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## Metallogeny of the Greenwood Mining Camp (082E02)

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## *Abstract*

The Greenwood mining camp comprises more than 25 former mines, including the Phoenix mine, an open pit copper-gold skarn deposit, and similar smaller producers such as Mother Lode, Oro Denoro, and Greyhound, several significant polymetallic vein deposits, and more than 120 surrounding mineral prospects.

The region is underlain principally by large Mesozoic and Tertiary granitic plutons that were intruded into the Proterozoic pericratonic Monashee complex and accreted Paleozoic and Mesozoic oceanic and arc rocks of the Slide Mountain and Quesnel terranes. These terranes were delaminated from the oceanic lithosphere and stacked against the continental margin of the North America craton by the mid-Jurassic. Overprinting by Cretaceous Laramide and post-Laramide Tertiary transtensional structures has complicated the geology.

The combination of igneous intrusion, limestone strata, and mineralization is repeated frequently throughout the camp, and there is little question that intrusion of the Jurassic and Cretaceous granitic plutons provided not only the thermal engine driving circulation of mineralizing solutions to produce pyrometasomatic and porphyry-type deposits, but that these intrusions also provided the structural setting for the development of many vein fissures. A linear lead isotope relationship that connects diverse deposit-types in the area appears to be the result of fluid mixing within a well-connected hydrothermal plumbing system.

The Phoenix ore body is localized by faulting, the footwall argillite, and impurity of the overlying limestone. Although igneous source rocks are unknown, it is assumed that a deep-seated granitic body under the mine area produced the mineralizing solutions that were channeled by faults to facies in the Brooklyn Group limestone favourable for replacement and deposition.

Current exploration is focused on some of the oldest and youngest assemblages in the Greenwood area. Units of the Slide Mountain terrane, such as the Paleozoic Knob Hill and Attwood groups, hold promise for the discovery of stratiform polymetallic VMS-type deposits. Tertiary mineralization includes epithermal Au-Ag veins, sulphur-poor silica sinter deposits, and Carlin-type deposits with bulk tonnage potential.

## *Introduction*

The Canadian Cordillera is a collage of oceanic and arc terranes that were accreted to the western margin of the North American craton during the Mesozoic (Price, et al., 1985). After final docking in mid-Cretaceous, the terranes were disrupted by major strike-slip faults. Post-accretionary volcanism and block faulting were particularly widespread during the Tertiary in the Intermontane Belt (Souther,

1977; Monger, et al., 1982).

The Grand Forks-Greenwood area is part of a well-mineralized region in the southern interior of British Columbia (Figures 1a and b). The map-area (082ESE) straddles several important physiographic-tectonic domains. Much of the area west of Christina Lake and the Arrow Lakes is part of the Interior Plateau; the Selkirk Mountains lie to the east, and the Okanagan Highlands are mostly west of the Kettle River.

Lode mineralization was first recorded near Greenwood in 1884 where major deposits of copper and gold were mined since the turn of the century (Brock, 1903). Most of the mineral production from the Greenwood mining camp is from copper-bearing skarn deposits, to a lesser extent polymetallic quartz veins and, less commonly, copper-gold porphyry deposits. A more detailed breakdown of the area shows 12 vein-type producers related to granodiorite stocks, four vein producers related to fault zones, six in skarns, two mineralized listwanites, one magmatic orebody, and one porphyry copper deposit. Production to date from the 26 principal mines stands at 32,044,173 tonnes of ore consisting of 38,278 kilograms of gold, 183,102 kilograms of silver, 270,945 tonnes of copper, 966 tonnes of lead, and 329 tonnes of zinc.

**Figure 1a: Geology, Legend and Mineral Occurrences of the Greenwood Mining Camp (082E02)**

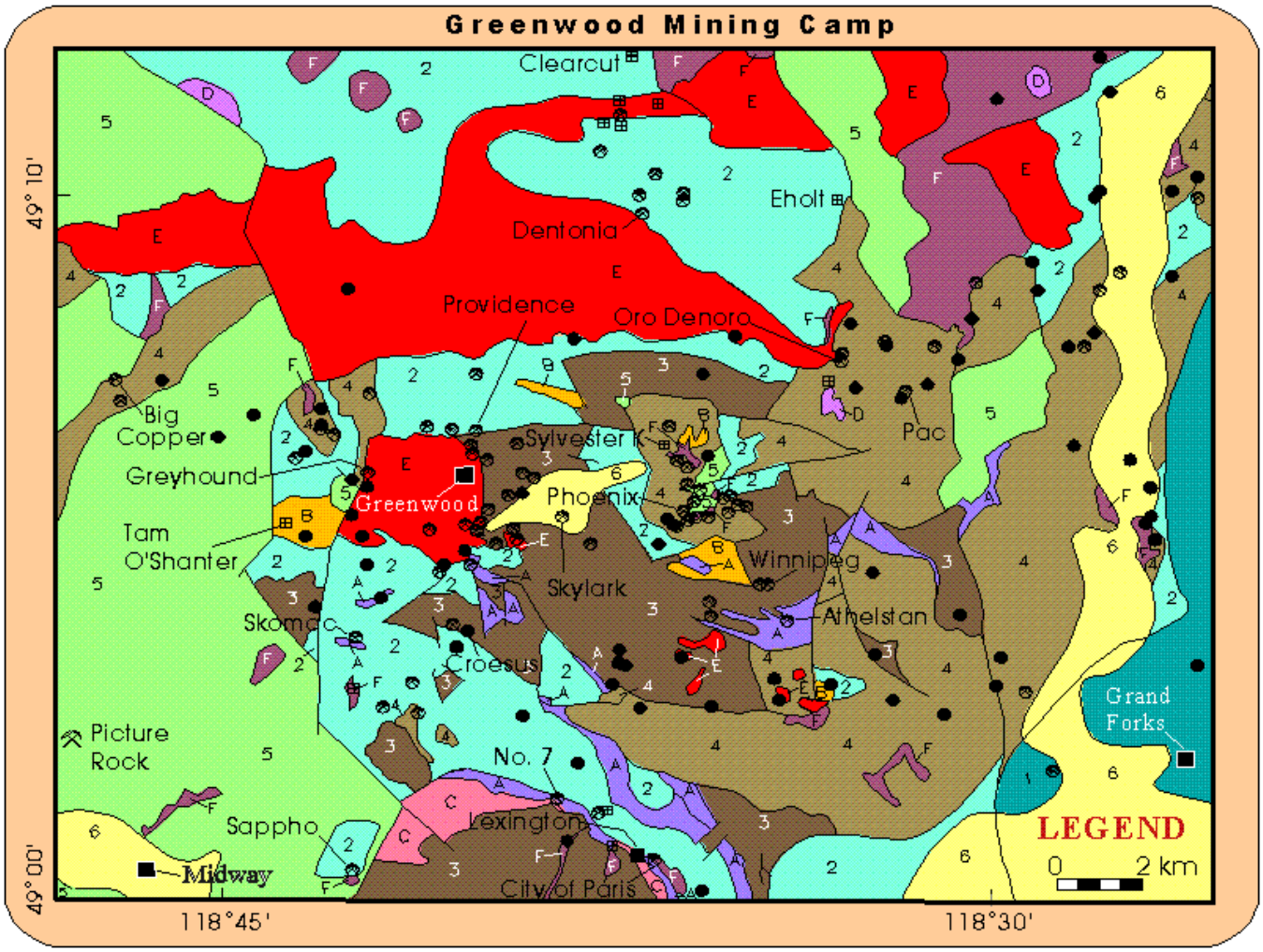
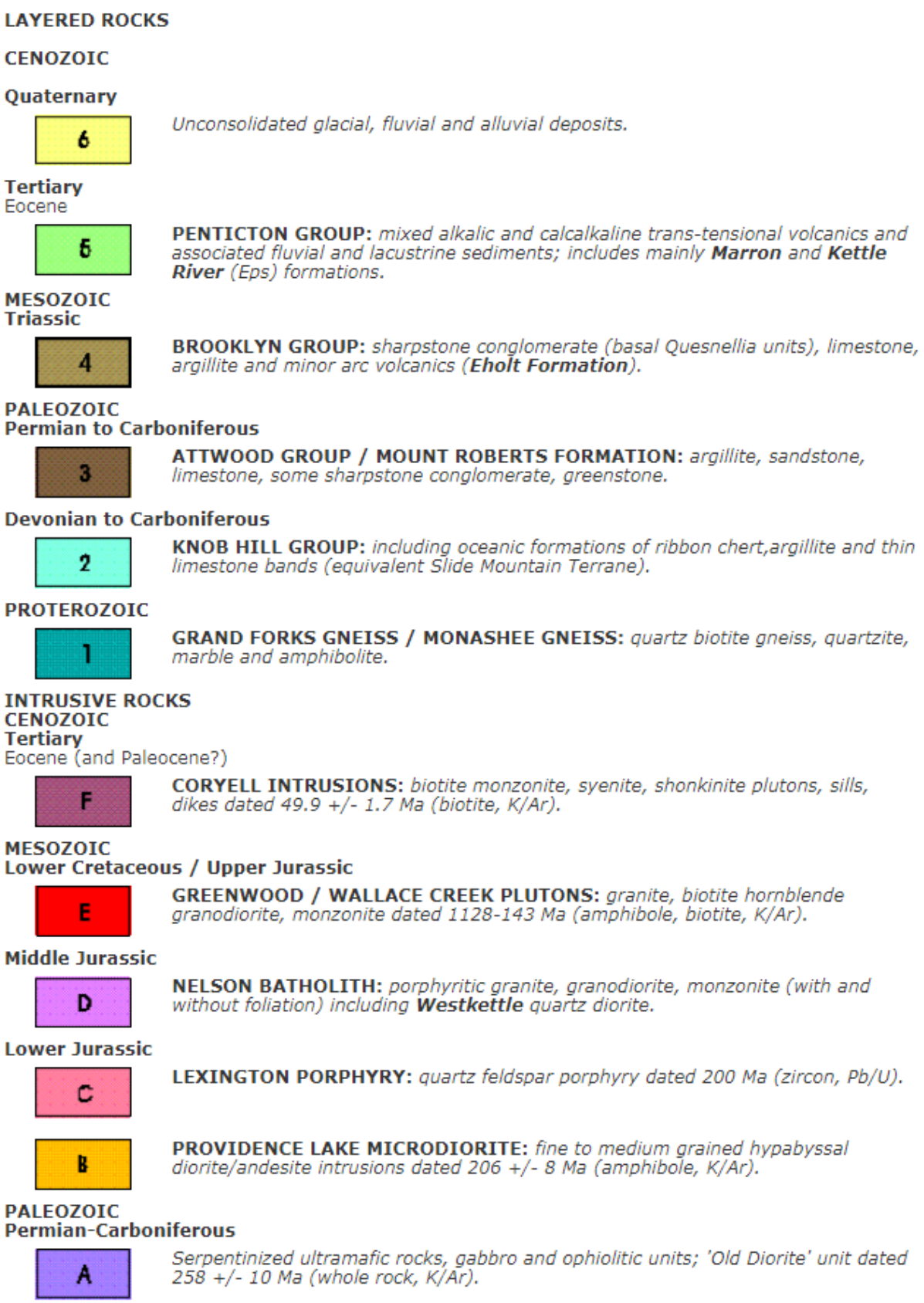


**Figure 1b: Geological Legend Greenwood Mining Camp:**



**Geological map and legend compiled from:**
**Church, B.N. (1986):** Geological Setting and Mineralization in the Mount Attwood - Phoenix Area of the Greenwood Mining Camp; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1986-2, 65 pages; Map scale 1:25,000.
**Fyles, J.T.** (1990): Geology of the Greenwood - Grand Forks Area, British Columbia NTS 82E/1,2; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-25, 37 pages; Map scale 1:50,000.
**Höy, T., Church, B.N., Legun, A., Gibson, G., Glover. K., Grant, B., Wheeler, J.O. and Dunne, K.P. (1994):** Geology of the Kootenay River Map Area; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-8; diskettes, map and text.
**Little, H.W. (1957):** Kettle River (East Half) British Columbia; *Geological Survey of Canada*, Map 6-1957, scale 1:253,440.
**Little, H.W. (1983):** Geology of the Greenwood Map-Area, British Columbia; *Geological Survey of Canada*, Paper 79-29, 37 pages; Map 1500A, scale 1:50,000 (082E02).
**Okulitch, A.V. (1978):** Thompson-Shuswap-Okanagan, British Columbia; *Geological Survey of Canada*, Open File 637, scale 1:250,000.
**Tempelman-Kuit, D.J. (1989):** Geology, Penticton, British Columbia; *Geological Survey of Canada*, Map 1736A, scale 1:250,000 (082E).
**Wheeler, J.O. and McFeely, P. (comp.) (1991):** Tectonic Assemblage Map of the Canadian Cordillera and adjacent parts of the United States of America; *Geological Survey of Canada*, Map 1712A, scale 1:2,000,000.

## *Geological Setting*

The Greenwood mining camp is a 400-square kilometre area bounded on the north by the Coryell and Ladybird plutons, on the west by the Toroda Creek graben, and on the east and south by the Granby fault and structures related to the Republic graben. The camp is underlain by more than a dozen mappable units comprising a variety of sedimentary, volcanic, metamorphic, and intrusive rocks that range from Paleozoic to Tertiary. The unit names used in this report are the same as those in current geological literature about the Boundary area of British Columbia and adjacent parts of Washington State.

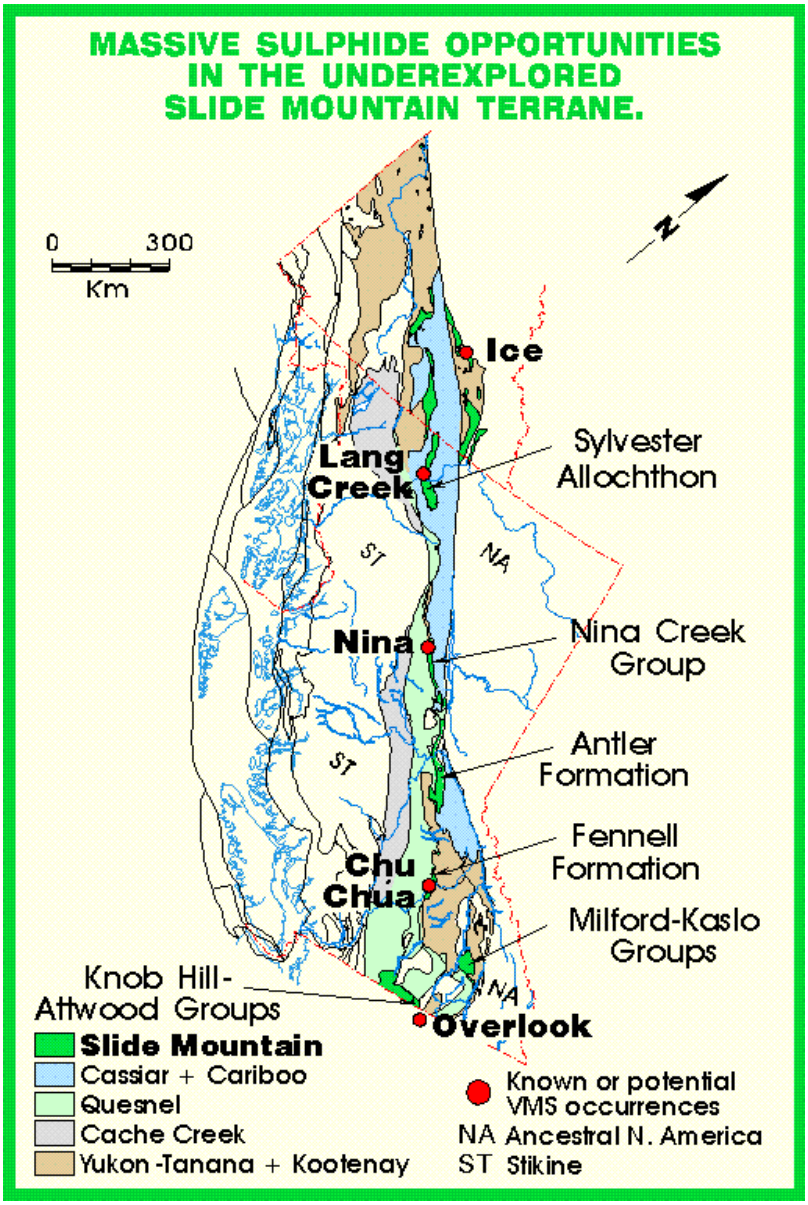
### Slide Mountain Terrane

Permo-Carboniferous ophiolitic ultramafic rocks, basic intrusions, and bedded oceanic suites of the Anarchist, Knob Hill, and Attwood groups in the Greenwood area are similar to units in the Slide Mountain terrane such as the Milford-Kaslo groups in the Kootenays and the Fennell Formation in the Clearwater area (Figure 2). The Knob Hill Group is Permo-Carboniferous (possibly as old as Devonian), and consists of banded metacherts, quartz-chlorite schist, amphibolitic schists and gneisses, and a few recrystallized limestone bands. The Attwood Group is Permian and consists mainly of dark argillite, greywacke, conglomerate, thick fossiliferous limestone lenses, and metavolcanic units. The 'Anarchist Group' comprises mostly undivided Knob Hill and Attwood formations that are folded and faulted. The Chesaw thrust fault (Jurassic) is locally exposed near the international border where ophiolites and Knob Hill Group are thrust over the Attwood Group (Cheney, et al., 1996). In the Greenwood area, imbricates of the Chesaw fault bound at least 5 separate belts of serpentinite, listwanite, and metagabbro (Fyles, 1990).

### Quesnel Terrane

The Quesnel terrane is represented in the area mainly by the Brooklyn Group (mid-Triassic) and the Nelson batholith and equivalent volcanic rocks. These rocks show evidence of penetrative deformation and chlorite-grade regional metamorphism. The Brooklyn Group is basal Quesnellia unit. The group structurally overlies both the Knob Hill and Attwood sequences and is characterized by thick basal 'sharpstone' conglomerate, interfingering shales and limestones, and an upper sequence of volcanic breccias (Church, 1986). The 'sharpstone' typically contains abundant clasts derived from older terranes composed largely of ribbon chert such as the Cache Creek and Knob Hill groups (Seraphim, 1956). The Nelson plutonic rocks (Jurassic) are considered feeders to Rossland volcanic rocks, which occur at the southern extremity of the Quesnel arc in the interior region of British Columbia (Hõy and Dunn, 1997).

Figure 2: Slide Mountain Terrane




### Post-Quesnellian Terranes

The Laramide orogeny (late Cretaceous/early Tertiary) in the Greenwood area is marked by intrusion of the Ladybird granite, and followed by post-Laramide orogenic collapse (Eocene) that features graben development and late plutonism, including emplacement of the Coryell batholith.

The Penticton Group (Eocene) is the youngest assemblage in the camp and consists of the Kettle River and Marron formations (Church, 1986). The Kettle River beds are fluvial and lacustrine feldspathic sandstones and siltstones; the Marron Formation comprises several alkalic and calcalkalic volcanic units fed in part by dikes and sills emanating from the Coryell batholith. These rocks were titled by block faulting related to graben development and major detachment tectonics (Tempelman-Kluit and Parkinson, 1986; Wingate and Irving, 1994).

## *Metallogeny*

The most important metallic mineral deposits of the Greenwood mining camp are massive sulphides and disseminations related mostly to skarns, porphyries, and veins. Other less common types of mineralization include volcanogenic massive sulphide deposits (VMS), magmatic-hydrothermal deposits, and unconformity related deposits. The following metallogenic interpretations are augmented by synoptic descriptions of the main deposit types in the Appendix of this report.

### Skarns

The history of the Greenwood mining camp is essentially the history of the Phoenix mine (082ESE020) and other large copper-gold skarn deposits in the area, such as the Mother Lode (082ESE034), Greyhound (082ESE050), and Oro Denoro (082ESE063) mines. In the case of the latter examples, the proximity of these ore deposits to the Wallace Creek granodiorite pluton and the Brooklyn Group limestone fits the classical setting of skarn deposits (Sutherland Brown et al., 1971; Ray and Webster, 1997). The combination of igneous intrusion, limestone strata, and mineralization is repeated throughout the camp. However, the Phoenix orebody is unusual in that it lacks a known accompanying granitic intrusion. Nonetheless, the extensive deposits of copper ore, which are almost exclusively stratabound with calc-silicate alteration of limestone, have all the characteristics of

metasomatic replacements. These replacements are composed of chlorite-epidote skarns containing variable amounts of garnet, calcite, and quartz, accompanied by blebs and disseminations of pyrite, chalcopyrite, magnetite, and specularite. The skarn and copper minerals are localized in a band of impure Brooklyn Group limestone above a well-defined footwall argillite. The thickness of mineralization varies from a maximum of 60 metres to less than 1 metre at the limits of mining. The ore beds generally dip east, but dips determined for individual beds vary because of N-S faults. Fahrni (1966) considered that a cryptic deep-seated granitic body under the mine area produced the mineralizing solutions, which were then channeled by the faults to facies in the limestone favourable for replacement and deposition.

It remains unclear if other deposits in the area, such as Eholt (082ESE239) and Emma (082ESE062) skarns, are related to plutons like the nearby Wallace Creek pluton or Coryell batholith. Peatfield (1978) and others argued that a transitional argillaceous zone between the sharpstone conglomerate and limestone in the Brooklyn Group may have been the site of original copper-iron deposition, and that subsequent metamorphism produced stratiform skarn-like deposits.

The Sylvester K (082ESE046) deposit is a steep easterly dipping zone of massive sulphides, mostly pyrite with some gold values. The deposit is 160 metres long, up to 2.5 metres wide and appears to be concordant within Brooklyn Group strata. Although a volcanogenic origin has been considered (Church, 1984), tuffs or vent rocks have not been identified in the area, and the deposit is on strike with the nearby San Jacinto (Marshall) (082ESE031) deposit, which is a more typical skarn. Church (1984) considered that metasomatizing fluids followed Providence Lake microdiorite dikes at San Jacinto then infiltrated carbonate unit bedding planes, with recrystallization producing granular or sugary textures that facilitated further infiltration and eventual wholesale replacement.

## Volcanogenic Massive Sulphide Deposits

The Slide Mountain terrane contains several volcanogenic massive sulphide deposits (VMS). Examples include the Chu Chua (092P 140) deposit in the Fennell Formation, the Nina (093N 011) deposit in the Nina Creek Group, and the Lang Creek (104P 008) occurrence in the Sylvester Allochthon (Figure 2). Similar Slide Mountain equivalent rocks in the Greenwood area have VMS potential. For example, the Clearcut Rhodonite (082ESE241) occurrence is a stratabound deposit associated with what appears to be the metamorphic equivalent of volcanic rocks and siliceous and pelitic sedimentary rocks of the Knob Hill Group. The absence of primary detrital textures in the silica-rich host rocks is consistent with a chemical precipitate protolith, either of sedimentary or hydrothermal origin. Many similar manganese deposits are considered distal equivalents of volcanogenic massive sulphide deposits (Simandl and Church, 1996).

The Overlook mine in Washington State is a VMS associated with the Attwood Group, where overturned limestone forms the hanging wall of the deposit (Lasmanis, 1996). The Overlook, previously thought to be skarn-related, is similar to the Sylvester K (082ESE046) deposit at Greenwood, which contains gold associated with magnetite and sulphides hosted by limestone.

The VMS model has also been applied to the Croesus (082ESE123) occurrence in the Greenwood camp. This showing consists of an alignment of sulphide lenses, several hundred metres in total strike length, associated with Attwood limestone, greenstone, and dark argillite. A cross-section of the main mineralized zone shows 7.5 metres of massive sulphides consisting of massive pyrite, pyrrhotite, sphalerite, and fine-grained chalcopyrite.

## Porphyry Deposits

The Lexington intrusion, accompanied by copper-gold porphyry-type mineralization, was emplaced in the early Jurassic, near the time the Quesnel arc accreted to the North American craton (Seraphim et

al., 1996).

The Lexington (082ESE041) and Lone Star copper-gold deposits are part of a 3-kilometre long linear porphyry system that straddles the U.S.-Canada border south of Greenwood. This system forms a northeast-dipping belt of sheared quartz porphyry and serpentinite. Theories regarding the genesis of the copper-gold porphyry mineralization generally involve faulting and emplacement of the Lexington intrusion, which has been dated 200 Ma (U/Pb zircon) (Church, 1992). The serpentinite in the Lexington area was emplaced first, as a ductile body into the northeast-dipping No. 7 (082ESE043) fault zone, which is thought to be an imbrication of the Chesaw thrust (Church, 1997).

Later, the Lexington magma, in one or several pulses, intruded the same fault zone, dividing the serpentine into upper and lower bodies. The parental magma was contaminated by, or derived from, Paleoproterozoic basement rocks (2445 Ma, U/Pb) (Church, 1992). Continued movement on the fault zone resulted in penetrative deformation of the serpentinite and the Lexington quartz porphyry. Although the porphyry is generally sheared, the margins of the body are locally intact and contain disseminations of pyrite, chalcopyrite, and minor molybdenite from the time of initial cooling, and concentrations of sulphides and magnetite resulting from contact metamorphism of serpentinite and liswanitic wall rocks. Later movement fractured the margins of the intrusion allowing emplacement of the City of Paris (082ESE042) vein system, which was then itself sheared by younger movement.

## Veins

An extensive and intricate fissure system provided the necessary channelways for the metalliferous solutions that formed the vein deposits of the Greenwood mining camp. In many cases, igneous intrusions served principally as heat engines in the process of convection and dispersion of the solutions. A linear lead isotope relationship that connects diverse deposit-types in the area appears to be the result of mixing in a well-connected hydrothermal plumbing system (Church, 1986).

The oldest veins in the Greenwood camp are mesothermal quartz veins with high silver values and variable amounts of gold, silver, copper, lead, and zinc. The Providence (082ESE001) and Dentonia (Jewel) (082ESE055) vein systems have been worked intermittently since the turn of the century. These veins are hosted mostly in the Knob Hill Group but originate in the adjacent Greenwood and Wallace Creek granodiorite stocks.

The workings of the Providence mine follow ore shoots in a narrow quartz vein. The ore minerals consist of pyrite, galena, sphalerite, chalcopyrite, tetrahedrite, proustite, native silver, and free gold in quartz carbonate gangue. The vein strikes 050 degrees and dips 40 to 60 degrees southeast. It has been traced underground for more than 370 metres and ranges from less than 1 to 75 centimetres wide. 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 workings the vein pinches to a gouge-filled fissure on passing from relatively hard silicified rocks to soft chloritic schists. On the lower levels, the vein appears to be more persistent in the silicified rocks than in the granodiorite.

The Dentonia vein, in the Jewel Lake area, trends northeasterly from the margin of the Wallace Creek pluton, cutting across greenstones, pelitic schists, and cherts of the Knob Hill Group. The vein averages about one metre wide and consists of grey disseminations and small pockets of sulphides in quartz. The ore minerals are pyrite and galena, with minor amounts of sphalerite, chalcopyrite, tellurides, and native gold. Abrupt changes in host rock composition appear to be an important control on mineralization, as vein attitudes refract and change in size at the interface of units of contrasting competency. Although the host rocks are not thought to have offered any special opportunity for

chemical reaction with ore bearing solutions, the view walls show local evidence of replacement. The age of the Dentonia vein is bracketed by the Wallace Creek granodiorite, which hosts the vein locally, and crosscutting young dikes. A sample of the granodiorite from the Denero Grande shaft area returned an early Cretaceous K/Ar date of 125 Ma (Church, 1986). The numerous feldspar porphyry and pulaskite dikes found in the mine workings are feeders to volcanic rocks in the Penticton Group (Eocene).

Many of the producing veins (Table 1) in the Greenwood camp are Mesozoic or Tertiary and hosted by the Attwood Group. The Skylark (082ESE011) vein is a silver-lead-zinc, quartz-carbonate fissure-filling deposit hosted by dark shales and greenstones of the Attwood Group. Similar veins in the Mount Roberts Formation, Burnt Basin camp (35 kilometres east of Greenwood), appear to be distally connected to the Nelson batholith.

Other sulphide-bearing veins, including the Winnipeg (082ESE033), Skomac (082ESE045), No. 7 (082ESE043), and Athelstan (082ESE047) lodes, are related to dismembered ophiolites in fault zones, and lack an obvious granitic source. At the Winnipeg mine, mineralization consists of pyrite, pyrrhotite, and pyrite in discontinuous quartz veins and lenses hosted by Attwood Group greenstones, ultramafic rocks, and associated gabbros. The veins fill fractures related to a major southeasterly trending fault. At the Athelstan and Jackpot (082ESE047) mines, the main units are serpentinite and listwanite, and the principal ores are gold and copper-rich sulphides. A band of listwanite up to 168 metres wide, extending between the Athelstan and Jackpot adits, is cut by an irregular system of fractures that served as channelways for ore-bearing solutions. The common ore minerals, pyrite and arsenopyrite, form replacements in the listwanite. The ore bodies are crescent-shaped in plan and section and plunge from 10 to 40 degrees easterly. The bodies range in thickness from 1 to 7.6 metres and were stoped over a length of 30 metres. The footwalls and hangingwalls of the ore bodies commonly follow well-defined fractures. The composition of the wall rock has had a marked influence on ore deposition such that the rocks containing a high percentage of carbonates were most susceptible to replacement by the ore-bearing solutions, whereas those composed of serpentine were the least susceptible.

Some of the youngest veins in the area are related to some of the oldest structures. For example, the City of Paris (082ESE042) vein system is associated with the No. 7 (082ESE043) fault zone and a belt of serpentinite that traverses the Lexington (082ESE041) property at the Canada-United States border (Little, 1983). The fault zone is an thought to be a continuation of the Chesaw thrust in Washington State (Cheney, et al., 1994). The associated serpentinite is interpreted to be part of a disrupted Paleozoic ophiolite composed primarily of peridotite (Fyles, 1990). Because of the incompetent nature of these rocks, the belt became the locus of shearing, thrusting, igneous intrusion, and vein mineralization. The common Mg-Fe carbonate-talc alteration (listwanite) and serpentinization are the product of major thrusting of the ophiolitic rocks.

The City of Paris veins record reactivation of thrusts at the contact between the Lexington quartz porphyry and hangingwall serpentinite during the development of the Republic graben. An analysis of fuchsite obtained from quartz splays in the listwanitic wall rocks yielded a K/Ar age of 56.7 ± 1.0 Ma (Church, 1997). In the early Tertiary these thrusts were reactivated by regional shortening at high angles to the developing northerly elongated graben structures and igneous activity (Church, 1997). Carr et al. (1987) interpreted the onset of regional extension in the southern interior of British Columbia to be 58 Ma (Paleocene/Eocene). The event is linked to interaction between the North American and the subducting Kula-Pacific plate boundaries (Struik, 1993).

Epithermal mineralization is best preserved in Tertiary structures. For example, the Knob Hill mine at Republic, Washington, exploits a significant epithermal gold-silver vein related to the Bacon Creek

fault at the west margin of the Republic graben (Lasmanis, 1996). In the Greenwood area, the Tam O'Shanter (082ESE130) is an epithermal prospect on the Deadwood segment of the Greenwood fault, which forms the east margin of the Toroda Creek graben. On the Tam O'Shanter prospect, the Greenwood fault divides the Penticton Group on the west and northwest from the Knob Hill Group to the east. The focus of exploration is a splay on the Deadwood fault that encloses a zone of basal Tertiary sedimentary rocks that are clay altered and locally silicified. A portion of the zone along the fault forms a silicified ridge that is characterized by brecciated fine grained mottled quartz with dark areas containing a small amount of fine pyrite.

### Other Deposits

Although remaining viable exploration targets, unconformity', 'Carlin-type' deposits and 'magmatic' have not been significantly mined in the Greenwood area. The Big Copper (082ESE053) deposit northwest of Greenwood consists of an oxidized cap with a small amount of native copper and copper carbonate accompanied by masses of black chalcocite assaying several per cent copper and appreciable silver and gold. The deposit is considered to be a pre-volcanic Tertiary regolith formed by weathering of mineralized Brooklyn limestone (Longe, 1977). The PAC (082ESE194) is a Carlin-type gold occurrence in the Summit area northeast of Greenwood where trenching exposed a small area of intensely silicified (sulphide-poor) Brooklyn limestone that has returned some high gold assays. Lateral secretion and transport of precious metals in sulphur-poor meteoric waters may be the process of mineralization. The 'magmatic deposits' of Sutherland Brown, et al. (1971) and 'alkali intrusion - associated Au-Ag deposits' of Lefebure and Hõy (1996) include the 'Au-Ag (PGE) deposits related to alkaline igneous rocks' described by Mutschler and Mooney (1993). The Sappho (082ESE147) deposit southwest of Greenwood is an example. Mineralization consists mostly of pyrite and chalcopyrite disseminations and pods in biotite shonkinite and pegmatitic phases of a small Coryell stock. The mineralizers are believed to represent immiscible fluids evolved in oxidized, $CO_2$-rich alkaline magma chambers.

## *Discussion*

Theories on the genesis of precious and base metal deposits in the Greenwood area generally involve igneous rocks. Epigenetic models, proposed by LeRoy (1912; 1913), McNaughton (1945), Seraphim (1956), and Ettlinger and Ray (1989) hold that some deposits are related to the emplacement of granitic intrusions. There is little question that emplacement of large granitic plutons can provide not only the thermal engine driving circulation of mineralizing solutions to produce pyrometasomatic and porphyry-type deposits but also provide the structural setting for the development of vein fissures. A syngenetic model introduced by Peatfield (1978) argues that other deposits have a volcanic-sedimentary origin and that the concentration of metals in certain stratigraphic units was during sedimentation, near volcanic vents or in backreef shale basins distal to volcanic sources.

A review of the magmatic history of southern British Columbia (Figure 3) shows Carboniferous to mid-Triassic volcanism is obscure and granitic plutons are almost always younger than this time interval (Armstrong, 1988). The oldest plutonic rock in the accreted terranes of the area, referred to as ‘Old Diorite’ and dated by K/Ar at 258 ± 10 Ma (late Permian), is closely associated with the belts of ultramafic rocks and the Knob Hill and Attwood groups (Church, 1986). These ancient rocks are poorly explored but contain hints of important mineralization such as found elsewhere in the Slide Mountain terrane. For example, several chromite lenses (082ESW149) and a nickel sulphide (082ESW055) occurrence near Rock Creek, west of Greenwood, are associated with the ultramafic rocks (Enns, 1971). Also, the Clearcut Rhodonite (082ESE241) and the Croesus (082ESE123) massive sulphide occurrences in the Knob Hill and Attwood groups, respectively, may be the first evidence of VMS deposits in the Greenwood area.

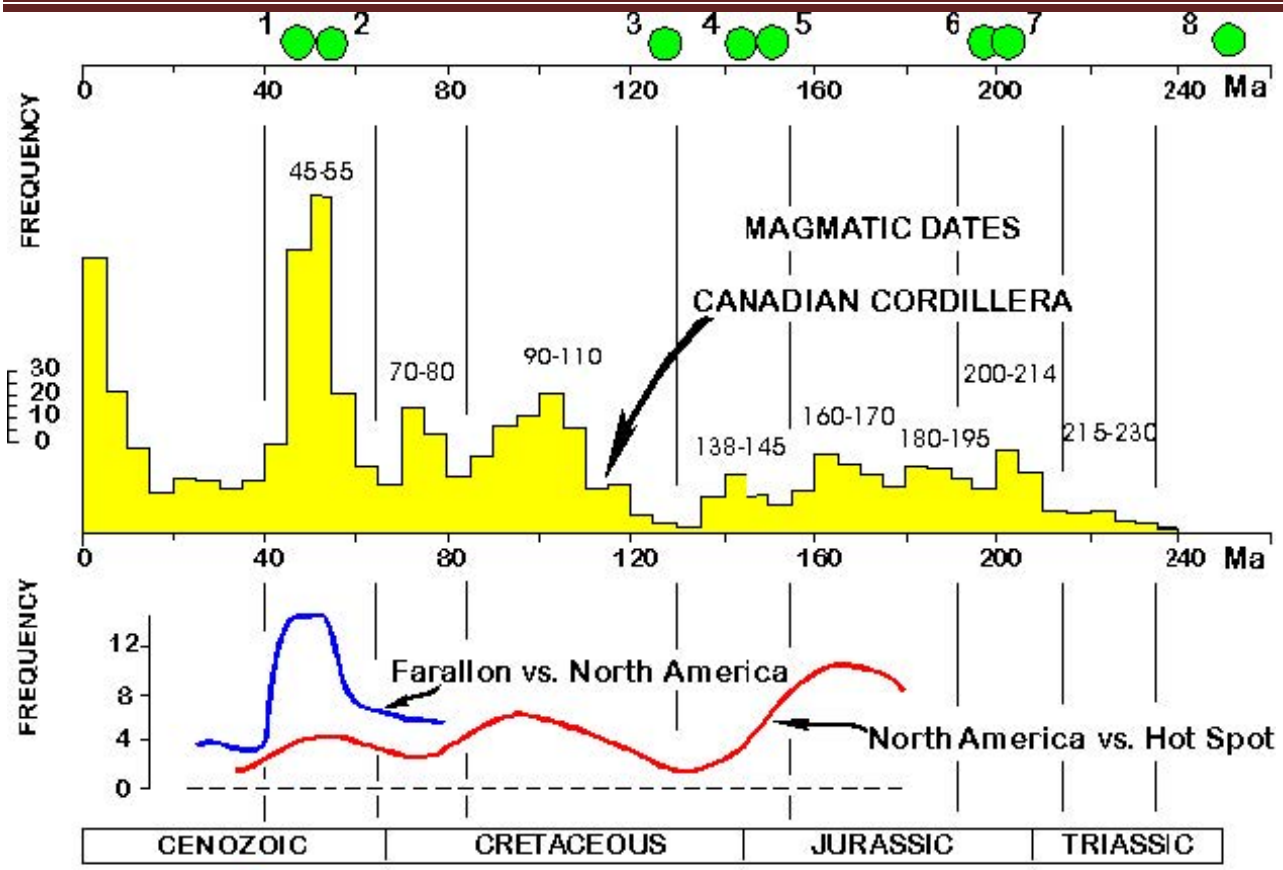



**Figure 3** RADIOMETRIC DATES FOR THE GREENWOOD AREA

| | | Lat. | Long. | Ma |
|---|---|---|---|---|
| 1 | Rock Creek chonolith (biotite) | 49°02.0' | 119°02.0' | **49.9+/-1.7** |
| 2 | City of Paris vein (fuchsite) | 49°00.6' | 118°36.5' | **56.7+/-1.0** |
| 3 | Wallace Creek granodiorite (amphibole) | 49°09.5' | 118°36.7' | **128+/-5.0** |
| 4 | Wallace Creek granodiorite (biotite) | 49°07.5' | 118°33.0' | **143+/-5.0** |
| 5 | Knob Hill schist (mica hornfels) | 49°07.5' | 118°34.3' | **150+/-5.0** |
| 6 | Lexington porphyry (zircon shell) | 49°00.5' | 118°36.5' | **200+/-2.3** |
| 7 | Providence Lake microdiorite (amphibole) | 49°06.3' | 118°36.3' | **206+/-8.0** |
| 8 | Winnipeg 'Old Diorite' (whole rock) | 49°04.4' | 118°34.3' | **258+/-10** |

According to Armstrong (1988) no granitic plutons of mid-late Triassic age are known in Quesnellia, although volcanic rocks of basic and intermediate composition are common. In the Greenwood area, the Providence Lake microdiorite body, dated by K/Ar at 206 ± 8 Ma, is thought to be consanguineous with the Eholt volcanics, the uppermost unit of the Brooklyn Group. The Providence Lake intrusion is weakly mineralized with disseminated pyrite and malachite, and the body appears to be the source of the Sylvester K (082ESE046) and San Jacinto (Marshall) (082ESE031) polymetallic skarn mineralization.

Southern Quesnellia stands out as a location of latest Triassic to early Jurassic granitic plutonism and accompanying porphyry Cu (Au, Mo) mineralization, such as associated with the Guichon Creek batholith, the Granite Mountain stock, and the Lexington intrusion. In the Greenwood area, the Lexington porphyry was intruded into thrusted oceanic rocks in the early Jurassic at 200 Ma, and

inherited zircon fractions dated 2445 Ma indicate that the porphyry was contaminated by Precambrian basement rocks in the process. Intrusion of the Lexington body in the early Jurassic suggests that at least the initial phase of accretionary docking of these oceanic rocks to the craton was completed at this time (Church, 1992). Final suturing of Quesnellia and the adjacent Slide Mountain terrane to North America was apparently completed between the early and middle Jurassic magmatic episodes as represented by the Nelson batholith in southern British Columbia (Armstrong, 1988).

There was little magmatism across the Cordillera from the latest Jurassic through the first half of the early Cretaceous. Notable exceptions include the Greenwood and Wallace Creek granodiorite plutons, dated by K/Ar at 128-143 ± 5 Ma. These intrusions are the most important mineralizers in the Greenwood camp and are directly or indirectly related to at least four Cu-Au skarn deposits, including the Mother Lode and Greyhound deposits, and 12 gold quartz and polymetallic veins, among which the Providence (082ESE001) and Dentonia (082ESE055) deposits are the chief ore bodies (Church, 1986).

From mid-Cretaceous onward, the Cordilleran margin of North America was largely assembled, and there were no major sutures east of the Coast Plutonic complex, although important igneous and tectonic events continued (Armstrong, 1988).

Other post-Quesnellian events include the Laramide orogeny (late Cretaceous/early Tertiary), which was marked by intrusion of the Ladybird granite in the Greenwood area, and followed by post-Laramide orogenic collapse (Eocene) featuring graben development and plutonism (the Coryell batholith). The City of Paris (082ESE042) vein system, dated by K/Ar at 56.7 ± 1.0 Ma, is the result of reactivation of a splay of the Chesaw thrust (Church, 1997). The somewhat younger Tam O'Shanter (082ESE130) epithermal deposit formed on the east bounding fault of the Toroda Creek graben northwest of Greenwood. At about the same time, the grabens were filled by the Penticton Group and coeval Coryell magmatism (K/Ar, 49.9 ± 1.7 Ma) and hydrothermal activity contributed Cu-Ag-Au (PGE) deposits such as Sappho (082ESE147) prospect west of Greenwood (Church, 1986; Mutschler and Mooney, 1991).

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## *Appendix*

The following synoptic descriptions of the principal mineral deposit types in the Greenwood-Grand Forks area (arranged alphabetically) are based on the data currently available in the MINFILE database of the B.C. Geological Survey. Mineral production in the Greenwood Mining Camp is listed in Table 1.

**Athelstan-Jackpot (082ESE047; Lat. 49° 3.9', Long. 118° 33.9'):**

The Athelstan-Jackpot mine is 8.5 kilometres southeast of Greenwood and 1.5 kilometres northwest of the confluence of Skeff and July creeks. Access to the mine is from an abandoned railway grade and connecting roads from the Winnipeg mine (082ESE033) and Hartford Junction to the northwest, and Highway 3 to the east.

The main production from the property during the period 1900 to 1940 was 16,739 tonnes of ore containing 187 kilograms of gold, 157 kilograms of silver, 50.8 tonnes of copper, and 193 kilograms of lead.

The Athelstan and Jackpot claims are underlain mainly by ultramafic rocks, including listwanite. The listwanite, consisting of talc and serpentine with subordinate carbonate minerals (ankerite and calcite) and mariposite, extends in an unbroken band up to 168 metres wide between the Athelstan and Jackpot adits. These rocks are cut by an irregular system of fracrures that served as channelways for ore-bearing solutions. The common ore minerals, pyrite and arsenopyrite, 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 three-metre wide open cut. Near surface, the ore is oxidized to limonite and a white arsenous oxide that attained shipping grade locally. The shape and size of several ore bodies that were mined can be inferred from the accessible workings. At the Jackpot mine, the two ore bodies mined from the adit crosscut were crescentric in plan and plunged from 10 to 40 degrees to the east along their longest axes. They ranged in thickness from one to 7.6 metres and probably averaged 3 metres. They were stoped along a length of at least 30.5 metres and across a width of at least 12 metres. At the Athelstan mine, the only accessible stope is about 18 metres long, averaging about 12 metres wide, and ranging from 1 to 2.4 metres in height. A winze sunk in the floor of this stope to a depth of 3.6 metres was entirely in ore.

The foot and hanging walls of the ore bodies commonly follow well-defined fractures, and in the mine workings, segments of ore are displaced by several northwesterly dipping normal faults. Sulphides extending beyond these fissures are commonly extremely erratic. The composition of the wall rock has had a marked influence on ore deposition; rocks containing a high percentage of carbonate minerals were most susceptible to replacement by the ore bearing solutions, whereas those containing appreciable serpentine were the least susceptible.

**Big Copper (82ESE053; Lat. 49° 07.4', Long. 118° 47.0'):**

The Big Copper deposit, on the Copper Mine claim, straddles the northeast-southwest trending ridge on Copper Mountain at the head of Wallace and Ingram creeks. Access to the property is by gravel road 8 kilometres west of Greenwood. The deposit adjoins the King Solomon (082ESE054) to the south.

The claim was located in 1887 and the earliest recorded development was in 1894, when a 5-metre shaft was sunk and a 12-metre tunnel driven. In 1917, the Big Copper and King Solomon mines together shipped 860 tonnes. In 1953 and 1954, further work led to the discovery of a body of sulphides, from which two carloads of ore were shipped.

On the Copper Mine claim (also known as 'Big Copper') the ore consists of an oxidized cap of red earthy hematite, with a small amount of native copper and copper carbonate accompanied by masses of black chalcocite below. The original ore assayed several per cent copper and appreciable silver and gold. Resampling of the old workings yielded grades ranging between 0.64 and 2.75 per cent copper across widths up to 4 metres. The copper-bearing unit is considered to be a pre-volcanic Tertiary regolith formed by weathering of mineralized limestone.

A diamond drill hole just west of the west boundary of the Copper Mine claim, encountered skarn mineralization associated with Brooklyn limestone, after penetrating 170 metres of Tertiary volcanic rocks. The last 16 metres of the hole were in skarn, including an interval from 179-180 metres of green epidote breccia in fine-grained dense purplish hornfels with 1-2 per cent disseminated pyrite.

## Table 1: Mineral Production in the Greenwood Mining Camp (082E02)

| MINFILE Number | Name | Mined (tonnes) | Gold | Silver | Copper | Lead | Zinc | Cadmium | First Year | Last Year |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (grams) | | (kilograms) | | | | | |
| 082ESE001 | PROVIDENCE (L.618) | 10426 | 183384 | 42551891 | 29 | 182657 | 117973 | 0 | 1893 | 1973 |
| 082ESE002 | ELKHORN (L.818) | 179 | 5193 | 456530 | 0 | 8156 | 1704 | 0 | 1905 | 1947 |
| 082ESE004 | GOLDFINCH (L.820) | 299 | 18102 | 88426 | 0 | 8038 | 1949 | 0 | 1902 | 1944 |
| 082ESE005 | BAY | 447 | 16981 | 14463 | 0 | 0 | 0 | 0 | 1904 | 1941 |
| 082ESE006 | EPU | 571 | 44601 | 229478 | 0 | 7624 | 1141 | 0 | 1903 | 1947 |
| 082ESE008 | DYNAMO (L.2087) | 385 | 3017 | 59220 | 0 | 27767 | 7292 | 0 | 1914 | 1955 |
| 082ESE010 | HELEN (L.691) | 42 | 186 | 6096 | 0 | 1861 | 117 | 0 | 1906 | 1940 |
| 082ESE011 | SKYLARK (L.763) | 35164 | 112721 | 17033147 | 9536 | 133305 | 48416 | 0 | 1893 | 1989 |
| 082ESE012 | CRESCENT (L.1711) | 250 | 1897 | 453762 | 0 | 3030 | 3482 | 0 | 1905 | 1959 |
| 082ESE013 | BROOKLYN (L.796) | 292834 | 854990 | 3430655 | 3567397 | 0 | 0 | 0 | 1900 | 1960 |
| 082ESE020 | PHOENIX (KNOB HILL) | 21552283 | 28340619 | 183035743 | 235692705 | 530 | 0 | 0 | 1900 | 1978 |
| 082ESE025 | SNOWSHOE (L.891) | 545129 | 1283993 | 4949950 | 6322089 | 0 | 0 | 0 | 1900 | 1911 |
| 082ESE026 | RAWHIDE (L.892) | 855634 | 1055668 | 6909502 | 8441446 | 0 | 0 | 0 | 1904 | 1916 |
| 082ESE028 | GOLD DROP (L.899) | 12 | 31 | 435 | 417 | 0 | 0 | 0 | 1900 | 1900 |
| 082ESE029 | BANK OF ENGLAND | 3 | 31 | 156 | 0 | 0 | 0 | 0 | 1938 | 1938 |
| 082ESE031 | MARSHALL (L.2388) | 370 | 15210 | 17635 | 472 | 2318 | 555 | 0 | 1967 | 1975 |
| 082ESE032 | GOLDEN CROWN | 2488 | 38537 | 69981 | 38053 | 0 | 0 | 0 | 1900 | 1941 |
| 082ESE033 | WINNIPEG (L.599) | 53316 | 363128 | 1136815 | 86463 | 173 | 0 | 0 | 1900 | 1940 |
| 082ESE034 | MOTHER LODE (L.704) | 4245875 | 5390837 | 21405520 | 34915323 | 0 | 0 | 0 | 1900 | 1962 |
| 082ESE035 | SUNSET (L.788) | 109305 | 144598 | 746938 | 866477 | 0 | 0 | 0 | 1900 | 1918 |
| 082ESE042 | CITY OF PARIS (L.622) | 1934 | 26686 | 150881 | 60390 | 960 | 151 | 0 | 1900 | 1963 |
| 082ESE043 | NO. 7 (L.623) | 13748 | 92409 | 3109897 | 0 | 97036 | 6227 | 0 | 1901 | 1945 |
| 082ESE044 | RUBY (L.1333) | 28 | 0 | 591 | 856 | 0 | 0 | 0 | 1956 | 1956 |
| 082ESE045 | SKOMAC | 3574 | 18550 | 851893 | 864 | 58435 | 35911 | 0 | 1903 | 1983 |
| 082ESE047 | ATHELSTAN (L.1065) | 16739 | 157195 | 186681 | 50796 | 193 | 0 | 0 | 1900 | 1940 |
| 082ESE048 | GOLD BUG (L.890) | 89 | 1336 | 68117 | 233 | 539 | 431 | 0 | 1901 | 1954 |
| 082ESE050 | GREYHOUND (L.1014) | 803326 | 15551 | 349007 | 596928 | 0 | 0 | 0 | 1970 | 1971 |
| 082ESE052 | MORRISON (L.654) | 2647 | 7153 | 26033 | 10717 | 0 | 0 | 0 | 1901 | 1903 |
| 082ESE053 | BIG COPPER | 2206 | 0 | 42642 | 71083 | 0 | 0 | 0 | 1912 | 1918 |
| 082ESE054 | KING SOLOMON | 1248 | 7869 | 52906 | 59161 | 0 | 0 | 0 | 1901 | 1955 |
| 082ESE055 | DENTONIA | 124644 | 1348459 | 8054963 | 6482 | 167997 | 4003 | 57 | 1900 | 1985 |
| 082ESE057 | HUMMINGBIRD | 942 | 23575 | 52501 | 254 | 82 | 37802 | 0 | 1900 | 1950 |
| 082ESE060 | B.C. (L.882) | 93874 | 31165 | 6664594 | 4093971 | 0 | 0 | 0 | 1900 | 1938 |
| 082ESE062 | EMMA (L.591) | 241538 | 211843 | 2433964 | 2350348 | 0 | 0 | 0 | 1901 | 1927 |
| 082ESE063 | ORO DENORO (L.692) | 123782 | 116450 | 953369 | 1690617 | 0 | 0 | 0 | 1903 | 1917 |
| 082ESE064 | R. BELL (L.1506) | 287 | 0 | 112749 | 21282 | 0 | 0 | 0 | 1901 | 1918 |
| 082ESE074 | LITTLE BERTHA (L.959) | 876 | 13251 | 120276 | 29 | 391 | 0 | 0 | 1900 | 1939 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 082ESE075 | PATHFINDER (L.782) | 239 | 746 | 4043 | 2330 | 0 | 0 | 0 | 1916 | 1916 |
| 082ESE079 | GOLDEN EAGLE | 1099 | 8927 | 81613 | 15296 | 0 | 0 | 0 | 1900 | 1941 |
| 082ESE112 | SPOTTED HORSE | 72 | 0 | 3328 | 0 | 2551 | 1286 | 0 | 1927 | 1965 |
| 082ESE122 | CYCLOPS (L.1244) | 259 | 0 | 0 | 0 | 0 | 15254 | 0 | 1952 | 1952 |
| 082ESE125 | RODERICK DHU (L.598) | 25 | 498 | 6874 | 0 | 0 | 0 | 0 | 1940 | 1940 |
| 082ESE126 | AMANDY (L.2795) | 1059 | 10637 | 196104 | 0 | 0 | 0 | 0 | 1936 | 1941 |
| 082ESE128 | MIDWAY MINE | 19 | 266 | 28617 | 0 | 156 | 156 | 0 | 1969 | 1979 |
| 082ESE130 | TAM O'SHANTER | 3 | 12 | 2052 | 0 | 0 | 0 | 0 | 1922 | 1922 |
| 082ESE135 | ELKHORN FR. (L.297S) | 44 | 249 | 241764 | 0 | 2268 | 5299 | 0 | 1925 | 1927 |
| 082ESE147 | SAPPHO (L.2039) | 102 | 0 | 6127 | 6161 | 0 | 0 | 0 | 1916 | 1918 |
| 082ESE149 | MABEL (L.609) | 106 | 435 | 1244 | 24 | 0 | 0 | 0 | 1937 | 1937 |
| 082ESE150 | LAKESIDE FR. (L.1023) | 156 | 1804 | 16143 | 0 | 0 | 0 | 0 | 1939 | 1941 |
| 082ESE151 | ETHIOPIA (L.932) | 34 | 311 | 23420 | 0 | 0 | 0 | 0 | 1922 | 1940 |
| 082ESE152 | NORTH STAR (L.1165) | 6178 | 23700 | 475285 | 0 | 9155 | 5307 | 0 | 1919 | 1940 |
| 082ESE153 | GOLD DROP (L.1415) | 335 | 5020 | 35894 | 53 | 758 | 160 | 0 | 1926 | 1988 |
| 082ESE158 | SEATTLE (L.652) | 296 | 902 | 4416 | 3093 | 0 | 0 | 0 | 1903 | 1916 |
| 082ESE163 | WINNER (L.1158) | 59 | 435 | 1026 | 0 | 0 | 0 | 0 | 1934 | 1940 |
| 082ESE165 | FREMONT(L.1217) | 5 | 31 | 4479 | 0 | 0 | 0 | 0 | 1918 | 1918 |
| 082ESE185 | COMBINATION | 11 | 653 | 60340 | 0 | 722 | 0 | 0 | 1923 | 1924 |
| 082ESE187 | SENATOR | 5178 | 9984 | 22674 | 10618 | 0 | 0 | 0 | 1903 | 1905 |
| 082ESE188 | BLUEBELL (L.2136) | 353 | 8055 | 3795 | 422 | 0 | 0 | 0 | 1938 | 1939 |
| 082ESE189 | YANKEE GIRL (L.1558) | 353 | 14308 | 11882 | 422 | 0 | 0 | 0 | 1936 | 1936 |
| 082ESE192 | KENO (L.1319) | 294 | 1244 | 101085 | 0 | 2711 | 275 | 0 | 1935 | 1940 |
| 082ESE212 | DEFIANCE (L.758) | 4 | 187 | 48054 | 0 | 122 | 0 | 0 | 1893 | 1924 |
| 082ESE215 | STRATHMORE (L.1018) | 198 | 4790 | 532638 | 0 | 4141 | 0 | 0 | 1906 | 1925 |
| 082ESE216 | LAST CHANCE (L.753) | 704 | 4665 | 3026166 | 0 | 0 | 0 | 0 | 1904 | 1935 |
| 082ESE247 | MAVIS (L.2877) | 29 | 591 | 1742 | 0 | 0 | 0 | 0 | 1905 | 1905 |
| 082ESE248 | DON PEDRO (L.2458) | 27 | 186 | 70635 | 0 | 0 | 0 | 0 | 1906 | 1919 |
| 082ESE249 | PRESTON (L.69S) | 16 | 62 | 18444 | 0 | 306 | 0 | 0 | 1906 | 1923 |
| 082ESE250 | PRINCE HENRY | 19 | 404 | 40060 | 0 | 1130 | 0 | 0 | 1906 | 1925 |
| 082ESE251 | TWIN (L.819) | 2 | 0 | 933 | 0 | 528 | 0 | 0 | 1922 | 1922 |
| 082ESE259 | LEAD KING (L.2071) | 7 | 0 | 9020 | 0 | 9612 | 1877 | 0 | 1950 | 1950 |
| 082ESE260 | SURPRISE NO. 3 | 87 | 0 | 2457 | 3717 | 0 | 0 | 0 | 1917 | 1918 |
| **Totals** | | **29153866** | **40044318** | **310909761** | **298996554** | **735252** | **296768** | **57** | **1893** | **1989** |

**Table 1: Mineral Production in the Greenwood Mining Camp (082E02)**

## City of Paris (082ESE042; Lat. 49° 00.5', Long. 118° 36.5'):

The City of Paris mine is 10 kilometres southeast of Greenwood and 1.1 kilometres north of the international boundary. Access to the mine is from the Boundary road, 1 kilometre west of the Phoenix - Lone Star haulage road.

Intermittent production from the City of Paris mine from 1900 to 1940 was 1926 tonnes of ore

containing 27 kilograms of gold, 139 kilograms of silver, 60 tonnes of copper and a small amount of lead and zinc. From 1962 to 1963, an additional 8 tonnes of ore was produced from the adjacent Lincoln claim, yielding 12 kilograms of silver, 373 kilograms of lead, and a minor amount of gold and zinc.

The City of Paris mine is on a vein system near the south contact of a major ultramafic lens. The system consists of two locally discontinuous, subparallel veins along the margin of a narrow serpentinite appendage flanking the main ultramafic body. The veins trend northwest at about 160 degrees and vary in width from 5 metres to mere stringers of ore. The vein 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 serpentinite appendage, is the source of much of the mined ore. The Lincoln vein is on the south side of the serpentinite appendage. Rocks in this area are impregnated with and traversed by stringers of quartz and calcite carrying sulphides, which diminish in amount with distance from the main lead. The ore on the northwest occurs in chutes and consists of argentiferous galena, sphalerite, tetrahedrite, chalcopyrite, and pyrite, whereas in the southeast drift the ore is almost massive pyrite and chalcopyrite. Some of the best assay results were obtained from the Lincoln shaft and portal area. The metal values are unevenly distributed, running in pay streaks. A grab sample from the vein near the Lincoln shaft assayed 2.1 grams per tonne gold, 182 grams per tonne silver, 1.84 per cent copper, 3.98 per cent lead, 0.12 per cent zinc, 0.073 per cent arsenic, and 0.93 per cent antimony.

The origin of the vein system is related to thrust reactivation at the contact between the Lexington quartz porphyry and hangingwall serpentinite during the development of the Republic graben. The veins clearly existed before emplacement of the Tertiary dikes, as evidenced by the damming of these dikes adjacent to the veins. However, the veins are also younger than the penetrative deformation that is commonly seen in the surrounding country rocks. An analysis of fuchsite obtained from quartz stringers in listwanite immediately north of the Lincoln workings, yielded a K/Ar age of 56.7 ± 1.0 Ma (Church, 1997).

**Clearcut Rhodonite (082ESE241; Lat. 49° 12.0', Long. 118° 37.0'):**

The Clearcut Rhodonite prospect is on the road leading to the microwave tower on Mount Roderick Dhu, 13 kilometres northeast of Greenwood.

The main exposure is a 10-metre long roadcut that displays pink pyroxmanganite and rhodonite coated with black manganese oxide. This rock has a sugary texture and grades into quartz-rich rock containing spessartine garnet and light coloured mica.

The host rocks are part of the Knob Hill Group that outcrops in a southeast-trending belt extending from the lower course of Clement Creek to Jewel Lake and thence to the area northwest of Mount Roderick Dhu. The Knob Hill Group consists of a variety of volcanic and sedimentary rocks converted to amphibolite and quartz-mica schists. The rocks are medium to fine grained, and medium to dark coloured. Foliation and gneissosity are commonly mistaken for primary bedding. The metasedimentary rocks consist of quartz (15 to 90 per cent), plagioclase, biotite, some garnet and magnetite, less common amphibole, chlorite, muscovite, and local andalusite. Because of recrystallization, metaquartzites and metacherts cannot be distinguished. The amphibolites generally form massive lenses, possibly derived from basaltic lava flows and pyroclastic rocks. Typically, the amphibolites consist of 40 to 70 per cent green amphibole and smaller amounts of plagioclase, quartz, magnetite, and titanite. Epidote, calcite, and quartz are abundant associated with small veins and fissures.

The Clearcut pyroxmanganite-rhodonite occurrence is a stratabound deposit associated with what appear to be metamorphosed volcanic rocks and siliceous and pelitic sedimentary rocks. The absence

of the primary detrital textures in the silica-rich host rocks is consistent with a chemical precipitate protolith, either of sedimentary or hydrothermal origin. Many similar manganese deposits are considered distal equivalents of volcanogenic massive sulphide deposits.

**Croesus (082ESE123; Lat. 49° 03.7', Long. 118° 40.0'):**

The Croesus claim is on the lower slopes of Mount Attwood, 2.5 kilometres south of Greenwood. Access to the area is from Highway 3 via the Lind Valley road and an old logging road that skirts the northwest spur of Mount Attwood.

The showings consist of aligned sulphide lenses (about 400 metres long) associated with limestone, greenstone, and black argillite units in the Attwood Group. The claim is bisected by a major southeast-trending fault along which units of the Attwood Group and serpentinite were thrust southwest over mainly cherts of the Knob Hill Group. A cross-section of the main mineralized zone shows 3 metres of limestone and 7.5 metres of massive sulphides and calc-silicates cut by a 15-metre dike. The principal sulphide minerals are massive pyrite and pyrrhotite, sphalerite and fine-grained chalcopyrite.

**Eholt (82ESE239; Lat. 49° 10.0', Long. 118° 33.0'):**

The Eholt property includes the Princess Louise, Delamar, and Orient Reverted Crown grant claims in the headwater area of Eholt Creek, 11 kilometres northeast of Greenwood and 16 kilometres northwest of Grand Forks. Access to the property is from several logging roads and the abandoned Kettle Valley Railway line through the settlement of Eholt, just north of Highway 3.

The Eholt property is underlain by moderately deformed Paleozoic and Mesozoic volcanic and sedimentary rocks and tilted but relatively fresh Tertiary beds. The rocks are cut by offshoots of the Wallace Creek granodiorite pluton and numerous small syenite and monzodiorite bodies related to the nearby Coryell batholith.

Two types of mineralization occur on the Eholt property: 1) massive sulphide and/or magnetite replacements in or associated with skarn occurrences; and 2) sulphide stringers and disseminations in the metavolcanics units and sharpstone conglomerate beds. The principal deposits are the 'Dead Honda' sulphide-rich skarn on the Orient claim, the 'Eholt Mountain' skarn containing disseminated sulphides on the Delamar claim, and the 'Brown Creek' skarn on the Princess Louise claim. Shallow workings at these localities expose garnet (± epidote, pyroxene) replacements in Brooklyn Group limestone and volcanic rocks containing pyrrhotite, pyrite, magnetite, and chalcopyrite in varying ratios and abundances. Drilling at Dead Honda tested a 200-300-metre wide, 1.5-kilometre long northerly trending mineralized zone containing sulphide-rich intersections of more than 25 metres grading up to 2.7 grams per tonne gold and 0.28 per cent copper. On the southwest slope of Eholt Mountain, disseminated pyrrhotite is in tremolite-altered Brooklyn sharpstone conglomerate. Southeast of Eholt Mountain, disseminations of pyrite, in concentrations of up to 3 per cent with traces of gold and copper, are common in fragmental metavolcanic rocks. Numerous dikes and sills related to the Coryell batholith form an intricate system cutting the mineralized areas.

**Greyhound (082ESE050; Lat. 49° 6.1', Long. 118° 42.1'):**

The Greyhound and Ah There (082ESE049) 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. The Mother Lode (082ESE034) and Sunset (082ESE035) claims lie 1700 metres to the northwest.

Production from the Greyhound open pit in the brief period of mine operations from 1970 to 1971 amounted to 803,326 tonnes of ore yielding 15.6 kilograms of gold, 349 kilograms of silver, and 597 tonnes of copper.

Work began on the Greyhound claim in 1900 with 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 adjacent 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 rock.

The property is underlain by skarnified units of the Brooklyn Group and granodiorite which forms the west boundary of the Greenwood pluton. Pulaskite dikes, 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, skarn, and granodiorite.

**Jewel (Dentonia) (082ESE055; Lat. 49° 9.7', Long. 118° 36.7'):**

The Jewel claim and four additional Crown-granted claims, including Denero Grande, Enterprise, Anchor, and Ethiopia (082ESE151), comprise what is known as the Dentonia property. This is centred approximately 10.5 kilometres east 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 between 1900 and 1985 totalled 124,644 tonnes of ore yielding 1348 kilograms of gold, 8055 kilograms of silver, 168 tonnes of lead, 4 tonnes of zinc, 6.5 tonnes of copper, and 57 kilograms of cadmium.

The claims are underlain by greenstones, pelitic schists, and chert of the Knob Hill Group that are cut by the Wallace Creek granodiorite pluton. The Dentonia quartz vein cuts northeasterly (020 degrees) across stratigraphic layering, averaging about 1 metre wide. Mineralization consists mostly of 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. Abrupt changes in host rock composition appear to be an important control on mineralization, as vein attitudes refract and change in size at the interface of units of contrasting competency. At the Jewel ore body, the vein is enlarged and somewhat refracted at the intersection of competent 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 fracture zone in homogeneous greenstone.

The age of the Dentonia vein is bracketed by the Wallace Creek granodiorite, which locally hosts the vein, and crosscutting young dikes. A sample of the granodiorite from the Denero Grande shaft area returned an early Cretaceous K/Ar date of 128 +/- 5 Ma (Church, 1986). The numerous feldspar porphyry and pulaskite dikes cutting across the mine workings are feeders to the Marron lavas of the Penticton Group (Eocene).

**Lexington (082ESE041; 49° 00.7', 118° 36.9'):**

The Lexington adit is 50 metres east of Goosmus Creek near the US border, 10 kilometres south of Greenwood. Access to the claim is 1.5 kilometres by dirt road west of the main Phoenix - Lone Star haulage road.

Much of the recent exploration has focussed on widespread, low-grade copper mineralization associated with the quartz porphyry intrusion on the Lexington, City of Paris (082ESE042), Lincoln (082ESE042), and adjacent claims. This porphyry mineralization is mostly contained in a 900-metre

long, 300-metre wide segment of the quartz porphyry exposed between the main ultrabasic intrusion and a smaller subparallel serpentinite splay near Goosmus Creek. The main ore minerals, pyrite and chalcopyrite, are primarily in fractures and disseminations and, to some extent, in quartz stockworks. Anomalous copper values have also been obtained in the serpentinite splay adjacent to the quartz porphyry intrusion near Goosmus Creek, just below the Lexington portal. This sheared serpentinite contains interfoliated impregnations and massive lenses of pyrite, chalcopyrite, and magnetite.

Ore reserves for this property, based on 1981 estimates, indicate 313,527 tonnes, grading 5.44 grams per tonne 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.

**Mother Lode (082ESE034; Lat. 49° 06.7', Long. 118° 43.0'):**

The property comprising the Mother Lode and Sunset (082ESE035) mines is centred 4 kilometres northwest of Greenwood at the elevation of 1050 metres. Access is by all-weather gravel road, which connects the property to the Mother Lode Creek road and Greenwood. The Greyhound (082ESE050) claim lies 1700 metres to the southeast.

Production from two periods of mining on the Mother Lode, 1900 to 1920 and 1957 to 1962, totalled 4,245,875 tonnes of ore yielding 5391 kilograms of gold, 21,406 kilograms of silver, and 34,915 tonnes of copper. Production from the Sunset between 1900 and 1918, totalled 109,305 tonnes of ore yielding 145 kilograms of gold, 747 kilograms of silver, and 866.5 tonnes of copper. Ore produced in 1960 from the Sunset is included with the Mother Lode.

Mineralization consists principally of pyrite, chalcopyrite, magnetite, and specularite, which are erratically distributed throughout skarn rocks. Chalcopyrite was most abundant in the Sunset mine, but tonnage was 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 cut by relatively fresh pulaskite porphyry dikes, feeders to the Marron lavas, and older, somewhat altered granodiorite offshoots of the Wallace Creek pluton. A granodiorite dike, about 30 metres wide, 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 ore bodies at Sunset that have developed in Brooklyn Group skarn rocks on the limbs of a northerly trending anticlinal structure. A thrusted panel 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.

**No. 7 (082ESE043; Lat. 49° 01.5', Long. 118° 38.4'):**

The No. 7 mine is on the claim of the same name, on a ridge crest 3.3 kilometres east of the confluence of McCarren and Gidon creeks, 7.5 kilometres southeast of Greenwood. Access to the property is 2.4 kilometres along a dirt road from the McCarren Creek road. The Lexington (082ESE041) and City of Paris (082ESE042) lie 2.5 kilometres to the southeast.

Intermittent operations of the No. 7 mine from 1901 to 1945 produced a total of 13,748 tonnes of ore yielding 92.4 kilograms of gold, 3110 kilograms of silver, 97 tonnes of lead, and 6.2 tonnes of zinc.

The mine is developed on a quartz vein on a major southeasterly trending fault that extends through

the City of Paris mine and on to the US border. The vein has been traced for a strike length of more than 300 metres. The vein ranges from 10 centimetres to 1.5 metres wide and dips 40 to 65 degrees northeast, having dike rocks or chloritic schists of the Knob Hill Group on the hanging wall and highly sheared talc-carbonate rocks of the serpentinite 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. Evidence of pre-mineral movement is furnished by unbroken vein quartz seams and lenses in the fault zone exposed at the southeast end of the 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 dikes.

The No. 7 fault zone considered to be a possible continuation of the Chesaw thrust in Washington State. The serpentinite is part of a disrupted Paleozoic ophiolite complex. Because of the incompetent nature of these rocks, the belt has become the locus of much shearing, thrusting, igneous intrusion, and vein mineralization. The common Mg-Fe carbonate (listwanite) alteration and serpentinization are thought to be related to thrusting of the ophiolitic rocks during the Jurassic. In the early Tertiary these thrusts were reactivated. Igneous activity at the same time is believed to be related to numerous vein deposits.

**Oro Denoro (082ESE063; Lat. 49° 07.6', Long. 118° 32.9'):**

The Oro Denoro and Emma (082ESE062) mines are centred 10.2 kilometres northeast of Greenwood, at the elevation 1200 metres, on the divide between Eholt and Fisherman creeks. 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, from 1903 to 1917, totals 123,782 tonnes containing 116.5 kilograms of gold, 953.4 kilograms of silver, and 1690.6 tonnes of copper (which does not include several thousand tonnes of ore shipped to the Phoenix mill in 1978). From the Emma mine, between 1901 and 1927, a total of 241,538 tonnes of ore was produced containing 212 kilograms of gold, 2434 kilograms of silver, and 2350 tonnes of copper.

The Oro Denoro mine is centrally located within a 2.4-kilometre long, north-south alignment of skarn deposits that include the Emma and Jumbo on the north and the Cyclops and Lancashire Lass (082ESE122) on the south. Mine development at Oro Denoro covers an area of about four hectares in the central part of the claim.

The orebody at the Emma mine is vertical and strikes northerly, roughly parallel to bedding in Brooklyn Group limestones near 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 – 1910), ore was drawn from several large stopes on two underground levels and five open pits. 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 appears to follow a number of large steeply dipping calcite lenses in the skarn adjacent to 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 the 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. East-west cross fractures trending approximately perpendicular to bedding in the limestone host rocks appear to have controlled

mineralization.

The most recent excavation, which is immediately west and south of the old quarries, is an open pit, 150 metres long and 45 metres wide, 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 is cut by several ore-controlling faults. The most significant is a pronounced shear that strikes 120 degrees from the north end of the main pit and through No. 1 quarry. Movement on this zone led to 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. Two minor faults dipping 80 degrees east and 75 degrees southeast caused local displacements of the skarn-granodiorite contact.

**PAC (082ESE194; Lat. 49° 07.2', Long. 118° 31.7'):**

The PAC showing and adjoining R. Bell and Cordick (082ESE064) mineral occurrences are 11 kilometres northeast of Greenwood, just east of Highway 3 and 2.5 kilometres south of Wilgress Lake.

The first recorded work in the area was on the R. Bell claim in 1896, when a shaft was sunk to a depth of about 30 metres on a seam of high-grade chalcopyrite in eruptive rocks. The claim was Crown granted in 1900 and by 1902 ore was shipped by the owners, the Granby Smelting Company. Total underground development at this time was 120 metres of shaft sinking and 180 metres of cross cutting and drifting. Exploration of the property continued intermittently after the production period and in 1927 a tunnel was driven connecting the R. Bell and Cordick claims following a southeaserly striking vein. The face of this tunnel displayed pyrite and hematite associated with quartz and calcite gangue minerals across a vein width of more than 1 metre. The host rock is greenstone stained locally with copper carbonate minerals and cut by a 30-metre wide, barren, pulaskite porphyry dike.

In 1995, after many years of inactivity, the discovery of a Carlin-type gold occurrence 150 metres from the R. Bell and Cordick copper skarn workings, sparked renewed exploration activity by Kettle River Resources Ltd. Trenching exposed 30 metres of intensely silicified limestone similar to the discovery outcrop. Assays from chip samples taken across structure returned 19.5 grams per tonne gold (2.4 metres) and 32 grams per tonne gold (1.8 metres). The mineralization is hosted in interbedded Brooklyn Group limestones and sharpstone conglomerates.

**Phoenix (082ESE020; Lat. 49° 05.5', Long. 118° 36.0'):**

The Phoenix mine, centred on the claim of the same name, is six kilometres east of Greenwood at 1370 metres elevation. Access to Phoenix is by paved road east from Greenwood or by an all-weather gravel road west from the Grand Forks section of Highway 3.

Mining in the Phoenix area was from four principal ore bodies underlying: 1) the Old Ironsides (082ESE021), Knob Hill (082ESE020) and Victoria (082ESE023) claims; 2) the Gold Drop (082ESE028), Rawhide (082ESE026) and Snowshoe (082ESE025) claims; 3) the Brooklyn and Idaho (082ESE013) claims; and 4) the Stemwinder (082ESE014) claim. Other claims associated with the Phoenix mine are Aetna (082ESE022), Curlew (082ESE024), Monarch (082ESE027), Gilt Edge (082ESE015), Red Rock (082ESE016), Bald Eagle (082ESE017), Grey Eagle (082ESE018), War Eagle (082ESE019), Bank of England (082ESE029), and Yellow Jacket (082ESE030). Figure 4 shows the geology, legend, and mineral occurrences of the Phoenix Mine Area.

Total production from the Phoenix mine between 1900 and 1978 was 21,552,284 tonnes of ore containing 28,341 kilograms of gold, 183,036 kilograms of silver, and 235,693 tonnes of copper. In addition:12 tonnes of ore were shipped from the Gold Drop mine in 1900; 855,634 tonnes from the Rawhide mine between 1904 and 1916; 545,129 tonnes from Snowshoe between 1900 and 1911; and

292,834 tonnes from the Brooklyn, Idaho, and Stemwinder operations between 1900 and 1960.

Systematic development, consisting of an extensive system of tunnels and stopes, began in 1895 and comprised three adit levels on the Old Ironsides and Knob Hill claims. To the east, five levels serviced in part by the Victoria shaft, were developed on the Victoria and Aetna claims.

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, and accessed by a 37-kilometre long network of tunnels. Intermittent mining took place by W.E. McArthur from 1920 to 1942, mainly from the Old Ironsides claim. This period produced 47,107 tonnes of ore. Renewed operations by the Granby company in 1959 began excavations which, by the final close of mining in 1976, resulted in removal of almost the entire old underground workings. This created a large elliptical 425 by 800-metre open pit, from which 9,070,560 tonnes of residual-low grade ore was extracted.

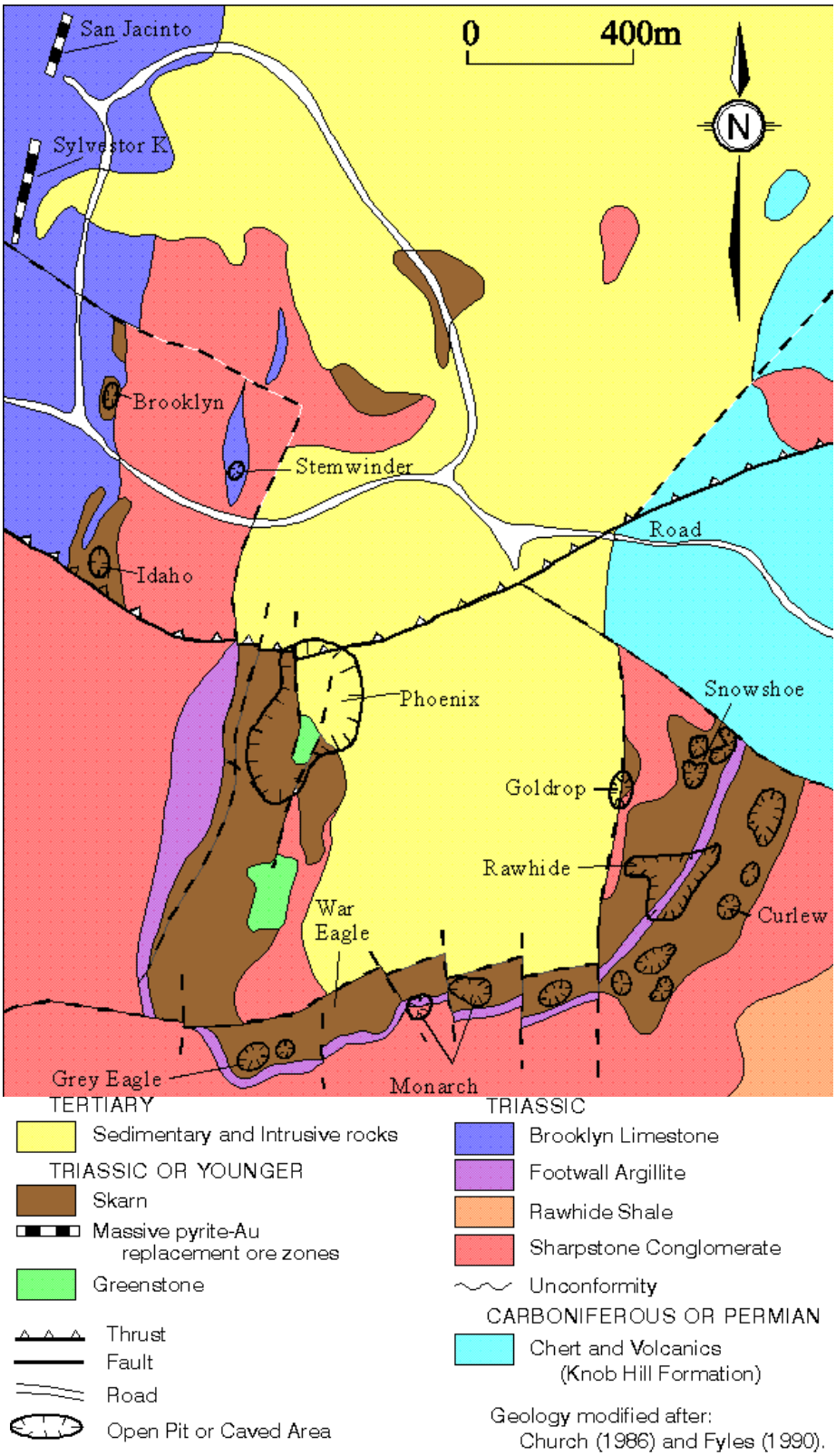
The Phoenix mine mine is underlain by an intricately folded, faulted, metamorphosed and mineralized sequence of Paleozoic and Mesozoic volcanic and sedimentary rocks that are by Eocene volcanic and epiclastic rocks (Figure 4). Paleozoic rocks include the Knob Hill Group, consisting mostly of chert, cherty argillite, greenstone, and a minor amount of limestone. Scanty fossil evidence indicates that the Knob Hill rocks may be as old as Devonian, although some geologists suggest a Permo-Carboniferous age (Little, 1983. These rocks are unconformably overlain by Brooklyn Group limestone, sharpstone conglomerate, and argillite and the Eholt volcanics considered to be Middle-Upper Triassic. The Brooklyn Group is cut by small microdiorite intrusions and is overlain by andesites of the Eholt Formation that may be coeval with the intrusions.

North-trending fold axes and a series of north-dipping thrusts, associated with serpentinite slices, have been identified in the pre-Tertiary assemblages. Locally, sedimentary rocks of the Kettle River Formation unconformably overlie the older rocks, including feldspathic sandstones and conglomerates with interbeds of rhyolite tuff and minor carbonaceous seams. These beds are overlain by trachyte and mafic phonolite volcanic rocks and cut by pulaskite and augite porphyry dikes and sills (Marron Formation).

The ores of the Phoenix area are almost exclusively the result of limestone alteration. The extensive deposits of low-grade copper ore in the Brooklyn limestone have all the characteristics of metasomatic replacements. These replacements are composed of chlorite-epidote skarn rocks with variable amounts of garnet, calcite, and quartz, accompanied by blebs and disseminations of pyrite, chalcopyrite, magnetite and specularite. The skarn and copper minerals are localized in a band of impure limestone above a well-defined footwall argillite. The thickness of mineralization varies from a maximum of 60 metres to less than 1 metre at the limits of mining. The ore beds are generally inclined downward to the east, but dips vary owing to a series of north-trending faults.

The main ore body outcrops on the Knob Hill and Old Ironsides claims, on the south side of a ravine that is the headwater area of Twin Creek. In its downward and eastward extension, the ore body passes onto the Victoria and Aetna claims. The area is divided by a pulaskite porphyry dike that is traceable southerly for 1200 metres from the Victoria claim through the Aetna and War Eagle claims. The dike is relatively fresh and appears unaffected by subsequent geological processes. It continues at depth for at least a few hundred metres, as proven by diamond drilling. The main body of ore, on the Knob Hill, Ironsides, and other westerly claims consists of two lenses that coalesce about central portions. The western lens is at least 750 metres long, from 12 metres to 38 metres thick, and from 112 metres to more than 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 57 metres. In its southern extension, the ore body appears to break up into

**Figure 4: Geology, Legend and Mineral Occurrences of the Phoenix Mine Area (082E02)**




subordinate ribs and wedges of ore separated by complementary ribs of almost barren gangue rock. A similar geometry also appears to occur to the east of the main ore body and the pulaskite porphyry dike, where a flat-lying zone, consisting in part of pay ore, was found on about the same level as No. 3 tunnel. The general strike of the outcrop of the ore body is 010 degrees 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 1000-metre long Victoria to Gold Drop tunnel, separates the east side of the Phoenix pit from an eastern extension of the Old Ironsides-Knob Hill skarn zone.

The **Gold Drop** mine (082ESE028) represents 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. In plan view, the deposit takes the form of a compressed crescent with northward trending horns, broken by the detached Gold Drop No. 1 ore body and the north Snowshoe body. The ore body rests on a floor of sharpstone beds; in the Gold Drop proper Brooklyn Group limestone and Tertiary intrusive rocks are absent. The ore body of the Gold Drop proper is developed in the southeast part of the Gold Drop claim, and the northeast part of the Monarch claim (082ESE027). The strike varies from 013 to 032 degrees, 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 strike of the Monarch drift is more than 320 metres, and its width to the boundary of the claim is about 96 metres. The thickness probably averages about 9 metres, diamond drill logs showing a range from 2 to 17 metres.

The **Rawhide mine** (082ESE026) is the continuation of the Gold Drop-Monarch ore body. The mine workings, underlying about three hectares on the western part of the Rawhide claim, consist of several large stopes and glory holes accessed by approximately 1400 metres of tunnelling on seven levels. The ore body, 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 (082ESE025) 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 3000 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. The south ore body is a continuation of the one developed at 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 were removed or left in stopes depending on their size and structure. Along the Snowshoe-Curlew boundary the footwall dips north at about 40 degrees. To the west, it has a curving strike to the north with easterly dips ranging from 30 to 65 degrees. North of the main shaft at the first cross-cut, the strike is northeasterly with southeast dips from 40 to 50 degrees. 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 180 metres and the east and west axis is about 80 metres long. The thickness of the ore according varies from 8 to 11 metres, with local swells giving a greater thickness in small areas.

The footwall rocks are sharpstone conglomerate beds, tuffs, and red and grey argillites, with local patches of quartzose crystalline limestone. The hangingwall consists of the garnet and epidote rocks of the mineralized zone into which the ore either fades, or from which it is separated by a gouge-filled fissure. The ore body at depth terminates abruptly against quartzose rocks of the Knob Hill group, on the plane of a presumably pre-mineral fault, which dips west at from 15 to 38 degrees. 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 with quartz, calcite, chalcopyrite, and pyrite in banded arrangement.

The north ore body was probably once connected to the South Snowshoe and Gold Drop No. 1 bodies at the surface but was separated by erosion. From the mine plans and sections, the main part of the

north ore body has a north-south length of 110 metres on the surface, a width ranging from 34 to 46 metres, and is from 2 to 17 metres thick, the average being about 11 metres. The dip of the footwall varies from 18 to 56 degrees east. A fault dipping 12 degrees west cuts the ore off. To the north, this fault steepens to 47 degrees and, with a displacement of about 12 metres, brings the lower part of the ore body to surface. The ore at this point lies on an augite porphyry dike that was intruded along the footwall. In its northern extension, the strike of the ore body swings to the northeast and the sharpstone footwall gives place to 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 (082ESE013) are on a mineralized zone crossing the valley of Twin Creek, about 700 metres northwest of the Phoenix pit. The zone has 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 exposed by the Brooklyn 'glory hole'; sharpstone beds lie to the east and the limestone to the west. The floor is mainly limestone with some sharpstone conglomerate in the southern part. The length is 564 metres, and the width varies from about 122 metres in the south to less than 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 5 working levels. 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 2300 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 (082ESE014) 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, seven 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 1967, 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 a tailings pond and water reclamation site near the Idaho workings.

The most widespread rock underlying the Brooklyn and Stemwinder mines is a Brooklyn Group sharptsone unit chert breccia consisting of subangular to subrounded fragments of white, red, and green chert, various types of volcanic and coarse-grained rocks; and local finely crystalline limestone. Two northerly trending, curved, lenticular bodies of limestone breccia occur near and in the Stemwinder mine. It consists of subangular fragments of greyish white finely crystalline limestone ranging from one to several centimetres, 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. 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 300 metres 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 prominent fault sets strike west of north. Faults of one set dip moderately to steeply east, and faults of the other set dip 25 to 40 degrees west. 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 gouge and subhorizontal lineations. Although the limestone breccia appears to be continuous at surface, in the workings it is cut into isolated blocks by the numerous faults. The blocks range from a metre to several metres, and are in fault contact with chert breccia on all sides. On No. 1 level, the segmentation is in a northerly trending belt roughly 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 in the old part of the Stemwinder mine is in this belt. The ore bodies are fault blocks of limestone breccia that have been partly recrystallized to coarse-grained grey calcite containing irregular veinlets and larger masses of chalcopyrite and pyrite. Generally, the mineralization ends at the faults bounding the limestone breccia blocks, but in a few places the chert breccia, for about a metre beyond such a fault, is brecciated and moderately well mineralized. The ore is strikingly different than at the Brooklyn mine. It lacks garnet or other calc-silicate gangue minerals, specularlite, and 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. 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.

In summary, the Phoenix ore body appears to be locallized by the fault system, the footwall argillite, and impurity of the overlying limestone. No igneous source rocks are known. Nevertheless, it is assumed that deep-seated granitic rocks under the mine area produced the mineralizing solutions which were then channelled by faults to favourable sites in the Brooklyn Group limestone for replacement and deposition.

**Providence (082ESE001; Lat. 49° 06.6’, Long. 118° 40.0’):**

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

The mine operated intermittently from 1893 to 1973. A total of 10,476 tonnes of ore were mined, yielding 183 kilograms of gold, 42,552 kilograms of silver, 183 tonnes of lead, and 260 tonnes of zinc.

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

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

The vein strikes 050 degrees and dips 40 to 60 degrees southeast. It has been traced underground for more than 370 metres, and ranges in width from < 1 to 75 centimetres. Unbroken quartz rarely extends from wall to wall; 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. Locally, 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 fracture on passing from 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 fracture. The older group, which is pre-mineral, strikes 030 to 050 degrees and dips gently northwest. Local dip reversals 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 footwall, thus indicating normal faulting. Offsets along these faults range from 1 to 24 metres. The maximum offset was measured along a fault that is now occupied by a post-mineral feldspar porphyry dike.

Locally, veins are slightly enlarged where they intersect these pre-mineral faults; elsewhere, 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 and the older group of faults.

**Republic, Non Such, Last Chance (Skomac) (082ESE045; Lat. 49° 03.6', Long. 118° 42.3'):**

This property, also known as the Skomac mine and previously operated by Robert Mines Ltd., is centred on a treeless south-facing hillside, 4 kilometres southwest of Greenwood. Access to the mine is about 3 kilometres by dirt road travelling north from Highway 3 near Boundary Falls.

Intermittent production from this property, from 1903 to 1983, totalled 3574 tonnes, yielding 18.5 kilograms of gold, 693 kilograms of silver, 58 tonnes of lead, 36 tonnes of zinc, and 864 kilograms of copper.

The mine is near the base of a diorite bluff between the elevations 850 and 1000 metres. The upper levels of the mine are almost entirely in the black phyllitic argillite unit of the Attwood Group. The lowest two levels follow a sheared ultrabasic intrusion occupying the contact between argillites and a large diorite body to the north. 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. An prominent set of younger cross fractures strikes 020 to 040 degrees, the same orientation as Tertiary dikes and faults cutting the veins.

Mine development began in 1894, after which several adits and shafts were worked. In the upper tunnel, the vein is persistent, but varies from 0.35 to 1.8 metres in width, and contains iron sulphides carrying gold and silver. The gangue is quartz with oxides of iron in the fractures. Below the collar of the main shaft, the lead splits into three veins in black argillite. The vein on the hanging wall is 20 centimetres wide, the one in the centre is 0.45 metre, and the one on the footwall is 0.66 metre wide. The ore minerals are galena, chalcopyrite, and pyrite, in a gangue of quartz.

The vein structures are thought to have originated by regional shear partitioned into incompetent units along the diorite contact. The ore shoots appear to be aligned gash structures, striking 015 degrees and plunging 40 degrees northerly.

**Sappho (082ESE147; Lat. 49° 0.3', Long. 118° 42.4'):**

The Sappho claim is centred 9.6 kilometres south of Greenwood and 0.6 kilometres north of the international boundary. Access to the property is 2.7 kilometres on a winding dirt road southeast of the Norwegian Creek road.

Production from this property is 102 tonnes of ore containing 6.1 kilograms of silver and 6.2 tonnes of copper. The old workings consist of a short adit and a cluster of pits and shafts in the central part of the claim. A grab sample of ore taken from one of the pits assayed 3.2 per cent copper and 0.9 gram per tonne platinum.

The principal rock types underlying the claim are a microdiorite intrusion (Jurassic?), exposed in the central area and southeast corner of the claim, and younger crosscutting Coryell syenomonzonite-shonkinite intrusions. Greenstones, of uncertain 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 these minerals in biotite shonkinite and pegmatoid phases of the Coryell intrusion. Sulphides are also found locally in skarns of epidote, chlorite, garnet, and magnetite near intrusive contacts.

**Skylark (082ESE011; Lat. 49° 05.5', Long. 118° 38.3'):**

The Skylark claim is centred 2.7 kilometres east of Greenwood and 0.8 kilometre southeast of Twin Creek. Access is 1.8 kilometres easterly by a winding dirt road from the main Greenwood to Phoenix road.

Mining on the Skylark claim in the period 1893 to 1940 was intermittent, with ore shipped for this period amounting to 1866 tonnes having 5282 kilograms of silver, 22.5 kilograms of gold, 25.8 tonnes of lead, and 4.8 tonnes of zinc. Recent production in 1988 and 1989 added an additional 33,298 tonnes, yielding 11,751 kilograms of silver, 90 kilograms of gold, 9.5 tonnes of copper, 107.5 tonnes of lead, and 43.6 tonnes of zinc.

The focus of interest on the Skylark claim is a mineralized quartz-carbonate vein in argillite and greenstone units of the Attwood Group. The vein dips 52 degrees southeast and has a strike length of about 200 metres. From two inclined shafts the vein has been followed to a depth of 24 metres where it is displaced easterly about 9 metres by a flat-lying fault. The ore readily breaks free from the wallrocks and is easily mined. The vein averages 15 to 20 centimetres wide and the best values are found in 'pay streaks' along the hanging and footwalls. The mineralization consists of galena, sphalerite, tetrahedrite, arsenopyrite, stibnite, ruby silver, and pyrite.

**Sylvester K (082ESE046; Lat. 49° 06.4', Long. 118° 36.3'):**

The Sylvester K claim and adjoining Marshall (082ESE031) claim 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 mine site.

The principal rocks underlying the Sylvester K and Marshall claims are sedimentary units of the Brooklyn Group and offshoot apophyses and dikes of the Providence Lake microdiorite stock. The Brooklyn beds are steep, mostly easterly dipping, comprising thick basal sharpstone conglomerates, overlain by a relatively thin transitional argillaceous facies, and a thick upper limestone unit. The Providence Lake microdiorite stock, dated by K/Ar at 206 +/-8 Ma (Church, 1986), cuts the limestone and conglomerate, feeding the slightly younger volcanic rocks of the Eholt Formation.

Mineralization comprises stratabound massive sulphides in limestone lenses and sulphide disseminations in the accompanying sharpstones and argillaceous rocks of the Brooklyn Group. The ore mineralogy consists principally of pyrite, smaller amounts of pyrrhotite and marcasite, and traces of chalcopyrite accompanied by carbonate minerals, quartz, and chlorite. Drilling 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 in this zone locally exceed 10 grams per tonne.

**Tam O'Shanter (082ESE130; Lat. 49° 05.4', Long. 118° 43.7'):**

The property, consisting of many claims and mineral leases, including the Tam O'Shanter and Bengal claims, is about 4 kilometres west of Greenwood, in the headwater area of Buckhorn Creek.

Early development on the Tam O'Shanter claim consisted of 2 shafts from the turn of the century and an adit driven in 1922 that followed a 'lead' of crushed country rock and soft gouge containing galena, chalcopyrite, and pyrite in a quartz gangue. From this operation, a 2.7-ton ore sample resulted in 12 grams of gold, and 2052 grams of silver.

The epithermal mineralization discovered on this property is related to Tertiary faulting and the associated alteration tends to be restricted to the Kettle River Formation. The predominant geological feature of the property is the steep northeast-trending Deadwood fault, which forms the eastern margin of the Toroda graben. The fault separates the Penticton Group on the west and northwest from the Knob Hill Group to the east. The major area of alteration and focus of exploration is at a splay in the Deadwood fault that encloses a zone of basal Tertiary Kettle River sedimentary rocks, which are clay altered and locally silicified. The northern portion of this zone, called the Bengal zone, is a silicified ridge of outcrops on which are a series of trenches and an old shaft (the Bengal shaft). The fine-grained quartz that forms the ridge is commonly brecciated and contains up to 10 per cent fine-grained pyrite. The mineralization here appears to be controlled by a small, steeply dipping, north-northeast trending fracture related to the main fault. A similar zone of alteration occurs in a conglomeratic facies of the Kettle River Formation, 200 metres south of the Bengal zone, where the Deadwood fault splays into two subparallel structures. Several backhoe trenches were dug at this point, exposing strongly clay-altered conglomerate between, and east of, the main faults, and a zone of massive, fine-grained, banded quartz, which is referred to as the 'Sinter zone'.

**Winnipeg (082ESE033; Lat. 49° 04.5', Long. 118° 34.3'):**

The adjoining Winnipeg and Golden Crown (082ESE032) claims are centred 7.5 kilometres east of Greenwood and 3.2 kilometres southeast of the Phoenix mine. 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 is reported to be 55,804 tonnes of ore yielding 402 kilograms of gold, 1207 kilograms of silver, 124.5 tonnes of copper, and 0.17 tonnes of lead.

The Winnipeg and Golden Crown claims were staked in 1891 on several small copper- and gold-bearing veins. Mineralization consists of pyrite, pyrrhotite, and chalcopyrite as discontinuous quartz veins and lenses hosted in greenstones of the Attwood Group, the 'Old Diorite' and associated ultramafic bodies.

The Golden Crown claim is underlain mostly by 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 are cut by a prominent southeasterly trending fault, from which the many quartz-filled gash fractures containing the ore were developed.