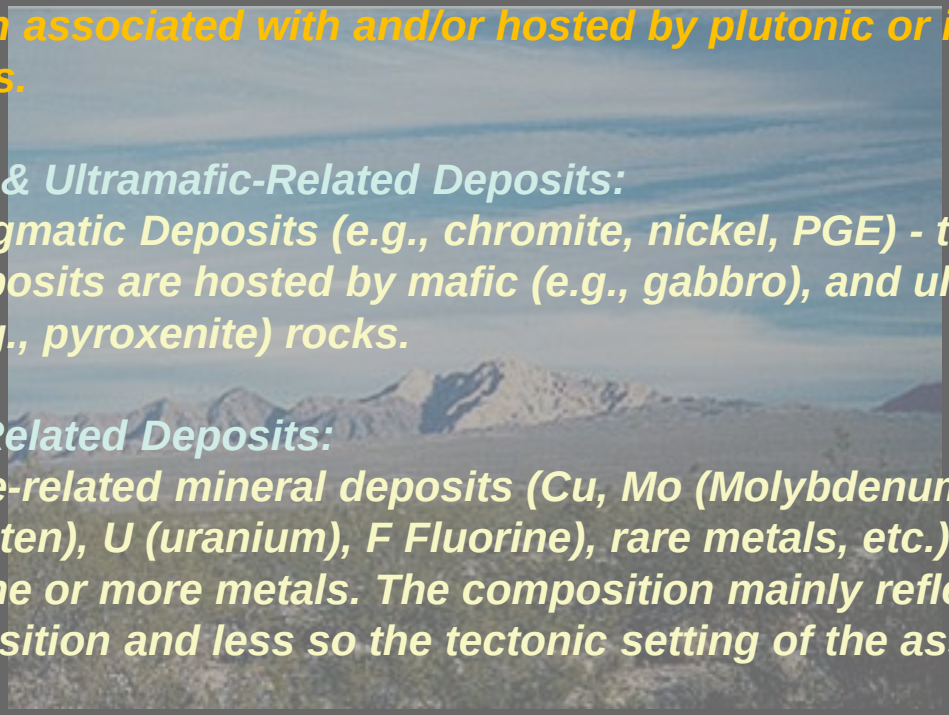
INTRUSION-RELATED DEPOSITS



Mineralization associated with and/or hosted by plutonic or intrusive igneous rocks.

Gabbro- & Ultramafic-Related Deposits:

1. ***Magmatic Deposits (e.g., chromite, nickel, PGE) - these deposits are hosted by mafic (e.g., gabbro), and ultramafic (e.g., pyroxenite) rocks.***

Granite-Related Deposits:

Granite-related mineral deposits (Cu, Mo (Molybdenum), Sn (Tin), W (Tungsten), U (uranium), F Fluorine), rare metals, etc.) occur as ore bodies with one or more metals. The composition mainly reflects the chemical composition and less so the tectonic setting of the associated igneous rocks.

1. ***Granophile Metal Deposits (e.g., Sn, W, F, Mo, U, rare metals including REEs) – these deposits are associated with light coloured granitic rocks; includes pegmatites.***

2. ***Porphyry Copper & Molybdenum Deposits (e.g., Cu, Mo and Au) – these deposits are associated with felsic intrusive rocks (porphyries).***

MAGMATIC DEPOSITS

Deposits in which the ore minerals have crystallized directly from a magma.

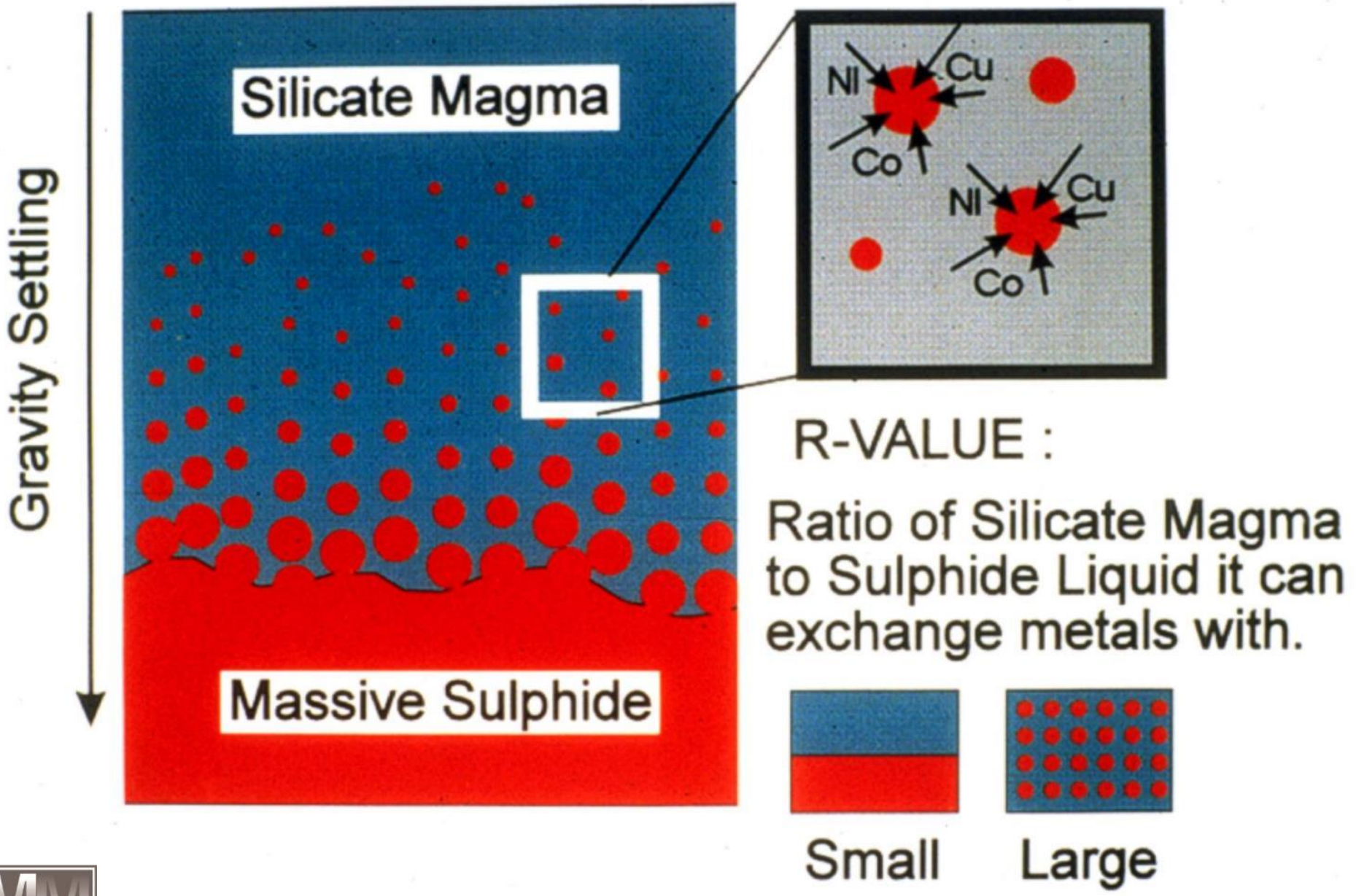
Generally found in mafic or ultramafic igneous rocks, typically layered complexes.

Three major deposit types:

i) Nickel-Copper Deposits
ii) Chromite Deposits
iii) Platinum Group Elements Deposits

Minor amounts of Cr and PGE are also recovered from eluvial or alluvial (placer) deposits.

Discovery Hill, Voisey's Bay



MAGMATIC NICKEL-COPPER DEPOSITS (+/- PGE)

Northern Lights
Voisey's Bay

BACKGROUND: *Most important source of nickel.*

ENVIRONMENT: *They occur in:*

Plutonic Rocks (form deep in the crust)……

a) layered plutons … typically very old (Precambrian), and generally hosted by gabbroic-troctolitic rocks (e.g., Sudbury and Voisey's Bay).

b) ultramafic rocks in old ocean floor (ophiolite) settings (e.g., NL, Quebec);

c) orogenic (rift-related) gabbroic and ultramafic intrusive rocks (e.g., Retty Lake in the Quebec Labrador Trough).

Extrusive Rocks (form on the surface from lava flows)……

Komatiitic (ultramafic rocks) flows or sills, mainly Precambrian (e.g., Kambalda, possibly Florence Lake, Labrador); spinifex textures are a distinctive feature. (PGE as a secondary by-product).

ORIGIN: *Form by magmatic processes - as a magma chamber begins to crystallize, nickel (+/-copper and PGE) become concentrated and combine with sulphur to form massive sulphides.*

NICKEL-COPPER (cont'd)

STYLE: *Stratiform, blanket-shaped bodies consisting of massive to stringer, net-textured sulphides located in the basal portions of both the layered intrusions (troctolite-gabbro-norite common host; occur locally in ultramafic rocks-pyroxenite, peridotite) and the ultramafic flows. Ophiolitic-hosted mineralization consists of veins, pods, lenses, sometimes focused along faults.*

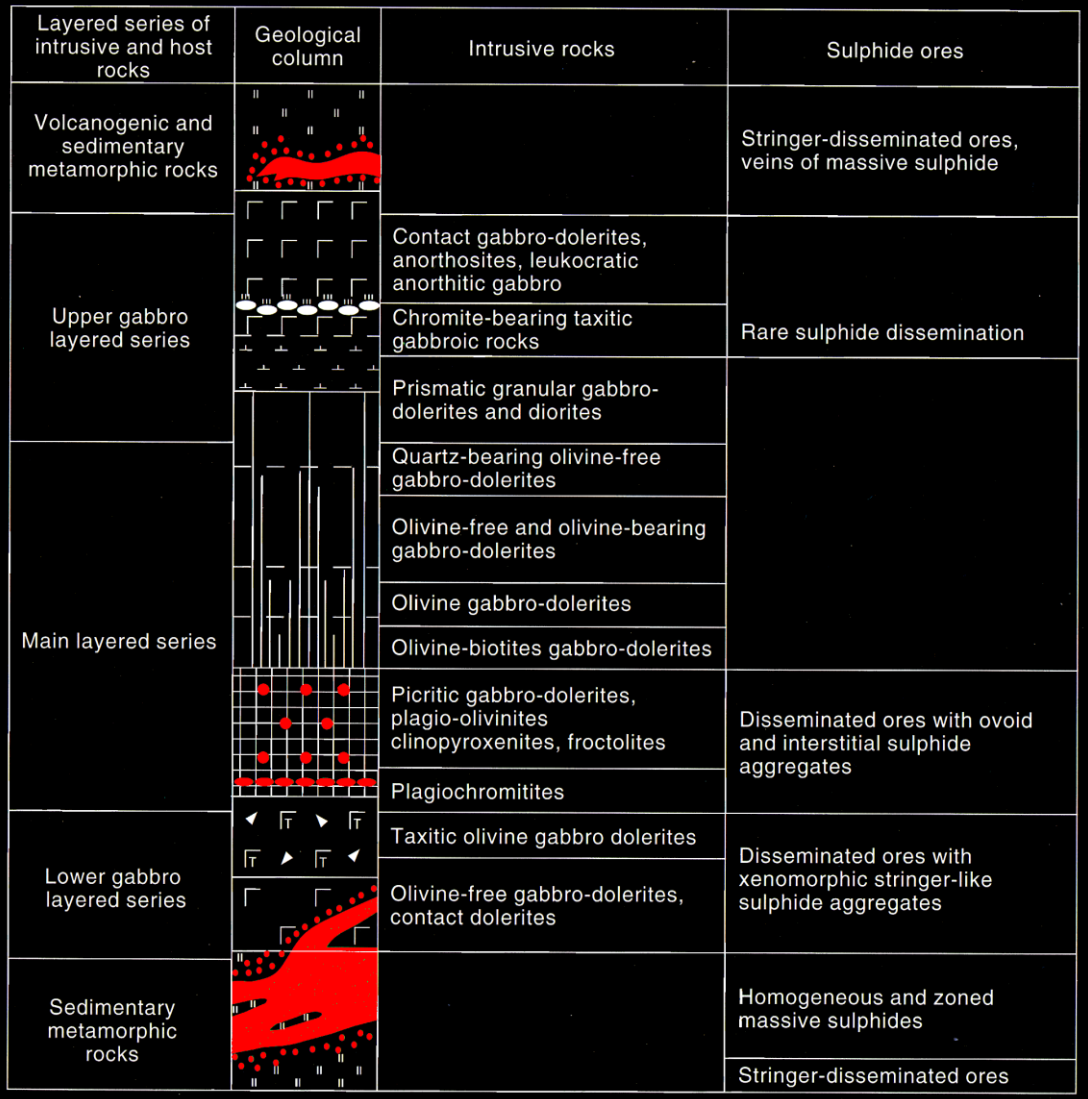
MINERALOGY: *Pyrrhotite, pyrite, pentlandite, chalcopyrite and possibly significant PGE (platinum, palladium, iridium, etc.), e.g., Noril'sk.*

ALTERATION: *None; however, sulphides may form large gossans.*

DISTRIBUTION AND SIZE:

Newfoundland… *A few small occurrence associated with ultramafic rocks in ophiolitic settings (e.g., Tilt Cove); possibly associated with layered intrusions in the Grenville, and central Newfoundland.*

NICKEL MINERALIZATION, NORIL'SK-TALNAKH



Nickel Mineralization, Komatiitic Flow

NOTE: Tilt Cove produced about 100 tonnes of nickel in the 1870's = about 20% of the world production at that time!

Labrador …… Nain Plutonic Suite (e.g.,Voisey's Bay - 150 million tonnes); Pant's lake Intrusion; Michikamau Intrusion

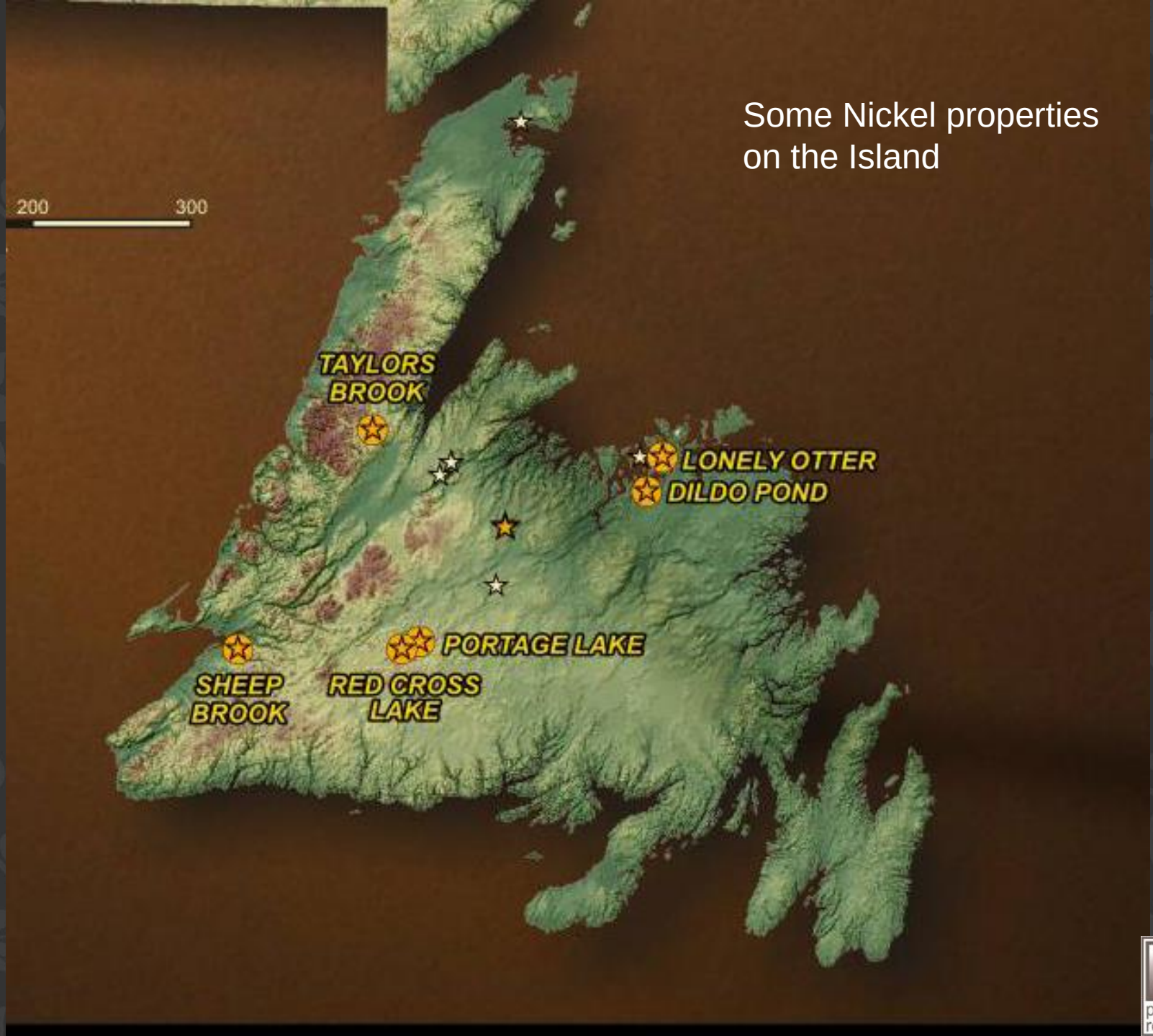
Florence Lake greenstone belt e.g., Baikie Prospect; ultramafic volcanic and intrusive rocks.

Gabbroic -ultramafic sills in the Labrador Trough.

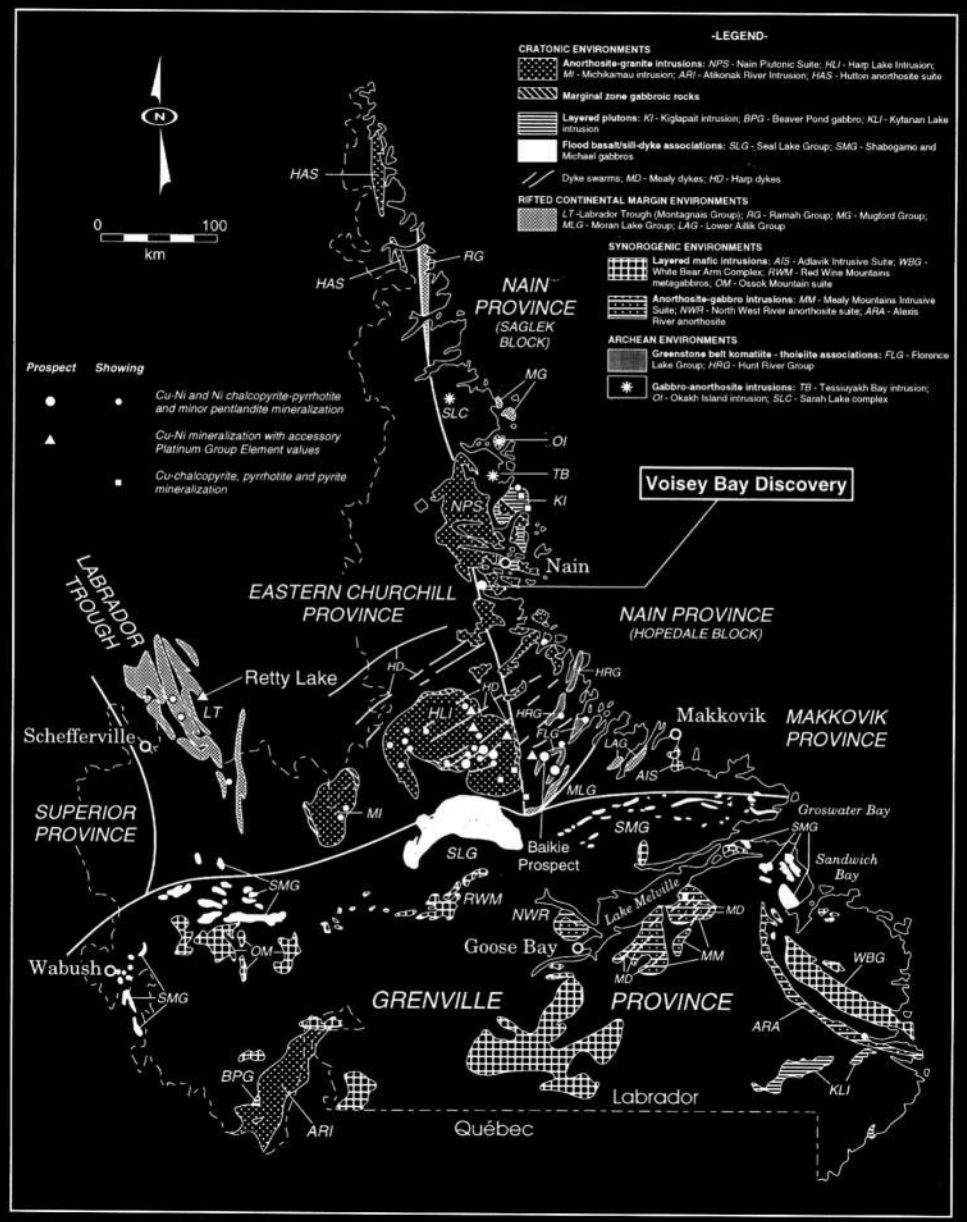
Massif-type anorthosite plutons (e.g., Harp Lake intrusion)

PROSPECTING METHODS:

Geological	Look for gossans and sulphides, ultramafic rocks weather reddish brown.
Geophysical	Pyrrhotite gives good mag response; EM for shallow deposits-disseminated ores in intrusive rocks will not respond to EM but may respond to IP. Komatiitic ores respond to EM.
Geochemical	Ni, Cu, Cobalt and PGE are good indicators.

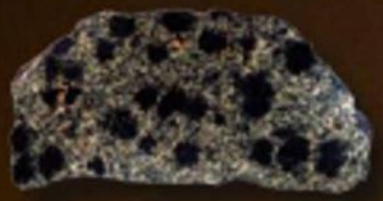


MAFIC MAGMATIC ASSOCIATION AND POTENTIAL NI-SULPHIDE ENVIRONMENTS OF LABRADOR

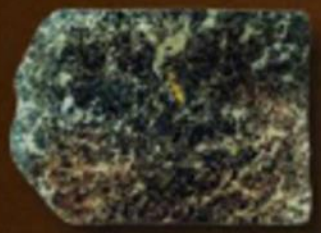


- NICKEL PROPERTIES AVAILABLE FOR OPTION
- NICKEL PROPERTIES OPTIONED
- NICKEL PROSPECTS AND SHOWINGS

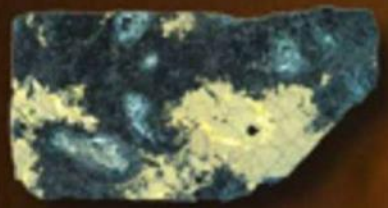
VOISEY'S BAY Ni-Cu-Co MINE



Leopard texture, mineralized gabbro or troctolite; Pant's Lake Intrusion - Labrador



High grade Nickel; Taylor's Brook Option - Newfoundland



Breccia ore; Voisey's Bay Deposit - Labrador

Core from Voisey's Bay Deposit - Labrador

Ultramafic Outcrop


Layered Troctolite-
Olivine Gabbro
Red Cross Lake

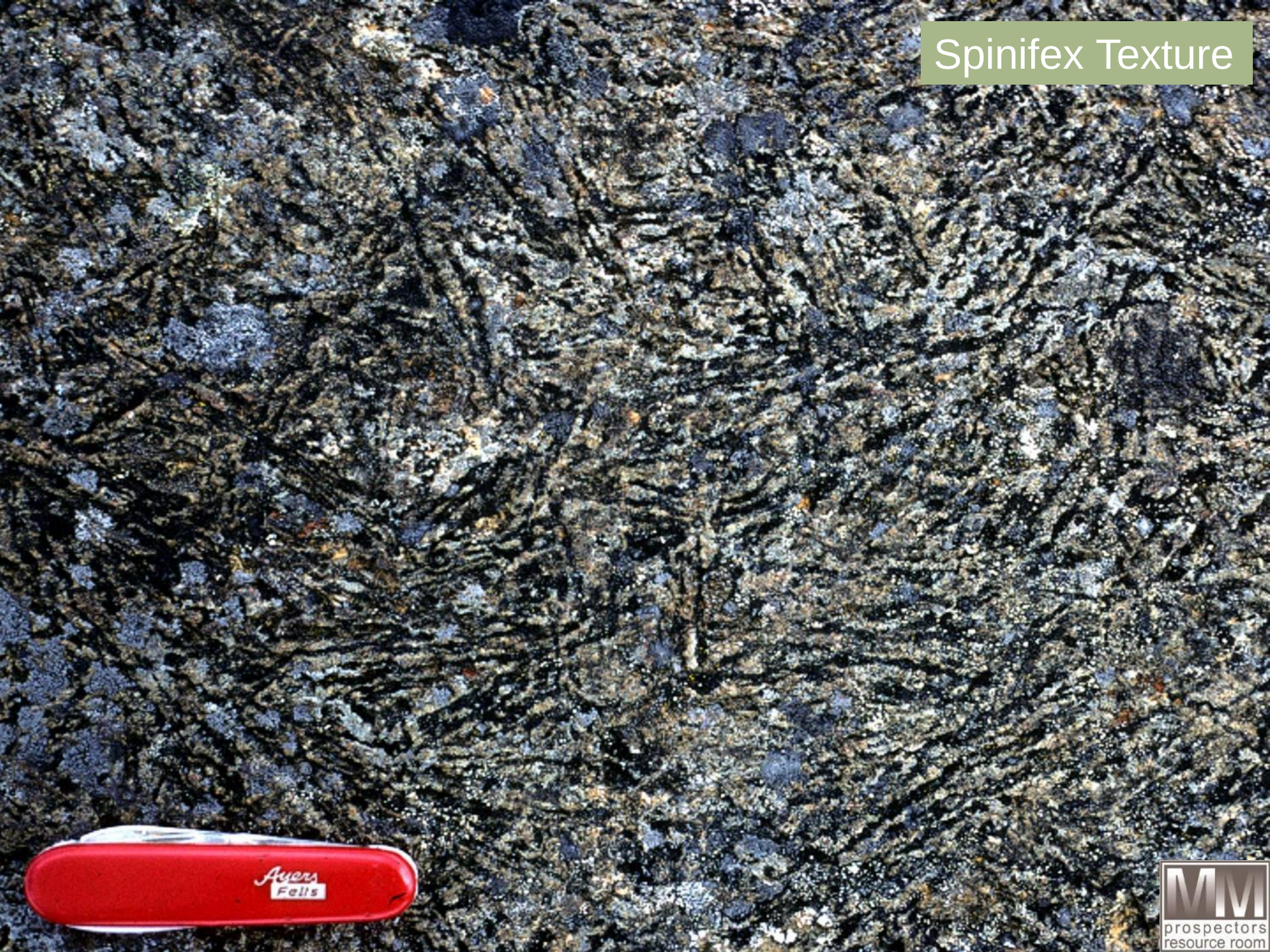

Layered Troctolite:
Voisey's Bay
MM
prospectors
resource room

Banded Pyroxenite-Peridotite

Komatiitic Flow – Florence Lake Group


Spinifex Texture
MM
prospectors
resource room

Spinifex Texture



Discovery Hill: Voisey's Bay

Massive sulphide pod: Okak Showing


Sulphides in Troctolite
MM
prospectors
resource room

Voisey Bay Ore

Voisey's Bay Ore

Voisey's Bay Disseminated (Net) Ore (Leopard Texture)

Copper and Nickel: Baikie Showing Florence Lake Group

CHROMITE DEPOSITS
(+/- PGE)

BACKGROUND: Chromite is mined almost exclusively from massive to heavily disseminated segregations in ultramafic or mafic igneous rocks. 75% of the world production comes from South Africa. Uses include stainless steel and nonferrous alloys; it really is an industrial mineral.

ENVIRONMENT: Two deposit types

i) Stratiform: (Bushveld-type)…intercratonic layered intrusive complexes (e.g., Bushveld and Stillwater) accounts for 90% of known reserves; generally of Precambrian age. PGEs may be the primary product (PGE-enriched chromitites).

ii) Podiform: (Alpine-type)…ophiolite complexes associated with orogenic belts, account for 55% of world production, generally Paleozoic or younger.


Podiform Chromite in Peridotite

CHROMITE DEPOSITS (cont'd)

STYLE:

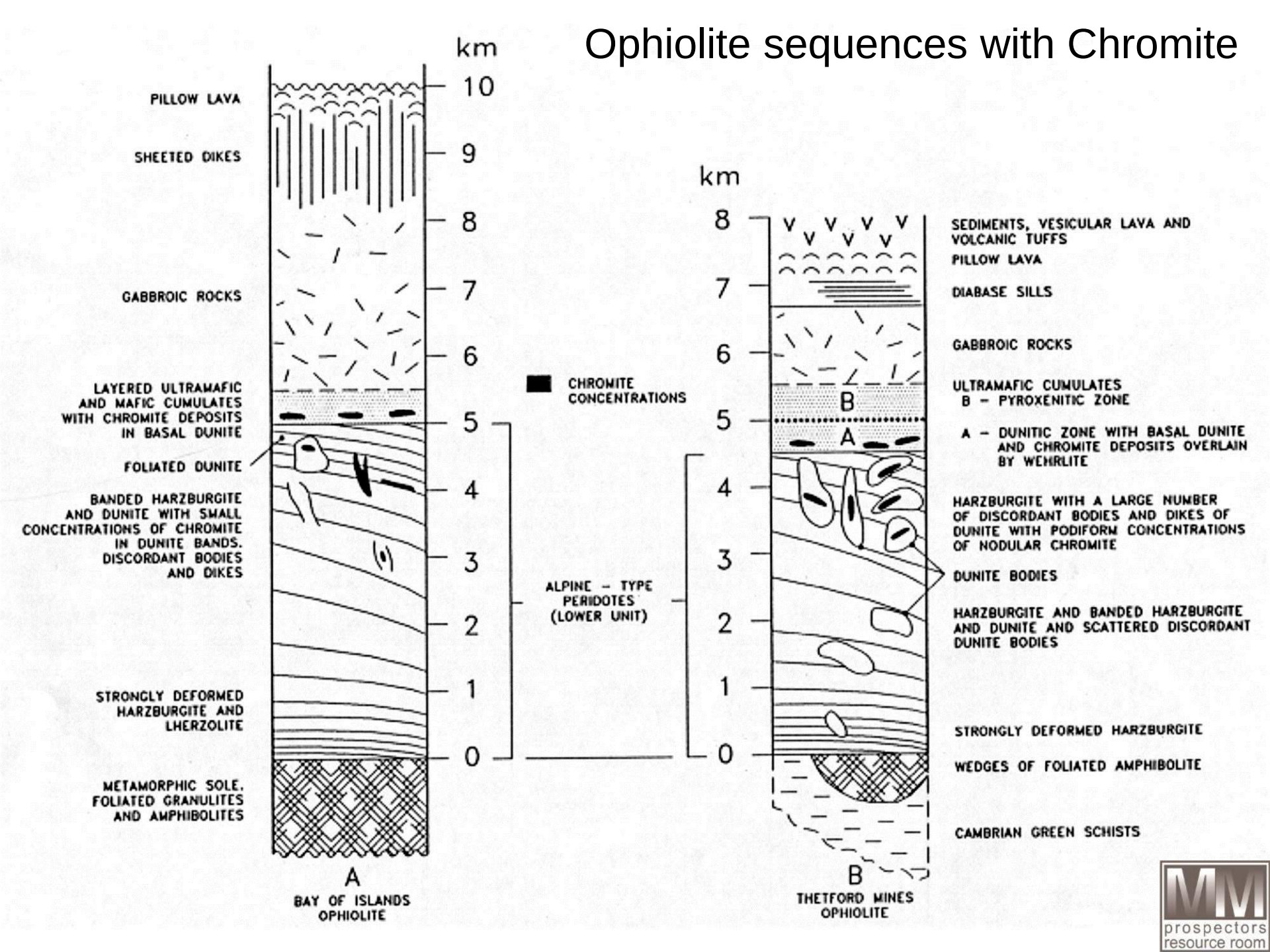
i) **Stratiform:** blanket shaped or sheet-like accumulations, in the lower parts of layered ultramafic to mafic igneous intrusions; individual chromite layers vary from <1 cm to >2m thick and may extend for kilometers. They are usually associated with ultramafic rocks.

ii) **Podiform:** disseminated and narrow layers 1 to 40 cm thick, lenticular or pod-shaped deposits that range from a few kilograms to several million tonnes. This style is discontinuous with no lateral extent. Almost exclusively in the ultramafic rocks, being most abundant in the tectonites, especially dunitic tectonites.

MINERALOGY: **Chromite** ((Mg, Fe)Cr2 O4) is the only mineral of chrome. Stratiform deposits may have associated PGEs (platinum, palladium, iridium, etc.).

ALTERATION: None; however, ultramafic host rocks typically weather reddish-brown.

Ophiolite sequences with Chromite



Chromite (cont'd)

DISTRIBUTION:

Newfoundland….Numerous small podiform deposits associated with the Cambro-Ordovician ophiolites sequences.Largest are Springer Hill and Bluff Head in the Lewis Hills Massif; marine placers occur in western Newfoundland.

Labrador……Large layer intrusions offer the best potential.

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

MAFIC MAGMATIC ASSOCIATIONS AND POTENTIAL NI-SULPHIDE ENVIRONMENTS OF LABRADOR

Chromite (cont'd)

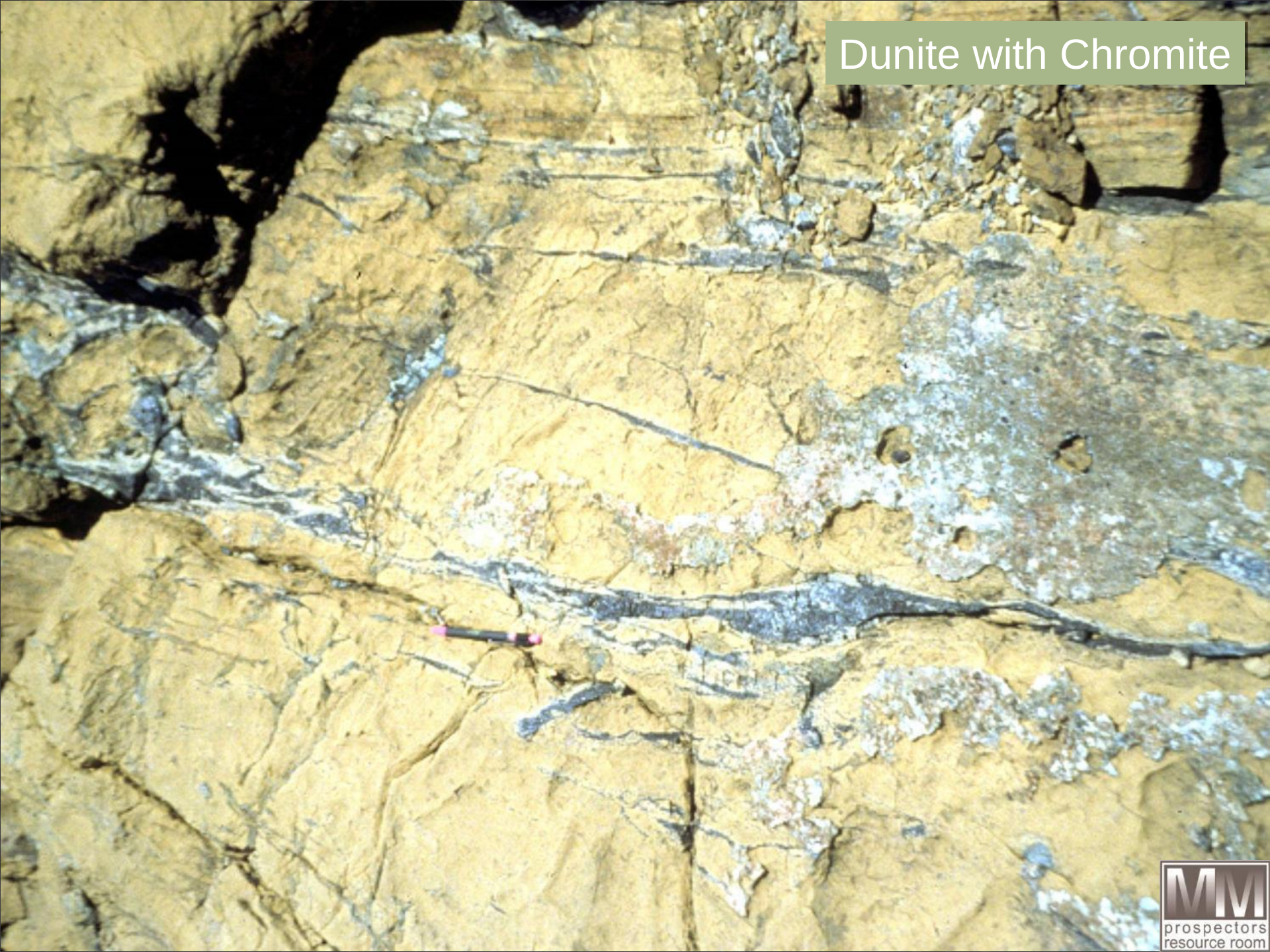
PROSPECTING METHODS:

Geological: Gossans formed by oxidation of sulphides; ultramafic rocks weather reddisn-brown / brown. Peridotite host for podiform mineralization; pyroxenite and gabbro hosts for stratiform mineralization.

Geophysical: Does not respond geophysically; however,associated sulphide may be responsive.

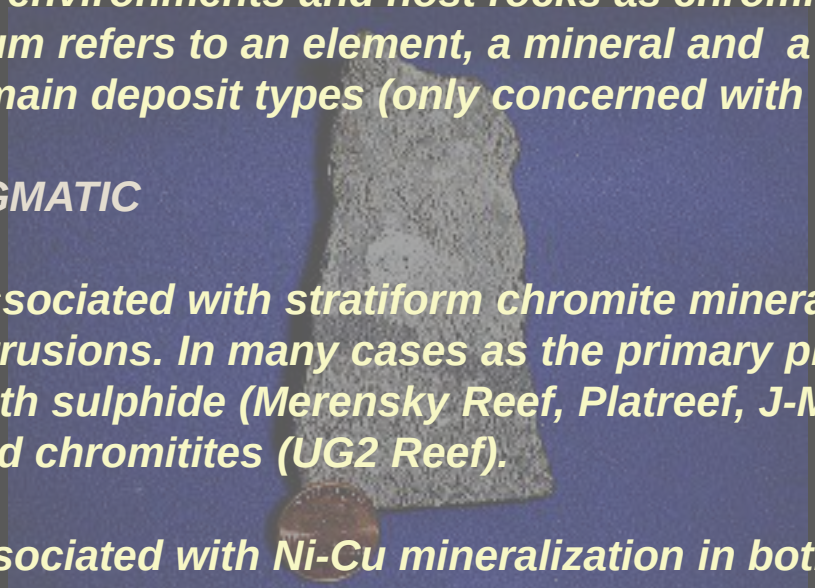
Geochemical: Cr, Ni, Cu, Co anomalies; panned concentrates from streams or tills

Ultramafic Outcrop Bursey's Hill,Gander


Dunite with Chromite
MM
prospectors
resource room

Chromite in Ultramafic Rock

PLATINUM GROUP ELEMENT (PGE) DEPOSITS



ENVIRONMENT: ***Similar environments and host rocks as chromite and nickel-copper. (Platinum refers to an element, a mineral and a mineral group. Three main deposit types (only concerned with magmatic here):***

1. MAGMATIC

i) Associated with stratiform chromite mineralization in layered intrusions. In many cases as the primary product associated with both sulphide (Merensky Reef, Platreef, J-M Reef, Great Dyke) and chromitites (UG2 Reef).

ii) Associated with Ni-Cu mineralization in both layered plutons (Sudbury, Noril'sk), and extrusive rocks (komatiites) (Kambalda, Thompson); associated with sulphides and is a by-product.

iii) Alaskan-type...zoned, concentric ultramafic to mafic intrusions of dunitic composition. High grade, low tonnage deposits; occurs as a primary product and is associated with chromitite and sulphides.

PGE (cont'd)

2. ALLUVIAL

i) Placer: platinum was discovered by the Spanish in stream beds with detrital gold in Columbia in mid-16th-century (the Rio Platino del Pinto). As the unknown metal has an extremely high melting point, it was regarded as useless and hindrance to the refining of gold, and was called platino meaning silver of poor quality. Most commonly spatially associated with ultramafic/mafic complexes of the Alaskan-type examples, Columbia, Urals.

ii) Paleoplacer: only known significant deposit is the auriferous-uraniferous conglomerates of the Witwatersrand.

3. HYDROTHERMAL: formed from epigenetic fluids and associated with shear zones cutting mafic/ultramafic host rocks with alkaline porphyry, copper-precious metal deposits and with late diagenetic flow of metal-bearing brines in carbonaceous sediments.

PGE (cont'd)

ORIGIN: Magmatic processes; placer; deuteric alteration; epigenetic fluids

MINERALOGY: PGE (platinum, palladium, iridium, Os, Ru, Rh): pyrrhotite, pyrite, pentlandite, chalcopyrite and Au.

ALTERATION: None; however, associated sulphides may form gossans.

DISTRIBUTION:

Newfoundland: Layer plutons in central NL, such as the Red Cross Lake intrusion, and those in the Grenville of Western NL.

Labrador: i) Massif-type anorthosite plutons in the Nain, Churchill and Grenville provinces, e.g., Harp Lake Intrusive Suite.

PGE Distribution in Labrador (Cont'd)

ii) Layered gabbroic plutons such as the Kiglapait Intrusion. Others include gabbros associated with the Nain Plutonic Suite, Harp Lake, etc.

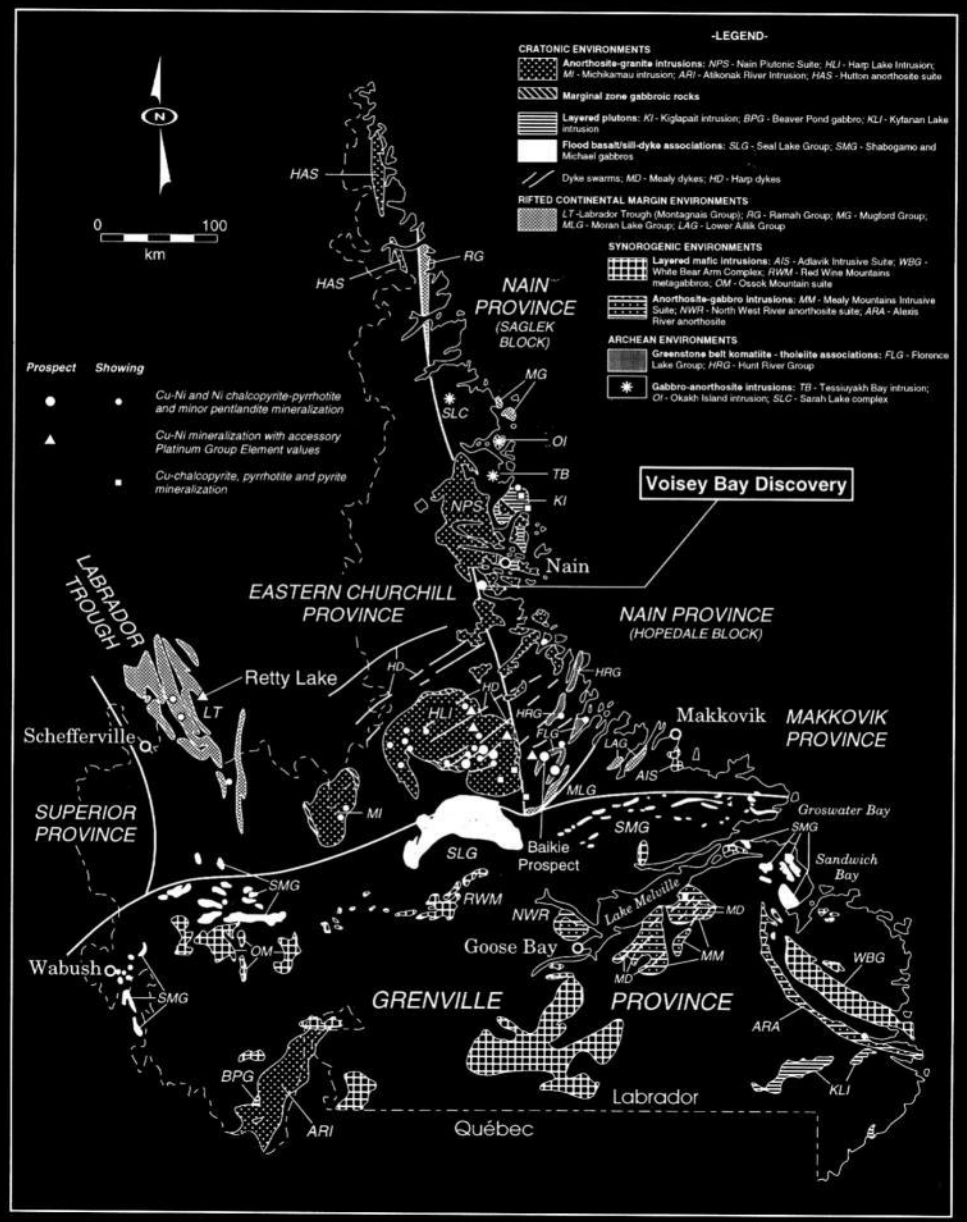
iii) Massive to weakly layered plutons. Examples include gabbro and norite Intrusions within the Grenville and include the Shabogamo, Red Wine Mts and White Bear Arm intrusive suites.

iv) Gabbro and ultramafic sheets and sills, includes high level intrusions located within or adjacent to supracrustal sequences, e.g., Labrador Trough sills (Retty Lake), basaltic rocks of the Seal Lake Group, ultramafic sills in Archean greenstone belts.

v) Archean layered anorthosite-gabbro-ultramafic intrusives. Sheet-like bodies In reworked Archean rocks of the northeastern Churchill Province and the Nain Province

vi) Hornblende gabbro-diorite-monzonite intrusions, e.g., Adlavik Intrusive Suite of eastern Labrador.

MAFIC MAGMATIC ASSOCIATION AND POTENTIAL NI-SULPHIDE ENVIRONMENTS OF LABRADOR



PGE (Cont'd)

Prospecting Methods

Geological: Gossans formed by oxidation of sulphides; ultramafic rocks Weather reddish-brown / brown.

Geophysical: Associated sulphides; pyrrhotite gives a good mag response; Komatiitic ores respond to EM; disseminated ores in intrusive rocks will not Respond to EM, but may respond to IP.

Geochemical: Ni, Cu, Co and PGE anomalies; panning.

Platinum