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

PRELIMINARY MAP NO. 59

GEOLOGY OF THE MOUNT ATTWOOD–PHOENIX AREA

N.T.S. 82E/2E

BY N.B. 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**

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	BLACK SHALE, GREYWACKE/LIMESTONE
3	SHARPSTONE CONGLOMERATE, CHERT BRECCIA, AND SANDSTONE

BASEMENT COMPLEX

KNOB HILL GROUP

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

IGNEOUS INTRUSIONS

TERTIARY

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

CRETACEOUS

F	ULTRAMAFICS; SERPENTINE, LISTWANITE
E	GRANODIORITE
D	GABBRO
C	QUARTZ FELDSPAR PORPHYRY

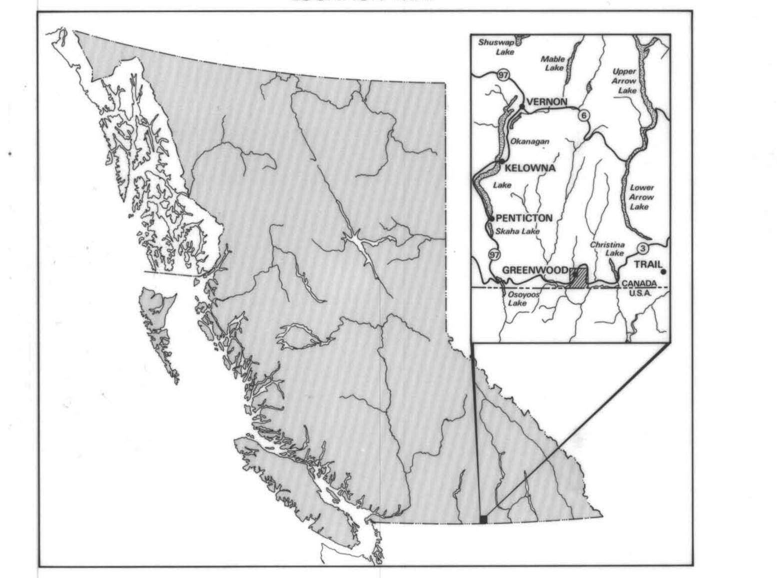
TRIASSIC

B	MICRODIORITE
A	OLD DIORITE

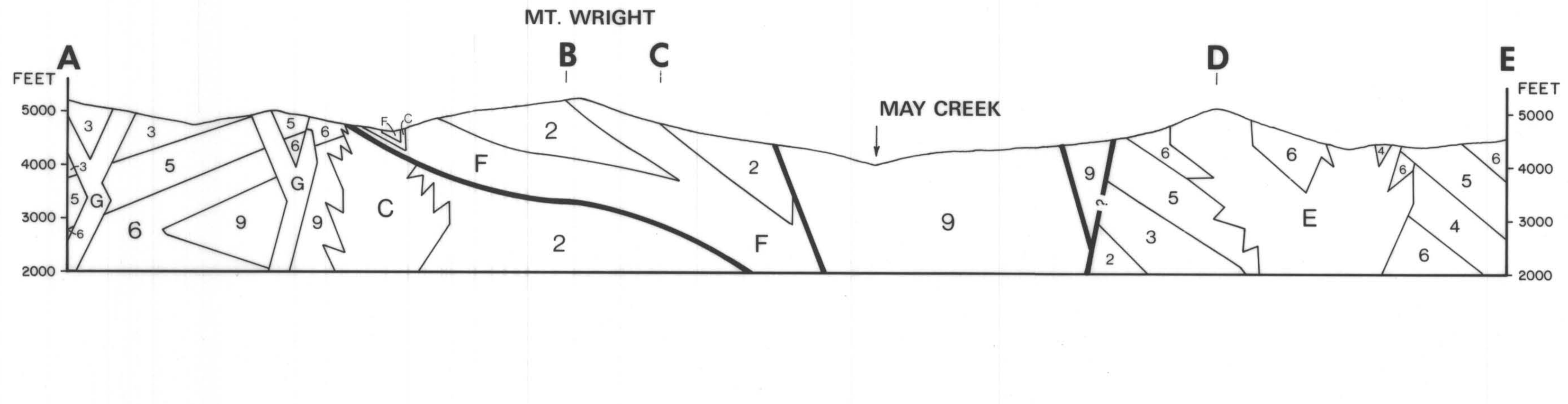
SYMBOLS

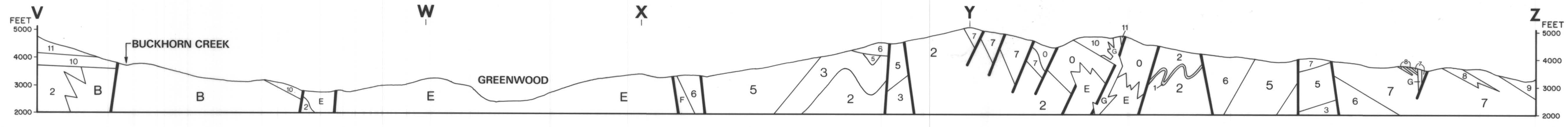
GEOLOGICAL BOUNDARY
BEDROCK EXPOSURE
BEDDING, SCHISTOSITY
FAULT
GLACIAL STRIAE
FOSSIL LOCALITY
LINE OF CROSS–SECTION A——B
TOPOGRAPHIC CONTOUR (INTERVAL, 250 FEET) 2750
POLE LINE, POWER LINE, PIPE LINE P
HIGHWAY, SECONDARY AND COUNTRY ROAD
RAILWAY
STREAM
LAKE

LOCATION MAP



GEOLOGICAL CROSS-SECTIONS





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NOTES TO ACCOMPANY PRELIMINARY MAP NO. 59

GEOLOGY AND MINERALIZATION IN THE MOUNT ATTWOOD-PHOENIX AREA, GREENWOOD, B.C.

BY B.N. CHURCH

Victoria
British Columbia
June 1985

GEOLOGY AND MINERALIZATION IN THE MOUNT ATTWOOD-PHOENIX AREA, GREENWOOD B.C.

by B.N. Church

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 some previous investigations including 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 published by McNaughton (1945), Seraphim (1956), Carswell (1957) and Little (1983).

The present study stems from new mapping utilizing the Granby Mining Company Ltd.'s 1:12000 scale topographic base, and information from previous property evaluations including the Lexington Mine (Church, 1970), Jewel Mine (Church and Winsby, 1974), Oro Denoro Mine (Church, 1976), Skomac Mine (Church, 1977), the Sappho (Church and Robertson, 1983) and Sylvester K (Church, 1984) prospects.

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 3000 feet (about 900 metres). Five peaks rising above 5000 feet m.s.l. elevation (1500 metres) are aligned, forming a divide that projects north from the 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 into 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 Boundary at the town of Midway.

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

HISTORY

Lode mineralization was first recorded in the Greenwood area near Boundary Falls in 1884; 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 one million tonnes of ore. Labour unrest in the Crows Nest coal field 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 the 1957 to 1959 period that an increase in copper prices combined with new mining technology resulted in large scale open pit production from the Mother Lode and Phoenix ore bodies. Production at Phoenix attained 2500 tonnes per day in 1972 and remained about the same until exhaustion of the ore in 1976.

A small production of precious metals from the 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, intermittant production has been recorded by Colt Resources Ltd. and Dentonia Resources Ltd. from 1974 to present from the Denero Grande property at Jewel Lake.

ACKNOWLEDGMENTS

Assistance rendered by mining and mining exploration personnel in the Greenwood area is greatfully acknowledged. Special thanks are owed G.O.M. Stewart and H.H. Shear of Dentonia Resources Ltd., J.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.

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

GENERAL GEOLOGY

Twenty-two geological units are distinguished in the Mount Attwood - Phoenix area (see accompanying map). These include a wide ranging variety of Paleozoic to Tertiary beds that reflect multiple episodes of deformation and igneous intrusion.

The relative stratigraphic position and age of these rocks is generally interpreted according to the rules of superposition of beds, degree of regional metamorphism, and cutting relationships of the igneous intrusions. Fossil evidence 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 more than 2400 outcrop control stations scattered throughout the area.

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).

Knob Hill Group

The Knob Hill Group is the oldest of four mutually unconformable assemblages. LeRoy (1912) first described these 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.

The chert beds, 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 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, are the only suggestion of fossil remains.

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

The maximum effect of thermal metamorphism appears to postdate the principal dynamic events. This is proved by the growth of fresh, randomly oriented, mica across the early penetrative fabric. Recrystallization is commonly best developed near the contacts of the major granodiorite bodies. Gneissic rocks adjacent to the eastern limits of the Wallace Creek (E) batholith were converted to hornfels consisting of small grains of quartz (25%) and biotite (35%) in a matrix of muscovite, feldspar, and quartz with accessory magnetite.

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 Mt. 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 3, no.3) demonstrate higher alumina and total alkalies content than chloritic schists (no.2) and quartz-rich schists (no.1) of the metasedimentary assemblage.

The only good marker 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-boundary fault of the Toroda Creek Graben, and 4.6 kilometres easterly on to the central ridge of Mt. Attwood. Smaller exposures are found north of Haas Creek in the Phoenix area, and on the Great Laxey claim 11.5 kilometres northeast of the camp ground.

Intense deformation and recrystallization of the marble (1) destroyed most primary structural features, including fossil remains. On the upper slopes of Mt. Attwood the band is discontinuous and forms en echelon marble pods.

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 43228 kilograms of silver since beginning operations in 1896 (Table 1).The 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 occur in a large 100 metre-long quartz lens in schists on the south slope of Mt. Attwood, and sulphide-bearing skarn deposits associated with the marble band (1). These 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 Attwood Group, underlying much of the central and southern part of the map-area, 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), confirmed 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 limestones are generally white and crystalline, although occasionally a core of black or drab limestone is to be seen; the argillites are 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 Mt. Attwood, the formation is about 250 metres thick and comprises mainly dark grey phyllitic argillite intercalated with thinly bedded greywacke, siltstones and a 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 3, no.8).

Molluscan shells including Warthia sp., Atomodesma sp., Bitaunioceras forms and crinoid stems from a small lens of fossiliferous grey limestone, 0.5 kilometres west of the mine, were determined to be Permo-Carboniferous age. Little (1983) reports 6 additional fossil localities on Mt. Attwood yielding a similar age.

The conglomerate beds (3) are intercalated with black argillite and conglomerates predominate near the base of the formation at the west summit of Mt. Attwood. These are chert pebble conglomerates clearly derived from the immediately underlying recrystallized Knob Hill chert Terrain. '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 rest directly on Knob Hill metachert and breccia.

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

An almost complete, but apparently overturned, section of the Attwood Group is found on Mt. McLaren and Rusty Mountain, where three of the main formations are identified - a lower zone of basalt and andesite lava, an intermediate zone of carbonaceous phyllite, an upper zone of quartz wacke and conglomerate - the total sequence being more than 300 metres thick. Overall, the units are almost horizontal, although 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 Mt. Attwood, in 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 and suggest an overall formational thickness of at least 100 metres. According to Little (1983), fossils found in a lens of sedimentary rock north of the Athelstan mine yielded a Permo-Carboniferous age, similar to that for collections from Mt. Attwood.

Petrographic examination of this 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 3, nos.4, 5, and 6) are similar and indicate a basalt composition.

The metabasalt unit (6) appears to rest disconformably on eroded basal sharpstone conglomerates (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 Mt. Attwood ridge. The limestone is a conformable, mostly light grey unit dipping 25 to 60 degrees northeast. It has a maxium development 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 fossils such as corals, 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 the the rocks of the Attwood Group is variable throughout the map area; it is rarely sufficient to destroy primary structures. Penetrative cleavage slip deformation is locally well developed and apparently accompanied by elongation of conglomerate clasts and the development of small chevron folds. The thermal effects are manifested in the argillites (5) by the development of incipient biotite in the rocks on Rusty Mountain and at the Skomac mine, and the growth of blue-green laths of secondary 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 has producted 5282 kilograms of silver since beginning operations in 1893 (Table 6). The mine is located on a quartz vein in argillite (5) near the east boundary of the Greenwood granodiorite stock (E). Similarly, the Skomac mine (Republic property) has produced 3186 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 1207 kilograms of silver and 402 kilograms of gold from sulphide bearing quartz veins in metavolcanic rocks (6) intruded by 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.

Brooklyn Group

The Brooklyn Group 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 Motherlode and Sunset mines north of Deadwood Creek, underlying much of the drainage basin of May Creek between Mt. Attwood and July Creek, and a small area in vicinity of the Ruby claim northeast of Boundary Falls.

Mapping and description of the Brooklyn rocks was initiated by Brock in 1902 and studies have 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 of the Group which consists of sharpstone conglomerate (7), limestone (8) and volcanic (9) formations. Little (1983) collected several fossil suites which yielded Middle and Upper Triassic ages for these rocks.

The sharpstone conglomerates (7) consist 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 and limestone derived from the diverse lithologies of the underlying metamorphosed Paleozoic terrain. Modal analyses of the sandy matrix of this rock give an average of chert and quartz, 40 per cent; amphibole and chlorite hash, 15 per cent; carbonates, 15 per cent; 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) viewed on the haulage road southeast of the Phoenix mine. Chemical analysis of the Rawhide shale (Table 4, 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 4, nos.9 and 10) reflecting the abundance of 'Knob Hill chert' clasts. Calculations based on analysis no.9 gives 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 about 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 carbonate clasts in carbonate mud matrix, 55 per cent; subangular to well rounded chert grains, 35 per cent; 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 4, no.12). 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 secured 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 the Eholt volcanic rocks (9) and the underlying Brooklyn beds (7) and (8). The Eholt Formation rests mainly on sharpstone conglomerate (7) south of the Phoenix road; to the north the same rocks overlie limestone (8).

According to J.T. Fyles (personal communication), volcanic breccias east of the Stemwinder claim in the Phoenix area, overlie an upper facies of 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 Mt. Attwood one 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) structurally 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 one metre in diameter, are embedded in 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). Without exact measurement, the thickness of Eholt volcanic rocks is estimated to be at least several hundred metres.

Structurally, the Triassic rocks 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 Mt. Attwood, and a more steeply inclined, inverted, west dipping limb exposed on the upper slopes of Mt. 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 formations dip east at about 50 degrees on average forming a monocline. Local reversals and deflections of beds give evidence of minor folds plunging about 30 degrees toward northeast. 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 tbe ore produced from the Greenwood area. A total of 31705089 tonnes of ore (Table 6) has been processed from skarn rocks (0) of the Phoenix, Motherlode, Greyhound, Marshall and Ruby mines. This has yielded 36130 kilograms of gold, 118241 kilograms of silver and 270944 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 the mineral bearing solutions.

The Oro Denoro Mine presents a classical model of 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 sharn is mostly a replacement of limestone (8) which was intruded by the Lion Creek granodiorite - the most easterly lobe of the Wallace Creek pluton (E).

The mine workings cover about four 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): garnet (grossularite 10%, andradite 90%), 85 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 5, no.1). The gain of a large amount 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 irregularlies and variations in the width of the skarn zone, from a few metres to many tens of metres, suggests that the reactions occurred only at places where ascending solutions were active. These solution, 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.

Penticton Group

The 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 2500 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 which consists of a slide complex and fanglomerate beds. The Penticton Group rests unconformably on pre-Tertiay granitoids, metamorphosed Mesozoic sedimentary and volcanic rocks, and older schists and gneisses. The age range of the Group, as determined from 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 Penticton 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 two kilometres east of Mt. 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, measuring about 200 metres thick, and the Marron volcanics, about 1500 metres thick, are inclined, averaging 35 degrees southeast, in a graben structure.

The Springbrook Formation (10a) occurs as a small conglomeratic deposit on a low ridge crest two kilometres east of Mt. Wright. This remnant paleochannel deposit is polymictic with clasts of diorite, greenstone, felsite, limestone, chert and a large number of other varieties of rock that represent the older units of the map area, including fragments of serpentine from the immediately underlying ultramafic terrain.

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 Phoenix pit and extend northerly for a total strike length of two 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 conglomerates (7). Locally, contact relations are obscured by intrusion along joints and bedding planes of pulaskite (12) sills and dykes which connect as feeders to the overlying Marron volcanic rocks.

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 comminuted material and clay. Exotic clasts such as skarn, chert and carbonates are usually only minor constituents. Modal analysis of a sandstone sample from the Wilgress Lake area shows quartz, 15 per cent; chert, 5 per cent; feldspar, 40 per cent; volcanic rock, 10 per cent; mica and opaque minerals, accessory; matrix, 30 per cent. 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 4, no.13) reveals some carbonate content, but otherwise a resemblance to rhyolite.

Origin of the Kettle River rocks appears to be a widespread volcanic source 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 of 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 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. At Phoenix, 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 4, 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. Within the map area, only subvolcanic porphyritic dykes and small stocks (6) represent this unit.

Petrographically, the Kitley Lake rocks are characterized by an abundance of glomerophenocrysts of feldspar commonly measuring 0.5 centimetres 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 2, 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 structure. 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 'wedding cake' tiered flow sequences, suggesting high fluidity of the original source magma.

Petrographically, the Nimpit Lake lavas are mostly fine 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 and are difficult to delineate at the 1:25000 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 4, no.2) corresponds well with the composition of fresh microdiorite dykes in the map area (Table 2, 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 subjacent sulphide deposit has been explored.

Structurally, the most important overprinting is Tertiary block faulting which is coincident with, and continued after the Marron volcanic events. The result is preservation of thick tracts of the Tertiary cover rocks such as 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 on the Tenas Mary horst which comprises 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 down faulted and tilted in a half graben structure. This movement rotated the Tertiary beds about 35 degrees easterly and displaced downward, by several hundred metres, the area immediately east of the Phoenix pit. This movement effectively severed the skarn zone which originally connected the Phoenix and Snowshoe ore bodies. Subsequent to this trap door movement, 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 Mesozoic and Tertiary granitoid diapiric stocks, dyke-like felsic porphyries and irregular ultramafic bodies.

Diorite (A): The principal outcrops of what appears to be the oldest intrusions in the area, termed 'Old Diorite', which lie in a belt coincident with the course of Lind Creek, extend across the map area from a point near Snowshoe Creek on the east to Hass 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 subhedral calcic plagioclase, 50 to 60 per cent, and green amphibole, 25 to 40 per cent, 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 1, nos.1 and 2).

The age of the diorite is estimated to be Lower Mesozoic 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-Upper Triassic age for the intrusion.

Microdiorite (B): Several consanguineous stocks of fine, even grained microdiorite are found across the map area. The most readily accessable 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 Upper Triassic (206 ± 8Ma) according to recent determinations by J. Harakal of the University of British Columbia.

Quartz Feldspar Porphyry (C): A group of related hypabyssal felsic intrusions, found in the south central part of the map area, have 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. 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 shows the following average composition: quartz, 5 per cent; perthitic orthoclase, 15 per cent; plagioclase, 45 per cent; quartz and feldspar matrix, 25 per cent; 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 ultramafic 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 ultramafic 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 1, 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 the quartz, and especially the feldspar, is reduced to small fragments, the feldspar being 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 ultramafic 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 subhedral plagioclase plates, about 55 per cent, interspersed with equant pyroxene grains, 20 per cent, (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 postdates the Triassic Brooklyn limestone host rocks (8) and predates crosscutting Tertiary dykes.

Granodiorite (E): Three compositionally similar granodiorite plutons are prominent in the map area, the largest of which 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 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 quartz, 25 per cent; microcline and plagioclase feldspar, 65 per cent; amphibole, 10 per cent; 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 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 1, 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.

Ultramafic Rocks (F): Serpentinized ultramafic rocks are widely distributed throughout the map area. The largest bodies occur on Mt. Wright, the northwest slope of Mt. Attwoood 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 semi-solid state, along unconformity surfaces and in fault zones. Elliptical shapes resembling pillows, found in some sheared phases of the ultramafic rocks, are structural in origin and not a volcanic manifestation.

The Mt. Wright ultramafic 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 about 500 metres near the summit of Mt. Wright, where it concordantly intrudes quartz mica schist (2).

Separate major ultramafic masses are enclosed within the Knob Hill Group and Attwood Group on Lind Creek and the adjacent northwest slopes of Mt. Attwood. A faulted sinuous ultramafic band lies along the unconformity between the the Knob Hill and Attwood Groups from Boundary Creek to the summit ridge of Mt. Attwood. On the summit ridge of Mt. Attwood the same ultramafic 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 ultramafic rock north of Skeff Creek has been offset from the main ultramafic belt at Neff Creek by an important fault trending northerly subparallel to July Creek. These ultramafic 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 ultramafic rock were intruded advantageously into the pre-existing sheared intrusive contact between the 'Old Diorite' (A) and the Attwood argillites (5).

These ultramafic 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 rust-brown coloured.

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

In thin section, a typical sample of ultramafic rock is composed of a cataclastic aggregation of antigorite, talc and carbonate minerals interspersed with ragged pyroxene remnants and concentrations of opaque ore 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 ultramafic rock (Table 1, no.8) shows approximatey 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. Ultramafic 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 ultramafic clasts is assigned to the Tertiary Springbrook Formation (10a).

Diorite and Monzodiorite (G): A series of scattered intrusions, petrographically similar to lavas of the Marron Formation, are considered to be among the youngest intrusive rocks in the map area. These include a wide variety 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 plagioclase plates, 20 per cent, biotite, 5 per cent, and pyroxene subhedra, 2 per cent. These mircophenocrysts range in grain size from 1 to 4 millimetres. They are set in a fine grained matrix of randomly oriented laths of plagioclase, 30 per cent, and potassium feldspar, 15 per cent, with interstitial wedges of quartz, 15 per cent, scattered biotite, 3 per cent, pyroxene, 2 per cent, magnetite, 2 per cent, apatite, 1 per cent, and alteration minerals, 5 per cent. Chemical analysis of a sample of this rock from the Mabel claim is very similar to analysis of monzodiorite from Lookout Hill, immediately north of Phoenix (Table 2, 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: quartz, 6.5 per cent; potassium feldspar, 27.2 per cent; plagioclase, 41.1 per cent; clinopyroxene, 22.8 per cent; and magnetite, 2.4 per cent; (Table 2, no.3).

The Coryell alkaline intrusion on the Sappho claim hosts sulphide mineralization bearing gold, silver, platinum and copper values. The principal phases of this intrusion are shonkinite and pyroxene monzonite. Subsidiary phases include small amphibolitic pegmatoids and segregations enriched in potassium feldspar. Mineralization consists of pyrite and chalcopyrite disseminated in shears and irregular blebs in biotite shonkinite and sericitized feldspathic phases.

The age of the Coryell intrusions is considered to be Eocene. This agrees with a 53 ± 5Ma potassium - argon date obtained on biotite from the Allendale Lake stock east of Okanagan Falls.

TABLE 1
ANALYSES OF IGNEOUS ROCKS

	1	2	3	4	5	6	7	8	9
Oxides Recalculated to 100:									
SiO_2	52.43	50.29	54.19	58.42	72.44	66.77	66.44	47.05	38.03
TiO_2	0.22	0.14	0.37	0.58	0.41	0.50	0.42	<0.04	0.50
Al_2O_3	19.45	16.87	15.64	17.92	16.25	15.89	16.22	1.06	16.18
Fe_2O_3	1.15	0.87	1.12	6.73	0.73	2.10	2.00	2.63	3.71
FeO	5.57	7.78	6.42		1.78	2.30	2.25	5.82	2.37
MnO	0.14	0.17	0.13	0.19	0.01	0.11	0.06	0.13	0.22
MgO	8.59	11.41	8.49	2.74	1.13	1.82	2.00	42.70	38.77
CaO	8.06	10.04	10.39	8.04	0.01	4.88	4.46	0.61	0.18
Na_2O	3.51	1.96	2.61	3.24	5.63	3.33	3.46	-	0.03
K_2O	0.88	0.47	0.64	2.14	1.61	2.30	2.69	-	0.01
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Oxides as Determined:									
H_2O+	3.24	3.95	2.41		3.42	0.92	0.87	8.63	12.50
H_2O-	0.28	0.26	0.11		0.17	0.19	0.24	0.20	0.27
CO_2	0.41	<0.14	<0.10		0.06	0.13	0.45	0.76	0.18
P_2O_5	0.20	0.20	0.16	0.14	0.10	0.50	0.18	0.20	0.20
S	0.01	0.01	0.20	<0.01	0.08	0.02	0.02	0.02	0.01

Key to Analyses

1. Feldspathic diorite north of Skomac mine - see Church (1985), No. 3, p. 5.
2. Gabbroic phase of 'Old Diorite' at Winnipeg mine.
3. Hartford Junction microdiorite - see Church (1984), No. 4, p. 8.
4. Providence Lake microdiorite from south shore of Providence Lake.
5. Lexington quartz porphyry, City of Paris mine - see Church (1970), No. 1, p. 419.
6. Wallace Creek granodiorite, Denero Grande shaft - see Church and Winsby (1974), No. 5, p. 44.
7. Lion Creek granodiorite, Oro Denoro mine area - see Church (1976), No. 6, p. 3.
8. Ultramafic intrusion at Skomac mine - see Church (1985), No. 4, p. 5.
9. Ultramafic body on north slope of Knob Hill.

TABLE 2
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

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.

TABLE 3
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	7.05	2.37	3.11	1.89	1.65	2.94	1.55
FeO	5.26		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		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		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

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 Mt. 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.

TABLE 4
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

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 (Penticton 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.

TABLE 5
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

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.

TABLE 6
ORE PRODUCTION FROM THE GREENWOOD CAMP

Deposit	Easting	Northing	Tonnes	Au kg	Ag kg	Cu Tonnes	Pb Tonnes	Zn Tonnes
Athelstan	858	357	34 163	198	231		7	
Bay	793	382	446	17	14			
City of Paris	825	296	2 041	27	152	60	1	
E Pluribus Unum	788	381	572	45	229		8	1
Gold Bug	773	410	341	3	66		26	7
Gold Drop	833	469	296	5	29			
Goldfinch	784	382	300	18	88		8	2
Greyhound	759	400	184 280	16	349	597		
Humming Bird	788	385	943	24	52			38
Jewel	825	466	123 260	1 219	7 170		163	3
Keno	840	358	352	2	102		3	
Last Chance	792	391	807	5	3 048		6	2
Marshall	829	408	249	12	15		2	
Mother Lode	747	412	4 209 252	5 548	22 441	36 278		
No. 7	803	315	13 746	92	3 110		97	6
North Star	861	422	6 180	24	475		9	5
Oro Denoro	869	425	354 755	328	3 381	4 018		
Phoenix	835	395	26 956 525	30 225	92 055	230 050	1	
Providence	782	409	10 647	189	43 228		193	125
Republic	751	354	1 531	18	3 186		21	9
Sappho	753	293	102		6	6		
Skylark	804	386	1 842	22	5 282		26	5
Winnipeg	852	367	55 806	402	1 207	127		

MINERALIZATION

Most mineral production in the Greenwood mining camp has come from copper bearing skarn deposits. To a lesser extent, production has been derived from gold and silver bearing quartz veins with minor lead and zinc values. Production to date from the 23 principal mines in the area is given in Table 6. The aggregated total for these mines is 31958436 tonnes of ore that yielded 38439 kilograms of gold, 185916 kilograms of silver, 271136 tonnes of copper, 571 tonnes of lead, and 203 tonnes of zinc.

The combination of a long geological history of mineralization and a wide range in types of deposits in the Greenwood area insures good potential for new discoveries. 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 Skylark silver 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 Skomac mine are examples of former operations and current prospects centred on precious metal veins in or adjacent to intrusive lenses of ultramafic rock of possible Cretaceous age.

The classical metallogenic model for the area, supported by LeRoy, McNaughton, Seraphim and Little, relates mineralization of a wide range of host rocks to the igneous intrusive events, especially the emplacement of granodiorite plutons (Figure 1). 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 (Figure 2)-(preliminary results supplied by K.E. Dawson of the Geological Survey of Canada). This linear lead relationship connects diverse deposits such as skarns nos. 1 and 2 with veins of ultramafic setting nos. 8, 9 and 10, and veins satellitic to the granodiorite nos. 5, 6 and 7. This pattern is characteristic of mixing, tying together diverse hydrothermal plumbing systems.

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

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