



**SALMON RIVER PROJECT, STEWART, BRITISH COLUMBIA  
(104E/1)**

**By D. J. Alldrick**

**INTRODUCTION**

In July, 1982 the Ministry initiated a study of the geological setting of precious metal deposits in the Salmon River Valley which trends north from Stewart for 35 kilometres. The specific objectives are:

- (1) Document structural and stratigraphic relationships of the host rock volcanic sequence and its contact relationships with adjacent terranes.
- (2) Determine the evolution and depositional environment of the volcanic system from petrographic and geochemical studies of the sequence.
- (3) Analyse the structural, stratigraphic, mineralogical, and trace element characteristics of the precious metal and base metal deposits of the area.
- (4) Conduct metallogenic studies and define areas of high mineral potential.
- (5) Sample for fossil and radiometric dating of the host rocks and ore zones and compare them with other volcanic terranes around the Middle Jurassic Bowser basin.

**HISTORY AND PREVIOUS WORK**

Prospectors began to explore the Stewart area in 1898 enroute to the Klondike. No major placer gold deposits were found but mineralized float led to the discovery of gold-quartz vein deposits. Continued prospecting located the gossan at Silbak Premier mine in 1910. Subsequently, the Stewart camp became the third greatest lode gold producing area in British Columbia. Between 1918 and 1968 the Silbak Premier mine production alone totalled 4.3 million tonnes grading 13 grams gold per tonne and 298 grams silver per tonne. Tipper and Richards (1976) outlined the tectonic evolution of the region. Major reports by Grove (1971) and Galley (1981) include historical reviews of geological studies in the area and extensive bibliographies. Barr (1980) provides a concise geological review of the Silbak Premier mining camp.

Exploration in the Stewart area during the past few years has been intensive. Companies are reassessing several known properties and testing interesting new prospects; for example, the Prosperity/Porter Idaho silver deposits; the Silbak Premier, Indian and Big Missouri mines;

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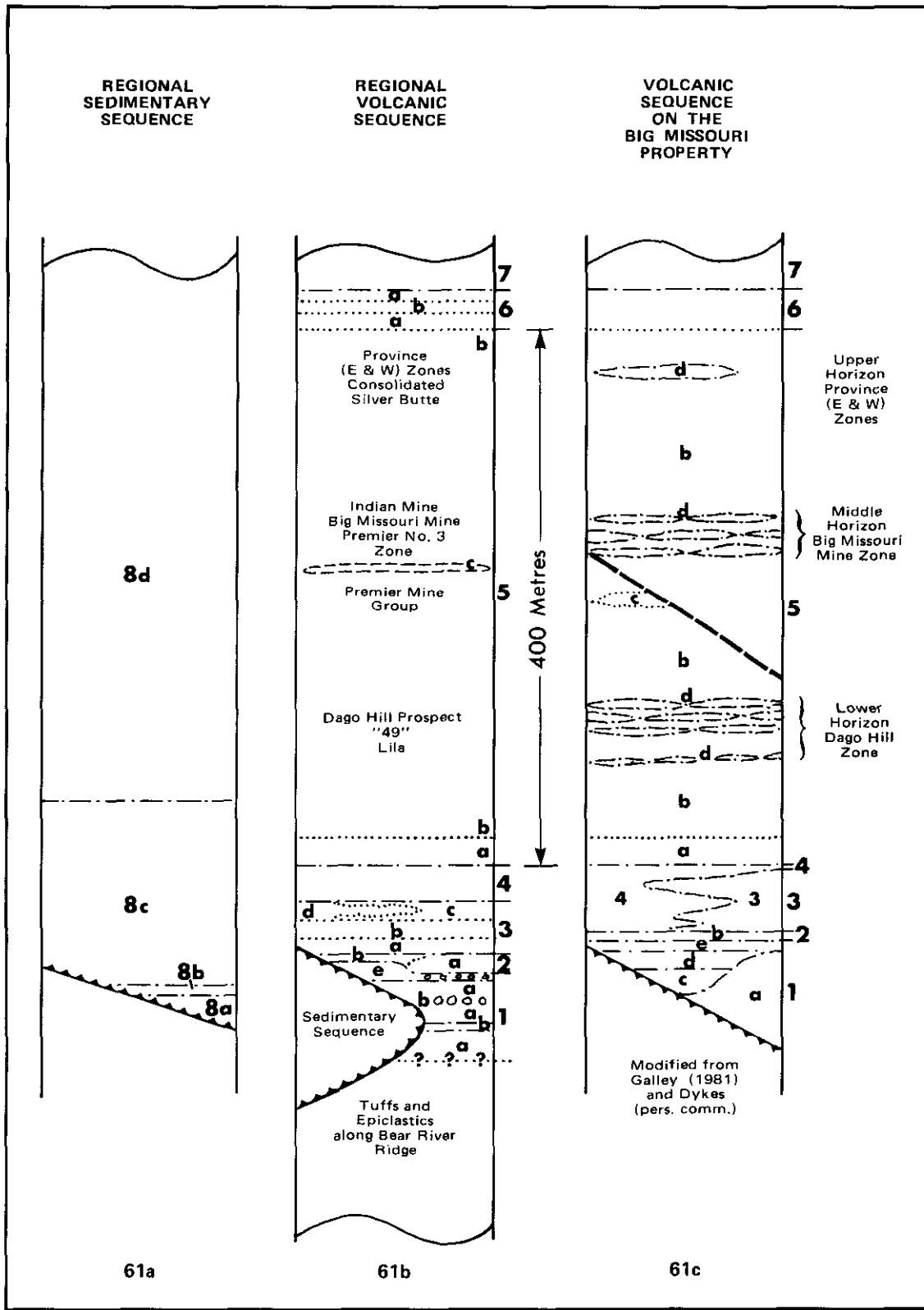


Figure 65. Schematic stratigraphic column.

the Consolidated Silver Butte Mines Ltd. deposit; and many scattered deposits in the Big Missouri claim group. There is also an ongoing exploration program around the producing Scottie Gold mine.

## REGIONAL GEOLOGY

The north-northwest-trending belt of volcanic rocks (shaded on Fig. 64) through the central part of the project area is the focus of this study. It is bounded by a thick sedimentary sequence trending north-northwest along the eastern edge of the map-area and is cut off by a series of intrusive rocks to the west (Tipper and Richards, 1976).

All the major ore deposits and almost all the smaller mineral deposits of the area occur within the volcanic sequence. Hanson (1935) and Grove (1971) identified this sequence as 'Hazelton Group' and 'Hazelton Assemblage' respectively. They assumed that all the volcanic terranes of

## LEGEND

(ALSO FOR FIGURES 66 AND 67)

### SEDIMENTARY SEQUENCE

- |  |  |
|--|--|
| 8a CONGLOMERATIC BLACK SILTSTONES AND SHALES | 8c BLACK TO GREY SILTSTONES            |
| 8b FOSSILIFEROUS LIMESTONE                   | 8d BLACK SILTSTONES AND PYRITIC SHALES |

### VOLCANIC SEQUENCE

- |   |   |
|---|---|
| 7 BLACK SILTSTONE   | <b>FELSIC VOLCANIC ROCKS (CONTINUED)</b>  |
| <b>INTERMEDIATE VOLCANIC ROCKS</b>  | 3 GRADED GREY TUFF (CONTINUED)  |
| 6a BLACK TUFF   | 3c TUFF, WITH LENSES OF 3d  |
| 6b BLACK LAPILLI TUFF, BLEACHED FRAGMENTS                                 | 3d MAROON TUFF  |
| 5a GREEN TUFF BRECCIA   | 2a RHYOLITE ASH FLOW TUFF, HIGHLY PYRITIC, LIMESTONE BOULDERS, SCORIA FRAGMENTS               |
| 5b GREEN TUFFS, LAPILLI TUFFS, AND FLOWS                                  | 2b RHYOLITE ASH FLOW TUFF, MINOR OR TRACE PYRITE, FRAGMENTS OF 1e AND SCORIA                  |
| 5c PURPLE TUFF  | 1a BLACK TUFF, FINE TO MEDIUM GRAINED   |
| 5d CHERT-CARBONATE LENSES, ±SULPHIDES                                     | 1b FOSSILIFEROUS LIMESTONE  |
| 4 PURPLE AND MAROON TUFF BRECCIA, LAPILLI TUFF, TUFF, AND EPICLASTIC ROCK | 1c PALE GREEN TUFF  |
| <b>FELSIC VOLCANIC ROCKS</b>  | 1d GREY-GREEN TUFF  |
| 3 GRADED GREY TUFF:   | 1e BLACK CARBONACEOUS LAPILLI TUFF, ABUNDANT PUMICE FRAGMENTS, LOCAL 1b NODULES, LOCAL PYRITE |
| 3a TUFF BRECCIA   |   |
| 3b LAPILLI TUFF   |   |

### SYMBOLS

- |                           |                    |
|---------------------------|--------------------|
| LITHOLOGIC CONTACT .....  | FAULT .....        |
| LITHOFACIES CONTACT ..... | THRUST FAULT ..... |

the region are contemporaneous with those of the type Hazelton area 200 kilometres to the southeast. Since fault and intrusive contacts border the volcanic sequence in the Stewart area, the correlation is tenuous. A richly fossiliferous limestone unit and fossiliferous limestone nodules occur in dark tuffaceous rocks of the sequence and may provide a definitive age for this metal-rich volcanic belt.

Throughout the area mapped this season, the sedimentary rocks were thrust westward over the volcanic rocks. The sedimentary sequence consists of black and grey siltstones and shales with basal conglomeratic horizons. A thin fossiliferous limestone crops out near the base of the sequence. Fossil age determinations completed in the mid-1960's (Grove, 1971) defined a broad Mesozoic age range. Grove assumed a Middle Jurassic age and identified these rocks as 'Bowser Assemblage.' Subsequently, Tipper and Richards (1976) described similar sedimentary sequences from the upper Hazelton Group. Consequently the exact age and correlation of this sedimentary sequence remains uncertain and the fossil horizon has been resampled for further macro and microfossil study.

A complex series of intrusive rocks along the western edge of the map-area define the eastern margin of the Coast Plutonic Complex. Based on limited K/Ar age dating by the United States Geological Survey, the various batholiths and smaller stocks range in age from Middle Jurassic to Middle Eocene (Grove, 1971). The compositions range from granodiorite to diorite. A wide variety of dyke rocks occur throughout the belt -- compositions range from aplite to gabbro. In some areas the intrusive rocks are spatially related to ore deposits, for example, at the Scottie Gold and Silbak Premier mines.

#### **VOLCANIC STRATIGRAPHY**

Volcanic units within the map-area (Fig. 66) strike north to north-northwest and generally dip to the west. Fragments of subjacent lithologies in tuff breccia, and grading in the thick ash flow of unit 3, suggest that stratigraphic tops are to the west. Galley (1981) identified graded beds in epiclastic rocks of unit 4 which also show that stratigraphic tops are to the west.

The overall thickness of the volcanic sequence must exceed 700 metres (Fig. 65) but total thickness cannot be estimated on the basis of this season's work. The siltstones of unit 7 may mark the top of the sequence. The lower part of the stratigraphic section has not been studied in detail but includes a thick section of tuffs, airfall tuffs, and epiclastic rocks (Fig. 65b). These are exposed along the Bear River Ridge south of Mount Shorty Stevenson.

Galley (1981) developed a detailed type section of the stratigraphy on the Big Missouri property. The few modifications to Galley's work are based on excellent rock exposures along the west slope of Mount Dillworth beyond his map-area. Selected features of the stratigraphic sequence (Fig. 65) are described following.

A fossiliferous limestone band (1b) is interbedded with tuffs of unit 1a on the northwest edge of the Mount Dillworth snowfield. Nearby, large nodules of the same fossiliferous limestone, up to 0.5 metre across, are enveloped in black carbonaceous tuff (unit 1e). Textures suggest that the nodules were unlithified carbonate mud balls when incorporated into the tuff. The same carbonaceous tuff typically contains angular white pumice fragments and locally hosts blebs of pyrite up to 3 centimetres in diameter. Dykes (personal communication) traced unit 1e as far south as Fetter Lake beside Dago Hill. This horizon either underlies unit 2 directly or is separated from it by a thin layer of unit 1a tuff.

Various workers identified the rocks of unit 2 as rhyolite, chert, or exhalite, but the exact composition and origin has not been determined. Resistant rhyolite ash flow tuffs (facies 2a) weather to bright rusty red, nodular outcrops that form a continuous ridge along the western edge of Mount Dillworth. They extend from the Troy Flats to the Unicorn No. 3 workings south of Mount Dillworth where a gradual decrease in the density of fragments and in the pyrite content marks the change to facies 2b, which is exposed discontinuously as far south as Fetter Lake. One thin exposure of facies 2b occurs on the west side of Slate Mountain, and another exposure of this unit can be traced from southeast of Long Lake to the west slope of Mount Shorty Stevenson; southward it gradually changes to facies 2a. Facies 2a carries up to 20 per cent disseminated very fine-grained pyrite in a translucent grey siliceous matrix. Locally the pyrite occurs as massive blebs up to 20 centimetres long. One stratiform pyrite seam on Mount Dillworth is 8 centimetres thick and 6 metres long. This tuff contains numerous rounded carbonate boulders that are recrystallized (?) to coarse-grained calcite; locally there are abundant, large angular fragments of black scoria.

Unit 3 consists principally of grey tuff. The altered maroon facies (3d) is significant because it develops by progressive alteration of the green-grey fine-grained tuff of facies 3c. Oxidation may result from either subaerial exposure or passage of oxygenating fluids through the tuff.

With the exception of the Dunwell and Riverside mines, all the mineral deposits on Figure 64 are hosted within medium green andesitic volcanic rocks of unit 5. The rocks are crystal tuffs, lapilli tuffs, tuff breccias, and flows. They are characterized by plagioclase and, less commonly, hornblende crystals and crystal fragments. The basal tuff breccia contains fragments up to 1.5 metres in diameter and one intact hexagonal fragment of columnar andesite, 1.2 metres across, is exposed on Mount Dillworth. Galley mapped a thin, trough-like lens of pillowed andesites on the Big Missouri property. Intermittent exposures and rapid lateral facies changes in the tuffs prevent correlation of individual strata along strike. Perhaps the purple tuff facies in this sequence will provide time-stratigraphic markers of local and possibly regional significance to mapping and exploration programs.

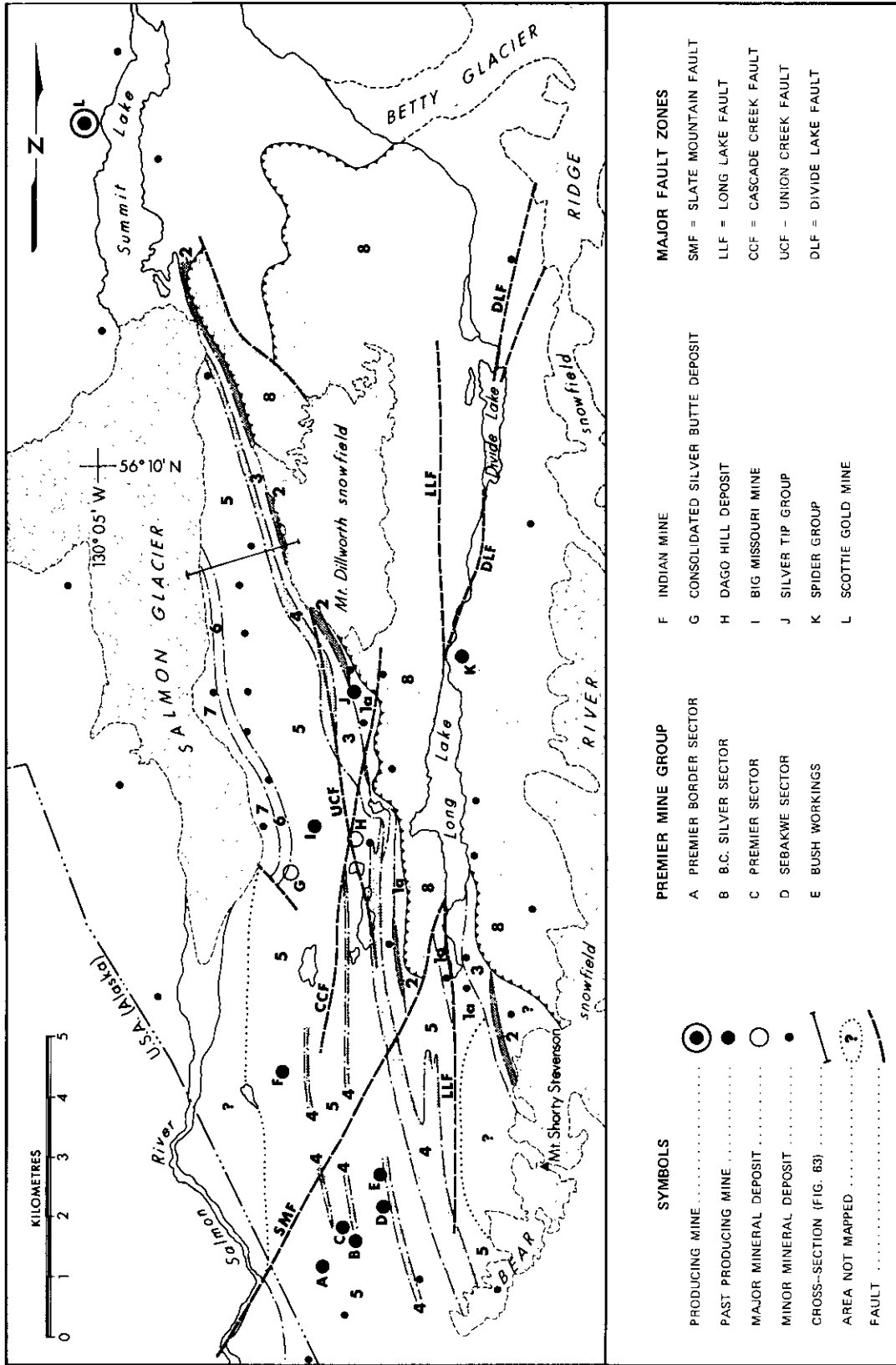


Figure 66. Geology and mineral deposits of the central Salmon River Valley.

Intermittently mineralized lenses of chert, chert-carbonate, and limestone (unit 5d) comprise ore host rocks along Big Missouri Ridge. These rocks and their precious metal mineralization were the focus of Galley's petrographic and geochemical research and his results are summarized here. There are many of these lenses on the Big Missouri property but only a few are mineralized. The chert-carbonate zones can occur as individual lenses or as a series of two or three stacked lenses lying 2 to 20 metres apart. The individual lenses vary up to 7 metres in thickness and have been traced over a maximum strike length of 1.8 kilometres. Typically, they contain angular andesite fragments near their lower contacts; lenses lower in the sequence carry abundant finely disseminated carbon. The chert-carbonate lenses may grade into massive chert or massive carbonate zones along strike.

The contact between units 5 and 6 is gradational. The medium green fine-grained andesites of unit 5 gradually darken and give way to the black tuff of unit 6. Rock textures remain the same in both units and the gradational contact undulates through large outcrop exposures. The orientation of contacts between units 5 and 6 and also between units 6 and 7 are uncertain (Fig. 67).

Greenschist facies metamorphism affected the volcanic sequence throughout the map-area. However, there is no macroscopic evidence of extensive thermal metamorphism adjacent to major intrusive bodies.

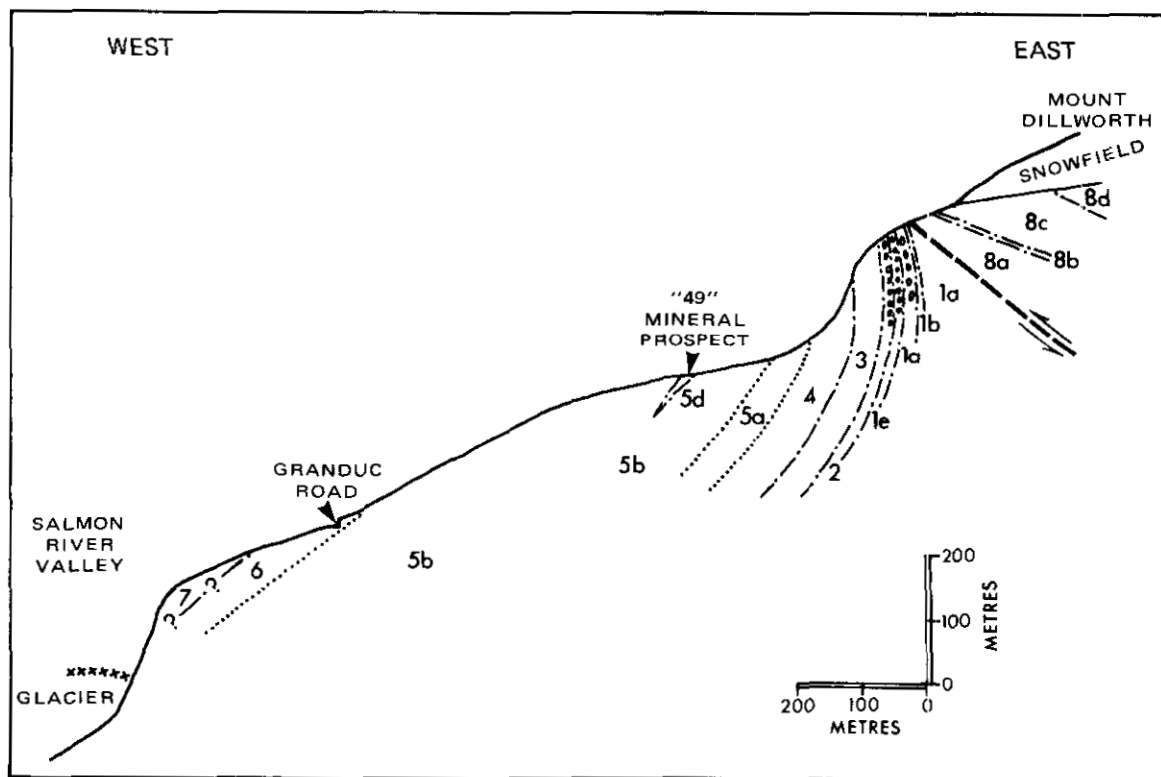


Figure 67. Geological cross-section on the west side of Mount Dillworth.

On a regional scale the volcanic sequence forms a west-dipping homocline averaging 50 degrees dip. Beds steepen to vertical and are locally overturned adjacent to the thrust fault contact (Fig. 67), but dips flatten on Mount Shorty Stevenson. Grove (1971) interpreted a major north-northwest-trending anticlinal axis east of Bear River Ridge. On property scale, gentle secondary warping has a 60-degree trend at Big Missouri (Galley, 1981).

Faulting within this terrane is common on both regional and local scales. Regional north-striking features form major topographic lineaments. One of these, the Long Lake fault, has strata down-dropped on the east side. Direction of movement along many of the faults has not been determined, but two northeast-trending fault zones have left lateral displacement and one major northwest-trending fault has relative right lateral movement.

Small-scale faulting is abundant throughout the area and creates difficulties both in correlating mineralized chert-limestone horizons and in estimating dilution factors for ore reserve calculations.

#### **MINERALIZATION**

Mineral deposits of the Salmon River Valley are categorized according to their structural settings as follows:

- (1) Stratabound deposits (±mineralized wallrock veins)
  - (a) Stratabound disseminated sulphide deposits:  
Big Missouri mine, Dago Hill prospect, Province East zone, Consolidated Silver Butte Mines Ltd. prospect (?)
  - (b) Stratabound massive sulphide deposits:  
Creek zone, Martha Ellen zone, Province West zone, TBI-3 zone, Premier No. 3 zone, Silbak Premier mine (?)
- (2) Massive sulphide vein deposits in major shear zones:  
Scottie Gold mine, Prosperity/Porter Idaho/Silverado mines, Indian mine
- (3) Quartz/breccia fissure vein deposits:  
Outland Silver Bar, Lakeview, Spider, Unicorn No. 3, Silver Tip

There is insufficient data available to classify the important Silbak Premier mine and Consolidated Silver Butte Mines Ltd. prospect with any certainty. Galley (1981) provides detailed descriptions and illustrations of selected examples of type 1a, 1b, and 3 deposits.

The abundance and specific mineralogy of sulphides distinguish the two categories of stratabound deposits. However, both can occur in the same area, as at the Dago Hill prospect. The disseminated types typically carry higher grades of gold and silver in pyrite, minor amounts of associated galena and sphalerite, and negligible chalcopryrite. The



massive sulphide types have typical polymetallic volcanogenic massive sulphide metal concentrations, that is, they have ore grade copper, lead and zinc sulphides with accessory but recoverable precious metals. Both styles of mineralization occur in chert-carbonate lenses (unit 5d); the massive sulphide types contain angular andesite fragments and underlie the cherty material. In contrast, in the Calcite Cuts showing near Dago Hill, disseminated sulphides are distributed through the hangingwall side of the chert but the lower half of the chert-carbonate lens is virtually barren.

Wallrock veins cut footwall strata or cut both hangingwall and footwall rocks in an area of stacked lenses. Disseminated coarse-grained pyrite, galena, sphalerite, and high precious metal values occur in blue-grey quartz-carbonate veins. If the vein density is high enough, the wallrock zone may constitute ore.

#### **MASSIVE SULPHIDE VEIN DEPOSITS IN MAJOR SHEAR ZONES**

These deposits have few features in common, but all are hosted within major fault/shear systems cutting through medium green andesite.

At Scottie Gold mine, ore-bearing veins are distributed along a conjugate shear system developed within and on the northern wall of a major south-east-trending fault. The high-grade gold mineralization occurs in a massive pyrrhotite zone up to 5 metres wide. This zone is symmetrically bordered by swarms of quartz-carbonate-pyrrhotite-base metal sulphide veins which envelope wallrock fragments that have been intensely hematized, silicified, and carbonatized (Williams, personal communication). Both the massive pyrrhotite core vein and the bordering vein swarms bear gold -- entire stopes with up to 60 grams gold per tonne have been produced from this structure. Average production grades to September, 1982 have been 17.5 grams gold per tonne. Overall gold/silver ratios are about 2 to 1.

Access to the mine workings is from an adit developed in the steep hillside overlooking Summit Lake, and exploration work has outlined additional ore grade material both above and below the present mining levels. To the southeast, the mineralization and the shear system feather out; to the northwest, toward the Summit Lake diorite stock, the shear and vein continue but precious metal values drop and base metal grades of the vein increase.

High-grade silver deposits of the Prosperity/Porter Idaho mine are 4 kilometres southeast of Stewart. Mineralization is localized in a series of at least six parallel shear zones. The shear zones trend 165 degrees, dip 60 degrees westward, and are roughly 175 metres apart. To the south, the shears terminate at, or are displaced by, a major north-dipping east-west fault zone. To the north, the shears are believed to continue under the permanent snowcap of Mount Rainey for more than 2.5 kilometres to the Silverado mine workings where sporadic mineralization is hosted by

parallel shear zones of identical orientation. Mineralization pinches and swells with the width of a shear zone, resulting in well-mineralized zones that are up to 11 metres wide, 250 metres long, and extend to at least 175 metres depth where old mine workings end, still in mineralization. The zones are complex, consisting of one or typically two central massive sulphide bands each about 60 centimetres wide but locally converging and swelling to 2 metres in width. This massive sulphide core is composed of argentiferous galena and lesser sphalerite; it provided 29 000 tonnes of direct shipping ore with an average grade of 2 500 grams silver per tonne (Grove, 1971). The wallrock adjacent to the massive sulphide veins carries an average grade of 686 grams silver per tonne over typical widths of 5 to 6 metres on both sides of the vein. These mineralized borders consist of intensely sheared country rock that is altered to quartz, buff carbonate, abundant manganese oxide, and sulphides. Early workers reported a mineral suite consisting of galena, sphalerite, native silver, ruby silver, freibergite, and minor amounts of pyrite, chalcopyrite, and argentite. Gold is conspicuous by its absence in this deposit -- typical assays are 0.17 grams gold per tonne.

At the Indian mine, mineralization is localized in part of a major, vertical, 155-degree-trending shear and fault zone. Mineralization exposed in the dumps, trenches, and old workings consists of massive, fine to coarse-grained galena with minor amounts of pyrite and sphalerite. Quartz with minor amounts of carbonate and chlorite are gangue minerals. The sulphides are banded and brecciated -- features that are attributed to post-mineralization movement along the fault zone. Major slickenside surfaces are exposed at the Galena Cuts zone where massive sulphide mineralization is 3 metres wide. The mine produced 13 000 tonnes of ore grading 120 grams silver per tonne, 3 grams gold per tonne, 4.4 per cent lead, and 5.5 per cent zinc (Grove, 1971). Esso Minerals Canada traced the fault structure for more than 1 200 metres north of the mine workings (McGuigan, personal communication).

#### **QUARTZ/BRECCIA FISSURE VEIN DEPOSITS**

Deposits of this type are abundant in the Salmon River Valley but have low tonnage potential and consequently are of lesser economic importance. The veins cut volcanic, sedimentary, and intrusive rocks, thus they represent a very late-stage mineralizing event.

The veins consist primarily of quartz but carry angular wallrock fragments plus scattered coarse crystals and fine-grained blebs and pods of sulphide minerals. Wallrock fragments within the veins are commonly silicified, but vein walls are sharp with little or no silicification of the wallrock. Drusy vugs are common. Sulphide minerals occur as euhedral crystals and as crystal aggregates of pyrite, sphalerite, galena, chalcopyrite, chalcocite, and freibergite; there is minor associated native silver. The sulphides are typically concentrated near the centre of the quartz vein and sulphide crystals may be up to 3

centimetres across. These vein deposits were extensively prospected and locally mined for their silver content. Galley (1981) reports gold values in the sulphides where fissure veins intersect a stratabound, sulphide-bearing chert-limestone horizon, and Grove (1971) noted free gold in the Silver Tip workings.

## **EXPLORATION**

All the mineral discoveries in the region can be attributed to intensive prospecting. The recent discovery of a precious metal deposit by Esso Minerals Canada on the Consolidated Silver Butte Mines Ltd. property (Northern Miner, November 4, 1982) resulted from an aggressive trenching program. The showing area has widespread, pervasive sericitic alteration with zones of abundant barren pyrite mineralization which had been trenched and sampled by previous workers.

The general sequence of exploration programs in the region can be summarized as follows:

- (1) Regional reconnaissance mapping to locate bleached and altered andesitic volcanic rocks, chert-carbonate zones, or sulphide mineralization in veins or fractures.
- (2) Detailed follow-up mapping and prospecting.
- (3) Intensive trenching and sampling.
- (4) Tightly spaced diamond-drill holes.

Geophysical test surveys have been completed over stratabound mineralized zones with moderately encouraging results (Dykes, personal communication). Electromagnetic surveys produce anomalous responses over the massive sulphide zones but abundant minor faulting that is common throughout the area creates problems. Water-saturated fault gouge produces anomalies and fault offsets disrupt the continuity and intensity of the anomalous response from a conductive massive sulphide lens. Induced polarization shows more promise as an exploration tool because it appears to discriminate between stratabound disseminated sulphide zones (strongly anomalous) and zones of disseminated pyrite in the altered host rocks (moderately anomalous). The cost of reconnaissance induced polarization surveys in this rugged terrane would be prohibitive, but the technique might be applied effectively over small grids as a prelude to trenching in areas of widespread or deep overburden.

## **GENESIS**

The vein deposits of the area are clearly epigenetic, but the process of formation of the stratabound deposits is less obvious. Stratigraphic relationships suggest that the chert-carbonate lenses are synvolcanic. A

volcanic exhalative genesis can be argued for the banded massive sulphide lenses which have 'normal' precious metal concentrations but the formation of disseminated precious metal-rich stratabound deposits may be more complex.

## CONCLUSIONS

The Salmon River Valley is one of the most active exploration areas in British Columbia and represents a distinct metallogenic province in the region. The precious metal deposits occur in a variety of structural settings but all the major deposits are hosted within one thick andesitic unit in a differentiated volcanic sequence. The deposits can be classified according to their geologic setting as (1) stratabound deposits of undetermined origin and (2) epigenetic vein deposits. Major exploration programs and prospect evaluation are expected to continue throughout the belt in 1983.

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