1955, Mamont supplied most of the ore.

According to old Minister of Mines reports, exploration on this property consisted of numerous open cuts and underground development comprising four adit tunnels, ranging 30 to 500 metres in length, and several shafts 3 to 30 metres deep.

The property straddles the southern contact of the Greenwood stock. The mine workings follow five broken, quartz-filled gash fractures, 5 centimetres to 1 metre wide, developed in granodiorite, metamorphosed Knob Hill rocks, and serpentinite. The ore minerals consist of pyrite, galena, sphalerite, and a minor amount of chalcopyrite.

There are no ore reserves quoted for this property.

E PLURIBUS UNUM

(Lat. 49°, 05.1′; Long. 118°, 39.6′; M.I. 082ESE006)

The 'E.P.U.' claim is 1.2 kilometres east of Greenwood at the elevation of 991 metres (3,250 feet); access is via the Bay mine which adjoins to the east.

Production from the 'E.P.U.' in the period 1903 to 1905 and in 1915 and 1947, totalled 571 tonnes of ore which yielded 44.6 kilograms of gold, 229.5 kilograms of silver, 7.6 tonnes of lead, and 1.1 tonnes of zinc. Approximately one-half of this production was achieved in 1905.

Galloway (1913, p. K141) provides a brief description: "A quartz vein from 6 to 12 inches [15 to 30 centimetres] wide, carrying in places high gold values, had been developed by a shaft 200 feet [60 metres] deep and shipments of ore, aggregating several thousand dollars, had from time to time been made. The bottom of the shaft shows a strong vein, but the values are quite low. At this point it was decided to run a crosscut tunnel to tap the vein at depth, ... At the time, the property possessed a hoist, pump, and steam drill capable of sinking to at least 400 feet [120 metres]. Capital for the driving of the tunnel was supplied by a complicated share system, partly cash and partly in work. The tunnel was first driven about 100 feet in a direction nearly parallel to the vein; then, from a point about halfway in the tunnel, another crosscut was started at an angle of about 35 degrees to the former; the tunnel then twists and turns, ... It should be noted here that the vein, as exposed, is in granite, while the tunnel, which is 1,700 feet [520 metres] long, is entirely in metamorphic rocks (altered sediments and volcanics). A few granitic dykes, probably apophyses from the main body, are seen in the tunnel."

The last production from 'E.P.U.' was in 1947. Restoration of 60 metres of collapsed tunnels at this time allowed mining of a faulted remnant of the vein below the bottom level.

There are no ore reserve estimates available for this property.

ELKHORN

(Lat. 49°, 06.6'; Long. 118°, 47.4'; M.I. 082ESE002)

The Elkhorn mine is centred on Highway 3 near the north boundary of Greenwood municipality.

Production from this property was episodic in the period 1905 to 1947 and has never exceeded 30 tonnes per year. Total recorded mine output amounts to 179 tonnes of ore which yielded 5.2 kilograms of gold, 456 kilograms of silver, 8.2 tonnes of lead, and 1.7 tonnes of zinc.

The mine workings consist of an inclined shaft 80 metres deep servicing a level at the bottom and an upper level at about 20 metres depth. The shaft is also connected to an intermediate adit level at 34 metres depth.

The underground workings follow a narrow quartz vein, dipping 45 to 65 degrees southeast, hosted by silicified Knob Hill schists outcropping near the north contact of the Greenwood granodiorite stock.

The ore minerals consist of pyrite, galena, sphalerite, and minor amounts of tetrahedrite and proustite. Some native silver has been reported in the stopes above the adit level.

According to McNaughton (1945, p. 18) "The vein is cut by several faults that strike north 30 to 50 degrees east and dip at low angles to the northwest. The hanging-wall has in each case moved down with reference to the foot-wall. Offsets along these faults range from a few feet to 30 feet [9 metres]. On the 110 foot level [adit level] the vein is cut by two post-mineral feldspar porphyry dykes, and has not been located beyond the dyke that is exposed 135 feet [41 metres] north-east of the inclined shaft. The other dyke, which is exposed in the level at the inclined shaft, has not offset the vein."

No ore reserves are available for this property.

GOLD DROP

(Lat. 49°, 10'; Long. 118°, 36.2'; M.I. 082ESE153)

The Gold Drop mine is 8.5 kilometres north of Greenwood and approximately 1 kilometre east of the south end of Jewel Lake. Access is from Jewel Lake road and Dentonia mine via the Jewel shaft.

Production from this claim was recorded over a period of seven years between 1926 to 1941. A total of 296 tonnes of ore was mined yielding 5 kilograms of gold, 29 kilograms of silver, and a minor amount of lead.

According to Mitchell (1946, p. A136): "On this property there are two adits approximately 1,800 feet [550 metres] east of the Dentonia (Jewel) vein and 52 feet [16 metres] apart vertically [Fig. 10]. These adits explore the Gold Drop vein at shallow depth. The lower adit, elevation 4,528 feet [1 380 metres], driven as a crosscut, gradually changes direction from slightly west of north to almost east and reached the vein about 220 feet [67 metres] from the portal. The vein was followed 55 feet (17 metres) in a northerly direction, and a small part of it was stoped. The upper adit, at elevation 4,580 feet [1 400 metres], is collared about 80 feet [24 metres] north-east of this stope and heads northerly for about 20 feet [6 metres] to the vein. It then follows the vein about 70 feet [21 metres] slightly east of north to a point where the vein splits. The left split is followed for 80 feet [24 metres] and the right split for about 250 feet [76 metres]. The latter split trends north easterly for about 80 feet [24 metres] and then runs parallel to the left split. Shipments to Trail have been made by previous operators from one small stope in the left split, from several small stopes in the right split, and from the lower adit."

The Gold Drop vein is a quartz-filled fissure ranging from a few centimetres to 1.5 metres wide and dipping 40 to 65 degrees southeast. Mineralization consists of sparce pyrite and a few specks of galena. The host rocks are schistose biotiferous metasedimentary formations.

No estimate of ore reserves is available.

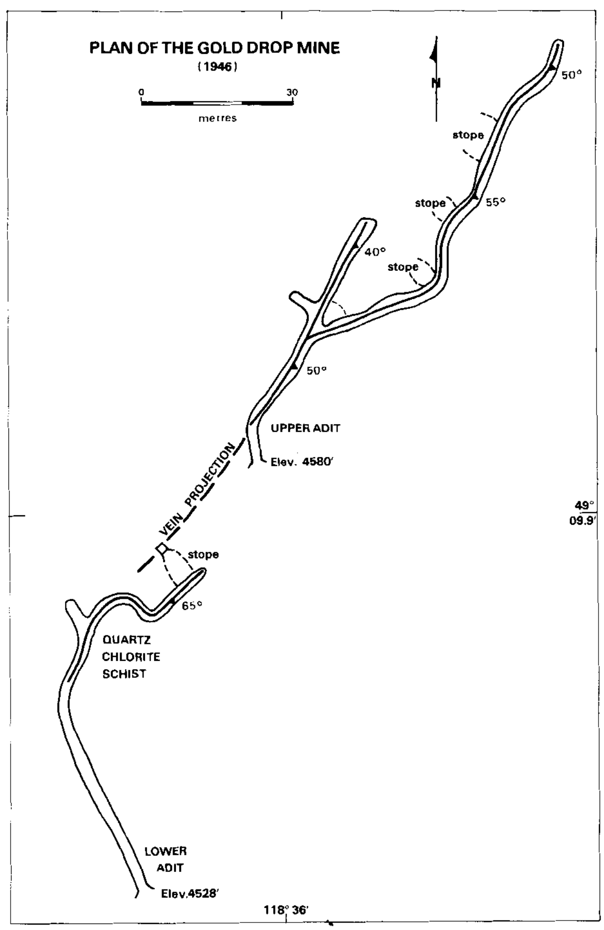

Figure 10. Plan of the Gold Drop mine.

GOLD FINCH

(Lat. 49°, 05.2′; Long. 118°, 03.9′; M.I. 082ESE004)

The Gold Finch claim is centred at an elevation of 914 metres (3,000 feet), 0.7 kilometre east of the post office at Greenwood. Access to the claim is from the "E.P.U." claim which lies immediately to the east and a spur road on the west which branches from the Lind Valley road.

According to Table 1, p. 197 of Index No. 3 to Publications of the British Columbia Department of Mines (1955), production from Gold Finch from 1902 to 1944 was 300 tonnes of ore having 18 kilograms of gold, 88 kilograms of silver, 8 tonnes of lead, and 2 tonnes of zinc.

Mining began on the Gold Finch claim in 1902 and by 1903 the workings consisted of a shaft 30 metres deep and approximately 30 metres of drifting plus some stope development. Target of these operations was a quartz vein in the east margin of the Greenwood granodiorite stock. This activity continued for several more years then the property lay dormant. In 1942 the property was reactivated with the installation of a small mining plant. A small tonnage of ore was obtained in 1944 prior to final closing of the mine.

No ore reserves have been reported.

GREYHOUND, AH THERE

(Lat. 49°, 06.1′; Long. 118°, 42′; M.I. 082ESE050)

The Greyhound and Ah There claims are centred just northwest of the confluence of Motherlode and Greyhound Creeks and approximately 2.5 kilometres northwest of Greenwood. The adjoining claims are readily accessible from the Motherlode Creek road.

Production from the Greyhound open pit in the brief period of mine operations from 1970 to 1971 amounted to approximately 221 200 tonnes of ore having 15.6 kilograms of gold, 349 kilograms of silver, and 597 tonnes of copper.

Work began on the Greyhound claim in 1900 with some underground exploration which included a shaft 60 metres deep and a crosscut driven from the bottom. At about the same time a shaft approximately 45 metres deep was put down on the Ah There claim. This activity resulted in a trial shipment of 24 tonnes of ore in 1903. Except for a number of brief exploration projects, such as some diamond drilling in 1912, 1916, and 1956, the property remained more or less dormant until open-pit mining on the Greyhound claim began in 1969 and continued through 1971. This excavation amounted to about 900 000 tonnes of ore and waste material.

The property is underlain mainly by altered formations of the Brooklyn Group, mostly skarn rocks, and granodiorite which forms the west boundary of the Greenwood stock. Pulaskite dykes, feeders to the Marron volcanic rocks, are common.

Mineralization consists of pyrite, chalcopyrite, pyrrhotite, magnetite, and specularite occurring on fractures and interstitially near the contact of the carbonate rocks, the skarn, and the granodiorite.

Ore reserves for the Greyhound pit are reportedly about 180 000 tonnes averaging 0.6 per cent copper.

JEWEL

(Lat. 49°, 10′; Long. 118°, 31′; M.I. 082ESE055)

The Jewel claim and four additional Crown-granted claims, including Denero Grande, Enterprise, Anchor, and Ethiopia, comprise what is known as the Dentonia property. This is centred approximately 0.7 kilometre east of the south end of Jewel Lake on the west slope of Mount Pelly. Access is by the Jewel Lake road which joins Highway 3 a few kilometres north of Greenwood.

Production in the period 1900 to 1980 from this property totalled 123 294 tonnes of ore having 1 219 kilograms of gold, 7 193 kilograms of silver, 163 tonnes of lead, and 3 tonnes of zinc. Most of this ore was mined from the Jewel and Enterprise claims in the periods 1912 to 1916 and 1934 to 1943. Minor production was realized from the Enterprise and Anchor claims in 1947 and 1948 and from Denero Grande in 1974, 1975, and more recently.

The Dentonia mine is aligned in a northerly direction on a 1 200-metre-long easterly dipping vein (Fig. 11). Entrance to the old underground workings is by two adits and four inclined shafts, the most important of which are the Jewel shaft and the Enterprise adit crosscut. The Jewel shaft, on the south part of the Jewel claim, connects five working levels and serviced the main orebody to a depth of about 120 metres. The Enterprise tunnel, at an elevation of about 1 200 metres (3,900 feet), was driven easterly from Jewel Lake to intercept the base of the Enterprise orebody at the boundary of the Jewel and Enterprise claims.

A mill was erected in 1909 and operated until the property was abandoned in 1914. A renewed period of mining prompted construction of a second mill which operated from 1933 to 1936.

The continuation of the Dentonia vein on the Denero Grande claim was actively explored in 1973. This led to the sinking of a vertical shaft to a depth of 90 metres (Plate XII). Stewart (1975, p. 42) reports: "By April 1975 over 1000 feet [300 metres] of drifting and raising in the vein had been done and the vein located by underground drilling to the north, south and below the new workings. Five stoping areas had been opened up and over 2000 tons of ore had been mined". Additional shaft sinking and drifting has been completed since 1980.

The geology of the property has been described in detail by Church and Winsby (1974, pp. 39 to 51). This work shows that the claims are underlain by Paleozoic metabasaltic rocks and basement schists intruded by the Wallace Creek granodiorite. The Dentonia quartz vein cuts across the strike of these formations averaging about 1 metre in width. Mineralization consists mostly of grey disseminations and small pockets of sulphides in quartz. The ore minerals are mostly pyrite and galena with minor amounts of sphalerite, chalcopyrite, tellurides, and some native gold.

Ore controls are attributed to several factors, the most important of which are deflections in the vein attitude and the response of the main fissure zone to sudden changes in the composition of the host rocks. Both of these features are present in the Jewel orebody. Here the vein is enlarged and somewhat refracted at the intersection of brittle granodiorite and the less competent schistose volcanic rocks. A major deflection in the strike of the vein is not so apparent in the case of the Anchor shoot at the greenstone/metaquartzite contact, although the vein is generally less steeply inclined. The great width of quartz in the main part of the Enterprise section appears to be solely the result of a major variation in the direction of the fissure zone caused by stresses acting on rather homogeneous greenstone.

According to Hedley (1941), the vein structure originated in response to regional stresses. Apparently, tensional gash fractures developed attendant to north-trending shears in response to compressional stress from the northeast, allowing the influx of quartz. The amount of movement was small and the direction is believed to have been largely horizontal. The host rocks are not thought to have offered any special opportunity for chemical reaction with the ore-bearing solutions, however, there was a tendency for the greenstone to split and fray under stress, the walls of the vein and septa showing some evidence of replacement.

The age of the Dentonia vein is bracketed by the Wallace Creek granodiorite which locally hosts the vein and crosscutting younger dykes. A sample of the granodiorite from the Denero Grande shaft area returned a Early Cretaceous potassium/argon date of 128 ± 5 Ma. The numerous feldspar porphyry and pulaskite dykes found in the mine workings are clearly feeders to the Eocene Marron lavas.

Indicated ore reserves are at least 2 000 tonnes grading 10 grams of gold and 70 grams of silver per tonne. It is the expressed intention of present mine management to drift northward from the Denero Grande shaft under the old Jewel workings where additional ore reserves are anticipated.

KENO, ORPHIR

(Lat. 49°, 04'; Long. 118°, 35.2'; M.I. 082ESE192)

The adjoining Keno and Orphir claims are centred on a low ridge just east of the Lone Star haulage road 3.9 kilometres south of Phoenix and 6.8 kilometres southeast of Greenwood.

Production from this property in the period 1935 to 1940 totalled 294 tonnes of ore carrying 1.2 kilograms of gold, 101 kilograms of silver, 2.7 tonnes of lead, and 0.3 tonne of zinc.

According to the Minister of Mines report (1933, p. A161): "Development consists of a 35-foot [11-metre] shaft, at 4,525 feet elevation [1 380 metres], on a banded quartz vein varying from 3 inches [8 centimetres] to 3 feet [0.9 metre] in width and striking north-south (mag.). The vein has been traced up for 800 feet [250 metres] and contains pyrite, sphalerite, gold, and silver. About 150 feet [46 metres] south of this shaft a crosscut was started with the idea of intersecting the shaft vein about 150 feet [46 metres] south and 25 feet [8 metres] lower in elevation."

A second steeply dipping quartz vein intersects the first, striking diagonally at about 110 degrees, across to the shaft. This vein is 15 to 50 centimetres wide and 200 metres in length.

The geology of the Keno claim consists of volcanic and metasedimentary beds of the Attwood Group dipping 50 degrees north. The same rocks, cut by a small granitic body, are exposed on the Evening Star claim adjoining Keno on the south.

Additional trenching and drilling in 1967 and 1980 have shed light on the geology, however, no known ore reserves have been reported for this property.

LAST CHANCE

(Lat. 49°, 05.7'; Long. 118°, 38.3'; M.I. 082ESE216)

The Last Chance claim (Lot 753) is on the road to Phoenix and centred 1.6 kilometres northeast of the Greenwood post office at the elevation of approximately 1 050 metres (3,500 feet).

According to Galloway (1927, p. 14), production totalled 667 tonnes of ore containing 23 kilograms of gold, plus some good silver values.

Plate XII. Portrayal of Denoro Grande headframe (1973).

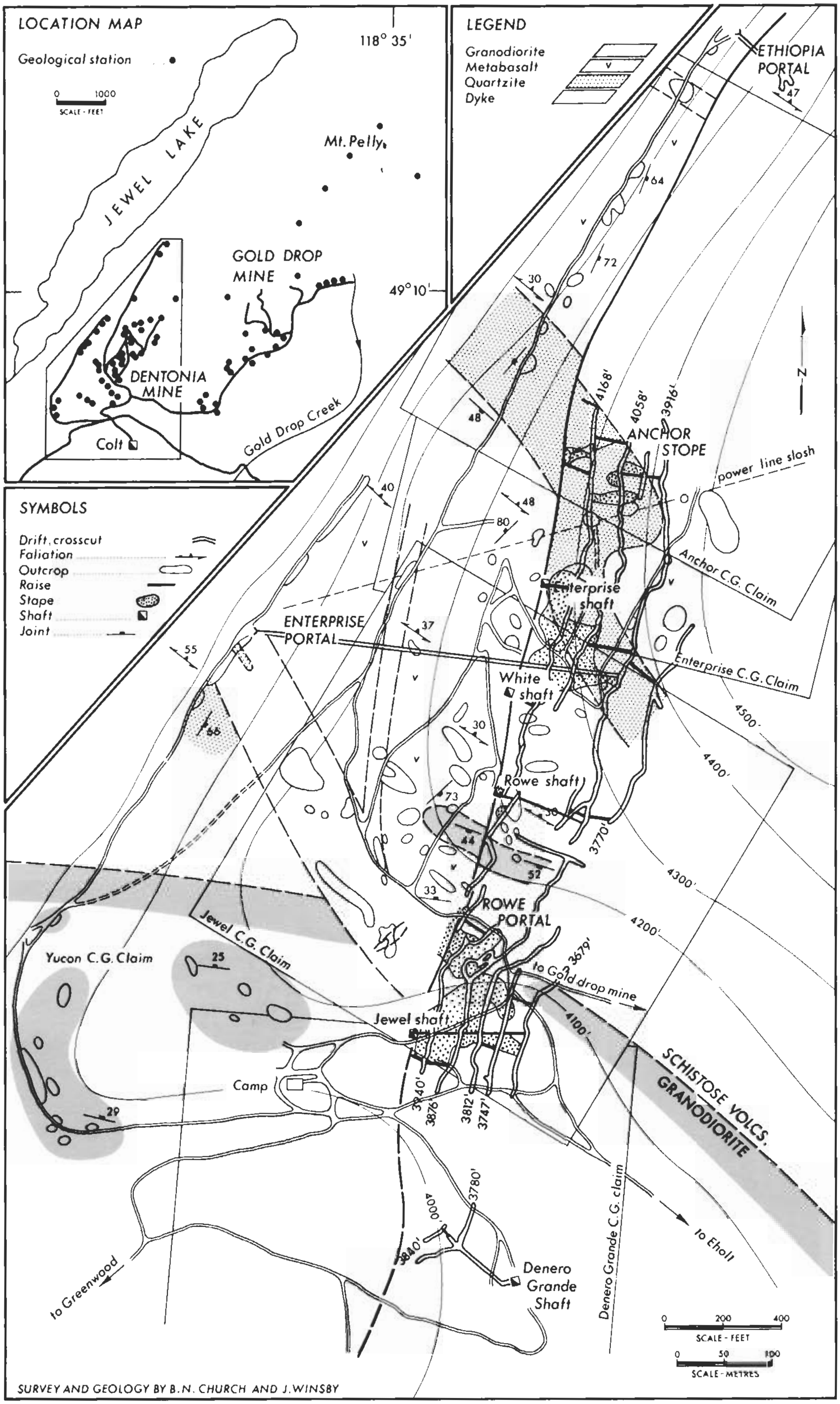

Figure 11. Geology of the Dentonia mine (after Church and Winsby, 1974).

The claim was staked in 1894 at which time a 12-metre-deep shaft was sunk. In 1898 a two-compartment shaft was developed to 30 metres without intersecting ore and the property was abandoned. By 1921 the workings were flooded, however, a small shipment of ore was completed from the dump which assayed 15 grams per tonne gold, 2 760 grams per tonne silver, 2 per cent lead, and 5 per cent zinc.

Mineralization consists of pyrite, galena, sphalerite, and tetrahedrite in irregular quartz and carbonate veins and lenses in a sheared talc-carbonate alteration zone in an ultrabasic intrusion. This intrusion follows the contact locally between the Greenwood granodiorite stock on the west and metamorphosed Attwood Group rocks on the east.

Ore reserve estimates are unavailable.

MARSHALL, SYLVESTER K

(Lat. 49°, 06.6′; Long. 118°, 32.2′; M.I. 082ESE031)

The Marshall and adjoining Sylvester K claims are centred near Providence Lake 1.7 kilometres northwest of Phoenix and 5.8 kilometres northeast of Greenwood. Access is via the Providence Lake road which runs north from the Phoenix minesite.

A total of 194 tonnes of ore was shipped from the Marshall claim in the period from 1967 to 1975. These deliveries yielded 15.2 kilograms of gold, 17.6 kilograms of silver, 0.5 tonne of copper, 2.3 tonnes of lead, and 0.6 tonne of zinc. There are no records of ore being processed or shipped from Sylvester K.

The Marshall claim was Crown granted in 1904. Several hand-dug trenches and two shafts near the west boundary of the claim are the only remnants from the early years of prospecting. The first major exploration activity was undertaken in 1938 when seven holes comprising 411 metres of diamond drilling and much bulldozer trenching were completed between the two old shafts. The first shipment of ore was in 1967 by lessees from an open cut on the 'San Jacinto zone' 120 metres west of Providence Lake. In 1968 this zone was explored further by 560 metres of diamond drilling and bulldozer trenching. This eventually resulted in ore shipments in 1971 and 1975.

On the Sylvester K claim, numerous old hand-dug pits and trenches are evidence of the early exploration. In 1982, following the discovery of an electromagnetic anomaly, trenching with a backhoe revealed sulphides in rough alignment with mineralization on the Marshall claim (Fig. 12). This was confirmed in 1983 with more extensive trenching and a program of 20 test holes totalling 1 900 metres of diamond drilling (Plate XIII).

The geology of the Sylvester K and Marshall claims has been described by Church (1983, pp. 7 to 14). The main rocks underlying these claims are sedimentary beds of the Brooklyn Group and offshoot apophyses and dykes of the Providence Lake microdiorite. The Brooklyn beds are a steep, mostly easterly dipping Triassic assemblage. These rocks consist of a thick basal sharpstone conglomerate formation, overlain by a relatively thin argillaceous transition facies and a thick limestone formation above. The Providence Lake microdiorite, dated 206 ± 8 Ma by potassium/argon analysis, intrudes these Brooklyn units and appears to be a feeder to somewhat younger volcanic rocks of the Eholt Formation.

Mineralization consists of massive sulphide replacements in limestone lenses and sulphide disseminations in adjacent argillaceous rocks in the transition zone of the Brooklyn sequence and within the sharpstone formation. The mineralogy of the ore is simple, consisting principally of pyrite with smaller amounts of pyrrhotite and marcasite and trace amounts of chalcopyrite accompanied by carbonates, quartz, and chlorite. The San Jacinto zone has a somewhat broader array of minerals which includes magnetite, specularite, galena, sphalerite, garnet, epidote, and amphibole. The effect of the mineralizing solutions on wallrocks of the ore zone is well displayed in the Sylvester K zone where the footwall argillites have been transformed locally into a fine-grained, biotite-bearing hornfels. Here numerous thin pyrite stringers carry gold and silver values for more than 10 metres distal from the massive sulphide bodies. Elsewhere, chlorite and hematite are common on joints and fractures in the host rocks.

The source of the mineralizing solutions is believed to be the microdiorite, although no significant mineralization is visible south of Providence Lake where the main microdiorite body intrudes the Brooklyn limestone. However, considering the wide range of microdiorite dykes in the area, it is possible that the principal plutonic body lies at depth.

The drilling program on Sylvester K delineated approximately 50 000 tonnes of mostly low-value pyritic ore in a zone 245 metres long and 1 to 6 metres wide. Spot gold grades within the zone locally exceed 10 grams per tonne.

MORRISON

(Lat. 49°, 06.4′; Long. 118°, 43.6′; M.I. 082ESE052)

This claim is 4.5 kilometres northwest of Greenwood at the elevation of about 1 040 metres (3,400 feet) on the north slope overlooking Motherlode Creek. A good gravel road connects the property directly to Greenwood.

Production from the Morrison is recorded from 1901 to 1903. A total of 2 647 tonnes of ore was shipped having 7.5 kilograms of gold, 26 kilograms of silver, and 10.7 tonnes of copper.

According to the Annual Reports of the Minister of Mines, prospect shafts and cuts were made on the property by 1897. By 1899 three mineralized zones (leads) were identified running nearly parallel with the creek. In a crosscut tunnel (1899, p. 766): "the first lead is cut at 90 feet [27 metres] in, and is about 12 feet [3.6 metres] wide; the second at 415 feet [125 metres] in, showing a width of some 5 feet [1.5 metres]; while the third is cut at 565 feet [170 metres], and is of some 70 feet [20 metres] wide, but of this width only a portion of some 20 feet [6 metres] would be worked. The tunnel at the face had gained a depth of 170 feet [50 metres]." Mine development to 1900 consisted of 660 metres of crosscuts and drifts, about 115 metres of sinking and raising, and 180 metres of surface trenching. By 1903 total tunnelling amounted to 1 140 metres.

Little is known about the geology of the Morrison other than it appears to be a low-grade skarn deposit with some crystalline limestone similar, perhaps, to the Mother Lode, Sunset, and Greyhound deposits. Mineralization consists of pyrite with some pyrrhotite and minor amounts of chalcopyrite.

No estimate of mineral reserves is available.

MOTHER LODE, SUNSET

(Lat. 49°, 06.7′; Long. 118°, 42.9′; M.I. 082ESE034)

The property comprising the Mother Lode and Sunset mines is centred 4 kilometres northwest of Greenwood at the elevation of 1 050 metres (3,500 feet). Access is by good gravel road which connects the property to the Motherlode Creek road and Greenwood.

Production from two periods of mining on this property, 1900 to 1920 and 1957 to 1962, totalled 4 245 875 tonnes of ore yielding 5 391 kilograms of gold, 21 406 kilograms of silver, and 34 915 tonnes of copper.

A detailed description of the Mother Lode and Sunset mines is given by LeRoy (1913).

The Mother Lode claim was staked in 1891 and Crown granted in 1899. Exploration began with an adit crosscut in 1896 followed by an expanded program of shaft sinking and completion of a smelter at Greenwood in 1901. Underground development to 1902 totalled 2 360 metres of tunnelling. In

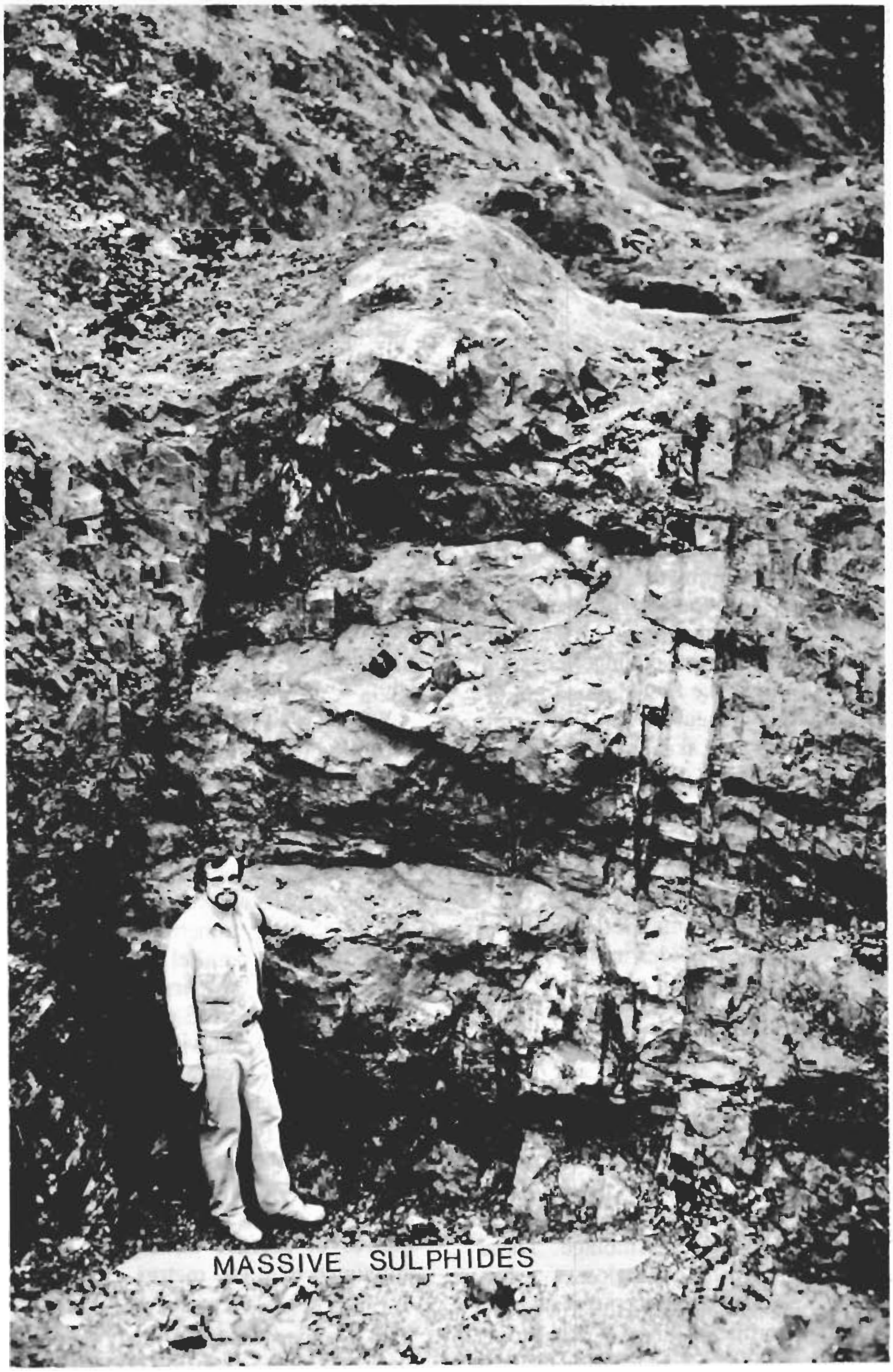

Plate XIII. Discovery trench of Sylvester K massive sulphide zone.

1908 the shaft was deepened to 150 metres forming the basis for mining on four levels. Operations continued until 1918 when the mine and smelter closed.

The Sunset claim was at first developed separately from Mother Lode. Exploration began in 1897 and 1898 with the sinking of several shallow shafts and completion of a 120-metre-long adit. Underground development to 1902 totalled 2 180 metres. Subsequently, the ore was mined from two main pits 120 metres apart measured in a northwest-southeast direction. Ore was processed at a smelter near Boundary Falls until 1918 when the mine closed.

The Mother Lode was renewed in 1956 as an open-pit mine supported by a 900-tonne-per-day mill. Production continued in 1959 at a reduced rate of 450 tonnes per day. This

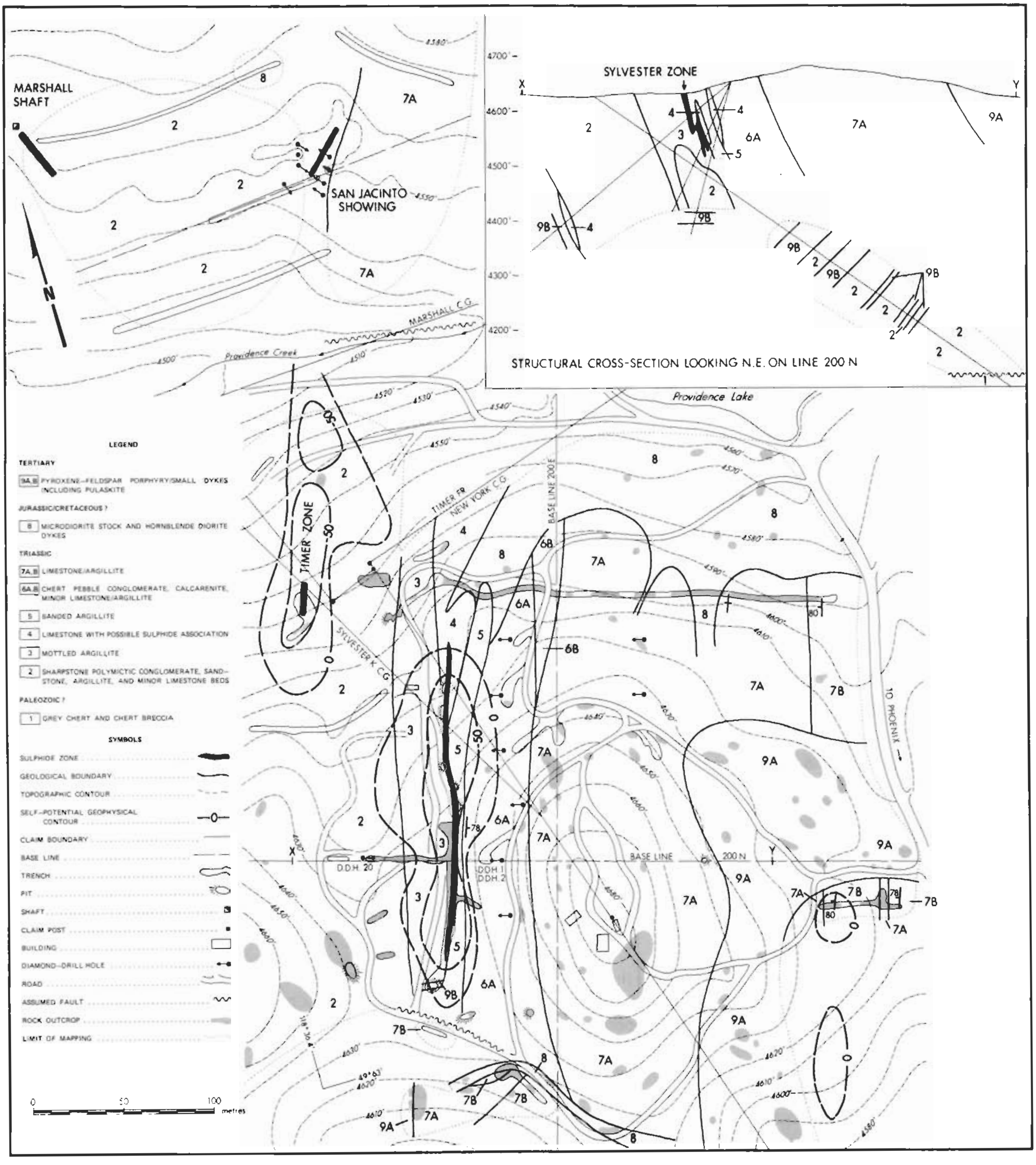

Figure 12. Geology and self-potential survey of the Marshall and Sylvester K claims (after Church, 1983).

was augmented somewhat in 1960 with ore from the Sunset mine. Operations closed in 1962 and the concentrator was removed from the minesite.

Mineralization consists principally of pyrite, magnetite, and specularite erratically distributed throughout the skarn rocks. Chalcopyrite is most abundant in the Sunset mine but tonnage is relatively small.

The host rocks for the ore at the Mother Lode mine are steep, easterly dipping conglomerates and limestones of the Brooklyn Group. In the area of the open pit the limestone is mostly converted to garnet skarn which is locally interbedded with epidote and actinolite. These rocks are intruded by relatively fresh pulaskite porphyry dykes, feeders to the Marron lavas, and older, somewhat altered, granodiorite offshoots of the Wallace Creek stock. A granodiorite dyke, about 30 metres thick, is visible in the pit and another occurs in the underground workings.

The Mother Lode orebody is flanked by limestone on the northwest and by a northerly trending normal fault on the southeast. The ore has a warped configuration trending northeast and then east at the north end of the body and steepening in inclination from 45 degrees southeast to nearly vertical at depth.

The geology of the Sunset mine is similar to the Mother Lode except there are two relatively flat-lying orebodies at Sunset that appear to have developed in skarnified Brooklyn rocks on the limbs of a northerly trending anticlinal structure. A thrusted underplate of Knob Hill chert passes only a short distance under the floor of the Sunset mine and at a slightly greater depth under the Mother Lode.

Ore reserves at the Mother Lode mine are based on estimated tonnage remaining in pillars and sills in the old underground workings and unmined mineralization between the 120-metre level and chert basement. The most recent calculations suggest a reserve of 300 000 tonnes grading 0.5 gram per tonne gold, 4.5 grams per tonne silver, and 0.65 per cent copper.

NO. 7

(Lat. 49°, 01.5′; Long. 118°, 38.3′; M.I. 082ESE043)

The No. 7 mine is 3.3 kilometres east of the confluence of McCarren and Gidon Creeks, on a ridge crest at the elevation of 1 370 metres (4,500 feet), 7.5 kilometres southeast of Greenwood. Access is a distance of approximately 2.4 kilometres travelling southerly and uphill by winding dirt road from the McCarren Creek road.

The intermittent operations of the No. 7 mine between 1901 and 1945 produced a total of 13 748 tonnes of ore yielding 92 kilograms of gold, 3 110 kilograms of silver, 97 tonnes of lead, and 6.2 tonnes of zinc.

The potential of No. 7 was recognized early in the Greenwood camp and the claim was Crown granted in 1895. By 1897 a 40-metre-deep inclined shaft was developed on the claim to service 60 metres of underground drifting. At the approximate time of final closing of the mine 50 years later, McNaughton (1945, p. 19) reports: "Mine workings comprise a 320 foot [100-metre] inclined shaft, adit levels at 40 and 300 feet [12 and 90 metres], and intermediate levels at 100 and 180 feet [30 and 55 metres]. Old mine maps show that the underground work on these four levels totals about 5200 feet [1 580 metres]. The 90 metre adit level is open from portal to face, a distance of about 1900 feet [580 metres], but the other levels are partly caved southeast of the inclined shaft. Other workings include an adit drift 130 feet [40 metres] northwest of the 40 foot [12-metre] No. 1 adit, a large number of surface pits, and a deep trench along the vein from which some underhand stoping was done."

The mine is developed on a quartz vein in a major southeasterly trending boundary fault between Knob Hill Group rocks on the northeast and Attwood Group rocks on the southwest. Contained in part within the fault zone and hosting this vein are a schistose quartz feldspar intrusion and younger ultrabasic rocks. A variety of Tertiary dykes has invaded and is superimposed on the vein structure.

The quartz vein at the minesite has been traced for a strike length of more than 300 metres (Fig. 13). The vein ranges from 10 centimetres to 1.5 metres wide and dips 40 to 65 degrees northeast, having dyke rocks or chloritic schists of the Knob Hill Group on the hangingwall and highly sheared talc-carbonate rocks of the ultrabasic body on the footwall.

Mineralization consists of pyrite, sphalerite, and some galena dispersed in blue-grey quartz along the central portion of the vein. The most productive part of the vein was southeast of the inclined shaft above the 55-metre level.

According to McNaughton (1945, p. 20): "A large number of northeasterly striking faults displace the vein. Displacements along these faults range from a few feet to almost 200 feet [60 metres]. The maximum displacement was measured on the fault exposed in the southeast end of the 300 foot [90-metre] level and on the surface 200 feet [60 metres] southeast of the long open cut. The vein has not been located beyond this fault. Movement along these faults has been largely post mineral. Evidence of some pre-mineral movement is furnished by lenticular seams of unbroken vein quartz up to 8 inches [20 centimetres] by 10 feet [3 metres] in the fault zone exposed at the southeast end of the 300 foot [90-metre] level. Subsidiary faults of small displacement are part of this same fault zone, and offset both vein and the post mineral quartz trachyte dyke. Thus this single fault zone has been the locus of both pre-and post-mineral movements."

No ore reserve estimate is available for this property.

NORTH STAR

(Lat. 49°, 10′; Long. 118°, 36′; M.I. 082ESE152)

The North Star claim, elevation 1 430 metres (4,700 feet), lies just east of the summit ridge of Mount Pelly, 1 kilometre east of Jewel Lake and 10.5 kilometres northeast of Greenwood. The claim is reached by dirt side road 2 kilometres from where it connects with the Jewel Lake to Eholt road near the Jewel shaft.

Production from the North Star mine was recorded each year in the period 1932 to 1940. The only other occasion was shipment of ore in 1919, apparently to test the mineralization. Total ore amounts to 6 178 tonnes containing 23.7 kilograms of gold; 475 kilograms of silver; 9.2 tonnes of lead; and 11.7 tonnes of zinc.

The North Star was Crown granted in 1904 following the discovery of a vein and the sinking of two shallow shafts on the property in 1897. Later development included a short crosscut (No. 1 adit), approximately 14 metres long, which was driven to intersect the vein below the shafts and a drift driven 40 metres on the vein where stoping resulted in the first shipment of ore.

According to Hedley (1936, p. D25): "The mineral deposit is a north-south quartz vein dipping to the east and crosscutting a thick series of schistose quartzitic sediments [Fig. 14]. Syenite and andesite dykes of irregular shape cut both sediments and vein. The vein may be traced completely across the claim in a series of exposures of tight walled rather barren quartz. As developed underground the vein is erratic; a maximum width of 4 feet [1.2 metres] is only attained locally, and some sections are less than 4 inches [10 centimetres] in width. Mineralization consists of pyrite, galena, chalcopyrite, sphalerite, and telluride in frequently crystalline quartz. Ore shoots are not continuous and are localized principally at abrupt changes in attitude of the vein."

Hedley continues: "No. 1 adit is driven on the southern boundary of the North Star claim. On surface, on the south, the vein outcrops as heavy barren quartz, and one caved shaft and some surface work do not clearly indicate the structure. In the second shaft 4 feet [1.2 metres] of white quartz is followed down at 42 degrees dip, and at 25 feet [8 metres] is 12 inches [30 centimetres] wide; rich pockets occur in this shaft. North, so far as shown, the vein is steeper and is comparatively straight. Mineralization as seen in surface strippings and at the collar of the northernmost shaft is scanty."

"Underground the behaviour of the vein is different; it is a highly irregular structure, with commercial ore localized where the irregularities are most pronounced. Dykes are of two sorts; one, the most prominent, is a biotite syenite brownish in colour and sometimes porphyritic when of medium grain, but grey in colour when fine grained. This latter phase of the syenite is very similar in appearance to a medium and, locally dark grey andesitic dyke, and it is the writer's opinion that the two are closely related in age and origin. The syenite is evidently quite irregular, as in the No. 2 adit and north drift, where it occurs as a stock like body. One sharp roll in the vein has been mined above No. 1 level, and between No. 1 and No. 2 on both sides of a post mineral syenite dyke; in this section high grade ore has been recovered. Another section has been stoped farther south above No. 1 level and is apparently worked out. Beneath this stope on No. 2 the vein is weak, but some ore is bound to occur between the two levels."

Renewal of exploration activity on the North Star and adjacent Gold Drop claims coincides with revival of the nearby Dentonia mine, however, no information is available on the ore reserves estimates resulting from this activity.

ORO DENORO, EMMA

(Lat. 49°, 07.6′; Long. 118°, 32.9′; M.I. 082ESE062 and 063)

The Oro Denoro and Emma mines are centred 10.2 kilometres northeast of Greenwood at the elevation 1 200 metres (4,000 feet) on the divide between Eholt Creek and Fisherman Creek. Access to these adjoining properties is about 0.6 kilometre southwest from Highway 3 by level gravel road along an old railway bed.

Production from Oro Denoro in the period 1903 to 1917 totalled 124 001 tonnes containing 117 kilograms of gold, 954 kilograms of silver, and 1 691 tonnes of copper (which does not include several thousand tonnes of ore shipped to the Phoenix mill in 1978). From the Emma mine a total of 240 948 tonnes of ore was produced in the period 1901 to 1927 containing 212 kilograms of gold, 2 434 kilograms of silver, and 2 350 tonnes of copper.

The Oro Denoro mine is centrally located within a 2.4-kilometre-long meridianal alignment of skarn deposits which includes the Emma and Jumbo on the north and the Cyclops and Lancashire Lass on the south (Fig. 15). Mine development began at Oro Denoro in 1896 and by 1900 the underground workings consisted of a shaft 70 metres deep and 240 metres of crosscuts and drifts. By 1908 an additional 40 metres of sinking and 20 metres of crosscutting were completed. The present mine workings cover an area of about 4 hectares in the central part of the claim (Plates XIV to XVIII).

At Emma mining began from a skarn zone exposed during railroad construction. By 1905 production was derived mainly from underground development which consisted of a two-compartment shaft 80 metres deep, with levels at 45 metres and 75 metres. A fire disrupted the operation in 1912, however, the workings were restored in 1916 and production continued until 1921. Underground development in this period included 50 metres of shaft sinking, 285 metres of raising, and 770 metres of drift and crosscut tunnelling.

The orebody at Emma is vertical and strikes northerly, roughly parallel to bedding in the Brooklyn limestone at the eastern contact of the Wallace Creek granodiorite body. Mineralization, consisting mostly of pyrite, chalcopyrite, and magnetite impregnations in garnetite, is mostly confined to a narrow zone about 8 metres wide and 100 metres long.

In the early period of mining at the Oro Denoro mine, 1903 to 1910, ore was drawn from a number of large stopes on two underground levels and five quarries. The two southernmost quarries, Nos. 1 and 2, were the principal source of copper ore. These are interconnected and have a general east-west elongation. The trend of the excavations follows the course of a number of large steeply dipping calcite lenses in the skarn by the granodiorite contact, which is near the north wall. Quarry No. 3, centred about 60 metres north of Nos. 1 and 2, is the second largest pit. Here mineralization was concentrated in a tongue of skarn projecting deep into the granodiorite mass. Quarries Nos. 4 and 5, centred about 45 metres northwest of No. 3, are relatively small. The magnetite-rich ore was situated between a small remnant of limestone in the skarn and the granodiorite. Control of the mineralization appears to have been east-west cross-fractures trending approximately perpendicular to bedding in the limestone host rocks.

The 1974 excavation, which is located immediately west and south of the old quarries, is an open pit that is 150 metres long and 45 metres wide; it is developed mainly in garnetite skarn at the summit of Oro Denoro's mine hill. The target of these workings was a mineralized zone near the south end of the pit.

The mine area is traversed by a number of faults that are significant ore-controls. The most important is a pronounced shear zone striking about 120 degrees that extends from the

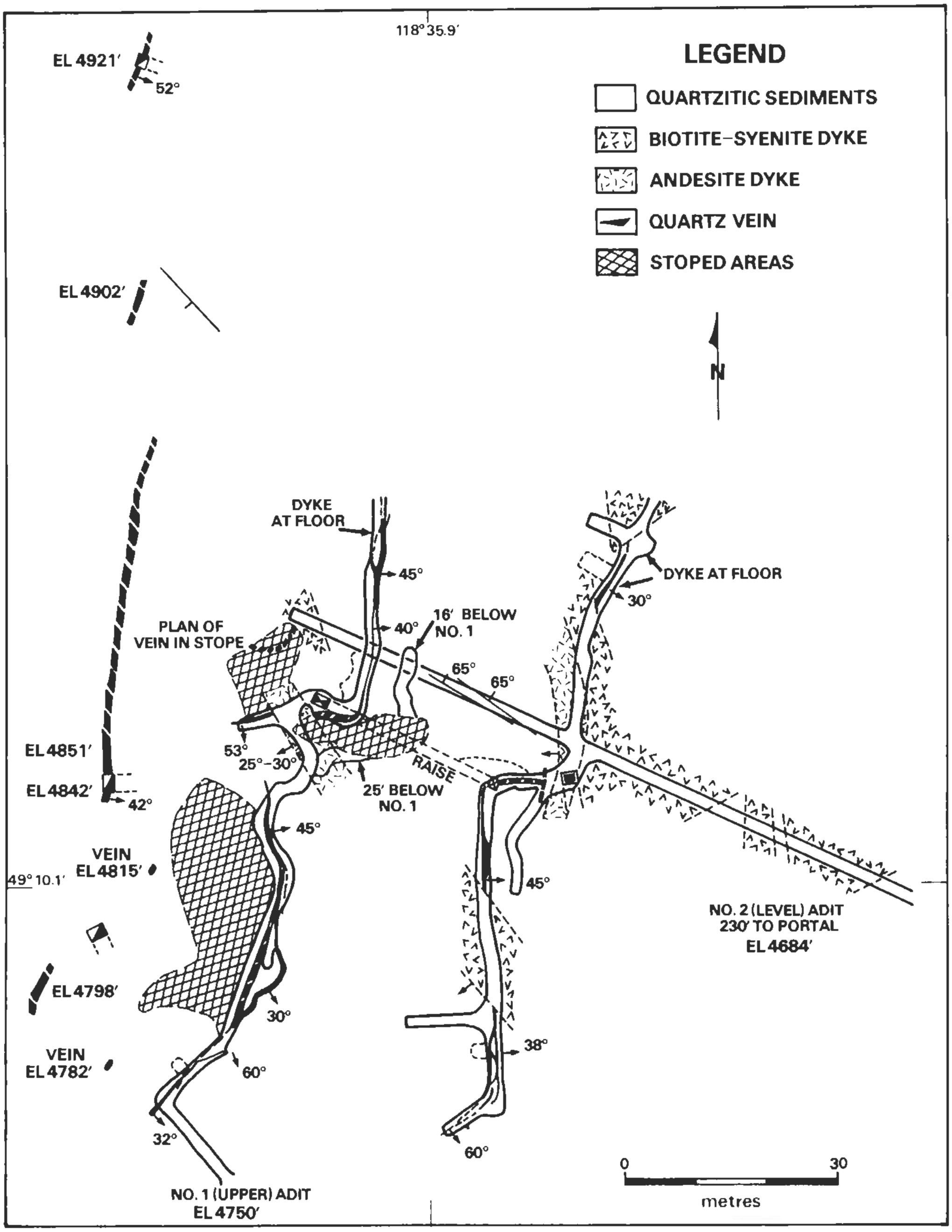

Figure 14. Plan of the North Star mine workings (after Hedley, 1936).

north end of the main pit and through No. 1 quarry. Important movement on this zone resulted in the emplacement of exotic formations in the skarn, such as a wedge of carbonaceous schist in the main pit and epidotized volcanic breccia along the south wall of No. 1 quarry. Of less importance are two minor faults dipping 80 degrees east and 75 degrees southeast which caused local displacements in the skarn-granodiorite contact and ore zone.

Ore reserves at Oro Denoro comprise, in part, sills and pillars in the old underground workings below the Granby pit. This mineralization is exposed in the lower adit level. According to old reports more than several hundred thousand tonnes of ore grading in excess of 0.5 per cent copper may still remain in the mine.

PHOENIX

(Lat. 49°, 05.6′; Long. 118°, 35.7′)

The several important mines of the area were developed around the old town of Phoenix which was centred on the claim of the same name located 6 kilometres east of Greenwood at the elevation of 1 370 metres (4,500 feet). Access to Phoenix is by paved road east from Greenwood and by an all-weather gravel road west from the Grand Forks section of Highway 3.

Mining in the Phoenix area was from four principal orebodies underlying (1) the Old Ironsides, Knob Hill, and Victoria claims (M.I. 082ESE020 and 021), (2) the Gold Drop, Rawhide, and Snowshoe claims (M.I. 082ESE025 and

Plate XIV. View of Oro Denoro open pit, looking south.

026), (3) the Brooklyn and Idaho claims (M.I. 082ESE013), and (4) the Stemwinder claim (M.I. 082ESE014).

Production to date from Phoenix is 26 956 525 tonnes of ore containing 30 225 kilograms of gold; 192 055 kilograms of silver; and 230 050 tonnes of copper. Most of this production was derived from the Old Ironsides, Knob Hill, and Victoria claims in the period 1900 to 1976. Also contributing to this total, 1 600 582 tonnes of ore was shipped from the Gold Drop mine up to the end of the operations in 1919, plus 855 464 tonnes from Snowshoe between 1900 and 1911, and 291 954 tonnes from the Brooklyn, Idaho, and Stemwinder operations between 1900 and 1949.

Systematic development on the Old Ironsides, Knob Hill, and Victoria claims began in 1895. The first ore, consisting of about 270 tonnes, was shipped in 1900. Under management of The Granby Consolidated Mining, Smelting and Power Co. an extensive system of tunnels and stopes was subsequently developed comprising three adit levels on the Old Ironsides and Knob Hill claims at the elevation of 1 440 metres (4,723 feet), 1 414 metres (4,640 feet), and 1 386 metres (4,548 feet) and five levels to the east on the Victoria and Aetna claims, serviced in part by the Victoria shaft, at the elevations of 1 451 metres (4,760 feet), 1 356 metres (4,446 feet), 1 334 metres (4,376 feet), 1 315 metres (4,314 feet), and 1 305 metres (4,281 feet). At the close of the first period of operations in June 1919, a total of 12 434 620 tonnes of ore had been mined from stoped areas exceeding 48 000 square metres in lateral extent, accessed by a 37-kilometre-long network of interconnected tunnels.

Renewed operations by Granby in 1959 began excavations which, by the final close of mining activity in 1976, resulted in removal of almost the entire old underground workings. This produced a large elliptical 425 by 800-metre pit from which 9 070 560 tonnes of residual low-grade ore was extracted (Fig. 16, *see* frontispiece).

According to LeRoy (1912, pp. 53, 55, and 78): "The extensive deposits of low grade copper ore, which have given rise to the important mining industry at Phoenix, occur in a mineralized area of the Brooklyn limestone which has all the characteristics of a zone of contact metamorphism. This zone is composed essentially of epidote and garnet, together with calcite, quartz, and chlorite" (*see* Plate XIX.) "The zone is considered to have been originally in great part limestone, which has been replaced metasomatically by lime silicates, chiefly epidote and garnet."

"The main ore body outcrops on the Knob Hill and Old Ironsides claims; in its downward and eastward extension it passes into the Victoria and Aetna claims. The body is composite in character and consists of two lenses which coalesce about their central portions. Along the outcrop, these lenses appear as two distinct bodies separated by a varying thickness of the gangue rocks. The western lens is at least 2,500 feet [750 metres] long, from 40 to 125 feet [12 to 38 metres] thick, and from 370 to over 900 feet [112 to over 275 metres] wide. The eastern lens is apparently not so long, but approaches the magnitude of the former in width and thickness. The combined thickness of the two at their point of junction is about 187 feet [57 metres]. In its southern extension this composite ore body appears to break up into subor-

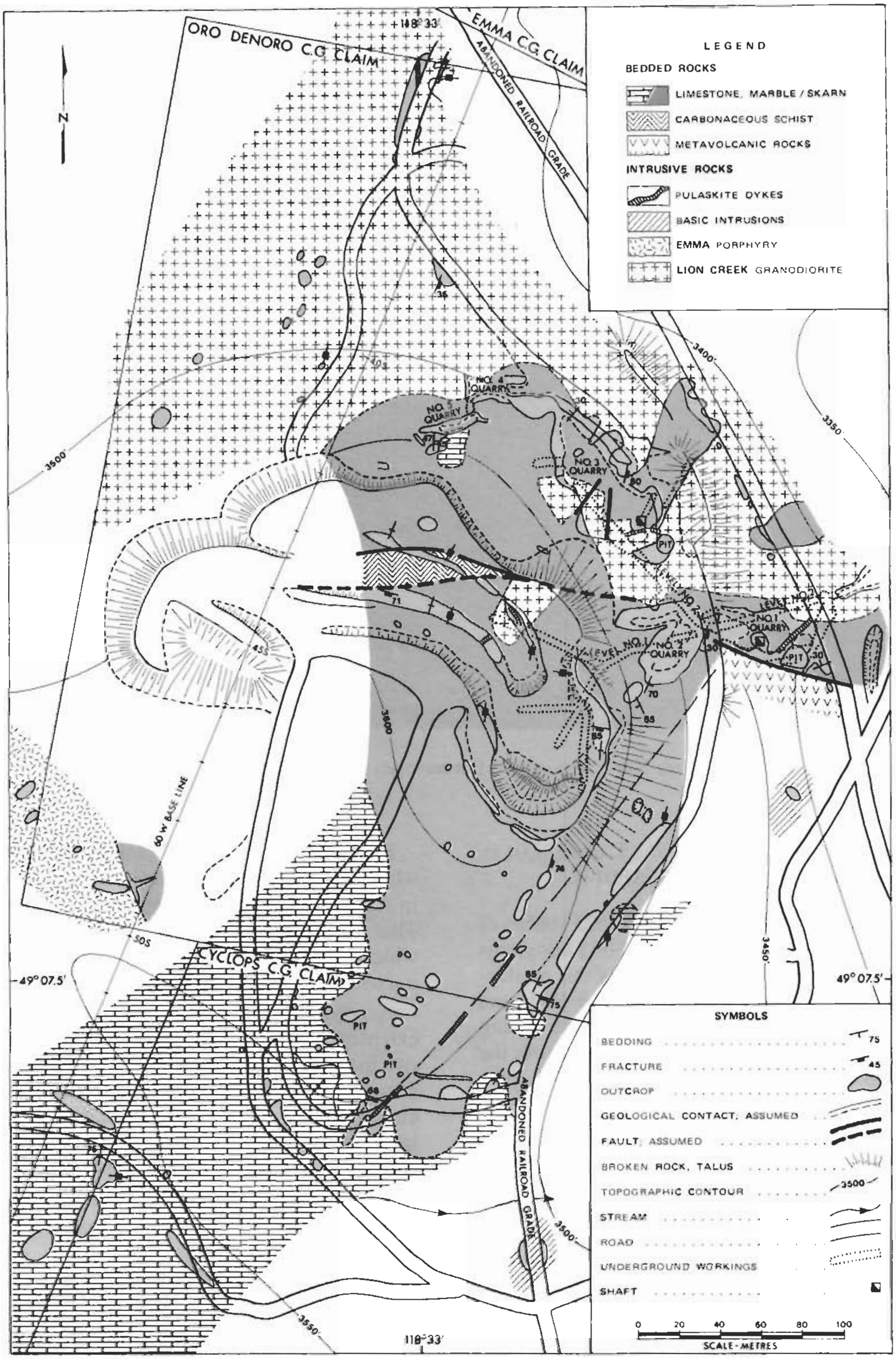

Figure 15. Detailed geology in vicinity of the Oro Denoro mine (after Church, 1976).

dinate ribs or wedges of ore, separated by complimentary ribs of almost barren gangue rock, and a similar condition also appears to occur to the east of the main ore body, where a rather flat lying zone, consisting in part of pay ore, has been found on about the same level as No. 3 tunnel. The general strike of the outcrop of the ore body is N. 10° E., with dips to the east ranging from 45 to 60 degrees. The dip flattens with depth and on the lower levels averages from 15 to 30 degrees."

A downfaulted block of Tertiary rock, viewed in the 1 000-metre-long Victoria to Gold Drop tunnel at elevation 1 450 metres (4,760 feet), separates the east side of the Phoenix pit from an eastern extension of the Old Ironsides-Knob Hill skarn zone (*see* Fig. 16).

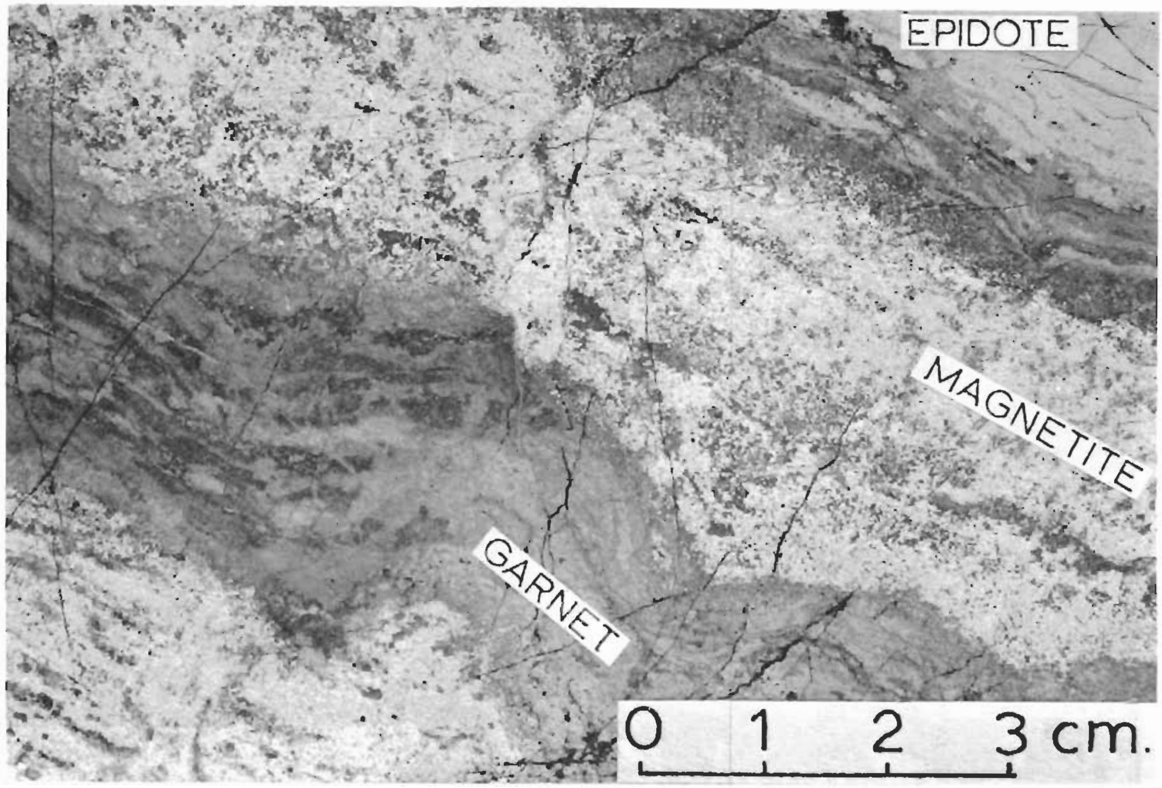

Plate XV. Oro Denoro, banded garnet-magnetite-epidote skarn.

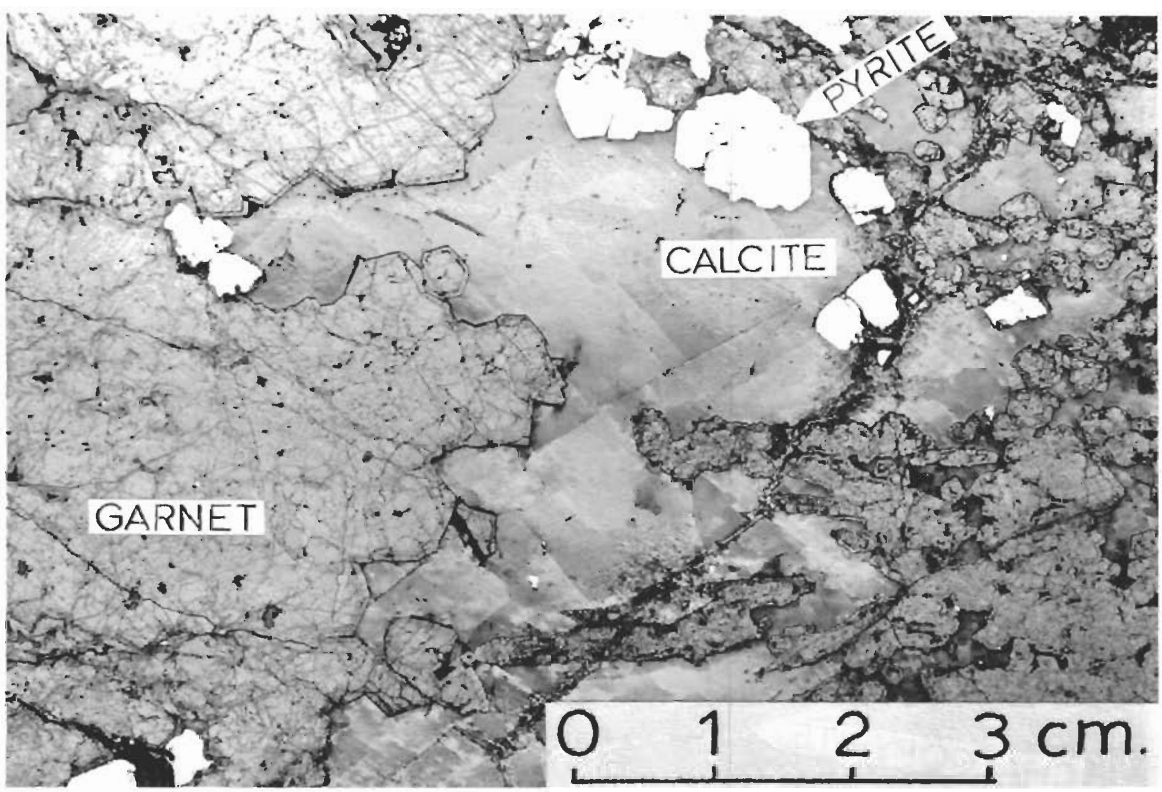

Plate XVI. Oro Denoro, garnetite with calcite and pyrite filling.

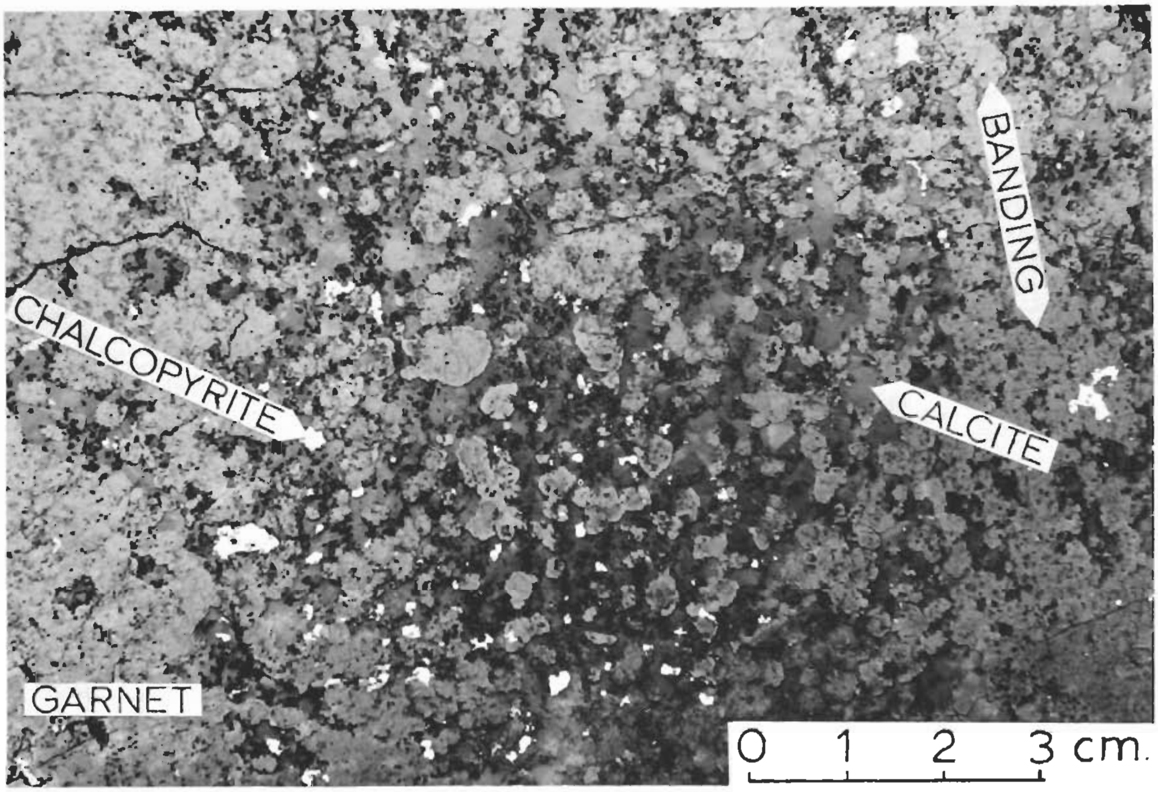

Plate XVII. Oro Denoro, garnetite with relic carbonate-rich bands and disseminated pyrite and chalcopyrite.

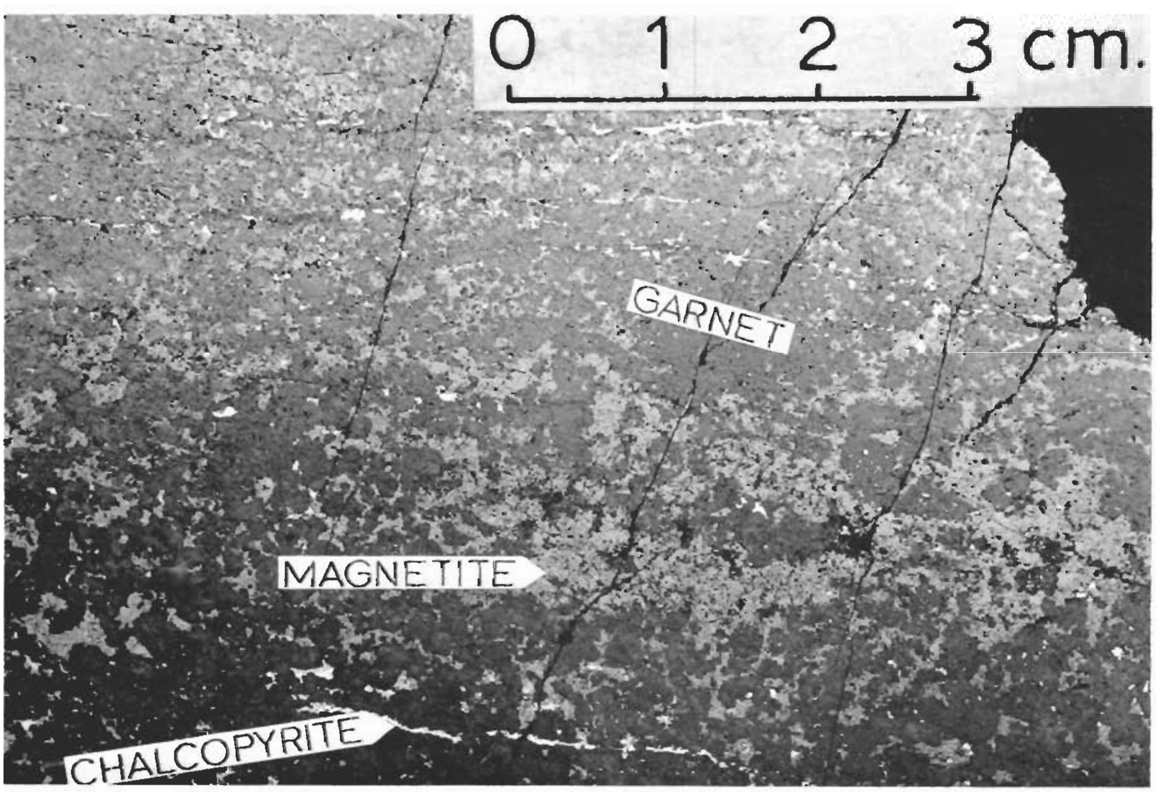

Plate XVIII. Oro Denoro, magnetite-rich garnetite with pyrite and chalcopyrite on cracks.

According to LeRoy (1912, pp. 81 and 82): "The Gold Drop mine develops only part of an extensive and practically continuous ore body, which outcrops on the Gold Drop claim, swings down and across the Rawhide and Curlew, and terminates on the Snowshoe claim. The whole, when broadly viewed, has, on a horizontal plan, the form of a compressed crescent with northward trending horns, broken by the occurrence of the detached ore body of the Gold Drop No. 1 and the north body of the Snowshoe. The ore body rests on a floor of jasperoids [unit 7], and in the Gold Drop proper there is an entire absence of Tertiary intrusives, or remnants of the Brooklyn limestone. The ore body of the Gold Drop proper is developed in the southeast part of the Gold Drop, and the northeast part of the Monarch claim. The strike varies from N. 13° E. to N. 32° E., with an easterly dip, which averages about 40 degrees, but flattens to about 25 degrees below the level of the Monarch drift."

"The known length of the ore body along the strike of the Monarch drift is over 750 feet [320 metres], and its width to the boundary of the claim is about 315 feet [96 metres]. The thickness probably averages about 30 feet [9 metres], the diamond drill logs showing a range from 7 to 55 feet [2 to 17 metres]."

The Rawhide mine develops the continuation of the Gold Drop-Monarch orebody. The mine workings, underlying about 3 hectares on the western part of the Rawhide claim, consist of several large stopes and glory holes accessed by approximately 1 400 metres of tunnelling on seven levels. The orebody, which attains a maximum thickness of 23 metres near the northwest boundary of the claim, rests on Brooklyn sharpstone conglomerate beds dipping 13 to 25 degrees north and northeast.

The Snowshoe mine consists of two main mineralized zones worked to a depth of about 65 metres. Development to the end of operations in 1911 included several open cuts, glory holes, two shafts, and a series of stopes accessed by 3 000 metres of tunnelling. Surface excavations, including a 70 by 120-metre pit, completed between 1957 and 1964, resulted in the production of about 270 000 tonnes of low-grade ore from the southern part of the claim.

LeRoy (1912, pp. 87 to 89) reports on the Snowshoe mine: "The south ore body is a continuation of the one developed in the Curlew, Rawhide, and Gold Drop mines. It is broadly considered as one ore body, though bands, wedges, and ribs of slightly mineralized gangue rock break its continuity. These are removed or left in the stopes depending on their size and structure. Along the Snowshoe-Curlew boundary the foot wall dips north at about 40°. To the west it then has a curving strike to the north with easterly dips ranging from 30° to 65°. North of the main shaft at the first cross-cut, the strike is northeasterly with southeast dips from 40° to 50°. In its downward extension, the ore body apparently swings to the northeast, which brings it adjacent to, or in contact with the north ore body. The north and south axis of the ore body is about 580 feet long [180 metres], and the east and west axis is about 270 feet long [80 metres]. The thickness of the ore according to the cross sections varies from 26 to 35 feet [8 to 11 metres] with occasional local swells giving a greater thickness over small areas."

"The foot wall rocks are jasperoids, tuffs, red and grey argillites with local patches of quartzose crystalline limestone. The hanging wall consists of the garnet and epidote rocks of the mineralized zone into which the ore either insensibly fades, or from which it is separated by a gouge filled fissure (slip). The ore body in depth terminates abruptly against the quartzose rocks of the Knob Hill group, on the plane of a presumably pre-mineral fault or contact plane, which dips west at from 15° to 38°. The ore body throughout is cut by numerous fissures which in places have a marked influence on the character of the ore, and which were the main channels of circulation of the ore bearing solutions. Many of these have been filled during the closing stages of deposition with quartz, calcite, chalcopyrite, and pyrite in banded arrangement".

"The north ore body was probably at one time connected surficially with both the South Snowshoe and Gold Drop No. 1 bodies, but has been separated by subsequent erosion."

"From the mine plans and sections the main part of the north ore body has a length north and south of 370 feet [110 metres] on the surface, a width ranging from 110 to 150 feet [34 to 46 metres], and is from 8 to 55 feet [2 to 17 metres] thick, the average being about 35 feet [11 metres]. The dip of the foot-wall varies from 18 to 56 degrees to the east. A fault dipping west at 12 degrees cuts the ore off. To the north this fault steepens to 47 degrees and with a displacement of about 40 feet [12 metres] brings the lower part of the ore body to the surface. The ore at this point lies on a dyke of augite porphyrite which has been intruded along the foot-wall. In its northern extension, the strike of the ore body swings to the northeast and the jasperoid foot wall gives place to the quartzose rocks of the Knob Hill group. The dip is to the southeast from 22 to 65 degrees, averaging about 45 degrees. The ore in this portion of the body was of higher grade than the average mined in the camp, particularly in the copper content."

The Brooklyn and Idaho mines are situated on a mineralized zone crossing the valley of Twin Creek approximately 700 metres northwest of the Phoenix pit. LeRoy reports (1912, p. 56): "The zone is an elongated pear shaped form, broad and shallow at the south, narrowing and becoming steeper to the north until it is enclosed by almost vertical walls of limestone, as shown by those of the Brooklyn 'glory hole', or of jasperoids to the east, and limestone to the west. The floor is mainly limestone with some jasperoid in the southern part. The length is about 1,850 feet [564 metres], and the width varies from about 400 feet [122 metres] in the south to less than 50 feet [15 metres] in the extreme north."

The Brooklyn mine, at the north end of the mineralized zone, was developed from two glory holes at surface and a number of underground stopes, serviced by a 130-metre inclined shaft with working levels at 24, 46, 76, 91, and 106 metres. The total recorded ore production is 258 290 tonnes, which includes the two main periods of operation from 1900 to 1908 and 1937 to 1940.

The Idaho mine, at the south end of the mineralized zone, includes an inclined shaft and two levels, the deepest of which connects with the 76-metre level of the Brooklyn mine. A total of approximately 2 300 metres of tunnelling was completed at the Brooklyn and Idaho mines by the first closing of operations in 1908. In the period 1963 to 1964 open-pit excavations in a 75 by 150-metre area near the Idaho shaft yielded an additional 130 000 tonnes of ore. Subsequently the area became the main tailings pond for the Phoenix mine.

The Stemwinder mine is 300 metres east of the Brooklyn and Idaho workings and 500 metres north of the Phoenix pit. Production from the Stemwinder began with a trial shipment of 4.5 tonnes of ore in 1895, 7 years after the claim was first located by prospectors. Intermittent production between 1900 and 1949 yielded 32 014 tonnes of ore from workings consisting of an open stope and glory hole connected to 450 metres of tunnelling on two levels, at 32 and 61 metres depth, serviced by an inclined shaft and two portals. These workings were the focus of later excavations, in the period 1964 to 1976, which produced a 55 by 146-metre open pit from which 73 322 tonnes of ore was supplied to the Phoenix mill. A total of 718 475 tonnes of waste rock from this operation aided in the construction of tailings pond and water reclamation site in the vicinity of the Idaho workings.

The geology of the area around the Brooklyn and Stemwinder mines has been described by White (1950, pp. 152 and 153): "The most widespread rock in this part of the Phoenix camp is a peculiar aggregate of subangular to subrounded fragments of white, red, and green chert; various types of volcanic and coarse grained granitic rocks; and, occasionally, finely crystalline limestone. The rock may be called chert breccia. It is one type of cherty material included in LeRoy's 'zone of jasperoids'. Two northerly trending, curved, lenticular bodies of another peculiar rock, which will be referred to as a limestone breccia, occur near and in the Stemwinder mine. It consists of subangular fragments of greyish white finely crystalline limestone ranging in size from half an inch to 6 inches, together with a few smaller fragments of chert, set in a fine-grained matrix of carbonate, chlorite, quartz, and clay minerals. Where faults are absent, the contact with the chert breccia is abrupt rather than gradational. Westward, near the Brooklyn mine, the chert breccia is in sharp contact along a northerly trending line with finely crystalline, thin-bedded, siliceous or argillaceous limestone. The distinct and regular bedding of the latter strikes north and dips 75 to 80 degrees eastward. Although the bedded limestone is more than 1,000 feet thick on the north side of Twin Creek, it appears to be absent a short distance to the south, on the opposite side of the drift-filled valley bottom."

"In the old part of the Stemwinder mine, faults are the most conspicuous feature. Two important fault sets strike variably west of north. Faults of one set dip moderately to steeply east, and faults of the other set dip 25 to 40 degrees westward. Faults of a third set appear to cut those of the other two sets. The third set strikes northeasterly and dips moderately or steeply to the northwest or to the southeast. They are characterized by much gouge and by fluting that is close to horizontal. Although on the surface the limestone breccia body appears to be fairly continuous, in the workings it is found to be cut into isolated blocks by the numerous faults. The blocks, ranging in size from a few feet to a few tens of feet, are in fault contact with chert breccia on all sides. On No. 1 level the segmentation occurs in a northerly trending belt roughly 200 feet [60 metres] wide. This belt is bounded on the west, almost directly below the glory hole, by a fault, beyond which the rock is all chert breccia."

"All of the ore of the old part of the Stemwinder mine occurs in this belt. The orebodies are fault blocks of limestone breccia which have been partly recrystallized as coarse grained grey calcite containing irregular veinlets and larger masses of chalcopyrite and pyrite. Usually the mineralization ends at the faults bounding the limestone breccia blocks, but in a few places the chert breccia for a few feet beyond such a fault is brecciated and moderately well mineralized. The ore is striking different to that of the Brooklyn mine. It contains no garnet or other lime silicate gangue minerals, no specularlite, and no quartz. However, it is similar to the Brooklyn ore in its virtual restriction to carbonate rocks and in its relation to faults which may well be pre-ore in age. The orebody mined in the Stemwinder glory hole was a block of mineralized limestone breccia bounded on both sides and below by faults. The lower bounding fault dips 25 degrees westward and contains a thin sheet of pulaskite porphyry. The intensity of the mineralization of the limestone breccia shows a marked increase near this fault."

Ore reserves of the Phoenix mine on December 31, 1974, were estimated to be 3 429 440 tonnes grading better than 0.40 per cent copper (*B.C. Ministry of Energy, Mines & Pet. Res.*, G.E.M., 1974, p. 35). Production from this date to end of operations on October 4, 1978, totalled 2 741 607 tonnes (*B.C. Ministry of Energy, Mines & Pet. Res.*, Mining in B.C., 1975-1980, Vol. 1, p. 10). Accordingly, it appears that several hundred thousand tonnes of submarginal ore remains.

Remaining mineralization can be seen locally on some oversteepened benches, such as are found in the upper southwest walls of the Phoenix pit (Plate XIX). Also, it is anticipated that mineralized zones may occur in the Brooklyn beds in the area covered by Tertiary rocks immediately east of the pit, including unworked pillars in the Gold Drop and Monarch mines.

PROVIDENCE

(Lat. 49°, 06.6′; Long. 118°, 40′; M.I. 082ESE001)

The Providence mine is situated immediately north of Providence Creek, 2.5 kilometres north of the Greenwood post office. A short access road, along the north boundary of Greenwood municipality, connects the mine directly to Highway 3, located 0.5 kilometre to the west.

The mine operated intermittently from 1893 to 1973 with the periods 1903 to 1920 and 1940 to 1945 being most productive. A total of 10 476 tonnes of ore has been mined yielding 183 kilograms of gold, 42 552 kilograms of silver, 183 tonnes of lead, and 260 tonnes of zinc.

The mine workings consist of about 3 000 metres of development on seven levels serviced by two main shafts (Fig. 17). The old shaft (No. 1), located 140 metres north of Providence Creek, gives access to the upper four levels to a depth of about 70 metres.

This, in combination with a winze on the fourth level, services the lower levels. Shaft No. 2 is 100 metres north of Providence Creek and 140 metres southwest of No. 1 shaft. Drifts from both shafts join on the third and fourth levels. Shaft No. 3, located 45 metres north of No. 1, is an inclined

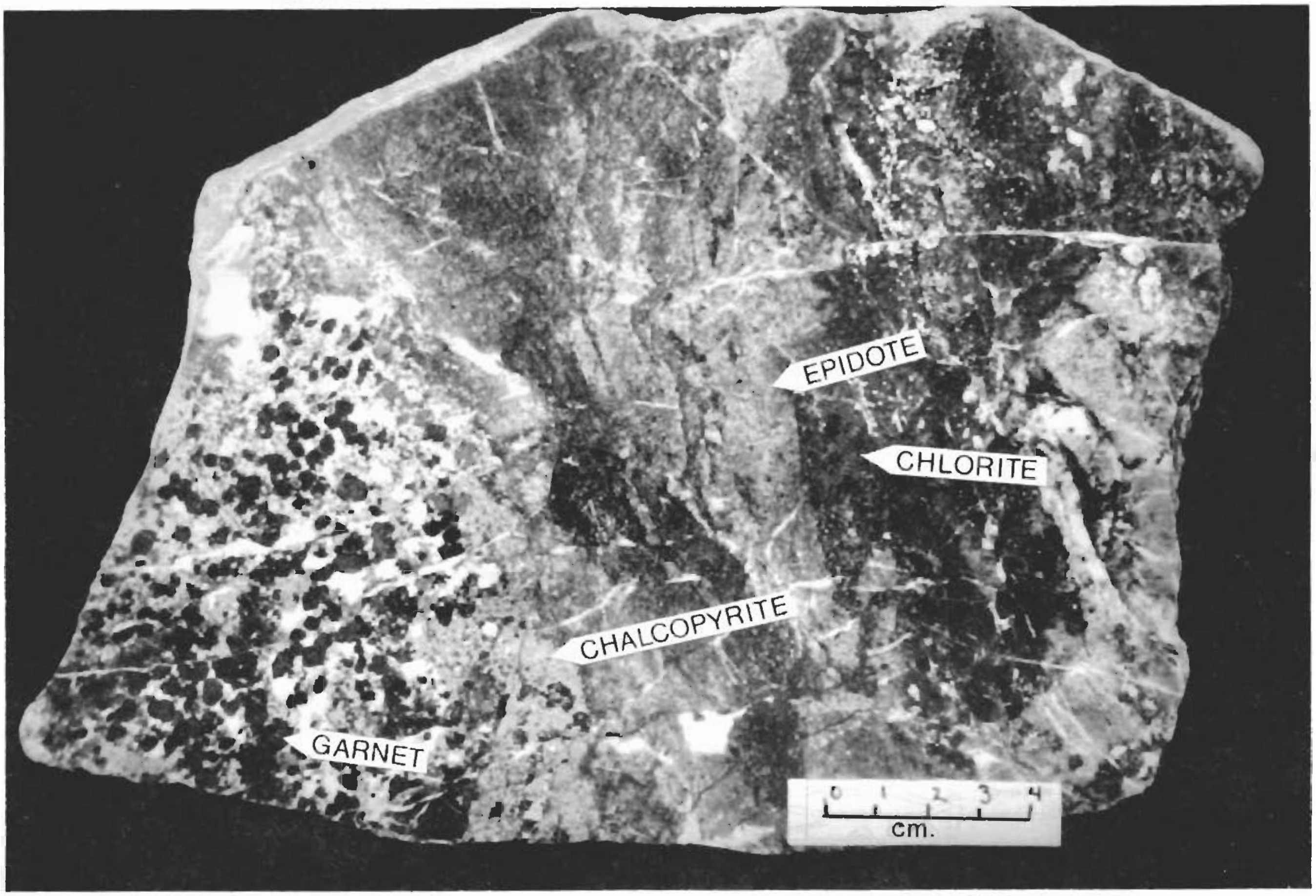

Plate XIX. Phoenix, garnet-epidote skarn hosting pyrite-chalcopyrite mineralization.

exploratory working about 25 metres deep, located 30 metres north of No. 1 shaft.

The Providence claim is almost entirely underlain at surface by greenish grey quartz chlorite schists of the Knob Hill Group; it lies at the northern boundary of the Greenwood granodiorite stock. The schists dip 30 to 70 degrees northeast and are cut by a northeast-trending Tertiary alkali feldspar porphyry dyke, which is exposed between the two main shafts. The granodiorite is encountered in the southwest part of the mine below the fifth level.

The workings mostly follow ore shoots within a narrow quartz vein. The ore minerals consist of pyrite, galena, sphalerite, chalcopyrite, tetrahedrite, proustite, native silver, and free gold in quartz carbonate gangue.

According to McNaughton (1945, p. 21): "Ore shoots occur within the quartz vein that strikes north 50 degrees east and dips 40 to 65 degrees southeast. It has been traced underground for more than 1,200 feet [370 metres], and ranges from a fraction of an inch to 2½ feet [0.75 metre] in width. Unbroken quartz rarely extends from wall to wall, and more commonly strands of quartz are separated by thin, lenticular bands of altered country rock. The vein is irregular in size and attitude on the lower levels. In a few places these changes can be correlated with the passage of the vein from one rock to another. Thus, in the northeast part of the fourth level, the vein pinches to a gouge-filled fissure on passing from the relatively hard silicified rocks to soft chloritic schists. On the No. 5 level the vein appears to be more persistent in the silicified rocks than in the granodiorite."

"Faults of at least two ages displace the mineral-bearing fissure. The older group, which is pre-mineral in age, strikes north 30 to 50 degrees east and dips gently northwest. Local reversals of dip were seen along several low-angle faults, and rolls in the fault plane were noted in every case where an individual fault could be traced for any distance. In each case the hanging-wall has moved down with reference to the foot-wall, thus indicating normal faulting. Offsets along these faults range from a few feet to 80 feet [24 metres]. The maximum offset was measured along a fault that is now occupied by a post-mineral feldspar porphyry dyke."

"Veins are in places slightly enlarged where they intersect these pre-mineral faults, and at other places narrow quartz stringers may follow the fault plane. The younger group of faults strikes north 30 degrees west to north 10 degrees east and dips at high angles. Displacements along these faults are small. They are post-mineral and offset the vein as well as the older group of faults."

There are no known published ore reserves for this mine.

REPUBLIC, NONSUCH, LAST CHANCE

(Lat. 49°, 03.6′; Long. 118°, 42.4′; M.I. 082ESE174)

This property, also known as the Skomac mine and currently operated by Robert Mines Ltd., is centred on a treeless south-facing hillside at elevation 900 metres (3,000 feet), 4

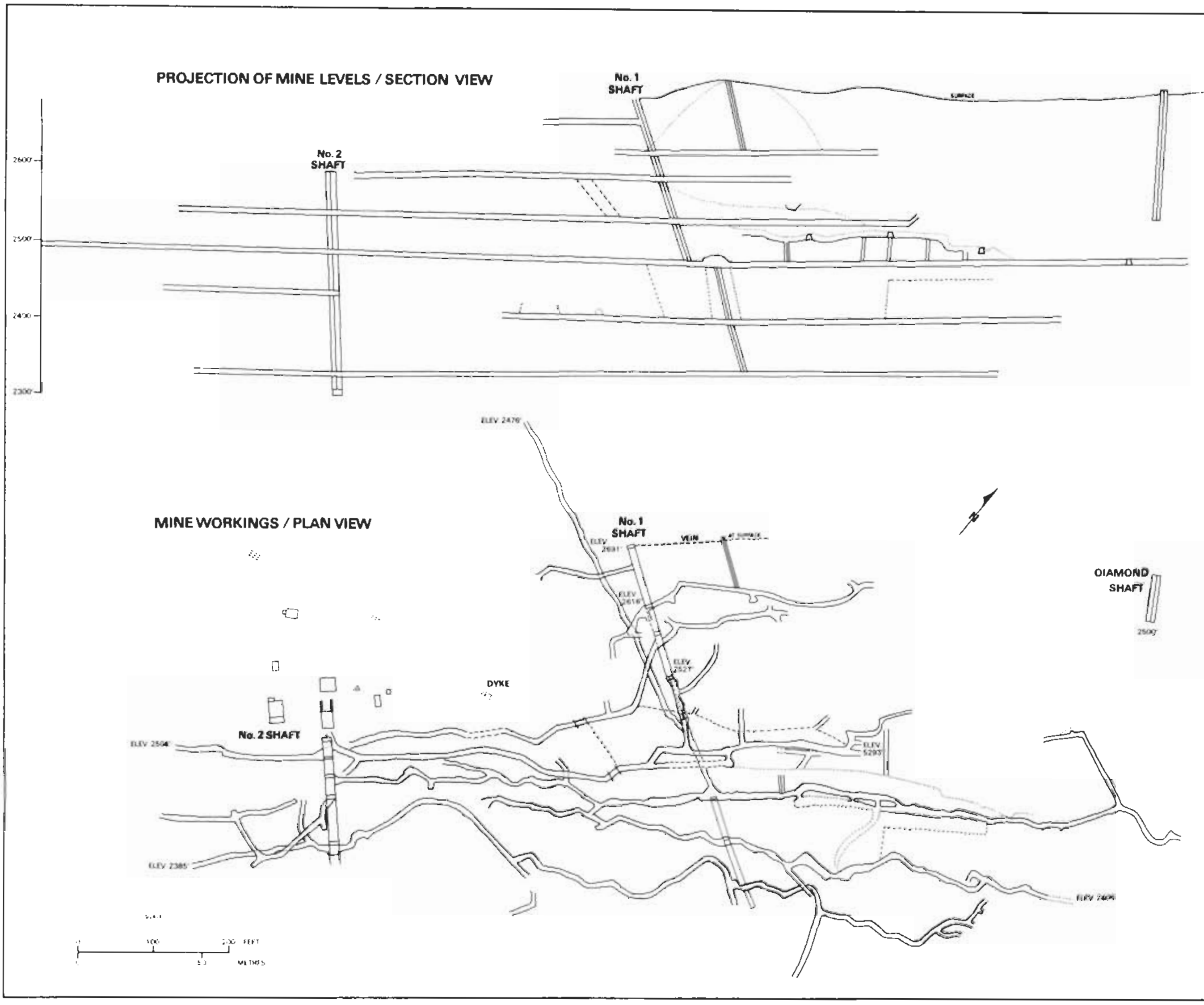

Figure 17. Composite plan of the underground working of the Providence mine (after Rigel Mines Ltd., 1937).

kilometres southwest of Greenwood. Access to the mine is by 3 kilometres of dirt road that leads north from Highway 3 near Boundary Falls.

Production from this property was intermittent in the period 1904 to 1937 and brief from 1962 to 1964 and 1975 through 1976. The total ore produced amounted to 2 513 tonnes having 21 kilograms of gold, 3 709 kilograms of silver, 50 tonnes of lead, and 26 tonnes of zinc.

The first mine development began in the period 1894 to 1896 when a number of adits and shafts were worked (Fig. 18). According to the Annual Report of the Minister of Mines (1922, p. N175): "The former company drove two tunnels, one approximately 75 feet [23 metres] higher than the other; the upper one extending 398 feet [121 metres] on the vein and the lower one 226 feet [69 metres], chiefly on the vein, with a crosscut from this tunnel a distance of 67 feet [20 metres]. An upraise was put in between the upper tunnel and surface 65 feet [20 metres] in height. In the upper tunnel the vein is persistent, but varied from 14 inches to 6 feet [0.35 to 1.8 metres] in width, and contained iron sulphides carrying gold and silver. The gangue is quartz with oxides of iron in the fractures."

"Numerous open cuts and shallow shafts have been excavated on the same lead higher up the hill on the Non Such claim, with about the same results. On the Last Chance claim, which adjoins the Non Such on the north-west, an inclined shaft was sunk, as far as could be ascertained, about 75 feet [23 metres] on the extension of the Non Such vein."

"About 25 feet [8 metres] below the collar of the shaft the lead is split in three veins interbedded in the slate. The vein on the hanging wall is 8 inches [20 centimetres] wide, the one in the centre 1 foot 6 inches [0.45 metre], and on the foot wall 2 feet 2 inches [0.66 metre] wide. The ore-minerals are galena, chalcopyrite, and iron pyrites in a gangue of quartz."

"Another drift had been run about 20 feet [6 metres] below the upper one to the west and the two drifts connected by a raise. At the end of the lower tunnel the vein had faulted to the south and had not been found again. The vein in this tunnel measures 30 inches [76 centimetres] across in the widest part and is well mineralized in galena, chalcopyrite, and pyrite containing gold and silver."

The present mine development consists of approximately 900 metres of tunnelling on 7 adit levels and a concentrator with a 90-tonne-per-day capacity (Fig. 19).

The minesite is situated near the base of a diorite bluff between elevations 850 and 1 000 metres (2,250 and 3,260 feet) (Plate XX). The upper levels of the mine are almost entirely within the black phyllitic argillite formation of the Attwood Group. The lowest two levels follow a sheared ultrabasic intrusion occupying the contact between argillites and the large diorite body to the north.

The several quartz veins in the mine were emplaced on closely spaced *en echelon* fractures dipping about 50 degrees northeast along a total strike length of about 180 metres (Plate XXI). An important set of younger cross-fractures strikes 020 to 040 degrees, a direction on which there has been intrusion of Tertiary dykes and some faulting of the veins.

The vein structures are thought to have originated when regional shearing stress was deflected into and taken up by the incompetent formations along the diorite contact. The ore shoots appear to be aligned gash structures, striking 015 and plunging 40 degrees northerly — almost at right angles to the principal shear direction.

The ore reserves of this mine based on geological projections suggest a potential of several tens of thousands of tonnes grading more than 3 grams per tonne gold, 250 grams per tonne silver, 1 per cent lead, and 1 per cent zinc.

SAPPHO

(Lat. 49°, 00.25′; Long. 118°, 42.33′; M.I. 082ESE147)

The Sappho claim, at 1 040 metres (3,400 feet) elevation, is centred 9.6 kilometres south of Greenwood and 0.6 kilometre north of the International Boundary. The property is 2.7 kilometres along a winding dirt road southeast of the Norwegian Creek road.

Production from this property was recorded from 1916 to 1918. This amounted to 102 tonnes of ore containing 6.1 kilograms of silver and 13.6 tonnes of copper.

The old workings consist mostly of a cluster of pits and shafts in the central part of the claim. In 1927 a short adit was driven south to intersect the same mineralization at depth (Fig. 20). A grab sample of ore taken from one of the pits assayed 3.2 per cent copper and 0.9 ppm platinum.

More recent work on Sappho was completed in the periods 1963 to 1964, in 1967, and from 1975 to 1978. This included bulldozer trenching, diamond drilling, and geophysical surveys across the areas of previous development in the central and northeast part of the claim.

The principal rock types underlying the claim are a microdiorite intrusion, exposed in the central area and southeast corner of the claim, and younger crosscutting Coryell syenomonzonite and shonkinite intrusions. Greenstones of un-

Plate XX. Panorama of the Skomac minesite, looking northerly at the main portals (numbered).

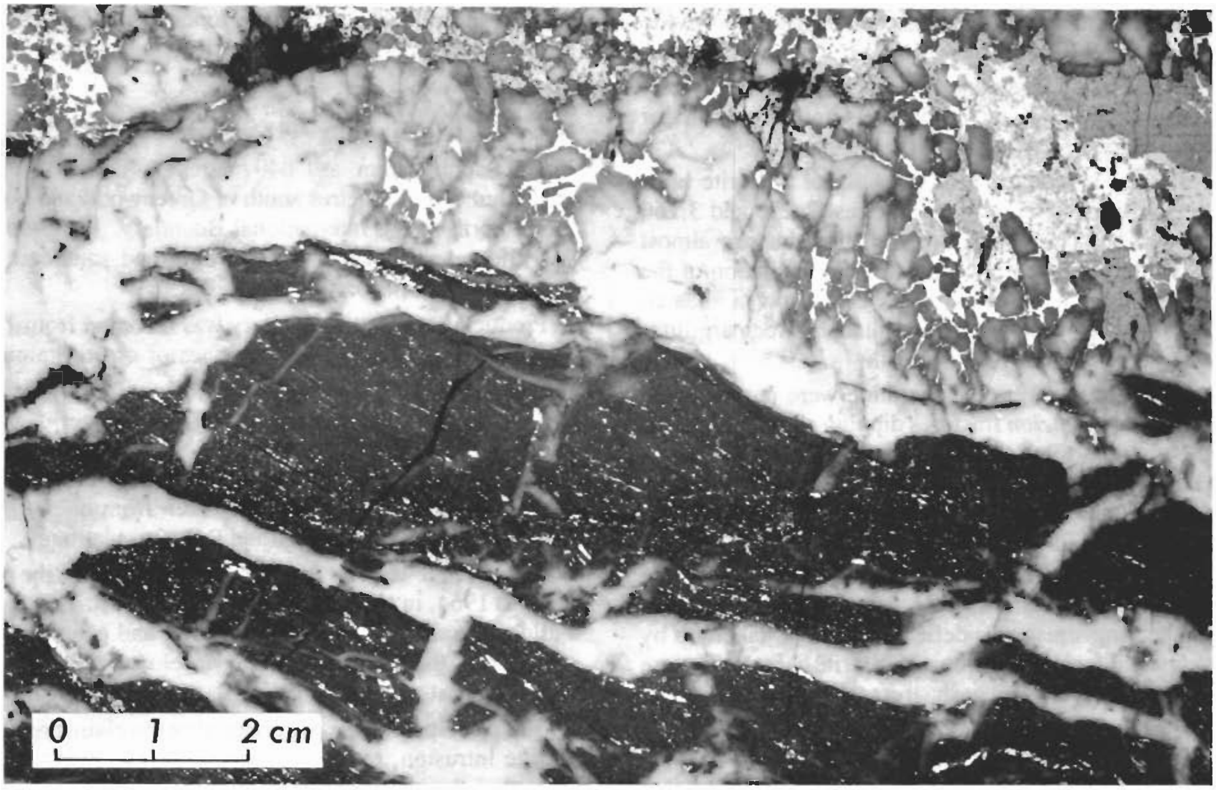

Plate XXI. Polished section of Skomac quartz vein, showing pyrite and galena (bright), tetrahedrite (medium grey), and sphalerite (dark grey).

certain age hosting these intrusions are well exposed near the east boundary of the claim and in the south-central area.

Mineralization consists mostly of pyrite and chalcopyrite disseminations in shears, and blebs and pods of the same minerals in biotite shonkinite and sericitized feldspathic pegmatoid phases of the Coryell intrusion. Sulphides are also found locally in skarns of epidote, chlorite, garnet, and magnetite near intrusive contacts.

There are no ore reserve estimates for this property.

STRATHMORE

(Lat. 49°, 06.2'; Long. 118°, 40'; M.I. 082ESE215)

The Strathmore claim is centred 1.7 kilometres northeast of the Greenwood post office and 0.5 kilometre east of Highway 3 at 910 metres (3,000 feet) elevation. Access is directly from Greenwood municipality which lies immediately to the west.

Production from this property between 1898 and 1925 amounted to 198 tonnes of ore containing 4.8 kilograms of gold, 533 kilograms of silver, and 4.1 tonnes of lead.

According to the Annual Report of the Minister of Mines (1924, p. B167): "Development-work consisted of 300 feet [91 metres] of drifting, a 40-foot [12-metre] shaft, and 45 feet [14 metres] of open-cutting and trenching. The property was mined about twenty five years ago and some ore shipped. Since that time but little has been done until the present syndicate took over the mine."

"The old workings consist of a tunnel and shaft and several drifts on the vein, as well as crosscuts. The vein varies in size from 1 inch to 1 foot [2.5 centimetres to 0.3 metre] and is mineralized with galena, iron pyrites, zinc, gold, and silver in a gangue of quartz. The country-rock is granite and diorite."

"A few feet to the north of the old workings the vein has been faulted in an easterly direction, throwing it up the hill. The ore lying to the north of the fault was discovered and is being mined by the present owners. After the upper part of the vein was stoped out a crosscut was driven below to develop the vein at a greater depth."

"Considerable difficulty was experienced owing to the lead being pinched to such an extent that it was unrecognizable and there being several other mineralized fissures."

"After crosscutting for about 60 feet [18 metres] to the east the owners decided to follow the first vein cut. The fracture opened into an ore-shoot at about 100 feet [30 metres] from the crosscut. As there is ore in the bottom of the drift, it seems likely that another lift will be taken on the vein mined by driving an upraise from the old workings."

"The ore carries from 0.23 to 1.82 oz. [7 to 57 grams] gold, from 128.4 to 176.4 oz. [4 to 5.5 kilograms] silver to the ton [tonne], and from 1.95 to 7.15 per cent. lead."

According to Galloway (1927, p. 42) a 915-metre (3,000-foot) tunnel (known as the Greenwood-Phoenix Tramway Bore) was driven eastward under the Strathmore claim from the Nelson claim in the period 1909 to 1913. A vein was cut 518 metres (1,700 feet) from the portal which was undoubtedly the Strathmore vein, although it was further into the hill than expected.

No work has been completed on the property in recent years and there is no indication of any ore reserves.

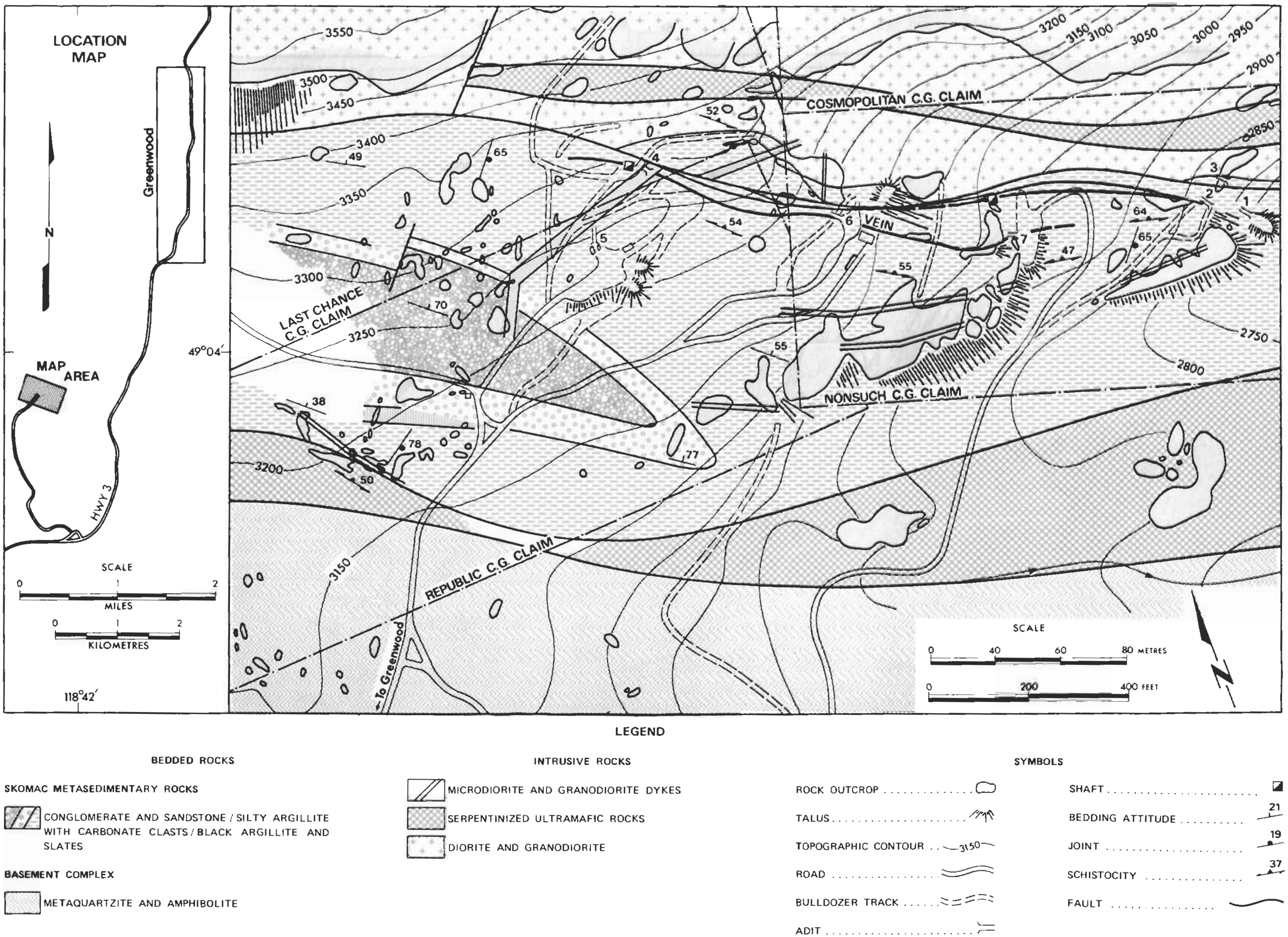

Figure 18. Detailed geology in vicinity of the Skomac mine (after Church, 1983).

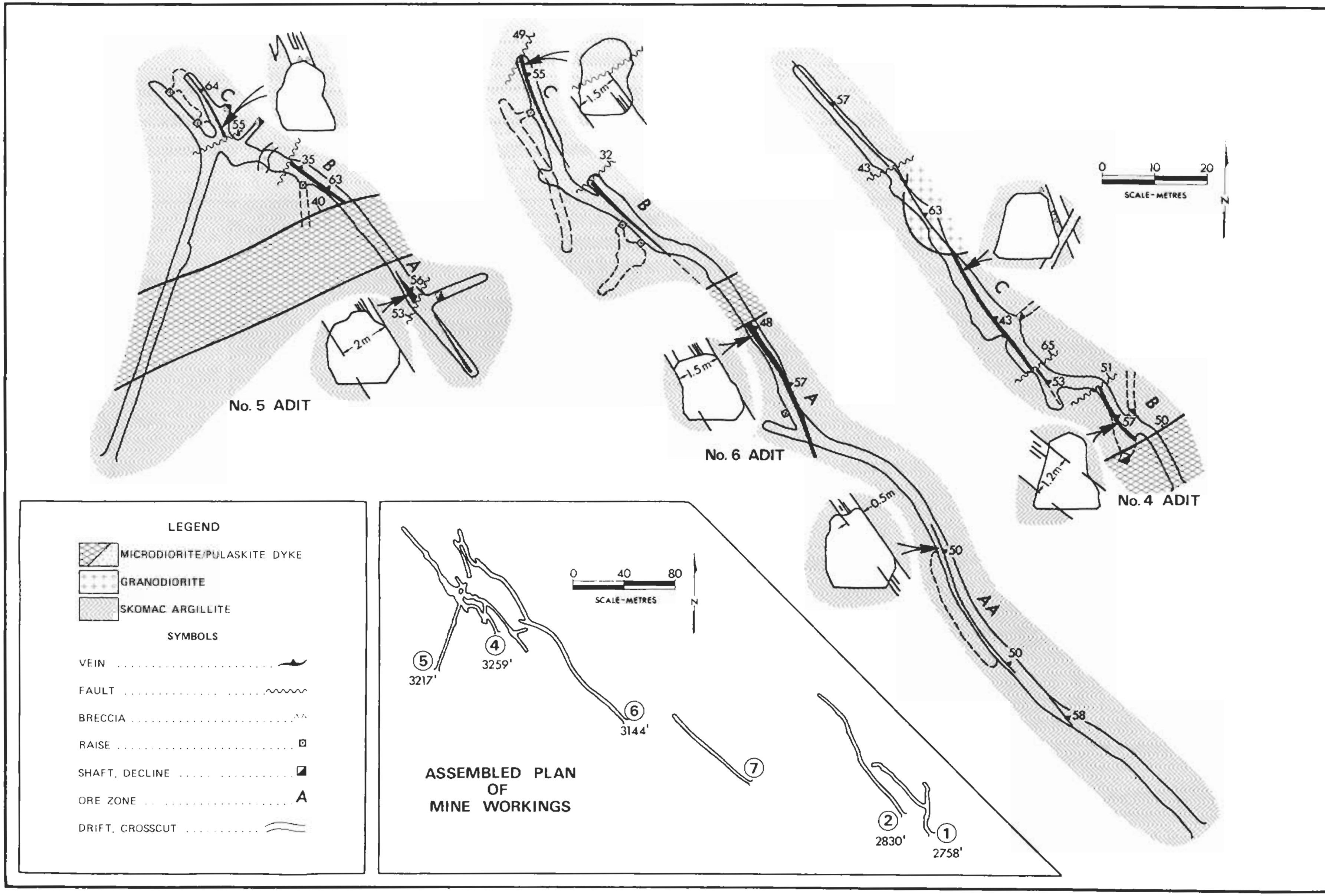

Figure 19. Underground geology of the Skomac mine (after Church, 1983).

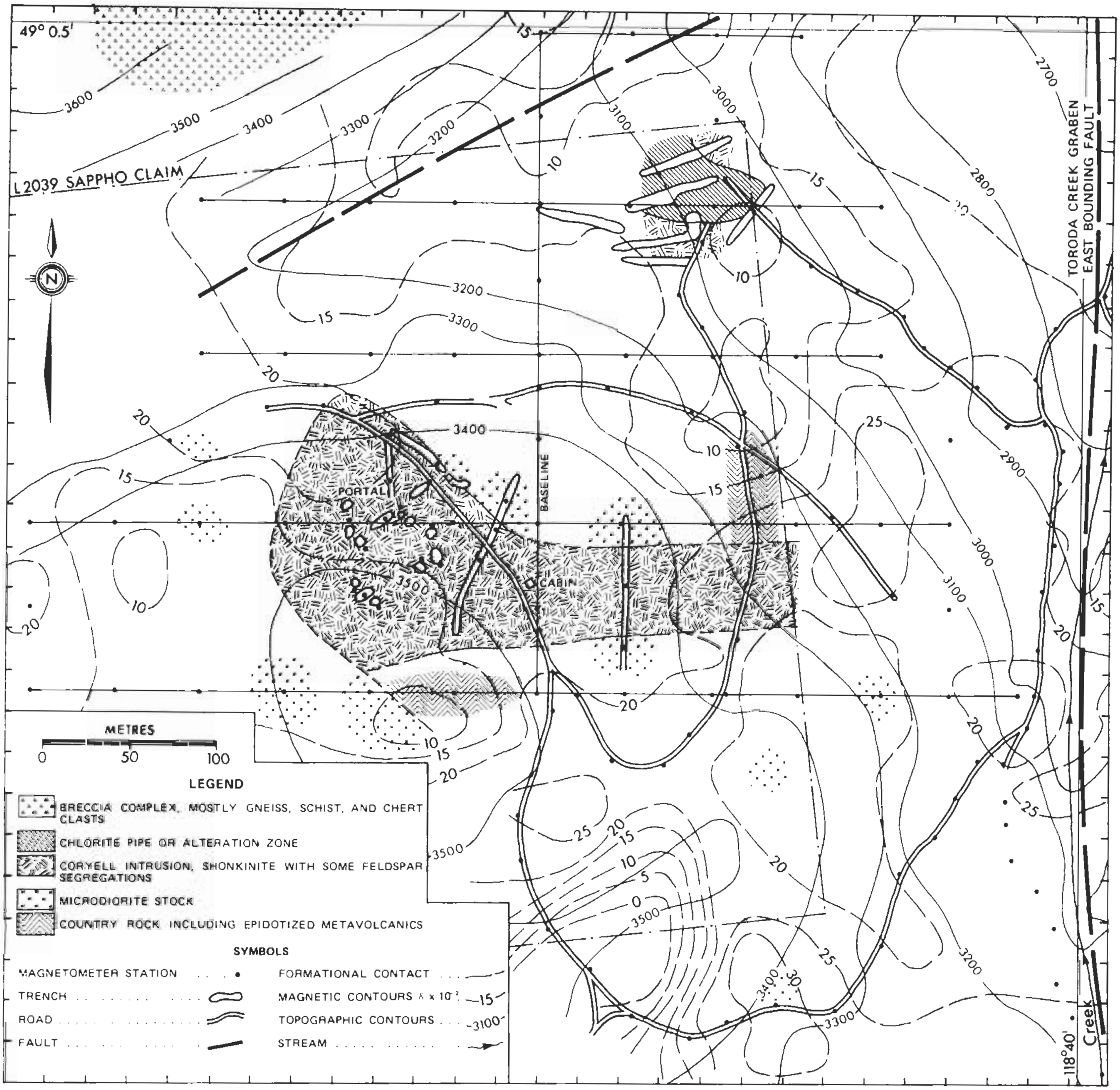

Figure 20. Geology and magnetometer survey of the Sappho prospect (after Church and Robertson, 1983).

SKYLARK

(Lat. 49°, 05.4'; Long. 118°, 38.25'; M.I. 082ESE011)

The Skylark claim is centred 2.7 kilometres east of Greenwood and 0.8 kilometre southeast of Twin Creek at elevation of 1 140 metres (3,750 feet). Access is 1.8 kilometres easterly by winding dirt road from the main Greenwood to Phoenix road.

Mining on the Skylark claim in the period 1893 to 1940 has been spasmodic with the greatest production attained from 1905 to 1907 and in 1915 and 1935. Total ore shipped amounted to 1 931 tonnes having 22.4 kilograms of gold, 5 283 kilograms of silver, 3.7 tonnes of copper, 26.2 tonnes of lead, and 4.8 tonnes of zinc.

The Skylark claim was located in 1892 and mined in the early years with some good results. According to the Report of the Minister of Mines (1904, p. G212): "The underground work consists of the following: — A shaft, dipping to the east at about 55° from the horizontal, follows the vein to a depth of 80 feet [24 metres]. At this point the vein faults to the east about 30 feet [9 metres]. It was easily picked up again by a cross-cut and a winze has been sunk on it for another 20 feet [6 metres]. This winze will be sunk 50 feet [15 metres] more as soon as possible. On the 80 foot level a drift has been run on the ledge for a distance of over 250 feet [76 metres]. This drift will be carried north and south as fast as possible."

"The ledge itself runs nearly north and south and dips to the east. It is very regular and varies in width from a few inches to over a foot. It carries a great deal of antimonial silver and native silver. The ore is easily mined, as the walls are exceptionally good and the ore is not frozen to them in the least."

Recently, Shear (1980, p. 2) reports that the Skylark vein has been worked and stoped down dip for 60 metres (200 feet) and along strike for 150 metres (500 feet): "The vein has been worked primarily from 2 inclined shafts. The deeper and newer one is 200' [60 metres] deep and was completed in 1906. The vein has been faulted by flat lying faults with the bottom thrown easterly for up to 30' [9 metres]. Therefore, the lower part of the shafts consist of crosscuts and winzes."

"The greatest recorded width on the vein is 30 inches [0.75 metre]. The values commonly occur as pay streaks near the hanging and foot walls. The pay streak near the hanging wall is the larger. Widths on it average 6 to 8 inches [15 to 20 centimetres] but a width of 15 inches [38 centimetres] is reported at one point. The mineralization has been described variously as fine grained steel galena with tetrahedrite and a little ruby silver; solid arsenopyrite with fine grained galena and sphalerite; and silver bearing stibnite with native silver. The vein material seen by the writer carried disseminated stibnite, galena, sphalerite and pyrite. The vein strikes north-south and dips about 55° east."

The host rocks for mineralization on the Skylark claim are the argillite and greenstone formations of the Attwood Group.

Ore reserve estimates for the Skylark mine have not been determined although recent exploration in the area has apparently uncovered a segment of the vein faulted from the south end of the mine workings.

WINNIPEG, GOLDEN CROWN

(Lat. 49°, 04.5'; Long. 118°, 34.3'; M.I. 082ESE032 and 033)

The adjoining Winnipeg and Golden Crown claims are centred 7.5 kilometres east of Greenwood and 3.2 kilometres southeast of Phoenix at elevation 1 350 metres (4,450 feet). Access to the property is 1.2 kilometres east from Hartford Junction by dirt road on an old railway grade.

Production from the Winnipeg and Golden Crown claims from 1900 to 1941 was 55 804 tonnes of ore yielding 402 kilograms of gold, 1 207 kilograms of silver, 1 245 tonnes of copper, and 0.38 tonne of lead. From this total 2 488 tonnes of ore was mined from the Golden Crown.

The Winnipeg and Golden Crown claims were staked in 1891. By 1897 both properties had undergone vigorous development. According to the Report of the Minister of Mines (1897, p. 595): "There has been found a number of, as yet, small veins in the same eruptive rock, in which the ore is gold bearing copper pyrites and pyrrhotite in a quartz gangue. The main tunnel was in 60 feet [18 metres] and was being run to cut five of these veins, with 280 feet [85 metres] to go to tap a vein, No. 2, on the top of the hill at a depth of 80 feet [24 metres]. One vein, No. 1, of this kind of ore described, 10 to 12 inches [about 0.27 metre] wide, had been crossed. A shaft had been sunk 60 feet [18 metres] on vein No. 2, which was 1 to 20 inches [3 to 50 centimetres] wide, of decomposed quartz and the sulphides from which high gold assays had been obtained, and the enclosing country rock was somewhat mineralized and also assayed a little in gold. Thirty feet [9 metres] south of No. 2 is vein No. 3, a small vein of quartz and sulphides exposed in a small cut. Near the road vein No. 5, as shown in a long trench, was 3 to 4 feet [about 1 metre] wide, of quartz, copper and iron pyrites and pyrrhotite, good samples of which have assayed $35 per ton in all values. It was proposed to sink a shaft here, and this is now down about 30 feet [9 metres]."

By 1899 the Golden Crown shaft had been sunk to a depth of approximately 90 metres on the main vein which ranged to 2.4 metres wide (Fig. 21). The Report to the Minister of Mines (1899, p. 763) recounts: "Cross-cut levels to the south, from the shaft to the lead, had been made at the 100 and at the 150-foot [30 and 46-metre) levels, and at the 300-foot [90-metre] level drifts were being run both north and south, but had not, at the time, reached ore, having been driven only about 20 feet [6 metres] each way from the shaft."

By 1903 development was completed on three leads. The Golden Crown shaft was down to 98 metres connecting several levels, the longest of which was about 275 metres.

On the Winnipeg the main shaft was developed on a vein that appeared to be aligned with the No. 4 vein exposed 100 metres to the northwest on the Golden Crown claim. By 1899 the Winnipeg shaft was sunk to a depth of about 90 metres with levels begun at 30-metre intervals. Total underground development by 1903 on the Winnipeg claim amounted to approximately 1 370 metres (4,500 lineal feet), and near the end of mine operations in 1912 it was estimated that there was more than 5 000 metres of tunnelling completed.

Mineralization on the property consists of pyrite, pyrrhotite, and chalcopyrite occurring in discontinuous quartz veins and lenses hosted in the metavolcanic formation (greenstones) of the Attwood Group and the 'Old Diorite' and associated ultrabasic intrusions. The Golden Crown claim is underlain mostly by the greenstones except locally along the east boundary of the claim and the southeast end of the underground workings where diorite is encountered. The Winnipeg claim is underlain mostly by diorite on the east and greenstones on the west. The claims appear to be traversed by an important southeasterly trending fault, off which the many quartz-filled gash fractures containing the ore may have developed.

Work completed recently suggests some ore potential south of the Golden Crown workings and also northeast of the Winnipeg shaft. A recent company report gives an estimated reserve of about 2 700 tonnes averaging 10 grams per tonne gold.

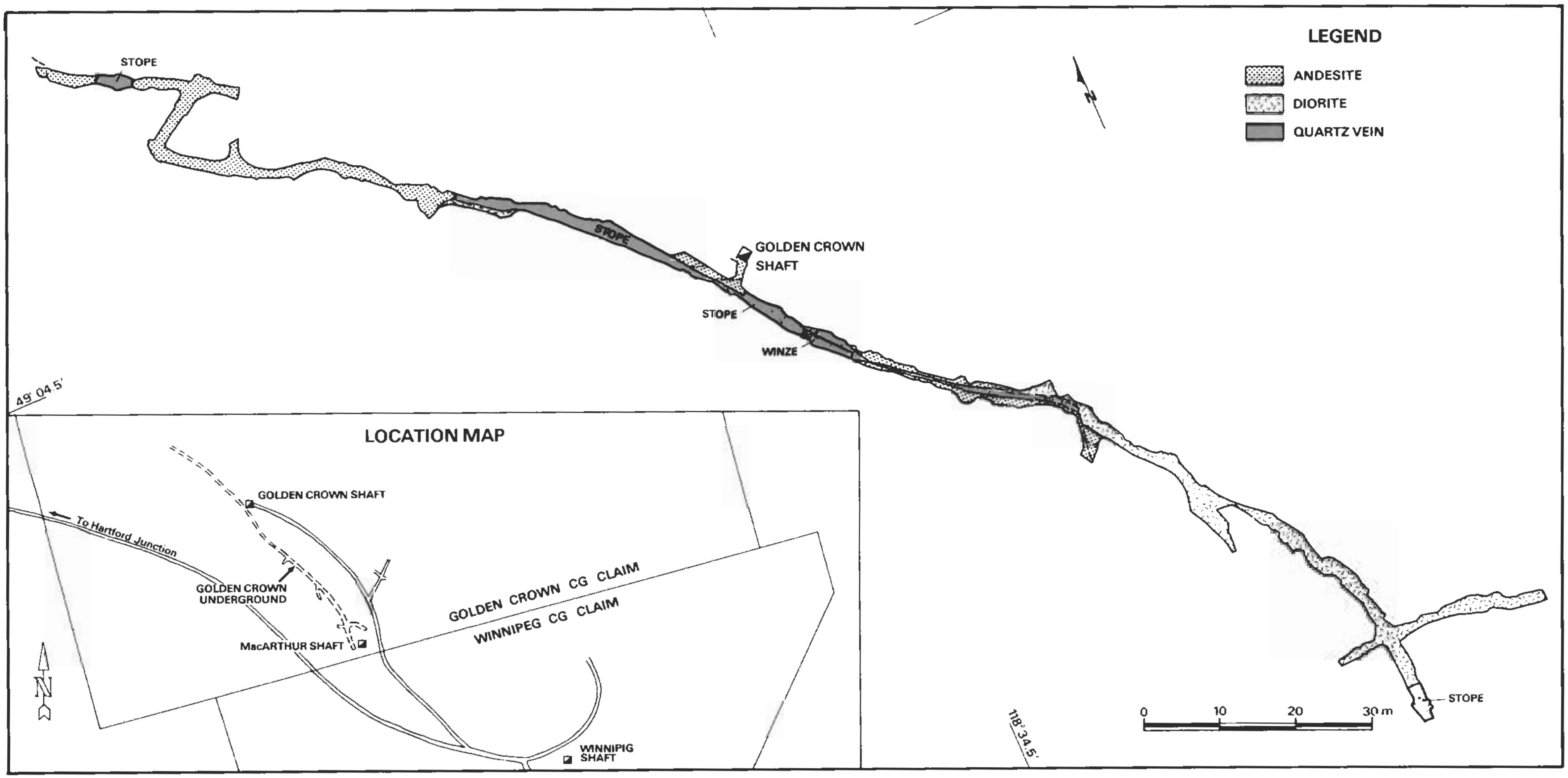

Figure 21. Geology of the Golden Crown mine, 30-metre level (after Keyte and Saunders, 1980).

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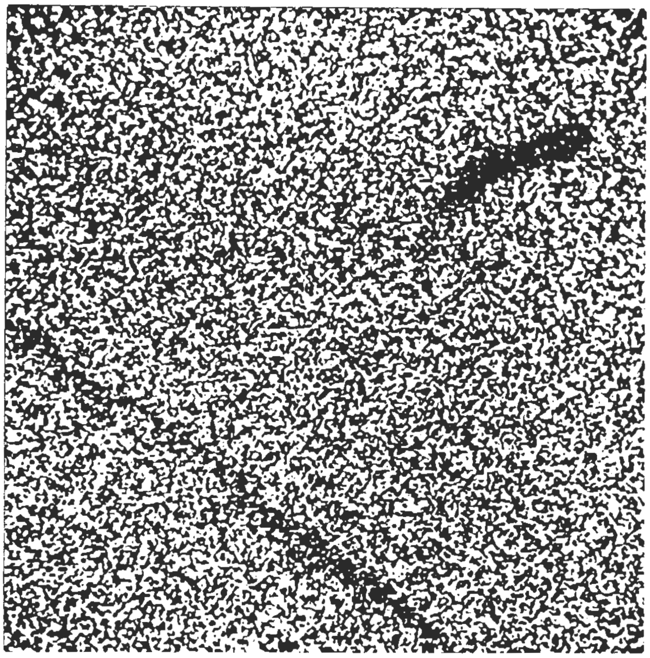
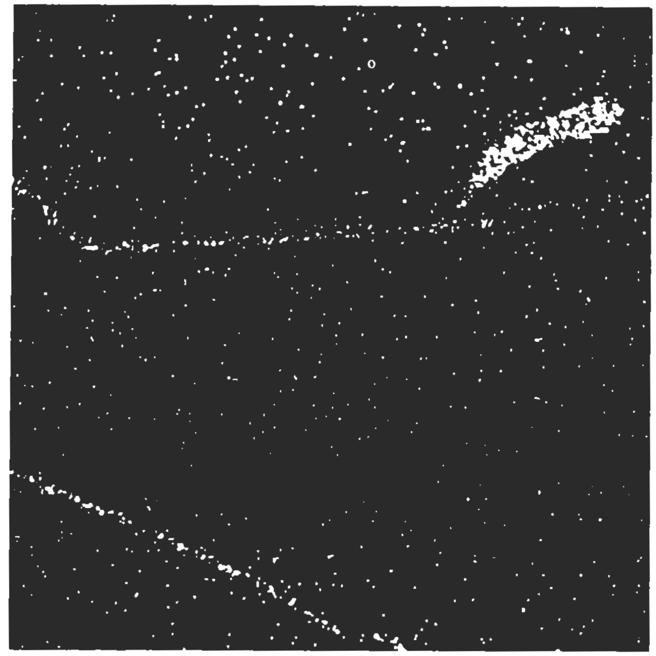
APPENDIX

Through the courtesy of A. M. Homenuke of Tri-Con Mining Ltd., the results of electron microprobe study of ore samples from the Lexington property are presented here. From company file No. B-179, dated June 25, 1973, it was reported to G. Anselmo of Can-Ex Resources Ltd. that sample No. DDH-4 (735 feet to 737 feet) assayed 1.93 ounces per ton gold. Microprobe analyses of this sample show the gold entirely associated with pyrite occurring along grain boundaries and as discrete inclusions. There was no gold seen on fractures nor associated with chalcopyrite (Plates XXII and XXIII).

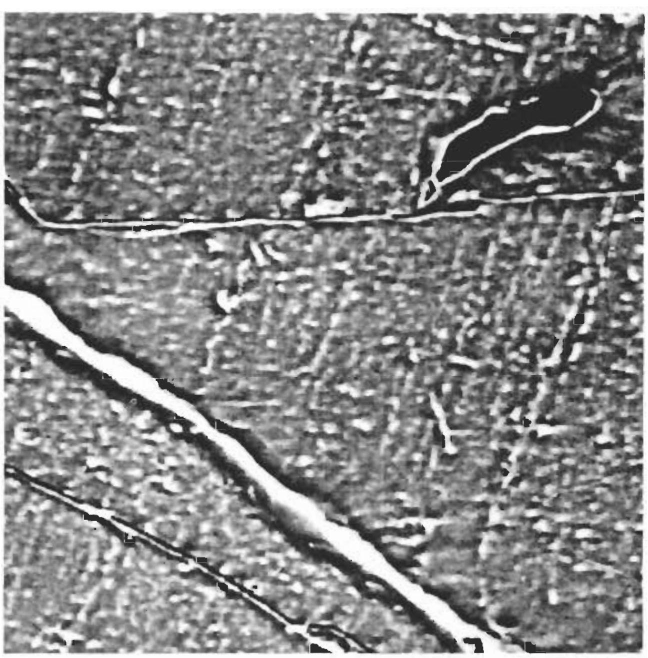
It is concluded from this that the gold would be reported with the pyrite in a flotation operation. The study also shows that the intimate association of chalcopyrite and pyrite would make flotation separation of these minerals difficult.



a.

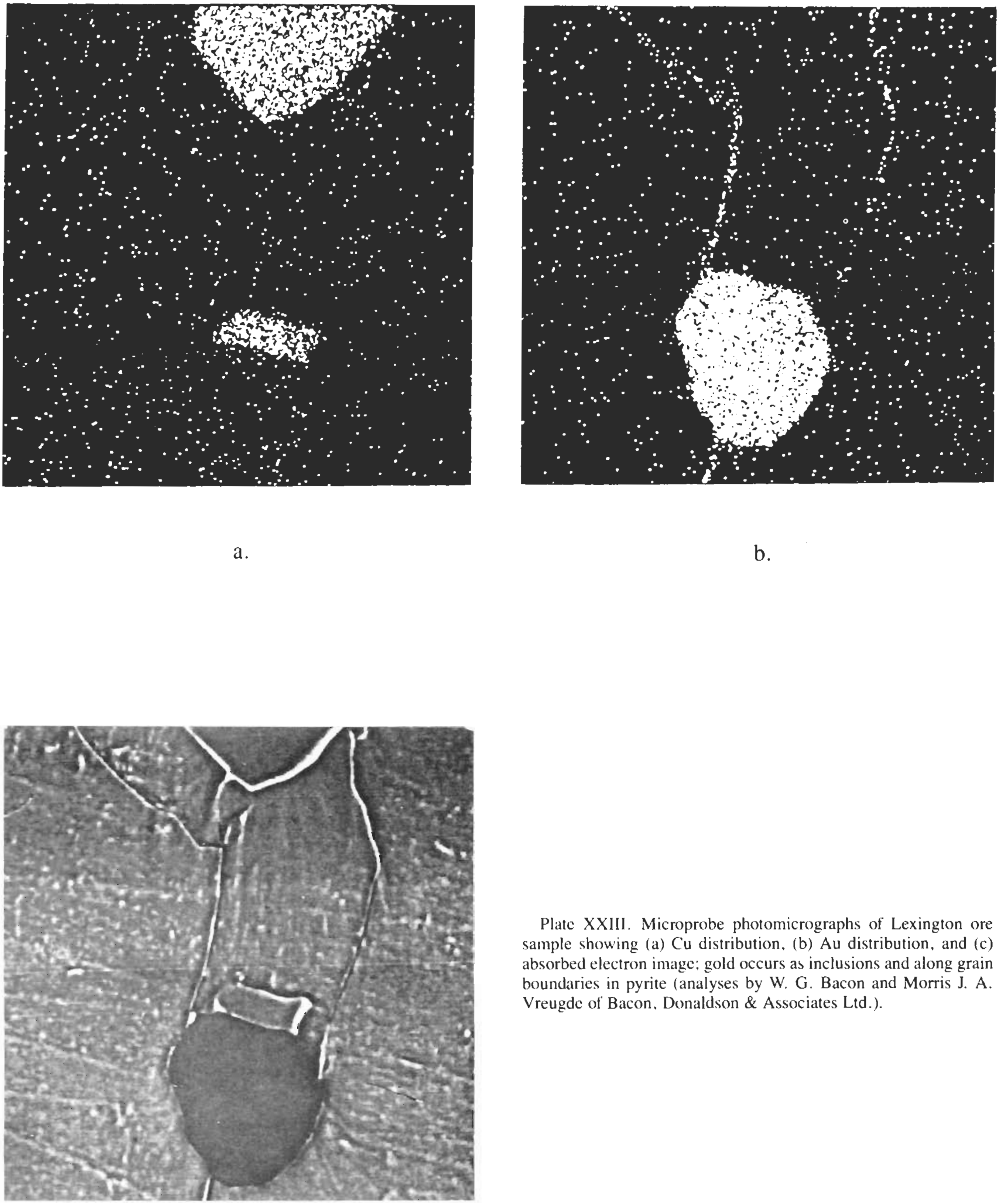


b.



c.

Plate XXII. Microprobe photomicrographs of Lexington ore sample showing (a) Fe distribution, (b) Au distribution, and (c) absorbed electron image; gold occurs as inclusions and along grain boundaries in pyrite; no gold occurs on fractures in pyrite (analyses by W. G. Bacon and Morris J. A. Vreugde of Bacon, Donaldson & Associates Ltd.).



a.

b.

c.

Plate XXIII. Microprobe photomicrographs of Lexington ore sample showing (a) Cu distribution, (b) Au distribution, and (c) absorbed electron image; gold occurs as inclusions and along grain boundaries in pyrite (analyses by W. G. Bacon and Morris J. A. Vreugde of Bacon, Donaldson & Associates Ltd.).

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

FIGURE 1

GEOLOGY OF THE MOUNT ATTWOOD–PHOENIX AREA

N.T.S. 82E/2E

BY B. N. CHURCH

SCALE—1:25 000

KILOMETRES 1 0 1 2 KILOMETRES

LEGEND

BEDDED ROCKS

TERTIARY

PENTICTON GROUP

	MARRON FORMATION
13	*PARK RILL MEMBER:* BROWN MEROCRYSTALLINE ANDESITE, MICRODIORITE
12	*NIMPIT LAKE MEMBER:* TAN TRACHYTE, PULASKITE SILLS AND DYKES
11	*YELLOW LAKE MEMBER:* PURPLE MAFIC PHONOLITE, MONZODIORITE SILLS
10	**KETTLE RIVER FORMATION:** MOSTLY ARKOSIC SANDSTONE, SOME CONGLOMERATES, AND MINOR RHYOLITE TUFF; (10a) **SPRINGBROOK FORMATION:** POLYMICTIC CONGLOMERATE

TRIASSIC

BROOKLYN GROUP

9	**EHOLT FORMATION:** MOSTLY MAROON AND GREEN VOLCANICLASTICS
8	LIMESTONE AND INTERCALATED ARGILLITE
0	SKARN
7	SHARPSTONE CONGLOMERATE, INTERCALATED SANDSTONE, AND SHALE

PERMO-CARBONIFEROUS

ATTWOOD GROUP

6	METAVOLCANICS, MOSTLY GREENSTONES (METAMORPHOSED BASALTS AND ANDESITES)
5 / 4	(5) BLACK SHALE, GREYWACKE; (4) LIMESTONE
3	SHARPSTONE CONGLOMERATE, CHERT BRECCIA, AND SANDSTONE

BASEMENT COMPLEX

KNOB HILL GROUP

2 / 2a	(2) METACHERT AND MICA SCHIST; (2a) AMPHIBOLITIC SCHIST AND GNEISS;
1	(1) MARBLE

IGNEOUS INTRUSIONS

TERIARY

H	**CORYELL:** SYENITE, MONZONITE, AND SHONKINITE
G	DIORITE, MONZODIORITE, PULASKITE

CRETACEOUS

F	ULTRABASICS; SERPENTINE, LISTWANITE
E	GREENWOOD AND WALLACE CREEK GRANODIORITE
D	CYCLOPS GABBRO
C	LEXINGTON QUARTZ FELDSPAR PORPHYRY

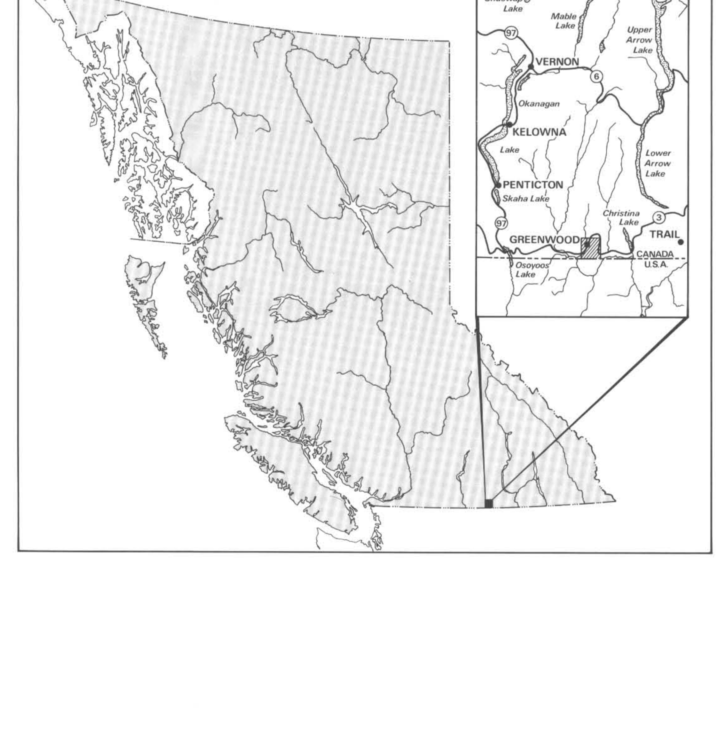
TRIASSIC

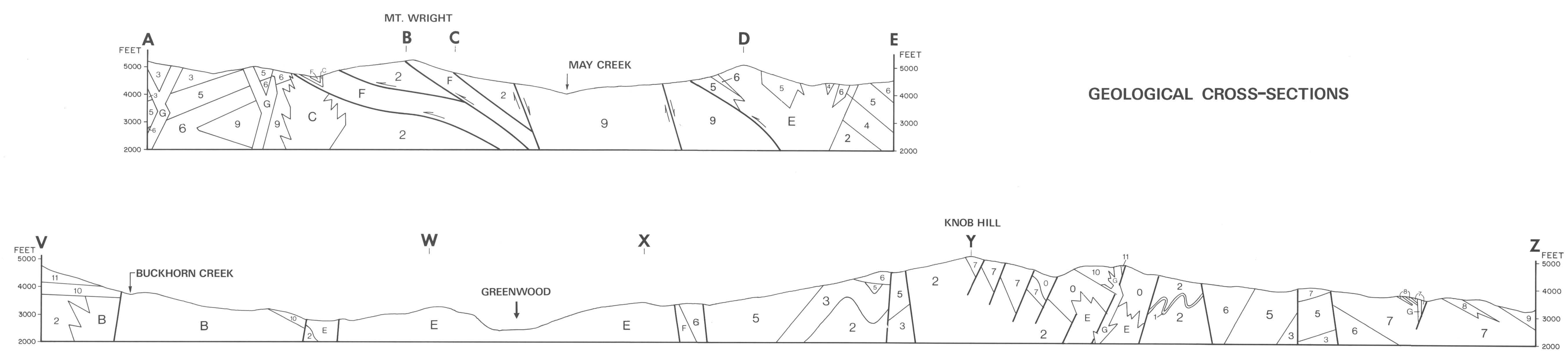
B	MICRODIORITE
A	OLD DIORITE

SYMBOLS

GEOLOGICAL BOUNDARY
BEDROCK EXPOSURE
BEDDING, SCHISTOSITY
FAULT, THRUST
GLACIAL STRIAE
FOSSIL LOCALITY
LINE OF CROSS-SECTION A—B
TOPOGRAPHIC CONTOURS (INTERVAL, 250 FEET)
POLE LINE, POWER LINE
HIGHWAY, SECONDARY AND COUNTRY ROADS
RAILWAY
STREAM
LAKE

LOCATION MAP





GEOLOGICAL CROSS-SECTIONS

LITHO'D IN CANADA

TO ACCOMPANY PAPER 1986–2

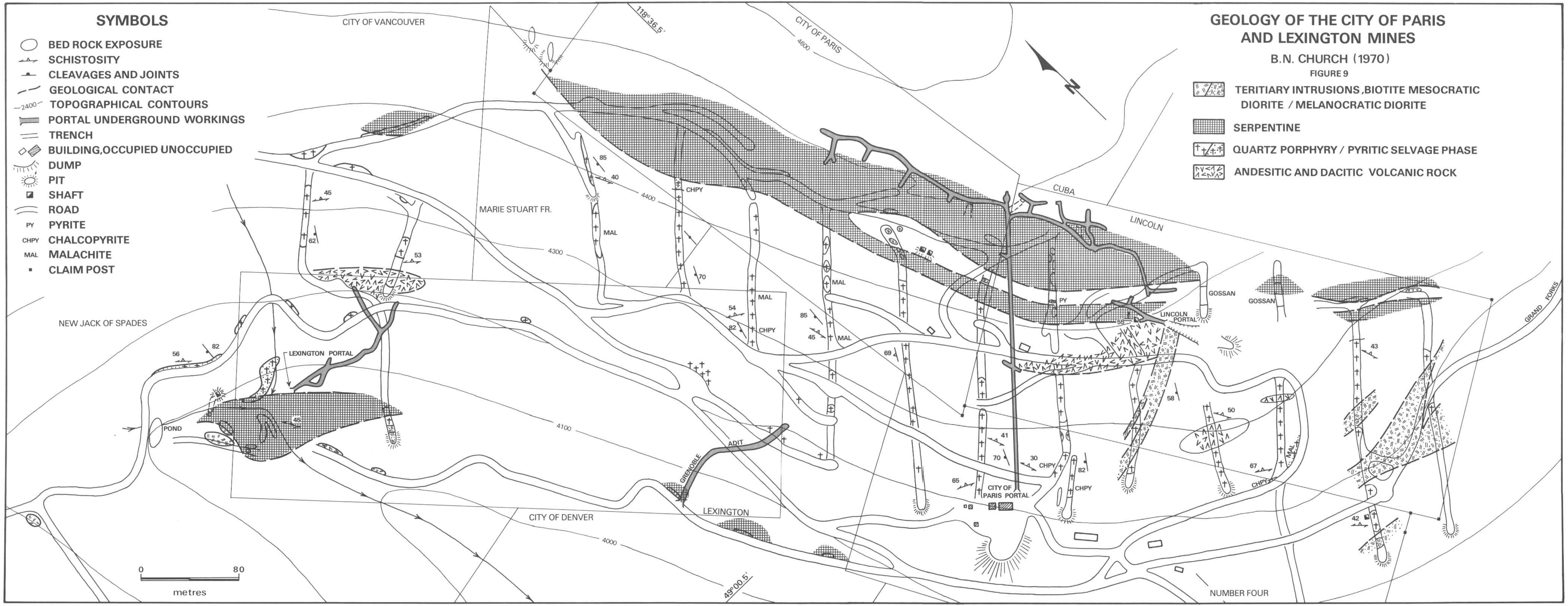
COMPOSITE PLAN OF THE NO.7 MINE

B.N.CHURCH

FIGURE 13

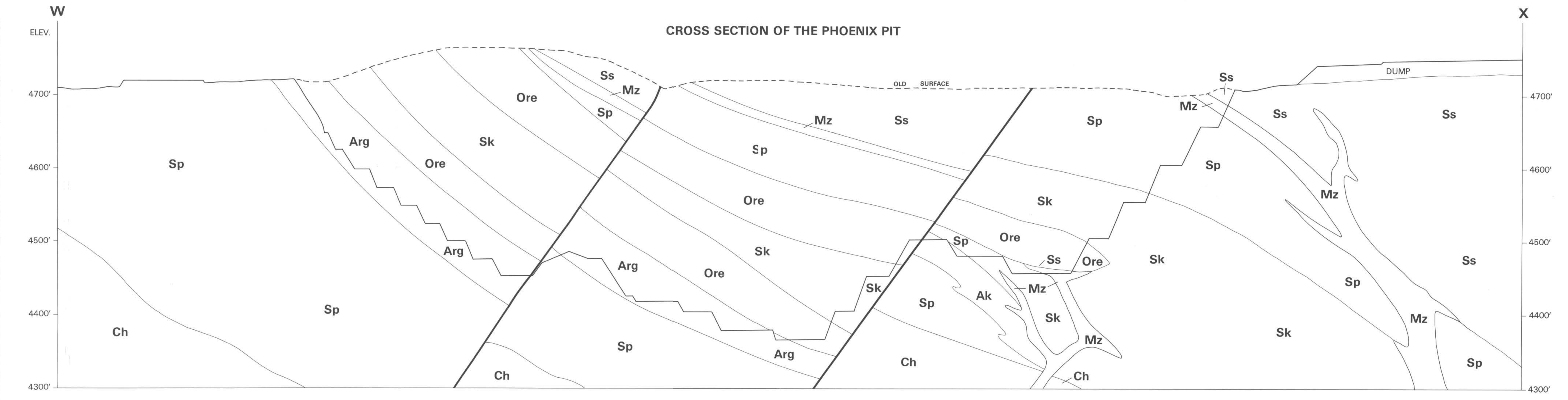
LITHO'D IN CANADA

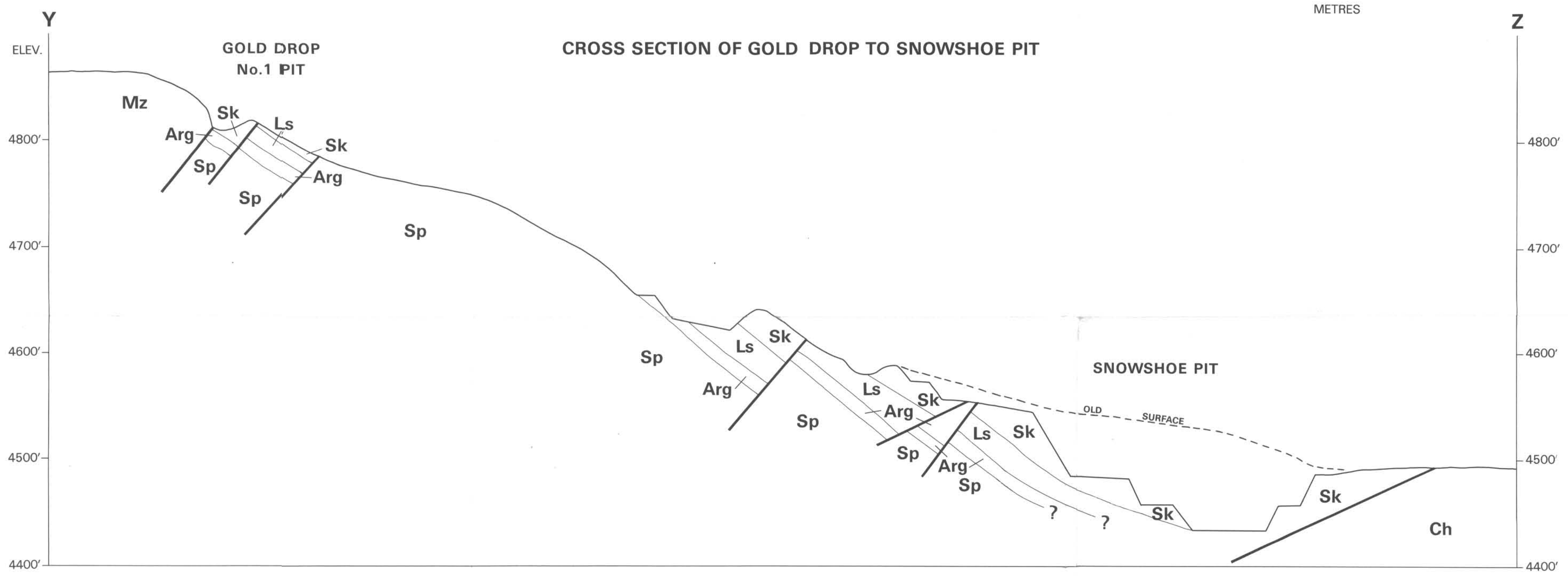
TO ACCOMPANY PAPER 1986-2



LITHO'D IN CANADA

TO ACCOMPANY PAPER 1986 – 2





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

GEOLOGY OF THE PHOENIX MINE

BY B.N.CHURCH

FIGURE 16

LEGEND

BEDDED ROCKS

PENTICTON GROUP (EOCENE)

- V — MARRON VOLCANICS
- Ss — KETTLE RIVER ARKOSE

BROOKLYN GROUP (TRIASSIC)

- Volc — EHOLT VOLCANICS
- Ls — LIMESTONE
- Sk — SKARN
- Arg — ARGILLITE AND SANDSTONE
- Sp — SHARPSTONE CONGLOMERATE

KNOB HILL GROUP (PRE-PERMIAN?)

- Ch — QUARTZ CHLORITE SCHIST AND METACHERT
- Gnst — MICA SCHISTS AND METAVOLCANIC ROCKS
- M — MARBLE

IGNEOUS ROCKS

- Mz — CORYELL MONZONITE, SHONKINITE
- Ak — ALASKITE DYKES
- Di — MICRODIORITE

SYMBOLS

- BEDDING
- FOLIATION
- GEOLOGICAL CONTACT
- FAULT (DEFINED, INTERPRETED)
- PORTAL
- TUNNEL
- TOPOGRAPHIC CONTOUR (FEET)
- PIT CONTOUR
- WASTE DUMP (BOTTOM, TOP)
- CROSS SECTION
- ROAD
- RAILWAY GRADE
- EDGE OF ROCK EXPOSURE
- CROWN GRANTED CLAIM — C.G.

CARTOGRAPHY BY M.S.TAYLOR
LITHO'D IN CANADA
TO ACCOMPANY PAPER 1986-2