SEDIMENT-HOSTED DEPOSITS

Three Main Types

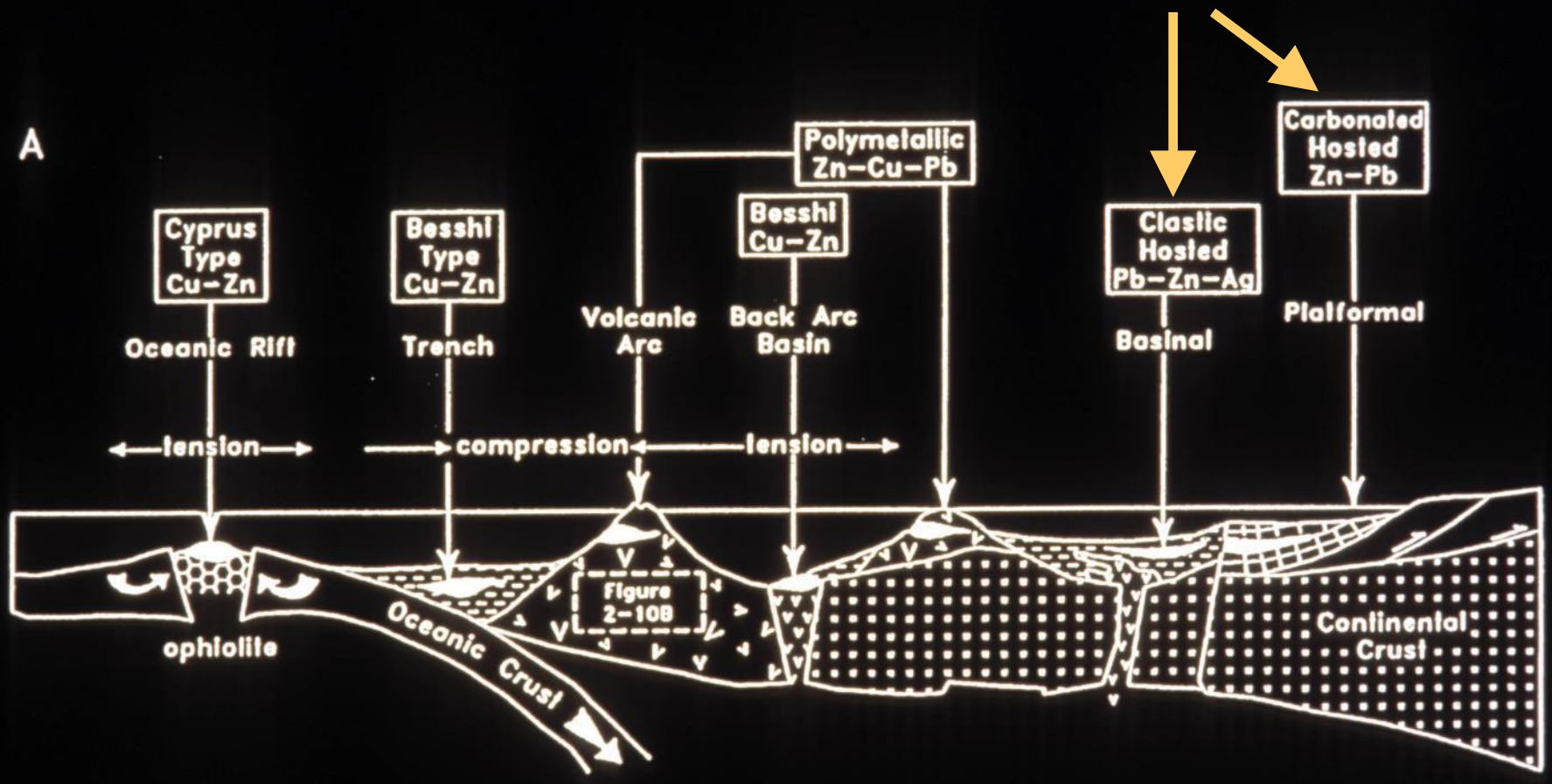
1. *Mississippi Valley Type (MVT)*
   "Epigenetic" stratabound Zn-(Pb) deposits hosted by carbonate sedimentary rocks.

2. *Sediment-Hosted Copper Deposits*
   "Epigenetic" disseminated Cu deposits hosted in reduced sedimentary rocks.

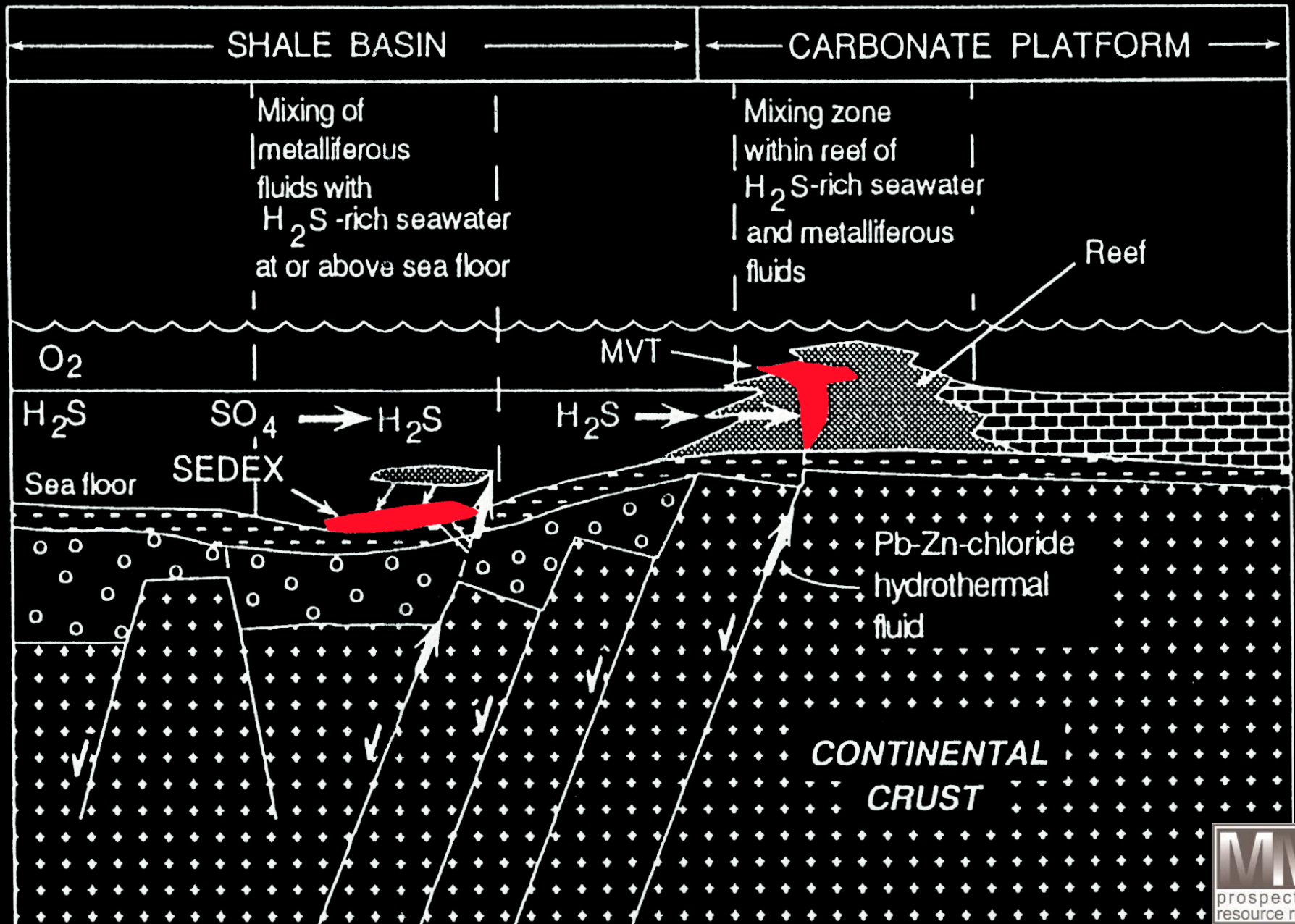
3. *Sedimentary-Exhalative (SEDEX) Type Deposits*
   "Syngenetic" stratiform, bedded Zn-Pb deposits hosted by fine-grained clastic sedimentary rocks.

These three types may be considered as a spectrum of base-metal ore deposits which form in sedimentary rocks at some time during the evolution of a sedimentary basin.

Sediment-Hosted Deposits



SEDEX AND MVT ENVIIRONMENTS



MISSISSIPPI -VALLEY TYPE DEPOSITS (MVT)

BACKGROUND: Zn-Pb deposits; generally <2 Mt, occur in clusters; generally < 10% Pb + Zn, and Zn dominated. A viable mine requires an overall grade > 8%, with ore beds > 15%Zn, and thicknesses >3m.

ENVIRONMENT: Ordovician platformal carbonate rocks (Appalachian Zinc,e.g., Daniel's Harbour), and Carboniferous basinal carbonate rocks (SW Mississippi Pb-Zn).

ORIGIN: Shallow, low temperature (90^0 to 150^0 C), epigenetic mineralization. Metals derived from compaction of sediments, carried by pore waters into porous units, particularly dolostone where porosity has increased.

This porosity may be primary (e.g., reefs, carbonate sands), or secondary (e.g., fracturing, dolomitization, paleokarst, faults, breccias). Organic matter and petroleum acts as a reducing agent, and enable precipitation of sulphides.

Colloform Sphalerite:
Daniel's Harbour Mine

MVT (cont'd)

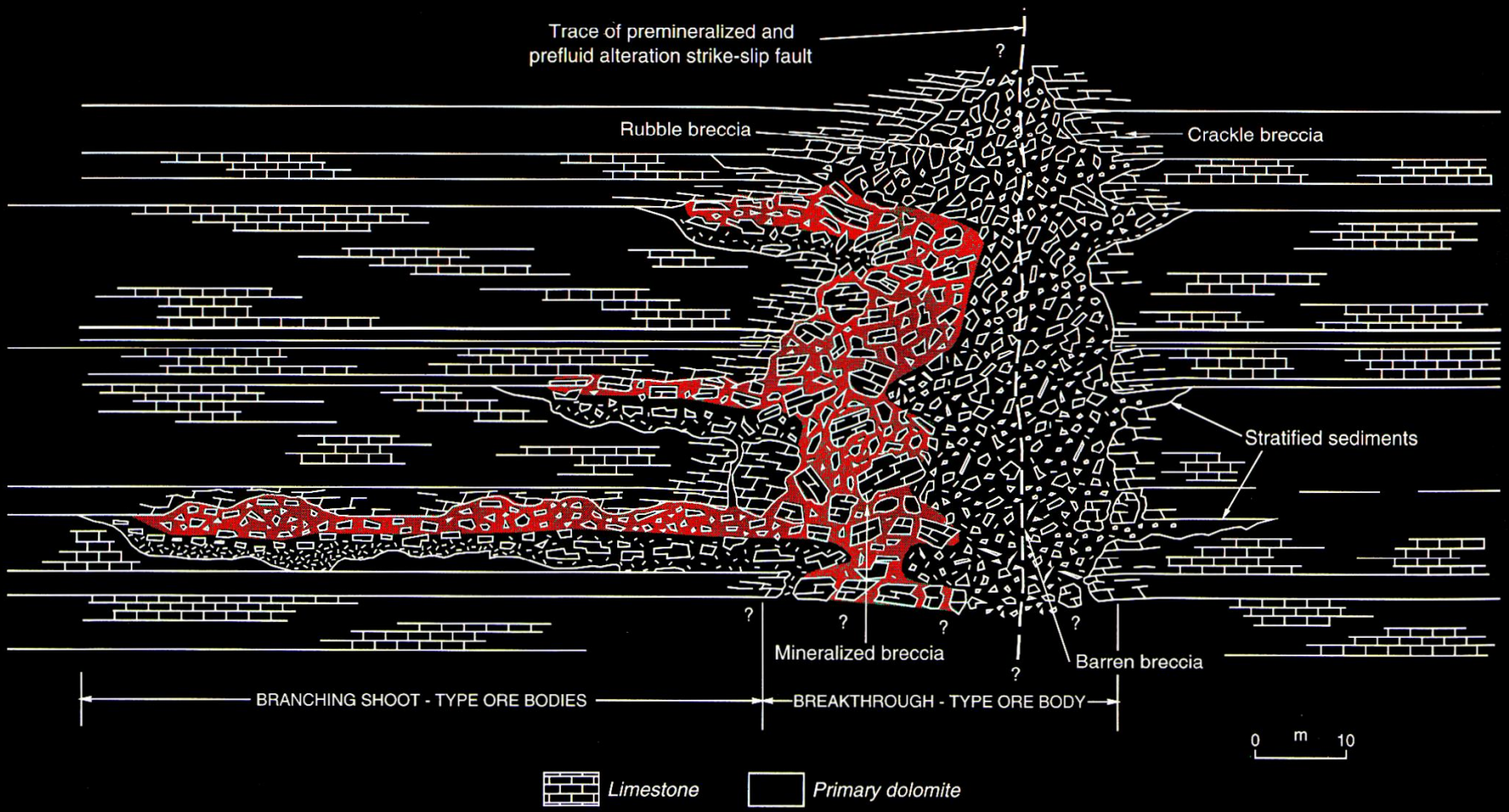
STYLE: *Stratabound deposits - occur in specific carbonate rock layers with lots of porosity and permeability as inter-crystalline pores, fractures, breccias and open cavities. Sulphides crystallize in significant concentrations in areas characterized by an abrupt increase in porosity as late cements in veins, pores, breccias, and fractures, and partially replacing the surrounding rock.*

Ordovician age deposits tend to be lensoid or linear (sinuous porosity channels); Carboniferous age deposits are irregular, coarsely crystalline, locally form veins with calcite.

MINERALOGY: *Ordovician mineralization is generally light coloured, coarsely crystalline sphalerite with relatively little galena; Carboniferous mineralization is generally light-coloured sphalerite and galena, lesser marcasite and pyrite. Accessories include barite, gypsum, and fluorite.*

ALTERATION: *No related alteration, and sphalerite and galena do not rust; dolomitization and collapse breccias are pre-mineralization. Primary and secondary porosity is important.*

MISSISSIPPI VALLEY TYPE DEPOSITS



DISTRIBUTION:

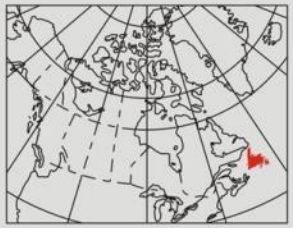
Newoundland

Ordovician platformal carbonate rocks deposited in a continental margin setting, western Newfoundland; Silurian carbonates, south of Hampden; Carboniferous rocks of the St. George Basin-marine interval of limestone and associated clastic rocks (Ship Cove Limestone, Codroy Group).

Labrador

Proterozoic carbonates Labrador City to Schefferville; possibly in the Ramah Group

GEOLOGY OF THE ISLAND OF NEWFOUNDLAND



Map compiled by J.P. Hayes
1987

Digital cartography by
T. Paltanavage, 1994

INTRUSIVE ROCKS

ORDOVICIAN TO DEVONIAN

Granitic and gabbroic intrusions

PROTEROZOIC II TO CAMBRIAN

Granitic and gabbroic intrusions

MVT (Zn-Pb)

DEVONIAN TO CARBONIFEROUS

Subaerial, lacustrine fluvial and deltaic clastic sedimentary rocks; minor limestone

SILURIAN

Shallow marine and subaerial clastic sedimentary rocks; volcanic and volcaniclastic rocks

DUNNAGE ZONE

CAMBRIAN TO SILURIAN

Marine clastic sedimentary rocks; island-arc volcanic and volcaniclastic rocks

CAMBRIAN TO ORDOVICIAN

Ophiolitic mafic - ultramafic rocks, pillow lava and related intrusions

GANDER ZONE

CAMBRIAN TO ORDOVICIAN

Clastic metasedimentary rocks and migmatitic equivalents

HUMBER ZONE

PROTEROZOIC III TO ORDOVICIAN

Authochthonous and parauthocthonous clastic and metasedimentary rocks

Platformal limestone and dolostone; includes clastic sedimentary rocks

Allochthonous sedimentary, mafic volcanic and minor metamorphic rocks

Basal clastic and carbonate sedimentary rocks; includes mafic volcanic rocks

PROTEROZOIC II and III

Orthogneiss, paragneiss and amphibolite

AVALON ZONE

PROTEROZOIC III TO ORDOVICIAN

Subaerial and marine clastic sedimentary rocks; minor limestone

PROTEROZOIC III

Marine and deltaic clastic sedimentary rocks

Mafic and felsic volcanic and volcaniclastic rocks

SEDIMENT-HOSTED MASSIVE SULPHIDE ENVIRONMENTS

MVT

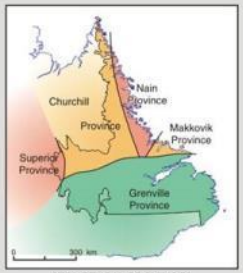
2- Labrador Trough

3-Ramah,Snyder &

Mugford Groups ?

GEOLOGICAL MAP OF LABRADOR

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
Department of Natural Resources
Geological Survey



STRUCTURAL PROVINCES

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

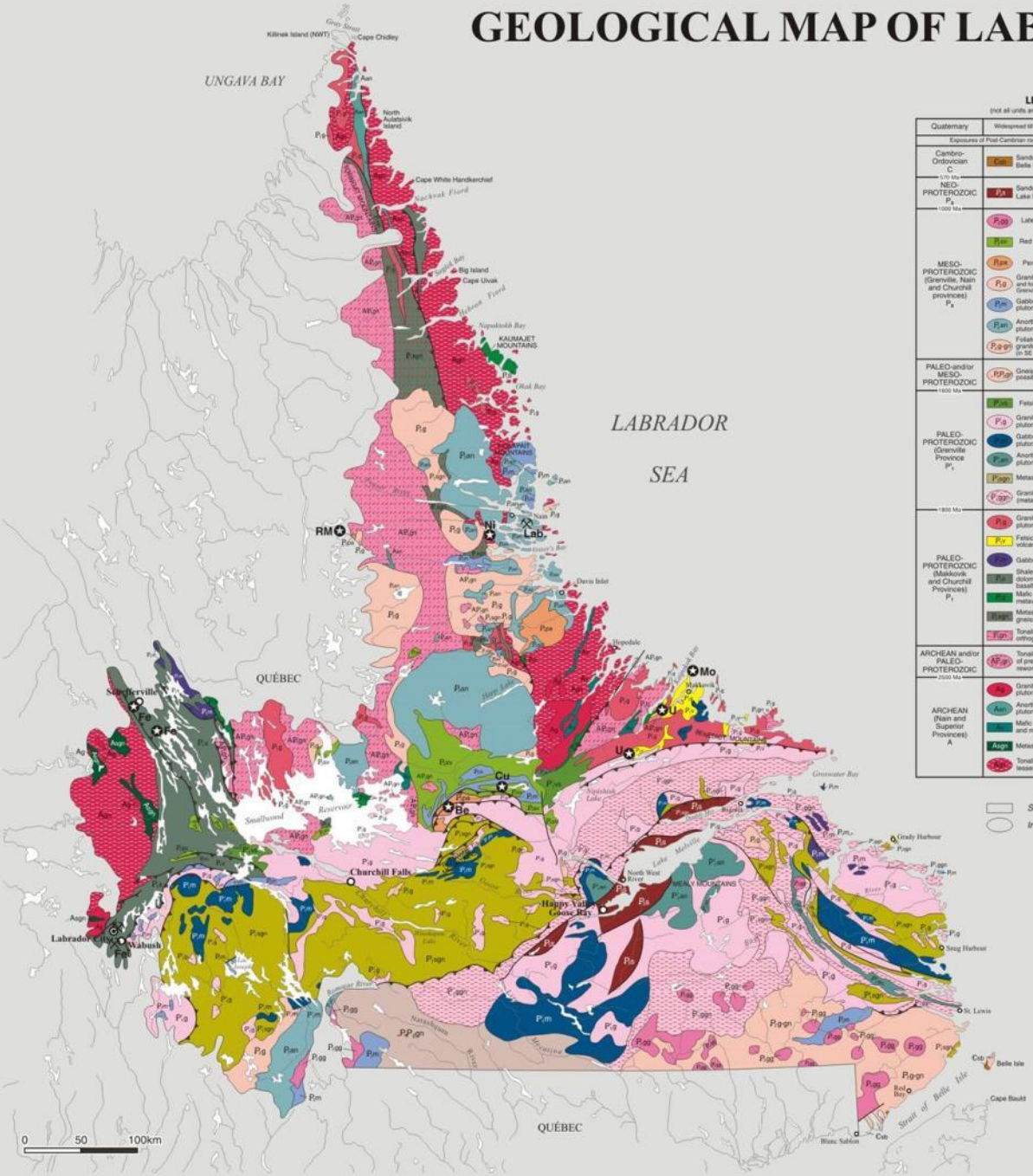
Notification of any errors or revisions would be welcomed by the Geological Survey

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_t	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

MVT (cont,d)

PROSPECTING METHODS:

GEOLOGICAL	*Ore bodies narrow and hard to find; low relief and glacial drift. Characterized by regional dolomitization; more specifically occur at the base of dolostones - transitions between limestones and dolostones; porosity critical; coarse-grained, grey and white (sparry) dolostones in mottled black and white rocks (pseudobreccia); commonly beneath unconformities; in dolostone beneath impermeable shale; and 'pinch-outs' against basements highs; faults and associated collapse breccias; organic trash important as a reducing agent; limestone breccias and reef facies carbonates. Boulder tracing.*
GEOPHYSICAL	*Sphalerite is non-magnetic and lacks electromagnetic conductivity; galena or pyrite may produce an IP anomaly.*
GEOCHEMICAL	*Zn in soils, streams and lakes, not much metal mobility in carbonate-dominated environments.*

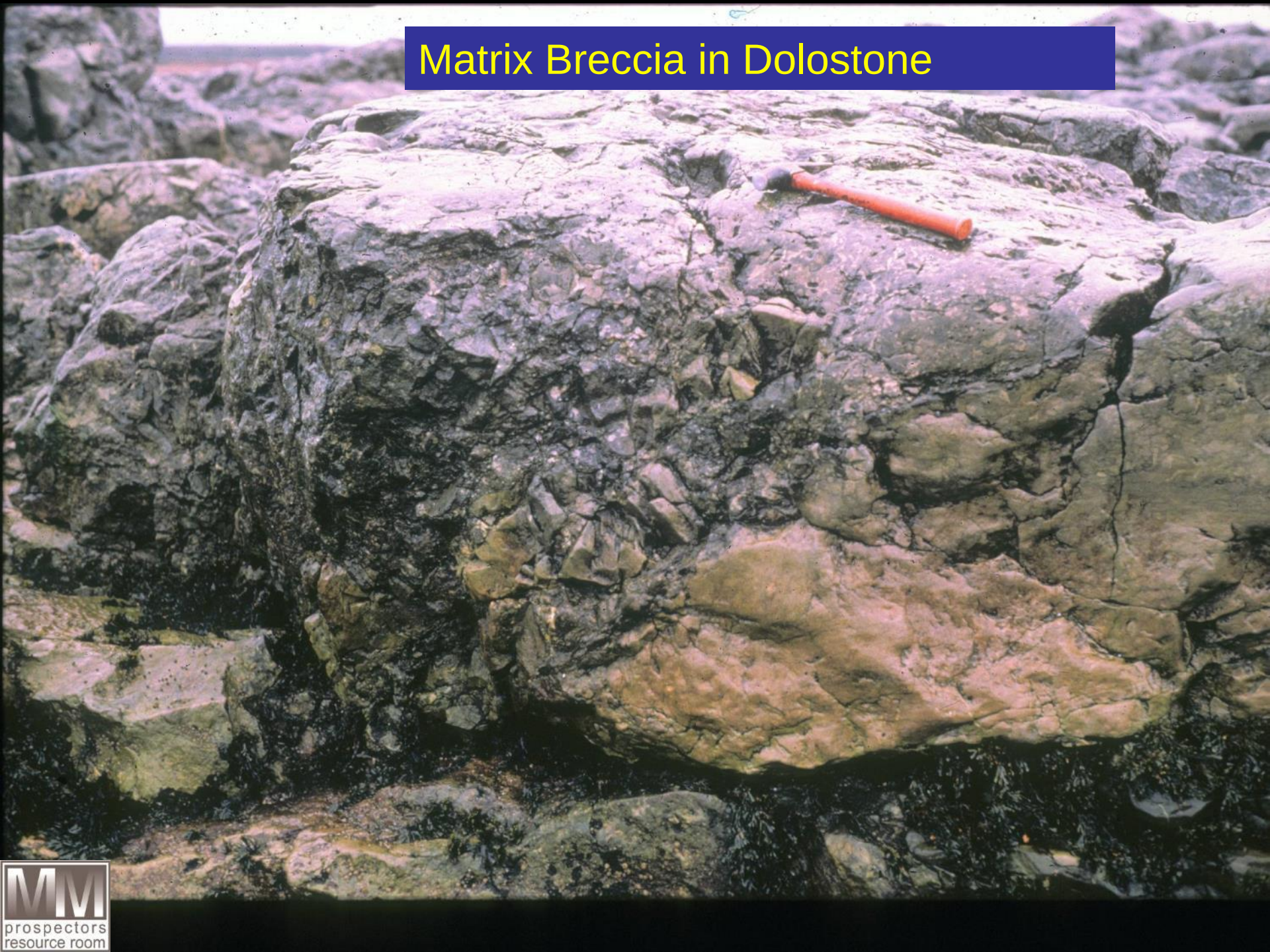
CarbonateTerrain: Great Northern Peninsula

Bedded Dolostone: Daniels Hbr Mine

6.6 Mt @ 7.9% Zn (Contained in >12 Lenses)

Dolostone Breccia

Matrix Breccia in Dolostone




Ryan’s Brook Cu-Pb-Zn,
Ship Cove Limestone

SEDIMENT-HOSTED COPPER DEPOSITS - SSC

Characterized by a prominent copper-rich zone in a red and grey bed sedimentary sequence; includes Redbed-Copper and Volcanic-Redbed types.

BACKGROUND: *20% - 25% of the world's Cu production (2nd only to porphyry Cu); significant Co (Central Africa), Pb (Poland), Ag (USA); may also contain Au, U, PGEs, rare metals.*

ENVIRONMENT: *Located in, or associated with, sedimentary basins filled with large thicknesses of continental red beds (may be volcanic rocks present), and overlain by grey/green rocks.*
The grey/green rocks are/were enriched in sulphur (pyrite, gypsum/anhydrite, carbonaceous material). Mineralization occurs in reduced grey/green rocks near the oxidation-reduction boundary; may be associated with gypsum & anhydrite beds (evaporites).

Most major deposits occur in shallow marine or saline lake rocks immediately overlying red, continental clastic sedimentary rocks.

SEDIMENT-HOSTED COPPER DEPOSITS (cont'd)

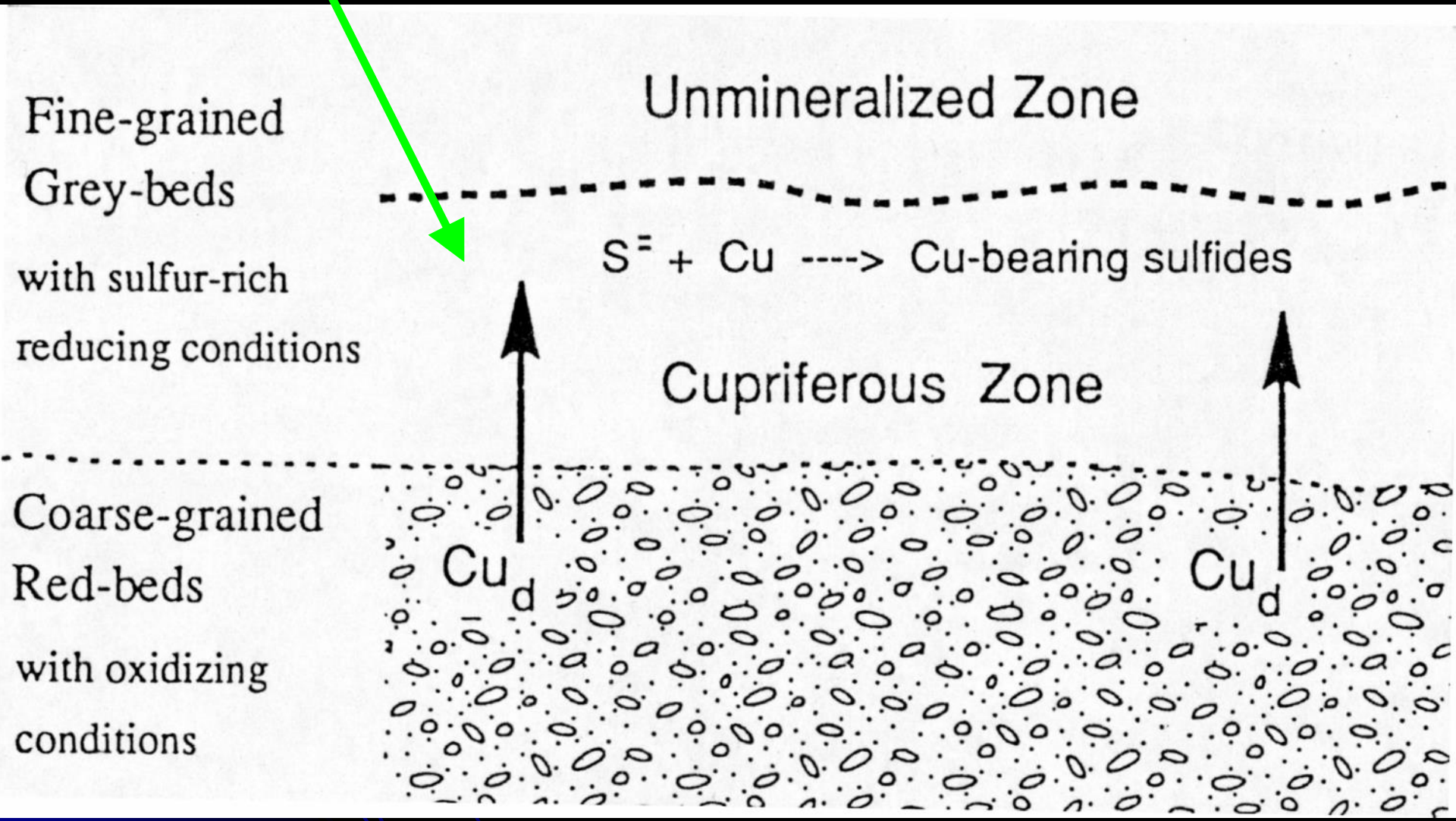
Deposits contained entirely within continental red bed sequences (Redbed-Copper type) are of lesser importance. Those deposits in red bed sequences containing volcanic rocks are called Volcanic-Redbed type.

ORIGIN: *Metals leached from sediments as water expelled by compaction, fluids migrate along porous horizons and faults to basin margins, metals deposited where reduced sulphur encountered.*

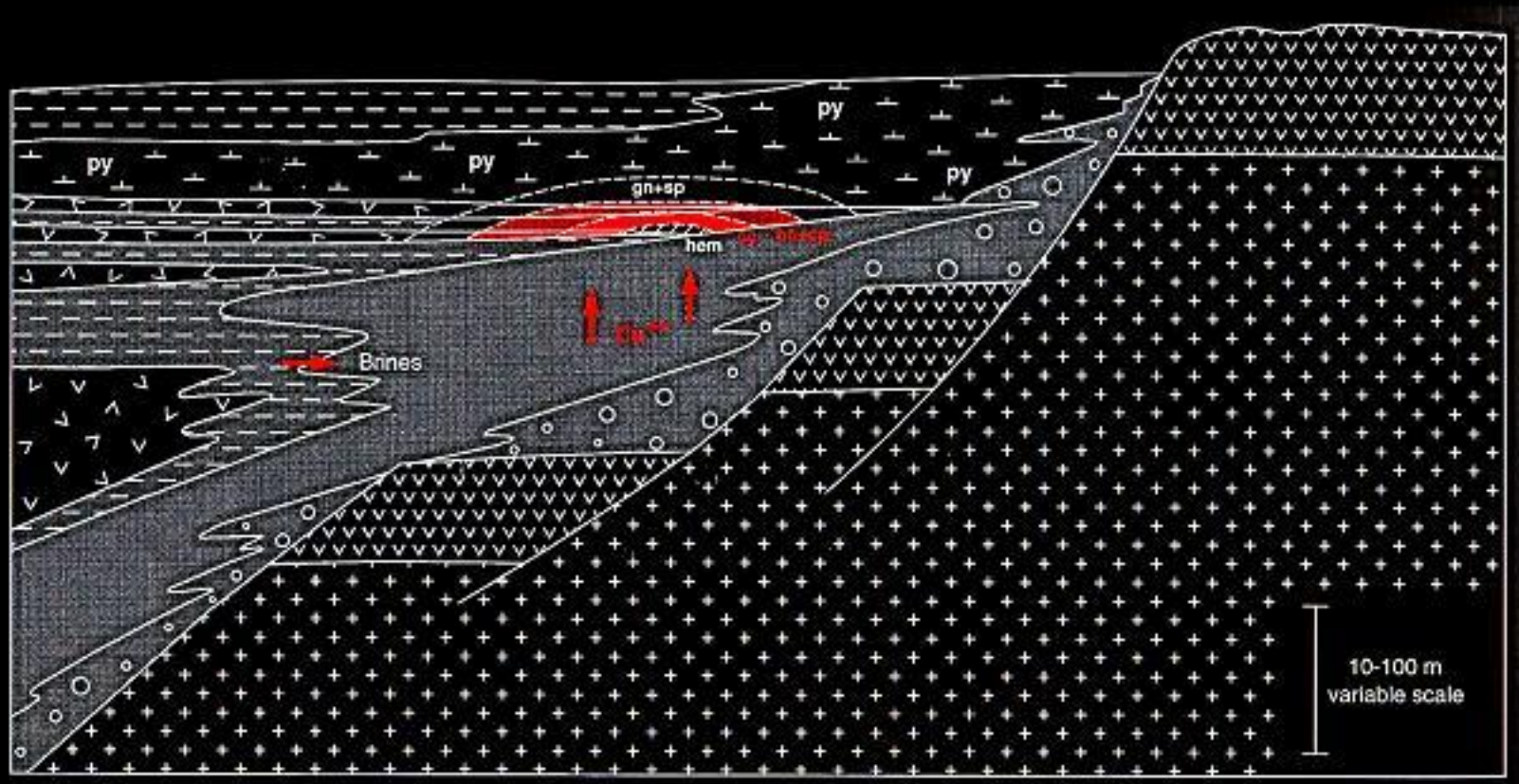
STYLE: *Disseminated sulphides that are usually stratiform along bedding planes. Mineralization usually continuous within beds or may follow old channels – in some places the mineralization may cut beds.*

MINERALOGY: *Fine grained, disseminations or clusters (around organic material) of chalcocite and bornite with lesser native Cu, chalcopyrite, galena, hematite and pyrite. May contain significant Ag, Co, U, Au and PGE sometimes.*

ALTERATION: *Bleaching of sediment due to reduction. Mineralization occurs at reduction fronts; oxidizing (red sandstone) to reducing (green sandstone); gossans.*


Reduction Front
Fine-grained
Grey-beds
with sulfur-rich
reducing conditions
Unmineralized Zone
S= + Cu ----> Cu-bearing sulfides
Cupriferous Zone
Coarse-grained
Red-beds
with oxidizing
conditions
Cu d
Cu d

REDBED CU- DEPOSITS



Siltstone or mudstone - grey-green

Limestone / marl / dolostone - grey-green, pyritic

Evaporites

Red siltstone or mudstone

Red sandstone

Red conglomerate

Basalt

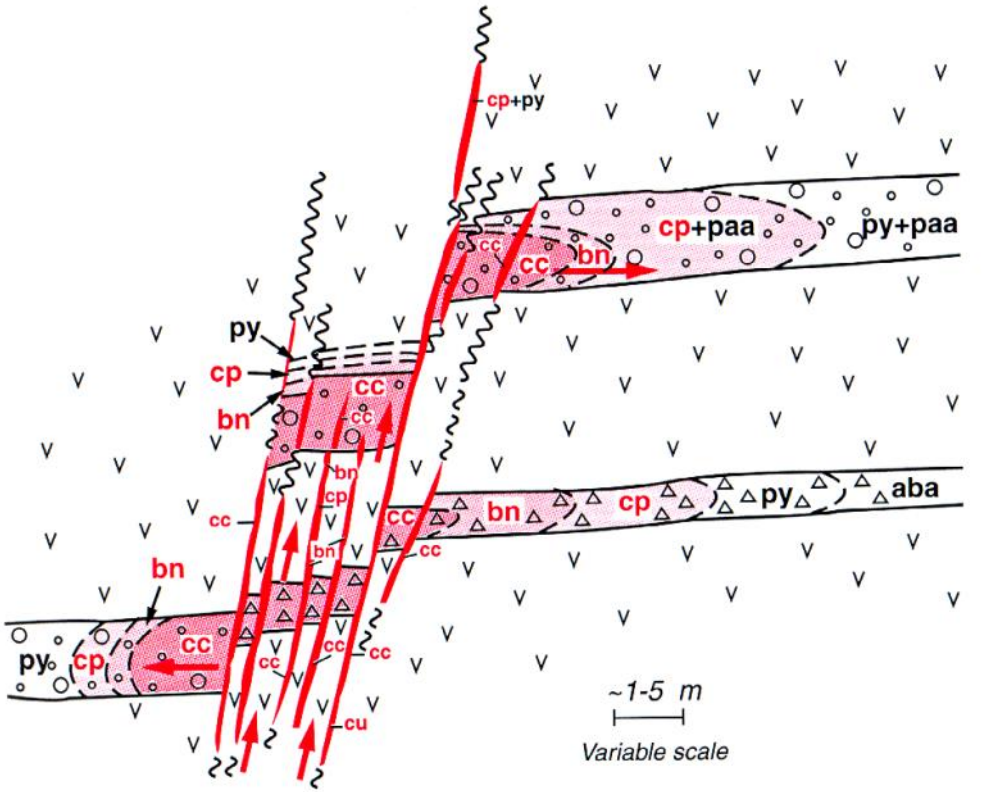
Basement

py : *pyrite*
gn + sp : *galena + sphalerite*
bn + cp : *bornite + chalcopyrite*
cc : *chalcocite*
hem : *hematite*

Direction of movement of formation water . . . .

Mineralogical zoning

Volcanic-Redbed Cu



Conglomerate

Flow-top breccia

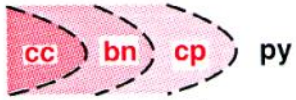
Dense lava flow

Cu: *native copper*
cc: *chalcocite*
bn: *bornite*
cp: *chalcopyrite*
py: *pyrite*
paa: *pale argillic alteration*
aba: *pink albite alteration*

Movement of ore fluid . . . . . →

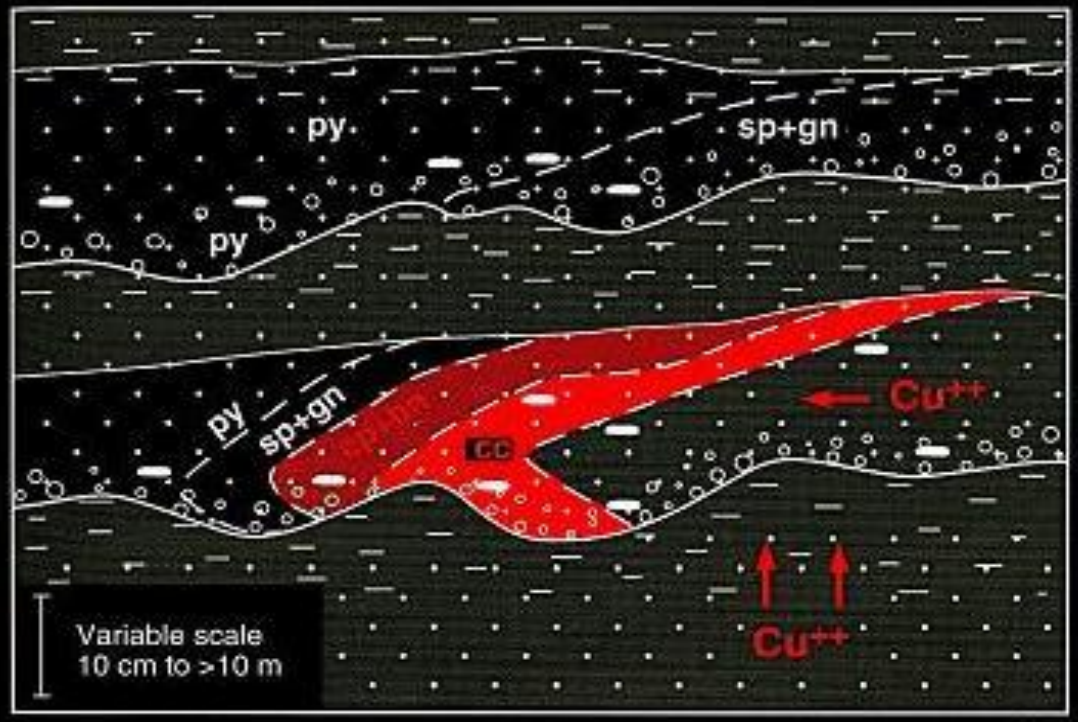
Fault occupied by copper-bearing vein with mineralogy indicated . . . cc

Fault . . . . . ≈



Mineralogical zonation

REDBED CU- DEPOSITS



GSC

Grey mudstone, sandstone, conglomerate

Red mudstone, sandstone, conglomerate

Mineralogical zone boundary . . .

Flow direction of cupriferous formation water . . . . . .

Coalified wood fragment . . . . . .

bn: *bornite*
cc: *chalcocite*
cp: *chalcopyrite*
gn: *galena*
py: *pyrite*
sp: *sphalerite*

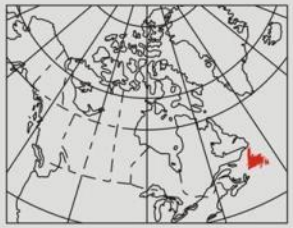
SEDIMENT-HOSTED COPPER DEPOSITS (cont'd)

DISTRIBUTION:

Newfoundland: *Sandstone and shale of the Carboniferous St. George Sub-basin (Snakes Bight Fm. of Anguille Group; Barachois and Codroy groups); Avalon Peninsula; central Newfoundland red bed sequences.*

Labrador : *Middle Proterozoic intra-continental red and grey beds, local mafic volcanics. Chalcocite, bornite and native copper as disseminations fracture- and breccia-fillings, and vesicular flow tops, e.g., Seal Lake Group*

GEOLOGY OF THE ISLAND OF NEWFOUNDLAND



Map compiled by J.P. Hayes
1987

Digital cartography by
T. Paltanavage, 1994

INTRUSIVE ROCKS

ORDOVICIAN TO DEVONIAN

Granitic and gabbroic intrusions

PROTEROZOIC II TO CAMBRIAN

Granitic and gabbroic intrusions

Redbed Cu (±U)

DEVONIAN TO CARBONIFEROUS

Subaerial, lacustrine fluvial and deltaic clastic sedimentary rocks; minor limestone

SILURIAN

Shallow marine and subaerial clastic sedimentary rocks; volcanic and volcaniclastic rocks

DUNNAGE ZONE

CAMBRIAN TO SILURIAN

Marine clastic sedimentary rocks; island-arc volcanic and volcaniclastic rocks

CAMBRIAN TO ORDOVICIAN

Ophiolitic mafic - ultramafic rocks, pillow lava and related intrusions

GANDER ZONE

CAMBRIAN TO ORDOVICIAN

Clastic metasedimentary rocks and migmatitic equivalents

HUMBER ZONE

PROTEROZOIC III TO ORDOVICIAN

Authochthonous and parauthocthonous clastic and metasedimentary rocks

Platformal limestone and dolostone; includes clastic sedimentary rocks

Allochthonous sedimentary, mafic volcanic and minor metamorphic rocks

Basal clastic and carbonate sedimentary rocks; includes mafic volcanic rocks

PROTEROZOIC II and III

Orthogneiss, paragneiss and amphibolite

AVALON ZONE

PROTEROZOIC III TO ORDOVICIAN

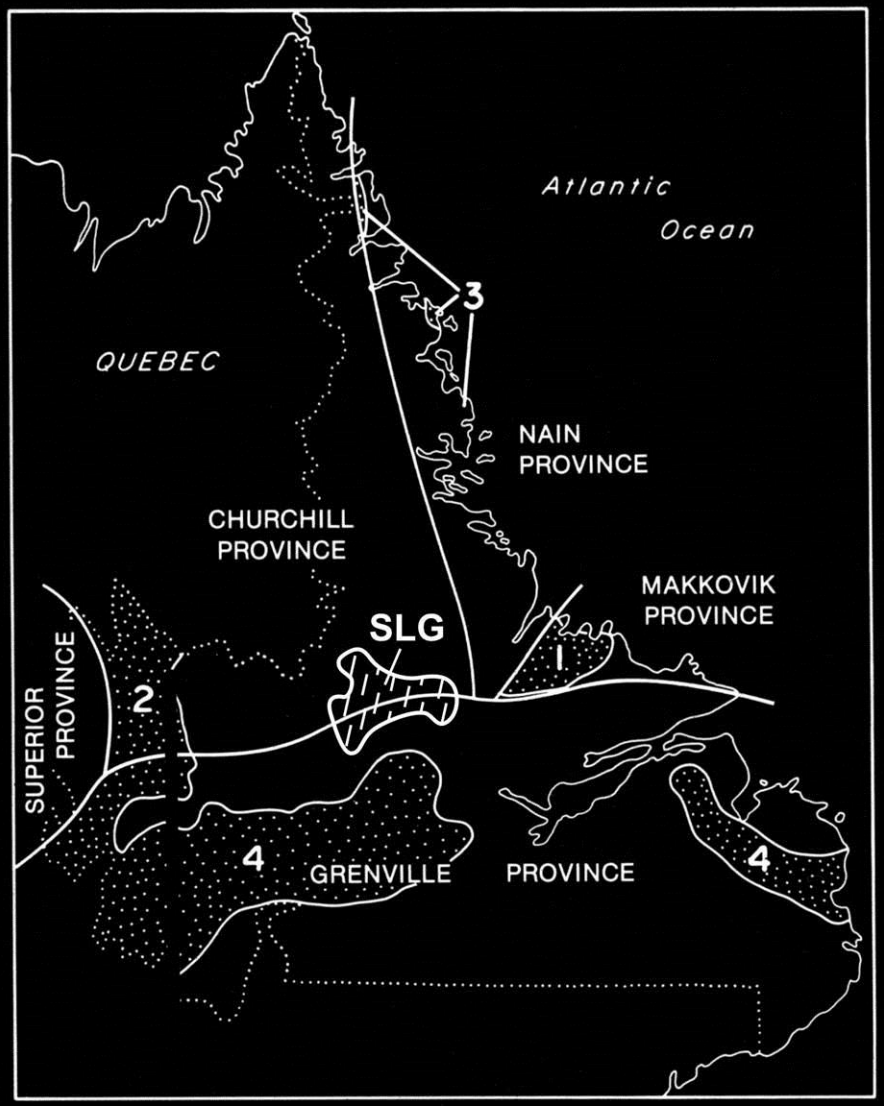
Subaerial and marine clastic sedimentary rocks; minor limestone

PROTEROZOIC III

Marine and deltaic clastic sedimentary rocks

Mafic and felsic volcanic and volcaniclastic rocks

SEDIMENT-HOSTED MASSIVE SULPHIDE ENVIRONMENTS



Labrador

SEDIMENT-HOSTED COPPER DEPOSITS (cont'd)

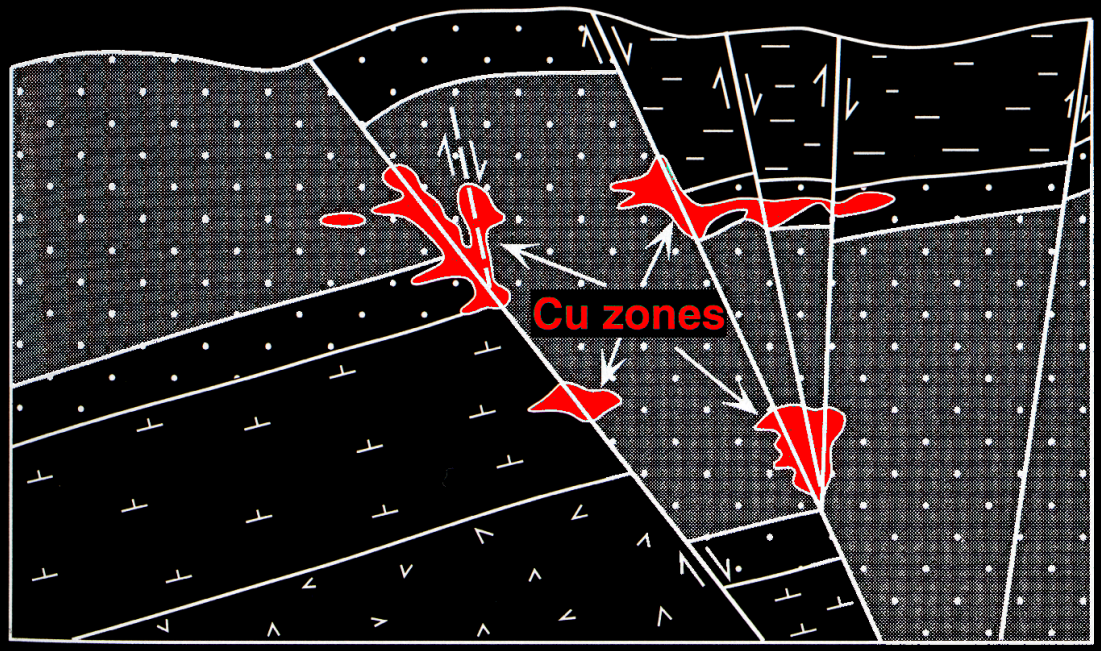
PROSPECTING METHODS:

GEOLOGICAL: *Red and grey clastic sedimentary rocks of a terrestrial and shallow marine-saline lake origin in a continental setting; organic and carbonaceous material, and pyrite provide good reducing agents.*
Look for cross-faults and gossans.

GEOPHYSICAL: *EM - disseminated sulphide may not give a good response; IP should work.*

GEOCHEMICAL: *Cu and Ag in soil, stream and lake sediments. May be weakly radioactive because of uranium.*

REDBED CU- DEPOSITS



Evaporites

Red mudstone, sandstone, conglomerate

Grey sandstone

Grey siltstone

Limestone/marl

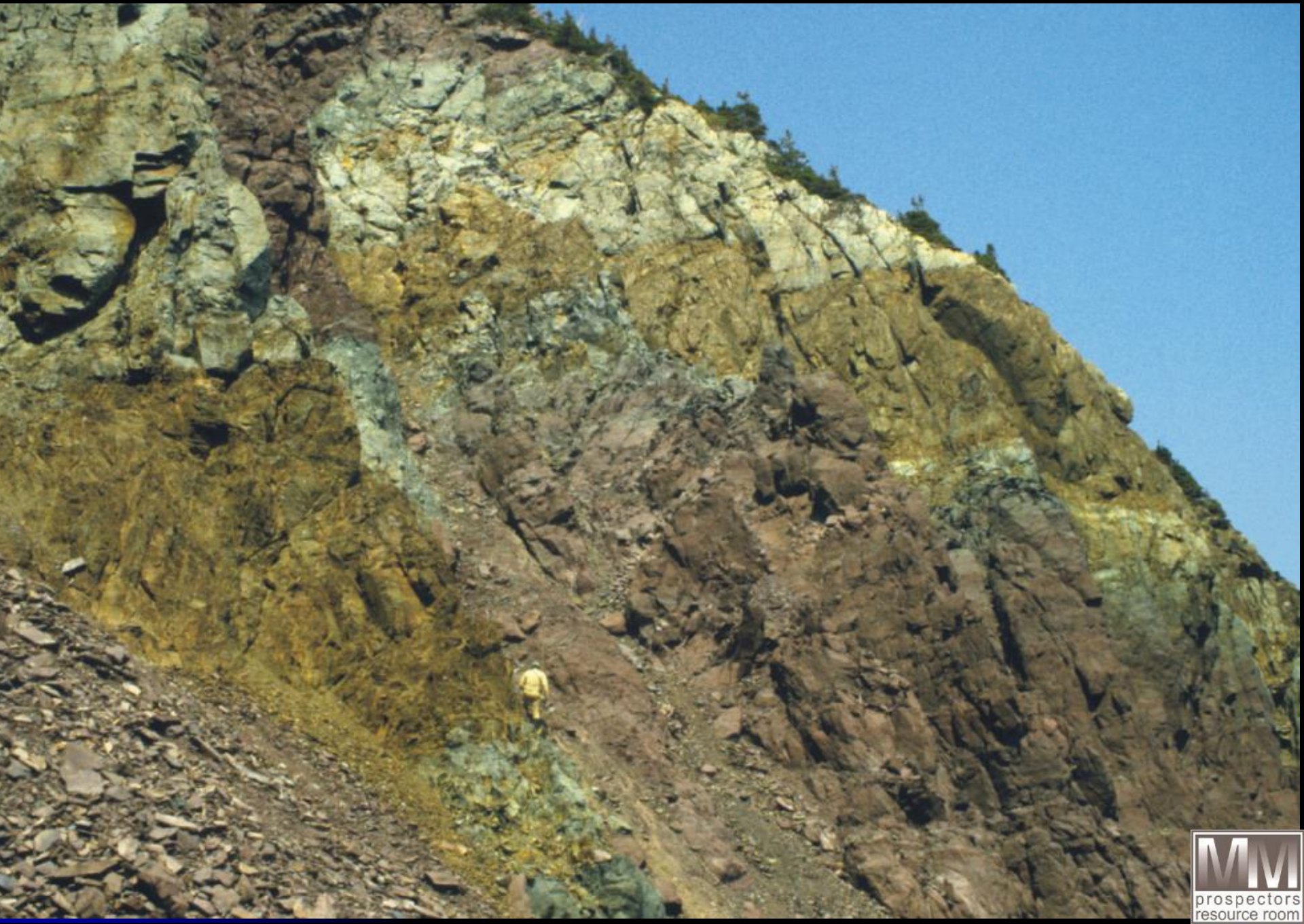
1 metre to 10s of metres

Blue Point Prospect (chalcocite)

Crown Hill Fm, Musgravetown Group

Malachite Stain
Avalon Peninsula

Chalcocite-Pyrite Zone, Blue Point Prospect



Red-Beds with Black Organic Debris
Windsor Point Group


Grey Beds, Ship
Cove Limestone

Chalcocite & Native Cu, Ellis Showing, Seal Lake Group

SEDIMENTARY EXHALATIVE TYPE (SEDEX)

BACKGROUND: *Accounts for 30% of the world's Zn production and 25% of Pb production; 50% and 60% of world's Zn & Pb reserves, respectively.*

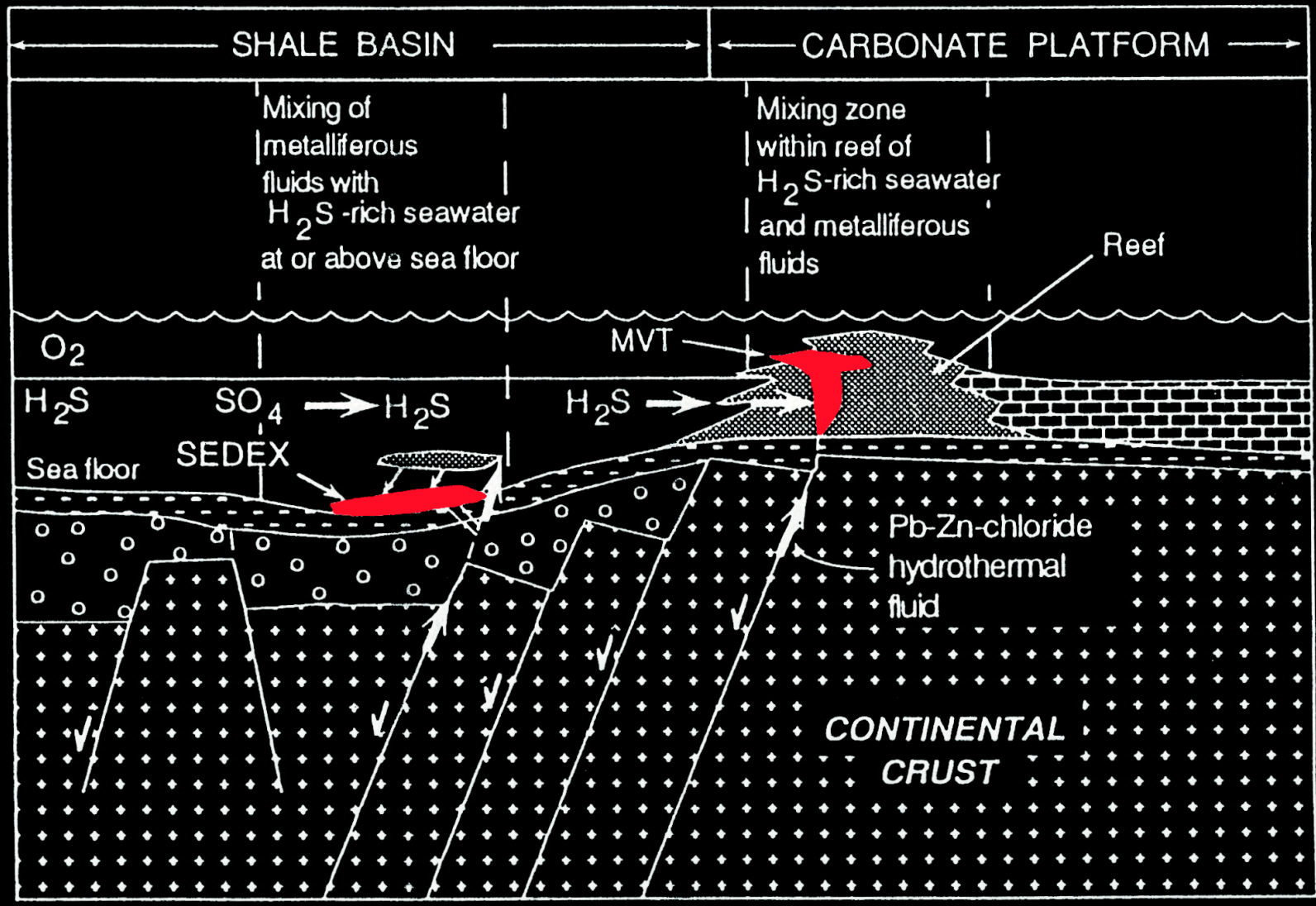
Also known as shale-hosted stratiform sulphide deposits

ENVIRONMENT: *Form in reducing marine basin environments associated with fine-grained carbonaceous rocks. Environments include continental shelves, intra-continental basins, and flysch basin sequences that cap thick sequences of coarse-grained clastic sedimentary rocks; sediment covered rift-basins. A high organic carbon content is essential. Barite is a major constituent.*

ORIGIN: *Through the discharge of metal-laden hydrothermal fluids, heated by magmatic activity, along faults into a reducing environment on basin floor. Host rocks typically black shale/siltstone (turbidite), mafic/felsic volcanic rocks nearby, occasional chert and limestone.*

Rowsells Harbour

SEDEX AND MVT ENVIIRONMENTS



SEDEX (cont'd)

STYLE: *Stratiform blanket-shaped massive sulphide +/-stockwork. Characterized by thin layers to massive thick beds.*

MINERALOGY: *Pyrite, pyrrhotite, sphalerite, galena, silver, barite and minor chalcopyrite (maybe significant in the stockwork), typically fine-grained except where metamorphosed (recrystallized).*

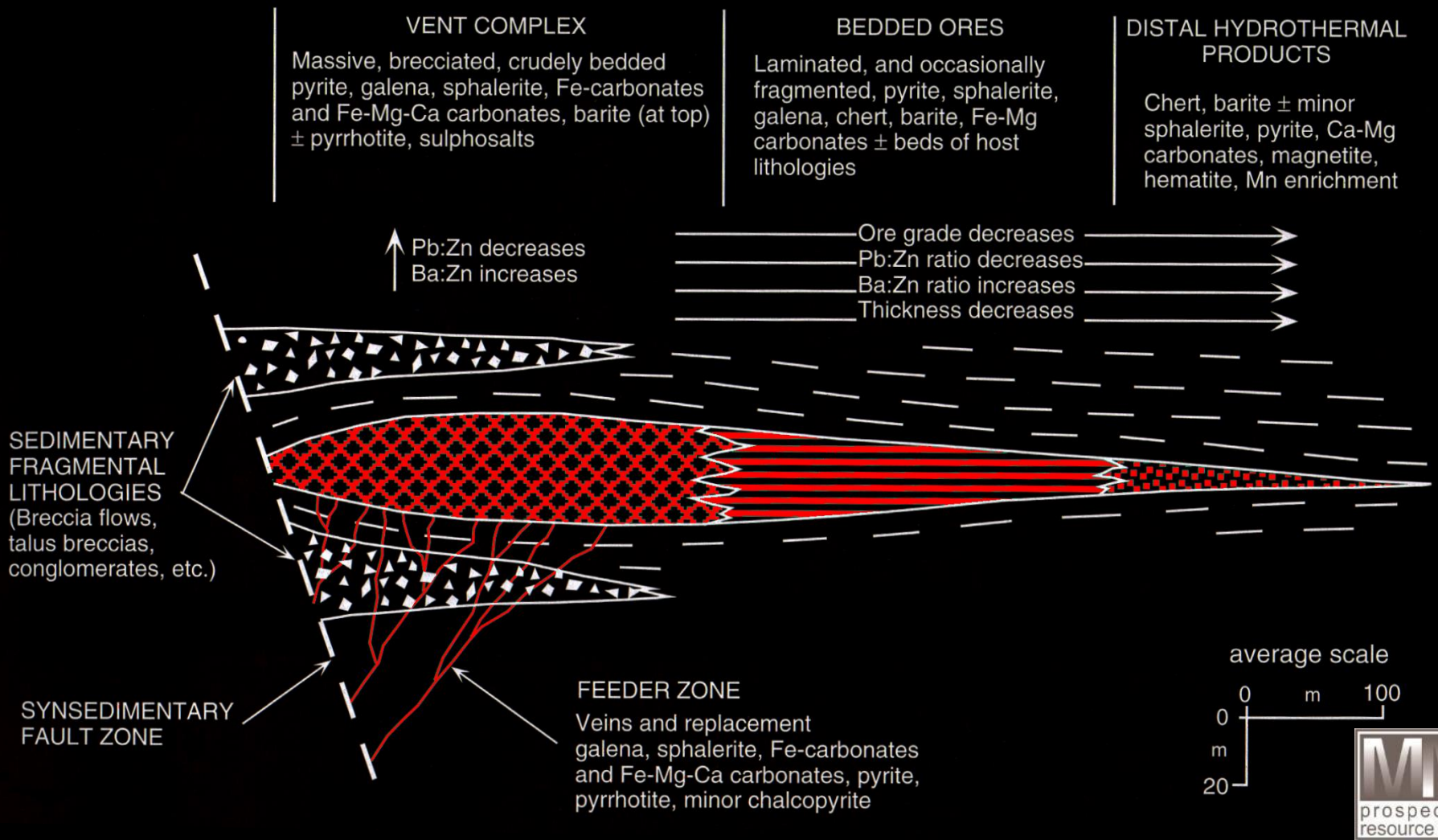
ALTERATION: *Altered feeder zone (Stockwork) of silica, chlorite, dolomite, tourmaline, pyrite and pyrrhotite; look for gossans.*

DISTRIBUTION:

Newfoundland: *Unknown; prospective areas include the Fleur de Lys belt, and western Newfoundland equivalent rocks.*

Labrador: *Schefferville & Howse Zones of Labrador Trough; Central Mineral Belt; basal clastic sequences of Moran Lake & Lower Aillik groups; Ramah, Snyder & Mugford groups; Grenville Province; Paradise River metasedimentary belt.*

SCHEMATIC OF THE CHARACTERISTIC FEATURES OF THE IDEALIZED SEDEX DEPOSIT



GEOLOGY OF THE ISLAND OF NEWFOUNDLAND

Map compiled by J.P. Hayes
1987

Digital cartography by
T. Paltanavage, 1994

INTRUSIVE ROCKS

ORDOVICIAN TO DEVONIAN

Granitic and gabbroic intrusions

PROTEROZOIC II TO CAMBRIAN

Granitic and gabbroic intrusions

DEVONIAN TO CARBONIFEROUS

Subaerial, lacustrine fluvial and deltaic clastic sedimentary rocks; minor limestone

SILURIAN

Shallow marine and subaerial clastic sedimentary rocks; volcanic and volcaniclastic rocks

DUNNAGE ZONE

CAMBRIAN TO SILURIAN

Marine clastic sedimentary rocks; island-arc volcanic and volcaniclastic rocks

CAMBRIAN TO ORDOVICIAN

Ophiolitic mafic - ultramafic rocks, pillow lava and related intrusions

GANDER ZONE

CAMBRIAN TO ORDOVICIAN

Clastic metasedimentary rocks and migmatitic equivalents

HUMBER ZONE

PROTEROZOIC III TO ORDOVICIAN

Authochthonous and parauthocthonous clastic and metasedimentary rocks

Platformal limestone and dolostone; includes clastic sedimentary rocks

Allochthonous sedimentary, mafic volcanic and minor metamorphic rocks

Basal clastic and carbonate sedimentary rocks; includes mafic volcanic rocks

PROTEROZOIC II and III

Orthogneiss, paragneiss and amphibolite

AVALON ZONE

PROTEROZOIC III TO ORDOVICIAN

Subaerial and marine clastic sedimentary rocks; minor limestone

PROTEROZOIC III

Marine and deltaic clastic sedimentary rocks

Mafic and felsic volcanic and volcaniclastic rocks

SEDIMENT-HOSTED MASSIVE SULPHIDE ENVIRONMENTS

SEDEX

1 - Moran Lake & Lower Aillik Groups

2 – Labrador Trough

3 – Ramah, Snyder & Mugford Groups

4 – Grenville Province

SEDEX (cont'd)

PROSPECTING METHODS:

GEOLOGICAL

Setting: Marine basin sequences with volcanic rocks of same age, i.e., thick sequences of clastic sedimentary rock consisting of interbedded greywacke, sandstone, conglomerate, mudstone/chert and abundant black shale/siltstone units.

Stockwork Zone: Silica, chlorite, dolomite, tourmaline, pyrite and pyrrhotite alteration.
Barite; cross-faults; gossans.

GEOPHYSICAL

EM: Black shales are very conductive and will mask less conductive sphalerite.
Mag: Pyrrhotite-rich deposits will exhibit a positive mag anomaly.

GEOCHEMICAL

Zinc, lead, manganese, barium haloes in soils, stream and lake sediments.

Folded Redcliff Shale with Greywacke Beds

Ramah Group with Pyrite Bed

Flysch Sequence Central Nfld

Flysch = Sediments eroded off mountains

Sediment-Hosted Sulphide, Chigaco Lake, Labrador Trough

Pyrite in grey chert bed in Shale, Howse Lake, Labrador Trough