2009-2 응용지구화학특강 Chapter 15

# A Volcanic-associated Massive Sulfide Deposit - Kidd Creek, Ontario


2009-23189

전수현

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# 15.1. Introduction

- Explaining the general features and different types of massive sulfide deposits is essential in designing and exploration program to fine more deposits of this type

- "Volcanic-associated massive sulfide deposits" will be shorten to VMS deposits in this study.

# 2. Volcanic-associated Massive Sulfide Deposits

# 15.2.1. Morphology

- **Stratiform, Lenticular**
- **Developed at the interfaces between volcanic units or volcanic sedimentary units.**

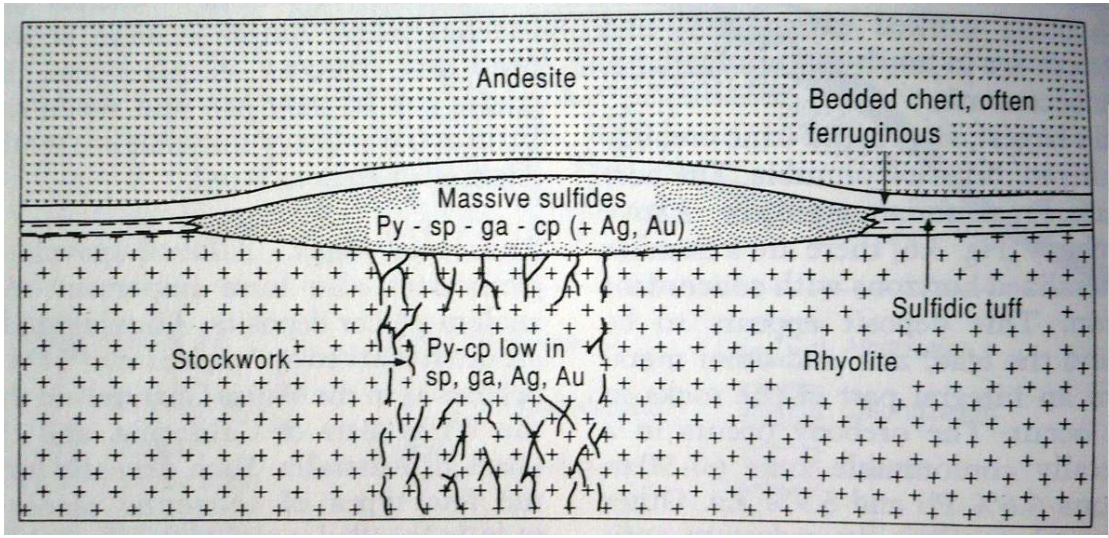



Fig 3.8 Schematic section through and idealized VMS deposit

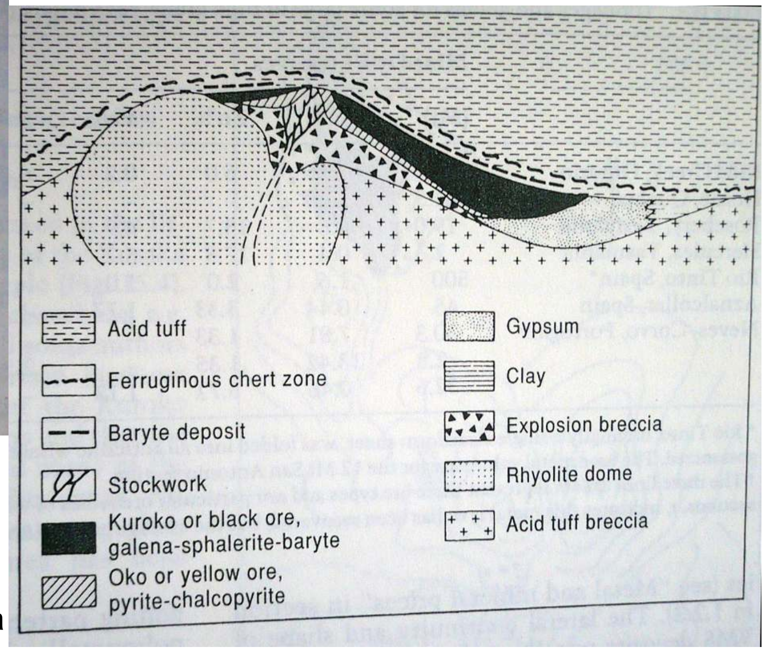



Fig 15.1 Stratigraphical distribution of VMS deposits in the Noranda area

# 15.2.2. Classification

- **Barrie and Hannington(1999) : Host rock composition**

  **(mafic, bimodal-mafic, mafic-siliciclastic, biomodal-felsic, and biomodal-siliciclastic)**

- **Hutchinson(1980)**

**iron : pyrite deposits**

**iron-copper : Cyprus type**

**iron-copper-zinc : Bessi type**

**iron-copper-zinc-lead : Kuroko and primitive type**

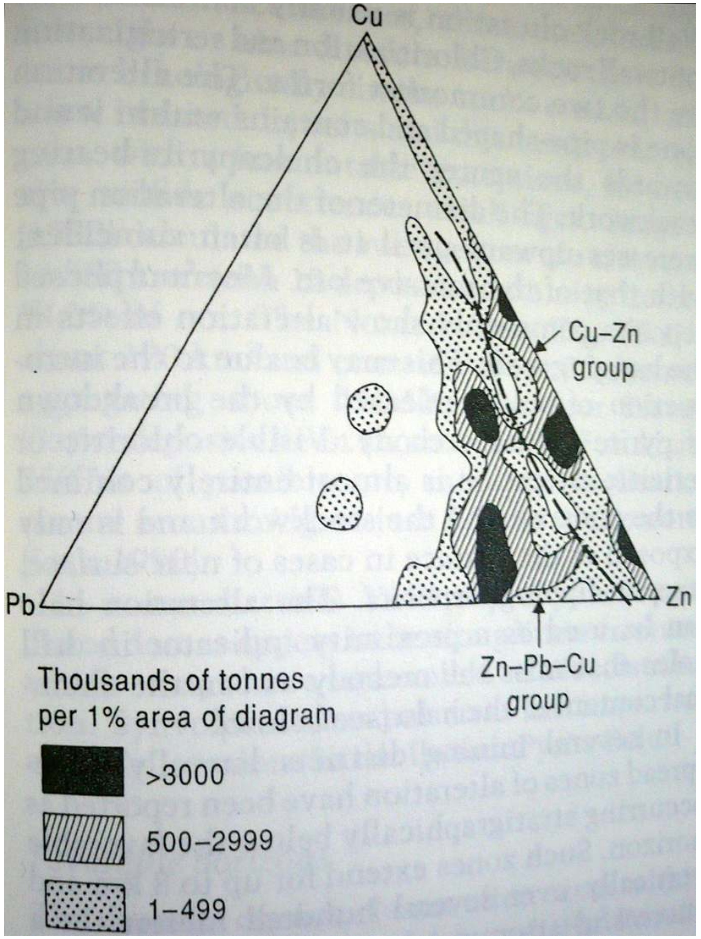



Fig 15.2 Schematic section through a Kuroko deposit. (Sato 1977)

# 15.2.3. Size, grade, mineralogy, and textures

- 0.1~10 Mt : 80% of known deposits – rich, big, profitable
- Mineralogy : 90% of iron sulfide(pyrite, pyrrhotite, chalcopyrite, sphalerite, galena etc)

- Polymetallic deposits

upper part : galena, spalerite

footwall : chalcopyrite, grades downward

# 15.2.4. Wall rock alteration

- Chloritization and Sericitization
- Pipe-shaped alteration zone
- Alteration halo : proximity indicator in drill holes
- Some alteration zone : wide spread (~8Km)

# 15.2.5. Some important field characteristics

- **Association with volcanic domes**
- **Cluster development**
- **Favorable horizons**
- **Structural controls**

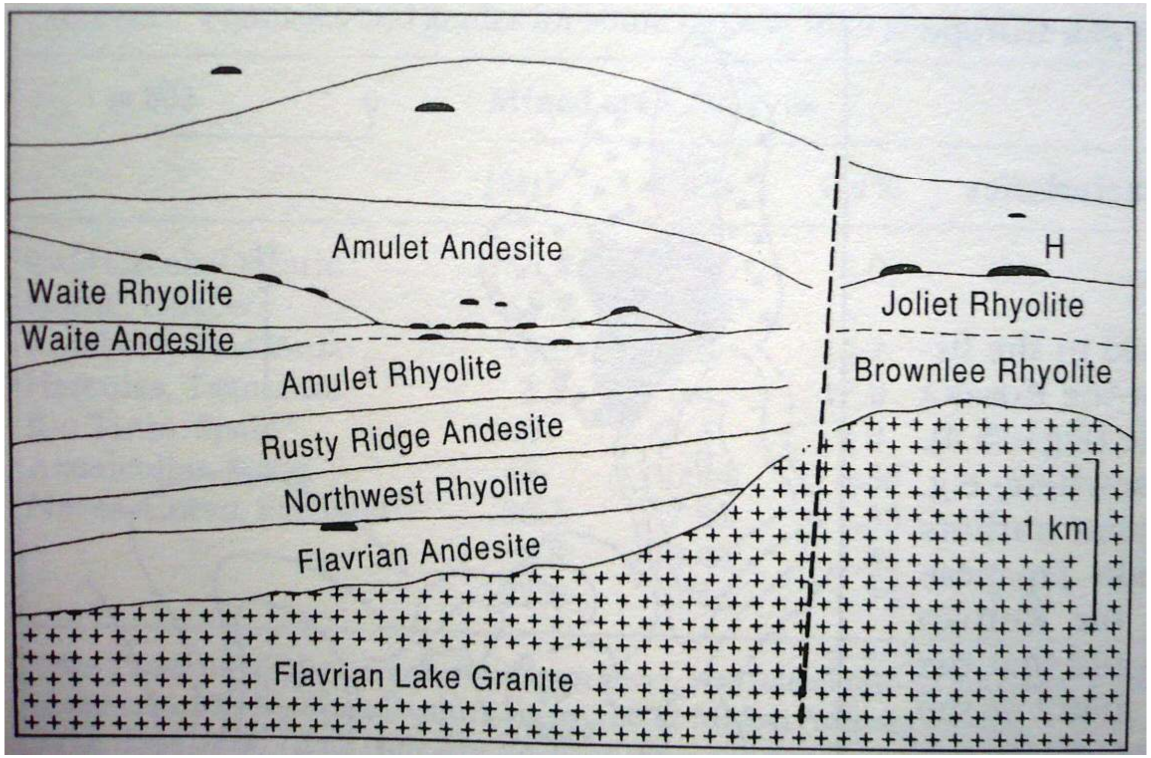



Fig 15.4 Distribution of dacite lave domes and Kuroko deposits, Kosaka District, Japan(Horikoshi 1970)

# 15.2.6. Genesis

- For many decades, many VMS deposits were considered to be epigenetic hydrothermal replacement orebodies.
- In the 1950s, syngenetic, submarine-exhalative, sedimentary orebodies, and deposits of this type have been observed; process of formation from hydrothermal vents (black smokers) at a larger number of places along sea floor spreading centers

# 15.2.7. Volcanic facies

- **Brecciated rhyolitic volcanics**

- **Formed close to structural magmatic vent which also vented hot springs**
- **Result of hydrothermal explosive events**
- **Result of caldera formation with which the ore-forming process was associated.**

# 15.2.8. Exploration geochemistry

- Widely used to delineate drill targets at depth
- Rock geochemistry

- Fe, Mg, Zn enriched & Na, Ca depleted

- Discriminate mineralized sequences of volcanics

- Surficial geochemisty : soil and stream sediment

# 15.2.8. Exploration geochemistry

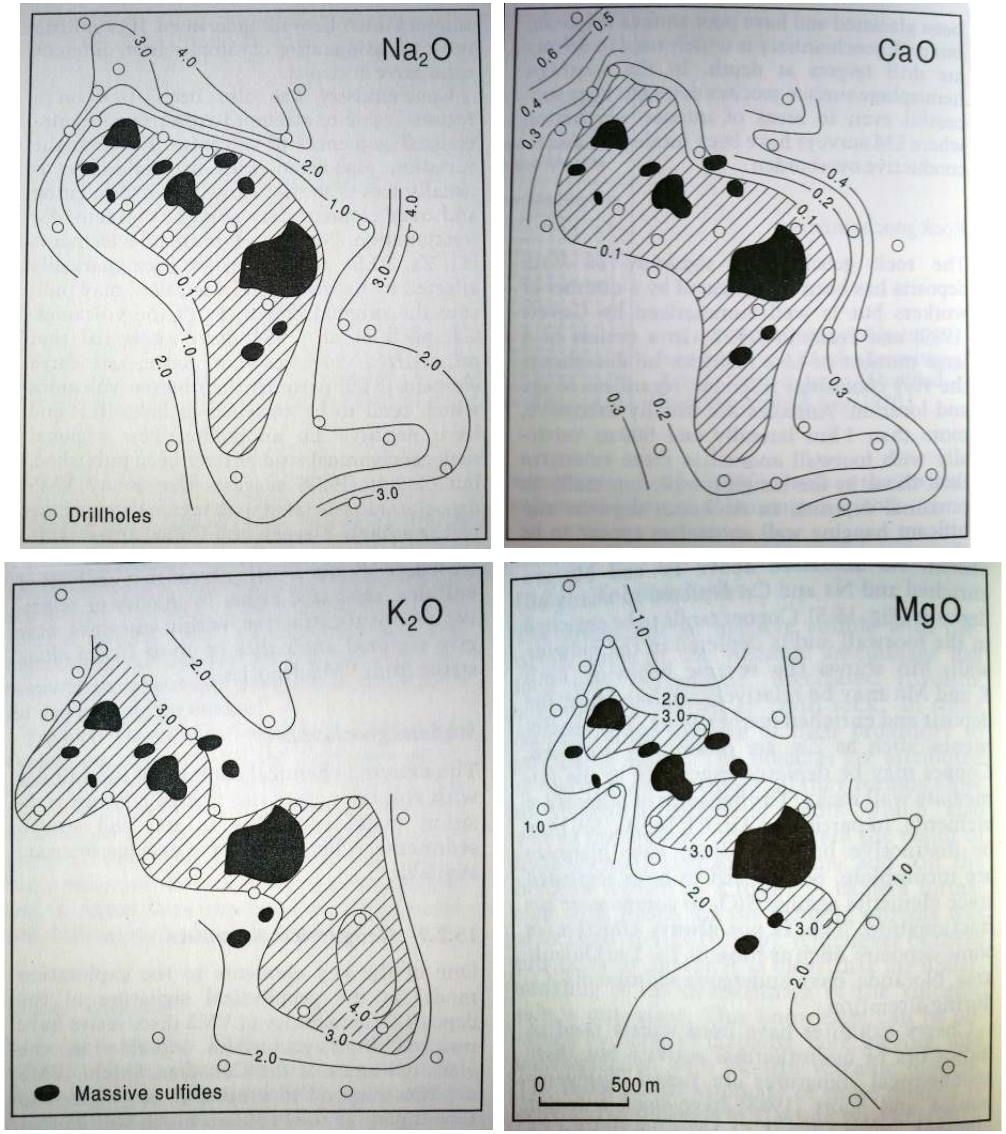



Fig 15.5 Major element anomalies in the footwall of the Fukasawa Mine, Japan

# 15.2.9. Geophysical signatures

- **Electrical connection, EM techniques, dense, gravity**
- **Mapping methods : aeromagnetic method**
- **Direct detection of sulfides**

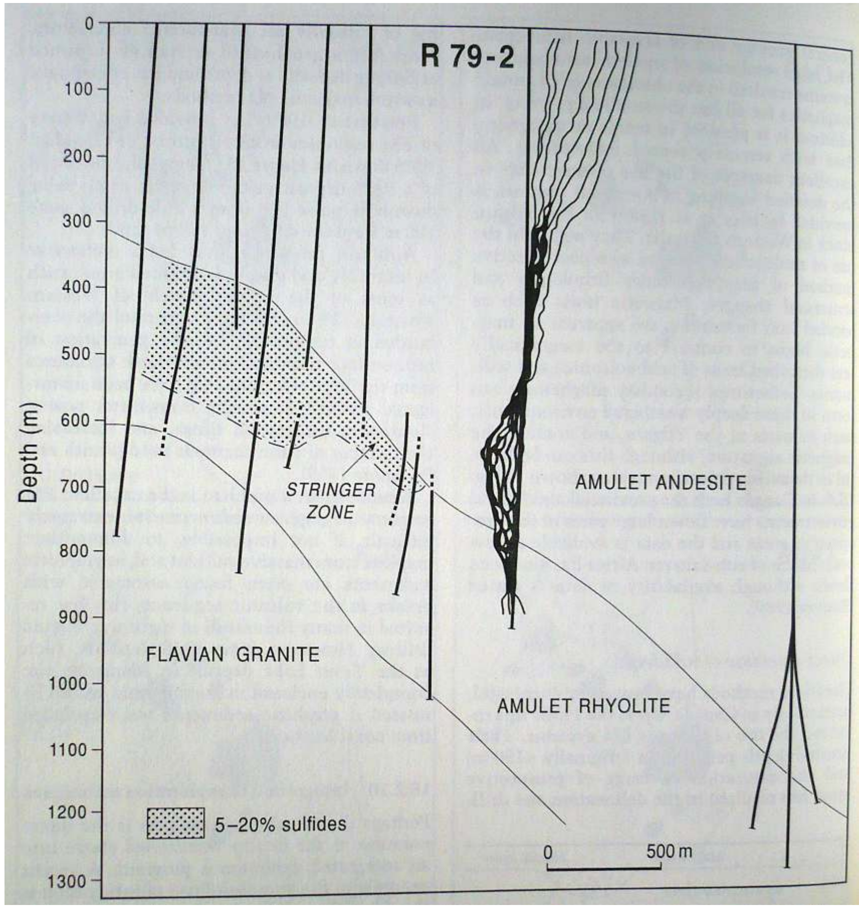



Fig 15.7 Downhole pulse EM survey at the Ribago deposit, Noranda, Quebec

# 15.2.10. Integration of exploration techniques
# 15.2.11. Environmental impact

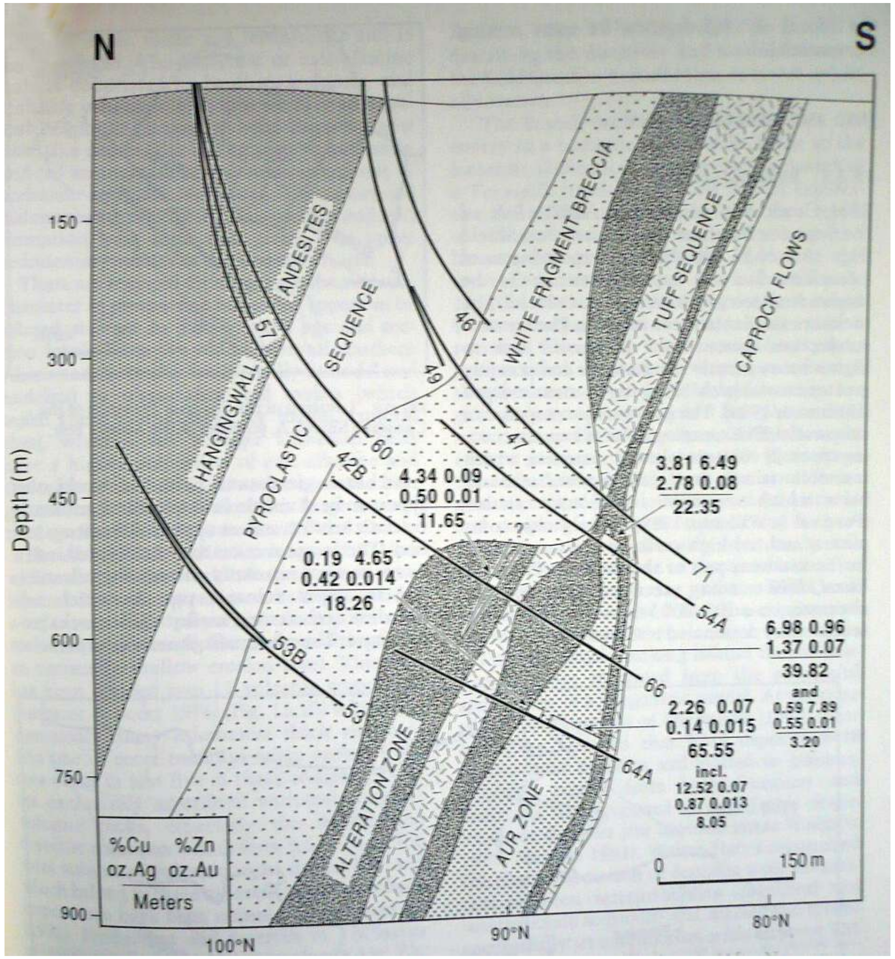



Fig 15.8 Section of the Louvicourt deposit

- **AMD**
- **Arsenic, Cadmium, Mercury**

# 3. The Kidd Creek Mine

# 15.3.1. Regional setting

- Archaean greenstone belt(2.7~2.6 Ga)
- Long x width : 800 x 200 $Km^2$
- Production and reserves of VMS ores : 424Mt, 4.4% Zn, 2.1% Cu, 0.1% Pb, 46g/t Ag, 1.3g/t Au (1990)

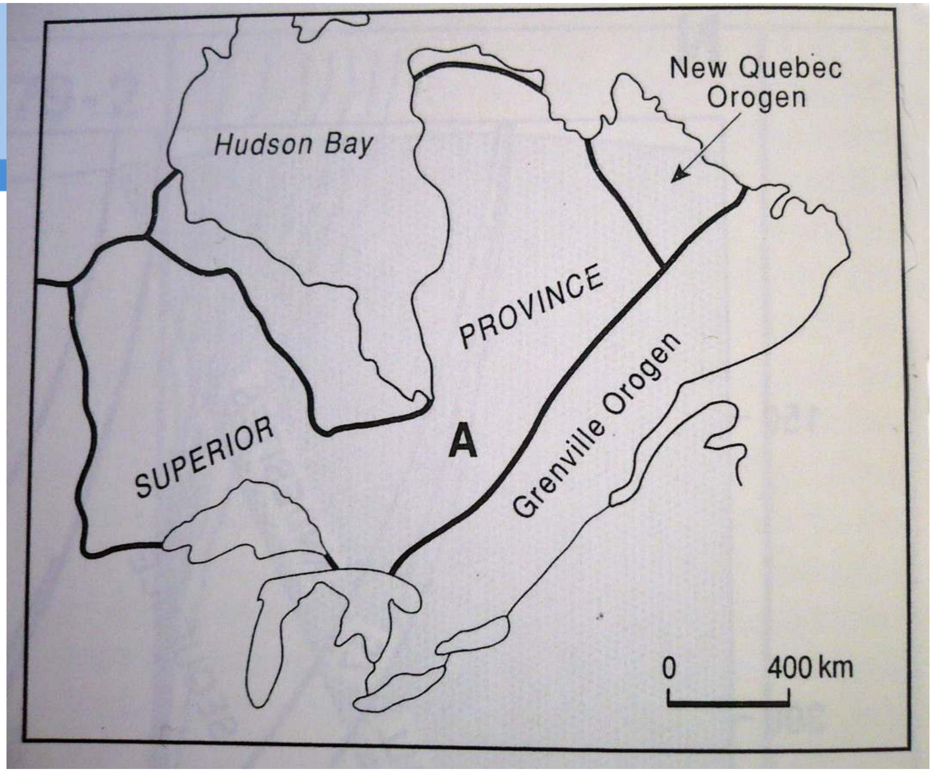



Fig 15.9 Location of the Superior Province of the Canadian Shield. A, position of the Abitibi Belt

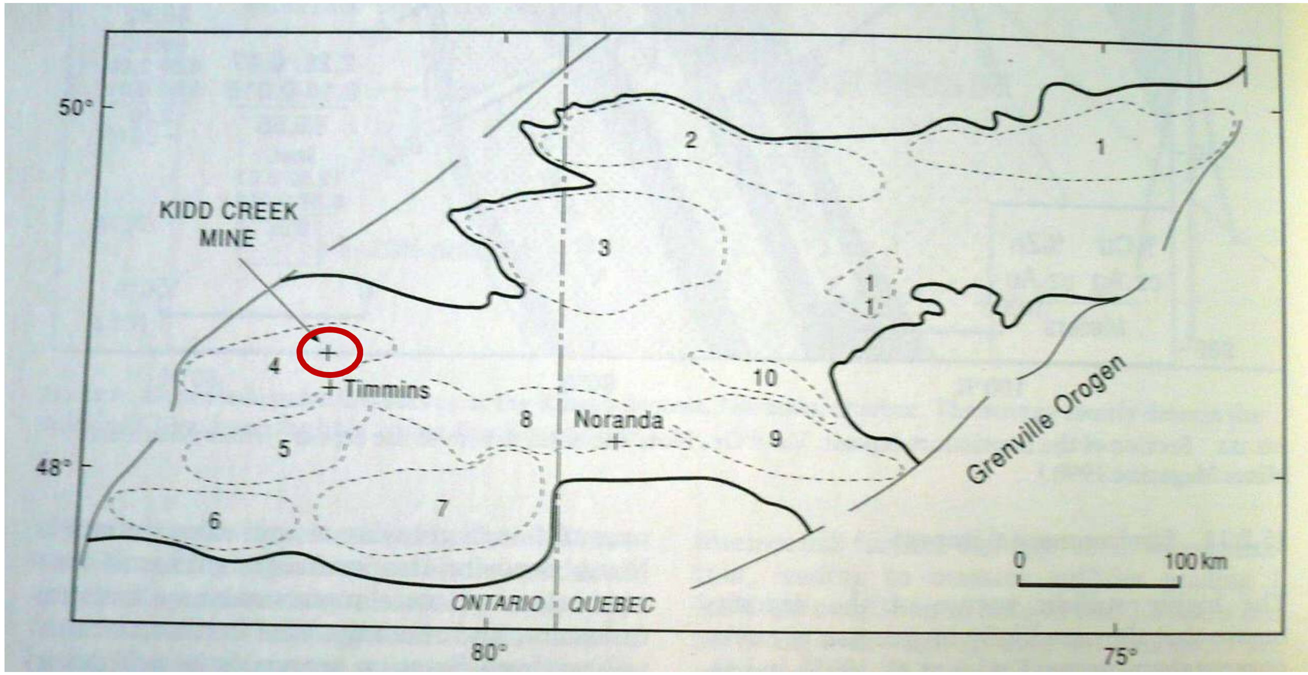



Fig 15.10 Distribution of volcanic complexes in the Abitibi Belt.

# 15.3.2. Exploration history

- Making a compilation of the geology based on outcrop and airborne magnetics
- Finding the most promising areas through EM system
- Drilling

| Footage | ft | Copper(wt %) | Zinc(wt %) | Silver(g/t) | Lead(wt %) |
|---|---|---|---|---|---|
| 0-26 | | Clay overburden | | | |
| 26-50 | 24 | 1.05 | Trace | 10 | - |
| 50-132 | 82 | 7.10 | 9.7 | 82 | - |
| 132-152 | 20 | 0.19 | 11.1 | 10 | - |
| 152-196 | 44 | 0.11 | 4.7 | 17 | - |
| 196-232 | 36 | 0.79 | 13.0 | 360 | - |
| 232-248 | 16 | 0.18 | 3.81 | 82 | - |
| 248-348 | 100 | 0.33 | 14.3 | 144 | 0.80 |
| 348-490 | 142 | 0.1 | 18.0 | 247 | - |
| 490-530 | 40 | 0.24 | 2.8 | 113 | - |
| 530-566 | 36 | 0.23 | 6.1 | 55 | - |
| 566-576 | 10 | 0.17 | 3.0 | 34 | - |
| 576-628 | 52 | 0.20 | 8.3 | 62 | - |
| 628-649 | 21 | 1.18 | 8.1 | 130 | - |
| 649-655 | 6 | - | - | - | - |

Table 15.4 Assays for sections from discovery hole K55-1

# 15.3.2. Exploration history

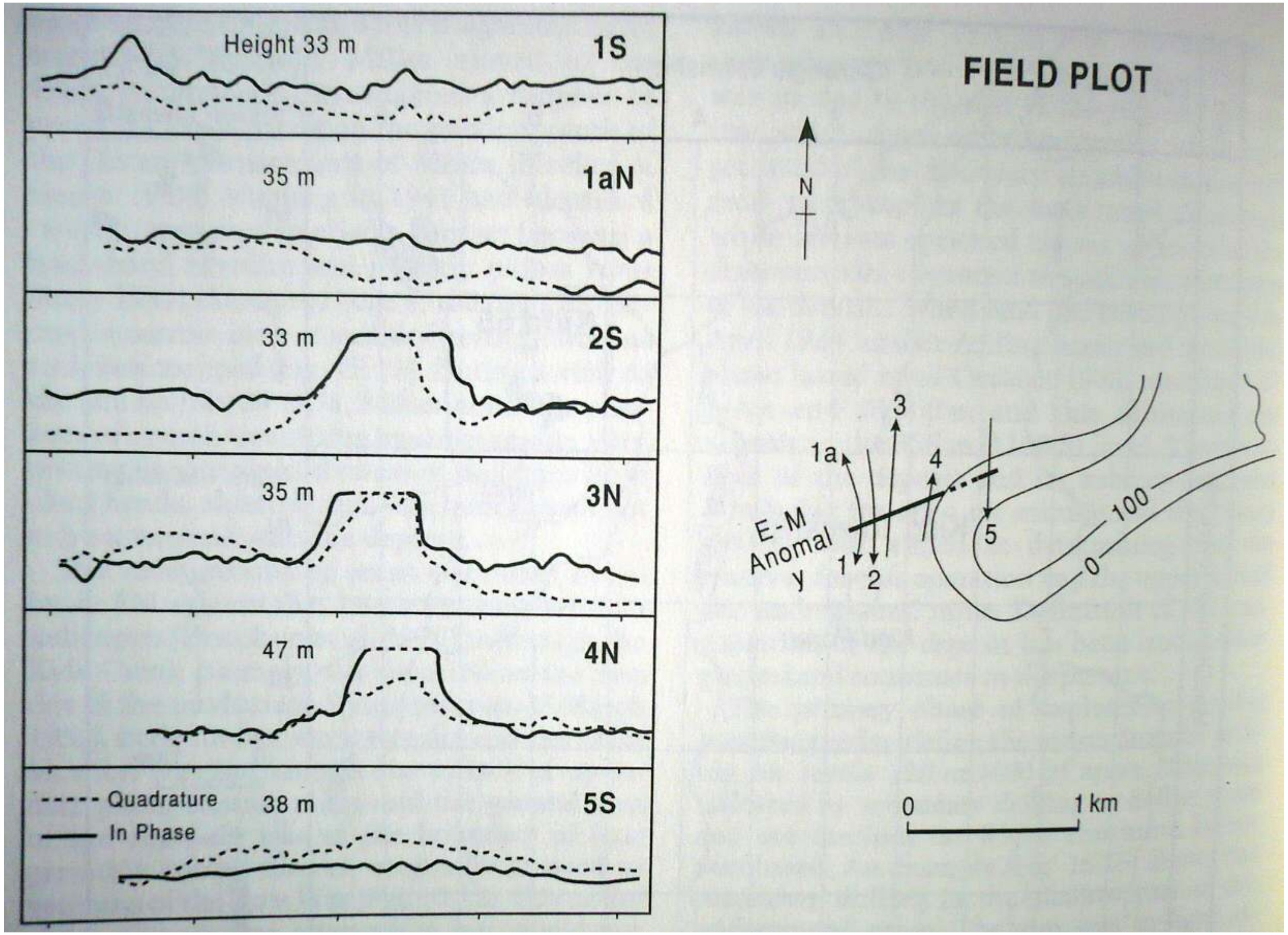



Fig 15.12 Trace of first airborne anomalies over the Kidd Creek deposit, March 3, 1959

# 15.3.2. Exploration history

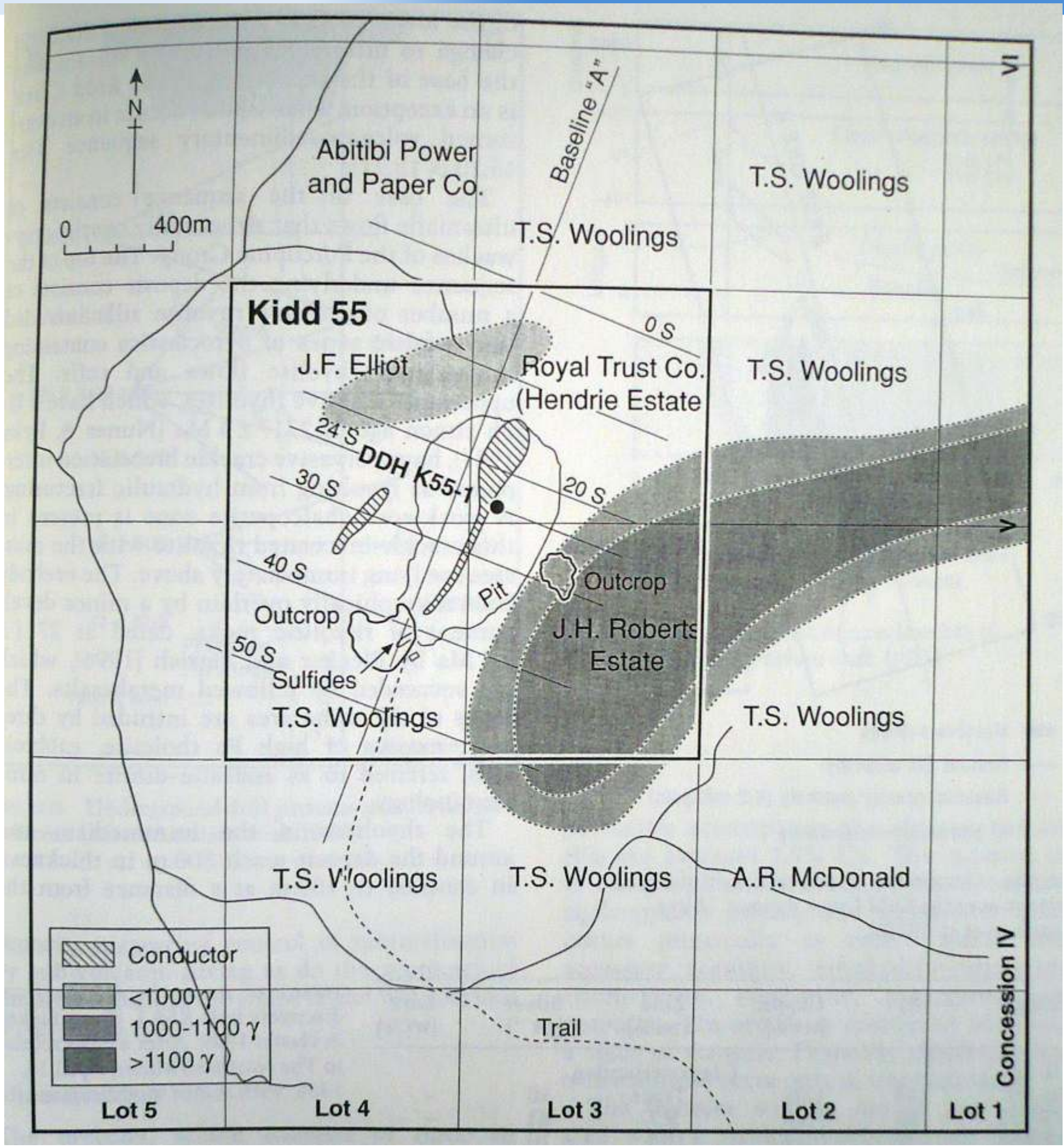



Fig 15.13 Map of the Kidd 55 locality showing the main EM conductor and the land holdings, the prospector's trench, and initial drillhole.

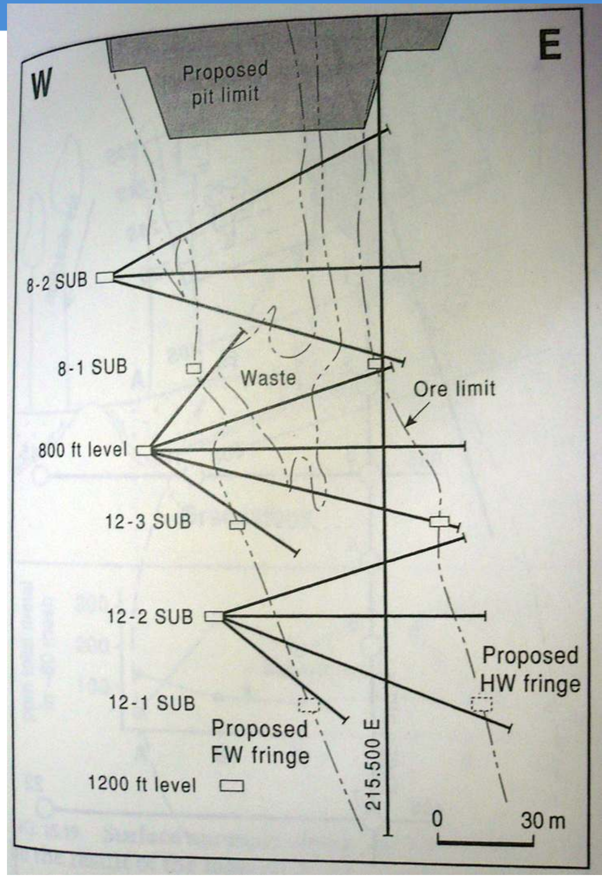
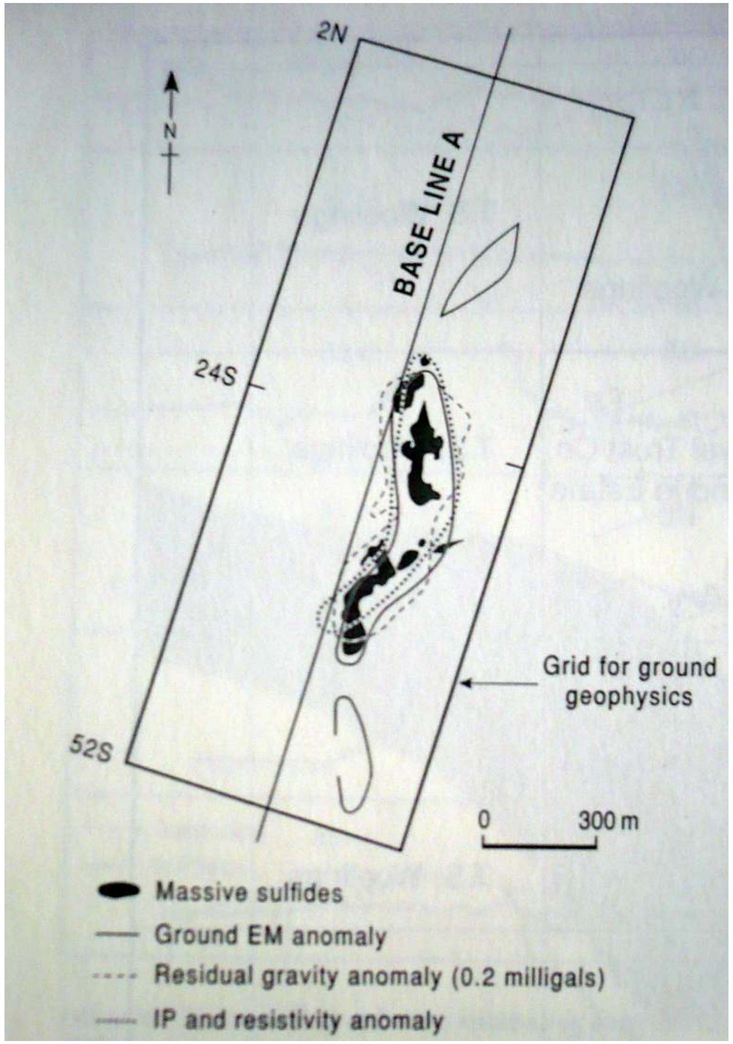



Fig 15.15 Underground drill patterns used to define reserves.

# 15.3.3. Exploration geophysics

- **EM, loop configurations, IP, gravity, magnetic ground surveys**



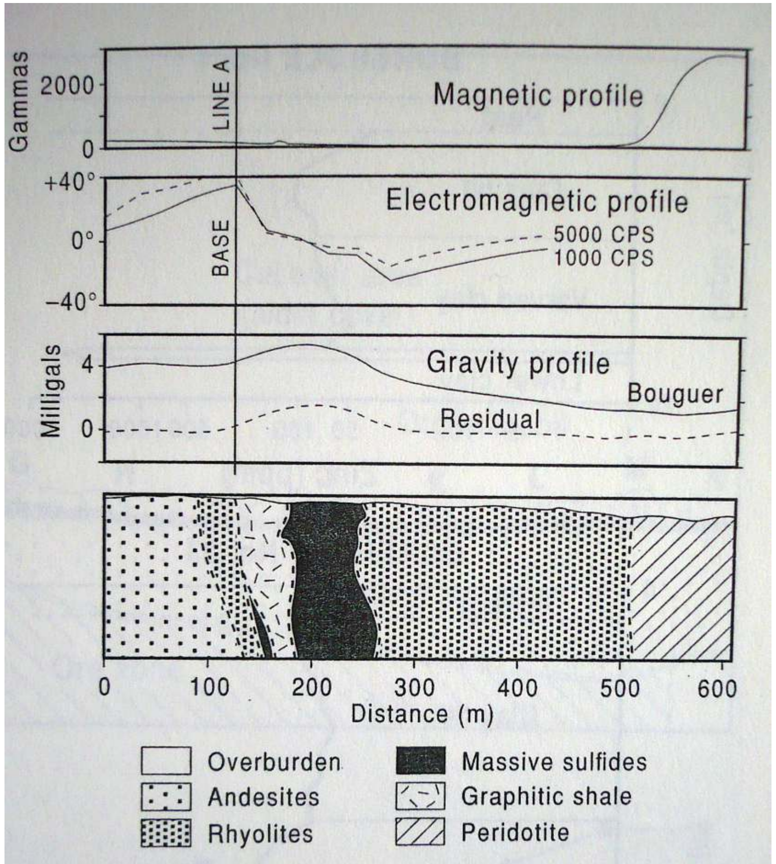




Fig 15.16 Geophysical section on line 24S

Fig 15.14 Composite geophysical map of initial surverys over the Kidd Creek deposit

# 15.3.4. Exploration geochemistry

- **Deposit area**

**: Clay belt covered with thick glacial material**

- **The blanketing effect of the glacial overburden**

**: limit the surface response to zinc anomalies in near surface organic soil.**

- **Sampling methods**

**: drilling, dispersion fans**

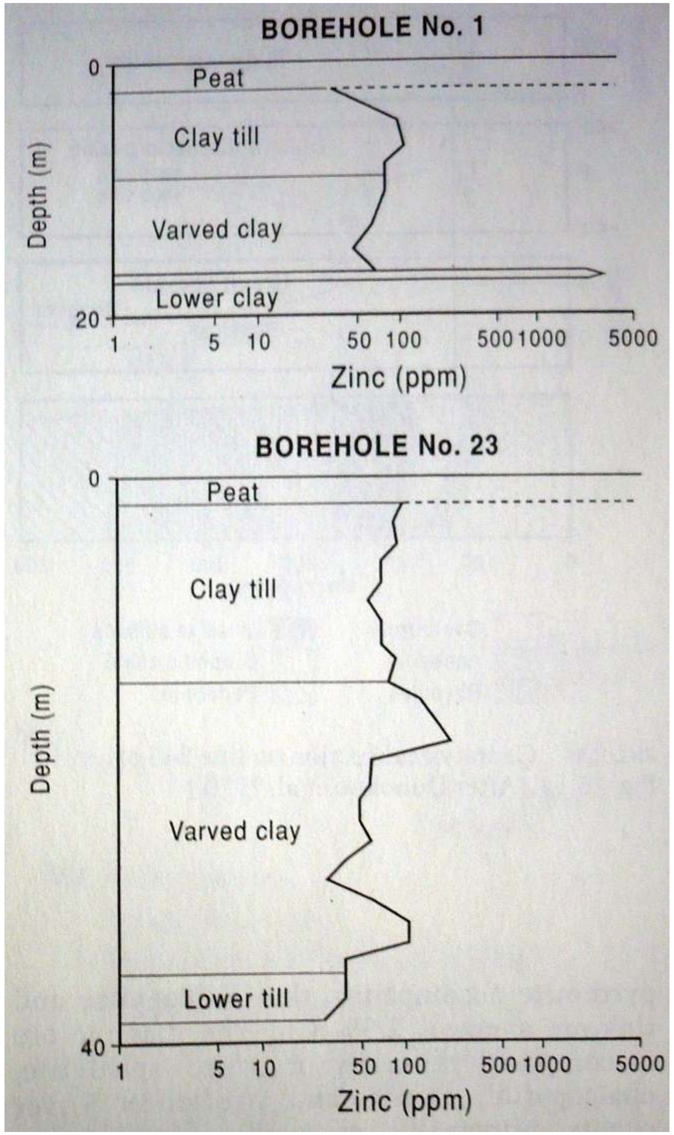
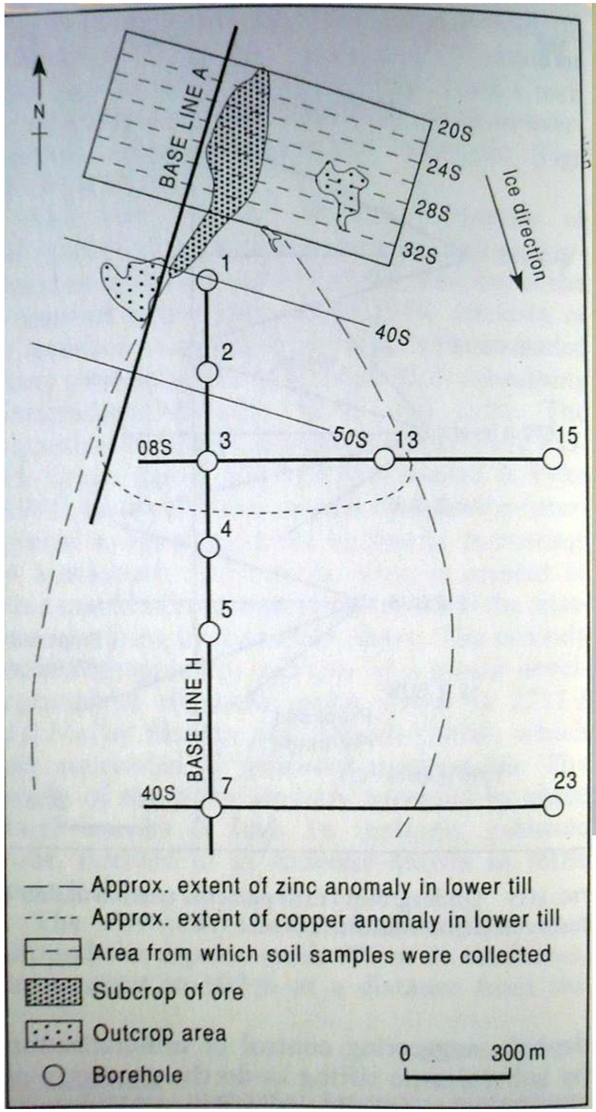



Fig 15.17 Section through glacial overburden over the deposit and to one side of it

# 15.3.4. Exploration geochemistry



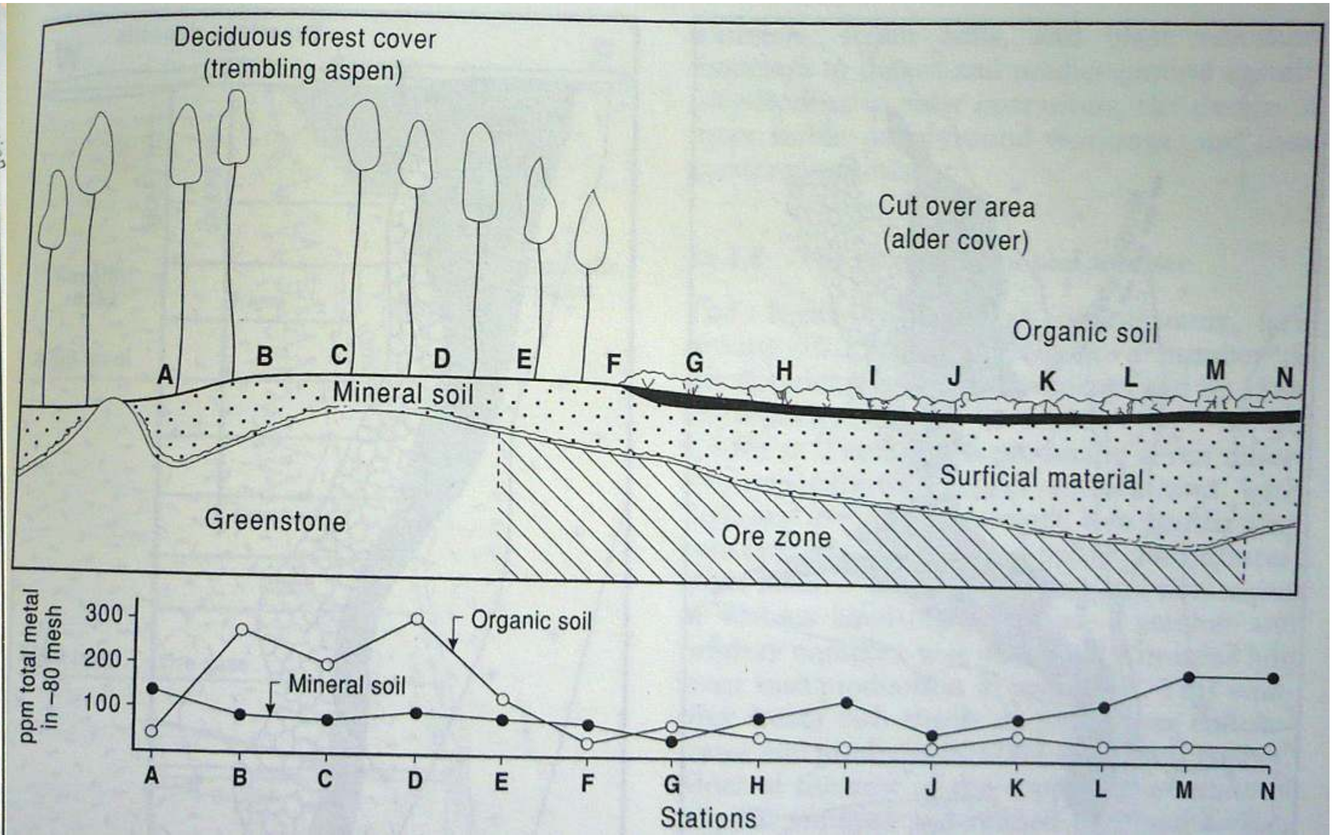




Fig 15.19 Surface anomaly along line 24S of Fig.15.18
The surface response in the organic soil is thought to be the result of the tapping of the deep anomaly by trembling aspen trees.



Fig 15.18 Fan-shaped anomalies in the lowermost till at Kidd Creek

# 15.3.5. Mine geology

▪ **Host rock**

**General exhalative deposits**

**: top of an archaean volcanic cycle where rhyolitic-dacitic top of the lower cycle is succeeded by a dramatic change to ultramafic and mafic volcanics at the base of the succeeding cycle.**

**Vocanic sedimentary sequence**

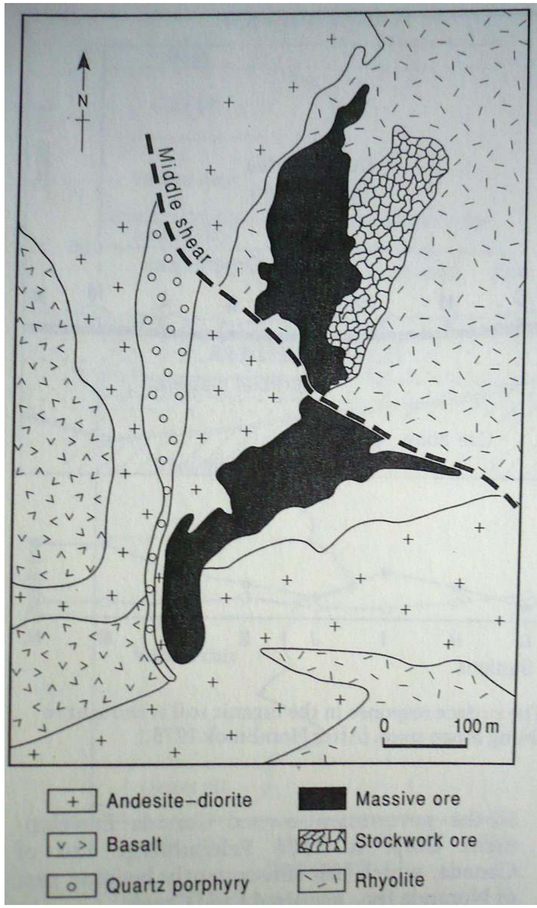
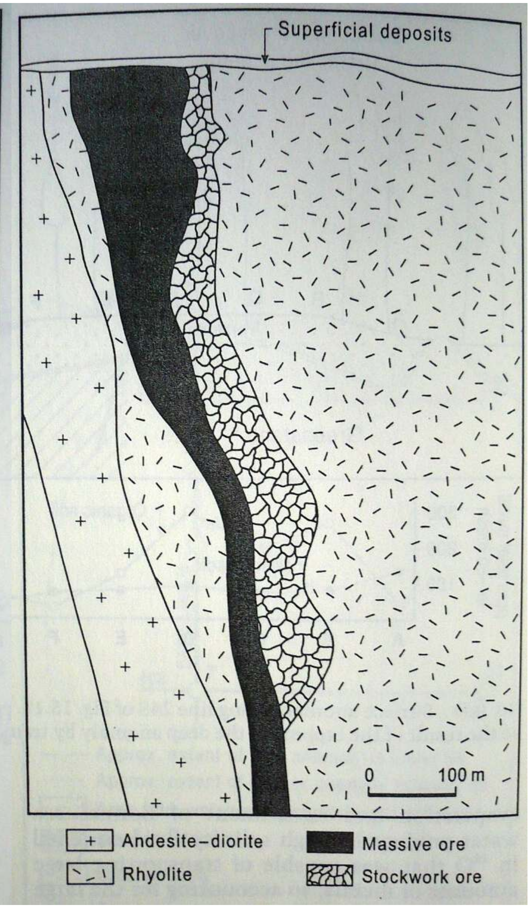



Fig 15.20 Bedrock geological map, Kidd Creek

Fig 15.21 West-east section through the North Orebody



# 15.3.5. Mine geology

- **Mineralisation**

**Orebody : Max thickness 168m, strike length 670m, depth 2990m**

**North orebody / Central + South orebody**

- **Wall rock alteration**

**Ultramafic flows and silicification the rhyolite**

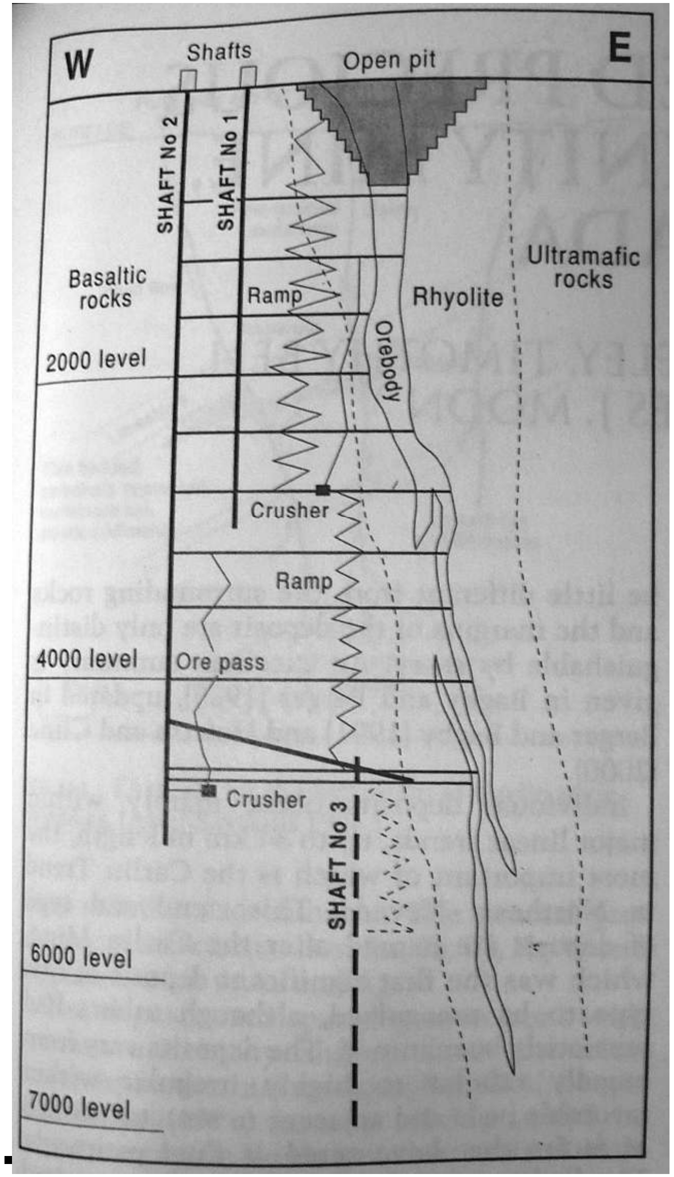
**Carbonate alteration**

**footwall stockwork zone strong chloritization, sericitisation and silicification**

- **Genesis**

**Exhalative origin, similar to many other deposits of Primitive-type**

# 15.3.6. Mining operations




- **Overall production was about 2 Mt from #1 and #2 mines**

Fig 15.22 Schematic east-west section through the Kidd Creek Mine showing location of shafts and ramp

## 15.3.7. Rock mechanics
## 15.3.8. The concentrator and Smelter

- **Instrumentation**

**: extensometers, strain cells, and blast vibration monitors**

- **Concentrator**

**: capacity(4.5 Mt / yr)**

**: Cu, Ag, Zn, Pb, Sn, Pyrite**

- **Smelter**

# 15.4. Conclusion

- **VMS deposits can constitute targets which is large, high grade, poly-metallic orebodies like Kidd Creek.**

- **Geochemical & Geophysical procedures can be used to search more VMS orebodies.**

# Thank You !