

# GEOLOGICAL INVESTIGATIONS OF THE H-W DEPOSIT, BUTTLE LAKE CAMP, CENTRAL VANCOUVER ISLAND (092F/12E)

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## INTRODUCTION

The Myra Falls deposits of the Buttle Lake mining camp (49° 34'N, 125° 36'W) occur in Paleozoic Sicker Group rocks of Vancouver Island, within the Wrangellia allochthonous terrane of the Insular Belt of the western Cordillera. The deposits are located at the south end of Buttle Lake, 90 kilometres by highway from Campbell River (Figure 1). The deposits include the past-producing Lynx and Myra orebodies, which were brought into production in 1967, and the producing H-W orebody and adjacent North Lens, discovered in 1979. In 1991 the Battle and Gap zones were discovered along strike and to the west of the H-W orebody and are scheduled to begin production in 1993. As of January 1, 1993 proven and probable geological reserves for the entire property are 12 516 300 tonnes grading 1.9 % copper, 0.5 % lead, 6.3 % zinc, 2.1 grams per tonne gold and 45.6 grams per tonne silver (Westmin Resources Limited Annual Report, 1992).

This paper is based on 1993 fieldwork involving relogging and sampling of selected drill-cores through the stratigraphic sequence hosting the H-W orebody, as well as preliminary lithogeochemistry and ore petrology. Robinson *et al.* (1994) describe stratigraphic relations in the Battle zone, which occurs at the same level in the camp stratigraphy as the H-W deposits. In order to avoid repetition of the general geology and mine stratigraphy the reader is referred to Robinson *et al.* (1994; this volume) for a detailed discussion. Earlier work on the geology and geochemistry of the volcanic hostrocks is summarized and discussed by Juras (1987); preliminary fluid inclusion results are reported by Hannington and Scott (1989).

## H-W STRATIGRAPHY

The stratigraphy at the H-W deposit comprises a series of relatively flat lying mafic and felsic volcanic units (Figure 2). Stratigraphic columns for two exploration holes that penetrated thick sections of the H-W orebody are given in Figures 3 and 4. The stratigraphically lowest unit, the Price andesite (DCp, Figure 2), forms the footwall to the sulphide mineralization and comprises at least 300 metres of massive to pillowed andesite flows and flow breccias, with minor volcanoclastic andesitic rocks. This unit is directly overlain by the Myra formation, the lowest part of which is the H-W horizon (unit 1, Figure 2). The H-W horizon comprises 50 to 100 metres of felsic subaqueous volcanoclastic and pyroclastic beds, lesser interbedded black mudstones, and a lens of quartz-feldspar-porphyrific rhyolite up to 50 metres thick.

Much of the footwall beneath the Main and North lenses is intensely altered to a sericite-pyrite-quartz assemblage, locally with significant chlorite. Lateral to this, the alteration is dominated by an albite-sericite-quartz assemblage. Least-altered samples are massive, feldspar-pyroxene-phyric andesite (Juras, 1987).

The massive sulphide lenses occur at the contact between the Price andesite and the H-W horizon (Figure 2). They are underlain by a strongly altered and pyritized feeder zone that extends at least 25 to 50 metres down into the andesitic footwall. Mineralization directly above the footwall andesite is typically massive pyrite with only trace disseminated chalcopyrite. This style grades vertically into massive pyrite with several percent disseminated chalcopyrite, that constitutes the bulk of the ore body. This massive sulphide is typically overlain by an upper interval of semimassive to disseminated polymetallic mineralization alternating with felsic mass-flow units. This upper interval of mineralization tends to be dominated by sphalerite, galena, tennantite and barite.

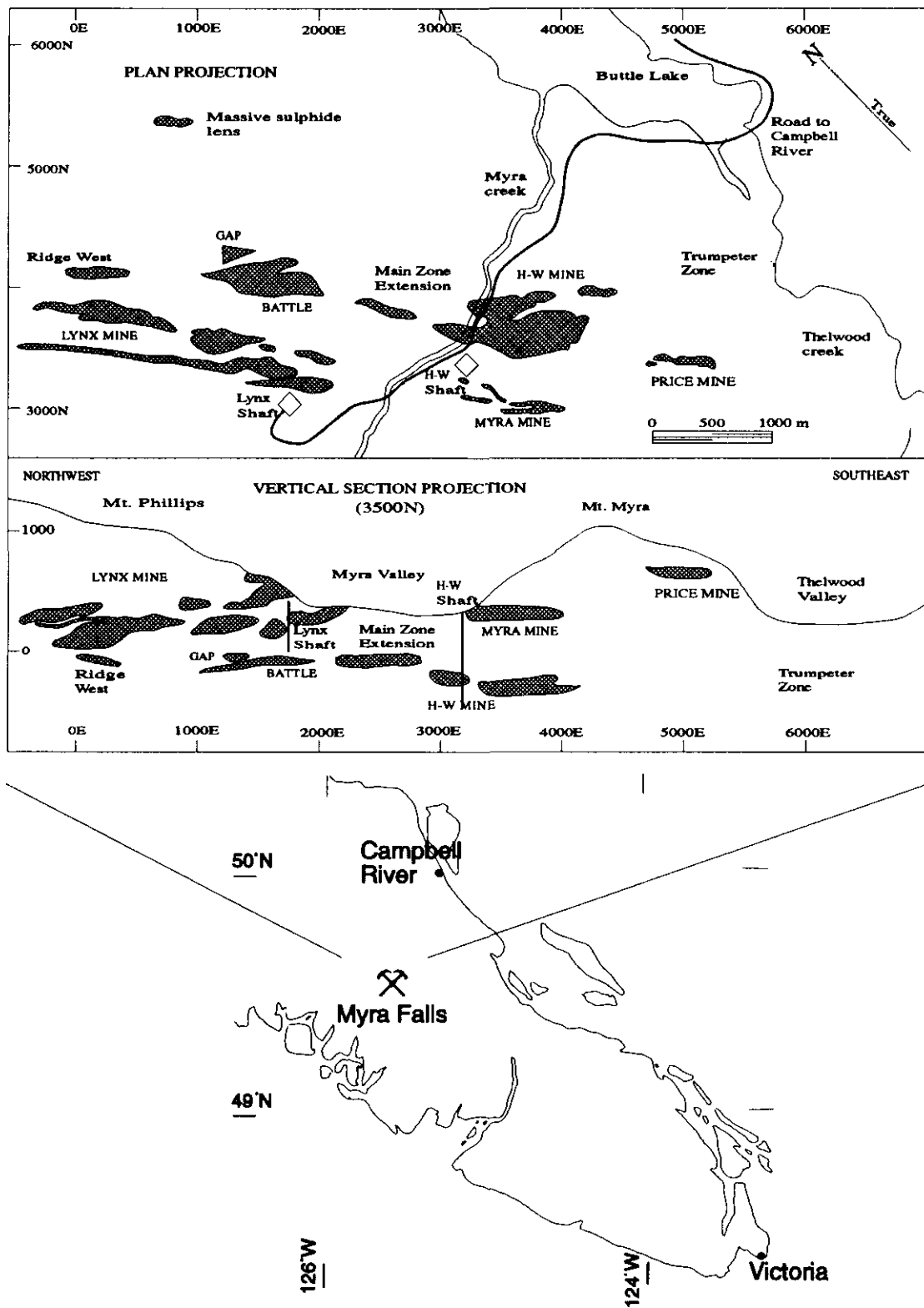


Figure 1. Location map for the Myra Falls massive sulphide deposits. Also shown is a longitudinal section of the relative locations of the various orebodies.

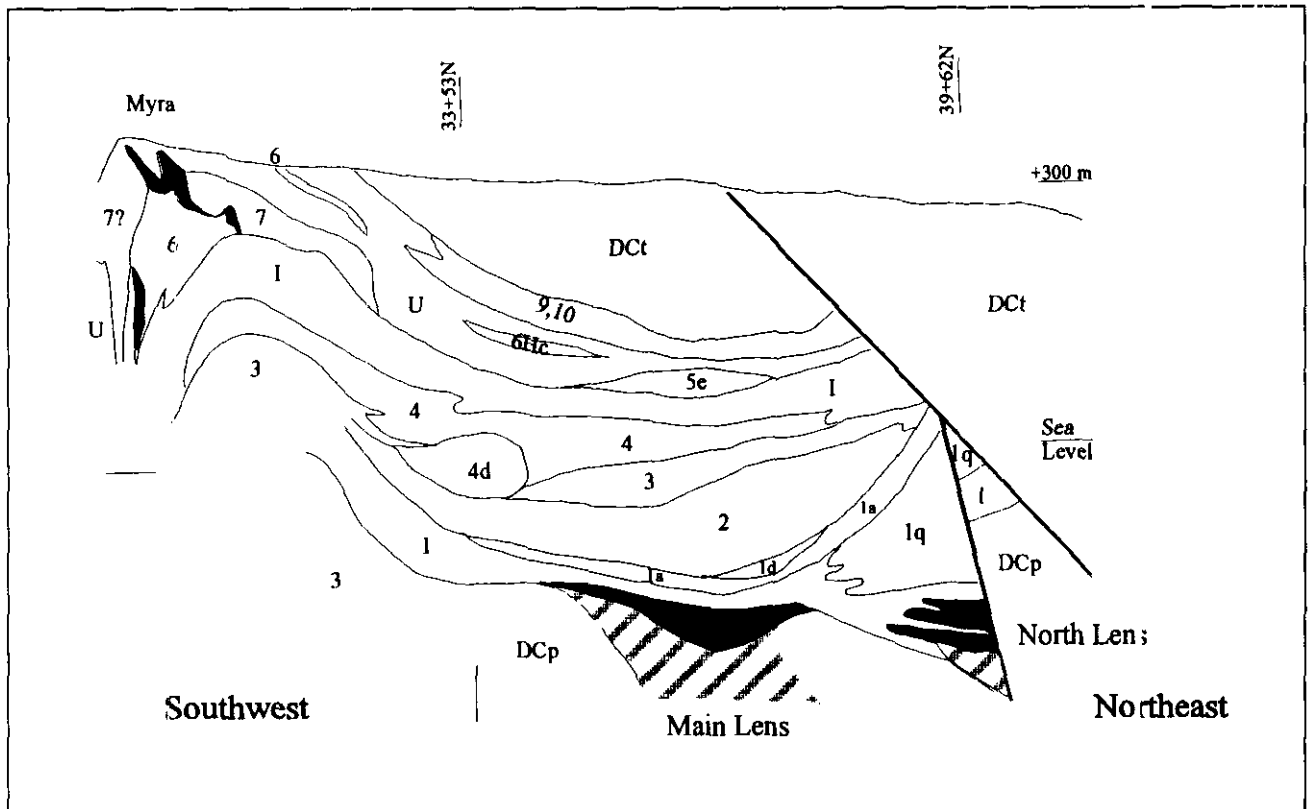


Figure 2. Stratigraphic section through the H-W area at 34+75E. DCp, Price Formation; 1, H-W horizon; 1a, argillite; 1d, dacite; 1q, quartz-feldspar-porphyrific rhyolite; 2, H-W andesite; 3, ore-clast breccia; 4, lower mixed volcanics; 4d, lower mixed volcanics, dacite; I, undifferentiated Myra formation, interzone units; 5e, andesite; 6, Lynx-Myra-Price horizon; 6Hc, Lynx-Myra-Price chert horizon; U, undifferentiated Myra formation, upper units; 7, G-flow unit; 9, upper rhyolite unit; 10, upper mafic unit; DCt, Thelwood formation. Solid black areas represent massive sulphide lenses, striped areas represent zones of massive pyrite alteration. After: Juras (1987).

The felsic mass-flow units of the H-W horizon are composed of a monomict assemblage of rhyolite clasts. Beds range from 0.1 to 1 metre thick and are generally graded, with younging directions up-hole. Clasts range from rounded to subangular and appear to have been reworked.

A large body of quartz-feldspar-porphyrific rhyolite (QFP) wedges into the H-W horizon about 50 to 100 metres to the north of the H-W deposit, and thickens progressively northwards. It can be traced for more than 2 kilometres westwards to the Battle zone. The H-W horizon also contains distinctive black mudstone intervals with interbedded felsic volcanoclastic rocks. Black mudstones that occur just above the H-W orebody continue northwards above the QFP wedge, but not below it.

The H-W andesite is a sill-flow complex that is partially intrusive into the H-W horizon. It comprises flows and breccias of basaltic andesitic and andesite that form a lens of several hundred metres in diameter above the area of the H-W deposit. To the southwest, in the area of 33+50N, the H-W andesite is overlain by a lens of siliceous dacite up to 75 metres thick (Figure 2). Above the H-W deposit, in the area of 39+50N, a

smaller dacite lens intervenes between the H-W horizon and the H-W andesite.

Stratigraphically above the H-W andesite is the ore-clast breccia, which consists of mainly andesite volcanoclastic debris-flows, locally with some rhyolite and minor sulphide clasts. This is followed by green tuff breccias and bedded coarse to fineuffs which mark the end of the first volcanic cycle. An overlying thick sequence of mafic-rich volcanoclastics with lesser rhyolite forms the second volcanic cycle, and is host to the Myra-Lynx-Price orebodies.

## LITHOGEOCHEMISTRY

A suite of 27 whole-rock samples from exploration holes W-111 and W-123 was analyzed by X-ray fluorescence using glass beads for major elements, and pressed pellets for trace elements. The locations of the samples are shown next to the stratigraphic logs in Figures 3 and 4. The purpose of the lithogeochemical study was to identify the main volcanic units, particularly where core and petrographic identification is difficult due to severe alteration.

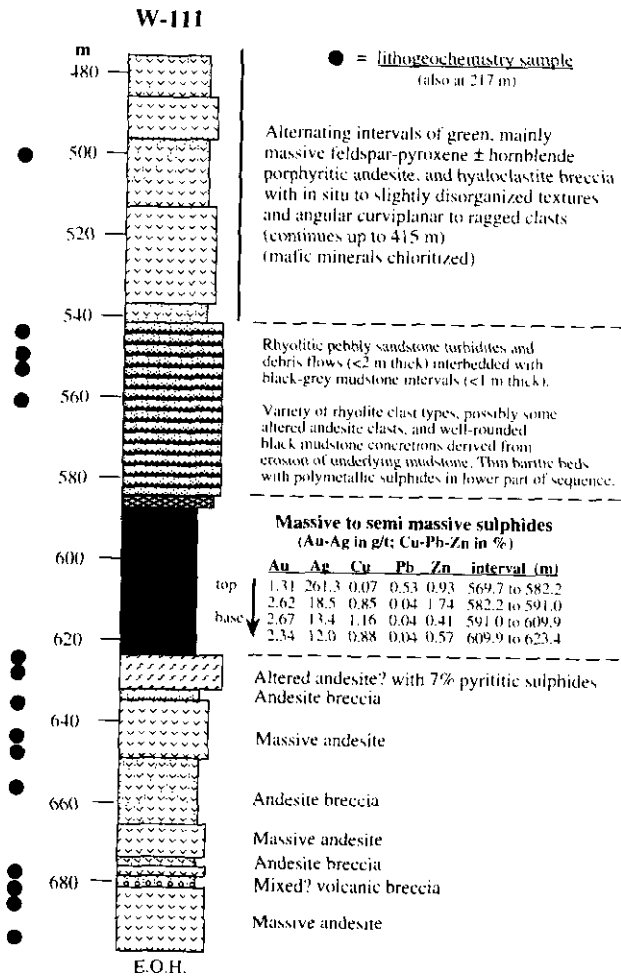


Figure 3. Stratigraphic column for drill hole W-111, H-W orebody. The black dots are litho geochemistry sample locations.

The litho geochemistry data for the H-W volcanic rocks have been examined using immobile element relationships (e.g. Ti-Al-Zr) to identify rock types and characterize alteration, as described by MacLean and Kranidiotis (1987), MacLean (1990), and Barrett and MacLean (1991). The results (Figure 5) define two main alteration trends in plots of both  $Al_2O_3$  versus  $TiO_2$  (a) and  $Al_2O_3$  versus Zr (b). These trends result from alteration of rhyolite and andesite precursors. Ideally, a single alteration line results from alteration of a homogeneous precursor, with the spread of points along a given alteration line reflecting the overall mass change in the mobile elements. Net mass gain in mobile elements moves a sample point from its precursor location along a line towards the origin, whereas net mass loss moves a point in the opposite direction.

The altered footwall andesites show a small compositional range in terms of their immobile element ratios. This primary range leads to a fan-like distribution for the altered samples (Figure 5). Of particular interest is the fact that the footwall andesite (DCp, Figure 2), which in places is altered

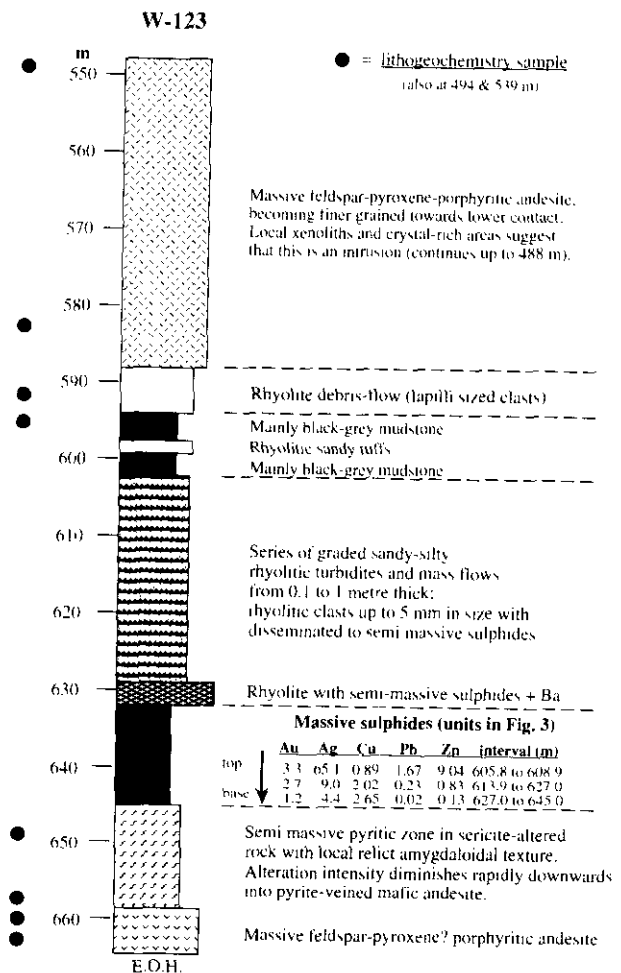


Figure 4. Stratigraphic column for drill hole W-123, H-W orebody. The black dots are litho geochemistry sample locations.

beyond recognition and contains up to 50% sulphides, yields a perfectly straight alteration line in the  $Al_2O_3$  versus  $TiO_2$  plot (Figure 5a). This indicates that the drilled interval from at least 636 to 682 metres was derived from an andesitic precursor with uniform immobile element ratios. A later study will present calculated elemental mass changes in the alteration zone of the H-W deposit.

Five samples of H-W andesite from the hangingwall (unit 2, Figure 2) have a tight  $Al_2O_3$  versus Zr composition (Figure 5b). Their major element composition, and lack of alkali exchange in particular, indicates that the H-W andesite is much less altered than the footwall andesite. Although the H-W andesite has slightly higher  $Al_2O_3$  versus Zr ratios than the footwall andesite, their  $Al_2O_3$  versus  $TiO_2$  ratios are similar, as are other trace element ratios. This suggests that the H-W and footwall andesites are compositionally closely related.

The single rhyolite alteration line (Figure 5) is rather unexpected, given the fact that the samples were taken from several felsic mass-flow or turbidite beds. These

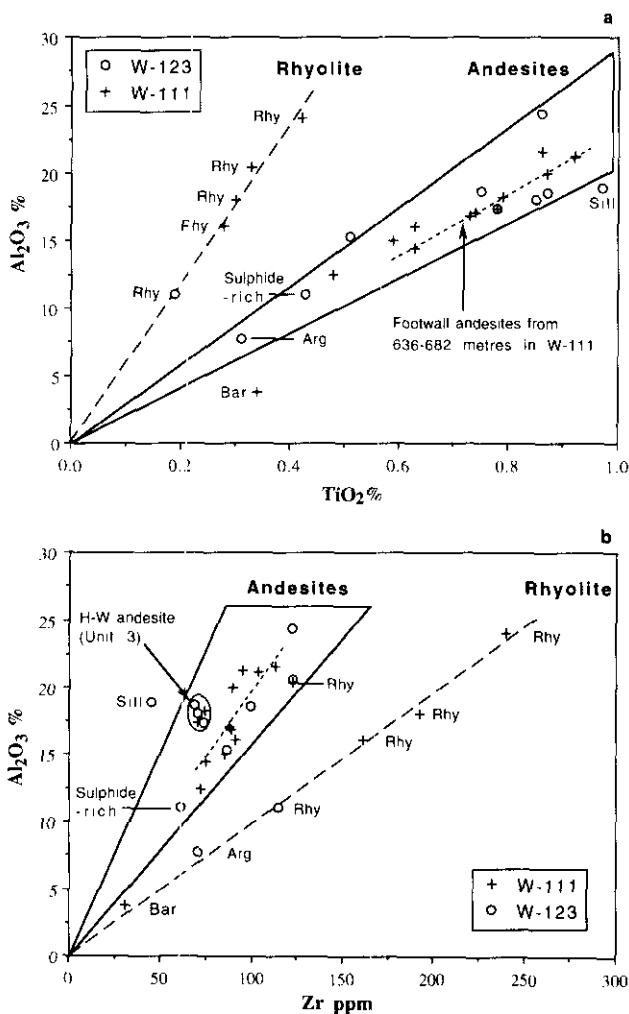


Figure 5. Plot of  $\text{Al}_2\text{O}_3$  versus  $\text{TiO}_2$  (a) and versus Zr (b) for volcanic rocks from the H-W lens, drill holes W-111 and W-123. Most of the samples fall along andesite or rhyolite alteration lines, making this technique a useful tool for discriminating between extremely altered rhyolites and andesites.

clastic rocks in fact had a heterolithic appearance due to the different textures and colours of the clasts. However, the slope of the felsic alteration line closely corresponds to a pure end-member rhyolite composition (based on Westmin Resources unpublished data for least-altered rhyolites). Thus, essentially all of the fragments must be of rhyolite composition. The monolithic nature of these beds suggests that they were rapidly emplaced (into a muddy basin at this particular locality).

It is of interest that the immobile element plots clearly indicate that several altered units logged by previous workers as rhyolites are actually andesite and vice versa. Thus, these plots can usefully serve to establish original rock types and improve stratigraphic correlation.

Samples in the H-W data set plot consistently in both  $\text{Al}_2\text{O}_3$  versus  $\text{TiO}_2$  and  $\text{Al}_2\text{O}_3$  versus Zr space, except for one rhyolite sample that has shifted onto the andesite alteration line, probably due to zirconium loss. This effect can occur in some felsic rocks if zirconium

becomes incompatible during magmatic fractionation or is lost by crystal sorting (MacLean and Barrett, 1993). For this reason,  $\text{Al}_2\text{O}_3$ - $\text{TiO}_2$  plots show the most consistent immobile element relations.

## SULPHIDE MINERALIZATION

The H-W deposit consists of the Main, North and Upper sulphide lenses, of which the first two occur at the base of the H-W horizon (unit 1). The lenses consist of fine-grained massive to thinly banded pyrite, sphalerite and chalcopyrite with minor bornite, galena and tennantite; gangue minerals are quartz, barite and sericite. The Main lens is some 1200 metres long, 500 metres wide and up to 80 metres thick (Juras, 1987). There is a general zoning from a pyrite core with sphalerite and chalcopyrite-rich areas, to a pyrite-poor barite-rich margin with notable sphalerite, chalcopyrite, galena and bornite (Walker, 1985). The Upper lens mineralization is near the top of the H-W horizon (unit 1). It comprises disseminated to locally massive polymetallic sulphides. Much of the intervening sequence of unit 1 felsic volcanoclastics is strongly altered, probably as a result of continued hydrothermal activity after formation of the Main and North lenses.

## MINERAL COMPOSITIONS

Polished mounts (total area  $\approx 92 \text{ cm}^2$ ) were prepared from six samples of disseminated, brecciated, banded and massive sulphide ores. These were characterized in terms of mineralogy, textures and mineral chemistry. The modal proportions of each ore and gangue phase were estimated visually: four stope samples from the H-W deposit contain 40 to 90 volume percent sulphides, averaging about 60%. Two drill-core samples from the Upper zone contain 8 to 15% sulphides. The five key ore minerals, in terms of average volume percent across the sample set, are: pyrite (28%), sphalerite (9%), chalcopyrite (7%), galena (1%) and tennantite (0.4%), averaging a total of 45% for all samples.

Four complementary techniques were used for mineral analysis. On scales ranging from about 0.01 to 1 millimetre, polished samples were analyzed for major, minor and trace elements. Elements expected at levels of 0.1 weight percent (1000 ppm) or more were analyzed by electron microprobe (EPM). A survey of minor and trace elements in the 5 to 5000 ppm range was conducted by proton microprobe (PIXE). A limited study of gold distributions ( $<10 \text{ ppm}$ ) was carried out using accelerator mass spectrometry (AMS) and ion microprobe (SIMS) methods.

The EPM and PIXE data indicate that common sulphides, particularly pyrite, almost always contain much less than 500 ppm (0.05 wt.%) arsenic. Silver occurs at significant levels in only two minerals, namely tennantite (0.1-1.2 wt.%) and galena (60-250 ppm, based on three PIXE analyses). Over 30 elements were analyzed by microprobe methods; the PIXE survey also yielded some minor element data. Cadmium is present in sphalerite and tennantite at concentrations of 0.33 and 0.1 weight percent, respectively. Chalcopyrite contains a

few tens of parts per million selenium and indium; tennantite contains up to 500 parts per million tellurium. Pyrite and chalcopyrite may each host tens of parts per million of molybdenum.

Good agreement in reconnaissance surveys of gold by SIMS, and its ultrasensitive variant AMS indicates that gold contents in pyrite and chalcopyrite are in the 25 to 1000 parts per billion range, with the higher values occurring in pyrite. This is inadequate to account for the 1.9 to 3.9 grams per tonne gold reported in the bulk assays. Contributions from submicroscopic inclusions at grain boundaries and scattered grains of gold or electrum (not seen in this study) may account for the balance. A third possibility not yet evaluated is a contribution from 'invisible gold' in tennantite (PIXE lacks the sensitivity required for a definitive check on gold).

## CONCLUSIONS

A preliminary interpretation of the lithological sequence in the H-W area is:

- i) Accumulation of a widespread mafic volcanic footwall of andesitic flows and sills.
- ii) Deposition of some massive sulphides on the mafic volcanic footwall.
- iii) Accumulation of felsic volcanoclastic debris-flows in the area of the H-W deposit but in felsic flows (or shallow sills) in the area of the north lens.
- iv) Continued sulphide deposition as infillings within porous unconsolidated felsic debris-flows, and local precipitation of barite and chert.
- v) Accumulation of pelagic black mud, with continued episodic deposition of felsic debris-flows in the black muds.
- vi) Emplacement of an andesite sill/flow complex (H-W andesite) into and onto the felsic debris-flow unit.
- vii) Accumulation above the H-W andesite of mafic-rich and lesser felsic volcanoclastics that form the second volcanic cycle and host the Myra-Lynx-Price orebodies.

Immobile element plots have been used to effectively identify heavily altered (and locally mineralized) rocks near the H-W orebody. These identifications allow the hangingwall-footwall contact to be established, and permit correlation of individual volcanic (and even volcanoclastic) units within the mine stratigraphy.

## FURTHER WORK

Our continued work at Myra Falls will include: definition of the H-W stratigraphy and extent of hydrothermal alteration using detailed lithochemistry and petrography; comparison of H-W stratigraphy with that of the Battle zone 1 to 2 kilometres to the west (Robinson *et al.*, 1994, this volume); identification of the mineral assemblages in the H-W orebody and the trace metal composition of sulphides and sulphosalts; and characterization of the temperatures and compositions of the mineralizing fluids. Once these volcanic units are identified using immobile element relations mass changes will be calculated for each mobile element in

order to reveal the intensity and distribution of hydrothermal alteration around the H-W orebody.

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