VOLCANIC-HOSTED MASSIVE SULPHIDE DEPOSITS - VMS

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).***

VOLCANOGENIC MASSIVE SULPHIDES

VMS Deposits are divided either:

A. On the Basis of Ore Composition - Two Types…

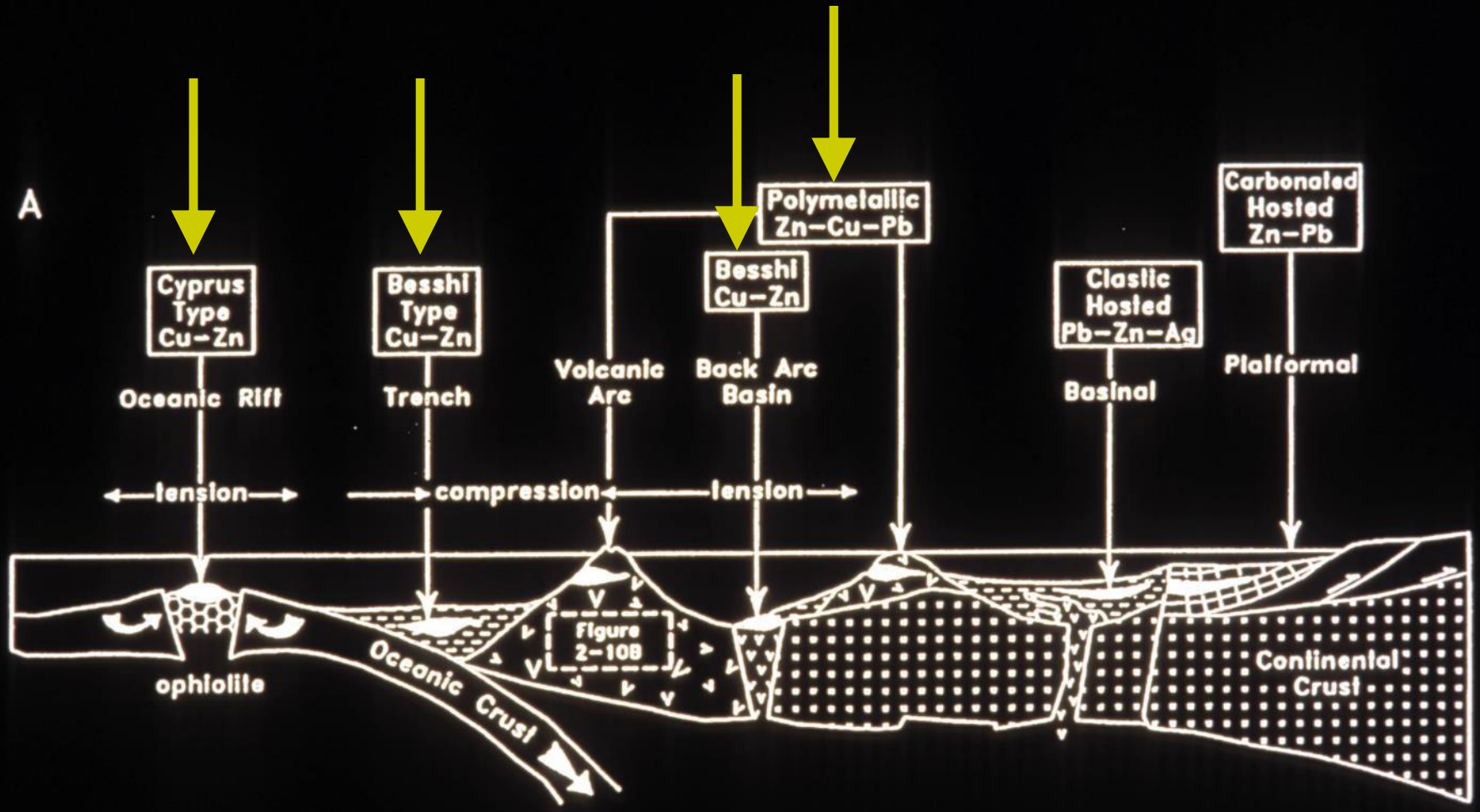
i) Cu-Zn Group ii) Zn-Pb-Cu Polymetallic Group or

B. On the Basis of Environment of Formation - Three Types …

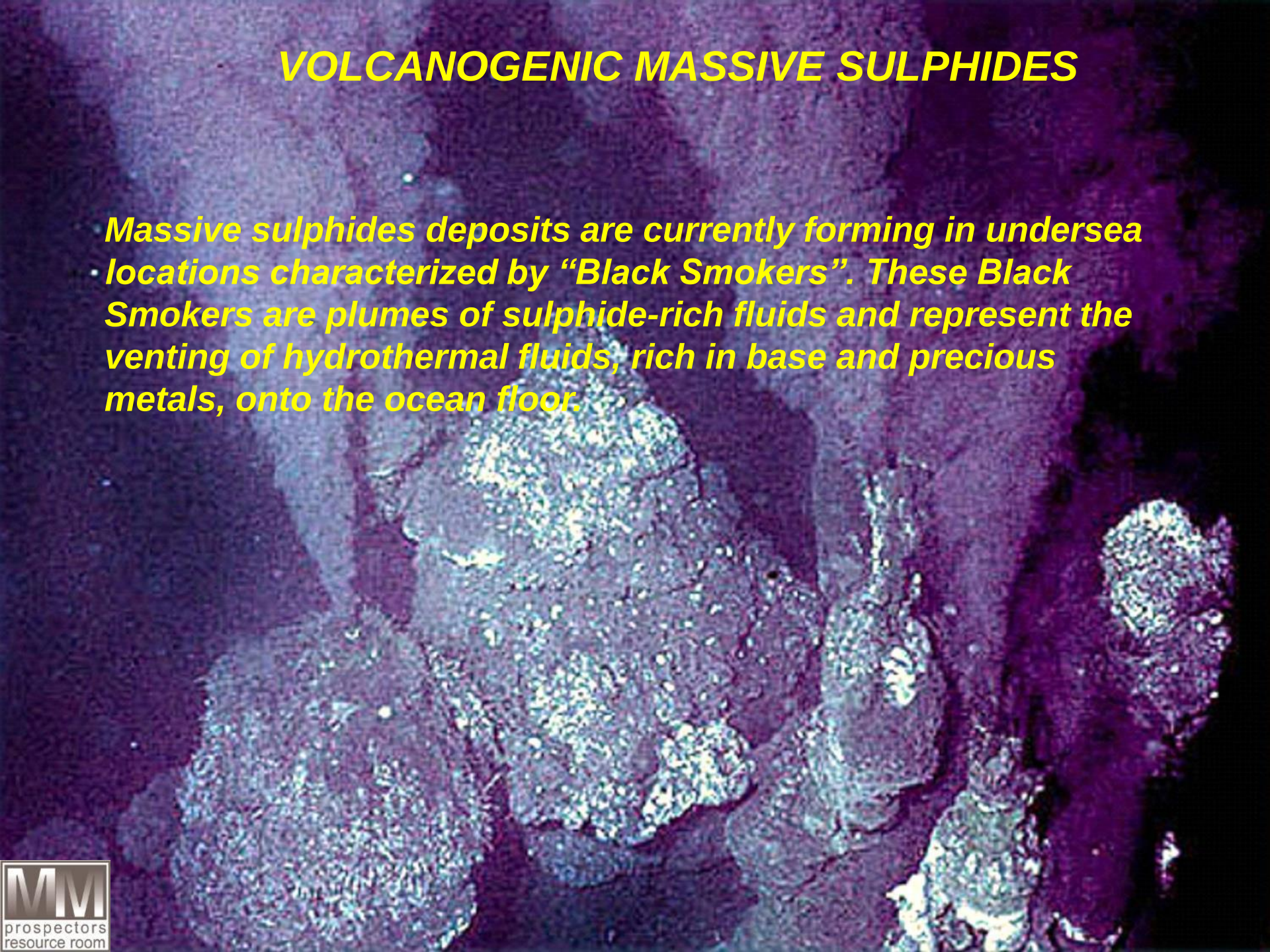
i) Cyprus (Cu-Zn) ii) Kuroko (Zn-Pb-Cu) iii) Besshi (Cu-Zn)

Lucky Strike Mine, Buchans

Typical Locations of Volcanic-hosted Deposits

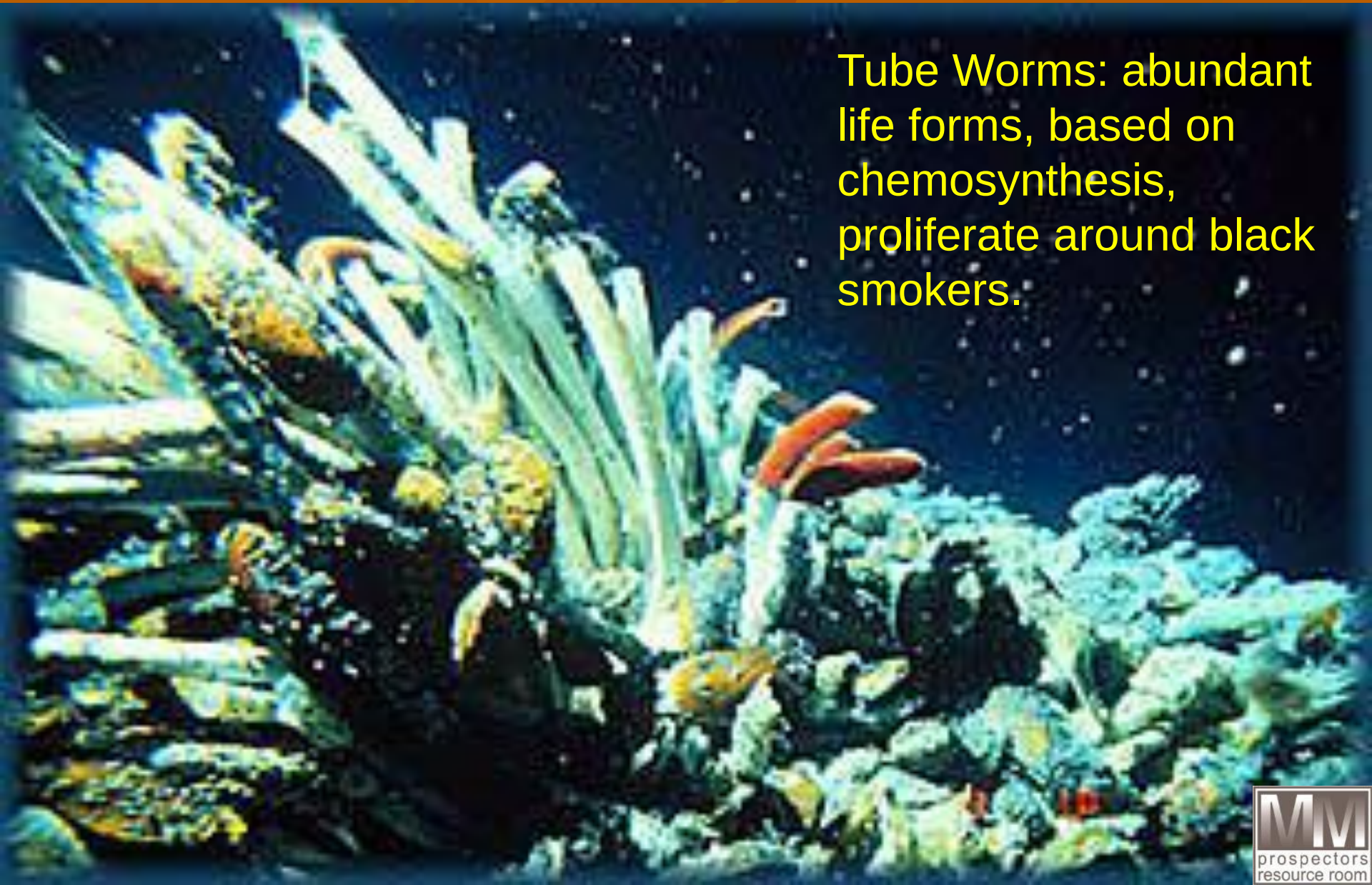


VOLCANOGENIC MASSIVE SULPHIDES



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.

VOLCANIC-HOSTED DEPOSITS



Tube Worms: abundant life forms, based on chemosynthesis, proliferate around black smokers.

VOLCANOGENIC MASSIVE SULPHIDES

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.

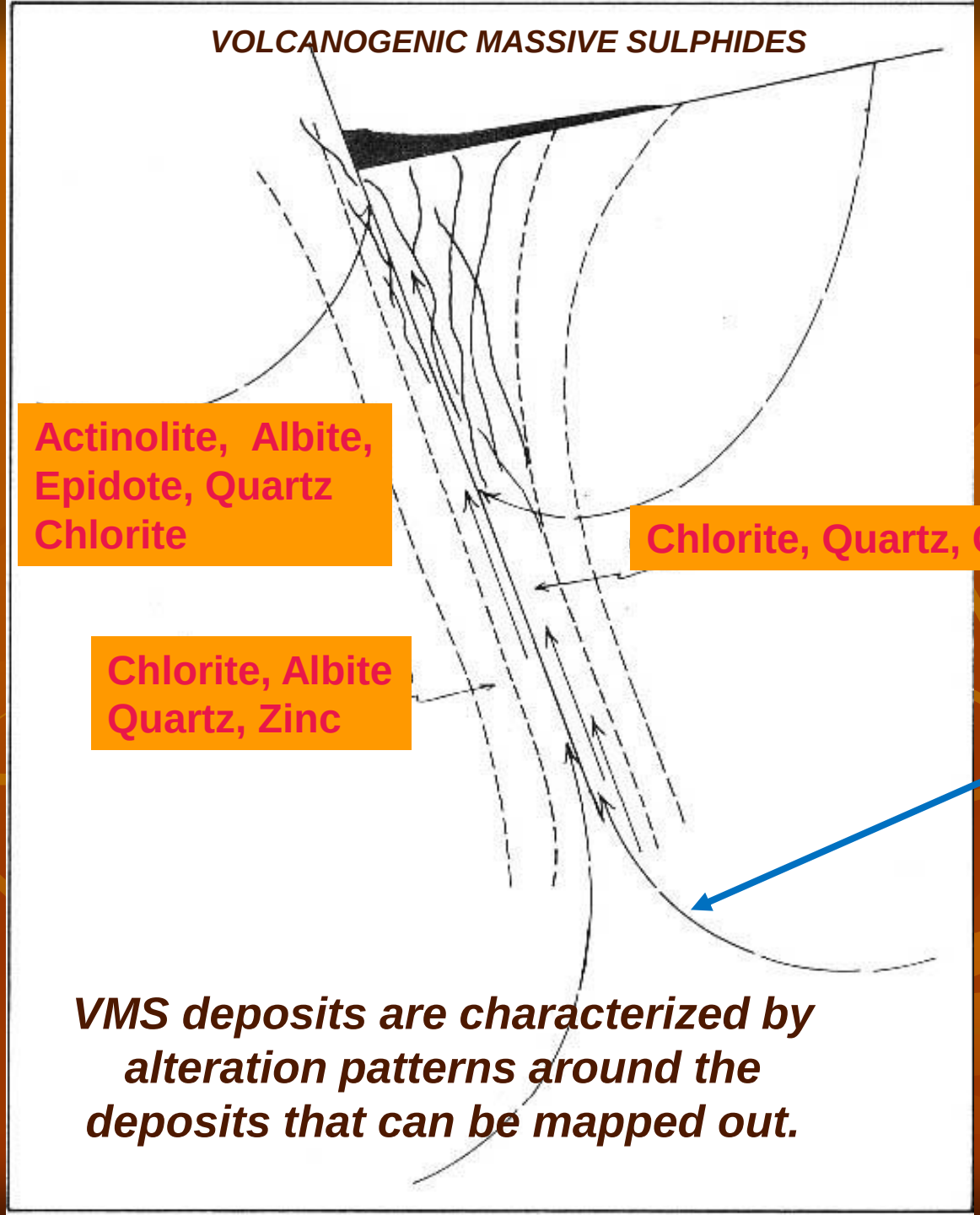
STYLE: Consists of two distinct parts:

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

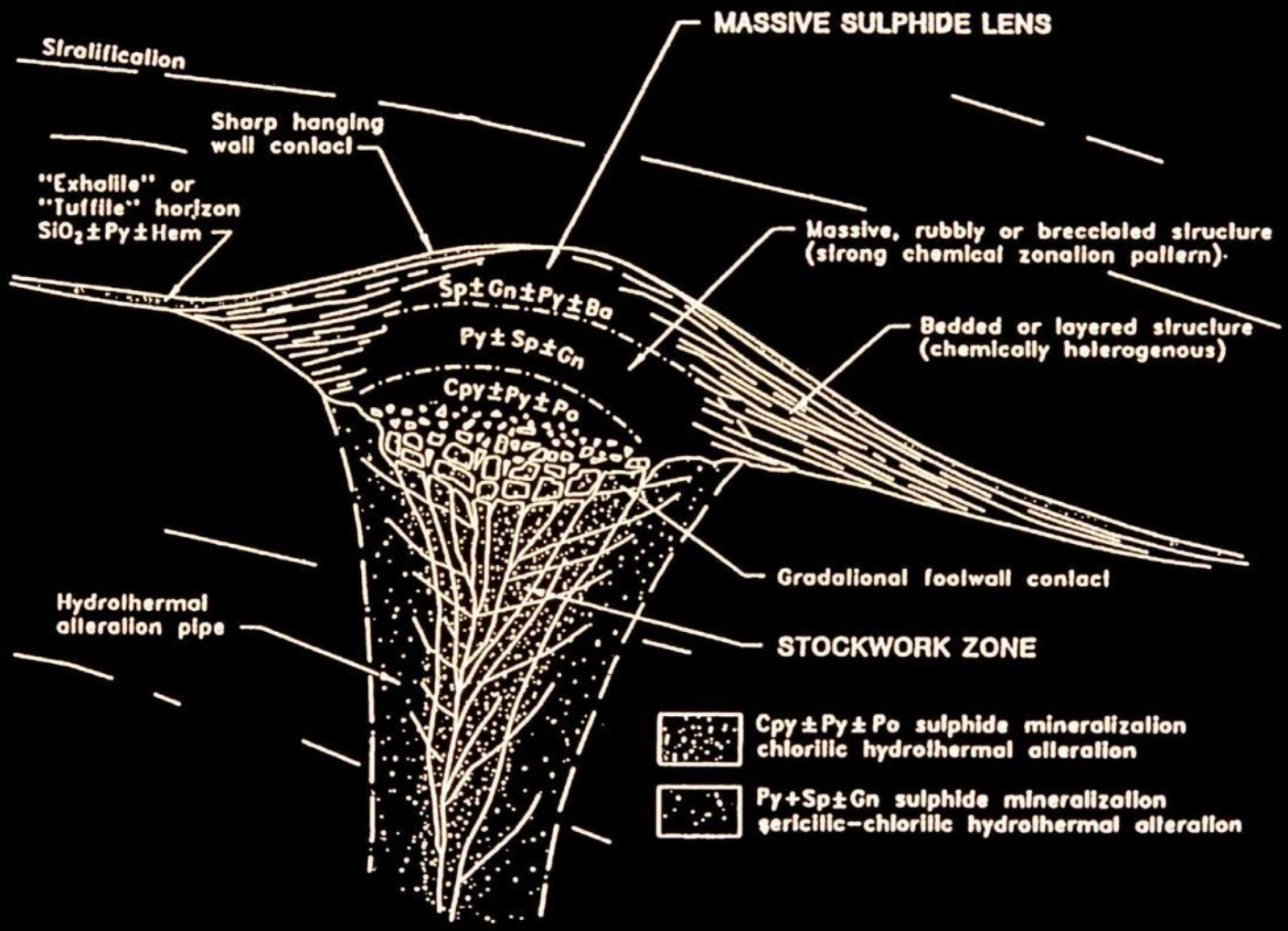
NOTE: The massive sulphides are often deposited in unstable areas; faulting and slumping result in **Transported Deposits.**

Alteration Minerals And Metals



VMS deposits are characterized by alteration patterns around the deposits that can be mapped out.

CHARACTERISTICS OF AN IDEALIZED VOLCANOGENIC MASSIVE SULPHIDE DEPOSIT



VMS DEPOSITS (cont'd)

The combination of base- and precious-metals maintains the importance of VMS deposits through the metals economic cycle.

Cyprus	Kuroko	Besshi
SETTING:		
Mafic volcanics (pillow lava) in rift/spreading (ophiolites) settings; felsic rocks rare.	Thick mixed volcanic and sedimentary sequences in island-arc settings; spatially associated with felsic volcanics.	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.

Cyprus	Kuroko	Besshi
MINERALOGY:		
Massive pyrite, chalcopyrite sphalerite, +/- Au; Stockwork pyrite & chalcopyrite	Polymetallic chalcopyrite, sphalerite, galena +/-Au, +/- Ag; stockwork pyrite-chalcopyrite	Pyrite or pyrrhotite, chalcopyrite, +/- cobalt
ALTERATION:		
High-temperature alteration, including metal depletion, alkali modification and silicification, is developed in the host rocks.		
Black chlorite & quartz in stockwork; sericite & silica around sulphides lenses	Black chlorite & quartz in stockwork; sericite & silica around sulphide lenses	Poorly preserved; chlorite and silica

VMS DEPOSITS (cont'd)

DISTRIBUTION:

Newfoundland

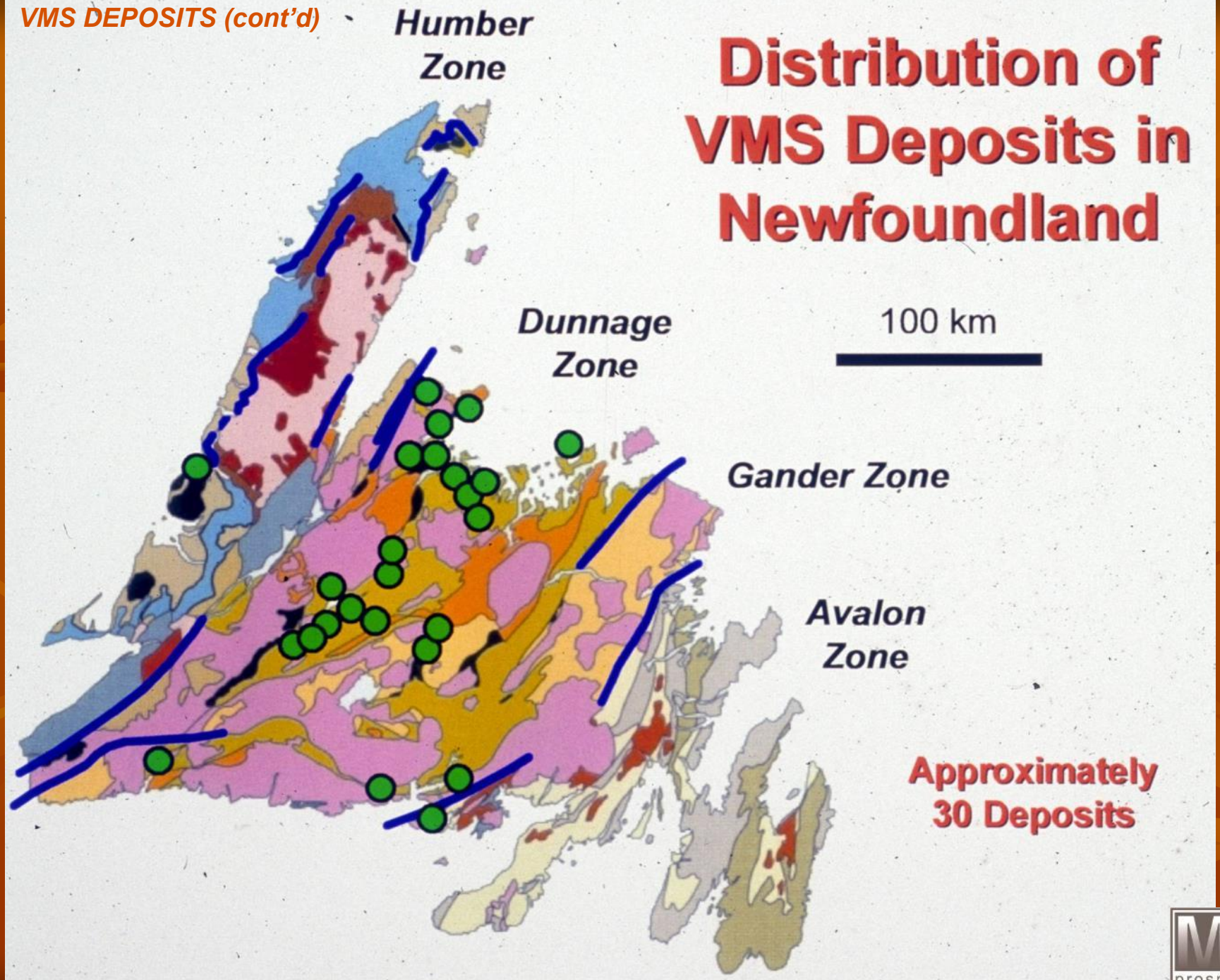
Ophiolite (rift) sequences:	Island-arc felsic volcanics:	Mafic clastic sequences:
York Hbr, Tilt Cove, Betts Cove, Little Bay, Whalesback, Skidder	Buchans, Ming, Lochinvar Oil Islands, Duck Pond, Victoria Mine	Great Burnt Lake, South Pond

Labrador

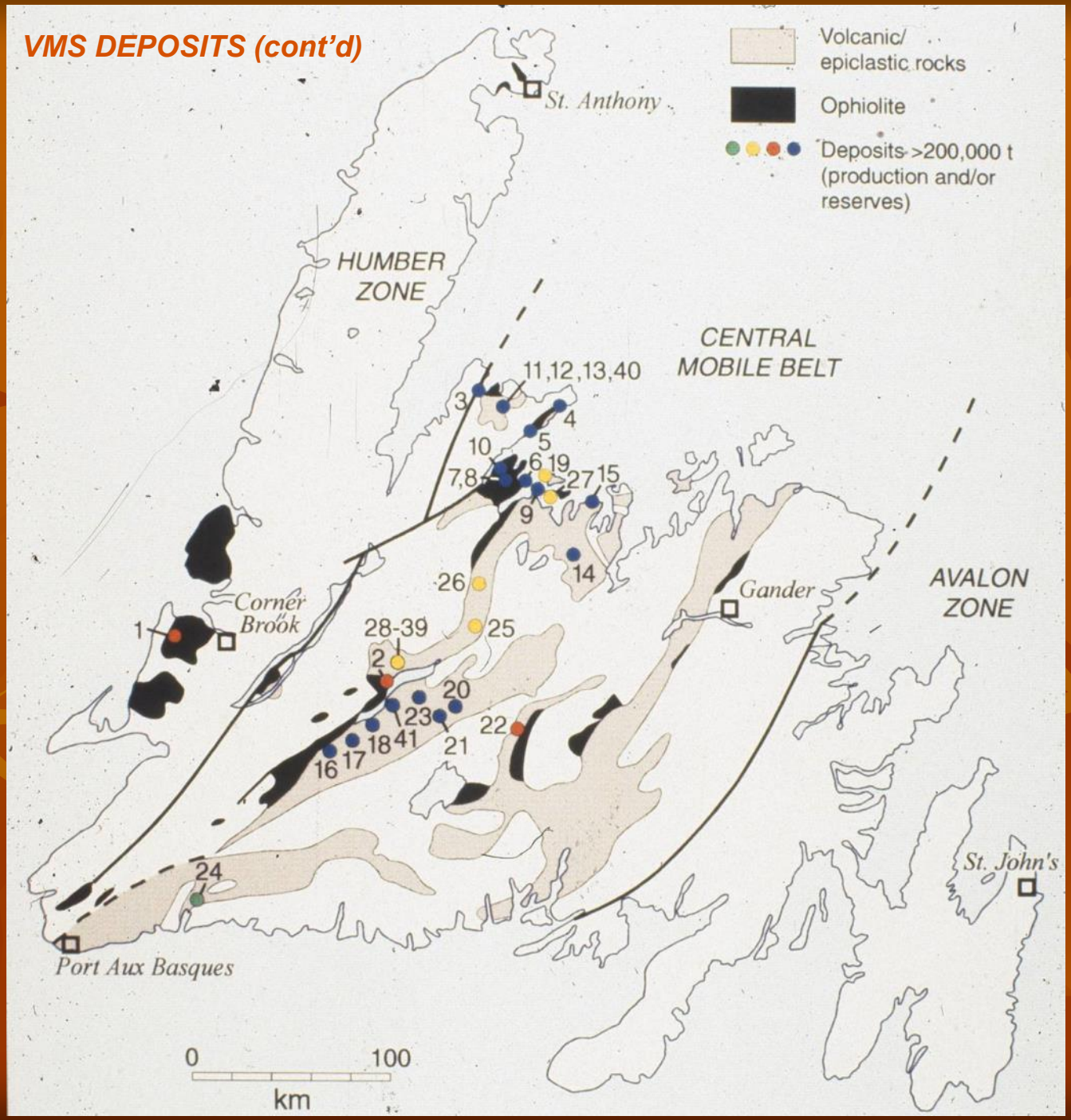
Hunt River and Florence Lake greenstone belts, southern Nain Province; Petscapiskau Group, Churchill Province; high grade greenstones in northern Nain & Churchill provinces; Proterozoic Letitia Lake & Blueberry Lake groups ?

SIZE:

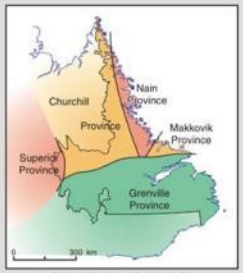
<1 mt to 9 mt of 1-12% Cu, 1-4% Zn	<1 mt to >16 mt up to 15% Zn, 8% Pb,1.5% Cu, Au, Ag	<1 mt at 2-3% Cu



VMS DEPOSITS (cont'd)



GEOLOGICAL MAP OF LABRADOR



STRUCTURAL PROVINCES

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
Department of Natural Resources
Geological Survey

Compiled by R.J. Wardle, 1993, from published maps of the Newfoundland Geological Survey and Geological Survey of Canada

Digital cartography by D. Leonard, Cartographic Unit, Geological Survey, Department of Natural Resources, Government of Newfoundland and Labrador

Notification of any errors or revisions would be welcomed by the Geological Survey

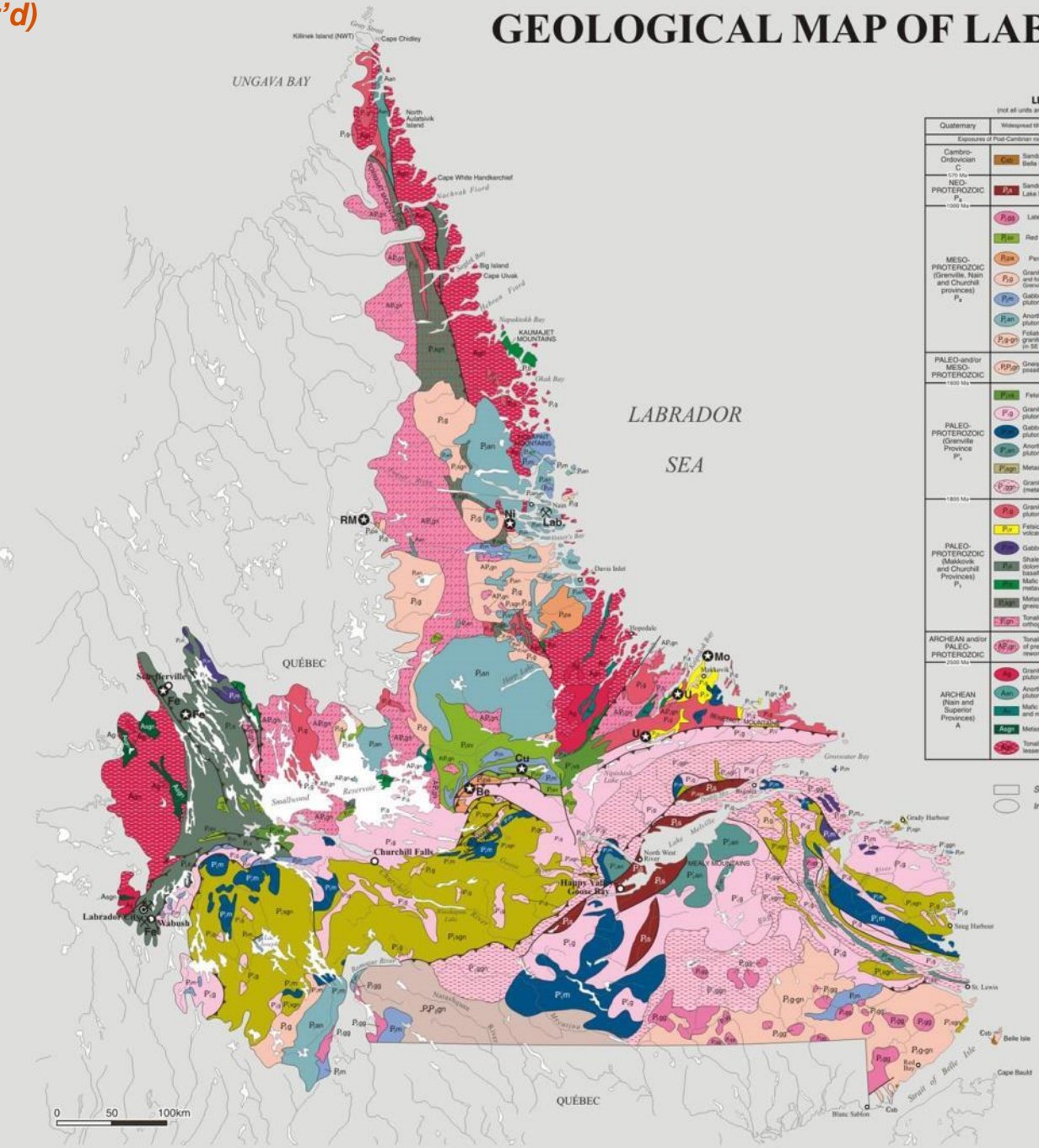
Electrostatic plot by the Geological Survey. For additional copies contact the Publications and Information Section, Geological Survey, Department of Natural Resources, Government of Newfoundland and Labrador. A digital version of this map in Coreldraw 4.0 format is also available upon request. It is not, however, geo-referenced and may not match maps of standard projection

Recommended citation
Wardle, R.J., 1996: Geological Map of Labrador, 1:2 million scale. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Map 95-23, Open File LAB/1133, version 1.0

Map Symbols

- Geological contact
- Thrust Fault
- Normal Fault
- Tear Fault (sinistral, dextral)
- Major mineral deposit
- Mine or Quarry

Ni	Nickel
Cu	Copper
Fe	Iron
U	Uranium
RM	Rare metals (e.g., zirconium, beryllium, yttrium)
Mo	Molybdenum
Be	Beryllium

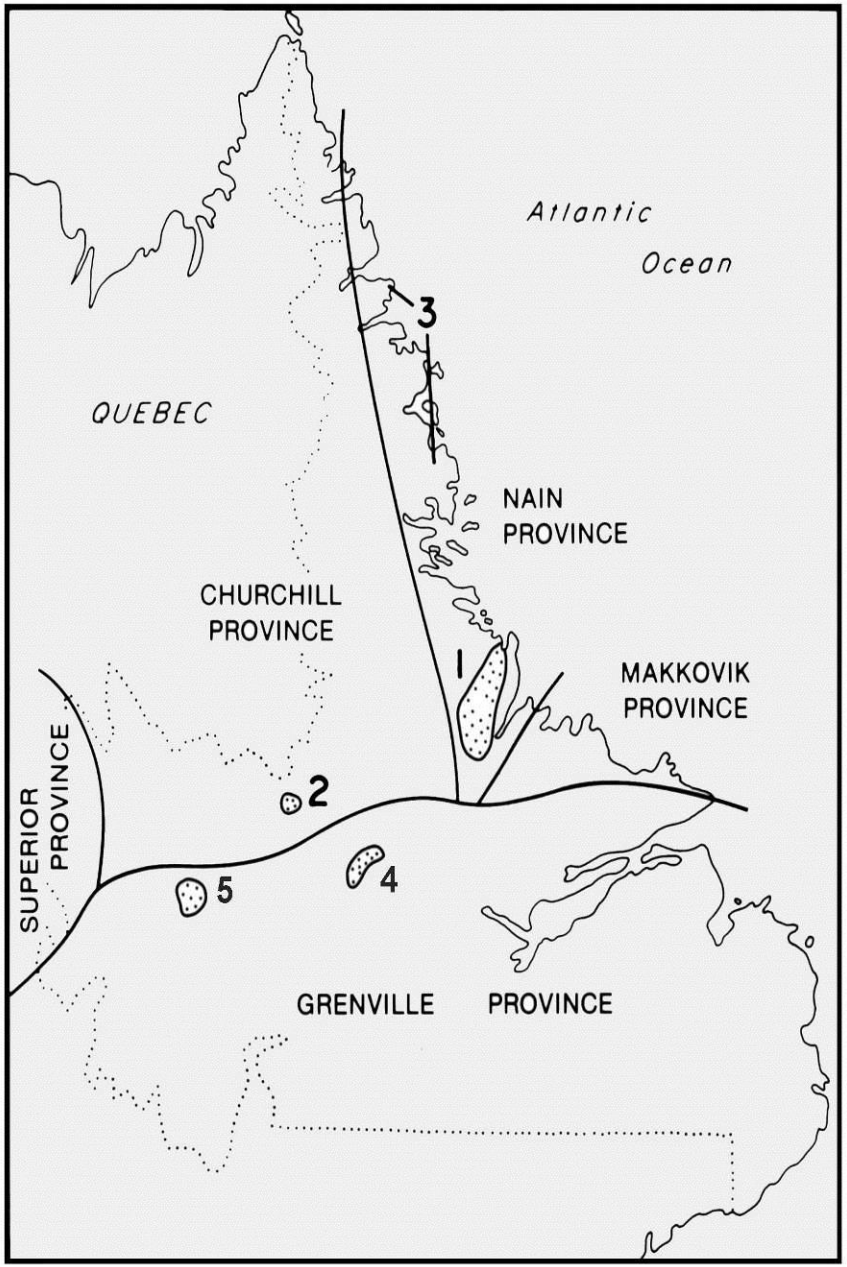


LEGEND

(not all units are in stratigraphic order)

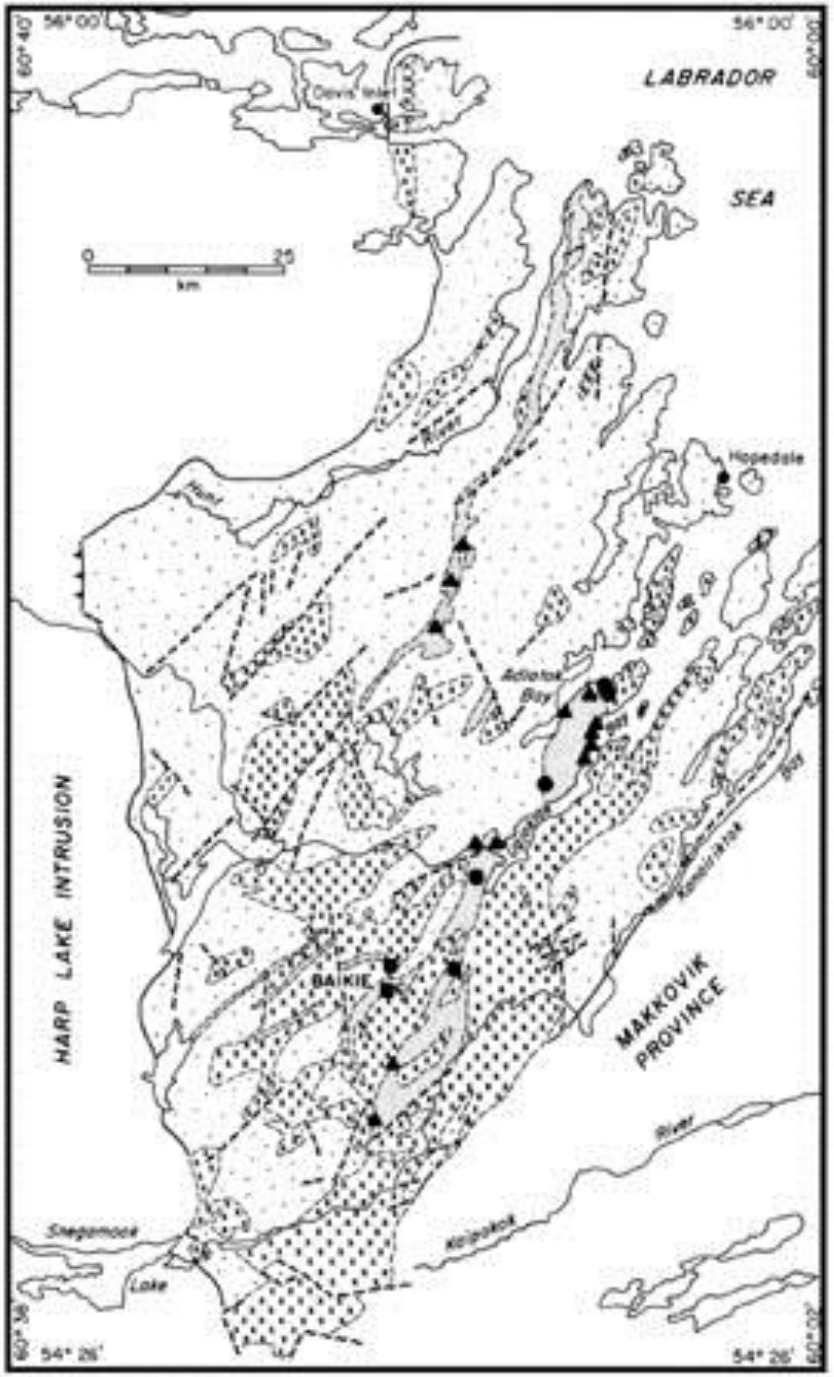
Quaternary	Widespread till and fluvioglacial sand deposits not shown on map	
	Exposures of Post-Cambrian rocks are too small to be shown on this map	
Cambro-Ordovician C	Sandstone, basalt and limestone of the Belle Isle Straits area	
570 Ma		
NEO-PROTEROZOIC P_x	Sandstone and conglomerate of the Lake Melville rift system	
1000 Ma		
MESO-PROTEROZOIC (Grenville, Nain and Churchill provinces) P_g	Late to posttectonic granite plutons	
	Red sandstone, shale and basalt	
	Peralkaline/alkaline intrusions & volcanic rocks	
	Granite plutons and foliated equivalents in Grenville Province	Mesoproterozoic rocks occur throughout central and southern Labrador. In the Nain and Churchill provinces they are posttectonic. In the Grenville Province they have been affected by deformation and metamorphism
	Gabbroic plutons	
	Anorthosite plutons	
	Foliated to gneissic granitoid plutonic rocks (in SE Grenville province)	
PALEO-and/or MESO-PROTEROZOIC	Gneisses of uncertain and possibly mixed age	
1600 Ma		
PALEO-PROTEROZOIC (Grenville Province P_g	Felsic volcanic rocks	
	Granite plutons	P_g rocks occur mainly in the northern Grenville Province where they were formed in the ca 1650 Ma Labradorian Orogeny
	Gabbroic plutons	
	Anorthosite plutons	
	Metasedimentary gneiss	
	Granitoid gneiss (metaplutonic rocks)	
1800 Ma		
PALEO-PROTEROZOIC (Makkovik and Churchill Provinces) P_k	Granite plutons	
	Felsic volcanic/ volcaniclastic rocks	
	Gabbro sills	
	Shale-sandstone, quartzite dolomite, ironstone and basalt	
	Mafic volcanic and metavolcanic rocks	
	Metasedimentary gneiss	
	Tonalitic orthogneiss	
ARCHEAN and/or PALEO-PROTEROZOIC	Tonalitic and minor metasedimentary gneiss of predominantly Archean age reworked in Paleoproterozoic	
2500 Ma		
ARCHEAN (Nain and Superior Provinces) A	Granite plutons	
	Anorthosite plutons	
	Mafic metavolcanic and metasedimentary rocks	
	Metasedimentary gneiss	
	Tonalitic orthogneiss and lesser metasedimentary gneiss	

Symbols
- Sedimentary, volcanic rocks
- Intrusive rocks



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 Be



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:

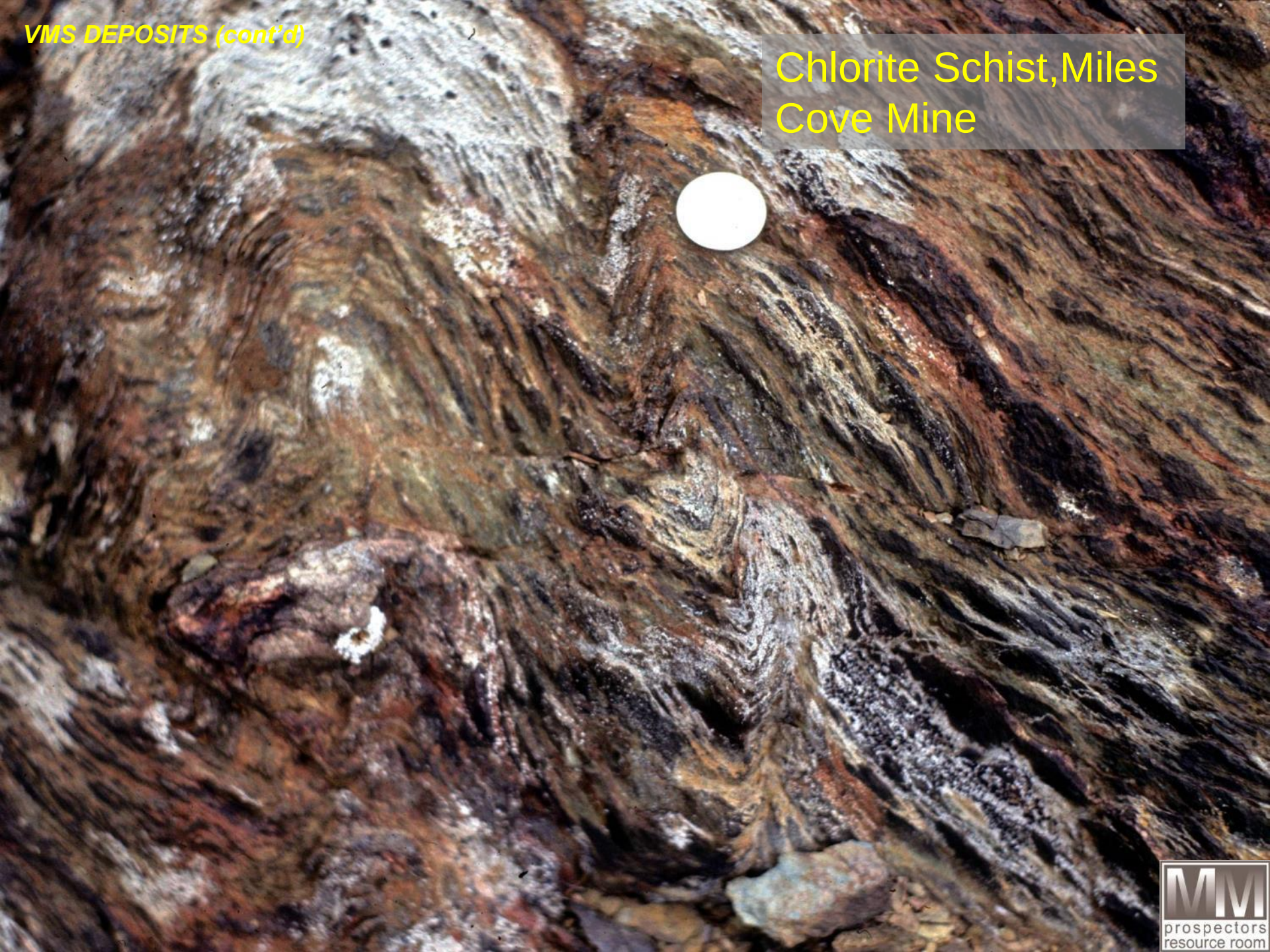
Geological	**NOTE: Deformation generally destroys primary features.** Felsic volcanic rocks and pillow lava are good indicators; Kuroko-type is characterized by felsic volcanics; Cyprus-type by pillow lava; Besshi-type by mafic-dominated clastic sedimentary rocks; a variety of volcanic rocks is good. 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

Pillow Lava,

Tally Pond Volcanics

Hematized & Epidotized Pillow Lava; Lush's Bight Group

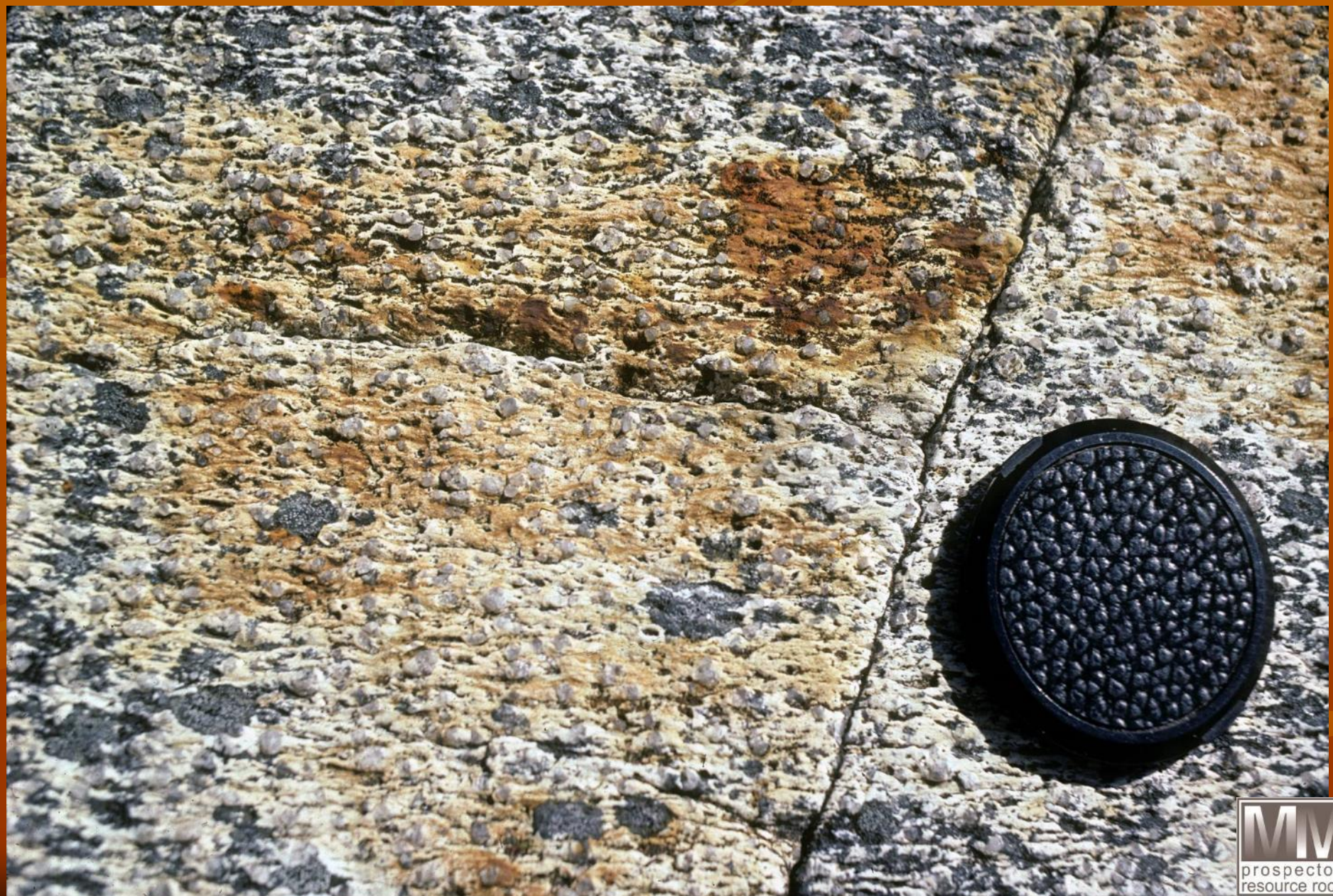


Chlorite Schist,Miles Cove Mine

Felsic Breccia, Tulks Hill Volcanics

Felsic Breccia, Victoria Lake Supergroup

Quartz-Crystal Tuff, Jacks Pond, Tulks Hill Volcanics Victoria Lake Supergroup



Silicified Breccia, Colchester Mine, Lushs Bight Group

Hydrothermal Crackle Breccia, Boundary Deposit

Gossan

Iron Formation, Nickey's Nose, Lushs Bight Group

Bedded Sulphides, Nickey's Nose, Lushs Bight Group

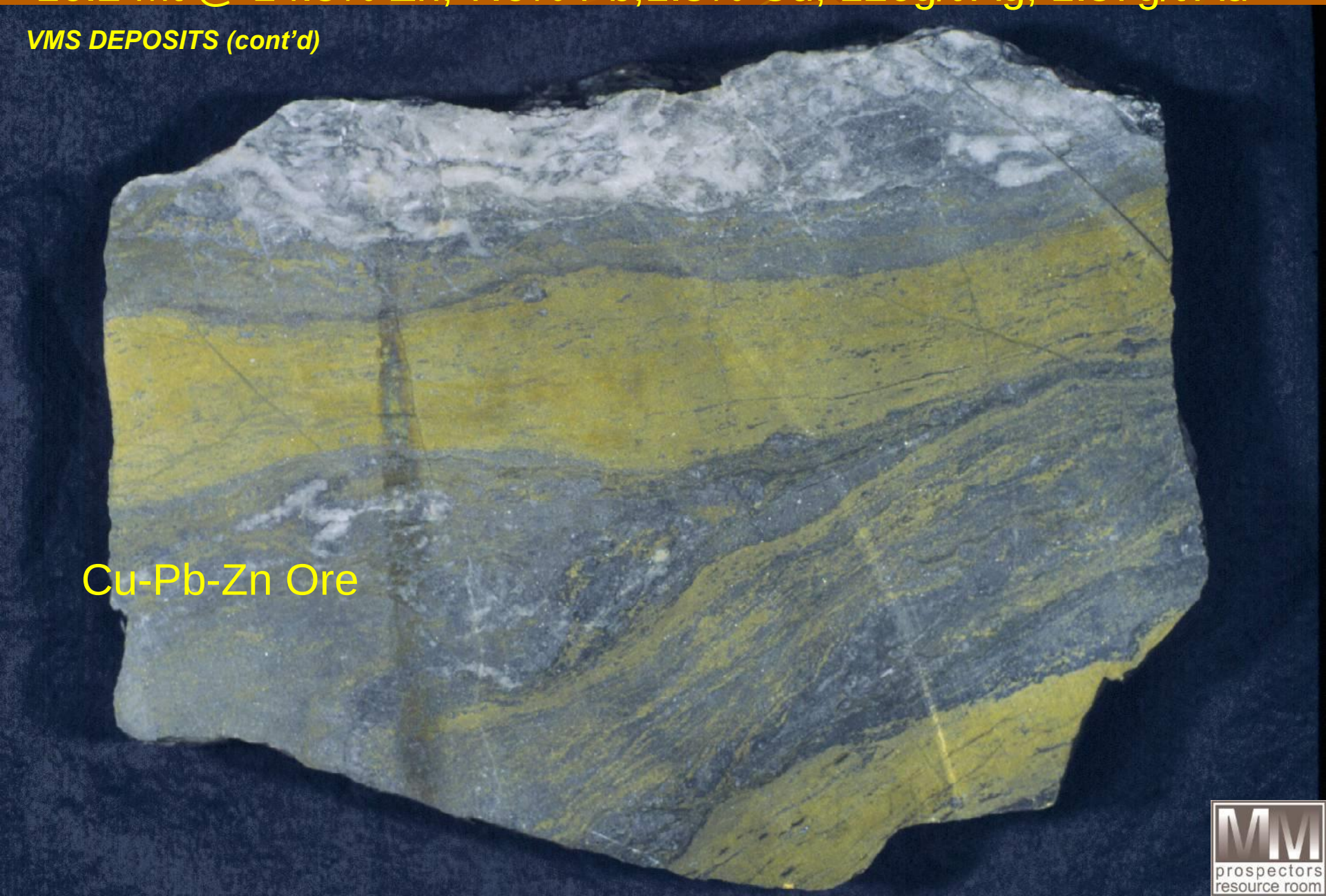
Little Bay Mine

2.6 Mt @ 0.8-2 % Cu

Banded Sulphide (pyrite and silica) Lens, Little Bay Mine

Buchans Mine
16.2 Mt @ 14.5% Zn, 7.6% Pb,1.3% Cu, 126g/t Ag, 1.37g/t Au

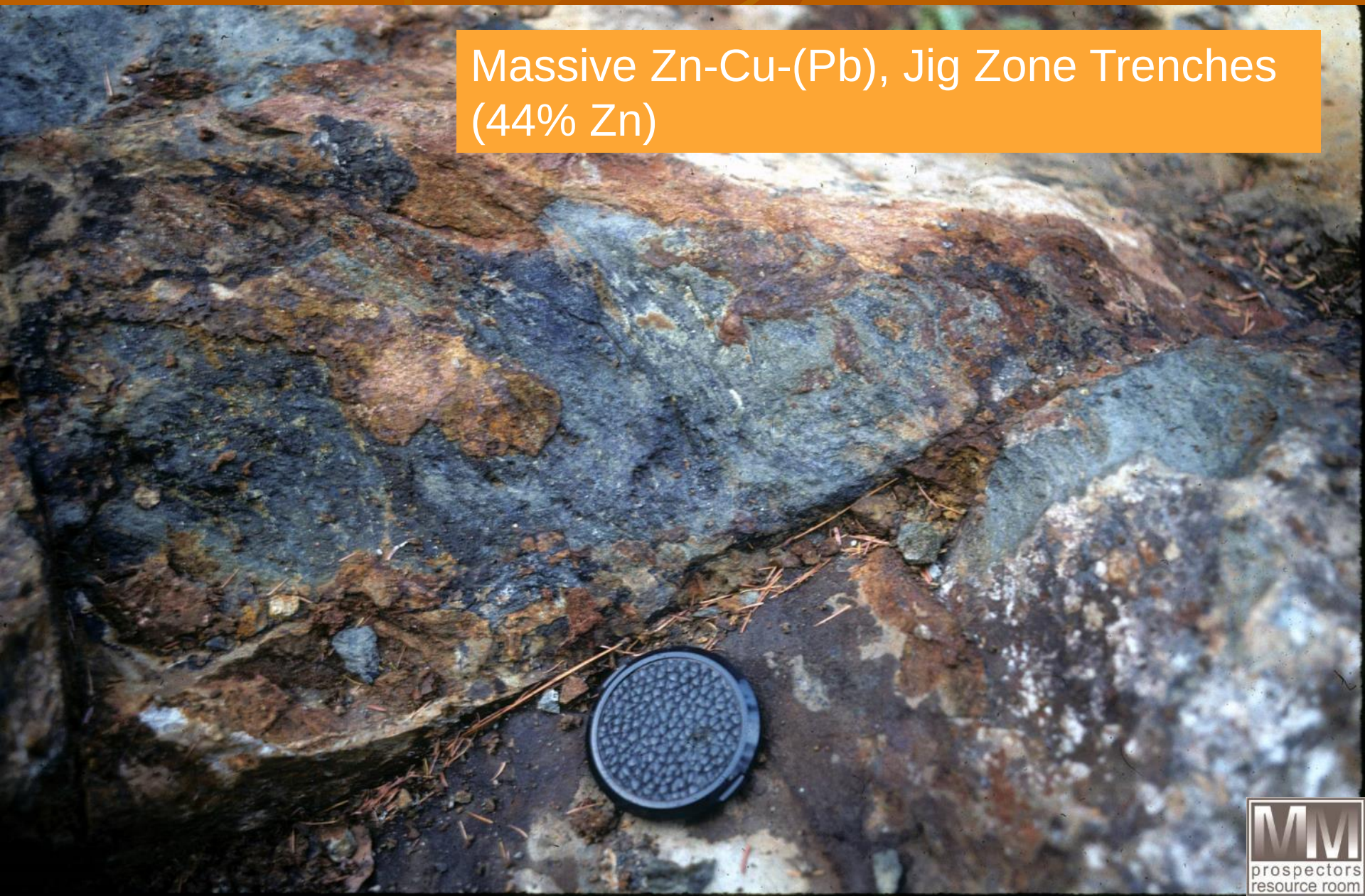
VMS DEPOSITS (cont'd)



Daniel's Pond

4.21 Mt @ 4.03% Zn,1.8% Pb, 0.37% Cu, 82.2 g/t Ag, 0.43g/t Au

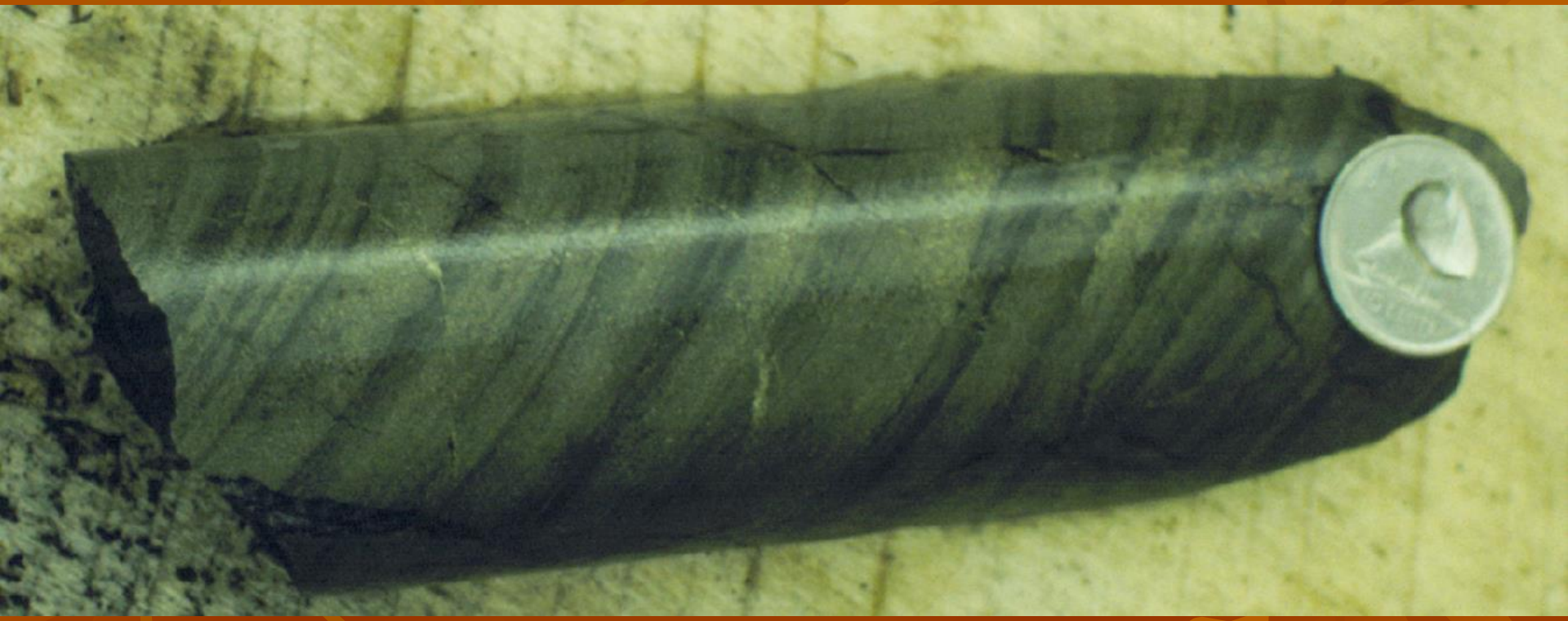
Victoria Mine
~ 50,000 Mt @ 0.5-11% Cu, up to 15% Zn



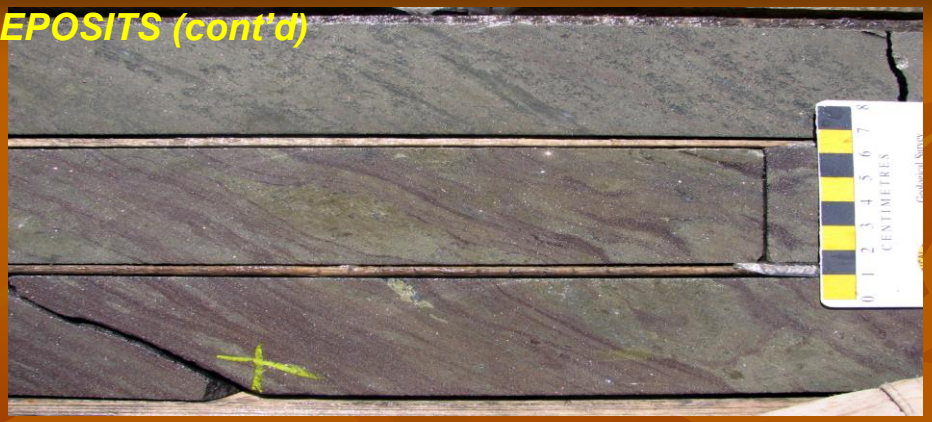
Duck Pond Deposit

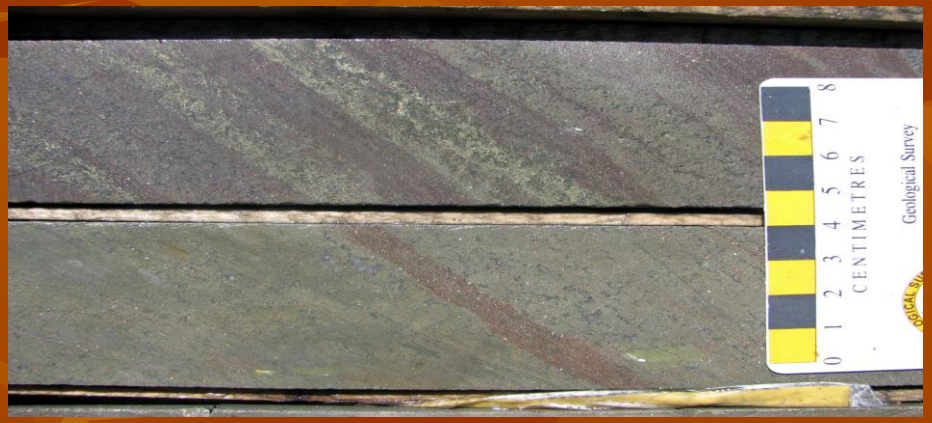
4.1 Mt @ 5.7% Zn, 3.3% Cu, 1.1% Pb, 59.3g/t Ag, 0.86g/t Au

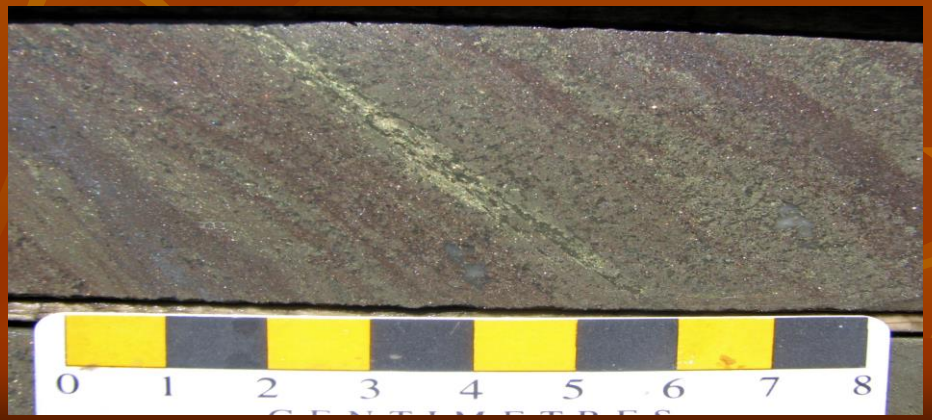
Boundary Deposit (Part of Duck Pond Mine)
0.5 Mt @ 3.5% Zn, 3.5% Cu, 0.5% Pb, 22.8g/t Ag



Bedded and Graded Cu-Zn Ore



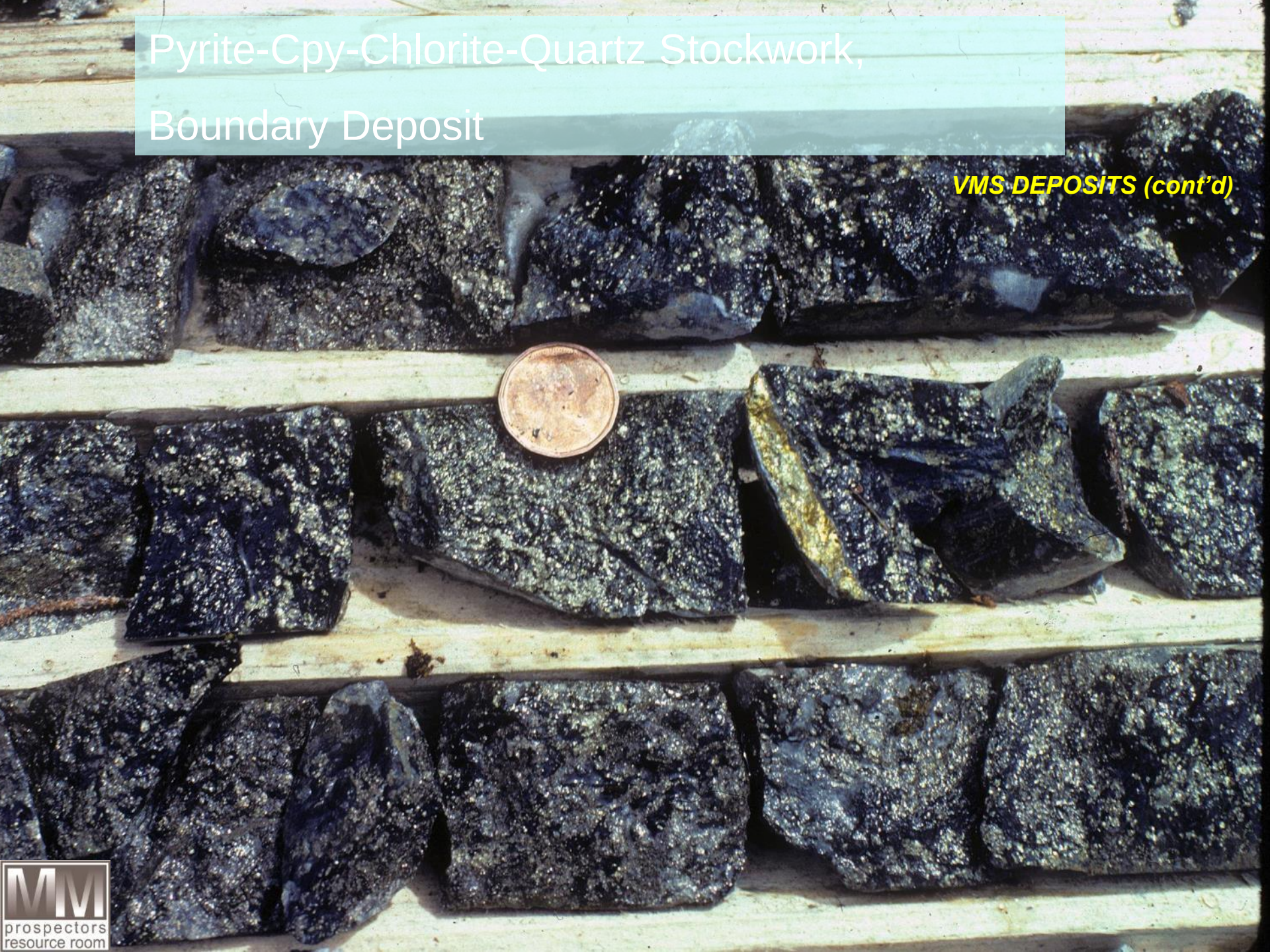




Zn-Cu-Pb Massive Sulphides, Boomerang Deposit

Pyrite-Cpy-Quartz Stockwork, Duck Pond Deposit

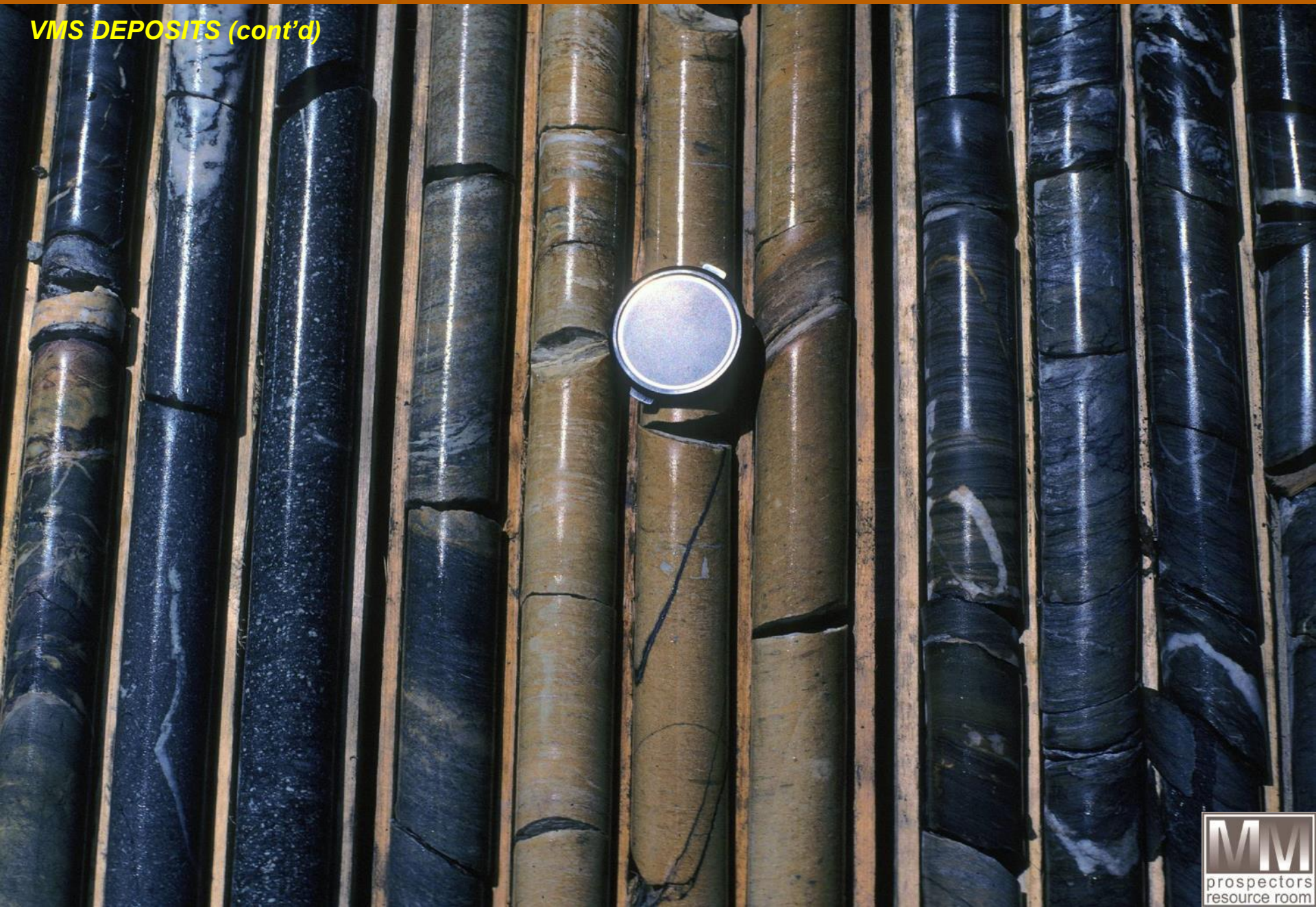
Pyrite-Cpy-Chlorite-Quartz Stockwork, Boundary Deposit



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