CHAPTER 7: MINERALISATION AND METAL ZONATION

7.1 Introduction

The Fenton Creek zone consists of two Zn-Cu +/- Pb massive sulphide lenses. The upper lens is the thickest and most massive of the ore body and ranges from 5 to 20 m (apparent thickness). The lower lens is 3 to 10 m of (apparent thickness) and dominated by disseminated sulphide mineralisation. At least three different styles of mineralisation have been identified including (1) Disseminated sulphides which occur within and proximal to the ore lenses (2) Semi-massive sulphides and (3) Massive sulphides which constitute the ore lenses. Ore mineralogy of these different styles indicate that pyrrhotite > sphalerite > chalcopyrite > galena. Tetrahedrite and bouronite are associated with galena. Petrographical evidence is in agreement with the metal zonation which indicate that along section 400N two general zones can be discriminated (1) iron + zinc + copper zone which correlates well with the upper lens and part of the lower lens and (2) iron + lead + gold + silver zone which correlates with the lower lens. This chapter endeavours to characterise the mineralisation styles, mineral/metal associations and metal zonation along section 400N and then use this information to compare metal zonation from section 300N and 500N.

7.2 Methods and Data Processing

Interpretation of the mineralisation and metal zonation is based on a total of 107 representative hand samples taken along section 400N and 470 assay results from samples collected along sections 300N, 400N and 500N of the Fenton Creek zone. Representative samples used in the description of the mineralisation have been taken from the same 107 samples collected along section 400N and used to describe the local geological units. Samples were cut on a diamond saw, photographed, and described. From the 107 specimens, 45 representative samples were made into polished thin sections and 10 of these polished thin sections were used for ore petrography. Assay samples were collected from intervals of visible mineralisation by Hudson Bay Exploration And Development Company employees and consisted ½ split or sawed NQ
sized diamond drill core of intervals ranging from 30 to 200cm with an average of 100cm (Gilmore et al., 1999). The samples were then sent to Hudson Bay Mining and Smelting Company Limited, where they were crushed with a steel jaw crusher, split and then pulverised using a chrome-steel disc mill. Sample is then fluxed into a bead that is digested using aqua-regia acid and then analysed using ICP and AA methods. Elements assayed for include iron, copper, zinc, lead, arsenic, silver and gold. All elements with the exception of arsenic have been grided and contoured along section using Surfer 7.0, a surface/subsurface mapping program.

Metal zonation and characterisation was determined using the combined results of the contoured assay data and the ore petrography from section 400N. Contoured assay data from section 300N and 500N have been included in Appendix G as a means of comparison between sections; however, no ore petrological studies were conducted on these sections in this study.

### 7.3 Mineralisation

The ore in the Fenton Creek zone occurs as two main strataform massive sulphide lenses ranging in thickness from 3 to 25m. The lenses have a parallel dip approximately 35 to 55° to the west and can be traced over at least 3 sections a distance of 300m (Figs. 3.3, 3.4 and 3.5). The upper ore lens is located along the transition between biotite-plagioclase and/or amphibole-plagioclase schists (probable basic igneous rocks) and metapelites, whilst the lower lenses are hosted within the minor metapelite and quartz—muscovite-sillimanite schist of the footwall (probable acid igneous rocks). The lenses are separated by a non-mineralised gap that ranges from 5 to 20m except in region intersected by diamond drillhole Har021 on section 400N where the lenses almost join to form one lens.

Three styles of mineralisation have been recognized along section 400N of the Fenton Creek zone: (1) disseminated sulphide pyrrhotite +/- sphalerite, chalcopyrite, galena and graphite (2) Semi-massive sulphide psuedo breccia pyrrhotite +/- sphalerite, chalcopyrite (3) massive sulphide pyrrhotite +/- sphalerite & chalcopyrite.

#### 7.3.1 Disseminated sulphides

Three types of mineral associations exist within the disseminated style mineralisation (A) Pyrrhotite +/- chalcopyrite-sphalerite, (B) Pyrrhotite +/- galena-chalcopyrite (C) Pyrrhotite +/- graphite-chalcopyrite-sphalerite. In general type A and B are found proximal to the ore bodies, while type C is very often within the ore position. Contacts are often sharp near the
semi-massive and massive mineralisation and gradational away from the ore lenses. The rocks hosting the disseminated mineralisation range in composition and degree of alteration from biotite-plagioclase schist to metapelite.

**Type A - Pyrrhotite +/- chalcopyrite-sphalerite**
Type A mineralisation is characterised by disseminated pyrrhotite with minor amounts of chalcopyrite, and sphalerite. This style of mineralisation is typically found proximal to the ore lenses within bedded/well foliated biotite-amphibolite-plagioclase schists with variable amounts of pelitic material. Pyrrhotite occurs as variable sized dissemination and blebs that increase in size and density as pelitic content of the host rock increases (Fig. 7.1). Chalcopyrite is a minor component of this mineralisation type and occurs as small disseminations (Figs. 7.1 E-G) while sphalerite exhibits similar characteristics to the pyrrhotite with disseminations becoming coarser and more frequent towards the ore lenses (Fig. 7.1D).

**Type B Pyrrhotite +/- galena-chalcopyrite**
In hand specimen type B mineralisation consists of disseminated pyrrhotite and galena (Figs 7.2 A and 7.2 D). This style of mineralisation is also found proximal to the ore lenses predominantly within clinopyroxene-plagioclase schists of the footwall. In thin section the mineralogy is pyrrhotite, galena, chalcopyrite +/- bournonite and tetrahedrite. Within the two representative samples of the type B mineralisation pyrrhotite is often intergrown with galena and chalcopyrite with sutured boundaries. Accessory minerals include bournonite (PbCuSbS₃), tetrahedrite (Cu, Fe)₁₂Sb₃S₁₃ and an unidentified mineral possibly a nickel or copper sulphides occur in close association to the galena and chalcopyrite are not seen in other mineral types (Figs. 7.2 E-G).

**Type C Pyrrhotite +/- graphite-chalcopyrite-sphalerite**
Type C mineralisation is characterised by disseminated graphite, chalcopyrite and sphalerite with disseminated to semi-massive pyrrhotite. This style of mineralisation is typically found immediately proximal to the massive sulphide lenses within metapelite (Figs 7.3 A-D). In thin section the mineralogy pyrrhotite, fibrous graphite, chalcopyrite, sphalerite with late pyrite replacing some of the pyrrhotite. The pyrrhotite often occurs as porphyroblasts which a have inclusions of graphite and chalcopyrite (Fig 7.3 E) and as lone disseminations.
Figure 7.1 Type A - Disseminated po +/- sph-cpy mineralisation.

A) Foliated biotite(biot)-K-feldspar(Kfs)-Sillimanite(Slm) schist (probable basic igneous rock) with disseminated pyrrhotite(Po)-chalcopyrite(Cpy)-sphalerite(Sph) mineralisation along foliation. Sample H25866 drillhole Har043 (396.40m).

B) Foliated clinopyroxene(Cpx)-plagioclase(Plag) schist (probable basic igneous rock) with disseminated pyrrhotite(Po)+/-chalcopyrite(Cpy)-sphalerite(Sph) mineralisation. Sample 75602H drillhole Har021 (358.75m).

C) Strongly foliated semi-metapelite with disseminated to stringer pyrrhotite(Po)+/-chalcopyrite(Cpy)-sphalerite(Sph) mineralisation. Sample 75506H drillhole Har010 (109.02m).

D) Metapelite with semi-massive pyrrhotite(Po)+/-chalcopyrite(Cpy)-sphalerite(Sph) mineralisation. Sample 75506H drillhole Har010 (109.02m).

E-G) (E) Sample H25866 (5x), (F) Sample 75602H (5x) and (G) Sample 75506H (5x) showing compositions of granoblastic pyrrhotite(Po)+/-chalcopyrite(Cpy)-sphalerite(Sph) disseminations (Note the reduction in inclusions within the sulphides as the samples become increasingly pelitic) (reflected light).
Chapter 7 - Mineralisation and Metal Zonation

Figure 7.2 Type B - Disseminated pyrrhotite +/- galena-chalcopyrite-sphalerite

A) Weakly foliated clinopyroxene(Cpx)-plagioclase(Plag) schist with disseminated pyrrhotite(Po) +/- galena(Gal)-chalcopyrite(Cpy)-sphalerite(Sph). Sample 75535H drillhole Har044 (481.51m).
B) Sample 75535H showing pyrrhotite(Po) and galena(Gal) aligned along a weak foliation (5x magnification, reflected light)
C) Twinning in bournonite(Bo) crystal associated with pyrrhotite(Po) and galena(Gal). Sample 75535H (10x magnification, reflected light with angled polarizer).
D) Granoblastic clinopyroxene(Cpx)-plagioclase(Plag) schist with blebs of pyrrhotite(Po) and disseminated chalcopyrite(Cpy)-sphalerite(Sph). Sample 75526H drillhole Har021 (319.75m).
E) Galena(Gal), pyrrhotite(Po), bournonite(Bo) and an unidentified mineral possibly bornite. Sample 75535H (20x reflected light).
F) Galena(Gal), bournonite(Bo), chalcopyrite(Cpy) and sphalerite(Sph). Sample 75535H (20x reflected light).
G) Tetrahedrite(Tet), pyrrhotite(Po), galena(Gal), chalcopyrite(Cpy) and an unidentified mineral possibly bornite. Sample 75535H (40x reflected light).
The characteristic graphite occurs as inclusions within cordierite poikioblasts (Fig. 7.3 G) and as discrete grains along a weak foliation. Chalcopyrite and sphalerite occur as disseminations and blebs throughout this type on mineralisation.

### 7.3.2 Semi-massive sulphides

The semi-massive sulphide mineralisation is dominated by pyrrhotite +/- sphalerite and chalcopyrite. This style of mineralisation is found within the ore lenses and is often hosted by clinopyroxene-amphibole-plagioclase schists. As previously mentioned the contacts between the semi-massive sulphides and the disseminated sulphides are often sharp (Fig. 7.4A). Within this mineralisation style pyrrhotite is 25 to 30% of the rock and often forms the matrix with lesser amounts of sphalerite. Chalcopyrite occurs as disseminations within deformed and subrounded clasts of host rock form a moderately developed durchbewegung fabric.

In thin section the mineralogy of the semi-massive sulphide is comprised of large 0.5 to 1cm recrystallized granoblastic mosaics of pyrrhotite and sphalerite both of which often having inclusions chalcopyrite. Minor pyrite has also been noted in some samples and is interpreted to have formed as a late alteration mineral associated with the breakdown of pyrrhotite to pyrite. Trace arsenopyrite has also been observed as discrete subhedral grains within the pyrrhotite.

### 7.3.3 Massive sulphides

The massive sulphide mineralisation as the name suggests is consists of > 40% massive sulphide. Due to metallurgical testing few samples of the truly massive sulphide were available for study along section 400N. The samples that were collected are composed of massive pyrrhotite +/- sphalerite and chalcopyrite (Figs. 7.6 B-D). The host rocks for the most part have been replaced by sulphide the remnant remains consist of a biotite-clinopyroxene-carbonate rich metamorphic rock most likely of basic igneous origin. The contacts of this style of mineralisation are often sharp and sometimes incorporate brecciated host wall rock (Fig. 7.6 A).

In thin section the massive sulphide comprises granoblastic mosaics of pyrrhotite, sphalerite and chalcopyrite that often display annealed textures. The pyrrhotite is often very coarse relative to the more highly variable grain size reflected in the sphalerite and chalcopyrite (Wells, 2000) (Figs. 7.6 A-D). Chalcopyrite most often occurs along the boundaries and as small inclusions within sphalerite (Fig 7.6 E-F). The sphalerite is dark brown to reddish-
Figure 7.3 Type C - Graphitic pyrrhotite +/- chalcopyrite-sphalerite mineralisation.

A) Graphitic metapelitic with disseminated pyrrhotite(Po) +/- chalcopyrite(Cpy) and sphalerite(Sph). Sample 75507H drillhole Har010 (119.6m).

B) Graphitic metapelitic with pyrrhotite(Po) and graphite(Graph) orientated along the foliation Sample 75615H drillhole Har044 (474.90m).

C) Graphitic metapelitic with semi-massive pyrrhotite(Po) +/- sphalerite(Sph)-chalcopyrite(Cpy) mineralisation. Sample 75507H Har010 (119.6m).

D) Graphitic metapelitic with semi-massive to massive pyrrhotite(Po) +/- chalcopyrite(Cpy) mineralisation. Sample 75520H drillhole Har018 (215.73m).

E) Fractured porphyroblast of pyrrhotite(Po) with inclusions of chalcopyrite(Cpy) & graphite(Graph). Sample 75507H drillhole Har010 (2.5x magnification, reflected light).

F) Grain of pyrite(Py) showing distinctive birds eye texture indicative of replacement of pyrrhotite(Po). Sample 75507H (40x magnification, reflected light).

G) Inclusions of graphite(Graph) within a cordierite poikiloblast (dashed circle) and as larger discrete grains. Sample 75507H (5x magnification, reflected light).
Figure 7.4 Semi-massive pyrrhotite +/- sphalerite-chalcopyrite mineralisation

A) Sharp contact of a semi-massive pyrrhotite (Po) +/- sphalerite (Sph)-chalcopyrite (Cpy) with foliated mineralised metapelites from drillhole Har044 (474.5m).
B) Sphalerite (Sph) rich semi-massive sulphide from sample 75534H drillhole Har044 (465.22m).
C) Semi-massive pyrrhotite (Po) - sphalerite (Sph)-chalcopyrite (Cpy) specimen with weakly developed durchbewegung fabric. Note domains of finely disseminated pyrrhotite (Po) & Chalcopyrite (Cpy) within coarser pyrrhotite (Po) - sphalerite (Sph). Sample 75611H drillhole Har021 (324.50m).
D) Well developed durchbewegung fabric within semi-massive Po-sphalerite (Sph)-Chalcopyrite (Cpy) ore. Sample 75614 drillhole Har044 (474.40m).
E) Close-up of disseminated Chalcopyrite (Cpy) within the deformed clasts. Sample 75614 drillhole Har044 (474.40m).
Figure 7.5 Zn-Cu massive sulphide ore

A) Sphalerite (Sph) rich matrix with disseminated pyrrhotite (Po) in the gangue. Sample 75534H (1.25x magnification, reflected light).
B) Close-up of semi-massive sphalerite (Sph) containing inclusions of pyrrhotite (Po) and chalcopyrite (Cpy). Sample 75534H (5x magnification, reflected light).
C) Copper rich clast with inclusions of chalcopyrite (Cpy) and pyrrhotite (Po). Sample 75532H (1.25x magnification, reflected light).
D) Close-up of pyrrhotite (Po), chalcopyrite (Cpy), sphalerite (Sph) inclusions showing the interconnectivity between inclusions. Sample 75532H (2.5x magnification, reflected light).
E) Iron rich cores in sphalerite (Sph) crystals. Sample 75534H (5x magnification, plane light).
F) Chalcopyrite inclusions occurring along sphalerite (Sph) grain boundaries. Sample 75534H (10x magnification, reflected light).
Figure 7.6 Massive pyrrhotite +/- sphalerite-chalcopyrite mineralisation

A) Brecciated contact of pyrrhotite(Po)-sphalerite(Sph) massive sulphides. Sample from drillhole Har010 (154.25m).

B) Massive granoblastic pyrrhotite(Po)+/-sphalerite(Sph) ore. Sample 75527 Har021 (345.00m).

C) Massive pyrrhotite(Po)+/-sphalerite(Sph) with quartz(Qtz) domains. Sample 75514 drillhole Har010 (157.08m).

D) Massive pyrrhotite(Po) ore. Sample 75513 drillhole Har010 (154.08m).

E) Typical massive ore of sphalerite(Sph) with numerous inclusions of chalcopyrite(Cpy) + pyrrhotite(Po) and chalcopyrite(Cpy). Sample 75527H drillhole Har021 (345.72m)(5x magnification, reflected light).

F) Massive pyrrhotite(Po) ore with minor sphalerite(Sph) and chalcopyrite(Cpy). Sample 75513 drillhole Har010 (154.08m) (1.25x magnification, reflected light).

G) Twinning of granoblastic red/brown sphalerite(Sph) crystals. Sample 75514H drillhole Har010 (157.08m)(8x magnification, plane polarized light)
brown suggesting iron rich end member and often displays well developed twinning (Wells, 2000) (Fig. 7.6 G).

7.4 Metal Zonation

Pyrrhotite, sphalerite, chalcopyrite and galena are the major mineral species observed in the ore lenses along section 400N and likely account for the bulk of the base metals (Fe, Cu, Zn and Pb). Minor accessory sulphide minerals include tetrahedrite, bournonite, pyrite and arsenopyrite that are only observed in minor amounts.

Gridded and contoured assay data for base and precious metals along section 400N have been generated to determine metal zonation (Figs. 7.7, 7.8 and 7.9). The results of the contouring indicate that Fe, Cu and Zn form roughly coincident anomalies which correlate well with the upper ore lens along the entire section as well as the lower ore lens above the large granitic intrusion. Correlation between the various mineralisation styles, ore lenses and metal zones are shown in Table 7.1.

Table 7.1 Table showing the correlations between ores lenses, style of mineralisation and the associated metals seen in the metal zonation.

<table>
<thead>
<tr>
<th>Dominant Lens</th>
<th>Mineral Types</th>
<th>Mineralisation Style</th>
<th>Metal Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper/lower lens</td>
<td>A - Po +/- Cpy-Sph</td>
<td>Disseminated</td>
<td>Iron-copper-zinc</td>
</tr>
<tr>
<td>Lower lens</td>
<td>B - Po +/- Gal-Cpy.</td>
<td>Disseminated</td>
<td>Iron-lead-silver-gold</td>
</tr>
<tr>
<td>Upper/lower lens</td>
<td>C - Po +/- Graph-Cpy-Sph</td>
<td>Disseminated</td>
<td>Iron-copper-zinc</td>
</tr>
<tr>
<td>Upper lens</td>
<td>Po +/- Sph-Cpy</td>
<td>Semi-massive</td>
<td>Iron-zinc-copper</td>
</tr>
<tr>
<td>Upper lens</td>
<td>Po +/- Sph-Cpy</td>
<td>Massive</td>
<td>Iron-zinc-copper</td>
</tr>
</tbody>
</table>

In detail, Fe distribution is fairly wide spread with a large halo of greater than 5% encompassing most of the ore lenses. The highest values of +25% occur in the upper ore lens in ddh Har021 and decrease down the dip of the lens. The Cu and Zn the follow same trend as the Fe with highest grades of >0.6% Cu and >7% Zn focussed in ddh Har021 and decrease in grade down dip (Figs. 6.7 and 6.8).

In detail, the distribution of Ag is also widespread with values of 5g/t covering much of the two lenses, however the highest grades of >35g/t occur immediately below the Fe, Cu and Zn highs intersected by drillhole Har021 in the lower lens. Pb distribution is similar to that of the Ag, however Pb appears more focussed and confined to the down dip portion of the lower lens below the large granitic intrusion and is low to absent portions of the lenses that are above the granitic intrusion. Au distribution is grossly coincident with that of Pb and to a lesser extent Ag, however, the highest values for Au appear intersected by ddh Har043
Figure 7.7 (A) Cross-section 400N showing the assay locations used in the gridding (B) Gridded and contoured assay data for Fe overlayed ontop of interpreted geology from Section 400N. Data gridded using a kriging method and a linear variogram model with anisotropy ratio of 3 and a preferred orientation of 50 degrees.
Figure 7.8 Gridded and contoured assay data for (A) Cu and (B) Zn overlayed on top of interpreted geology from Section 400N. Data gridded using a kriging method and a linear variogram model with anisotropy ratio of 3 and a preferred orientation of 50 degrees.
Figure 7.9 Gridded and contoured assay data for (A) Pb and (B) Ag overlayed on top of interpreted geology from Section 400N. Data gridded using a kriging method and a linear variogram model with anisotropy ratio of 3 and a preferred orientation of 50 degrees.
Figure 7.10 Gridded and contoured assay data for (A) Au and (B) As overlayed on top of interpreted geology from Section 400N. Data gridded using a kriging method and a linear variogram model with anisotropy ratio of 3 and a preferred orientation of 50 degrees.
Figure 7.11 Gridded and contoured assay data for (A) Zn ratio and (B) Cu ratio. As overlayed onto interpreted geology from Section 400N. Data gridded using a kriging method and a linear variogram model with anisotropy ratio of 3 and a preferred orientation of 50 degrees.
100m down dip from the highest Pb and Ag. In general terms Pb, Ag and Au coincide well and correlate with the lower ore lens and/or are proximal to the Fe, Cu and Zn dominating the upper lens (Table 7.1).

Examination of the kriged Zn ratio \([100 \times \text{Zn}/\text{Zn}+\text{Pb}]\) values and the Cu ratio \([100 \times \text{Cu}/\text{Cu}+\text{Zn}]\) values (Fig. 7.11) show a good correlation between low Zn ratio <25 and high Cu ratio >80 focussed on drillhole Har043, which is located down dip from the best or grades in Har021. This occurrence may represent an up flow zone along which hot hydrothermal fluids could have travelled to be deposited further along in the region intersected by Har021, however further investigations would be required to confirm such a claim. Previous investigation by Huston and Large (1987) and Gemmell and Large (1992) on the Hellyer VHMS deposit showed that in the Hellyer system Cu ratio values >5 highlighted the central feeder zone to the system and that Zn ratio values greater than 67 corresponded to temperatures less than 200°C and that Zn ratio values less than 61 corresponded to temperatures of 240°C to 300°C. Using these results as a general guide it would appear as though the region intersected by Har043 may have been the hot spot for the system causing the mineralisation contained in the Fenton Creek zone.

Griding and contouring of assay data along sections 300N and 500N indicate similar results to those seen along section 400N (Appendix G). In general Fe, Cu and Zn are all grossly coincident with each other and correlate with the upper ore body. Ag, Au and Pb where present are also generally coincident and correlate with the lower ore body. Lateral correlation between sections indicate that Fe, Cu and Zn are highest grade in upper lens of sections 400N and gradually decrease towards sections 300N and 500N. Comparisons of Pb and Ag between sections indicate focussed distributions and higher values along section 400N that decrease towards 300N and 500N. A property investigation with mineralogical control is required to make further informed interpretations.
7.5 Summary

Investigations into representative samples collected along section 400N indicate at least three different types of mineralisation that include disseminated, semi-massive and massive styles. The disseminated mineralisation can be further divided into three types of mineral associations (A) Pyrrhotite +/- chalcopyrite-sphalerite, (B) Pyrrhotite +/- galena-chalcopyrite-tetrahedrite (C) Pyrrhotite +/- graphite-chalcopyrite-sphalerite. Spatially type B was observed proximal to the semi-massive and massive mineralisation while type A and C were observed both and proximal to the semi-massive and massive styles of mineralisation. This observation in mineralisation styles is reflected in the metal zonation.

Grided and contoured assay data indicate that Fe, Cu and Zn form roughly coincident anomalies which correlate well with the upper ore lens along the entirety of section 400N as well as the lower ore lens above the large granitic intrusion. In general terms Pb, Ag and Au coincide well and correlate with the lower ore lens and/or are proximal to the Fe, Cu and Zn dominating the upper lens. Plotting of the Zn ratio and the Cu ratio indicate a potential feeder vent intersect by Har043 and adjacent to the thickest portion of massive sulphide intersected by Har021 on the Fenton Creek property.
8.1 Introduction

The aim of this chapter is to (1) briefly review the past and current genetic models proposed for polymetallic Zn-Cu VHMS deposits in the Snow Lake Assemblage (2) summarize and comment on the results of this study (3) propose a suitable genetic model for the Fenton Creek Zn-Cu massive sulphide deposit (4) discuss exploration implications and suggest future work to be completed on the Fenton Creek zone.

8.2 Previous Genetic Models

Two main genetic models have been proposed to explain the classical mound and sheet-like styled VHMS deposits of the Snow Lake Assemblage. The 'traditional' view of the VHMS deposits of the Snow Lake Assemblage is that geochemically similar rhyolite complexes and the well documented zones of hydrothermally altered rocks associated with the VHMS deposits are a result of seawater-dominated geothermal activity by heat from the Sneath Lake and Richard Lake synvolcanic tonalite intrusions (Walford and Franklin, 1982; Bailes, 1987). In the past this genetic model has been widely accepted and greatly influenced the exploration for VHMS deposits in the region by focussing attention towards the synvolcanic intrusions, rhyolite complexes and associated alteration.

Recently work by Bailes and Galley (1999) and Smye et al. (1999 has suggested that the synvolcanic tonalite intrusions are only partly responsible for the generation of heat required to set up a hydrothermal system and that mounting evidence also supports a genetic model in which arc rifting may play an important role in the formation of VHMS deposits by generating anomalously high heat flow, fracturing and fluid circulation. This relatively new genetic model as applied to the Snow Lake district may have important implications for future exploration of VHMS deposits in the region since it targets previously unfavourable environments which might have been explored using the 'traditional' genetic model.
8.3 Discussion

The following section summarizes and discusses the significant findings of this study with which helped to determine a suitable genetic model for the Zn-Cu massive sulphide lenses found in the Fenton Creek zone.

1. Reinterpretation of geologic logs by the author with the aid of lithogeochemical data has divided the Fenton Creek stratigraphy into five generalized groups including quartz-muscovite-sillimanite schist located in the footwall, biotite-clinopyroxene-plagioclase schist and amphibole-plagioclase schist located in the immediate hanging wall, quartz-biotite-sillimanite schist in the upper hanging wall, metapelitic sediments occurring in the ore horizon and in the upper hanging wall and flat lying post kinematic granitic intrusions cross-cutting all lithologies. The results of this reinterpretation show that the Fenton Creek ore lenses are hosted between a felsic footwall and mafic hanging wall, which may reflect a bimodal volcanic sequence.

2. Geochemical discrimination of the biotite-clinopyroxene-plagioclase schist and amphibole-plagioclase schist found in the immediate hanging wall to the ore lenses indicate that they are geochemically similar to arc-rift basalts found in the Snow Creek Formation. This may support the notion that the Fenton Creek massive sulphide was deposited in a rift environment.

3. Mass balance calculations of the footwall quartz-muscovite-sillimanite schist indicate mass losses of 8g/100g Si and 2g/100g Na and minor mass gains of K. The results of the mass balance calculations in conjunction with the mineral assemblage of K-feldspar-sillimanite-cordierite-anthophyllite +/- base metals suggest that the footwall quartz-muscovite-sillimanite schist may have been subjected to weak sericite +/- chlorite alteration.

4. Interpreted hydrothermal alteration appears stratiform and confined to the footwall and does not extent into the hanging wall. This suggests that the alteration may have been synvolcanic with the deposition of the footwall rocks and that alteration ceased prior to the deposition of the hanging wall.

5. Use of geologic logs and lithogeochemistry indicate large thicknesses of rhyodacitic volcaniclastic rocks (+200m thickness) in the upper hangingwall to the ore lenses. This suggests deposition from some type of a mass flow (i.e. turbidite) along the flanks of a subaqueous volcano or in arc rift environment.
6. Carbon isotopes indicate that the graphite in the metapelitic rocks which are often associated with the ore lenses has a biogenic signature. This evidence suggests the presence of organic life (i.e. black smoker) near the deposition site and/or a quiescent environment where carbonaceous debris could accumulate.

7. This study confirms previous work by Wells (2000) that mineral assemblages observed in the pelitic and metabasic rocks indicate that the Fenton Creek zone has been subjected to amphibolite facies metamorphism with moderate to high pressures (in excess of 3000 bars) and with temperatures that range from 550° to <725°C.

8. Study of the metal associations and zoning indicate that Fe, Cu and Zn form roughly coincident anomalies which correlate well with the upper ore lens along the entirety of section 400N as well as the lower ore lens above the large granitic intrusion. In general terms Pb, Ag and Au anomalies coincide and correlate with the lower ore lens and/or are proximal to the Fe, Cu and Zn dominating the upper lens. Cu and Zn ratios indicate the higher temperatures in the Fenton Creek system along section 400N are intersected by drillhole Har043 down dip from the thickest part of the ore lens intersected by Har021. This might also indicate the sight of a potential hydrothermal vent.


8.4 Fenton Creek Models

Geologic diamond drillhole logging, lithogeochemistry and carbon isotopes of the Fenton Creek deposit support the interpretation of two sheet-like stratabound Zn-Cu +/- Pb, Ag, Au rich massive sulphide lenses hosted within a mixed graphitic metapelite horizon between a quartz-muscovite-sillimanite schist footwall and a biotite-clinopyroxene-plagioclase/amphibole-plagioclase schist hanging wall. Hydrothermal alteration thought to be associated with massive sulphide deposition is represented by K-feldspar, sillimanite, muscovite, cordierite and anthophyllite (interpreted sericite altered zone) is confined to the footwall and does not appear to occur in the hangingwall.

Three potential styles of VHMS deposit types best fit the characteristics listed above for the Fenton Creek Zn-Cu deposit (1) bottom fill brine pool VHMS (McDougall, 1984) (2) Distal brine pool (Sato, 1972) (3) synvolcanic seafloor/subseafloor replacement style VHMS
Chapter 8 - Genetic Model and Discussion

Figure 8.1 - Generalized diagram showing three models used to explain the genesis of sheet or blanket-style VHMS deposits which have stratabound footwall alteration (modified after Large, 1992).

(Blaise et al., 1988; Franklin, 1990; Large, 1992) (Fig. 8.1). Though none of the deposit styles can be ruled out completely, evidence from this study including geochemically identified arc-rift related basaltic volcaniclastics/flows, thick sequence of rhyodacite volcaniclastics and lack of a hydrothermal alteration in the hanging wall favours a synvolcanic seafloor exhalative and/or sub-seafloor replacement style VHMS deposit in an arc rift environment. An idealized schematic diagram modified after the replacement model proposed by Large (1992) illustrates the several potential stages of development of the Fenton Creek massive sulphide deposit (Fig. 8.2).

Regardless, of the accuracy of the genetic model; the Fenton Creek zone represents a newly discovered massive sulphide deposit which shows many VHMS characteristics, some of which are similar to the deposits found in the Snow Lake Assemblage and other features which suggest it formed in a very different environment distinguish it from other deposits in the region. Based on lithogeochemical discriminations and a very generalized stratigraphy of the Snow Lake Assemblage, the Fenton Creek zone may represent a new mineralised horizon in the arc-rift volcaniclastics (Fig. 8.3).
Chapter 8 - Genetic Model and Discussion

Figure 8.2 - Simplified schematic diagram illustrating the proposed stages of development of the Fenton Creek zone based on an arc-rift genetic model and volcaniclastic input from various sources.
8.5 Future Exploration

The discovery of the Fenton Creek poly-metallic Zn-Cu massive sulphide deposit represents a significant new mineral discovery in a previously unexplored stratigraphy. The implications for further exploration and discovery are summarized below:

1. Assuming the Fenton Creek zone is hosted between rift fill mafic volcaniclastics of the Snow Creek Formation and undetermined rhyolitic volcaniclastics, future exploration might be well advised to explore at this stratigraphic level along strike from the Fenton Creek zone looking for evidence of similar deposits.

2. Continued use of electromagnetic geophysical techniques to target short strike length (100-500m) conductors even in regions with significant graphite as the graphite is...
consistently found mixed in with massive sulphide ore.

3 As recommended by Wells (2000) and confirmed in this study K-feldspar staining is a very effective means of visually identifying weak footwall alteration.

8.6 Future Work

It is recommended that the following work be considered if future development is carried out on the Fenton Creek zone:

1. Uranium-lead dating of zircons from the quartz-biotite-sillimanite schist (hanging wall rhyodacite) and/or the quartz-muscovite-sillimanite schist (footwall rhyolite). This dating should allow for more confident determination of the stratigraphic position of the Fenton Creek deposit and how it relates to other deposits in the Snow Lake district.

2. Review and select a least altered precursor sample of the footwall and hanging wall rhyolite/rhyodacite well away from the mineralised zones so to better characterise the mass changes related to hydrothermal alteration. This may help to determine further geochemical ore vectors and targeting parameters.
REFERENCES


References


Bruce, E. L., 1915, "Amisk Lake District, northern Saskatchewan and Manitoba."


Goodfellow, W. D., 1975, "Major and minor element halos in volcanic rocks at Brunswick No. 12 sulphide deposit, N. B., Canada."


Kraus, J. and Williams, P. F., 1999, Structural development of the Snow Lake Allochthon and its role in the evolution of the southeastern Trans-Hudson Orogen in Manitoba, central Canada. NATMAP Shield Margin


