GEOLOGY OF THE BEAVERDELL AG-AU-ZN-PB VEIN DEPOSIT
SOUTH-CENTRAL BRITISH-COLUMBIA

826344

GEOLOGY 558: MARTHE ARCHAMBAULT, APRIL 1984

INTRODUCTION

The Beaverdell silver-lead-zinc (gold) mine, near the town of Beaverdell, is situated in the Westkettle River valley in south-central B.C. It is accessible by Highway 33 and is located 96 km. south of Kelowna and 48 km. north of Rock Creek. The mine area is centered approximatively 1.6 km. east of the village of Beaverdell, on the west slope of Wallace Mountain. Prospecting started in 1889. Production of silver was intermittent between 1900 and 1913 and continuous since 1913 when the Kettle Valley Railway reached Beaverdell. The 50 ton-per-day mil was constructed in 1950 and expanded to 108 tonnes per day in 1954. Teck Corporation acquired the mine in 1970.

REGIONAL GEOLOGY

The regional geology has been described by Reinecke (1915) as follows:

Rocks of the **Wallace Group** are the oldest in the district (Mesozoic). They consist, from oldest to youngest, of white to grey, coarse grained crystalline limestones, fine grained grey hornfels, banded hornblende andesite tuffs, augite andesite lavas and some basic, coarse grained intrusives which consist of pyroxenite, hornblendite, harzburgite and olivine gabbro and occur as dyke sheets and irregular bodies. The sediments and tuffs are cut by the andesite dykes which in turn are intruded by a dull green hornblende diorite porphyry. Andesites and tuffs constitute about 80% of the group. The whole group has been metamorphosed.

The Wallace Group is intruded by the [redacted] They are granitic aplites found near the edge of the batholith, quartz latite porphyries cutting the batholith but older than the Beaverdell batholith, [redacted] and hornblende andesite porphyries both of [redacted]. It is pinkish white, medium to coarse grained, unfoliated and composed of porphyritic orthoclase, oligoclase, quartz and biotite. Hornblende is absent. A few dykes of quartz latite porphyry radiate from the main mass.

The **Curry Creek Formation** (Oligocene) consists of 60 m. of extremely fine grained, dense, white tuff overlying about 760 m. of conglomerate with occasional beds of arkosic sandstones. The conglomerate consists ,˜ rounded pebbles of Westkettle quartz diorite; diorite, andesite, tuffs and sediments of the Wallace Formation and occasionally of Beaverdell quartz monzonite.The granitic pebbles are well rounded and vary in size from coarse grained sand to boulders 1 m. in diameter. Conglomerate usually occurs in beds 3 to 17 m. thick and tuffs occur in beds rarely over 3 cm. thick. In certain places the formation rests upon breccias

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The Wallace Group is intruded by the **Westkettle Batholith**, composed of quartz diorite (Jurassic), which underlies a wide area along the Westkettle river. The quartz diorite is equigranular, medium grained and contains feldspar, quartz, biotite and hornblende.

Four varieties of dykes occur around the batholith and are evidently related to it. They are granitic aplites found near the edge of the batholith, quartz latite porphyries cutting the batholith but older than the Beaverdell batholith, quartz monzonite porphyries and hornblende andesite porphyries both of which cut the Westkettle batholith. It is itself intruded by the **Beaverdell Stock** of quartz-monzonite of Eocene age. It is pinkish white, medium to coarse grained, unfoliated and composed of porphyritic orthoclase, oligoclase, quartz and biotite. Hornblende is absent. A few dykes of quartz latite porphyry radiate from the main mass.

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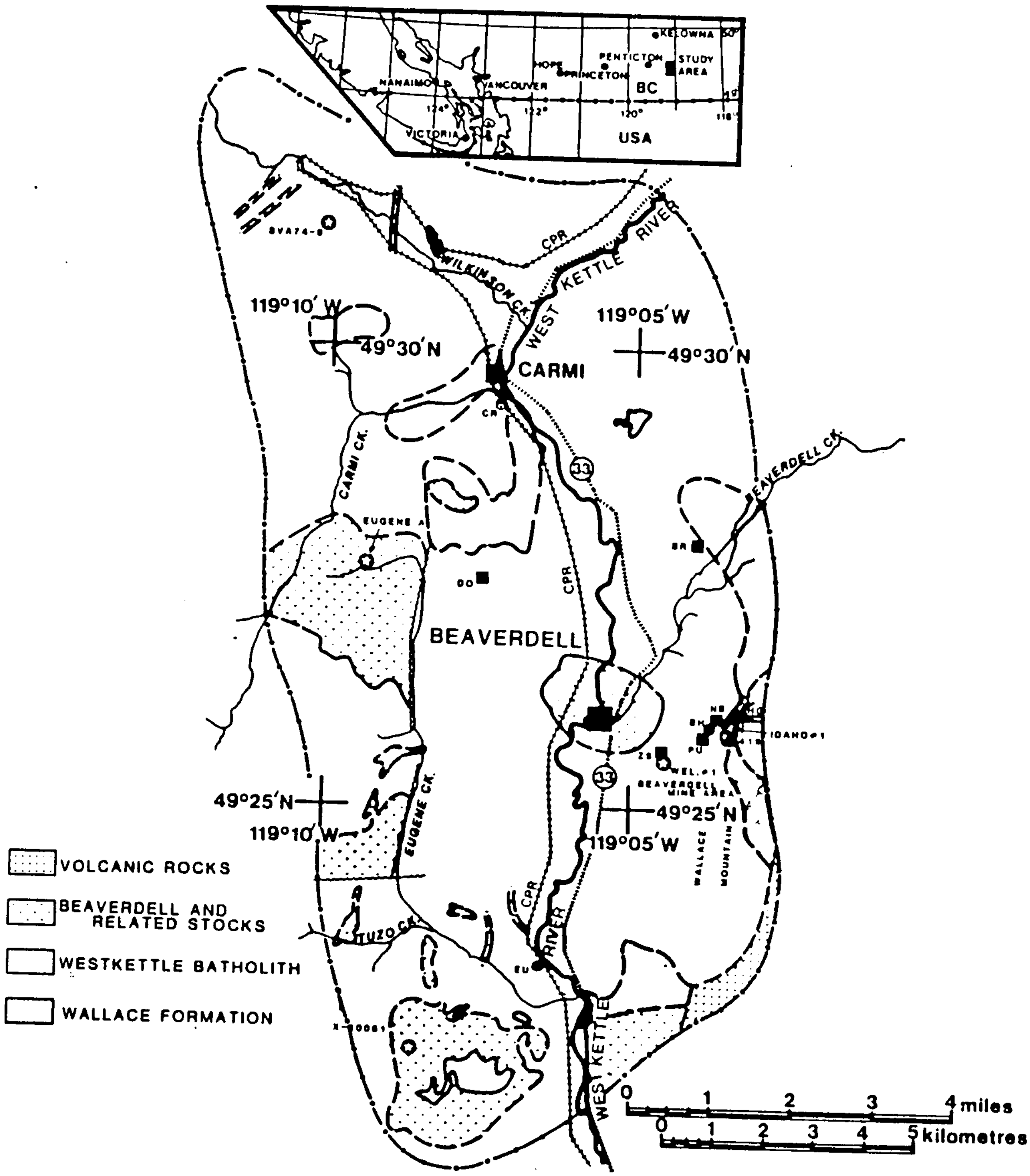

Figure 78. Regional geology with locations of major mines in the Beaverdell mine area, south-central British Columbia. Modified from Reinecke, 1915 and Christopher, 1975a, 1975b, and 1976.

made up of angular fragments of the underlying Wallace Formation which is interpreted to be talus. Fragments are of all sizes up to 5 cm. across, packed together in a groundmass of finer material of the same kind.

The youngest rocks are a series of lavas of the **Nipple Mountain** Formation, probably of Miocene age, which overlie uncomformably the Curry Creek and other formations. They consist of six main types: olivine basalt, augite andesite, hornblende andesite, biotite andesite dacite and trachyte. Dykes of material resembling the Tertiary lavas intrude the Wallace Formation, the Beaverdell quartz-monzonite and the Curry Creek Formation.

AGE RELATION OF THE CARMI, BEAVERDELL DISTRICTS (from Watson, 1981)

Pb isotope data is more usefull if time can be determined from independant data such as K-Ar ages and geological information. In the present case there are three possible constraints:
1- the stratiform mineralization in the Wallace Formation would be Permian (0.27 Ga) from correlations with the Anarchist Group (Peatfield,1978),
2- the Westkettle batholith being part of the Nelson intrusion would be Jurassic (0.15 Ga),
3- the Beaverdell stock being equivalent to other quartz monzonite stocks which gave Tertiary K-Ar ages (0.05 Ga).

Plots of the galena-lead isotope analyses on the 206Pb/204Pb vs 207Pb/204Pb and 206Pb/204Pb vs 208Pb/204Pb show two distinct clusters: group A and group B. Group A includes the Carmi gold vein deposit and other deposits within the Wallace Formation or in the Westkettle granodiorite in close proximity with the Wallace Formation Group B includes the Beaverdell silver vein deposit which is contained mainly in the Westkettle granodiorite.

The most probable model to explain the two groups assumes that they formed at different times under different conditions. Thus:
1- the Carmi-type, gold-bearing vein system is probably Jurassic and formed as a result of the intrusion of the Westkettle batholith,
2- the Beaverdell-type, silver-bearing vein system is probably Tertiary and related to the intrusion of the Beaverdell stock.

STRUCTURE AND MINERALIZATION

Mineralization is found in a northeast trending 3 km. by 0.8 km. belt on the west slope of Wallace Mountain. Most of the veins are hosted in the Westkettle granodiorite but some mineralization is found in the older Wallace Formation which overlies the batholith at the eastern end of the mine. The structure tends to horsetail and disperse in the gneissic Wallace Formation. No mineralization is known in the younger Beaverdell stock (Watson, 1981).

Propylitic alteration is found in the wallrock up to 8 m. from the vein. Amphiboles are almost completely altered to chlorite and feldspars are replaced by clay and calcite. The veins are mineralized fissures former . long east-trending faults in the western part of the mine and along northeast-trending faults in the eastern part of the system. The veins range from a few cm. to a m. in width and average 0.3 m.They are rarely continuous for more than 5 to 10 m. without offsets of up to 150 m. horizontal distance. White (1949) classifies the faults into 5 types:
1- high angle, northerly striking, normal faults (strike 00 to N20

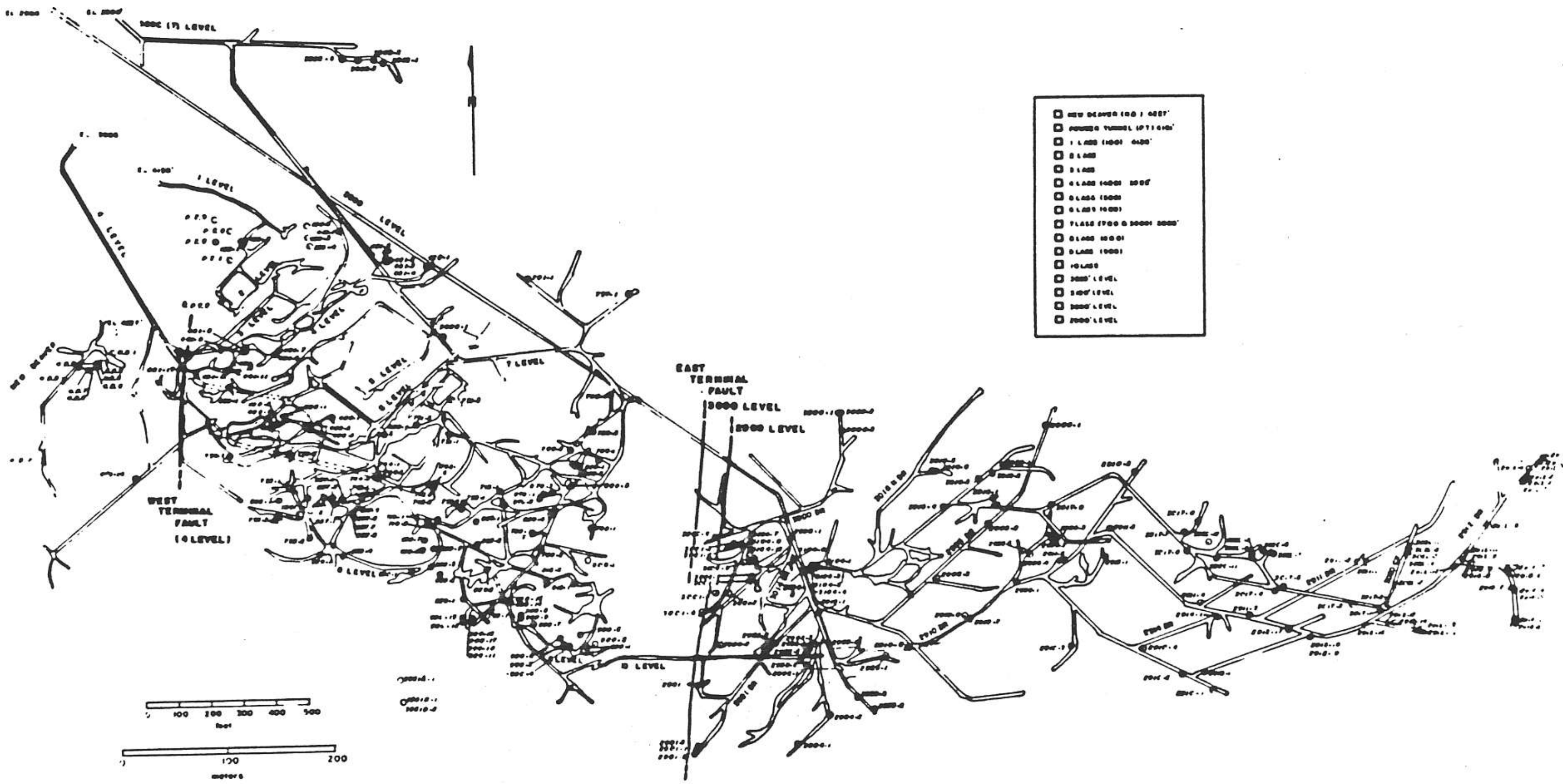

Figure 79. Sample locations (data in Table 1) on the composite plan view of the Upper and Lower Lass vein system, Beaverdell area. Mine drifts, stopes, and the West and East Terminal faults are located.

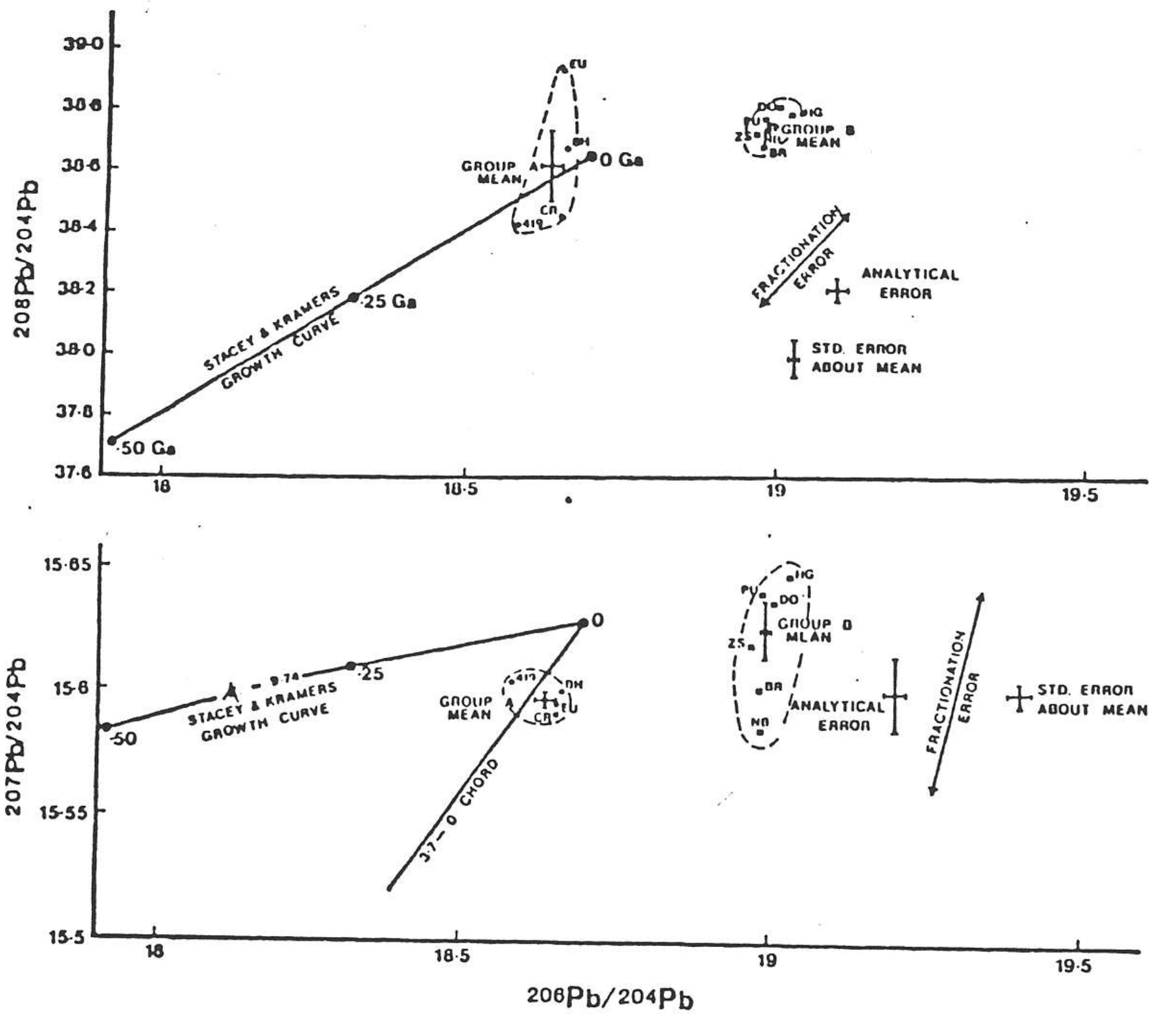

Figure 2-2: $^{206}Pb/^{204}Pb$ versus $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ versus $^{208}Pb/^{204}Pb$ for Samples from the Beaverdell Area, South-Central B.C.

and dip 80 to 50 east); they appear to be younger than the ore and they cut the productive belt of Wallace Mountain into several large blocks;
2- low angle, northerly trending,strike slip faults (dips range from 18 to 50 west); late movement has occured but they are thouth to have originated prior to mineralization;
3- northeasterly striking, high angle, normal fault (dip moderate to northwest); they are numerous and cut the veins into short segments, each of which has moved downward to the northwest. Usually the displacement is only a few feet. In the Highland Lass mine the general effect of this fault system has been to flatten the dip of the general ore zone from 50 to 34 degrees;
4- northeasterly trending, slice fault. These faults cut across the veins making very acute angles with them in both strike and dip (the dip is in the same direction as that of the veins). It is not uncommon to find that the ore on both sides of a slice fault is dissimilar in mineralogy, values and internal structure. They appear to be in part pre-ore in age and may have had an effect on the distribution of mineralization;
5- cross faults (northerly striking and dipping in either direction) cause either small normal or reverse displacement of the orebodies.

MINERALOGY (Watson, 1981)

Quartz is the main gangue mineral and is occasionally accompanied by calcite and fluorite. The main metallic minerals are galena, sphalerite and pyrite, with lesser amounts of arsenopyrite, tetrahedrite, pyrargyrite, chalcopyrite, polybasite, acanthite, native silver and pyrrhotite (Staples and Warren, 1946; Boyle, 1968). The veins generally exhibit well developped banding and a consistant paragenetic sequence. Many samples contain one or more of the following stages:

Stage 1: an initial deposition of quartz was followed by pyrite accompanied at times by minor amounts of sphalerite;
Stage 2: the pyrite was brecciated, surrounded, and, in places, extensively replaced by arsenopyrite;
Stage 3: very dark sphalerite (at times opaque in polished thin sections) formed next; this sphalerite often contains emulsion chalcopyrite along regular crystallographic grids;
Stage 4: the main depositional stage of galena and sphalerite followed; this sphalerite tends to be lighter in colour and generally contains very little chalcopyrite;
Stage 5: silver minerals such as pyrargyrite, tetrahedrite and polybasite were formed in the most recent mineralizing stage and a: closely associated with galena. Silver minerals sometimes replace galena or are exsolved along crystallographic planes, suggesting that they were formed immediately after the formation of galena;
Stage 6: the veins were filled with a later gangue, dominantely of quartz;
Stage 7: some supergene silver mineralization, typified by the presence of native silver wires and plates, ·· s superimposed on th upper part of the vein system.

Supergene silver mineralization was excluded from this study. Nevertheless, within the Upper and Lower Lass mines (at the east end of the Beaverdell mine area), the silver values decrease to the east with increasing depth, while gold values increase (Watson and Godwin, 1982).

SILVER-GOLD ZONATION IN THE LASS VEIN SYSTEM (Watson, 1981)

Statistics were done on 209 samples of vein material, analized for Zn, Pb, Fe, Cu, Cd, Ag, Ca, Mg, Mn, Co, Ni, Au, As, Hg and Sb.The mine plan view was reconstructed to account for post ore faulting.
All elements have lognormal distributions and can be partitionned inta 1, 2 or 3 populations. The correlation matrix of elements indicates that Ag is associated with galena, sphalerite and sulphosalts and Au with pyrite and chalcopyrite.
Two zones of distinctive mineralization were outlined. The boundary between these two zones trens north and lies within the Lower Lass mine, about 120 m. to the east of the East Terminal Fault. The two zones are characterized in table 1. The elements Cu, Ca, Mg and As

TABLE 1

UPPER WESTERN ZONE	LOWER EASTERN ZONE
- high Ag values	- high Au values
- moderate Zn and Pb values	- moderate to high Zn and Pb values
- more gangue than the eastern zone	- low Ag values
- thinner veins than the eastern zone	
- multiple veins and stringer zones	
- central location between the foot and hanging wall	- occurs in several small locations along the footwall

show consistent values throughout the mine. Gold does not correlate arsenopyrite. The last point of table 1 implies that Ag mineralization formed after Au mineralization.
Fluid inclusions in sphalerite and quartz from the Lass vein system can be divided into three groups based on their homogenization temperatures. They are not found in spatially distinct portions of the vein and many samples contain fluid inclusions falling into more than one group. In several cases it is possible to associate a specific temperature with individual stages of mineralization.
Group 1: Primary inclusion, with or without CO_2, formed between 260 and 310 C, from solutions with an average of 13 equivalent weight NaCl,represented by stages 1 to 3.
Group 2: Pseudosecondary inclusions formed between 230 C and 260 C, with salinities from 0.6 to 14 equivalent weight percent NaCl, represented by stages 4 and 5.
Group 3: Pseudosecondaru and secondary inclusions formed between 180 C and 220 C, from solutions containing 0.4 to 14equivalent weight percent NaCl and are represented in stages 4 to 6.
Temperatures calculated from sulphur isotope data for sphalerite-galena pairs (268 C to 320 C) are in close agreement with temperatures of homogenization of the primary fluid inclusions (Group 1).

CONDITION OF FORMATION (Watson, 1981)

The higher temperature 260 C to 310 C, more saline solutions, some of which contain CO_2, are believed to have been the source of the gold mineralization. The lower temperature 180 C to 240 C, less saline solutions would be the source of the silver mineralization which is associated with galena and sphalerite of later stages in the paragenetic sequence. This change in temperature and salinity is

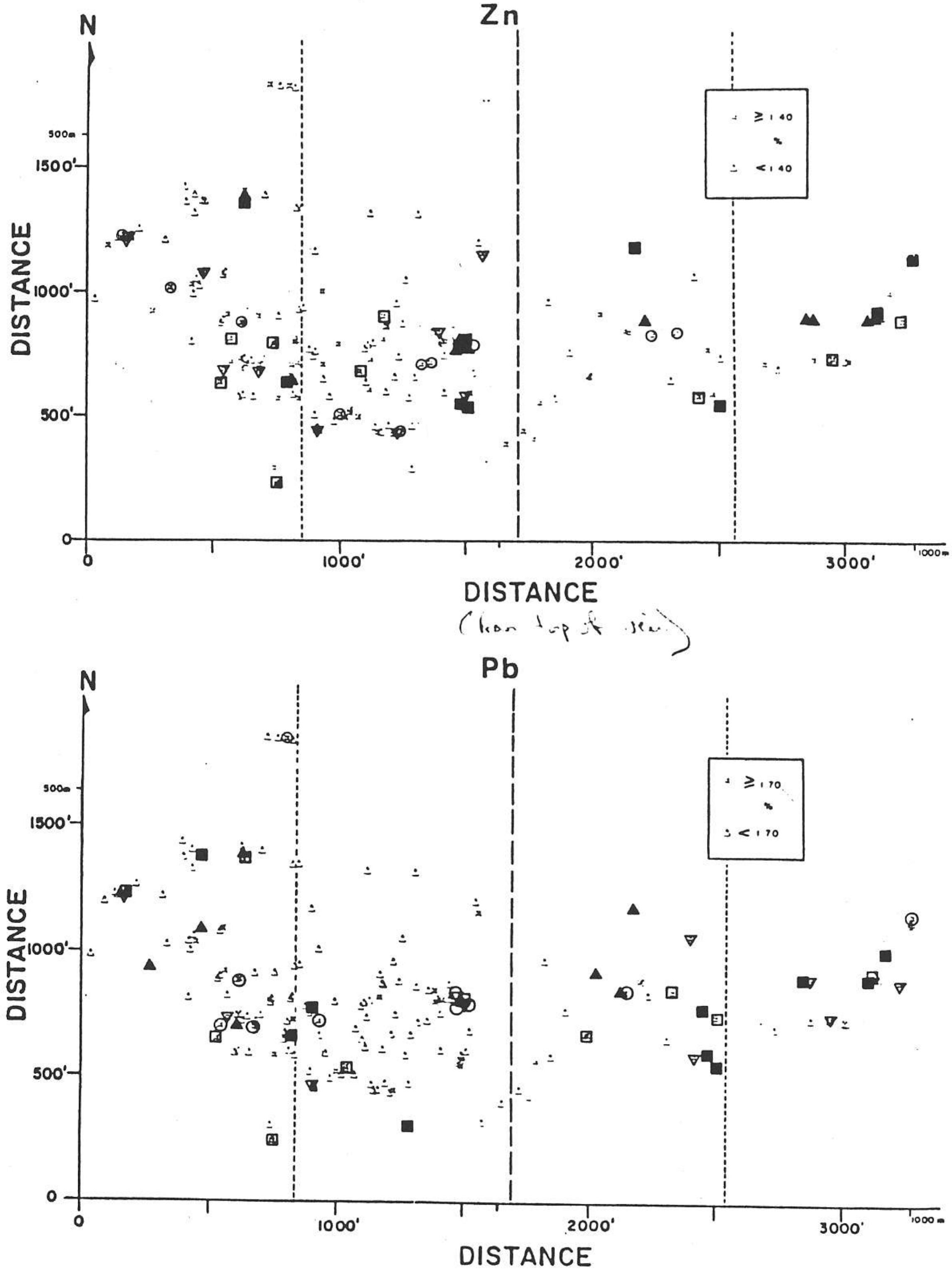

Figure 82. Reconstructed plans of the Lass vein system, Beaverdell mine area. The highest 50 analyses for zinc (top) and lead (bottom) are plotted using the following: solid square, first 10; solid triangle, second 10; open square, third 10; open triangle, fourth 10; and open circle, fifth 10.

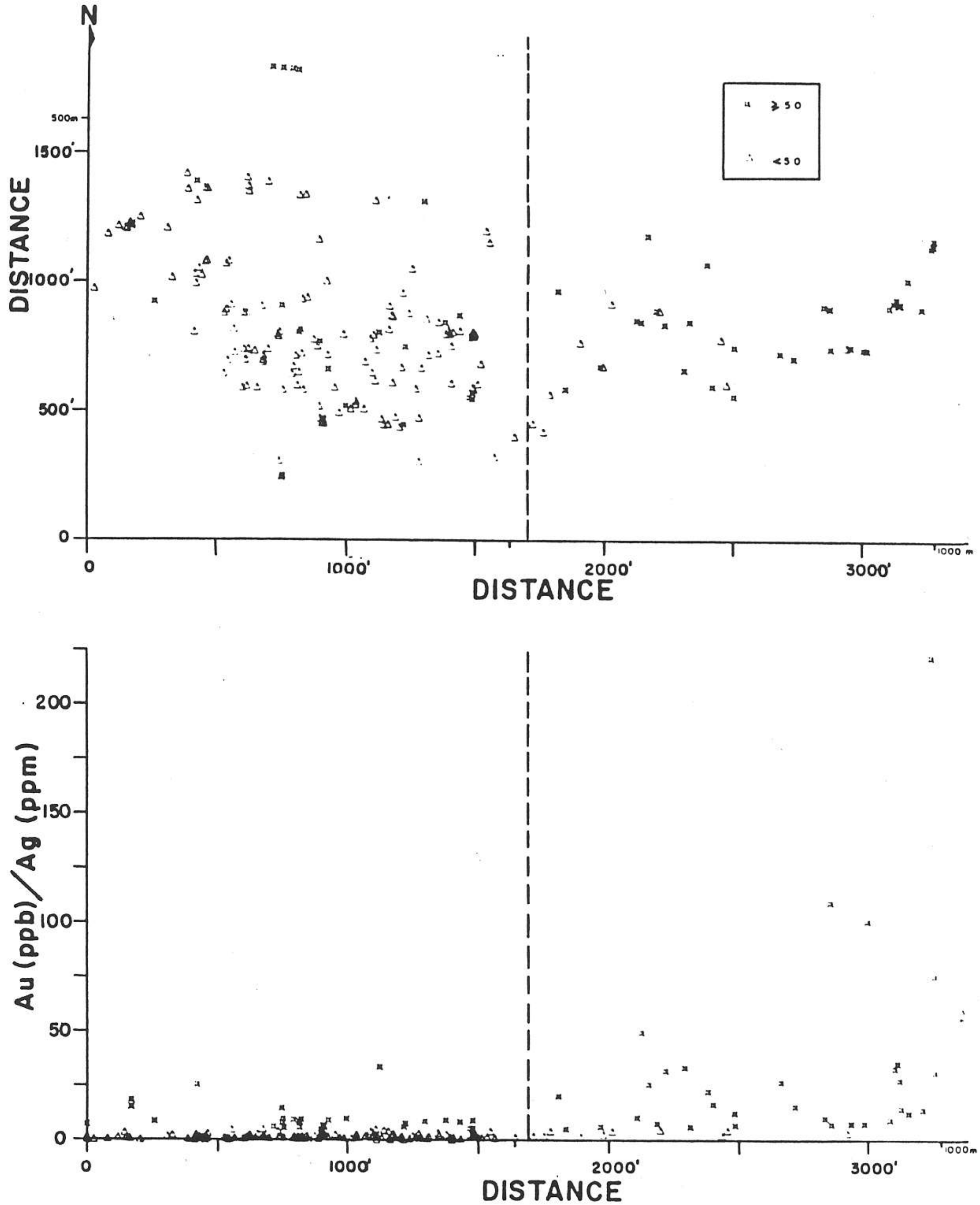

Figure 84. Reconstructed plan and 'section' plot of the Lass vein system, Beaverdell mine area. Gold (ppb)/Silver (ppm) values are separated into two populations, above and below a ratio of 5. Long dashed line marks the boundary between silver and gold-rich sections of the mine.

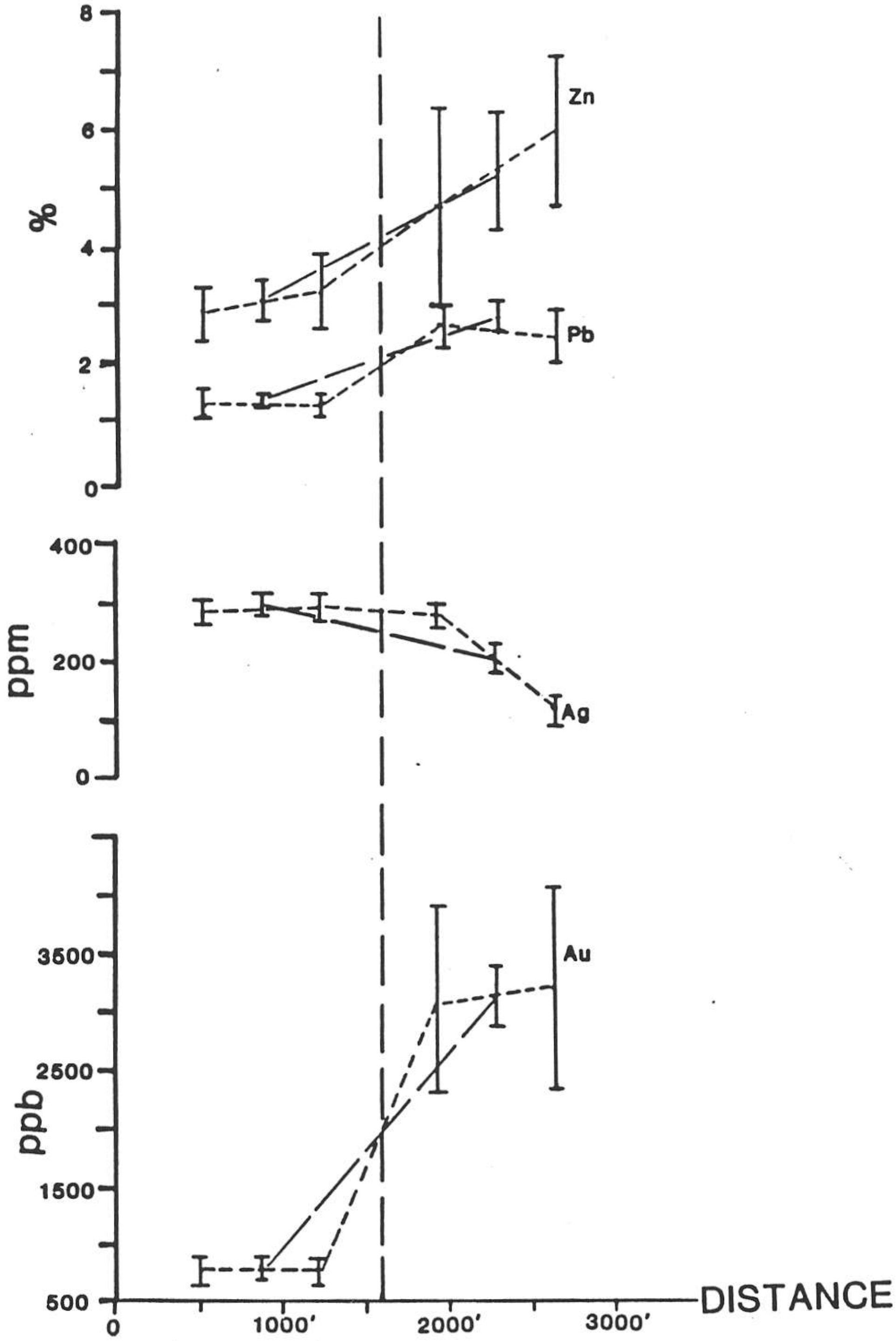

Figure 85. Plot of arithmetic means and standard errors of the mean for gold, silver, lead, and zinc, aft.r ivision of the Lass vein system, Beaverdell area, into two and four sections (see Figs. 81 to 84). Left-hand side of the plot is uppermost, western section of the vein system; the right-hand side is down dip, deepest, and easternmost section of the mine. Distance is measured along the reconstructed plane of the vein.

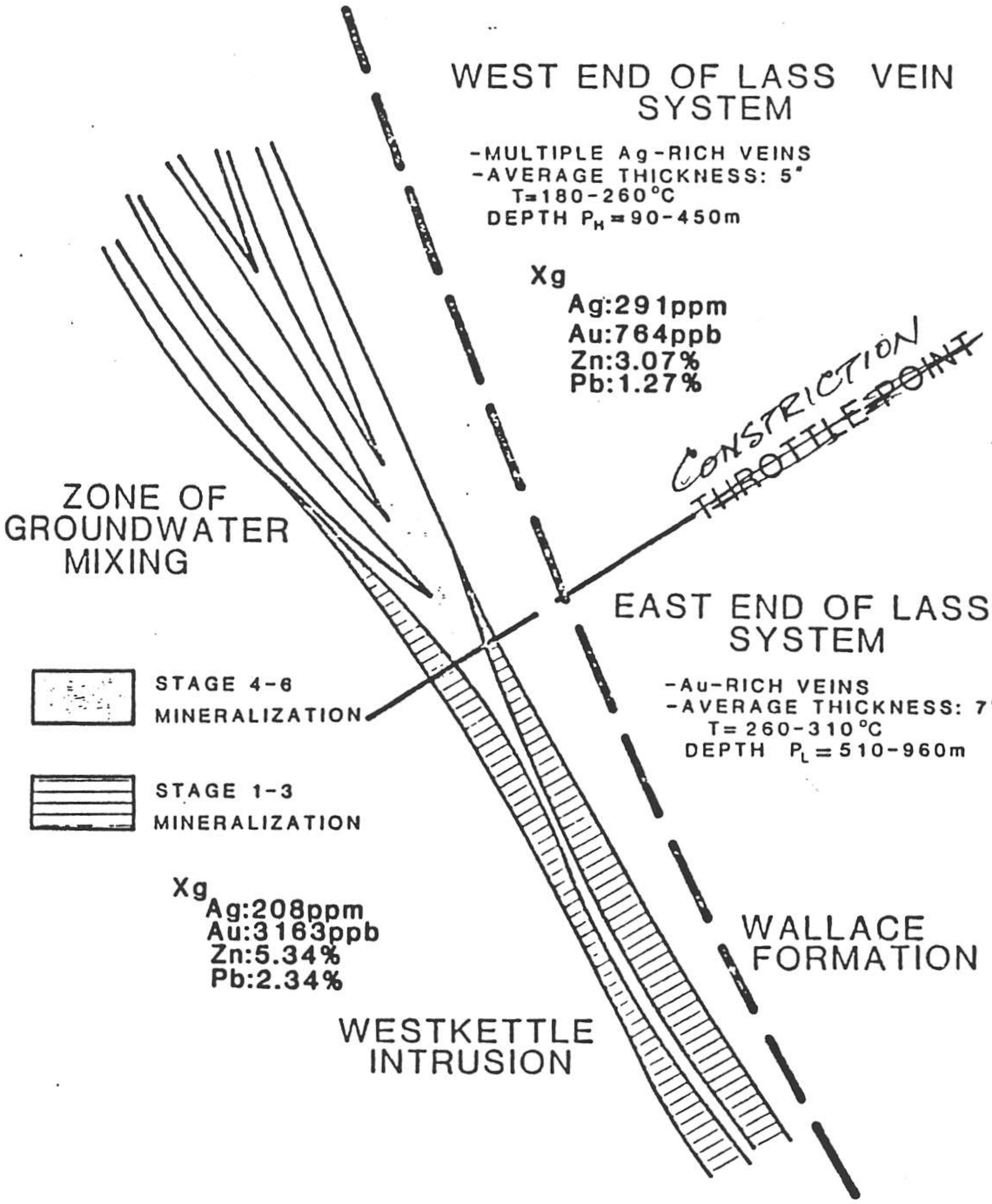

Figure 86. Model of the Lass vein system, Beaverdell area. The vein is divided into an upper, silver-rich part and a lower, gold-rich part. Average values for key elements and vein thicknesses are noted on the model. Mineralization stages and temperature and depth (P_H = hydrostatic pressure, P_L = lithostatic pressure) estimates are from fluid inclusion studies (Watson, 1981).

caused by mixing of the original fluids with cooler and less saline ground water above the constriction in the vein. Lithostatic pressures are dominant below the constriction and hydrostatic pressures above. The gold bearing veins are more consistent in thickness since they form below the constriction where the fluids are under greater and more consistent pressure. Gold would be deposited in minerals precipitated from the chloride rich relatively hot (> 260 C) fluids. Silver occurs higher in the system where the veins are thinner, more stringer zones occur, and cooler, less saline conditions prevale.

CONCLUSION (Watson, 1981)

The Carmi gold bearing vein system is probably Jurassic in age and related to the intrusion of the Westkettle (Nelson) batholith
The Beaverdell silver bearingsystem is probably Tertiary in age and related to the intrusion of the Beaverdell stock. It is known to have two definite zones: a deeper high gold, low silver and moderate to high lead-zinc zone and a higher, high silver, moderate lead-zinc zone.

As exploration parameters, the galena-lead isotope analyses can be used to determine the age of mineralization. The fluid inclusion and sulphur isotope methods can be used to determine the level within the hydrothermal system of the younger Tertiary veins.

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