Tom Schroeter
Dept of Energy, Mines & Petroleum Resources
Smithers, BC

Selected precious metals deposits of Northern British Columbia

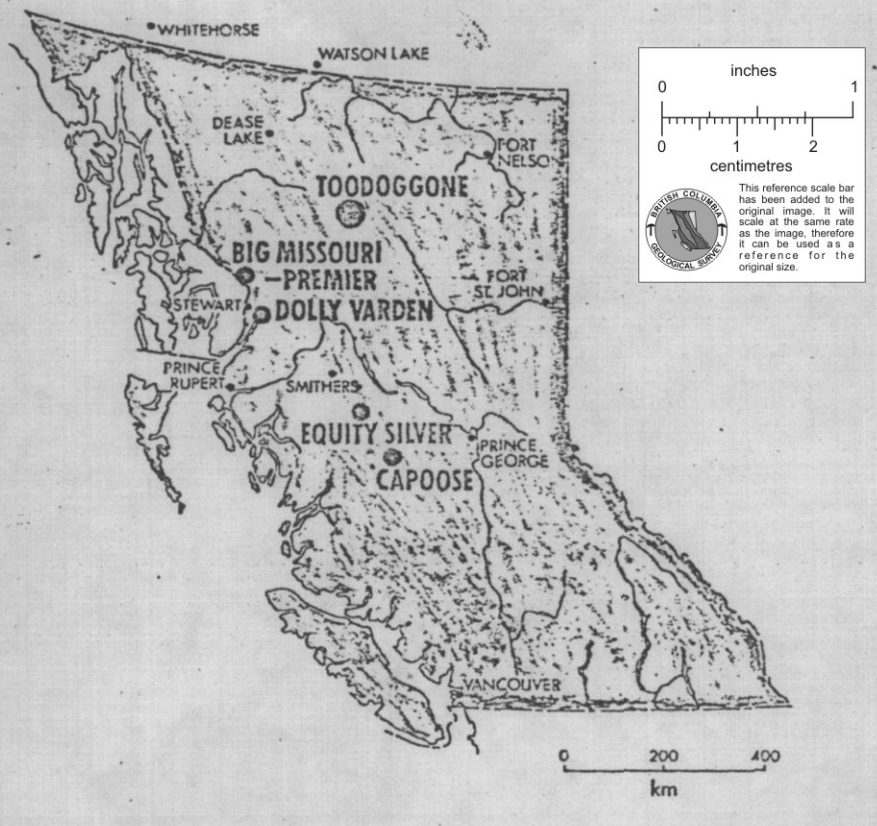
Previous knowledge and understanding of high-level 'geothermal' deposits in northern BC has been limited or restricted to historical descriptions such as that of the Premier Camp near Stewart. More recent geologic theory and understanding, together with a tremendously increased economic value of precious metals, has resulted in the discovery of several new gold and/or silver deposits or districts in BC. Some may be referred to as 'geothermal' or epithermal and others as volcanogenic. Most are high-level and exhibit many features characteristic of similar type deposits in Colorado, Nevada, and Mexico.

Five of these areas are: the Toodoggone District, Capoose Prospect, Equity Silver Mine, Big Missouri — Premier Deposits, and the Dolly Varden — Torbrit Deposits (Figure 1).

TOODOGGONE AREA

The Toodoggone area is situated approximately 300km north of Smithers and is one of the most isolated areas, geographically speaking, in the province. Access is restricted totally to aircraft. A 1600m gravel airstrip capable of accommodating a Hercules aircraft provides the only access for the Baker gold-silver mine and several other prospects in the area.

Figure 1. Selected precious metals deposits of northern BC



Early mining dates back to the early 1930s when placer claims near the junction of Belle Creek and the Toodoggone River were worked. Exploration remained quiet until the late 1960s when numerous companies began searching for the large tonnage, low-grade porphyries (copper ± molybdenum). Numerous claims were staked, the most significant to date being the Chappelle claims which include the Baker Mine recently brought into production by Du Pont of Canada Exploration.

The 1970s saw little exploration, with the exception of the Baker Mine and the Lawyers gold-silver prospect; but 1980 heralded the beginning of an era for this gold-silver 'Province'. Currently there are over 4000 active units within the Toodoggone area, with approximately 3500 of those being staked over the past year.

Property work of varying degrees has been carried out on such prospects as Baker (ex-Chappelle), Lawyers, McClair, Metsantan, Saunders, Fin (ex-Pine), Kemess, Shas, Attycelley and Firesteel.

Geology

The Toodoggone area lies within the eastern margin of the Intermontane Belt. The oldest rocks are wedges of crystalline limestone up to 150m or more thick. These have been correlated with the Asitka Group of Permian Age. The next oldest rocks belong to the Takla Group of Upper Triassic Age and consist of andesitic flows and pyroclastic rocks. The Omineca Intrusions of Jurassic and Cretaceous Age (K/Ar Age 186 my to 200 my, obtained by the GSC) range in composition from granodiorite to quartz monzonite. Some syenomonzonite bodies and quartz feldspar porphyry dykes may be feeders to the Toodoggone volcanic rocks which unconformably overlie the Takla Group.

'Toodoggone' rocks consists of a pile of complexly intercalated volcanic and volcanic-sedimentary rocks of Lower to Middle Jurassic Age, 500m or more in thickness, resting on the west flank of 'basement' rocks. They extend over a

northwesterly trending belt at least 90km in length and 15km in width.

At least three principal subdivisions are recognized.

(1) Lower Volcanic. Andesitic volcanic rocks consisting of maroon and green porphyritic flows and pyroclastics.

(2) Upper Volcanic. Intermediate alkalic assemblage including trachytes, crystal and lithic tuffs with intercalated dust tuff and quartz feldspar porphyries. Welded tuffs exist locally. The characteristic orange colour of the trachytic rocks has resulted from oxidation to hematite while the rock was still hot — possibly during late stage pneumatolysis. A coeval period of explosive volcanism and intrusion of syenomonzonite bodies was accompanied by brecciation along zones of weakness (predominantly large scale faults and attendant splays) resulting in silicification and precious and base metal deposition to varying degrees.

(3) Upper Volcanic — Sedimentary? Lacustrine volcanic sediments and possibly younger andesitic flows. Minor quartz feldspar porphyries.

A subaerial to shallow water environment of deposition of 'Toodoggone' volcanic rocks is postulated to have occurred in a northwesterly trending line of volcanic centres.

To the west, flat-lying to gently west dipping Upper Cretaceous to Tertiary pebble conglomerates and sandstones of the lower Tango Creek Formation of the Sustut Group unconformably overlie Takla Group and 'Toodoggone' volcanic rocks.

Structure

'Toodoggone' volcanic rocks dip gently (15 to 30°) to the west. The most obvious and probably most important structures in the area are long northwesterly trending fault systems (eg McClair system). Attendant with these larger faults are abundant splays. Northerly trending faults are also common.

Repeated, extensive normal block faulting from Jurassic to Tertiary time (over lengths of greater than 60km) provided the necessary channelways for mineralizing solutions to penetrate. Prominent gossans often are associated with structural zones but may or may not contain sulphides other than pyrite.

Mineralization

Four main types of polymetallic mineral deposits are recognized, of which two are pertinent to this paper.

(1) 'Porphyry' Cu ± Mo ± Ag ± Au. Mainly associated with Omineca Intrusions (186 to 200 my). Chalcopyrite, pyrite, with or without molybdenite, occur as fractures, as disseminations, or in quartz veins within intrusive rocks and host volcanic rocks (mainly Takla Group andesites). The silver (>.1 oz/ton) and gold (>0.015 oz/ton) byproducts from this type may be significant. Ex: Kemess, Fin (ex-Pine), Riga, Pillar, Rat, Mex.

(2) Precious and Base-Metal ('Geothermal') Epithermal Au + Ag ± Cu ± Pb ± Zn.

(a) The Fissure — Vein Type is associated with predominantly silicified zones (quartz veins and/or old volcanic centres) related to repeated, extensive normal block faulting and possible tensional fractures formed during late doming.

Recurrent broken faults guided intrusions, hydrothermal ('geothermal') activity, and important later mineralizing solutions. An episodic, near-surface sealing cap, or 'low pH cap', consisting of mainly illite and sericite located in the hangingwall may also have acted as a trap for mineralizing solutions.

Hydrostatic boiling is a key to mineral deposition and may occur anywhere in the system depending on the salinity and temperature of the water. In terms of exploration guides, it will be important to determine by laboratory studies (ie fluid inclusion studies) if indeed boiling has occurred.

Principal ore minerals, occurring in open space fillings, include fine-grained argentite (acanthite (>80% Ag), electrum (>20% Au), native gold, native silver, and minor amounts of chalcopyrite, pyrite, galena, and sphalerite. Rare constituents include bornite, polybasite, stromeyerite, and secondary chalcocite, cerussite, malachite, and covellite. Gangue minerals include amethystine to white quartz, chalcedony, adularia, albite, calcite, hematite, Mg-rich siderite, ankerite, chlorite, kaolinite, and rarely barite and fluorite.

Mineralization tends to be non-uniform (ie occurs in shoots) and rarely exceeds more than 20% of the vein system. Base metals are deposited earlier than precious metals. Acanthite and electrum occur in clouded areas which may exhibit boiling textures caused by episodic pressures. Sharp-edged breccia fragments are sometimes strongly replaced by quartz, adularia or sericite. Several episodes of fracturing occurred as evidenced by breccia fragments being enclosed within later mineralized veins.

Preliminary chemical data suggests the following: host 'Toodoggone' rocks are quartz normative; K_2O/Na_2O ratio increases toward mineralization; and sulphur values are very low (<.04%).

Trace elements, including Cu, Pb, Zn, Ag, Au, Hg, Sr, Ba, Mo, Sb, Se, Te, Th, U, W, As and Bi are all low, except of course in the mineralized zones where slight anomalies are noted. There is an increase in Si, H_2O and K and a decrease in Al, Fe, Na, Ti, P_2O_5 and Ba, in zones of mineralization.

The Ag:Au ratio of this type is approximately 25:1. Ex: Chappelle, Lawyers, Metsantan, McClair, Cliff Creek, Shas, Saunders?

As suggested by Larry Buchanan, with Fischer-Watt Mining Co, deposits of this type may be vertically stacked with barren zones in between ore-bearing zones and thus the depth potential must be explored for.

(b) Hydrothermally Altered and Mineralized Type. This is associated with major fault zones and possible post subsidence of volcanic centres followed by a doming of cauldera cores. Pyrite is the most common sulphide present with minor amounts of galena, sphalerite, and rarely molybdenite and scheelite. This type is probably somewhat older of contemporaneous with fissure-type mineralization. Volcanic centres are strongly leached and sulfotarically altered to varying intensities consisting of clay minerals and silica with some areas containing alunite (eg Alberts Hump and Kodah). Epidote is a common alteration product. The 'low pH cap' mentioned earlier may now overlie areas of mineralization. Ex: Kodah, Alberts Hump, Saunders, Chappelle.

Mineral Prospects

The two most significant properties to date are the Baker Mine and the Lawyers prospect. 94E/6E 094E 026

(1) Baker Mine (ex-Chappell). Camp and mill facilities at the Baker Mine are complete and production was scheduled for early April 1981 at a rate of 100 tons/day. During the fall of 1980 surface cut mining down to about 6m was carried out and since then underground development has been in progress from the 55 Level. Mineable reserves are 100,000 short tons containing 0.92 troy oz of gold and 18.7 troy oz of silver per ton.

Seven quartz vein systems mostly occupying fault zones have been identified in the area of the mine, with the main vein (Vein A), consisting of two or more subparallel veins traced over a length of 435m, a width of 10 to 70m, and a vertical depth of at least 150m.

Individual veins within the system vary from 0.5m to greater than 9m in width. A variety of quartz vein textures and cross-cutting relationships indicate a complex history of mineralization with multiple depositional stages. Fine-grained acanthite, pyrite, electrum, chalcopyrite, bornite, native gold, sphalerite, galena, chalcocite, covellite, polybasite and stromeyerite occur within the highly fractured and brecciated quartz system intrusive into Takla Group andesite and 'dacite'.

Higher grade mineralization is associated with grey quartz which occasionally contains visible acanthite (Ag_2S).

Alteration minerals include pervasive laumontite, chlorite, pyrite, anhydrite and silica.

It is interesting to note that one sample of high-grade ore assayed 0.23% Mo. Tellurium values range between 16 ppm and 38 ppm.

94E/6E (094E 037)

(2) Lawyers. The Lawyers Au-Ag prospect is located 12km north of the Baker Mine. Fine-grained acanthite, electrum, native silver with minor pyrite, chalcopyrite, galena, sphalerite and tetrahedrite occur in a gangue of predominantly amethystine to white quartz and adularia with minor calcite intrusive into the Upper Volcanic subdivision of "Toodoggone' trachytes.

Secondary minerals include malachite, chalcocite and cerussite. The structurally controlled mineralized zone varies from 60 to 75m in width and has been partially drill tested over a north-south length of 610m and a vertical depth of 60m. Typical open spaced epithermal textures are observed in the fissure zone. Grades of mineralization are erratic with some nearby float assaying over 20 oz/ton Au and 700 oz/ton Ag.

Other Prospects. Other active prospects in the area include Cliff Creek, Metsantan, McClair, Saunders, Shas, Fin, Dryborough, Kemess, and Attycelly.

Summary

In summary, it must be concluded that the Toodoggone area represents a rich polymetallic epithermal mineral 'Province'.

CAPOOSE PROSPECT

The Capoose precious metals 'bulk' silver and base metals prospect is located a few kilometres north of Fawnie Nose, approximately 110km southeast of Burns Lake.

Geology

The Fawnie Range, in the vicinity of the Capoose property, is composed of a complexely fault broken conformable sequence of metamorphosed interbedded meta-greywacke, argillite and pyroclastic volcanic rocks and flows of rhyolitic and andesitic composition (of probable Upper Hazelton Group Age ?) unconformably overlying andesitic rocks of the Takla Group.

The eastern side of the Capoose property is underlain by sediments and maroon tuffs of probable Upper Jurassic Age (Hazelton Group ?). Belemnites and pelecypods found in the sequence have not yet been positively identified and are only indicative of a broad Jurassic to Cretaceous Age. In places, belemnites have been replaced by pyrite.

Conformably overlying a limey argillite unit with an attitude of 170°/20°W is an acidic unit consisting of rhyolitic pyroclastic and flow rocks. Phenocrysts of highly embayed quartz are set in a cryptocrystalline groundmass of quartz and feldspar. Flow banding averages 135°/15°W with a strong vertical jointing at 090°, parallel to the major structural zones. Local 'balling' or pisolitic formation within rhyolite has produced beds with 'balls' up to 30cm in diameter.

Alteration and Texture

The most striking feature of the metamorphosed rhyolitic and andesitic units, in the vicinity of mineralization, is the ubiquitous presence of amber brown coloured garnets occurring as disseminations, as fracture fillings, as vein fillings in quartz, and as replacement nuclei.

X-ray diffractometry and emission spec data indicate the composition of the garnets to be approximately $Sp_{63}Al_{29}Gr_8$ (ie Mn-rich). Garnets range from fresh to totally altered or replaced by a mixture of quartz ± sericite ± opaques. Hydrothermal solutions have cracked the garnets and they have subsequently been healed by sulphides (mainly pyrite). The process of 'garnetization' is postulated to have involved growth by nucleation and dispersion. A dispersion rim of predominantly quartz and/or sericite within replaced garnets is common. The textures suggest that crystallization took place rapidly under strong chemical or energy gradients. Dendritic growth textures are also exhibited.

It is further postulated that growth was diffusion-controlled as a result of the composition of the large crystals (ie garnets) differing appreciably from the groundmass (qtz ± fsp). The skeletal texture of garnets implies difficulty in nucleation.

Globular to botryoidal and fracture filling hematite is common in rhyolitic rocks. Epidote and chlorite are common alteration products in the andesitic rocks.

Structure

The predominant structures in the area are east-west faults exhibited by small linear depressions on Fawnie Range. Diamond drilling has also identified numerous fault gouges. Broad warping of thin bands in the argillite unit occur.

Mineralization

Three zones of precious ('bulk-silver') and base metals mineralization have been identified.

Zone 1. Galena, pyrite, pyrrhotite, chalcopyrite, arsenopyrite and sphalerite occur as disseminations (esp galena), as replacement of garnets (nuclei and attendant dispersion halos), and as fracture and/or vein fillings within garnetized and silicified rhyolite tuffs, breccias and flows and minor interbedded andesitic rocks in a steeply west dipping structurally controlled zone. Tetrahedrite, pyrargyrite, electrum, native gold, and cubanite have also been reported. Precious metals also occur within galena and sphalerite. Pyrite is ubiquitous and may have formed throughout the mineralizing event.

Zone 2. Located immediately to the west of Zone 1, this is similar style to Zone 1 with possibly a little more arsenopyrite.

Zone 3. Located to the north of Zone 1, this is also similar style to Zone 1 with more 'massive' to vein-type textures.

In all three Zones, Garnet replacement and mineralization are closely related.

Although it is much too early to talk about average grades, an estimate for such a 'bulk' silver type of mineralization might be 45 gm/tonne Ag with additional values in Au, Cu, Pb, and Zn. Much higher grades exist locally. It is interesting to note that a sample collected by myself assayed 0.03% Mo and 0.03% W.

Summary

It is postulated that a magmatic source provided heat and mineralizing solutions intrusive into rhyolitic and andesitic rocks, possibly near an old volcanic centre, resulting in replacement of garnets by sulphides and formation of mineralized veinlets and possibly more massive bodies of mineralization.

EQUITY SILVER MINE

93L 14 (093L 001)

The Equity Silver copper-silver-gold-antimony high-level volcanogenic deposit, located 35km southeast of Houston, is currently in production (open pit) with reserves estimated at about 28-million tonnes grading 106.3 gm/tonne silver, 0.384% copper, 0.96 gm/tonne gold, and 0.85% antimony.

Three principal mineralized zones — Southern Tail, Main and WTR — trending for some 2400m along a major NNE-SSW structural break have been outlined.

Tetrahedrite, chalcopyrite, pyrite, sphalerite, galena, arsenopyrite, magnetite and specular hematite with associated tourmaline, andalusite, scorzalite, pyrophyllite, sericite, quartz, dumortierite and corundum occur as stockworks, as disseminations, and as massive 'pods' within a window of a steeply west dipping sequence of intermediate to acidic pyroclastic and volcaniclastic sedimentary rocks of Mid to Upper Mesozoic Age. The 'Goosly Sequence' consists of the following (from the oldest to youngest).

(1) Clastic Division — composed of a lower polymictic conglomerate and an upper chert pebble conglomerate, thought to be correlative with the Skeena Group.

(2) Pyroclastic Division — a heterogeneous sequence of interbedded dust, ash, and lapilli tuffs, breccia, and reworked pyroclastic debris. These units are host to the copper-silver ores and have been extensively altered. The Pyroclastic Division is thought to be correlative with the Kasalka Group of Upper Cretaceous Age but further age dating will be required to confirm this.

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(3) Sedimentary — Volcanic Division — composed of interbedded tuff, sandstone, and conglomerate.

(4) Volcanic Flow Division — uppermost unit composed of andesitic and dacitic flows.

This 'Goosly Sequence' is flanked by shallow dipping Tertiary andesites and basalts. Two stock-like intrusions crosscut the 'sequence'. A quartz monzonite stock (K-Ar age date 55.8 ± 2.3 Ma) with sparse copper-molybdenum mineralization cuts Mesozoic strata 400 to 600m west of the ore zones and is thought to be contemporaneous with or younger than the main mineralizing event. A gabbro — monzonite complex (K-Ar age date 48.4 ± 1.9 Ma) intrudes Mesozoic strata immediately east of the Main Zone and WTR Zone and is believed to be post ore.

Main Zone ores are fine-grained, generally occurring as disseminations; whereas, **Southern Tail Zone** ores are coarse-grained and occur predominantly as veins. Sulphides are best developed in zones of intense fracturing and brecciation, but, in general, are restricted to a tabular fracture zone which roughly parallels stratigraphy. However, copper-silver sulphides occur throughout the stratigraphic column.

The WTR Zone is a northerly extension of the Main Zone and appears to be more massive in nature. In addition to high-grade assays of Cu, Ag, Au (up to 4.8 ppm) and Zn, visible molybdenite and scheelite were observed.

The Tourmaline Zone occurs in the hangingwall over a surface area of approximately 1000m x 600m. Pyrite is ubiquitous with minor amounts of chalcopyrite, sphalerite, galena and tetrahedrite in veins.

It is postulated that sulphides were deposited syngenetically within the pyroclastic division and that a contemporaneous or younger major structural break (or breaks), roughly parallel to stratigraphy, together with intrusion and hydrothermal alteration and mineralization by the quartz monzonite stock, resulted in a remobilized and overprinted mode of mineralization consisting of massive sulphide-type and high-level porphyry-type.

At least three stages of alteration have been recognized — an early pervasive solfataric phase characterized by pyrite, chalcedonic silica, and muscovite, a contact phase created by intrusion of the gabbro-monzonite complex adjacent to the Main Zone producing pyrrhotite, andalusite, scorzalite, corundum, and sillimanite in a contact aureole about 90m wide, and a late phase characterized by quartz, sericite, chlorite and tourmaline.

The potential for more ore at Equity Silver is considered very good.

BIG MISSOURI PROSPECT

The Big Missouri precious and base metal prospect is located 25km northeast of Stewart and is currently being evaluated for its potential open pit extraction of precious metals by Westmin Resources (formerly Western Mines Limited).

Between 1938 and 1942 Cominco Ltd produced approximately 850,000 tons of ore containing 58,384 oz of Au, 52,677 oz of Ag, 2712 lb of Pb, and 3920 lb of Zn from a 60m wide zone with an average grade of 0.117 oz/ton Au and 0.9 oz/ton Ag.

Geology

Two main rock units separated by an angular unconformity crop out on the property.

(1) Lower — northwesterly trending Lower Jurassic **Hazelton Group** flows and volcanogenic sediments.

(2) Upper — tightly folded immature sediments of the Middle to Upper **Bowser Group.**

The Hazelton Group is greater than 3000m thick with the top half having formed as a result of subacqueous volcanism in which highly explosive ash flow and air fall deposition was followed by quieter effusions of thick andesitic lava flows and pyroclastic flows. Within green andesites, 1 to 2m thick gold-silver and lead-zinc bearing chert layers were precipitated as chemical sediments originating from fumarolic centres active at periods during andesitic volcanism. Fissures in the andesites acted as conduits for metal-rich brines, and alteration of country rock, in the form of 'envelopes' of sericite, quartz and pyrite is common. The pyroclastic layers above the chert layers allowed fluids to discharge further creating a more extensive hangingwall alteration.

The Coast Plutonic Complex crops out west of the Salmon Glacier and includes the Texas Creek, Boundary, and Hyder Plutons ranging in age from Lower Jurassic to Cretaceous.

Mineralization

The most abundant base metal sulphides are galena and sphalerite with accessory chalcopyrite. Associated precious metals include polybasite, pyrargyrite, electrum, native silver and native gold. They occur as disseminations, as veinlets, and as lenses within chert horizons, and there appears to be a distinct association of precious metals with galena and/or sphalerite. Quartz, carbonate and up to 15% fine-grained black carbon are the common gangue minerals.

Conclusion

A syngenetic, epithermal mode of mineralization related to volcanism is postulated for the Big Missouri deposit.

PREMIER DEPOSIT

The historic Premier Mine is located 5km south of the Big Missouri property. Production until 1953 totalled 4.7-million tons of ore yielding 1.8-million oz of gold, 41-million oz of silver, and important lead-zinc byproducts. The recovered grade was 0.38 oz/ton Au and 8.7 oz/ton Ag for an overall silver:gold ratio of 25:1.

Mine workings exist over a 2000ft vertical interval and a maximum width of 50ft. A syndicate under the name British Silbak Premier, is currently re-exploring and re-evaluating this important gold-silver deposit.

Mineralization

Pyrite, sphalerite, galena, and chalcopyrite occur telescopically within an extensive northeasterly elongated replacement shear zone in silicified and chloritized volcanic and volcaniclastic rocks localized along a system of complexely intersecting shears over 1675m in length and 185m in width. Individual ore shoots, with uniform plunges to the west, are found as isolated or overlapping enechelon pipe-like lenses. A true bonanza of native gold, electrum, argentite, pyrargyrite, polybasite, and native silver occurs in a gangue of quartz, calcite, barite, and adularia. Rare amounts of mercury and scheelite have been noted.

The mineralized veins appear to have been localized in a cataclastite zone adjacent to the Texas Creek Pluton (situated to the west), and a particular volcanic conglomerate appears to have been most amenable to deformation, alteration, and mineralization. The so-called 'Premier Porphyry' is actually epiclastics metasomatically altered and intensely fractured by the Texas Creek Pluton. The overlying Betty Creek Formation is believed to have acted as an impervious barrier to ore solutions (Barr 1980).

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DOLLY VARDEN — TORBRIT

The Dolly Varden-Torbrit silver deposits are located 27km north of Alice Arm and are currently being re-explored and re-evaluated.

Total production from mines in the area up to 1959 (including Wolf, North Star and Torbrit) is estimated to be over 20-million oz of silver and 10-million lb of lead from 1.4-million tons of ore with an average grade of 15.45 oz–ton Ag. and 7.8% Pb. Reserves are in the neighbourhood of 1-million tons grading 8.9 oz/ton Ag. There is no gold.

Mineralization

Mineralization is contained in steeply dipping quartz veins, varying up to 15m in width, which have intruded a sequence of interstratified and interfingering clastic and pelitic sedimentary rocks and mafic volcanics of Jurassic Age (Hazelton Group).

Two stages of mineralization are recognized.

(1) Quartz — carbonate — pyrite with minor chalcopyrite — common propylitization = 1st generation mesothermal.

(2) Crustiform and colloform argentiferous galena, sphalerite, pyrargyrite, and native silver within a quartz — calcite — barite — jasper gangue; wall rock alteration is minor = 2nd generation epithermal = economic mineralization of area.

A lateral epithermal zoning outwards and eastwards from a pluton to the west is suggested by a progressive change from west to east from Au-Cu mineralization to Cu ± Ag to predominantly Ag mineralization.

SUMMARY

In summary, the geologic environments, structural styles, and alteration and sulphide assemblages associated with high-level precious metals and base metals deposits in central and northern BC are slowly but surely emerging as bone fide exploration targets and undoubtedly many more deposits are yet to be discovered.

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