Volcanic-hosted or Volcanogenic base- and precious-metal mineralization is typically hosted by, or associated with, submarine volcanic and/or volcaniclastic rocks. Although volcanogenic rocks are generally the host, unrelated sedimentary marine rocks may be present.

Two main types:
- Base Metal Volcanogenic Massive Sulphides (VMS)
- Ni-Cu Deposits (These will be discussed under magmatic deposits).
VMS Deposits are divided either:

A. On the Basis of Ore Composition - Two Types…
   i) Cu-Zn Group   ii) Zn-Pb-Cu Polymetallic Group  or

B. On the Basis of Environment of Formation - Three Types …
   i) Cyprus (Cu-Zn)  ii) Kuroko (Zn-Pb-Cu)  iii) Besshi (Cu-Zn)
Typical Locations of Volcanic-hosted Deposits

- Cyprus Type Cu-Zn
  - Oceanic Rift
  - Tension

- Besshi Type Cu-Zn
  - Volcanic Arc
  - Compression

- Besshi Cu-Zn
  - Back Arc Basin
  - Tension

- Polymetallic Zn-Cu-Pb
  - Volcanic Arc

- Ciastic Hosted Pb-Zn-Ag
  - Basinal

- Carbonated Hosted Zn-Pb
  - Platformal

- Ophiolite
  - Oceanic Crust
  - Continental Crust

Figure 2-10B
Massive sulphides deposits are currently forming in undersea locations characterized by “Black Smokers”. These Black Smokers are plumes of sulphide-rich fluids and represent the venting of hydrothermal fluids, rich in base and precious metals, onto the ocean floor.
Tube Worms: abundant life forms, based on chemosynthesis, proliferate around black smokers.
BACKGROUND: A major source of copper, zinc, lead, silver & gold; by-products include cadmium, tin, antimony.

ENVIRONMENT: Island-arc, back-arc and oceanic ridge settings

ORIGIN: Hot fluids (hydrothermal) leach metals from sub-seafloor rocks, the fluids migrate into fault systems where they flow upwards and are vented onto the sea floor and the metals are deposited on or immediately below the sea floor.

STYLE: Consists of two distinct parts:

i) Stockwork Zone located in the lower part of the deposit and consists of crosscutting veinlets and disseminations of pyrite, chalcopyrite; lesser sphalerite and galena

ii) Massive sulphides located above the stockwork zone and consist of banded /bedded chalcopyrite +/- sphalerite , +/- galena; possibly Au, Ag

NOTE: The massive sulphides are often deposited in unstable areas; faulting and slumping result in Transported Deposits.
VMS deposits are characterized by alteration patterns around the deposits that can be mapped out.
CHARACTERISTICS OF AN IDEALIZED VOLCANOGENIC MASSIVE SULPHIDE DEPOSIT
The combination of base- and precious-metals maintains the importance of VMS deposits through the metals economic cycle.

**Cyprus**

**SETTING:**
- Mafic volcanics (pillow lava) in rift/spreading (ophiolites) settings; felsic rocks rare.

**Kuroko**

- Thick mixed volcanic and sedimentary sequences in island-arc settings; spatially associated with felsic volcanics.

**Besshi**

- In clastic rocks in rifted basins & oceanic regimes (pelites & turbidites) associated with mafic volcanic & intrusive rocks.

At the bottom of VMS-producing systems are subvolcanic intrusions that act as a heat source to drive the hydrothermal fluids.
### VMS Deposits (cont’d)

#### MINERALOGY:

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyrus</td>
<td>Massive pyrite, chalcopyrite sphalerite, +/- Au; Stockwork pyrite &amp; chalcopyrite</td>
</tr>
<tr>
<td>Kuroko</td>
<td>Polymetallic chalcopyrite, sphalerite, galena +/- Au, +/- Ag; stockwork pyrite-chalcopyrite</td>
</tr>
<tr>
<td>Besshi</td>
<td>Pyrite or pyrrhotite, chalcopyrite, +/- cobalt</td>
</tr>
</tbody>
</table>

#### ALTERATION:

*High-temperature alteration, including metal depletion, alkali modification and silicification, is developed in the host rocks.*

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyrus</td>
<td>Black chlorite &amp; quartz in stockwork; sericite &amp; silica around sulphides lenses</td>
</tr>
<tr>
<td>Kuroko</td>
<td>Black chlorite &amp; quartz in stockwork; sericite &amp; silica around sulphide lenses</td>
</tr>
<tr>
<td>Besshi</td>
<td>Poorly preserved; chlorite and silica</td>
</tr>
</tbody>
</table>
DISTRIBUTION:

**Newfoundland**

<table>
<thead>
<tr>
<th>Ophiolite (rift) sequences:</th>
<th>Island-arc felsic volcanics:</th>
<th>Mafic clastic sequences:</th>
</tr>
</thead>
<tbody>
<tr>
<td>York Hbr, Tilt Cove, Betts</td>
<td>Buchans, Ming, Lochinvar</td>
<td>Great Burnt Lake,</td>
</tr>
<tr>
<td>Cove, Little Bay, Whalesback,</td>
<td>Oil Islands, Duck Pond,</td>
<td>South Pond</td>
</tr>
<tr>
<td>Skidder</td>
<td>Victoria Mine</td>
<td></td>
</tr>
</tbody>
</table>

**Labrador**

- Hunt River and Florence Lake greenstone belts, southern Nain Province; Petscapiskau Group, Churchill Province; high grade greenstones in northern Nain & Churchill provinces; Proterozoic Letitia Lake & Blueberry Lake groups

SIZE:

- <1 mt to 9 mt of 1-12% Cu, 1-4% Zn
- <1 mt to >16 mt up to 15% Zn, 8% Pb, 1.5% Cu, Au, Ag
- <1 mt at 2-3% Cu
VMS DEPOSITS (cont’d)
Distribution of Volcanic rocks in Labrador that may host VMS Deposits.

1 - Archean Hunt River and Florence Lake belts, Nain Province
2 - Petscapiskau Group, Churchill Province
3 - High-grade Metavolcanic Rocks in supracrustals, Nain Province
4 - Proterozoic Letitia Lake Group, Central Mineral Belt
5 - Proterozoic Blueberry Lake Group, Central Mineral Belt
VMS DEPOSITS (cont’d)

Some base metal occurrences in central-eastern Labrador.

Triangles - Pyrite
Circles - Cu
Squares - Cu-Ni Showings
X - Intrusive Rocks
Heavy Stipple - Greenstone Belts
Light Stipple - Gneiss
PROSPECTING METHODS:

**Geological**

*NOTE: Deformation generally destroys primary features.*

Felsic volcanic rocks and pillow lava are good indicators;

Kuroko-type is characterized by felsic volcanics; Cyprus-type

by pillow lava; Besshi-type by mafic-dominated clastic

sedimentary rocks; a variety of volcanic rocks is good. Faulting,

especially cross-faulting, and structural complexity; boulder

tracing; gossans, if pyrite-rich.

**Alteration**

Chloritization, sericitization and some silicification; chloritized

felsic volcanics are better than chloritized mafics; disseminated

sulphides in altered rock; barite.

**Geophysical**

EM (except sphalerite-rich bodies), IP, Mag surveys

**Geochemical**

Copper, zinc, lead and barite anomalies in stream and lake

sediments, soil and tills.
Rocks typically seen in vicinity of VMS Deposits
Hematized & Epidotized Pillow Lava; Lush’s Bight Group
Chlorite Schist, Miles Cove Mine
Felsic Breccia, Tulks Hill Volcanics

VMF DEPOSITS (cont'd)
Felsic Breccia, Victoria Lake Supergroup
Quartz-Crystal Tuff, Jacks Pond, Tulks Hill Volcanics
Victoria Lake Supergroup

VMS DEPOSITS (cont’d)
Hydrothermal Crackle Breccia, Boundary Deposit
Gossan
Iron Formation, Nickey’s Nose, Lushs Bight Group
Bedded Sulphides, Nickey’s Nose, Lushs Bight Group
Banded Sulphide (pyrite and silica)
Lens, Little Bay Mine

Little Bay Mine
2.6 Mt @ 0.8-2 % Cu
Buchans Mine
16.2 Mt @ 14.5% Zn, 7.6% Pb, 1.3% Cu, 126g/t Ag, 1.37g/t Au

Cu-Pb-Zn Ore
Daniel’s Pond
4.21 Mt @ 4.03% Zn, 1.8% Pb, 0.37% Cu, 82.2 g/t Ag, 0.43 g/t Au

Banded Zn-Pb-(Cu)
Victoria Mine
~ 50,000 Mt @ 0.5-11% Cu, up to 15% Zn

Massive Zn-Cu-(Pb), Jig Zone Trenches (44% Zn)
Duck Pond Deposit
4.1 Mt @ 5.7% Zn, 3.3% Cu, 1.1% Pb, 59.3g/t Ag, 0.86g/t Au

Massive Zn-Cu-Pb Sulphides
Boundary Deposit (Part of Duck Pond Mine)
0.5 Mt @ 3.5% Zn, 3.5% Cu, 0.5% Pb, 22.8g/t Ag

Bedded and Graded Cu-Zn Ore
Zn-Cu-Pb Massive Sulphides, Boomerang Deposit
VMS DEPOSITS (cont’d)

Pyrite-Cpy-Quartz Stockwork, Duck Pond Deposit
Pyrite-Cpy-Chlorite-Quartz Stockwork, Boundary Deposit

VMS DEPOSITS (cont’d)
VMS DEPOSITS (cont’d)

Black Chlorite-Chalcopyrite, Little Bay Mine
Carbonate-Sericite-Chlorite Alteration, Victoria Mine

VMS DEPOSITS (cont’d)
Carbonate-Sericite-Silica Alteration, Victoria Mine
Transported Ore
Buchans Mine
Transported Ore, Boundary Deposit