Mineral Deposits of the Upper Kitsault River Area, British Columbia (103P/W)

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KEYWORDS: Economic geology, Lower Jurassic, Hazelton Group, silver production, quartz-barite-carbonate-sulphide-oxide (Ag) deposits, quartz-sericite-chlorite-sulphide (Cu, Au) deposits, stockwork deposits, mesothermal, epithermal vein deposits, exhalative deposits, silver, lead, zinc, barium, strontium, copper, gold, Red Point, Homestake, Wolf, Torbrit, Northstar, Dolly Varden, Sault, Red Mountain, Eskay Creek.

INTRODUCTION

This report describes the mineral deposits of a portion of the northern Coast Mountains southeast of Stewart, British Columbia. It is based on public domain reports and visits to selected deposits; however, none of the underground workings were examined. The work was funded under the Provincial Government's Corporate Resource Inventory Initiative (CRII) as one part of the Ministry's contribution to the North Coast Land Resource Management Planning process. Other parts include a limited fluid inclusion study of upper Kitsault River rocks, geological mapping and stream sediment sampling programs in the Ecstall River area and stream sediment sampling around Porcher, Dundas and other off-shore islands. They will be reported on separately. In addition, the Ministry has scanned and released North Coast area assessment reports on its website (www.em.gov.bc.ca/geology).

The upper Kitsault River area hosts two past-producing silver mines, Dolly Varden (MINFILE 103P 188) and Torbrit (MINFILE 103P 191), and numerous other prospects that range in size from small showings to developed deposits. The latter include Northstar (MINFILE 103P 189) and Wolf (MINFILE 103P 198). There are four types of mineral deposits: 1) epigenetic copper-gold chlorite-pyrite vein stockwork deposits (*e.g.* Red Point (MINFILE 103P 196) and Homestake (MINFILE 103P 216)); (2) epigenetic silver-lead-zinc quartz-carbonate vein deposits (*e.g.* Wolf); (3) either epigenetic or syngenetic silver-lead-zinc-barium-strontium deposits (*e.g.* Torbrit, Northstar and Dolly Varden) and (4) syngenetic strontium-barium-lead-zinc-silver deposits (*e.g.* Sault (MINFILE 103P 233)). They are all hosted by lower Jurassic volcanic and sedimentary strata, near the top of the Hazelton volcanic arc sequence. There are conflicting opinions as to the origins of some of the deposits. In the absence of new data, this report makes no attempt to resolve the issues. It describes some of the more important occurrences and comments on possible similarities to precious-metal deposits at Red Mountain (MINFILE 103P 086) and Eskay Creek (MINFILE 104B 008).

PREVIOUS WORK

Most of the mineral deposits in the Stewart area were located in the late 1800s and early 1900s. Prospectors moved into the Kitsault River area, north of Alice Arm, in the early 1900s and staked the first discoveries in the upper Kitsault River area in 1913. The principal showings had been found by 1921, when the first phase of production at the Dolly Varden mine came to an end.

The showings in the Kitsault River area are referred to in Ministry of Mines Annual Reports and described in some detail by Hanson (1922, 1935) and Black (1951). Carter and Grove (1972) produced a 1:250 000-scale compilation map of the geology of the Kitsault River area in the early 1970s, and Grove (1986) discussed it in a bulletin on the geology and metallogeny of the "Stewart Complex", a term he applied to the volcanic and sedimentary rocks between the eastern margin of the Coast Plutonic Complex and the western margin of the Bowser Basin. He describes a broad regional zonation of mineral deposits within the Complex and notes the potential for silver deposits in the Alice Arm portion. The area was mapped at 1:50 000-scale by Alldrick *et al.* (1986) and described by Dawson and Alldrick (1986). Alldrick also discusses the stratigraphy of the area in a review of the distribution of volcanic centres in the Stewart Complex (Alldrick, 1989).

The mineral potential of the Stewart Complex has been recognized for over a century (Grove, 1986; Alldrick, 1993). However, over most of that period, precious-metal exploration was solely directed toward finding epigenetic vein deposits. In 1988, two discoveries added considerably to the range of deposit types explored for. The Eskay Creek deposit, a major gold-enriched, subaqueous hot-spring deposit, was discovered 100 km northwest of Stewart and the Red Mountain deposit, a major intrusion-related gold deposit, was found 20 kilometres east of Stewart. These discoveries lead to numerous exploration programs in the Stewart Complex in the late 1980s and early 1990s. Many of them are described in assessment reports filed with the Ministry and available on the Ministry's website.

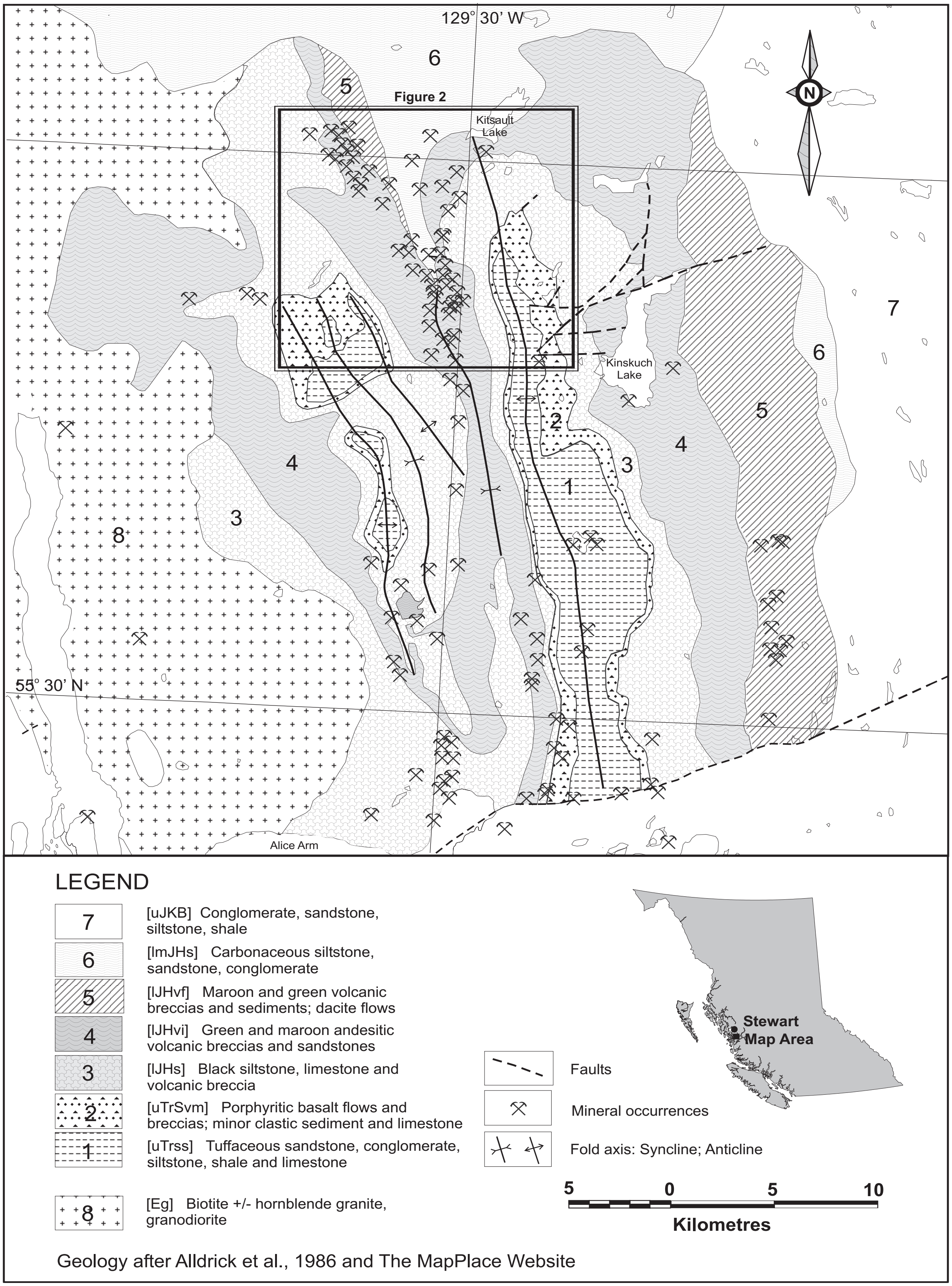

Figure 1. Generalized bedrock geology map of the Kitsault River area showing mineral occurrences and location of area studied.

Although there were no major government mapping programs in the Kitsault River area in the 1990s, several more modest programs helped to define the geology. Godwin *et al.* (1991) used plots of lead isotope values from galena samples from a broad area of northern British Columbia to differentiate between Jurassic and Tertiary-age mineralization. The same year, Greig (1991) mapped southeast of Kitsault Lake. In 1992, Mortensen and Kirkham (1992) obtained an approximate U-Pb zircon age for syngenetic mineralization near Kitsault Lake and, in 1994, Greig *et al.* (1994) mapped the geology of the Cambria Icefield area, including the uppermost part of the Kitsault River drainage. Most recently, Evenchick and Mustard (1996) studied the stratigraphy and structure of Bowser Lake Group sediments on the east side of the Stewart Complex. The geology of the Skeena-Nass area has been compiled by MacIntyre *et al.* (1994a) at 1:250 000-scale and it is this map that is available on the Ministry website.

GEOLOGY

The simplified geological maps of the Kitsault River area (Figures 1 and 2) are adapted from MacIntyre *et al.* (1994a). They are based on the work of Alldrick *et al.* (1986) who identified six stratigraphic units formed during two cycles of arc volcanism. From bottom to top, they include: 1) a thick flysch-siltstone layer (base unseen), topped by black limestone [uTrss]; (2) a mixed succession of locally-pillowed augite, feldspar and olivine porphyritic basalt flows, breccias and derived conglomerates [uTrSvm]; (3) mixed clastic sediment and volcanic breccia capped by a distinctive polymictic (chert or siltstone supported) conglomerate [lJHs]; (4) porphyritic andesitic pyroclastics (tuffs and breccias) and related flows and sills with 10-15% intercalated argillite, limestone and chert [lJHvi]; (5) alternating maroon and green volcanic breccias and conglomerates with discontinuous dacite flows and pyroclastics that are thought to be derived from discrete volcanic centres [lJHvf]; and, (6) black marine, fossiliferous shale, siltstone and wacke [lmJHs].

Units 1 [uTrss] and 2 [uTrSvm] are similar to upper Triassic Stuhini Group strata found elsewhere in northern British Columbia (MacIntryre *et al.*, 1994). Units 3 [lJHs], 4 [lJHvi] and 5 [lJHvf] are broadly correlatable with lower Jurassic rocks of the Hazelton Group, as defined by Grove (1986) in the Stewart area. Unit 3 is equivalent to the Unuk River Formation and Units 4 and 5 include rocks similar to those found in the overlying Betty Creek Formation. Unit 5 is discontinuous in the Kitsault River area and contains felsic rocks near its top that are equivalent in age and setting to Mount Dilworth Formation strata, as defined by Alldrick (1993). Unit 6 [lmJHs] resembles the Salmon River formation. It disconformably overlies older Hazelton Group strata (Dawson and Alldrick, 1986) and is, in turn, overlain by Bowser Lake Group sediments.

The strata are deformed into a series of relatively open, northwest trending, doubly plunging folds that limit the exposure of sub-Bowser Group strata in the Kitsault River area to a belt approximately 40 kilometres long and 25 kilometres wide (Alldrick *et al.*, 1986). The Kitsault River more or less follows the axis of the Kitsault River syncline, a major structure that has infolded volcanic and sedimentary rocks near the top of the Hazelton arc at both ends of the belt. The syncline is bounded by the Varden Glacier anticline to the west and the Mount McGuire anticline to the east (Figure 2). Fold configuration and topography affect the distribution of Units 4 and 5, which host most of the mineral showings in the area (Dawson and Alldrick, 1986).

Although there are relatively few faults mapped in the area, Greig *et al.* (1994) identified a high-angle, northeasterly dipping fault west of Homestake Ridge while mapping around the southern edge of the Cambria Icefield. There may be other unmapped structures of this type, formed during the shortening event that affected Bowser Lake Group and older rocks in the Cretaceous (Evenchick and Mustard, 1996).

Property-scale mapping by Campbell (1959) and Mitchell (1973) suggest that faulting has occurred episodically since the waning stages of arc volcanism. It includes a considerable amount of post-mineral faulting. Devlin and Godwin (1986) and Devlin (1987), show that the northern axis of the Kitsault River syncline has been disrupted by two sets of faults and Drown *et al.* (1990a,b) describe several northwesterly trending structures that splay off a major, northerly trending shear zone (Figure 3a,b).

Although the map area is bounded by rocks of the Coast Range Batholith to the west, there are relatively few intrusions mapped within it. Those present, are (1) subvolcanic intrusions emplaced during or shortly after Stuhini and Hazelton Group volcanism; (2) quartz monzonite intrusions of Eocene-age; and (3) a variety of Late Tertiary, cross-cutting dikes. The subvolcanic variety are relatively common in Unit 4 and are an important feature of the "Copper Belt", west of the headwaters of the Kitsault River (Black, 1951; Carter, 1970; Grove, 1986). Grieg *et al.*, (1994) mapped Goldslide intrusions in the area west of Homestake Ridge. They are similar to intrusions found at Red Mountain, on the north flank of the Cambria Icefield and are approximately contemporaneous with Hazelton volcanism. Greig *et al.* (1995) obtained a U-Pb age of 201.8 +/- 0.5 Ma from zircons from one of the intrusions near Red Mountain and a K-Ar age of 194 +/- 8 Ma from hornblende from a nearby Hazelton Group tuff breccia.

MINERALIZATION

There are numerous mineral occurrences in the Kitsault River area (Figure 1). Compositionally, they conform to three principal types: 1) Copper and gold-rich quartz-chlorite stockwork deposits; (2) silver-rich quartz-sulphate-carbonate deposits; and (3) molybde-

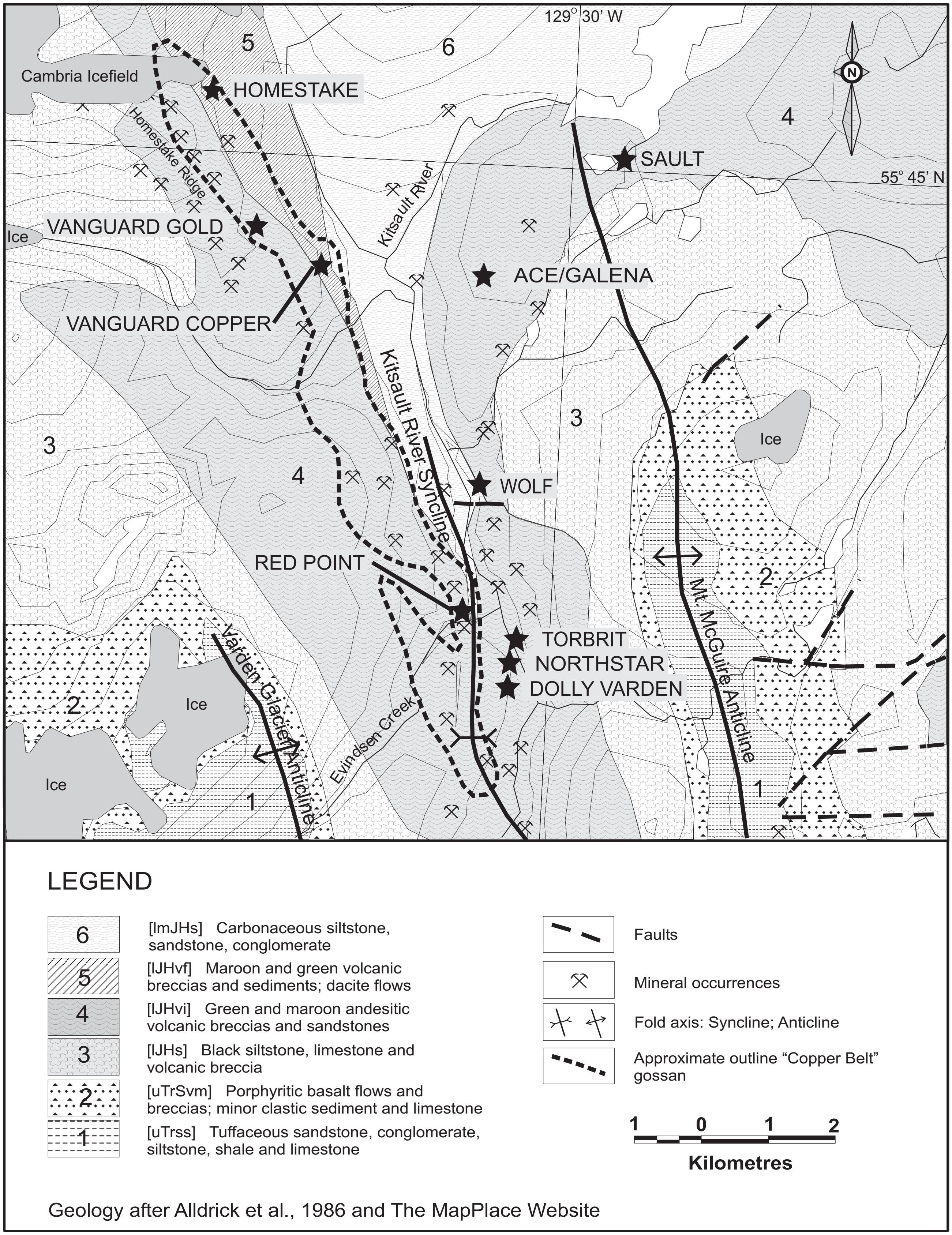

Figure 2. Generalized bedrock geology map of the upper Kitsault River area showing the location of the "Copper Belt" and mineral occurrences discussed in the report.

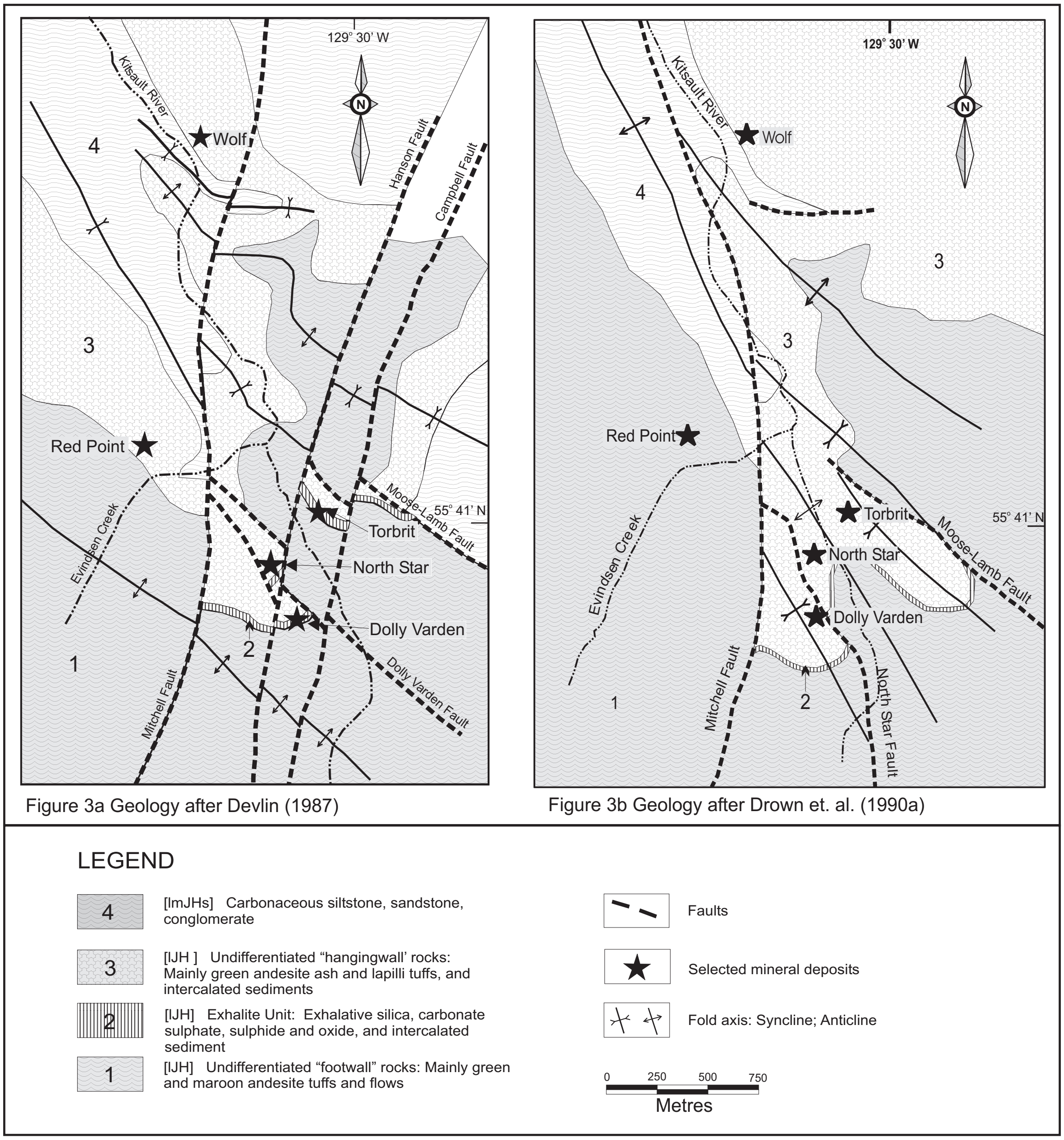

Figure 3a,b. Generalized bedrock geology maps of the upper Kitsault River area showing the structural and stratigraphic relationships inferred by Devlin (1987) and Drown *et al.* (1990a).

num-rich quartz stockwork deposits. The first two types are most abundant and are of particular importance in the upper Kitsault River area. They are considered to be Lower Jurassic in age and formed more or less contemporaneously with the Hazelton volcanic arc (Alldrick *et al.*, 1987; Godwin *et al.*, 1991). The third type is considerably younger; it is associated with a suite of Eocene-age (Alice Arm) quartz monzonite intrusions (Alldrick *et al.*, 1986).

The relationship between the gold-rich and silver-rich deposits in the upper Kitsault River area is uncertain. Although they are both hosted by Hazelton Group rocks below the Salmon River Formation disconformity, they have different styles of mineralization and they are found on different sides of the Kitsault River syncline. The Homestake, Red Point and related copper-gold deposits are in the "Copper Belt" (Black, 1951, Thompson and Michna, 1978), which is an extensive zone of dike injection and gossan development in Unit 4 and Unit 5 on the southwest side of the Kitsault River syncline. The Dolly Varden, Torbrit and related silver deposits occur with fewer dikes and considerably less gossan development in tuffs and breccias in Unit 4 on the northeast flank of the same structure.

The silver-rich, quartz-sulphate-carbonate deposits in the upper Kitsault River area (*e.g.* Dolly Varden and Torbrit) were historically considered to be structurally controlled (Black, 1951; Campbell, 1959; Mitchell, 1973; Thompson and Michna, 1978). However, more recently, Devlin and Godwin (1986) and Devlin (1987) have suggested that they may be exhalative in origin. Tupper and McCartney (1990) provide evidence that suggests that the nearby Sault deposit is stratiform; having formed through exhalation into a restricted marine basin near the top of the Hazelton volcanic arc.

Red Point (MINFILE 103P 196)

The Red Point Cu-Au-Ag prospect (latitude 55º 41' 28'' N, longitude 129º 31' 14'' W) is approximately 24 kilometres north of Alice Arm, on the north side of Evindsen Creek, west of its confluence with the Kitsault River (Figure 2). It is 1.5 kilometres northwest of the Torbrit portal and was linked to the Dolly Varden - Torbrit road by a trail. It is accessible now only by helicopter.

The area was explored by Granby Consolidated Mining, Smelting and Power Company in the early 1910s, and short adits were driven on several of the more attractive copper prospects in the area in the late 1920s. Dolly Varden Mines Limited acquired the area in 1961 and Dolly Varden Minerals Incorporated conducted geological, geochemical and geophysical exploration programs in 1986, locating a wide-spread, precious-metal, soil geochemical anomaly. Three years later, the company trenched and sampled the Red Point and several neighbouring showings and drilled 25 holes for an aggregate length of 2257 metres (Drown *et al.*, 1990b).

The volcanic rocks at the south end of the "Copper Belt" (Figure 2) are predominantly grey-green andesites and andesitic tuffs (Unit 4) that have a northwest strike consistent with their location on the western limb of the Kitsault River syncline (Alldrick *et al.*, 1986; Devlin, 1987; Drown *et. al.*, 1990b). The rocks are intruded by feldspar porphyry dikes ("Kitsault Intrusions") for a distance of approximately 15 kilometres, between the Cambria Icefield and the Kitsault River (Black,1951; Carter, 1970; Mitchell, 1973; Grove, 1986). However, these intrusions are not specifically mapped by Alldrick *et al.* (1986), Devlin (1987) or Drown *et al.* (1990b). They are included with the volcanic rocks.

The rocks are cut by numerous, steep, northwest-trending faults that predate and control much of the later alteration and mineralization, which occurred in stages. First, the rocks were deformed over a broad area and pervasively altered to sericite, quartz and pyrite. The more altered rocks along some of the major northwest-trending faults were then overprinted by potassium feldspar and re-deformed into extensive areas of "crackle-breccia". The brecciated rocks were later altered to chlorite and mineralized with pyrite. Other sulphides were deposited still later. Chalcopyrite, sphalerite and galena occur with chalcedony, quartz, carbonate and chlorite in veins and in the breccia cement (Drown *et al.*, 1990b). The rocks are cut by northeast-trending faults.

The Red Point and other prospects in the area are structurally controlled. They are northwest-trending "replacement zones" or quartz veins that locally contain appreciable amounts of copper, gold and silver. They are widespread and erratically distributed throughout the broad deformation and alteration zone. The rocks are pyritic and form highly gossanous outcrops.

Homestake (MINFILE 103P 216)

The Homestake Cu-Au-Ag prospect (latitude 55º 45' 32'' N, longitude 129º 35' 15'' W) is on Homestake Ridge, between the West Kitsault River and the Kitsault River, south of the Cambria Icefield (Figure 2). It is at the north end of the "Copper Belt", approximately 35 kilometres southeast of Stewart.

The property covers a prominent gossan that was located in the early 1900s and explored for copper and gold prior to the Second World War. Consolidated Homestake Mining and Development Company drove an adit on the Homestake claim in the 1920s and British Lion Mines Limited drove two more on the same structure in the 1930s. MINFILE reports that the latter extracted a small (7.9 tonnes) bulk sample with an average grade of 140 g/t gold, 203 g/t silver, 7.5% copper and 3.8% zinc.

Other prospects on the ridge, including Vanguard Gold (103P 091) and Vanguard Copper (103P 210) deposits were explored by Canex Aerial Explorations Limited in the 1960s. Newmont Exploration of Canada Limited consolidated ownership in the area in the late 1970s. The company interpreted some of the siliceous volcanic rocks as rhyolite and explored the area for volcanogenic massive sulphide deposits. In the mid 1980s, Cambria Resources Limited reinterpreted the accumulated data and changed the exploration focus back to epithermal vein-type deposits. Noranda Exploration Company Limited acquired the property in 1989. It conducted a substantial amount of grid work and drilled twelve holes, for an aggregate length of 1450 metres.

The geology of the area is described by Black (1951), Coombes (1986) and Chinn *et al.* (1990). The ridge is underlain by a northwest-trending package of andesitic agglomerates, flows and related tuffs and intercalated argillic sediments (Units 4 and 5). However, there has been extensive injection of dikes and sills of hornblende feldspar porphyry subparallel to the regional trend. As at Red Point, the intrusions are broadly coincident with the "Copper Belt" gossan. They pre- and post-date mineralization (Coombes, 1986).

The bedded strata and intrusive rocks are cut by northwest and east-trending brittle faults, fractures and breccia zones that have focused fluid flow. The rocks have been sequentially silicified, sericitized, chloritized, carbonatized and locally intensely pyritized. Some of the rocks have also been mineralized with chalcopyrite, sphalerite, galena and trace amounts of arsenopyrite and tetrahedrite. The economically more significant sulphides generally occur with quartz, calcite and lesser barite in vein and stringer stockworks and as pods and blebs in the matrix of the breccias.

Petrographic work suggests a minimum of three stages of vein development. Quartz veins containing pyrite, chalcopyrite and sphalerite are crosscut by carbonate veins and veinlets enriched in galena, arsenopyrite and tetrahedrite, and both of the above are overprinted by barite (Coombes, 1986). Rock and soil geochemical data also suggest multiple events. Copper is enriched with gold at Homestake; however, lead and zinc are more commonly found with silver near the Vanguard prospects. According to Chinn *et al.* (1990), the Vanguard area geochemical anomalies overlie altered volcanic rock on the west side of a major west-dipping fault. The age of the fault is uncertain; however, it marks the eastern contact of the volcanic unit in the area. The sedimentary rocks in the footwall of this fault are barren.

At Homestake, mineralization occurs in a quartz vein stockwork in a zone of intense silica-sericite-pyrite alteration in deformed, brecciated andesite and hornblende feldspar porphyry. The stockwork contains variable amounts of chalcopyrite, galena, sphalerite, pyrite and barite and it locally contains large pods and lenses of chalcopyrite. Higher-grade copper samples are locally strongly enriched in gold and mercury (Black, 1951; Chinn *et al.* 1990). The best copper and gold values at the Vanguard Copper prospect are from a pervasively chloritized, brecciated volcanic rock and the best silver values are from a quartz-carbonate vein (Chinn *et al.*, 1990). MINFILE reports that the Vanguard Copper deposit has an inventory of 11 800 tonnes grading 8.6% copper, 2.4 g/t gold and 141 g/t silver.

Wolf (MINFILE 103P 198)

The Wolf Pb-Zn-Ag property (latitude 55º 42' 27'' N, longitude 129º 31' 01'' W) is on the east side of the Kitsault River, approximately 25 kilometres upstream from Alice Arm and 6 kilometres southwest of Kitsault Lake (Figure 2 and 3 a,b). Prior to the mid-1980s, the property was accessed by the Dolly Varden - Torbrit mine road. It is accessible now by helicopter.

The Wolf deposit was located at the same time as the Dolly Varden and Torbrit deposits and saw considerable exploration in the early 1910s. By 1916, it was expected to supply lower-grade ore to a concentrator proposed for the nearby Dolly Varden mine (Muralt, 1985). In 1964, the Sunshine Mining Company optioned the property, drove an adit and crosscut and further developed the deposit (Carter, 1964). Dolly Varden Mines Limited continued the work, extended the drift and drilled the property four years later.

In 1980, Dolly Varden Minerals Inc. contracted Derry, Mitchener and Booth Limited to make an independent assessment of the reserves at the Wolf and nearby Northstar deposits. It also arranged for Wright Engineers Limited to determine the feasibility of mining the deposits at a rate of 275 tonnes per day, for six months of the year (Thompson and Pearson, 1981). The Company's Annual Report for 1971 shows that, at that time, the Wolf deposit had a resource of 485 324 tonnes grading 336 g/t silver, 0.59% lead and 0.12% zinc.

The geology of the area is described by Carter (1964) and Thiersch (1986). The deposit is composed of three north-northeasterly trending, near vertical, quartz-carbonate "replacement" zones in deformed andesitic tuffs and agglomerates near the apparent top of the Hazleton volcanic arc (Unit 4). The three zones are shear-hosted and may be fault off-set portions of a single occurrence (Thompson and Pearson, 1981). The shear-zone that hosts the mineralization is discordant to regional stratigraphy; however, it is not known whether it cuts through the disconformity below the Salmon River Formation strata (Unit 6) in the core of the Kitsault River syncline (Figure 2).

The zones are composed of quartz and carbonate with local concentrations of barite, jasper and sulphide. They are strongly internally brecciated and they appear to have formed in stages, as a result of intermittent movement on the controlling structure. Early-formed quartz was deposited with pyrite to create a vein with a variety of open space filling textures. This was later brecciated and cemented by a second generation of pyrite with sphalerite, galena and chalcopyrite. This was, in turn, brecciated and the sulphides present were recrystallized, giving the latest generation of pyrite a distinctive "framboidal" texture. The final stage was marked by the introduction of calcite with sphalerite and galena (Thiersch, 1986). The silver minerals were probably introduced relatively late in the deposit's development. Carter (1964) found that pyrite, galena, sphalerite, magnetite, hematite and silver-bearing minerals (pyrargyrite, tetrahedrite and native silver) are in small fractures in zones of fine-grained, crushed quartz, interstitial to larger quartz fragments.

Although inconclusive, sulphur and oxygen isotope studies carried out at the universities of Calgary and Alberta, suggest that the fluid that formed the Wolf deposit was of mixed origin. Sulphur isotope data suggest derivation from magmatic and sea water fluid sources, and oxygen isotope data suggest derivation from volcanic rocks and marine sediments (Thiersch, 1986). Devlin (1987) obtained similar results from samples from the nearby Torbrit mine and both authors conclude that the Wolf and neighbouring Dolly Varden and Torbrit deposits were formed by related hydrothermal systems.

Torbrit (MINFILE 103P 191)

The Torbrit Ag-Pb-Zn deposit (latitude 55º 41' 14'' N, longitude 129º 30' 21'' W) is on the east side of the Kitsault River, approximately 23 kilometres upstream from Alice Arm (Figure 2). In the 1920s, access was by trail or narrow-gauge railway from Alice Arm. In the mid-1940s, the railway was replaced by a road. Since the late 1980s, it has been accessible only by helicopter.

The Torbrit deposit was located and explored while the neighbouring Dolly Varden mine was in production. It was first developed in the mid to late-1920s, when a small tonnage of higher-grade ore was removed and processed through a small (45 tonnes per day) mill. The operation closed in 1930. Torbrit Silver Mines Limited bought the property in 1946 and subsequently built and operated a

350 tonnes per day, hydroelectric-powered mill, flotation concentrator and cyanidation plant. The mine produced 1 251 387 tonnes of ore yielding 579 996 kilograms of silver (80% in concentrate shipped to Trail and 20% as bullion), 3.5 kilograms of gold, 4 868 323 kilograms of lead and 283 037 kilograms of zinc between 1949 and 1959. MINFILE shows that it has a residual resource of 786 285 tonnes grading 311.90 g/t silver, 0.42% lead and 0.50% zinc.

The main deposit (Figures 2 and 3 a,b) is a crudely arcuate, northwest-plunging lens within an otherwise sub-economic sheeted "vein" in a moderately northwesterly dipping shear zone that cuts massive Hazelton volcanic rocks (Unit 4). The higher-grade, mineable zones are defined by assays and are conformable with the main vein. Early workers considered that the deposit formed through replacement of breccia along a tensional fault system (Black, 1951; Campbell, 1959; Mitchell, 1973). According to Campbell, the controlling breccia zone was likely deformed and folded prior to the introduction of the fluid that formed the "vein" and the economically significant portion formed where the shear was folded about a tight synformal axis. The mineralized lenses plunge to the northwest, parallel to the axis of this minor fold. Campbell (1959) notes the presence of horse-tail veins extending into the hangingwall of the deposit and an abundance of more or less altered country-rock fragments in its footwall.

Mitchell (1973) describes two stages to the mineralization. In the first, he suggests that breccia that formed along a major structure underwent mesothermal alteration; it was pervasively altered to quartz and carbonate and mineralized with pyrite. In the second, he suggests that the altered breccia was cross-cut by a series of high-angle faults and the original structure was reopened and mineralized during a later epithermal event. He concluded that the Torbrit, Northstar and Dolly Varden deposits were part of a single replacement vein deposit that was later disrupted by faulting.

The main vein at Tobrit is composed of barite, three varieties of silica (quartz, jasper and chalcedony) and carbonate. Where mineralized, it also contains small amounts of sulphide and oxide (magnetite, hematite, pyrite, sphalerite, galena, chalcopyrite, tetrahedrite, pyrargarite (ruby silver)) minerals and traces of native silver. The vein is compositionally banded and it is also colour-banded, commonly subparallel to deposit contacts and to the schistocity of the surrounding rock. Its gangue minerals contain vugs lined by quartz crystals with well-shaped terminations. In some localities, the deposit has a pronounced mottled appearance as different gangue mineral assemblages selectively replace country-rock fragments (Campbell, 1959).

Campbell (1959) analyzed crustiform barite samples from Torbrit by X-ray fluorescence and determined that they contained between 0.52 and 1.05% strontium. He also looked for systematic variation in Sr/Ba ratio in barite samples from throughout the mine, but did not find it. Barite Sr/Ba ratios are controlled both by temperature of formation and the Sr/Ba ratio of the coexisting fluid and Campbell concluded that both must have varied within the deposit during deposition. Campbell also used sphalerite composition data to obtain a preliminary temperature estimate (270º C) for the deposit. He concluded that the occurrence was intrusion-related and epigenetic in origin, possibly formed during deformation in the late Cretaceous to early Tertiary period.

In 1985, Devlin mapped parts of the upper Kitsault River valley at 1:5000 and 1:2000 scales to establish the stratigraphic and structural setting of the principal deposits and related showings (Figure 3a). He also studied the petrography and lithogeochemistry of the host rocks and determined whole-rock potassium-argon age dates. In addition, he studied the sulphur, oxygen, carbon and lead isotope contents of selected minerals. Based on the above studies, on the presence of sub-rounded ore fragments in tuffs found in the hanging wall of the deposit, and on the recognition of a stockwork vein system in the footwall of some of the deposits, Devlin concluded that the Torbrit, Northstar and Dolly Varden deposits were fault off-set segments of a single stratiform deposit (Devlin and Godwin, 1985; Devlin, 1987).

Devlin (1987) mapped a thick succession of shallow-water Hazelton Group volcanic and related volcano-sedimentary rocks under the fossiliferous sediments (Unit 6) exposed in the core of the northwest-plunging Kitsault River syncline. Within it, he identified a distinctive silica, carbonate, sulphate and sulphide-bearing horizon that he considered to be exhalative in origin. His mapping shows that the unit is underlain by a minimum 1200 metres of weakly-altered, green-maroon basaltic tuff; green-maroon porphyritic andesite; and green andesitic shard tuff (Unit 4). It also shows that it is overlain by approximately 1000 metres of pale grey basaltic to andesitic tuff; maroon basaltic to andesitic ash-lapilli tuff; dark green andesite tuff; grey-green porphyritic andesite; and pale green andesitic ash tuff (Units 4 and 5).

The exhalative unit can be traced for several kilometres along strike on the northeast side of the Kitsault River syncline. According to Devlin (1987), it hosts Dolly Varden, Northstar and Torbrit deposits and exhibits regional-scale zonation. He suggests that differences between the deposits are consistent with changing fluid chemistry, brought about by mixing of exhalative fluids and sea water, and differing depths of deposition. The horizon shows gradation from a silica-sulphide exhalite facies (Dolly Varden), through a carbonate-sulphate-sulphide exhalite facies (Northstar), to a sulphate-oxide-sulphide exhalite facies (Torbrit). The Dolly Varden deposit is inferred to have formed under less oxidizing, deeper water conditions than were found at Torbrit (Devlin and Godwin, 1986; Devlin, 1987).

Stable isotope data for selected samples from Wolf, Torbrit, Northstar and Dolly Varden indicate that the sulphur in the sulphide species may have originated from a source that was predominantly magmatic, and that found in the associated barite most likely came from oxygenated lower Jurassic seawater. The oxygen isotopes in barite, quartz and carbonate are compatible with a sedimentary marine origin and derivation from heated (ca. 245º C) sea water (Devlin, 1987).

Lead isotope ratios for galena crystals from the Wolf, Torbrit, Northstar, Dolly Varden and Red Point deposits cluster with those of other Early Jurassic deposits in the Stewart-Iskut area (Godwin *et al.*, 1991), suggesting that the mineralization is penecontemporaneous with the development of the Hazelton volcanic arc (Devlin, 1987). However, three volcanic rocks collected in the area gave whole-rock potassium-argon age dates (68.1 - 72.2 +/- 2.5 Ma.) suggesting a Late Cretaceous age of formation, inconsistent with the inferred age of the Hazelton volcanic arc. The samples are thought to have suffered argon loss during lower-greenschist facies metamorphism (Devlin, 1987).

Mapping around the Torbrit and other deposits shows considerable structural complexity in the Lower Jurassic Hazelton volcanic and sedimentary rocks on the east flank of the Kitsault River syncline (Alldrick *et al.*, 1986). According to Devlin (1986), rocks in the nose of the syncline are cut by near-vertical, northwest-trending structures that down-drop to the west. Later, near-vertical, north to northeast trending faults display moderate up and down motion (Figure 3a). Some of the post-mineral faults host late lamprophyre dikes. Drown *et al.* (1990a,b) also show that the silver deposits originally formed as a single occurrence; however, they suggest a different fault arrangement for splitting them up (Figure 3b).

Dolly Varden Minerals Inc. drilled a single hole under the Torbrit deposit in 1990, as part of a major exploration program for exhalative silver deposits associated with the known deposits in the area (Drown et. al., 1990a; McGuigan and Melnyk, 1991). The hole was collared to the northwest of the Torbrit glory hole and intersected 30 metres of "clastic" chalcedonic quartz, barite and minor sulphide. Analysis of core samples indicated anomalous concentrations of silver, copper, lead and zinc.

Northstar (MINFILE 103P 189)

The Northstar Ag-Pb-Zn deposit (latitude 55º 41' 06'' N, longitude 129º 30' 30'' W) is on the west side of the upper Kitsault River, approximately 23 kilometres north of Alice Arm (Figure 2). It is across the river from the Torbrit mine and can only be accessed by helicopter.

The deposit was located at approximately the same time as the Dolly Varden and three adits had been driven on it, and several high-grade bulk samples had been removed by the time the Dolly Varden mine closed in 1930. Torbrit Silver Mines Limited explored the deposit while its Torbrit mine was in operation but felt that the grade was too low to allow for production. Derry, Mitchener and Booth Limited resampled and redrilled the Northstar deposit in 1979/80 and identified a diluted reserve of 128 424 tonnes grading 401.4 g/t silver, using a 137 g/t silver cut-off (Thompson and Pearson, 1981). This reserve, along with comparable resource data for the Wolf deposit, was factored into a feasibility study that was then being conducted by Wright Engineers Limited.

Early workers (Black, 1951; Mitchell, 1973) described the Northstar deposit (Figure 2) as a high-grade lens in a replacement "vein" in Hazelton Group volcanic rocks (Unit 4). The vein strikes northeast and has a moderate to steep northwest dip. The deposit is cut by minor faults subparallel to its contacts and by lamprophyre dikes that have a similar strike but a more vertical dip.

Although it is less well documented than the Torbrit occurrence, the Northstar deposit is reported to be composed of barite, quartz and carbonate and to display similar banding and crustiform textures to those found across the river. The vein contains minor amounts of sulphide and sulphosalt minerals (pyrite, marcasite, galena, sphalerite, chalcopyrite, pyrargarite and argentite) and native silver. However, they are unevenly distributed and the mineable part is a tabular body within the plane of the vein. Devlin and Godwin (1986) and Devlin (1987) consider the Northstar deposit to be exhalative in origin and, based on the lack of oxide minerals, suggests that it may have formed in slightly deeper water, under slightly less oxidizing conditions than existed at Torbrit.

Dolly Varden Minerals Inc. applied Devlin's exhalative model to the Dolly Varden area and conducted major exploration programs in 1989 and 1990. It drilled the Northstar deposit down dip of the main adit and located the mineralized "exhalite" horizon below an andesitic debris flow unit. The "exhalite" unit is described as having a lower carbonate-rich (silica-calcite-barite) facies that is essentially barren and an upper sulphide and oxide-bearing facies that is weakly mineralized. The latter contains knots and patches of pyrite and trace amounts of chalcopyrite, honey-coloured sphalerite, galena and jasper. It is partially fragmental (Drown et. al., 1990a and McGuigan and Melnyk, 1991). Some of the holes drilled through the "exhalite" unit intersected substantial thicknesses of chlorite-calcite-pyrite alteration stockwork in its footwall. (Drown et al., 1990a).

Dolly Varden (MINFILE 103P 188)

The Dolly Varden Ag-Pb-Zn mine (latitude 55º 40' 55'' N, longitude 129º 30' 32'' W) is on the west side of the upper Kitsault River, approximately 22 kilometres upstream from Alice Arm (Figure 2). It was the first mine opened in the area and it triggered the development of much of the early infrastructure. It is accessible now by helicopter.

The original Crown-granted claim was located in 1910. By 1917, ore shoots at Dolly Varden were sufficiently well delineated that Dolly Varden Mines Company arranged for a contractor to build a narrow-gauge railway up the valley from Alice Arm. Unfortunately, the cost proved to be far higher than anticipated and the mining company was forced into bankruptcy. The contractor operated the mine between 1919 and 1921 and shipped high-grade "direct shipping" ore to smelters at Anyox and Tacoma (Muralt, 1985). Including intermittent production between 1935 and 1940, the mine produced 33 434 tonnes of ore containing 42 451 kilograms of silver. According to MINFILE, it has an inventory of 42 633 tonnes grading 754.1 g/t silver.

The Dolly Varden deposit was developed on five levels and several sublevels, and from three small glory holes. Early workers, including Black (1951), describe a single, arcuate, north-dipping replacement "vein" within a package of massive, altered and pyritic volcanic agglomerates and tuffs (Unit 4). The deposit is composed of quartz with lesser carbonate, barite and pyrite, and trace amounts of galena, sphalerite, chalcopyrite, tetrahedrite, pyrargarite and native silver. It is banded, ranges in colour from white through grey to black and it contains fragments of locally derived wallrock. The economic minerals are in relatively limited shoots within the vein. Sulphide contents are thought to increase with depth. Near surface, the shoots are strongly enriched in native silver and the glory hole stopes are reported to have yielded bonanza grades. Controls on the ore shoots are uncertain; however, Black (1951) notes their proximity to a major synclinal fold axis and Mitchell (1973) discusses the significance of cross-cutting structures.

Devlin and Godwin (1986) show that the deposit is bounded on the north by the Dolly Varden fault, an early northwest-trending structure and is cut by moderate to steep north to northeast-trending faults, some of which contain post-mineral lamprophyre dikes. To the west, the deposit terminates at the Mitchell Fault (Figure 3a). They also suggests that a major northwesterly trending fault (Hanson Fault) may have affected water depth during deposition. Devlin and Godwin (1986) divide the Dolly Varden deposit into western and eastern portions, based on mineralogical differences and suggests that the higher sulphide content found in the eastern portion may reflect exhalation in deeper water than was found further west or further north. However, Drown *et al.* (1990a) show no sign of the Hanson Fault (Figure 3b).

Dolly Varden Minerals Inc. traced the mineralized horizon in 1989 and drilled four holes in 1990 testing for the downdip extension of the mineralized zone. The holes intersected several zones of possible "exhalite" - a quartz-sulphide breccia composed of jasper, chalcedonic quartz and pyrite with trace amounts of economic sulphides. Two of the holes also encountered chlorite-calcite-pyrite stockwork alteration in the footwall of the deposit. The hostrock is similar to that found under the Northstar deposit (Drown *et al.*, 1990a; McGuigan and Melnyk, 1991).

Sault:Kit:Frog:Kitsault (MINFILE 103P 233)

The Sault property (latitude 55º 45' 04'' N, longitude 129º 29' 24'' W) includes several Zn-Pb-Ag-Sr-Ba prospects on the south shore of Kitsault Lake. It is at the head of the Kitsault River, approximately 30 kilometres upstream from Alice Arm (Figure 2). Access is by helicopter or float plane.

The showings were located in 1966 and explored intermittently until 1984. That year, Cominco Limited undertook a variety of geological, geochemical and geophysical surveys and drilled eight holes for a total length of 1269 metres (Tupper and McCartney, 1990). The property was acquired in 1988 by Oliver Gold Corporation (50%), Aber Resources Limited (25%) and Tanqueray Resources Limited (25%). The joint venture partners conducted regional and local exploration programs and the following year drilled a further five holes for an aggregate length totaling 998 metres (Tupper and McCartney, 1990). Lac Minerals Limited held the property in the mid-1990s (Sieb, 1995).

The Sault property (Figure 2) straddles the disconformity mapped at the top of the Hazelton volcanic arc. It is underlain by volcanic and sedimentary rocks (Units 4 and 5) and by fossiliferous sediments (Unit 6). The rocks are draped over the axis of the Mount McGuire anticline (Alldrick et. al., 1986) and the strata commonly display easterly to northeasterly strikes and relatively shallow dips towards the north or northwest. Greig (1991), mapping in an area under the disconformity to the southeast of Kitsault Lake, found a significant but volumetrically small amount of intermediate to felsic volcanic and associated clastic rocks on top of more abundant maroon and green andesitic pyroclastic rocks. The mineralized rocks near Kitsault Lake are underlain by feldspar-rich andesite to rhyolite tuff and lesser epiclastic material and overlain by andesitic to basaltic tuff, intercalated with minor flows and intermixed with epiclastic material.

The mineralization is in a carbonate unit interbedded with the volcanic rock, a short distance below the disconformity. The unit is up to 8 metres thick; however, rapid facies variation and block faulting have made it difficult to trace downdip. It includes a lower section of metalliferous carbonate diamictite, limestone and mudstone; a central volcaniclastic interval; and an upper sequence of laminated carbonate, sulphate and sulphide that contains a minor amount of tuff, chert and volcanic rock (Tupper and McCartney, 1990). The carbonate is crenulated and has micro-folds that plunge at a shallow angle to the north-northeast.

Tupper and McCartney (1990) refer to company reports by MacRobbie, written in 1988, that suggest that the mineralized carbonate deposits may be restricted to syn-sedimentary grabens that acted as traps for local accumulations of carbonate, sulphate and minor sulphide mineralization. The carbonate unit has been traced for approximately 5 kilometres along strike; however, it may extend further to the southwest. Mortensen and Kirkham (1992) report finding similar rocks including "1-2 cm thick conformable (?) layers of pale, fine-grained, sphalerite" in thinly laminated sedimentary rocks in drill core on the Ace/Galena (103P 208) Ag-Pb-Zn property, 2.5 kilometres southwest of the "Showing Lake" occurrence at Sault.

The Ace/Galena is otherwise described as being composed of silver-rich galena stringers in a bleached pyritic tuff in the footwall of a quartz-breccia vein that incorporates fine-grained fragments of country rock. The vein is controlled by a northeast-trending, moderate northwest-dipping fault that projects towards the Sault property (Carter, 1968).

Although the mineralized carbonate at Sault contains laminated to bedded and locally framboidal pyrite, fine-grained sphalerite and galena and locally well-bedded celestite, metal values are generally low. Drillhole K89-11 contained the best intersection reported in 1989. It assayed 1.3% zinc, 0.12% lead and 26.5 g/t silver over 4.95 metres (Tupper and McCartney, 1990). The sulphate at Sault was originally described as barite; however, Blackwell (1986) submitted samples for X-ray fluorescence analysis and found that they are highly enriched in strontium and contain only modest (0.1% to 0.5%) amounts of barium.

Mortensen and Kirkham (1992) analyzed zircons from a feldspar-phyric unit (probably a welded dacitic ash-flow tuff) 100 to 200 metres stratigraphically below the mineralized horizon and determined a U-Pb age of 193.5 +/- 0.4 Ma. This is an approximate age for the mineralization and for the cessation of volcanism in the upper Kitsault River area.

DISCUSSION

The subvolcanic, feldspar porphyry dike swarm that defines the "Copper Belt" on the western side of the Kitsault River syncline is an important control on mineralization in the upper Kitsault River area. Thompson and Michna (1987) suggest that the dikes are part of a "diorite to granodiorite intrusion" complex and show the mineralization is epigenetic and epithermal in origin. They describe four zones:1) copper and gold mineralization within and along the northeastern extremity of the "intrusion" (*e.g.* Homestake); (2) copper within the "intrusion" and copper-silver within volcanic rocks adjacent to the "intrusion" (*e.g.* Vanguard showings); (3) silver and silver-lead showings in volcanic rocks further away from the intrusion (*e.g.* Dolly Varden, Torbrit) and (4) more distal silver properties further east, including the Sault occurrence. The deposits are zoned from high-temperature in the west to low-temperature in the east.

The "Copper Belt" dikes are poorly differentiated but they are known to include Goldslide-type intrusions similar to those mapped at Red Mountain, 30 kilometres to the northwest (Greig *et al.*, 1994). Rhys *et al.* (1995) suggest that the Red Mountain gold deposit has "porphyry" affinities and speculate that the intense alteration found at Red Mountain may have been caused by fluids derived from a hornblende-biotite-quartz porphyry phase of the Goldslide intrusion suite. The fluids altered intrusive and volcanic rocks at Red Mountain to sericite-quartz-pyrite and chlorite-K-feldspar-sericite-titanite. They then formed tourmaline veins, altered the rocks to K-feldspar-pyrite-titanite-actinolite and deposited a semi-tabular body of gold-silver mineralization within an overprinted pyrite-pyrrhotite stockwork.

Some of the dikes in the "Copper Belt" are similarly intensely altered and mineralized and may have contributed the large volumes of porphyry-type fluid required to cause the extensive alteration and mineralization observed in the area. Others are described as being post mineral, constraining the time of alteration (Coombes, 1986). The Homestake and Red Point deposits in the "Copper Belt" appear to have been formed during a protracted period of alteration and mineralization. Early-formed copper-gold mineralization is overprinted by somewhat later-formed silver-lead-zinc mineralization and barite.

Although there are few coeval dikes mapped on the east side of the Kitsault River syncline, the Dolly Varden and Northstar deposits are partially underlain by a stockwork breccia that is described as being similar in appearance to rock found at Red Point and Homestake (McGuigan and Melnyk, 1991). The breccia is cemented by quartz, chlorite and pyrite with minor amounts of chalcopyrite and sphalerite. Drown *et al.* (1990a,b) note that similar rock is found in alteration zones underlying volcanogenic massive sulphide deposits and they suggest that the "Copper Belt" alteration zone may have formed in the footwall of the Dolly Varden - Torbrit exhalative horizon.

In an unpublished report, Mitchell (1973) suggests that the deposits in the upper Kitsault River area may be controlled by a ring structure that formed late in the development of the Hazelton volcanic arc. He suggests that the structure focused emplacement of the dike swarm on the west limb of the Kitsault River syncline and developed the breccia zone found on the east limb. The breccia was later silicified and carbonatized, re-brecciated near cross-faults and mineralized to created the ore-shoots found at Torbrit, Northstar and Dolly Varden. Mitchell (1973) suggests that the Wolf deposit formed along one of the cross-structures. It has had a prolonged history of mineralization and deformation, starting with deposition of quartz and pyrite (but without gold) and ending with precipitation of carbonate, sphalerite and galena, with silver

Devlin and Godwin (1986) and Devlin (1987) provide a different interpretation for the origin of the deposits. They suggest that the Torbrit, Northstar and Dolly Varden deposits are stratiform and exhalative and that differences between them may be attributable to formation under differing depths of water. Based on isotope studies, Devlin (1987) suggests that the deposits are lower Jurassic in age, formed during the development of the Hazelton volcanic arc and that the fluids that formed them may have included seawater. Thiersch (1986) found sufficient points of similarity between the sulphur and oxygen isotopes in the various minerals at Wolf and Torbrit to conclude that, whatever their origin, the deposits were probably formed by related hydrothermal systems.

The Eskay Creek Au-Ag-Cu-Zn subaqueous hot-spring deposit, 120 kilometres to the northwest, formed during the waning stages of volcanism in the Hazelton volcanic arc. It formed as a result of intra-arc rifting that occurred at an equivalent time to the transition between Unit 5 and Unit 6 in the Kitsault River area. According to Roth *et al.* (1999), the stratigraphic succession at Eskay Creek includes, from bottom to top, basal andesite, marine sedimentary rocks, intermediate to felsic volcaniclastic rocks, rhyolite flow domes, (mineralized) carbonaceous shales and basalts. Unit thickness and facies distribution at Eskay Creek suggest that the rhyolite domes were emplaced along active faults and breached the sea floor, partially filling an adjacent basin or trough with debris. The intrusions focused fluid flow which led to the creation of chimneys and mounds on the seafloor. These later collapsed to form barite and clastic sulphide-sulphosalt debris that was redeposited with argillaceous sediment on top of the volcaniclastic detritus in the basin.

The Sault prospects also formed in small basins formed through intra-arc rifting during the waning stages of Hazelton arc volcanism. They are locally thick-bedded exhalative deposits that are predominantly composed of carbonate and sulphate. They contain a small amount of sulphide but lack appreciable precious-metal content. The basins may have been simultaneously filled with clastic debris as the rocks show locally extreme thickness and facies variation. The metals present in the Sault exhalite (strontium, barium, silver, lead and zinc) deposit are similar to those found in the silver-rich deposits in the nearby upper Kitsault River valley and they may be genetically related.

SUMMARY AND CONCLUSIONS

Hazelton Group strata in the Alice Arm area are well mineralized and McIntyre *et al.*, (1994b) put the Alice Arm tract (JH26) in second place, after the Brucejack Lake (JH30) area, in their ranking of the metallic mineral potential of the Skeena - Nass area. The volcanic and sedimentary rocks in the Alice Arm area contain numerous mineral prospects and host two past producing silver mines near the head of the Kitsault River. The Dolly Varden and Torbrit mines produced 622 407 kilograms of silver between 1919 and 1959.

Based on published accounts, there are four, possibly related types of showings in the Upper Kitsault River area: These include: 1) epigenetic Cu-Au chlorite-pyrite vein deposits (*e.g.* Red Point, Homestake); (2) epigenetic Ag-Pb-Zn quartz-carbonate vein deposits (*e.g.* Wolf); (3) either epigenetic or syngenetic Ag-Pb-Zn-Ba deposits (*e.g.* Torbrit, Northstar, Dolly Varden); and (4) exhalative Sr-Ba-Pb-Zn-Ag deposits (*e.g.* Sault).

The deposits appear to be zoned outward from the Homestake occurrence in the "Copper Belt" as there is a rapid reduction in copper and gold and an increase in silver, lead and zinc in the occurrences found to the south and east. The deposits appear to have formed during two principal stages of mineralization. The copper and gold-rich deposits were formed during an early, sulphide-rich event coeval with the emplacement of dikes on the west side of the Kitsault River syncline. The silver-rich deposits formed during a later, relatively sulphide-poor event that overprinted the copper and gold deposits on the west side of the syncline and formed separate deposits on the east side. The fluids that formed the Dolly Varden and Torbrit deposits may have been cooler and more oxidized than those that formed the copper and gold-rich deposits. The strontium-rich deposits at Sault may be surface expressions of the second, silver-rich phase of mineralization.

Copper and gold-rich mineralization on the west side of the Kitsault River syncline is structurally controlled and related to the emplacement of subvolcanic dikes that may be emplaced along a ring structure. Volcanic, sedimentary and intrusive rocks are fractured and locally intensely altered to potassium feldspar, sericite and chlorite. The fractures contain abundant pyrite, lesser chalcopyrite and native gold. This style of mineralization has much in common with the Red Mountain Au-Ag deposit, which is hosted by similar rocks on the northern side of the Cambria Icefield.

There are few reported coeval dikes underlying the mineral deposits on the east side of the Kitsault River syncline and the controls on mineralization are less certain. Although there is some development of a chlorite-pyrite rich stockwork, similar to that found in the "Copper Belt", underneath the silver deposits at Dolly Varden and Northstar, the deposits themselves are low in sulphide content. They are composed of quartz, carbonate, barite, traces of pyrite, sphalerite, galena, chalcopyrite, tetrahedrite, pyrargarite and native silver.

The Dolly Varden, Torbrit and Northstar deposits may be epigenetic "replacement" deposits, as suggested by Campbell (1959), Mitchell (1973) and others, or exhalative, as proposed by Devlin and Godwin (1986) and Devlin (1987). In the absence of new data, or access to the old workings, this review is unable to resolve the issue. However, it seems likely that all the deposits are genetically related and formed at relatively shallow depth.

The Sault area prospect has a similar geochemical signature to those around Tobrit and may also be related. It appears to be exhalative in origin. The mineralization is in small basins that formed during the waning stages of Hazelton volcanism. The basins filled with clastic detritus, carbonate, sulphate and trace amounts of sulphide. The geologic setting appears to be similar to that of the Eskay Creek Au-Ag deposit.

The mineral deposits in the upper Kitsault River formed at a time of considerable tectonic instability during the waning stages of Hazelton arc volcanism. Subvolcanic intrusions appear to have provided magmatic fluid and heated sea-water brines. Brittle faults appear to have provided tensional sites for epigenetic mineralization and developed sea floor grabens for syngenetic deposits. The data show that there is considerable potential for several styles of precious-metal bearing mineralization in Hazelton Group strata in the Alice Arm area. In addition to silver-rich deposits similar to those previously found at Dolly Varden and Torbrit, there is excellent potential for gold and silver-rich deposits similar to those found at Red Mountain and Eskay Creek. This study reaffirms the high mineral potential of the area.

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