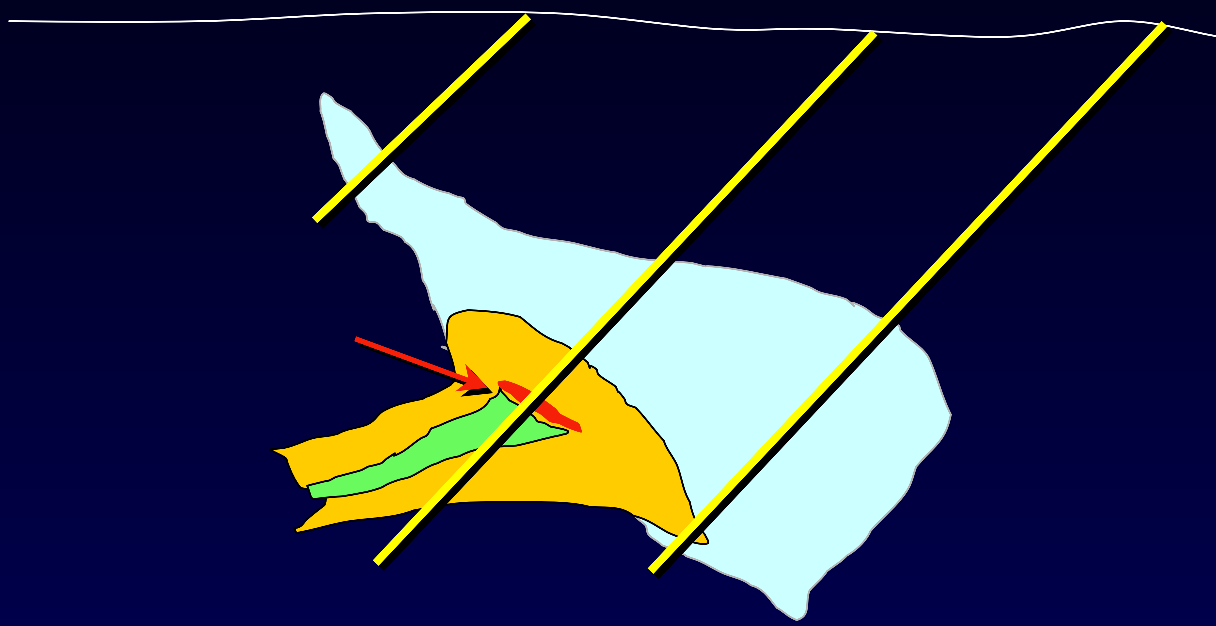
Lithogeochemical Halos: VHMS and SEDEX



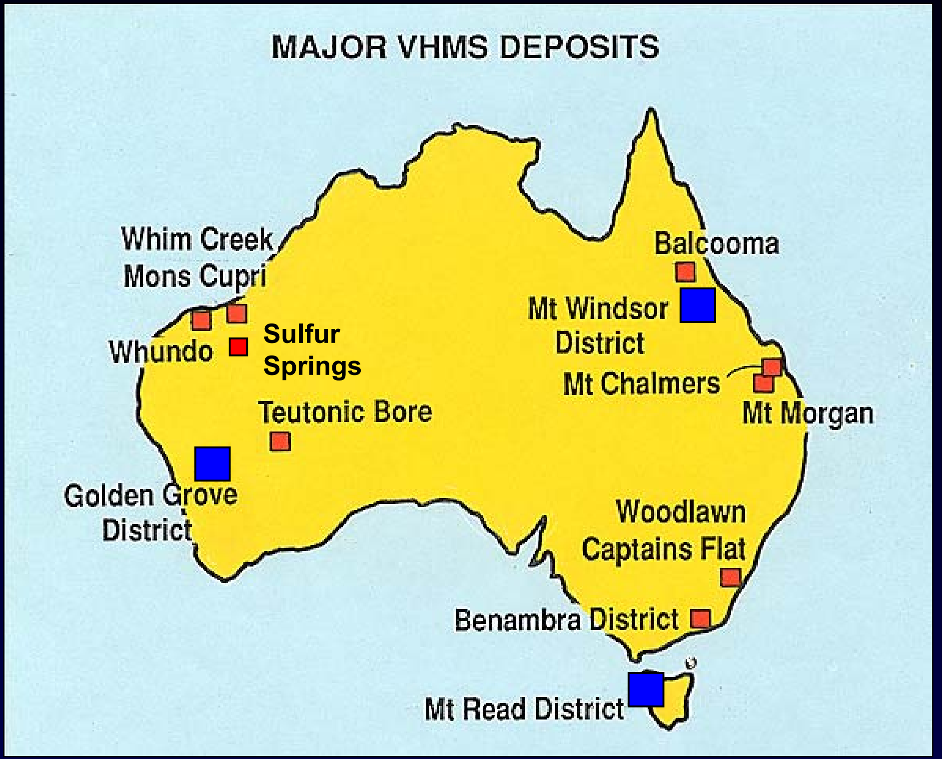
Ross R. Large
Centre for Ore Deposit Research (CODES)
University of Tasmania

Use of alteration Lithogeochemistry in Exploration

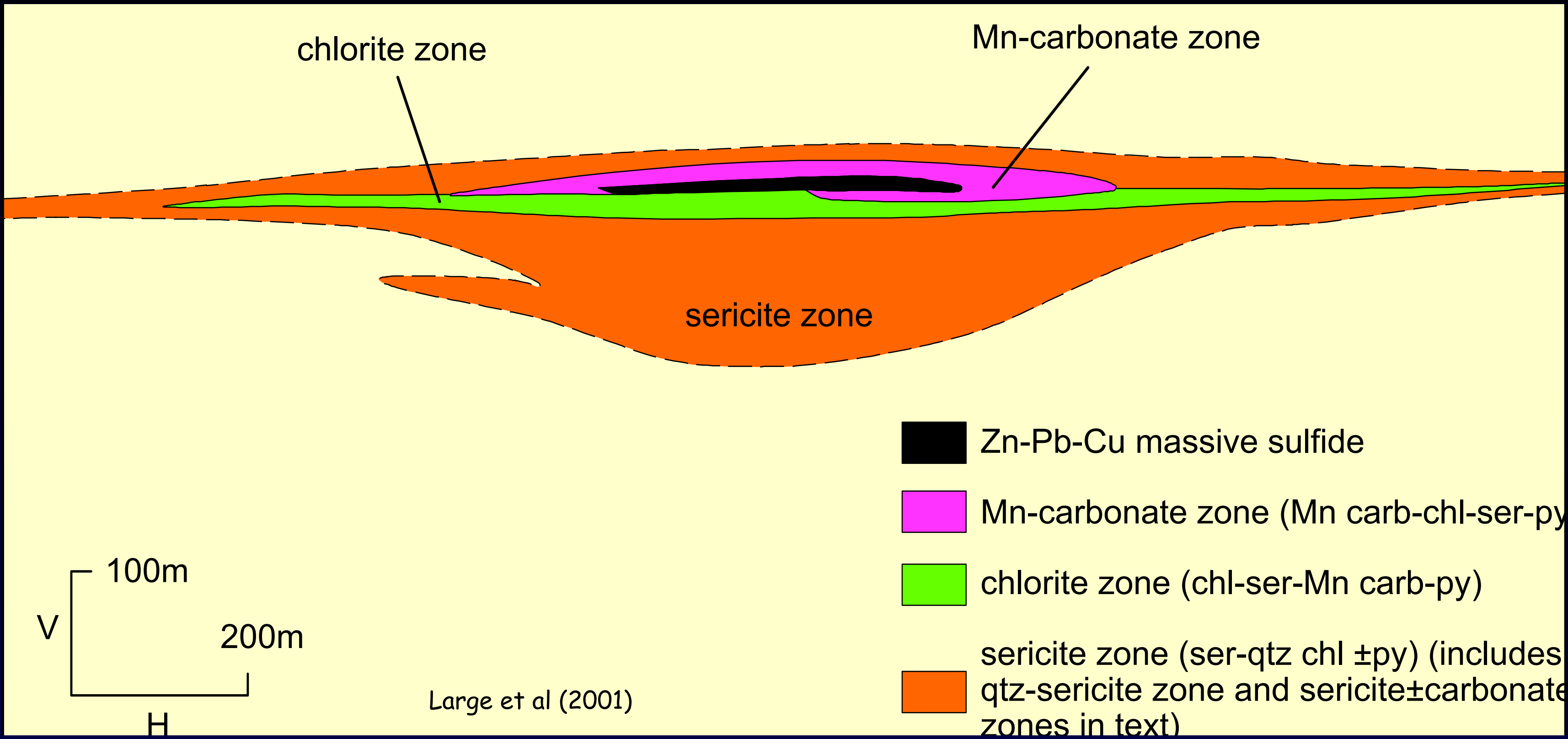
- VHMS deposits (AMIRA P439)
- SEDEX deposits (AMIRA P384 & 384A)

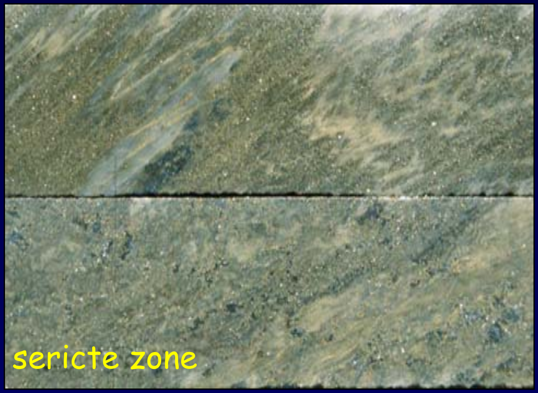
CODES-AMIRA VHMS Alteration Project

- 3 years
- 11 industry & government sponsors
- 8 staff & 9 PhD/MSc students
- Regional and deposit scales

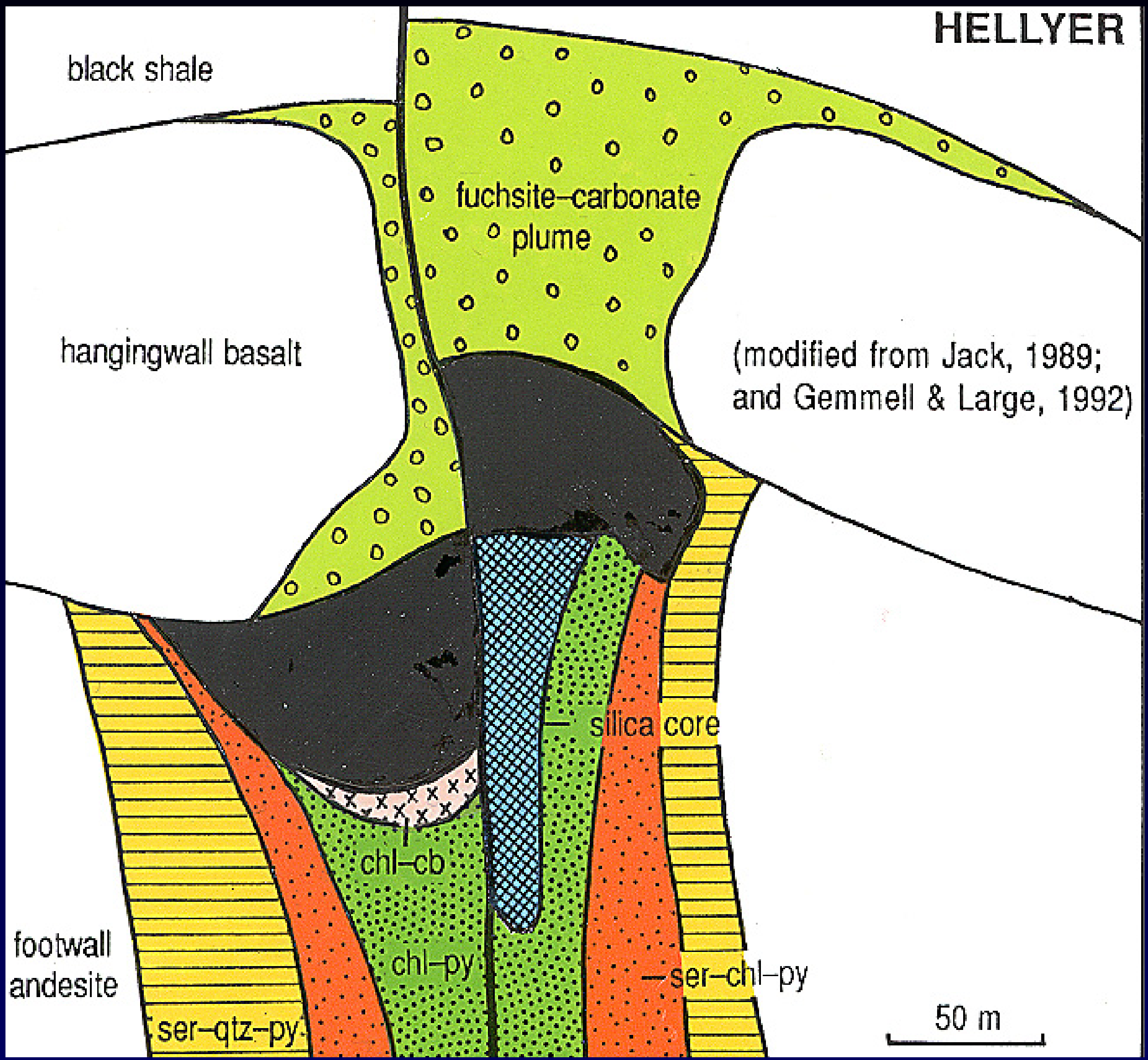


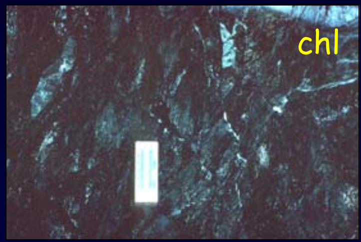
Rosebery Cu-Zn-Pb: Alteration Zonation

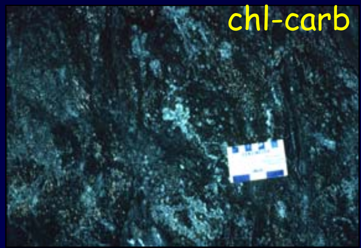




Hellyer Zn-Pb-Cu –Alteration Zonation







The Alteration Box Plot for VHMS Systems

- **Based on the Ishikawa alteration index developed for Kuroko deposits**

- **AI** $= \dfrac{100(MgO+K_2O)}{(MgO+K_2O+Na_2O+CaO)}$

elements added by alteration
chlorite & sericite alteration

elements subtracted by alteration
replacement of plagioclase & glass

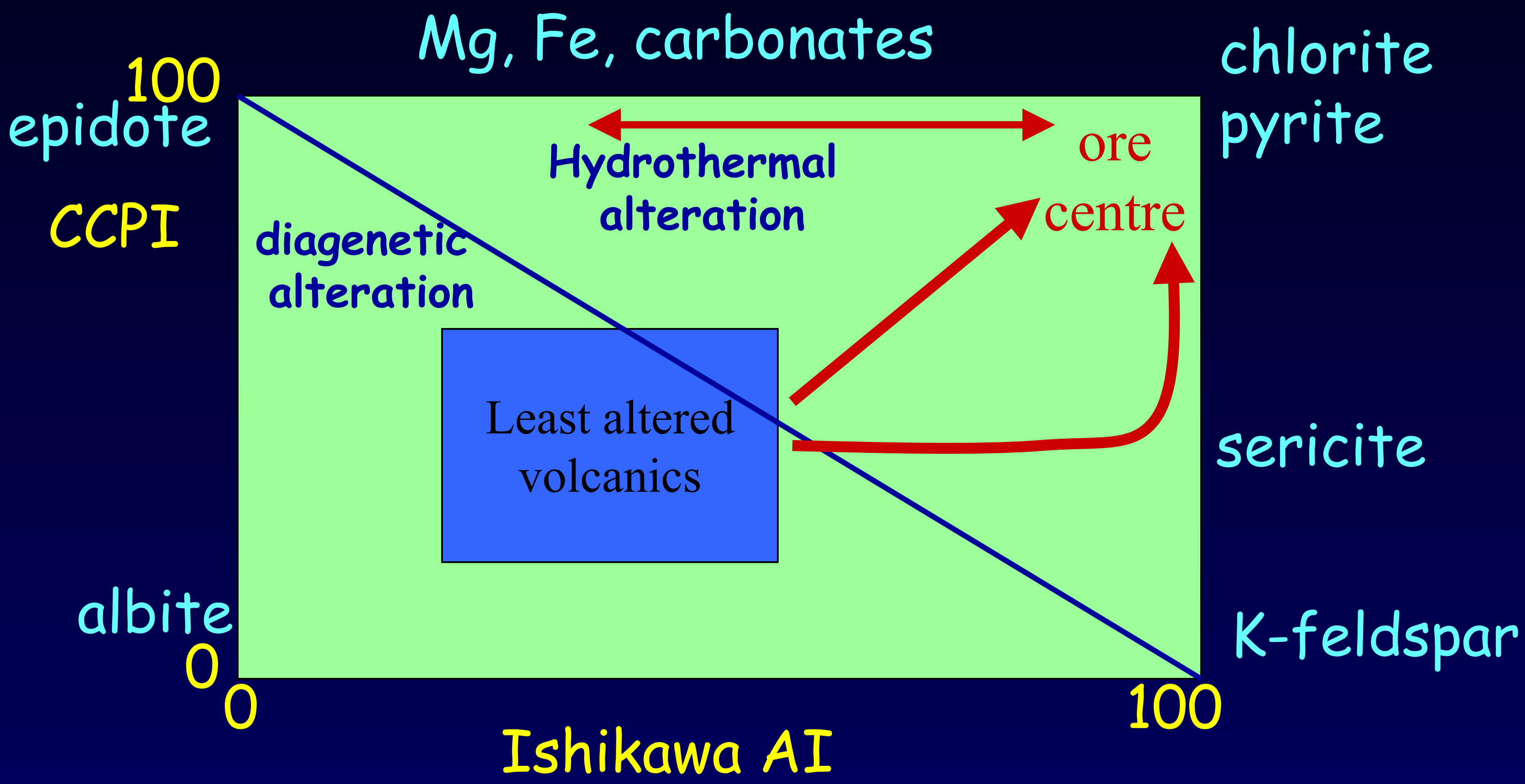
- **Varies from ~40 (unaltered) to 100 (altered)**

Other VHMS vector

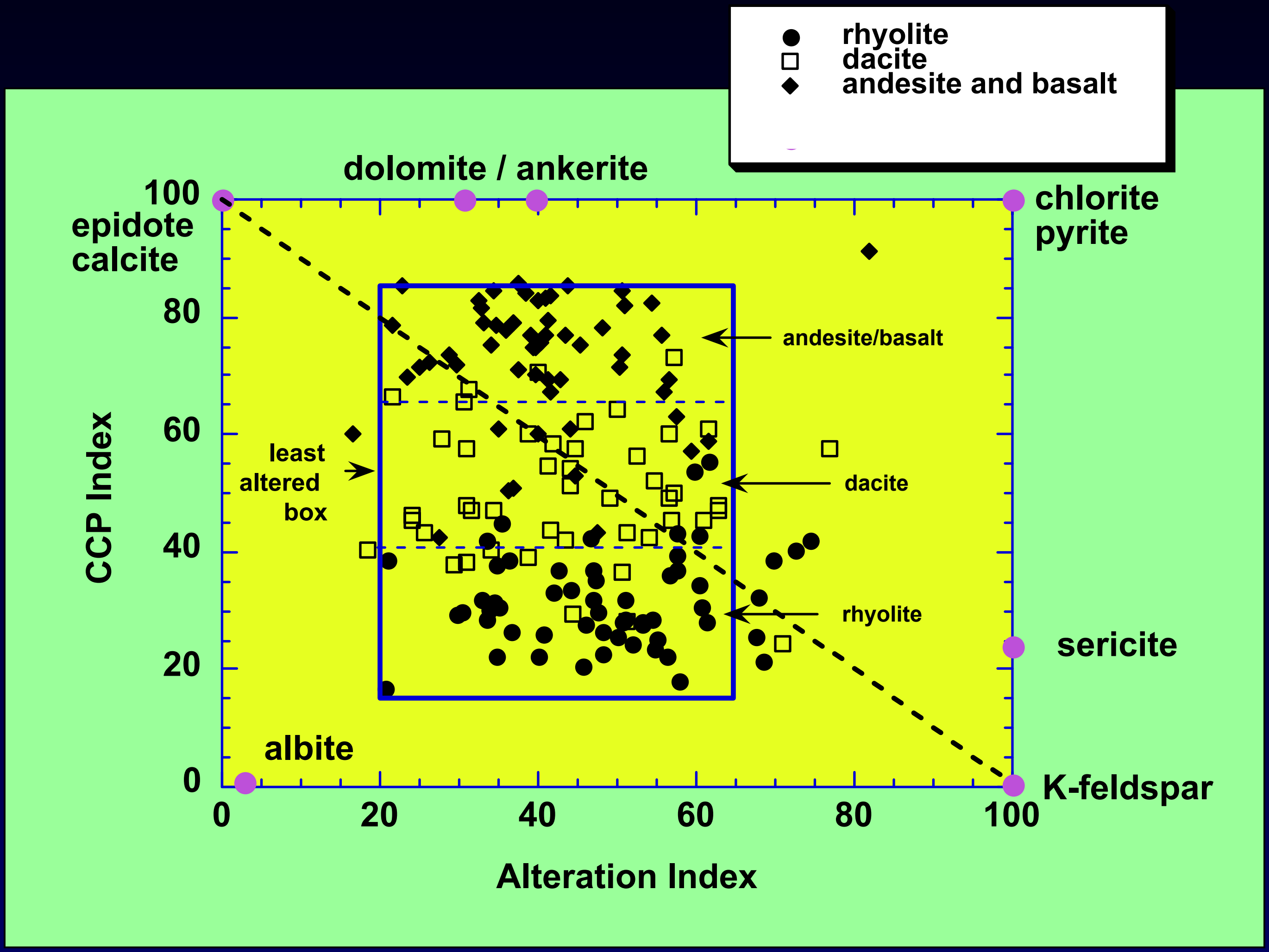
- Chlorite-carbonate-pyrite index: CCPI
- Measures the intensity of these proximal alteration minerals
- $$CCPI = \frac{100(MgO+FeO^*)}{(MgO+FeO^*+Na_2O+K_2O)}$$
- Enables the separation of chlorite, sericite and carbonate alteration.

VHMS Alteration Box Plot

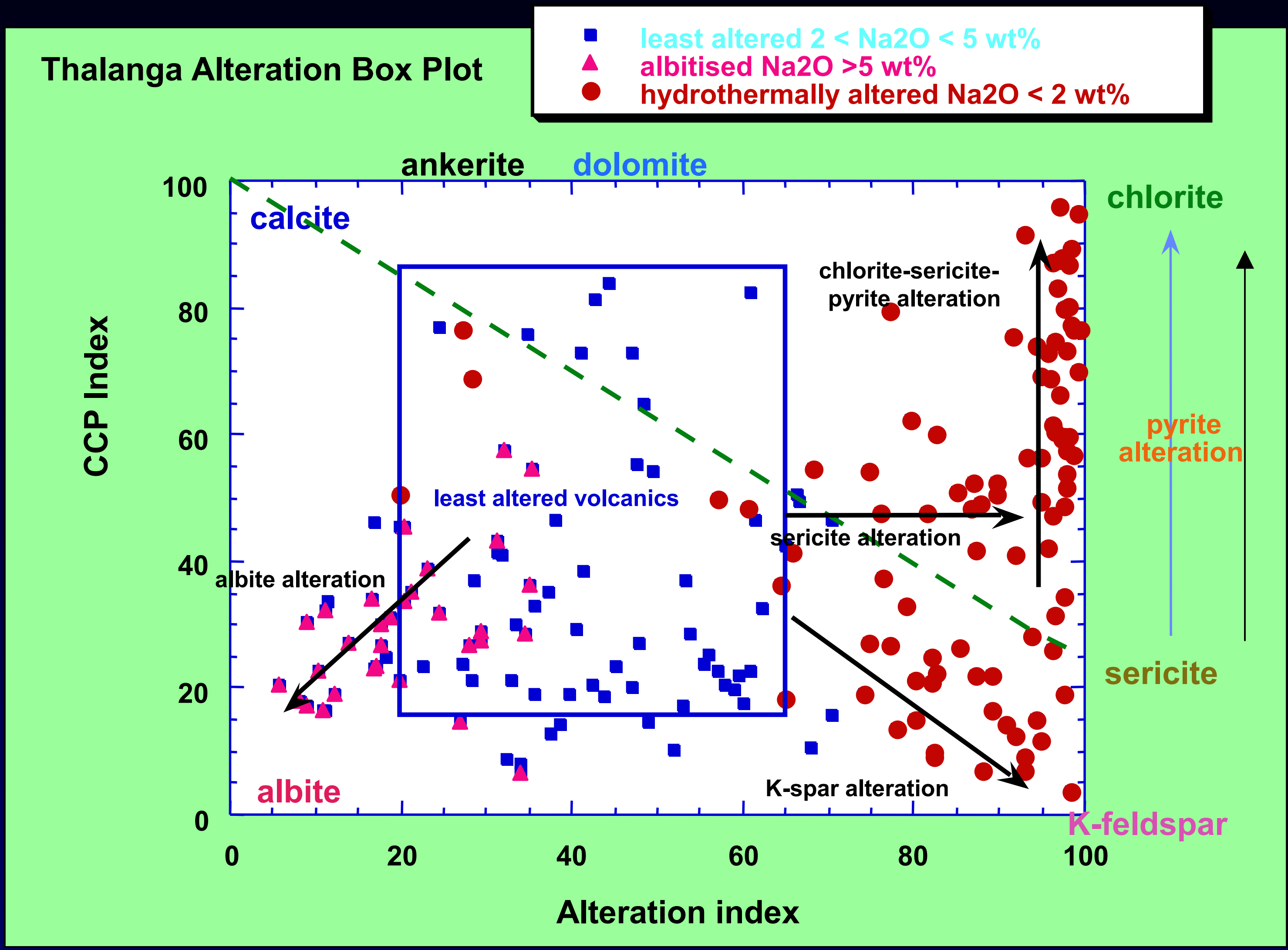
Large, Gemmell, Herrman, Paulick & Huston (2001)



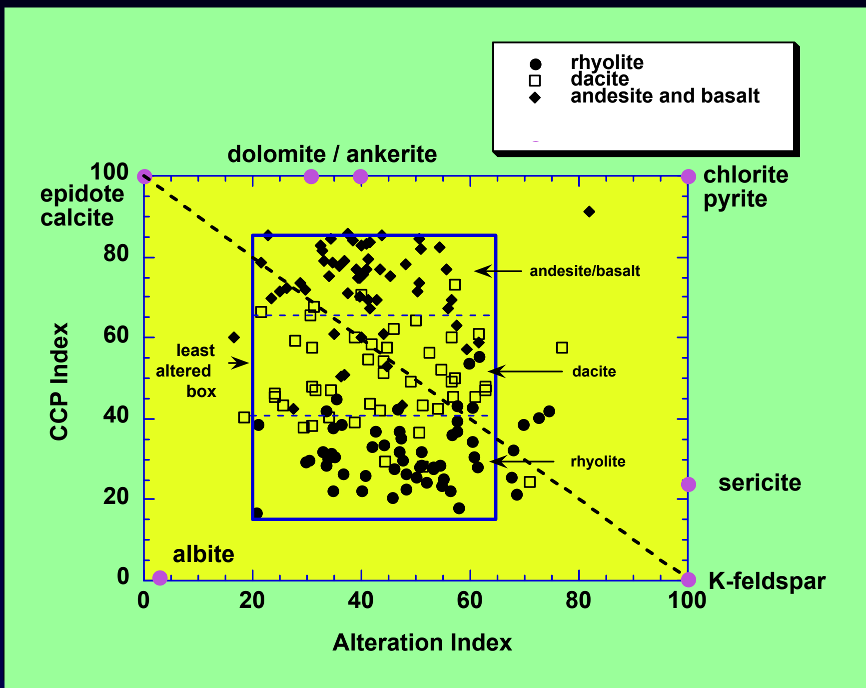
Least altered volcanics
Mt Read Volcanic Belt



Example; Thalanga VHMS



Advantages of alteration vector plots



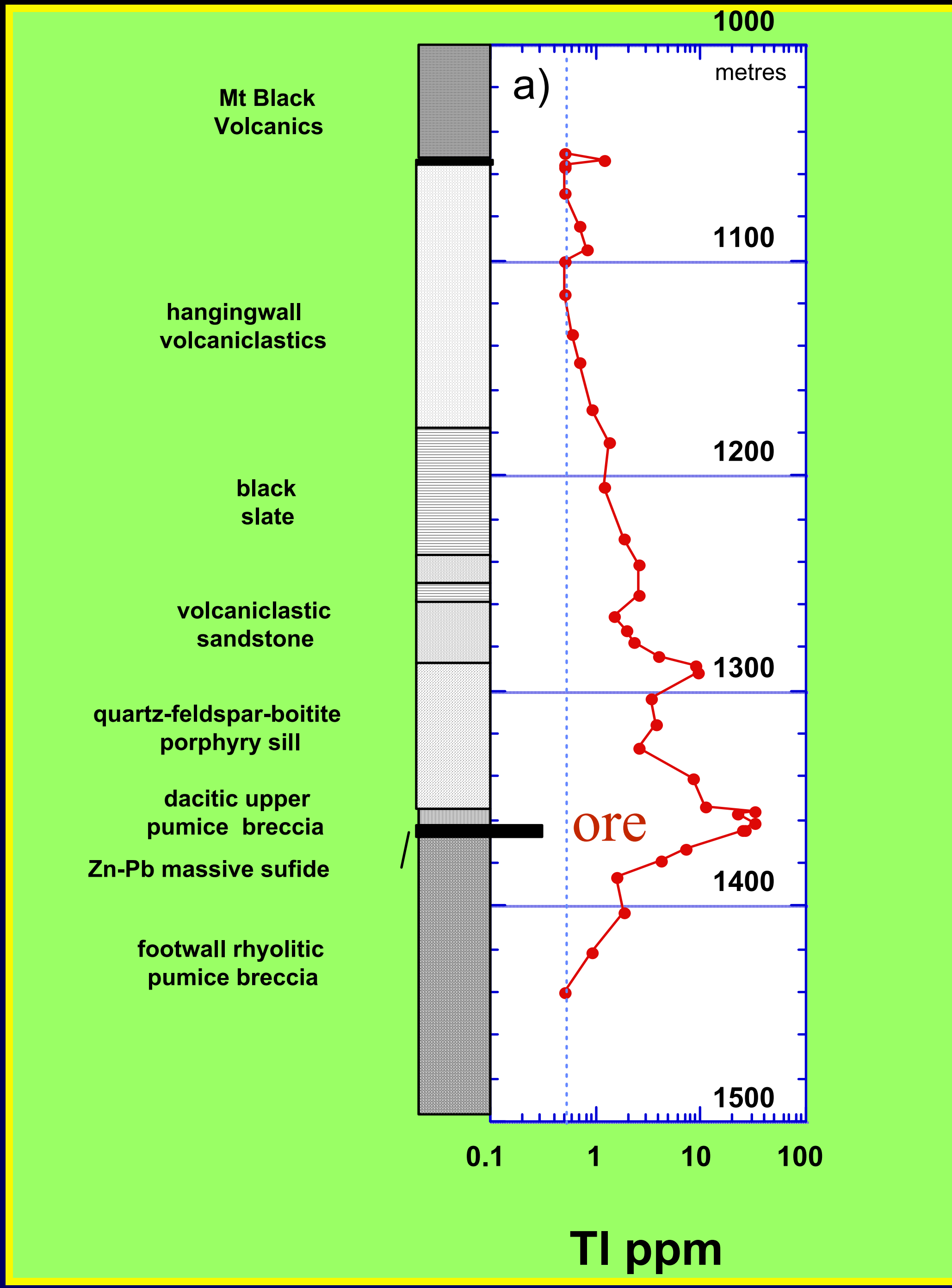
- Simple to apply
- Defines least altered rocks
- Relates geochemistry to mineralogy
- Shows alteration trends
- Defines very weak alteration
- Distinguishes hydrothermal alteration from diagenetic and metamorphic "alteration"

Best Halos and Vectors

- Ishikawa AI
- Mn
- S/Na_2O
- Ba/Sr
- Tl and Sb

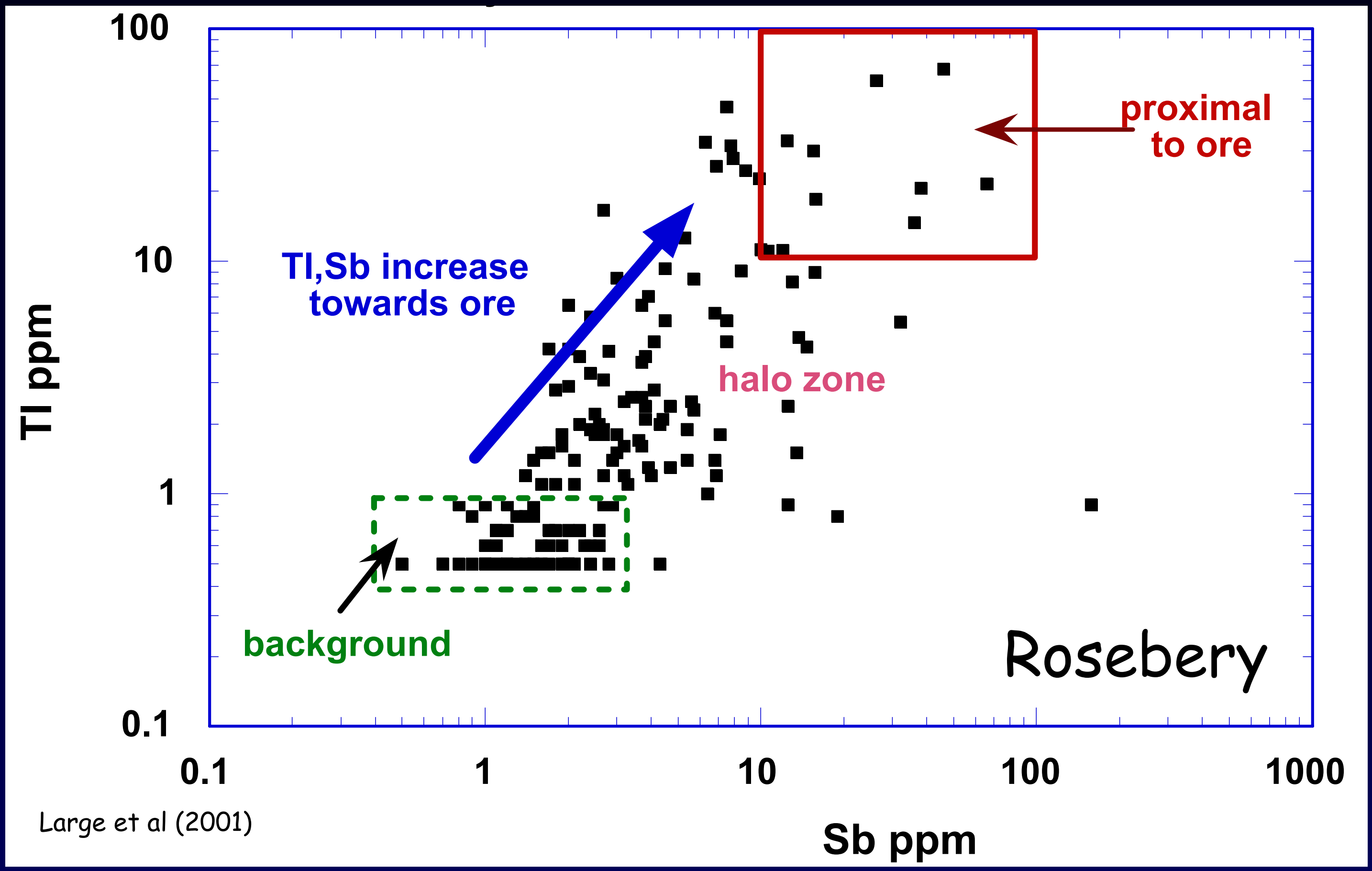
↓ Increasing size

Rosebery thallium halo



Thallium and Antimony Halos

- very useful vectors for polymetallic VHMS deposits

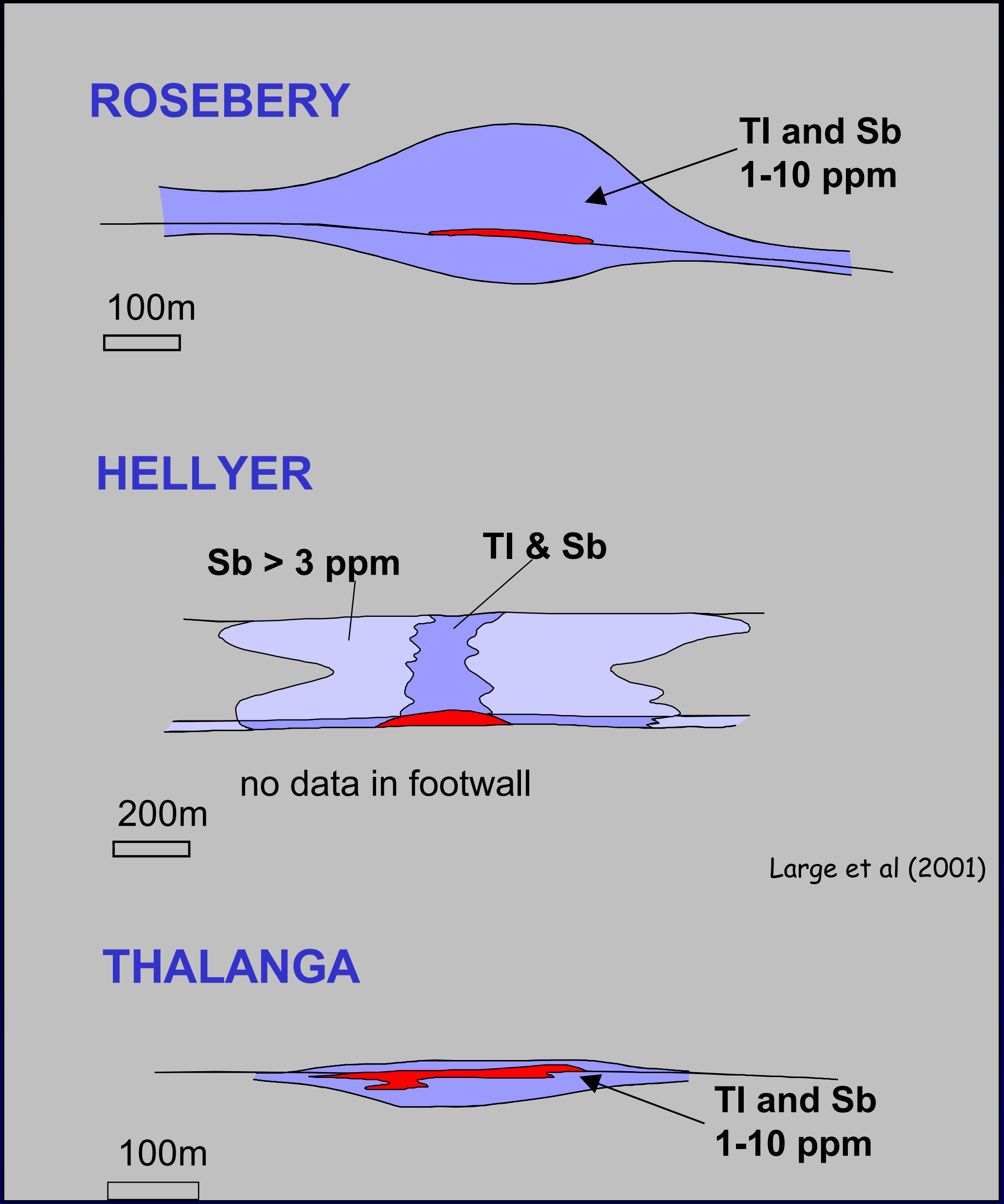


Thallium and Antimony Halos

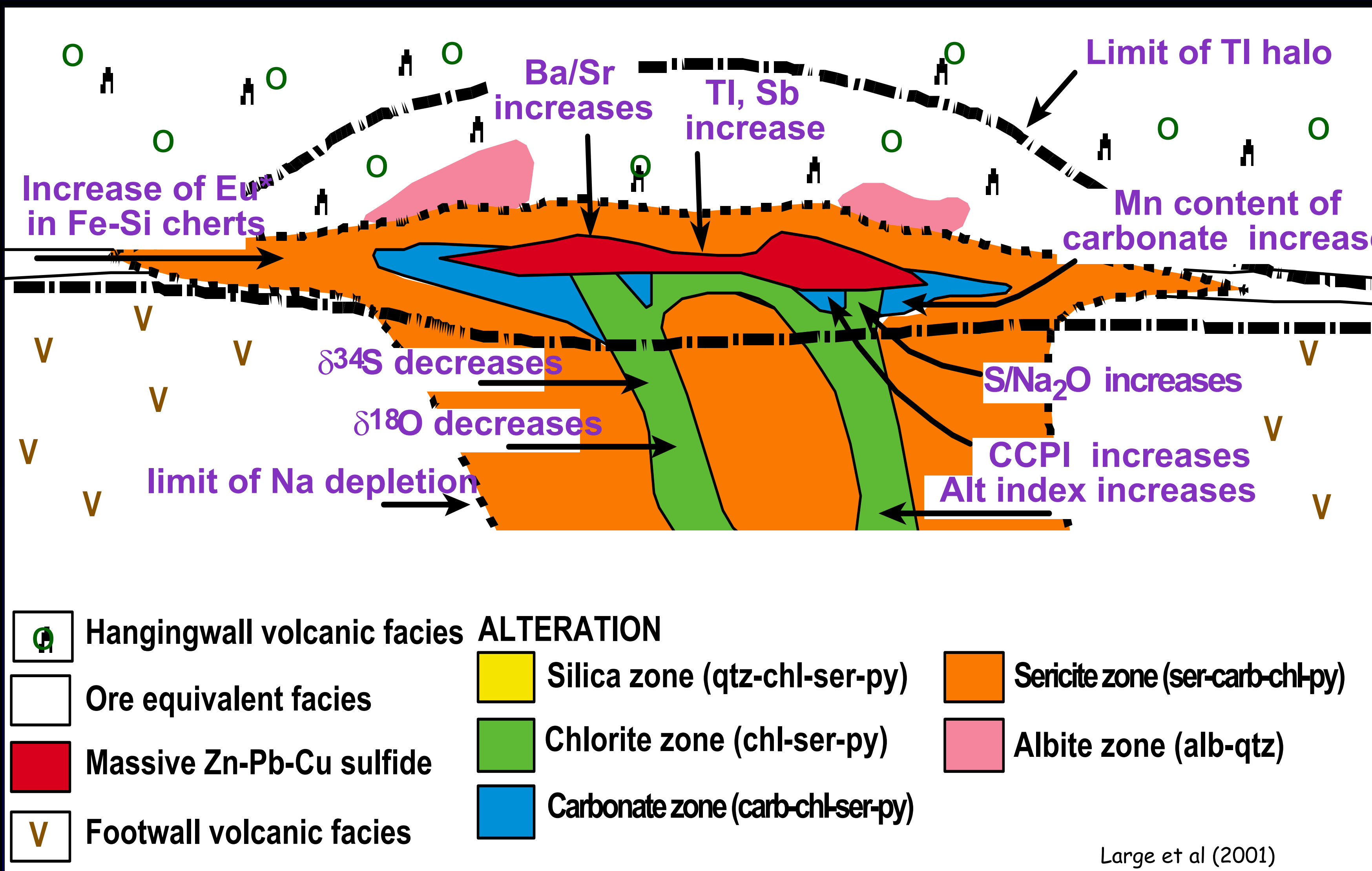
- Up to 100ppm Tl and Sb proximal to ore and 1-10 ppm within halo zone

- Sb and Tl halo within favourable horizon and extending vertically and laterally into hangingwall

- Tl (> 1 ppm) up to 50 m into HW and FW and along favourable horizon

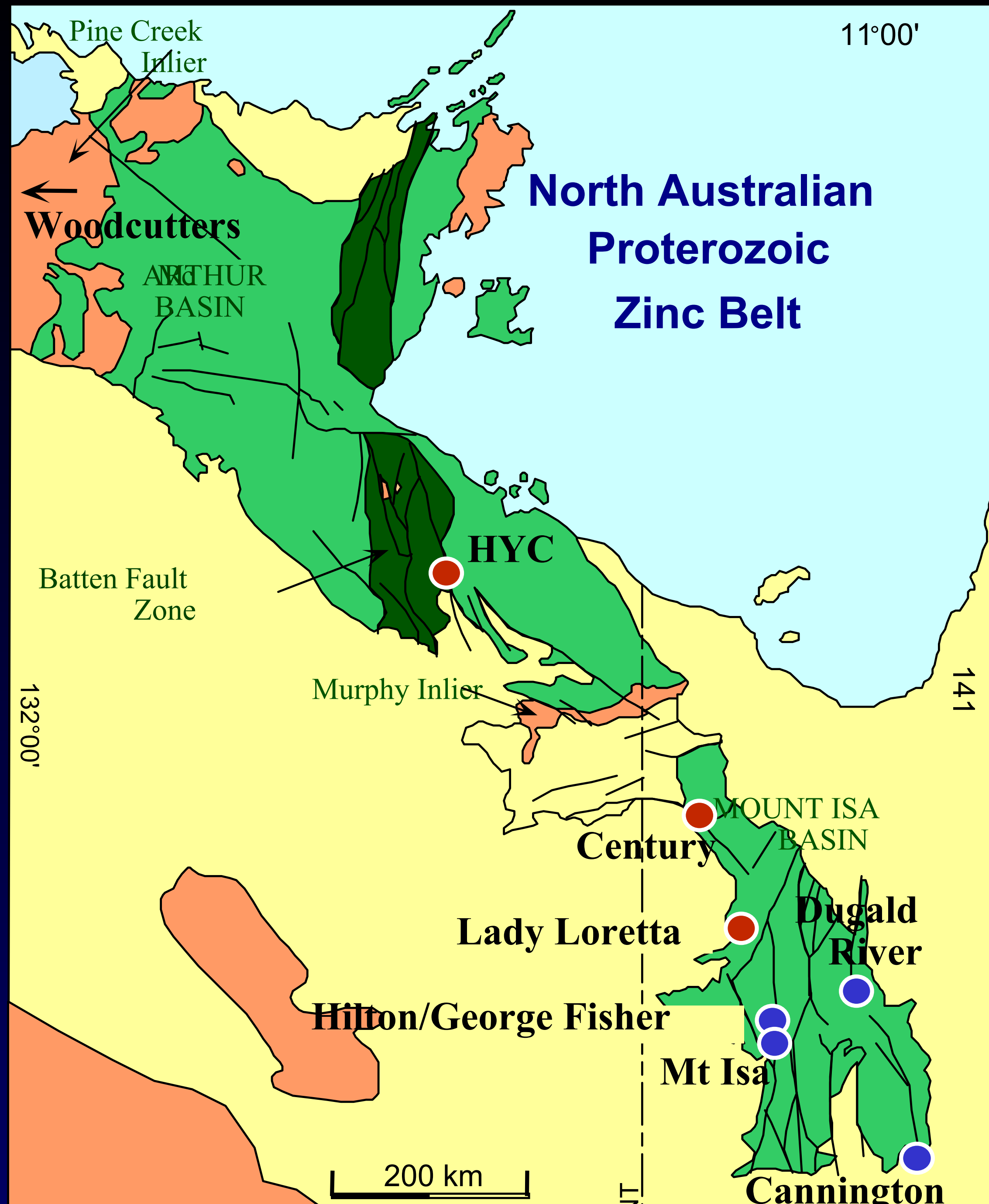


Zn-rich Polymetallic VHMS Deposits



Halos and Vector Diagrams for SEDEX Systems (AMIRA P384)

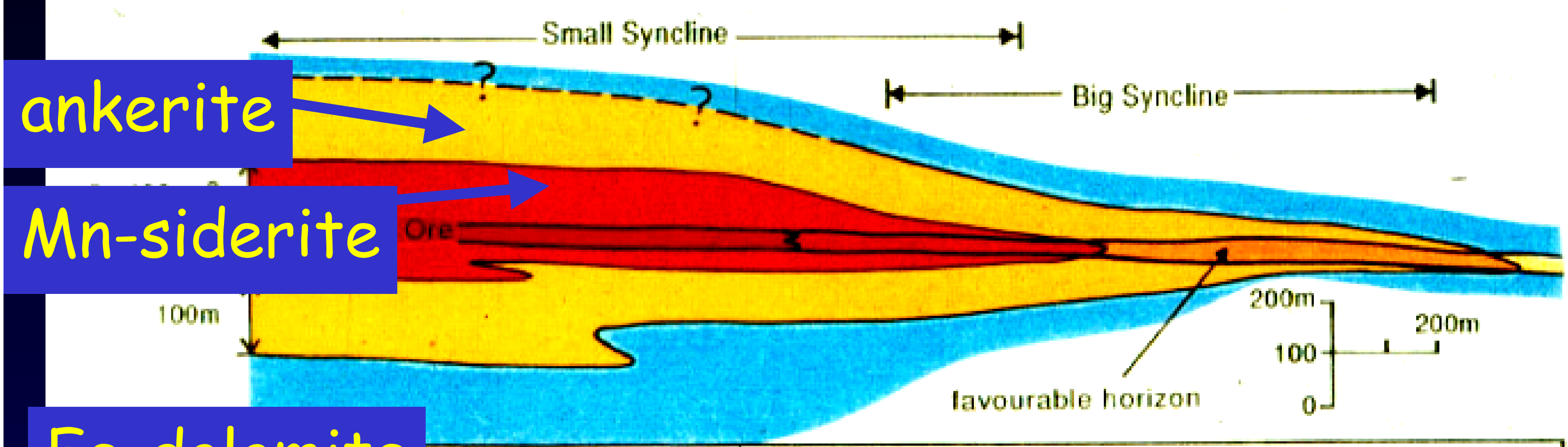
- Based on research at Lady Loretta and HYC
- Controlled by the change in chemistry of carbonate minerals as you approach the orebody.
- Dolomite -> ferroan dolomite -> ankerite -> Mn-siderite -> Zn-Pb ore



North Australian Proterozoic Zinc Belt
Pine Creek Inlier
11°00'
Woodcutters
McARTHUR BASIN
HYC
Batten Fault Zone
Murphy Inlier
132°00'
141
30'
MOUNT ISA BASIN
Century
Lady Loretta
Dugald River
Hilton/George Fisher
Mt Isa
Cannington
200 km

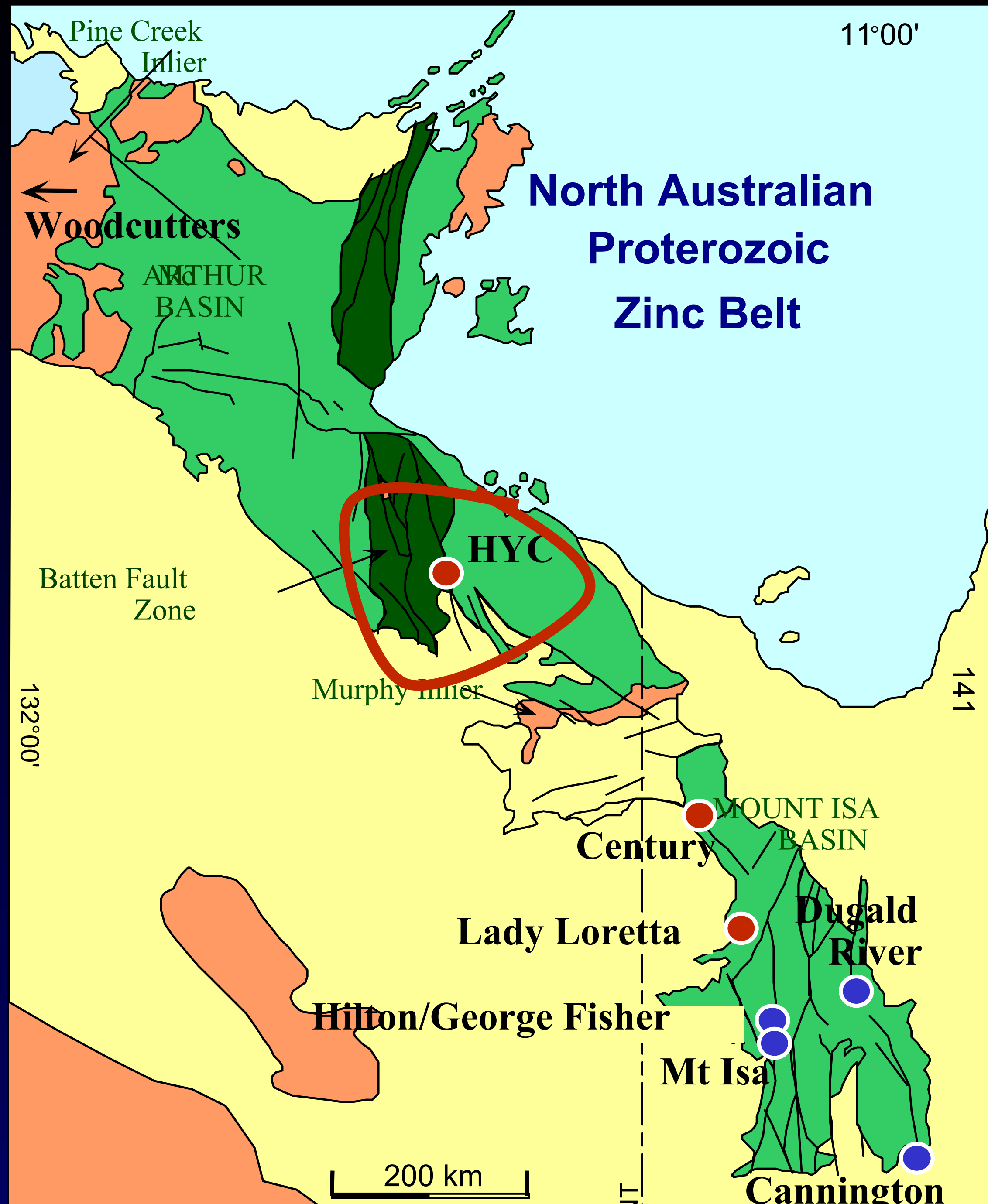
Fe-Mn-carbonate halo model

LADY LORETTA HALO MODEL



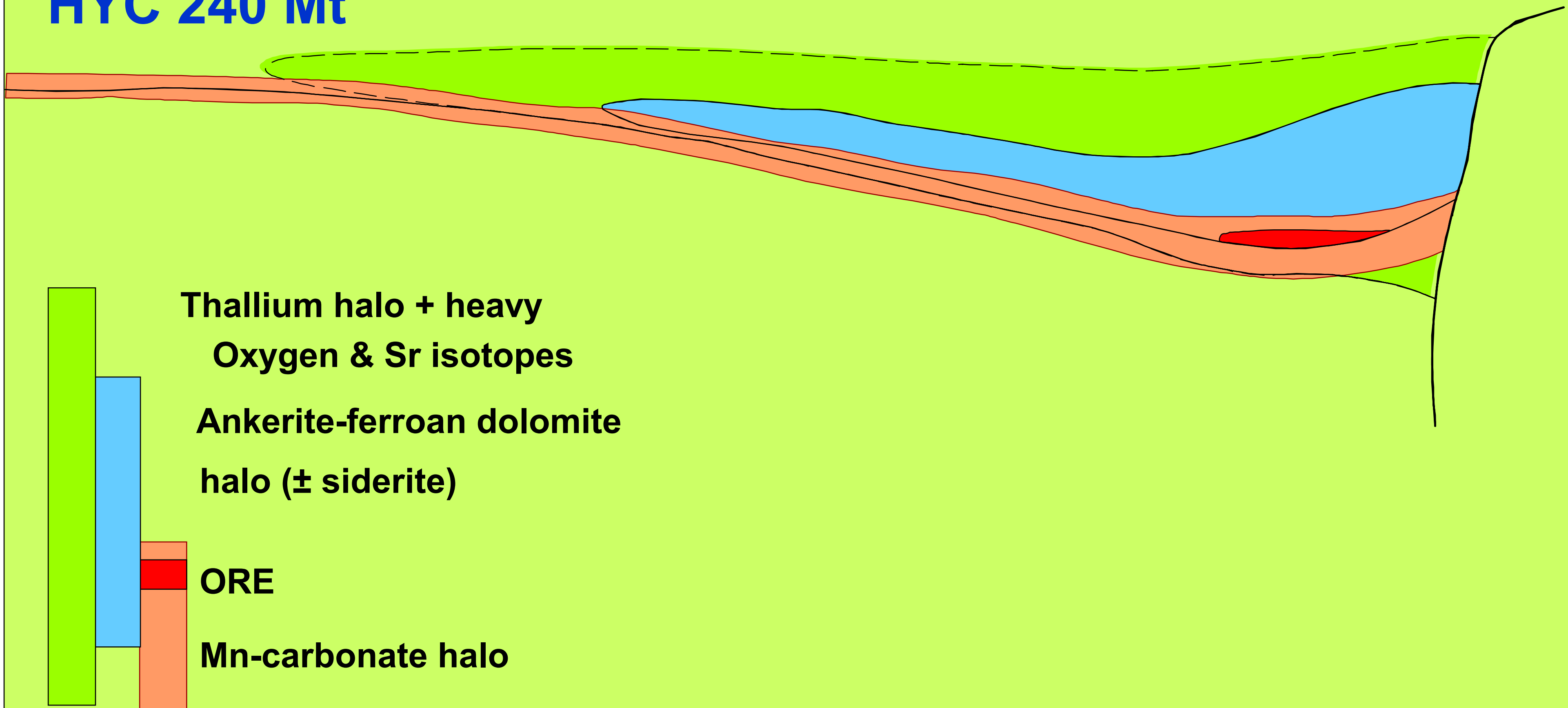
		Pb	dominant Carbonate	Tl	MnO	CaO	Sr	K_2O
Zn-Pb ore	>5%	>1000ppm	siderite	>50ppm	0.01-0.4%	0-1%	100-1000 ppm	no pattern
Siderite zone	100ppm to 5%	10-1000	siderite	2-50	0.01-1%	0-1%	10-500	
Ankerite halo	20-200ppm	<70	ankerite	2-50	0.01-0.4%	1-30%	<100	
Dolomite background	<50ppm	<30	dolomite	<4	<0.02	1-30%	<100	

Siderite halo in siltstone host rocks


North Australian Proterozoic Zinc Belt
Pine Creek Inlier
11°00'
Woodcutters
ARTHUR BASIN
HYC
Batten Fault Zone
Murphy Inlier
132°00'
141
30'
MOUNT ISA BASIN
Century
Lady Loretta
Dugald River
Hilton/George Fisher
Mt Isa
Cannington
200 km

Sedex Zn-Pb-Ag footprint of overlapping halos

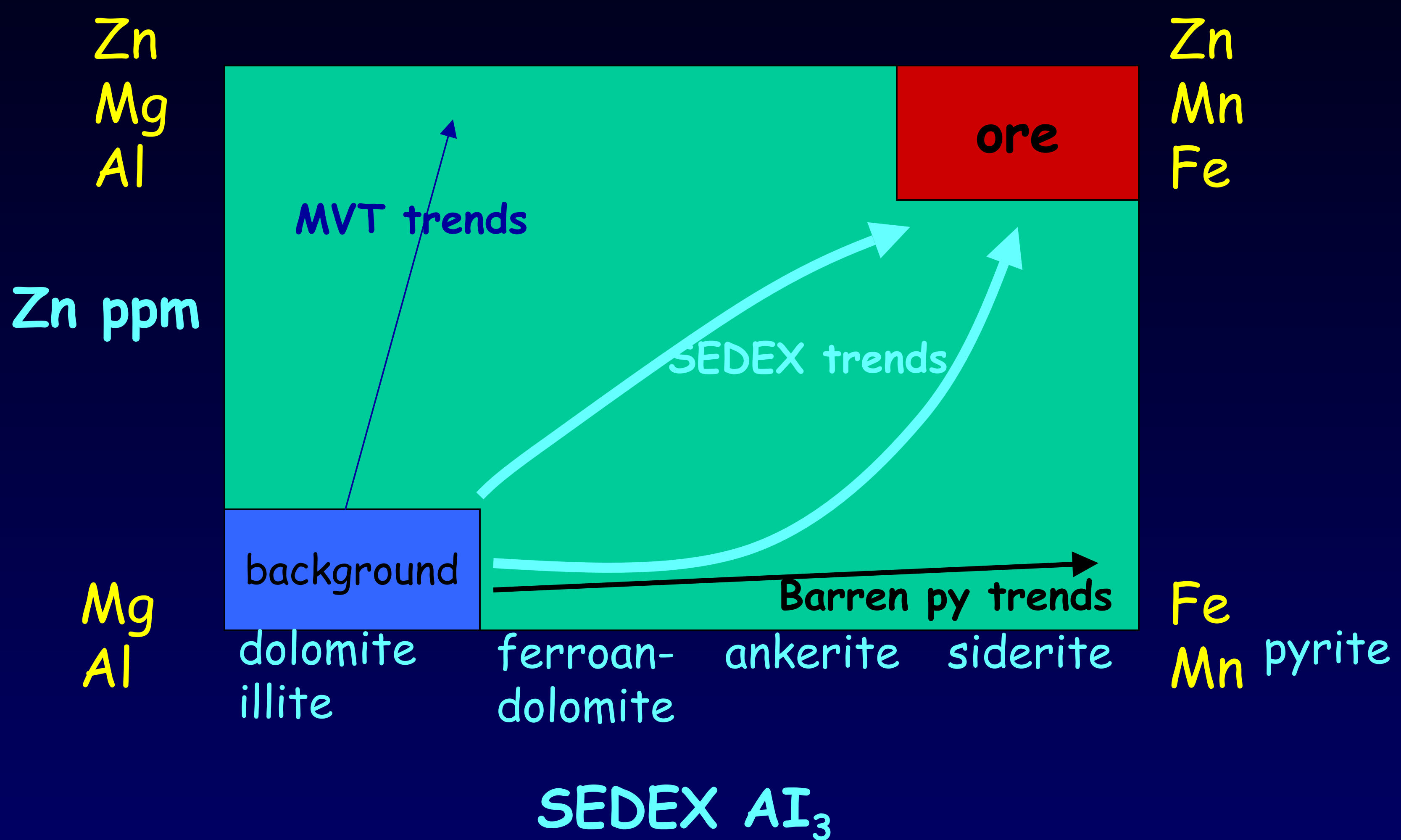
HYC 240 Mt



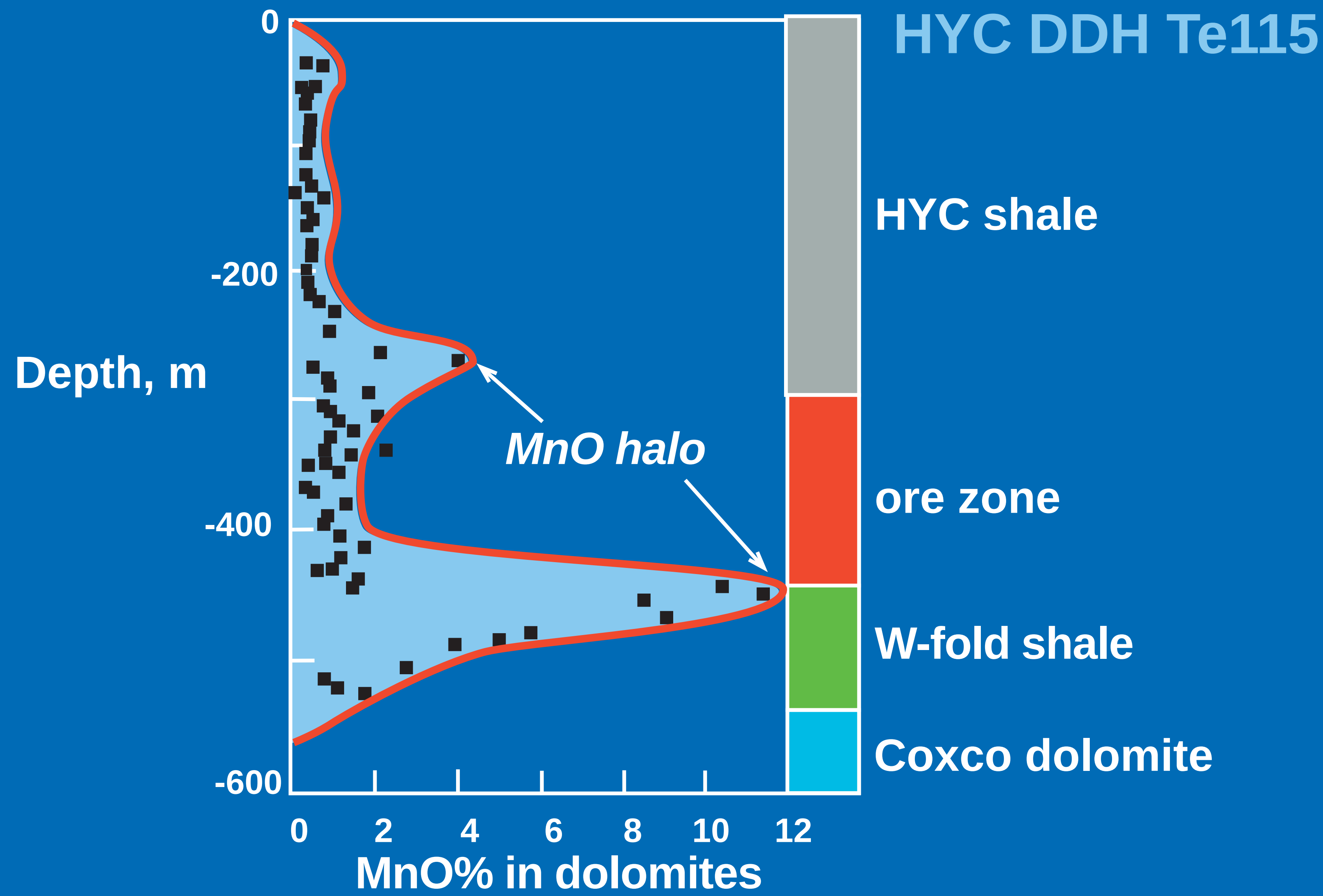
Key Vectors

- SEDEX $AI_3 = \dfrac{100(FeO^* + 10MnO)}{(FeO^* + 10MnO + MgO + Al_2O_3)}$
- $MnO_d = \dfrac{MnO^* 40.03}{CaO}$ (MnO content in dolomite)
- Tl, C/O isotopes in carbonates, Sr isotopes

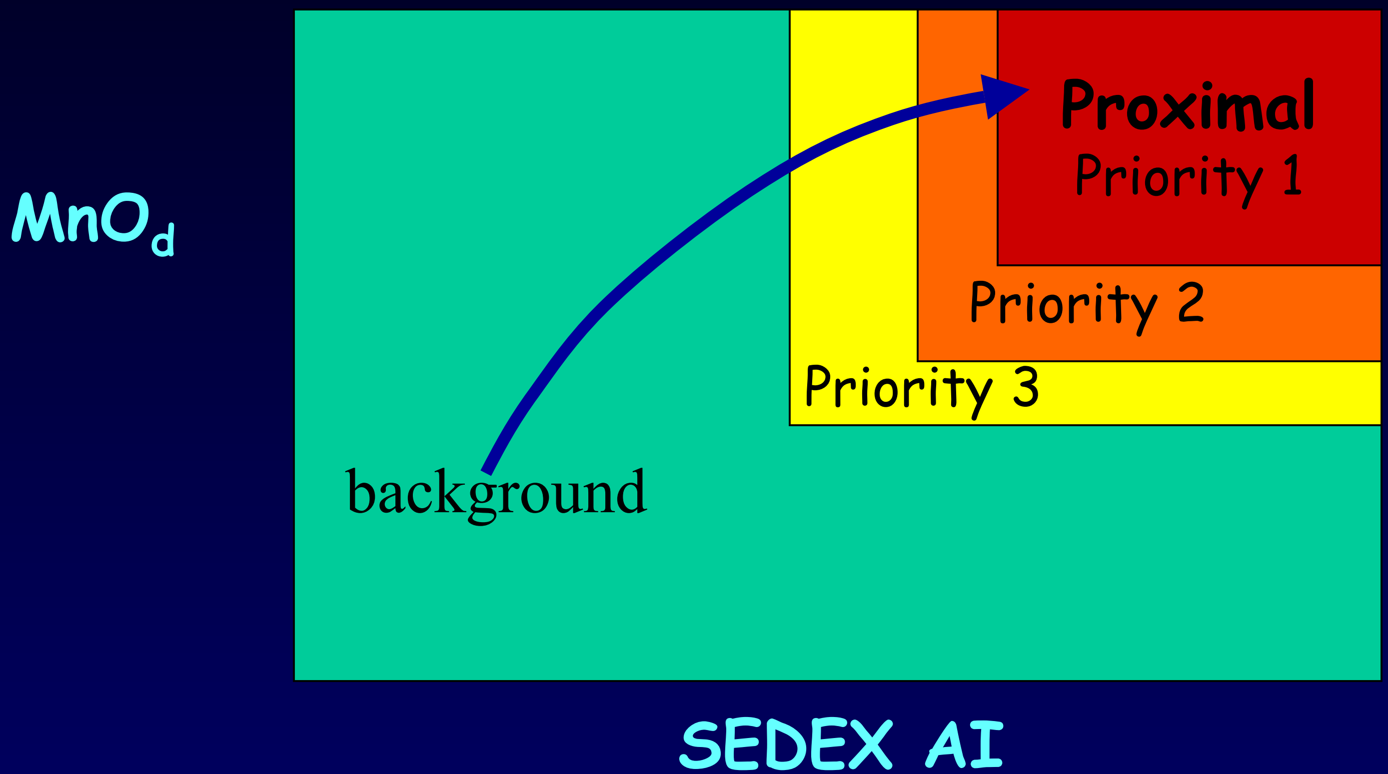
SEDEX Vector Plots



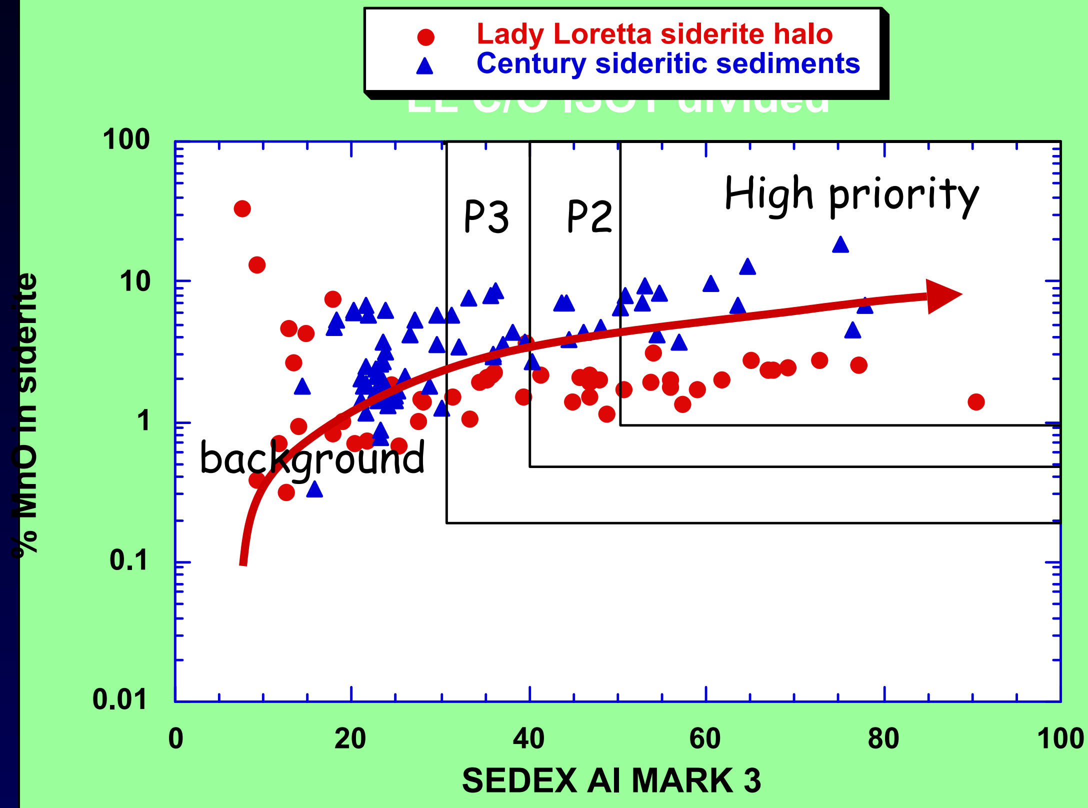
Mn content in carbonate

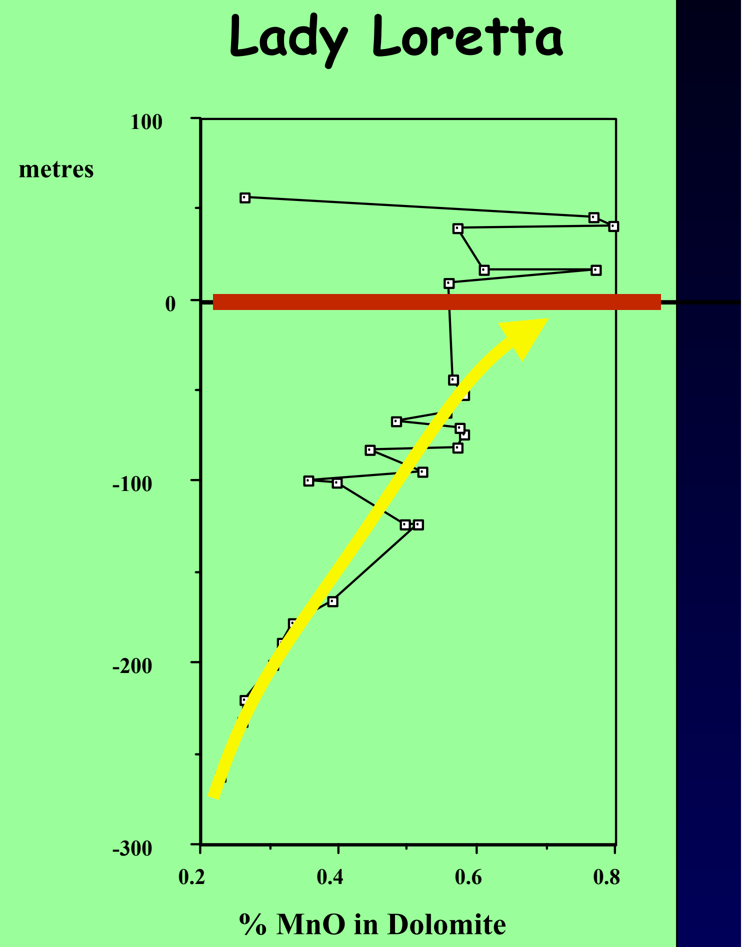


SEDEX Vector Plots



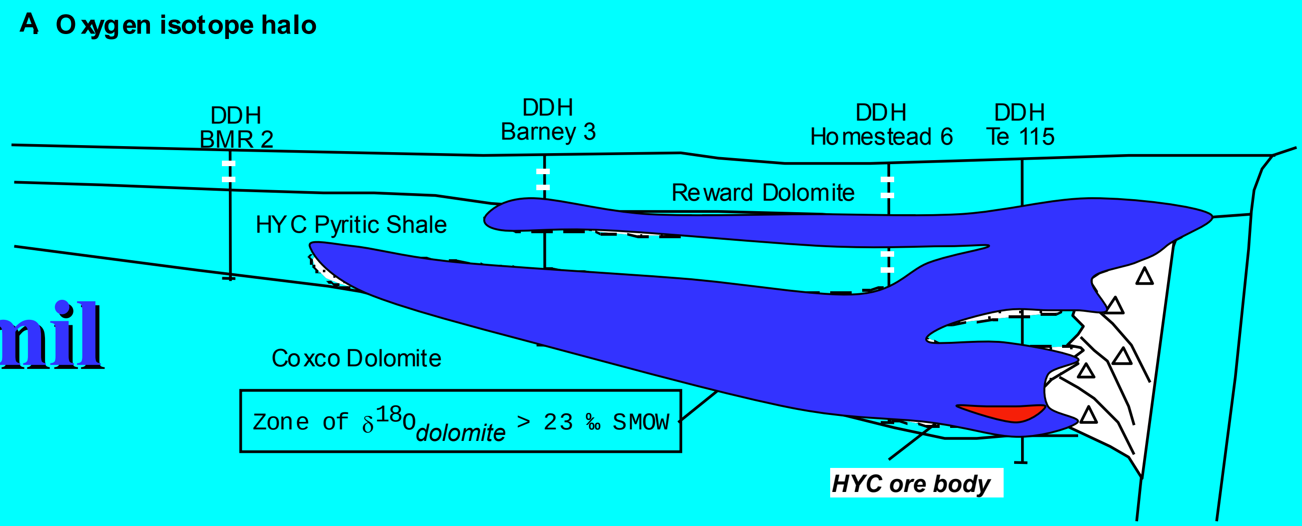
Vector plots for SEDEX



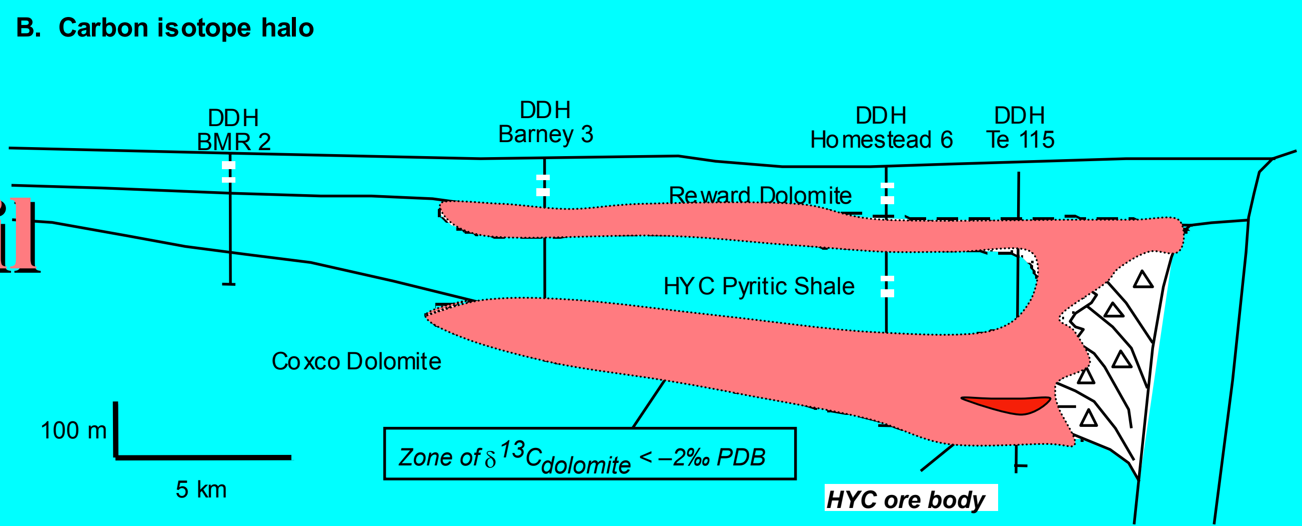


C-O isotope halos at HYC

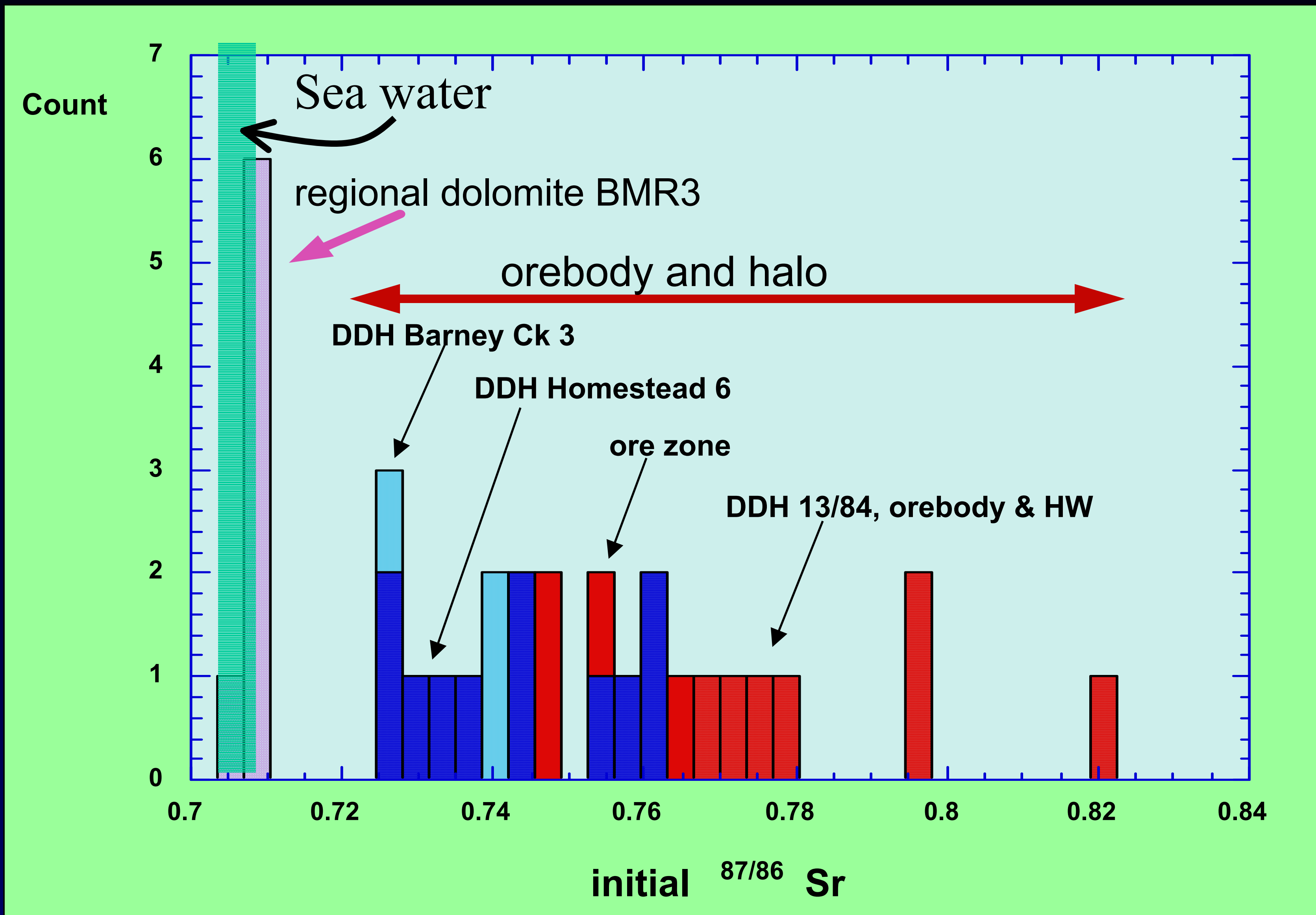
Oxygen
> 22.5 permil



Carbon
< -2permil



Initial $^{87/86}Sr$ range



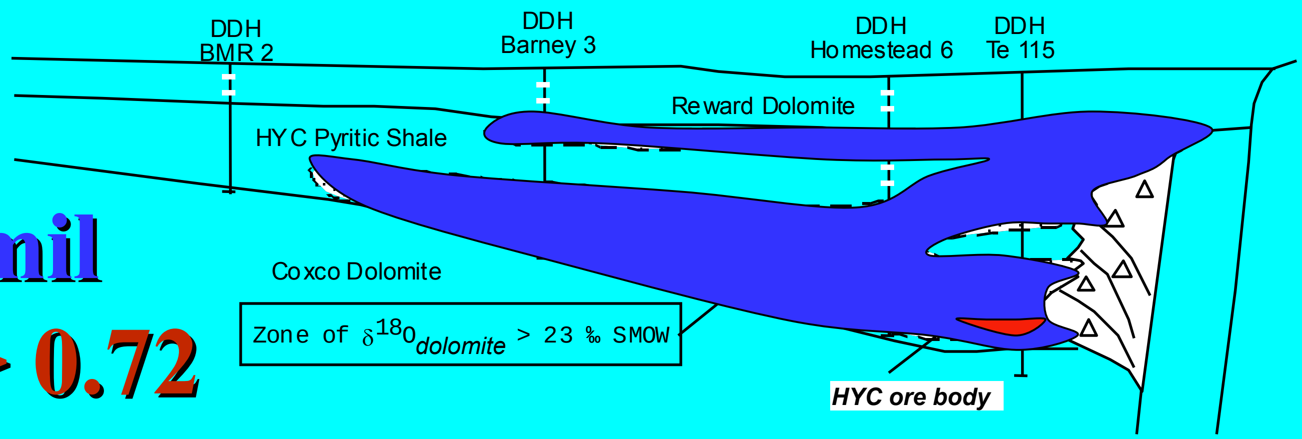
C-O isotope halos at HYC

Oxygen

➢22.5 permil

$^{87}Sr/^{86}Sr > 0.72$

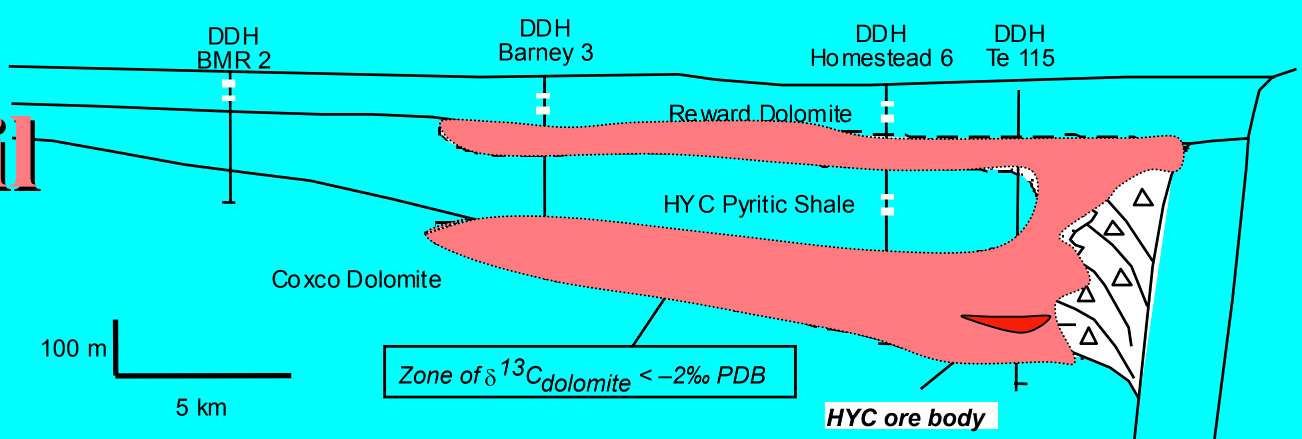
A Oxygen isotope halo



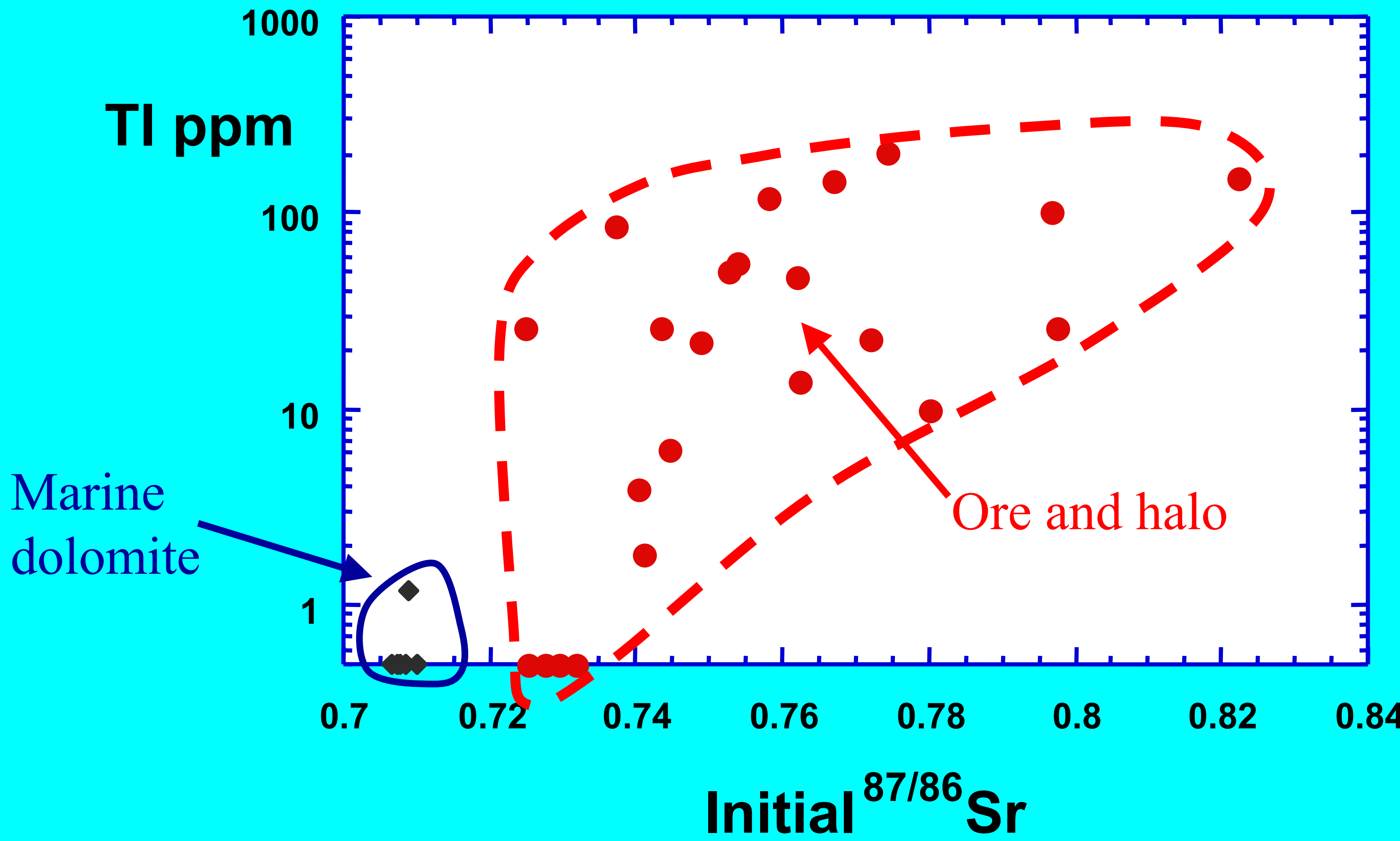
Carbon

< -2permil

B. Carbon isotope halo

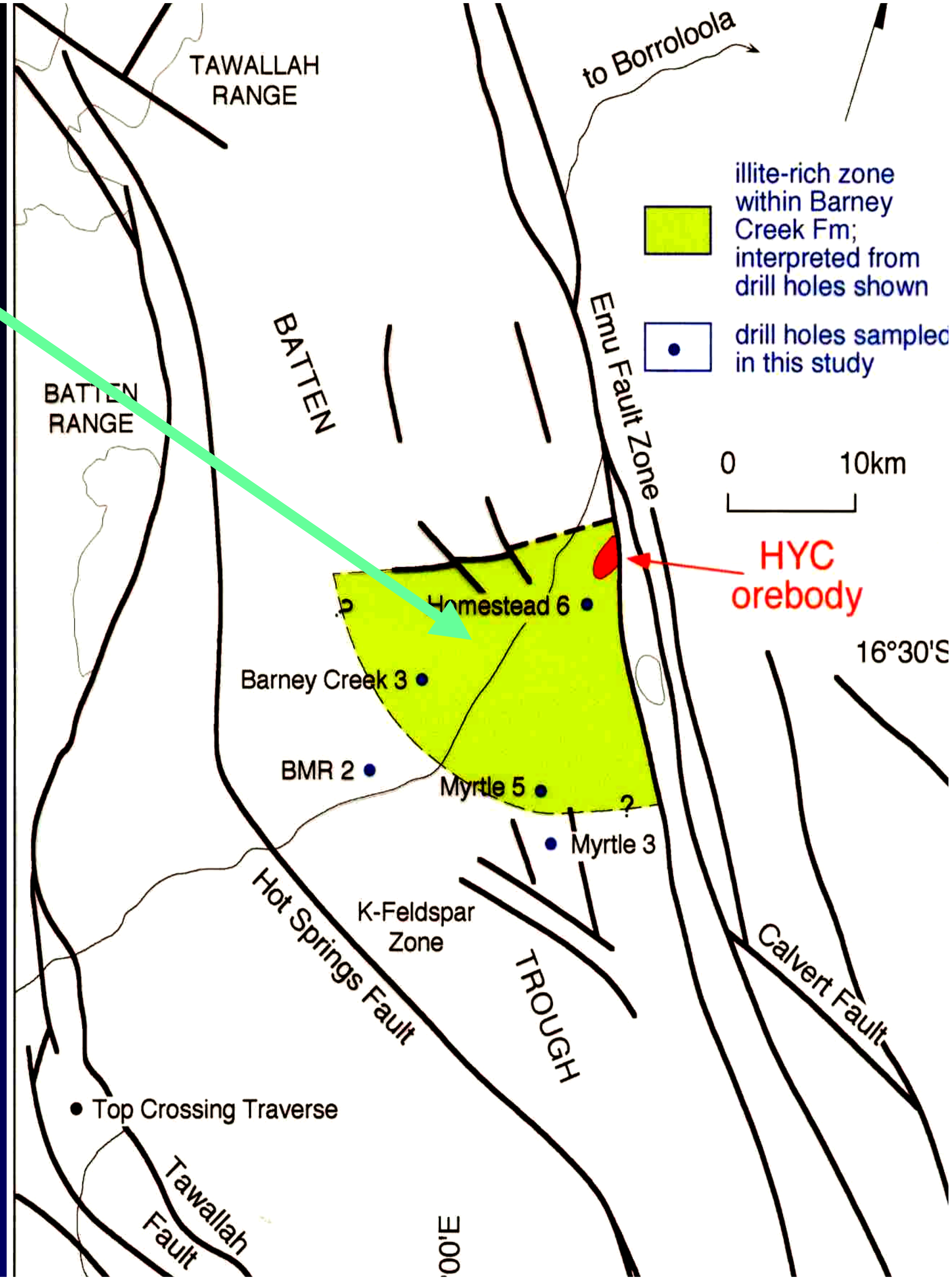


Thallium- Sr isotope halo

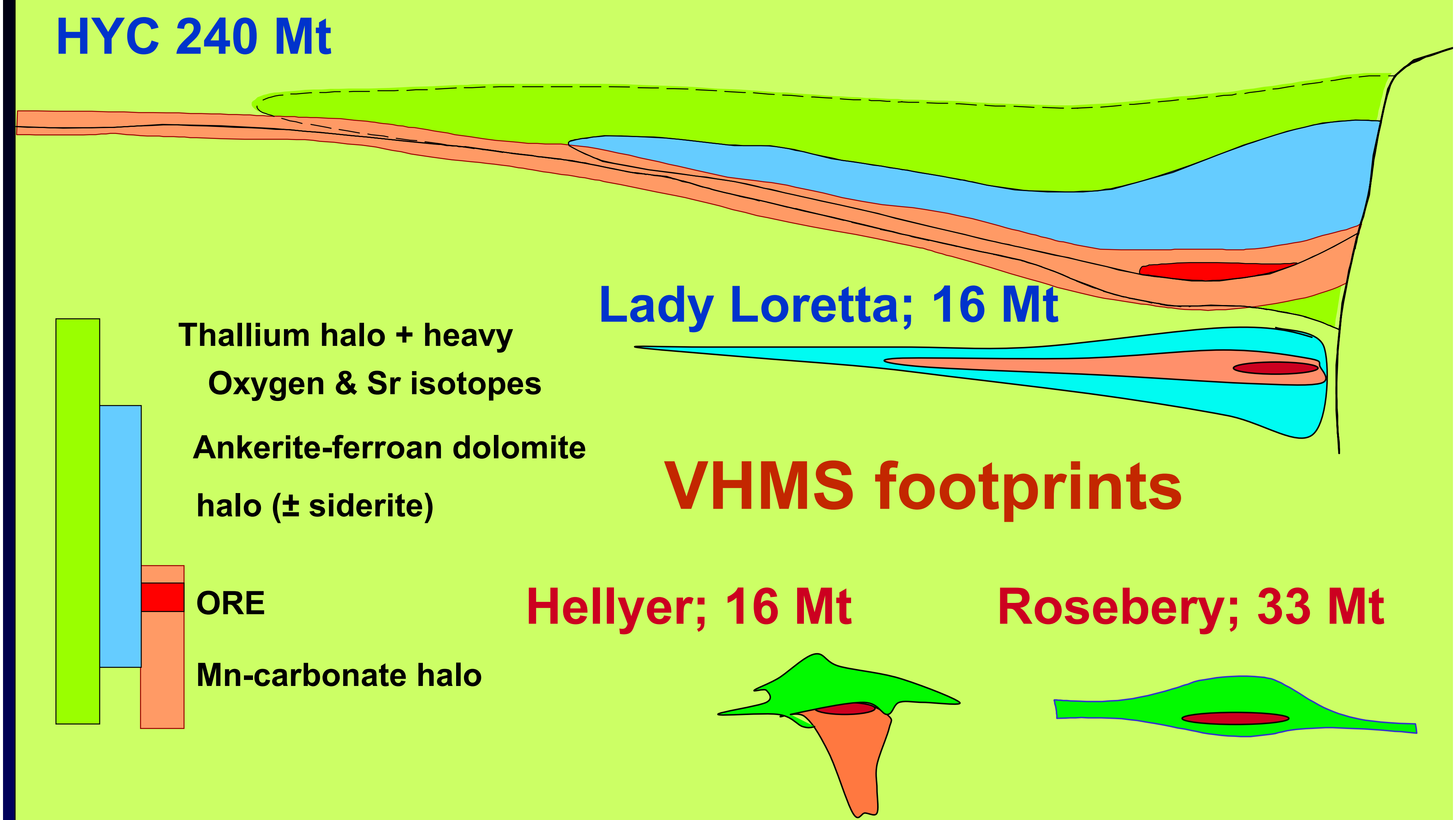


HYC Halo

- Sedex AI > 50
- MnO_d > 1.5 wt%
- Tl > 4ppm
- $\delta^{18}O$ > 22.5 permil
- $\delta^{13}C$ < -2 permil
- $^{87/86}Sr$ > 0.7200



Sedex Zn-Pb-Ag footprints of overlapping halos



END