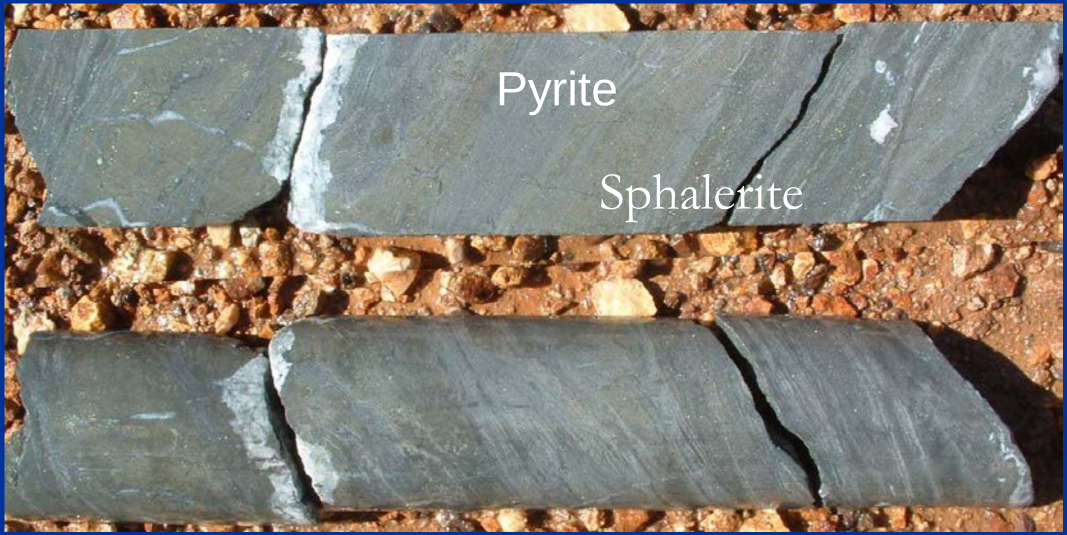
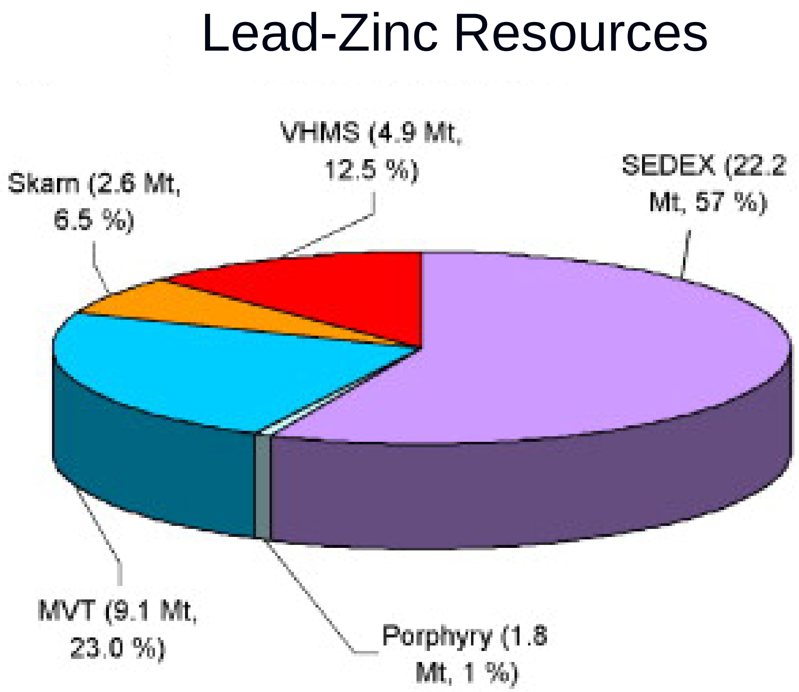
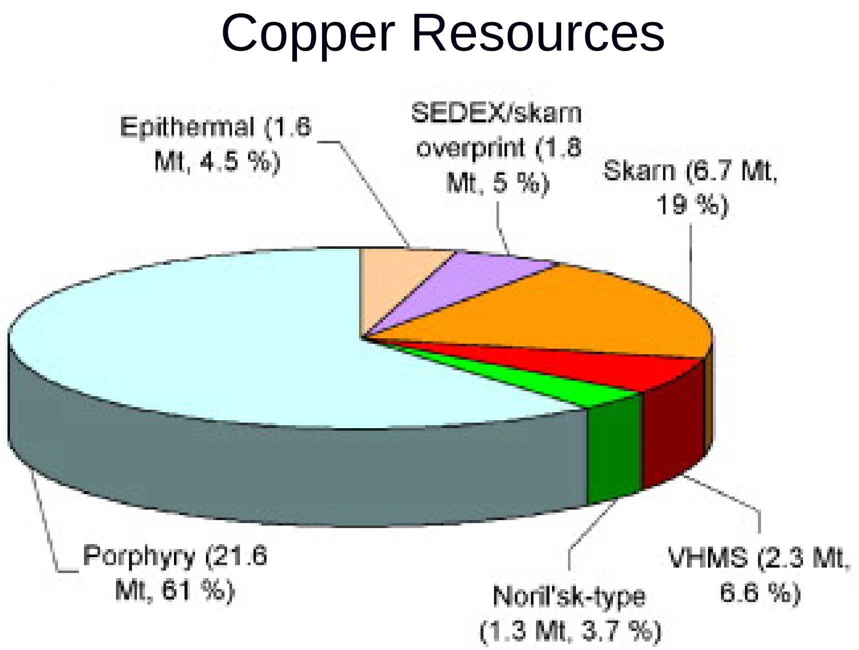
Volcanogenic Massive Sulphide (VMS) Deposits

VMS Deposits in Outcrop and Core

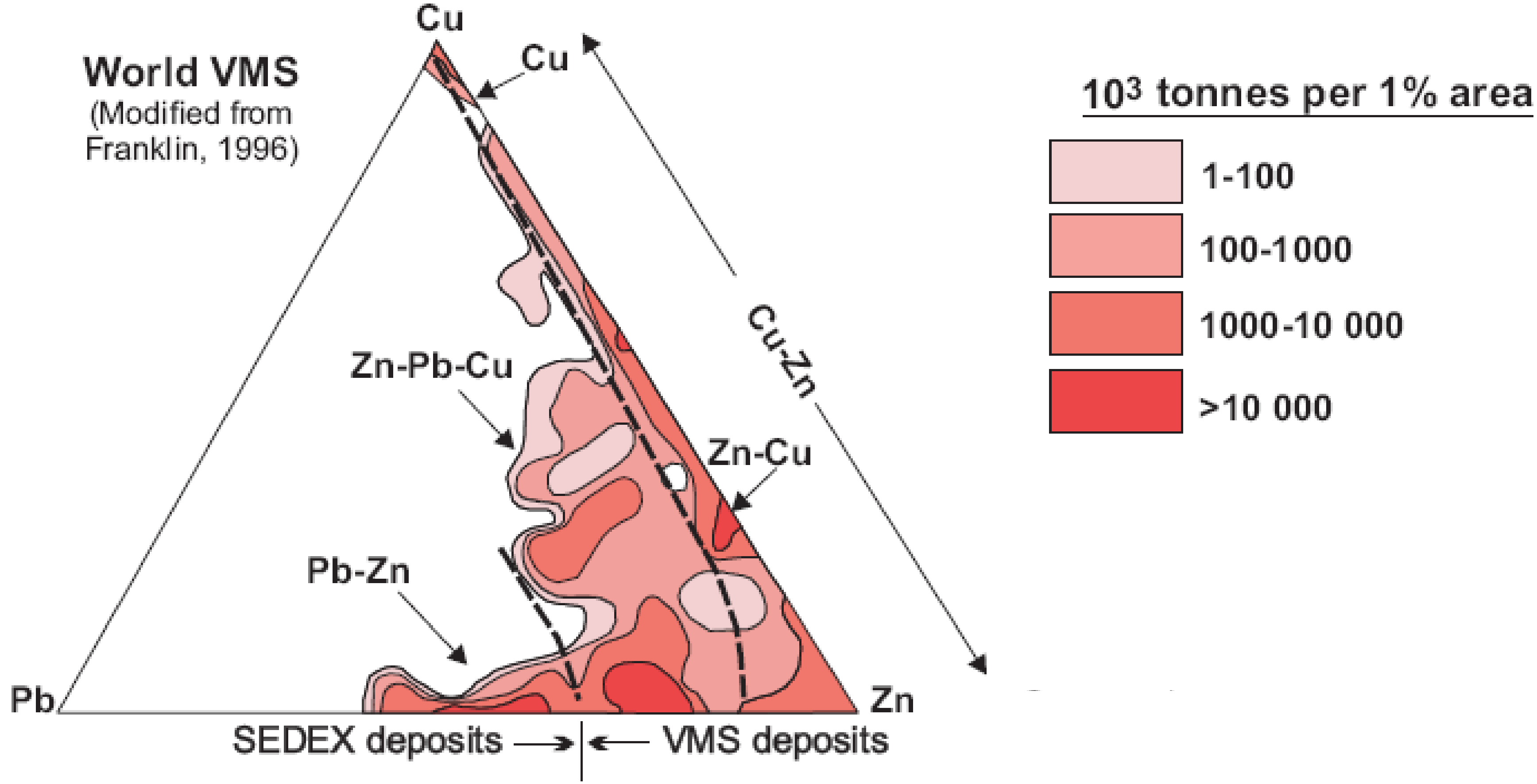


The Importance of VMS Deposits as a Copper, Zinc and Lead Resource





Metal Distributions in VMS Deposits



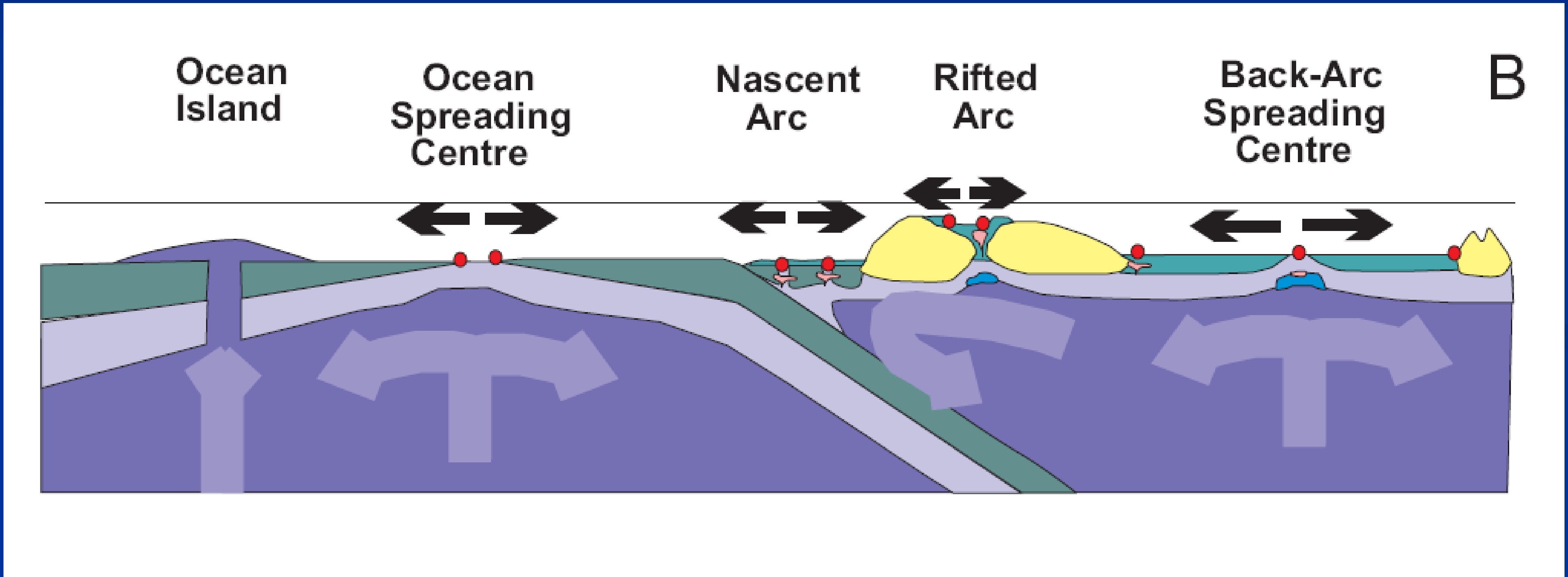
Grade and Tonnages of VMS Deposits

Table 15.3 Average grade and tonnage data for VMS deposits of selected regions. (Data from Large *et al.* 1987 and Lydon 1989)

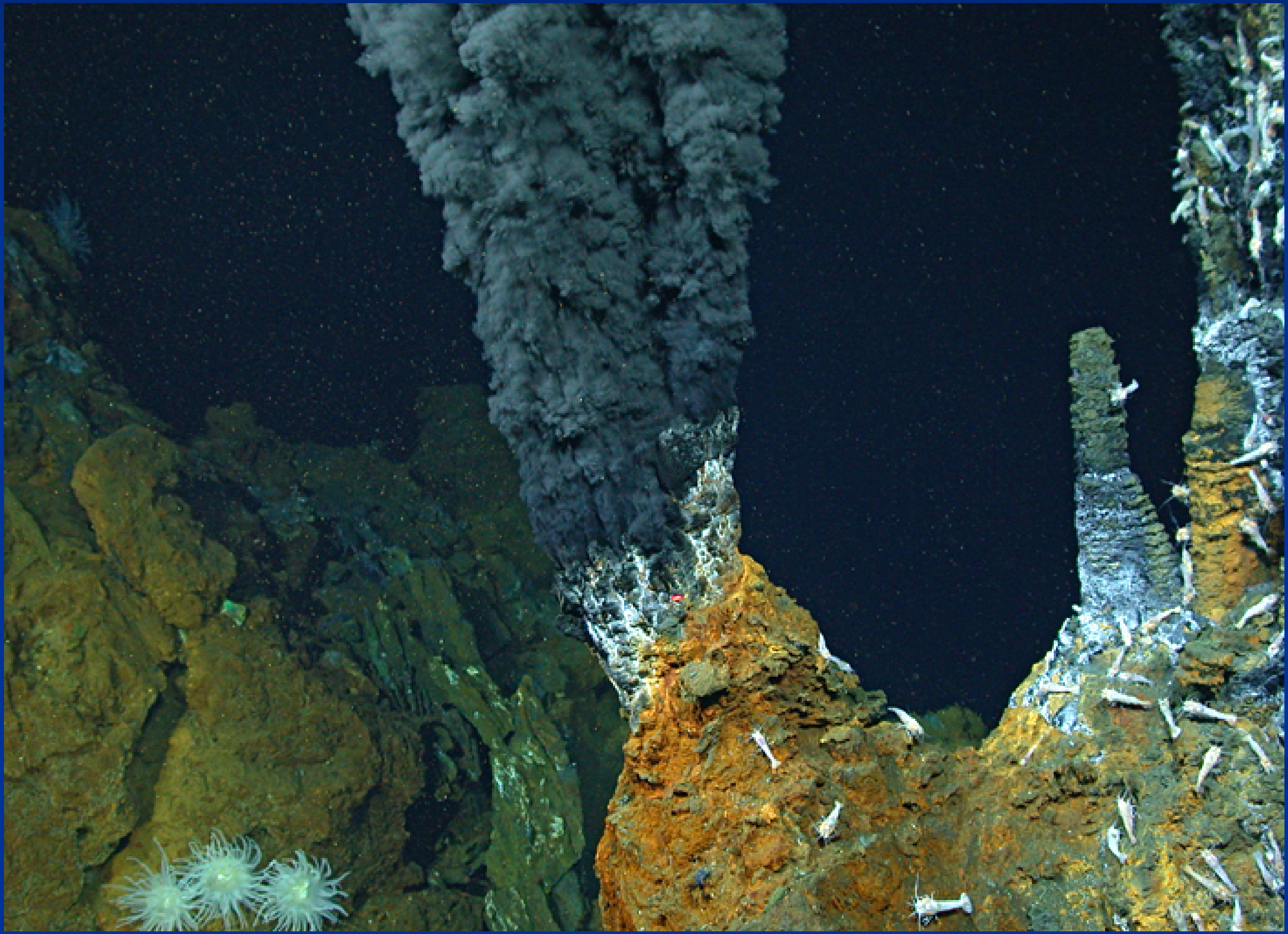
Region	Dominant deposit type	Number of deposits	Average grade[a] Cu (%)	Zn (%)	Pb (%)	*N* –	Ag ($g\ t^{-1}$)	Au ($g\ t^{-1}$)	Tonnage (Mt)
Abitibi Belt, Canada (Archaean)	Cu–Zn	52	1.47	3.43	0.07	47	31.9	0.8	9.2
Norwegian Caledonides (Palaeozoic)	Cu–Zn	38	1.41	1.53	0.05	0	na	na	3.5
Bathurst, New Brunswick, Canada (Palaeozoic)	Zn–Pb–Cu	29	0.56	5.43	2.17	28	62.0	0.5	8.7
Green Tuff Belt, Japan (Tertiary)	Zn–Pb–Cu	25	1.63	3.86	0.92	7	95.1	0.9	5.8
Tasman Geosyncline, Eastern Australia (Palaeozoic)	Cu–Au	42	1.3			5	17.2	2.1	6.4
	Zn–Pb–Cu[b]		0.48	15.15	6.28	4	160.0	3.0	

[a] *N* = Number of deposits for which data available to calculate average Ag and Au grades.
[b] Data in this line is for some Tasmanian deposits only.

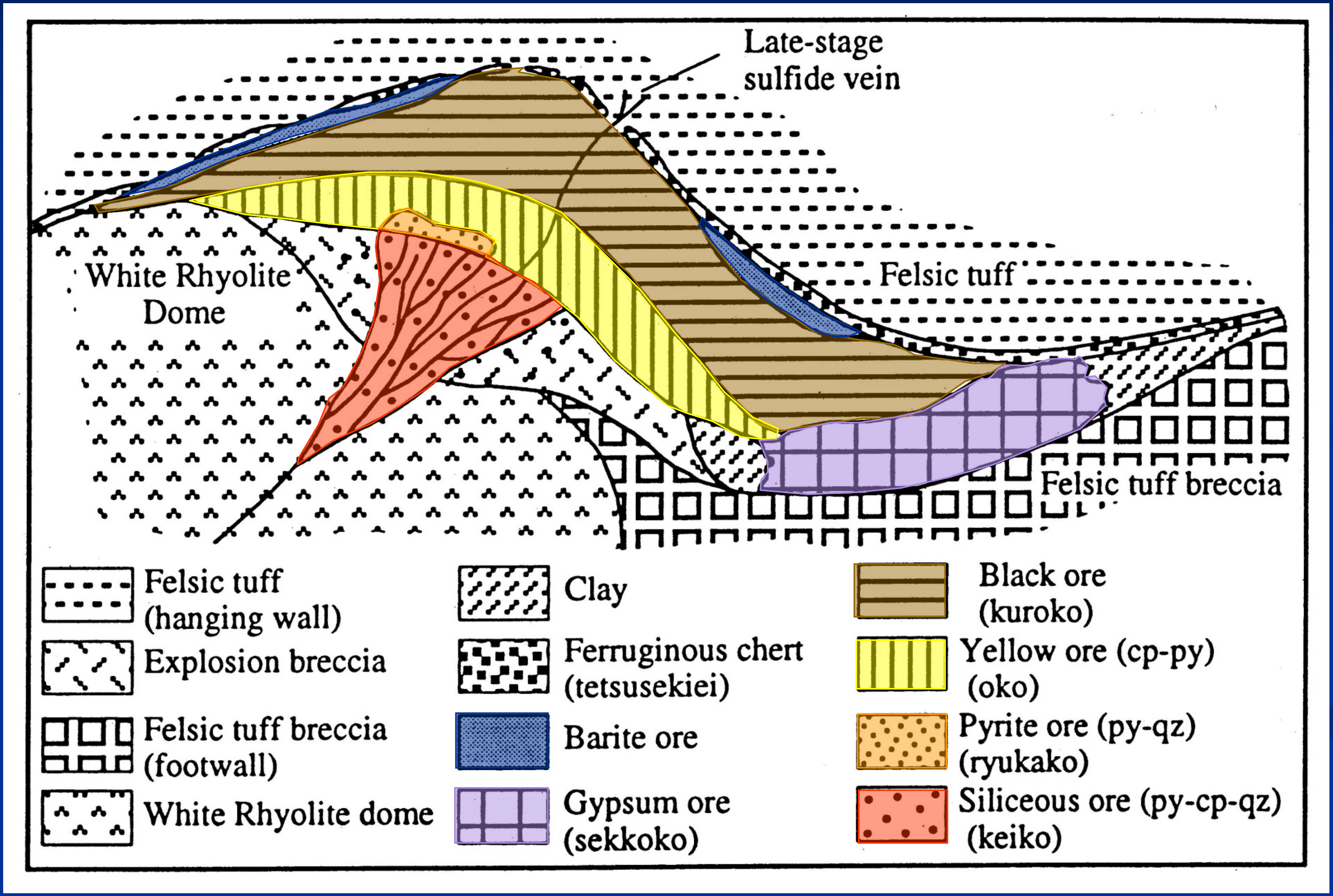
The tectonic settings of VMS deposits



The tectonic settings of VMS deposits

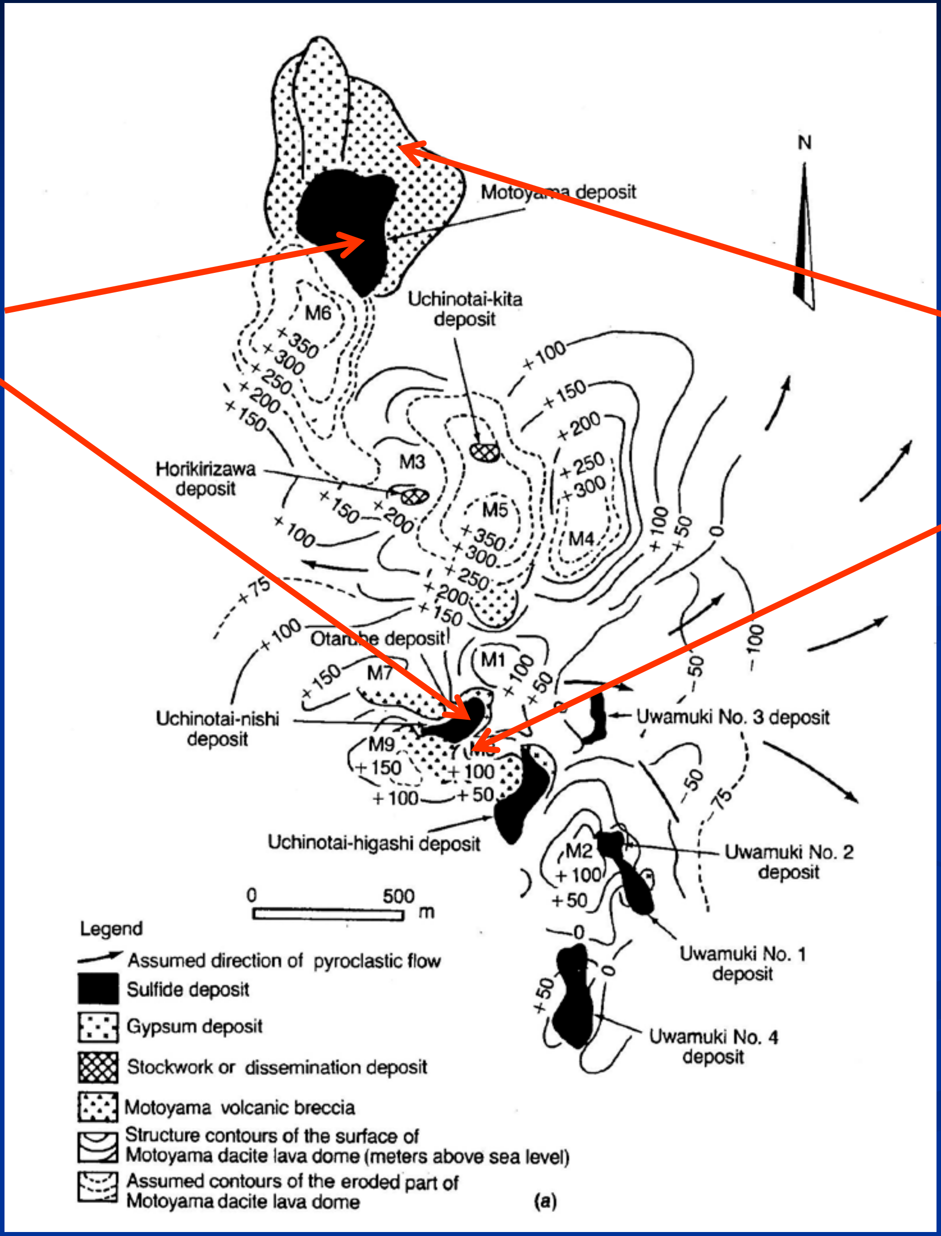


Kuroko Type VMS deposits



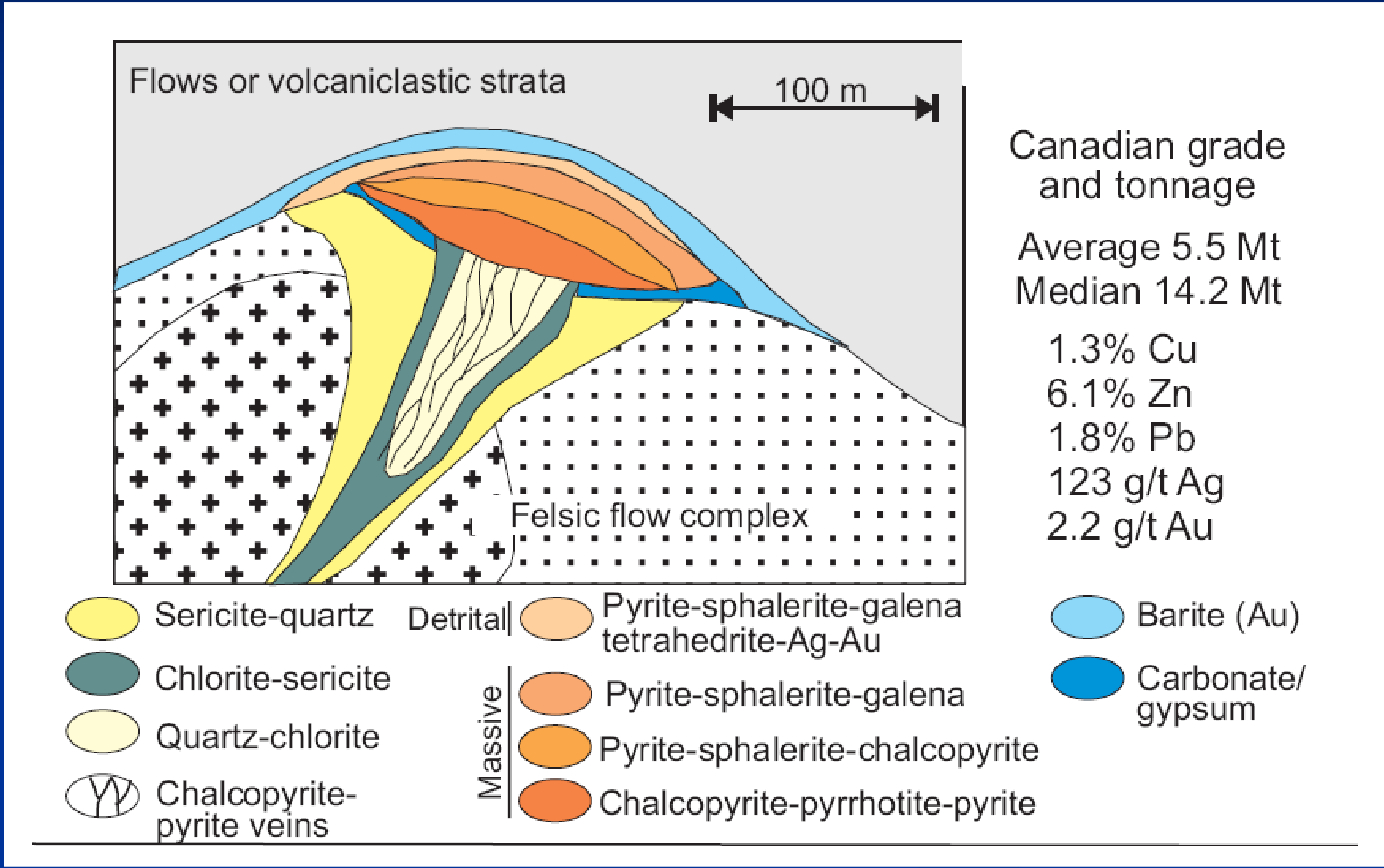
Paleogeographic Setting of Kuroko Deposits

VMS Ores



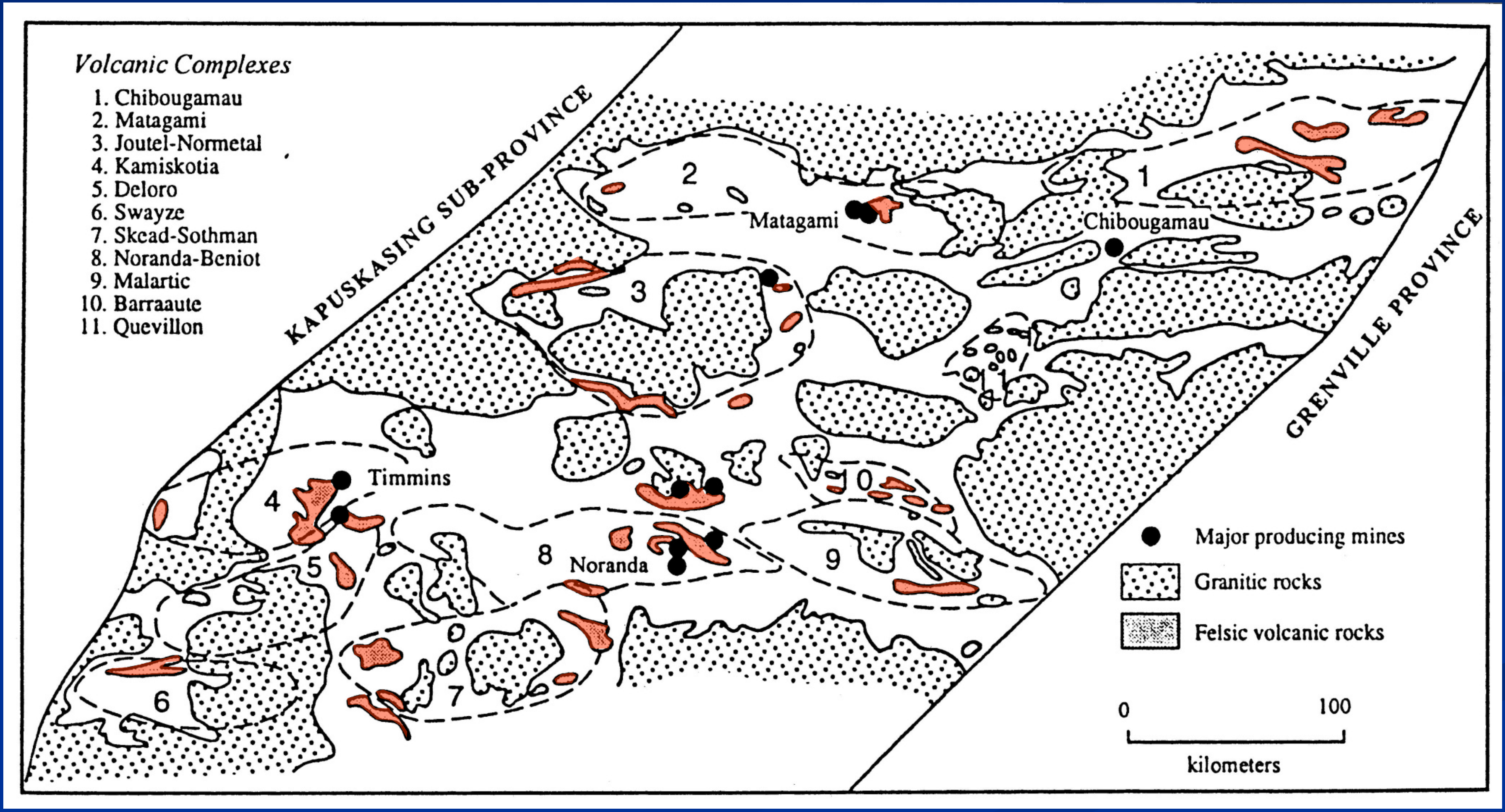
Gypsum

Canadian Noranda-Type VMS Deposits

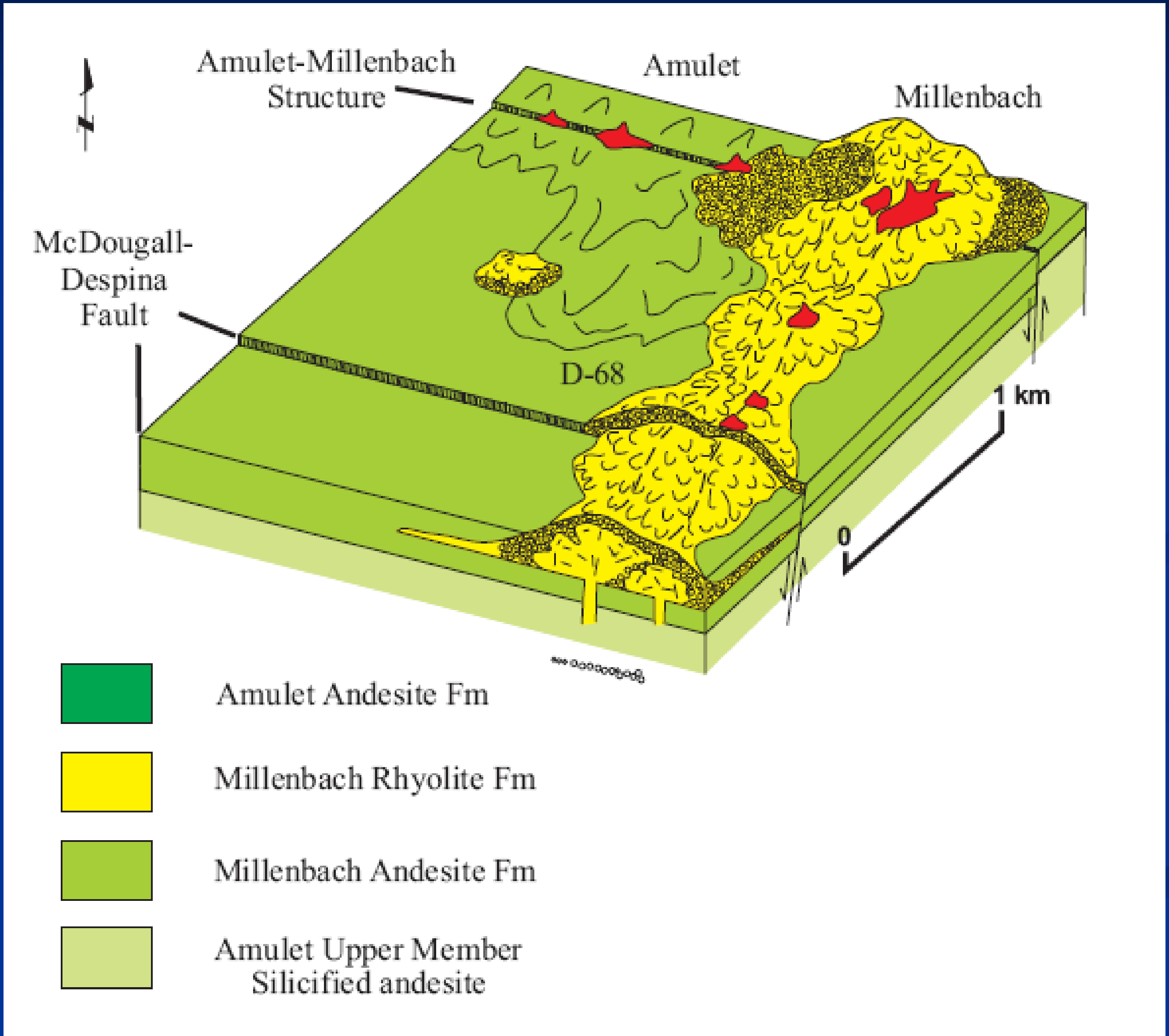


Abitibi Greenstone Belt

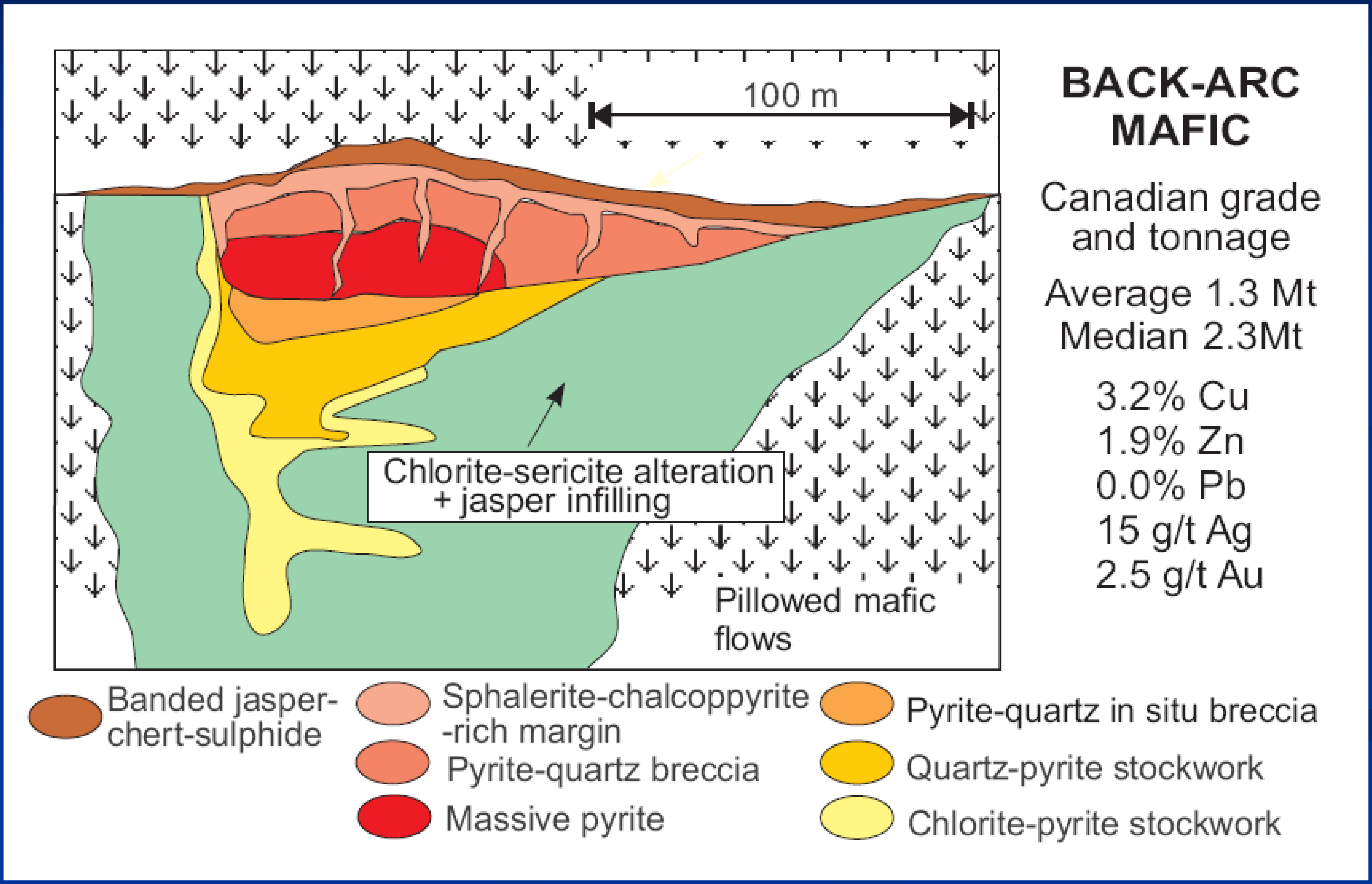
VMS Deposits



Distribution of Noranda-type VMS deposits

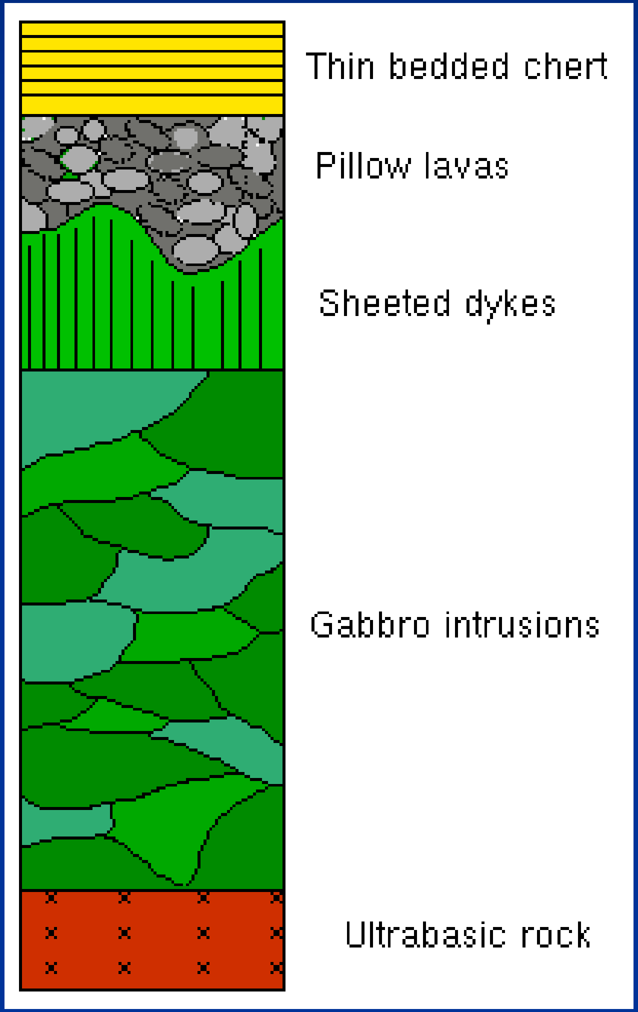


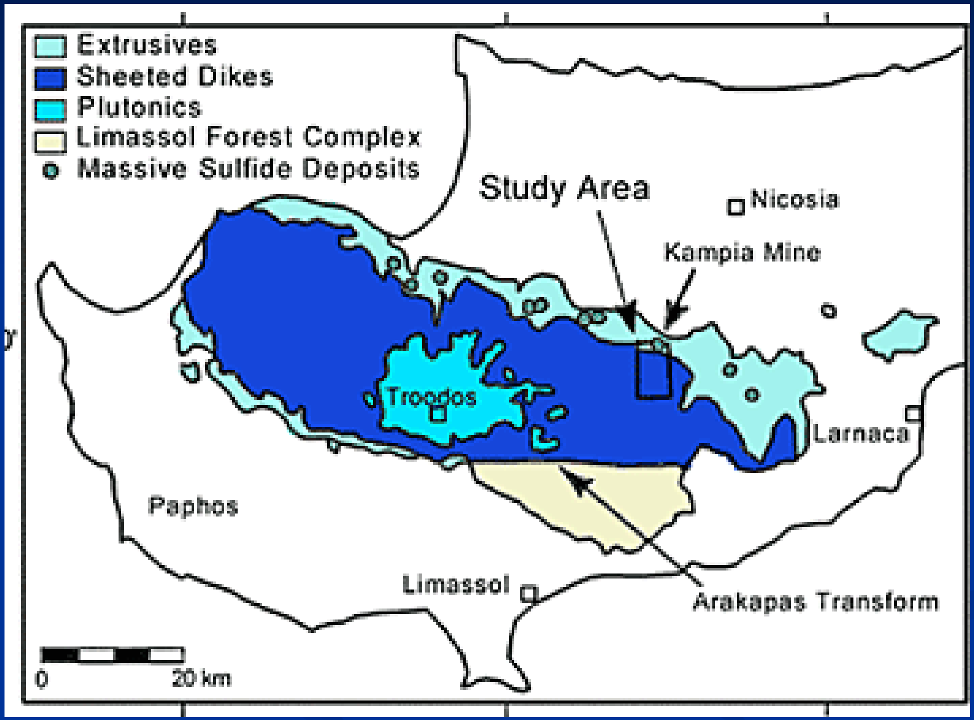
Besshi-type Deposit - Back-Arc rift setting

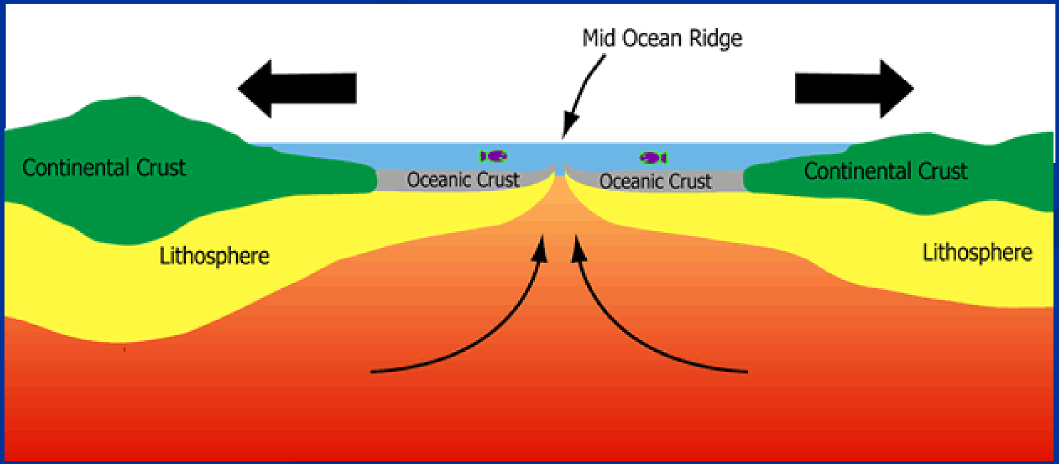


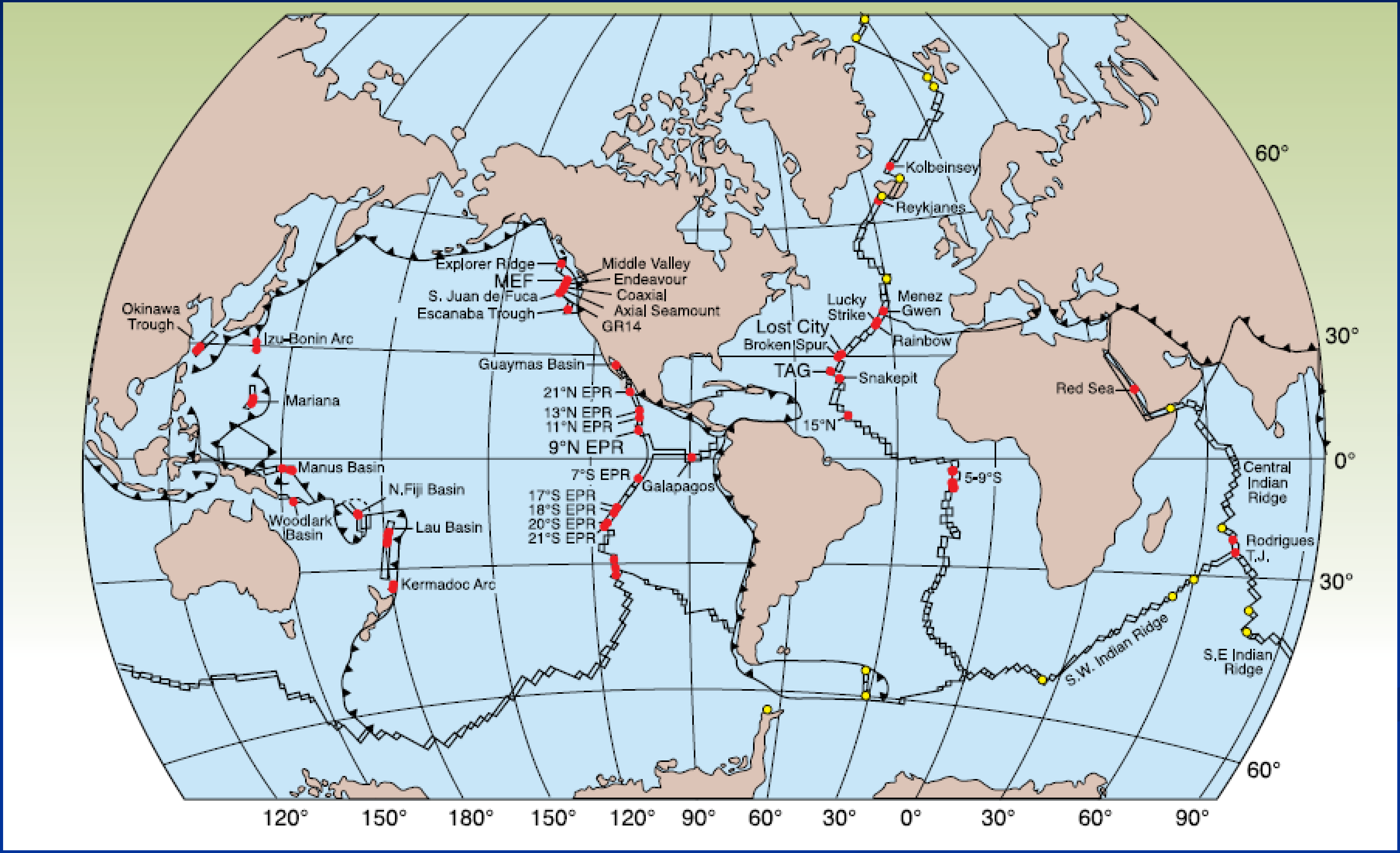
Cyprus-type VMS deposits (Cu, Minor Zn)

Ophiolite
(A slice of oceanic crust)



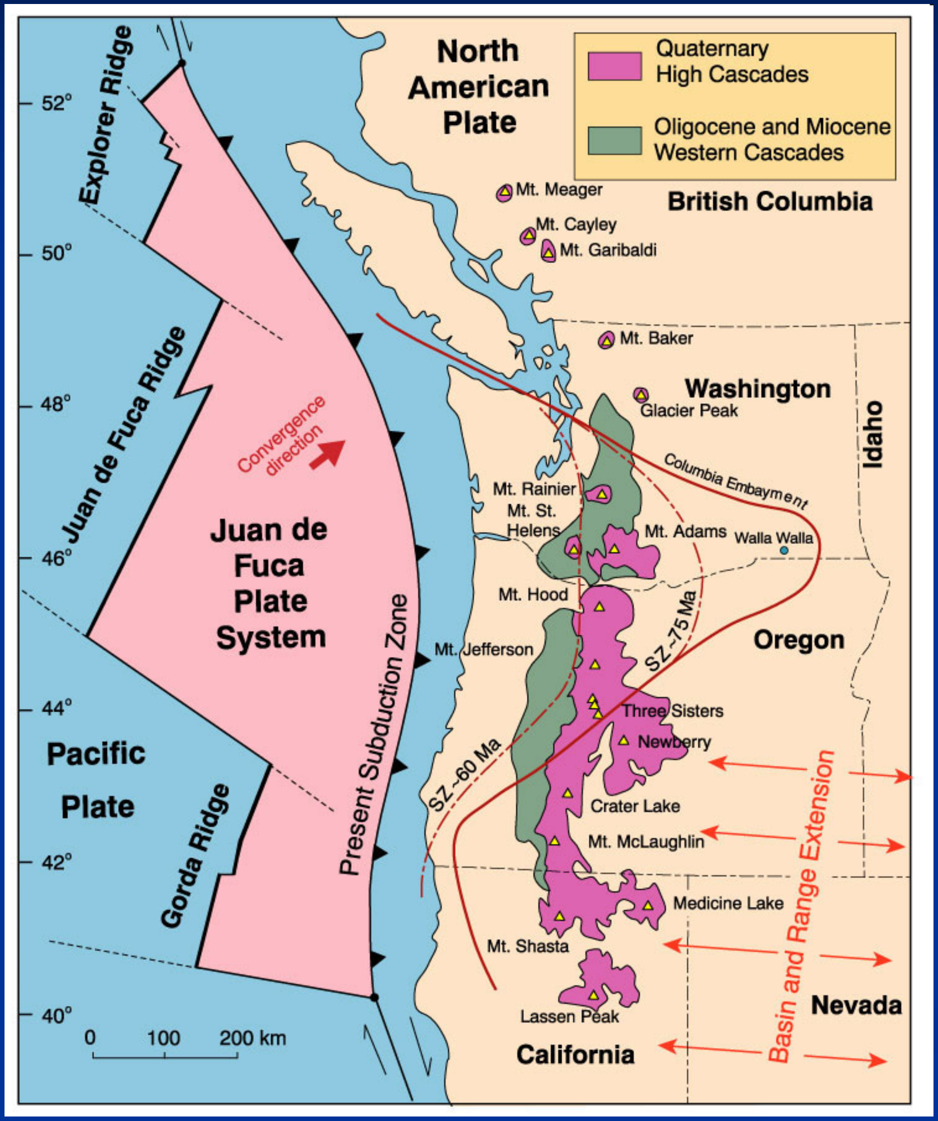


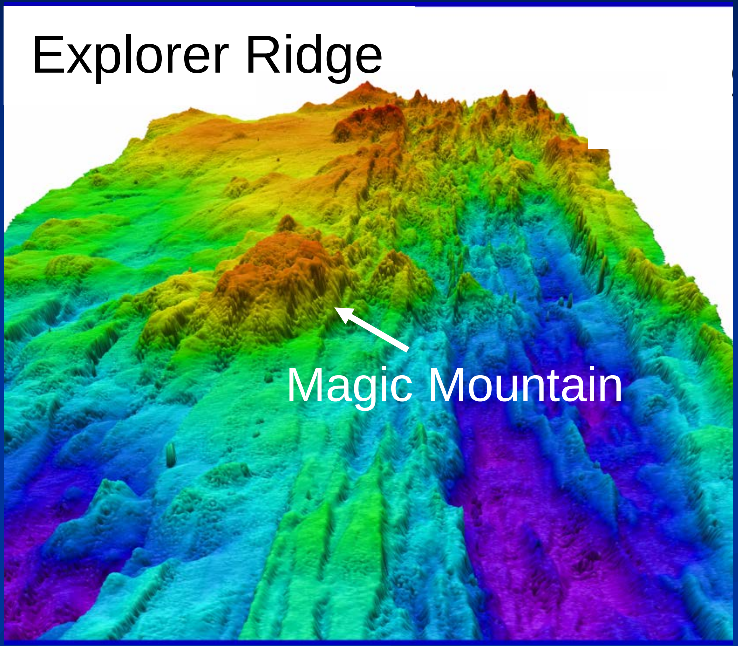




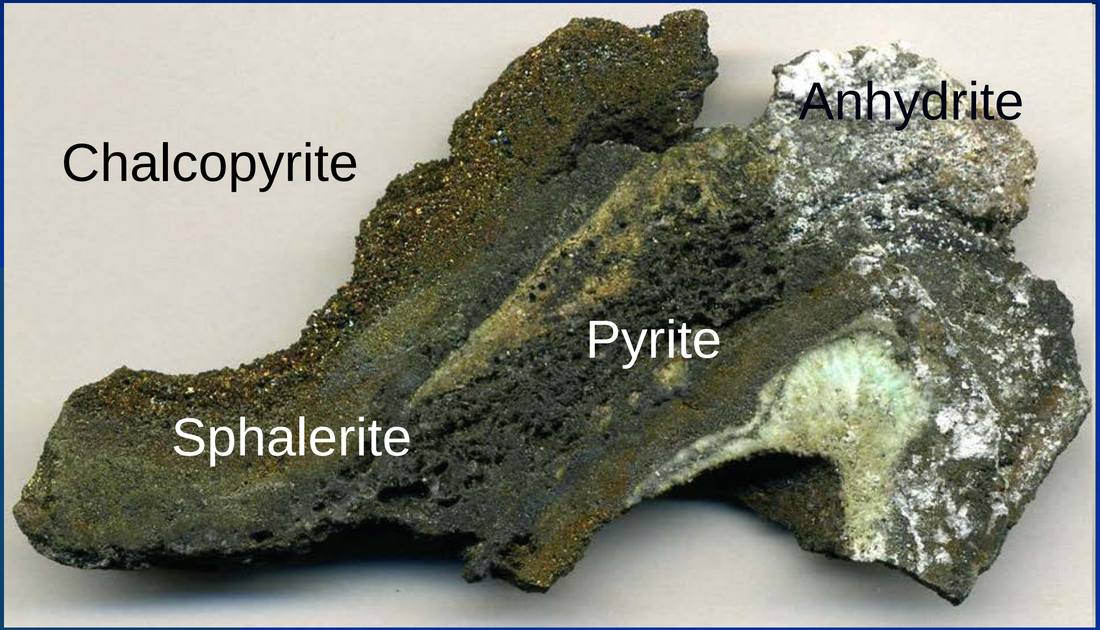
Kolbeinsey
Reykjanes
Middle Valley
Explorer Ridge
Endeavour
MEF
S. Juan de Fuca
Coaxial
Escanaba Trough
Axial Seamount
GR14
Okinawa Trough
Izu-Bonin Arc
Lucky Strike
Menez Gwen
Lost City
Broken Spur
Rainbow
TAG
Snakepit
Guaymas Basin
Mariana
21°N EPR
13°N EPR
11°N EPR
9°N EPR
15°N
Red Sea
Manus Basin
7°S EPR
Galapagos
5-9°S
Central Indian Ridge
N.Fiji Basin
17°S EPR
18°S EPR
20°S EPR
21°S EPR
Woodlark Basin
Lau Basin
Rodrigues T.J.
Kermadoc Arc
S.W. Indian Ridge
S.E Indian Ridge
60°
30°
0°
30°
60°
120°
150°
180°
150°
120°
90°
60°
30°
0°
30°
60°
90°

Explorer Ridge – a VMS Deposit in the Making

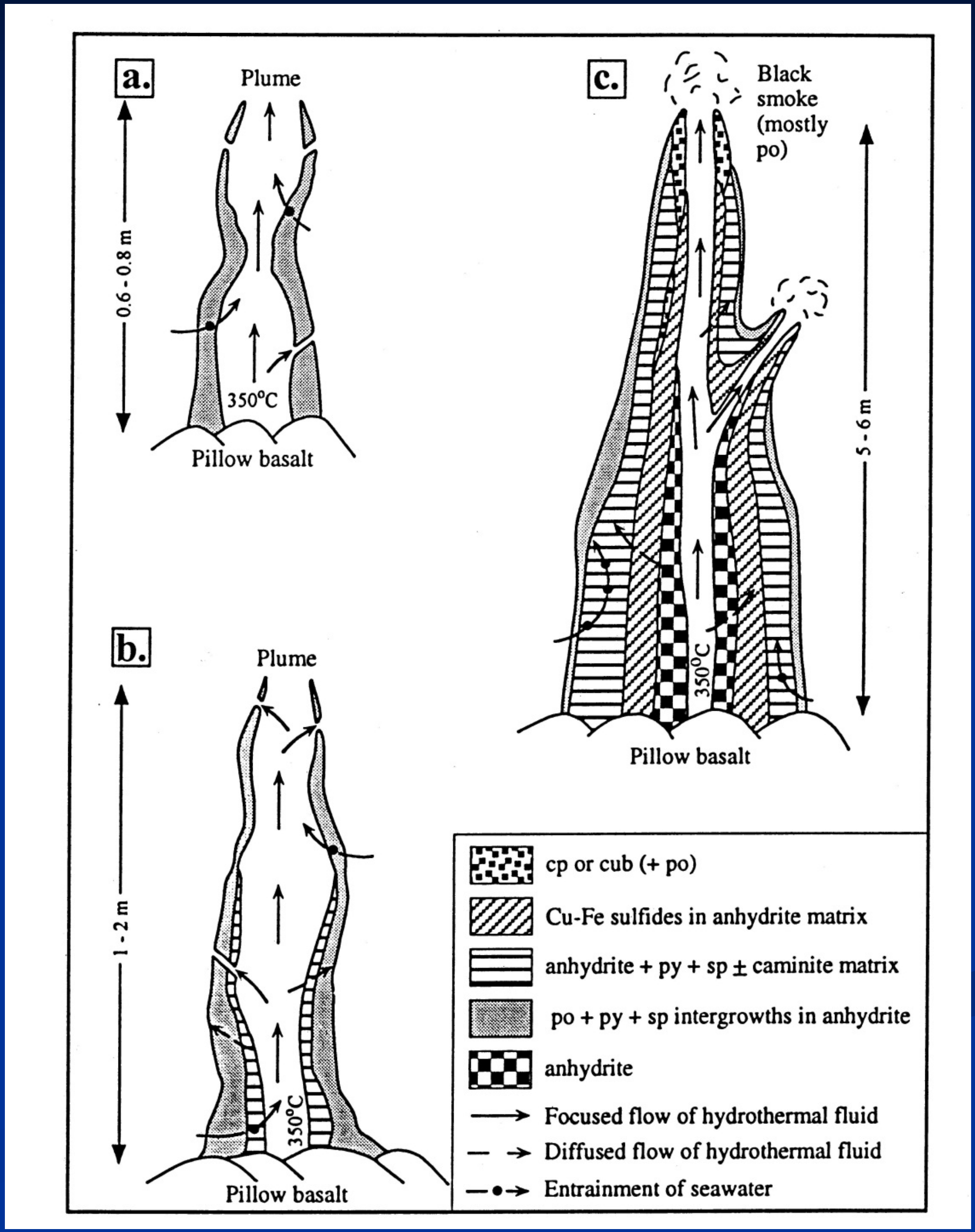




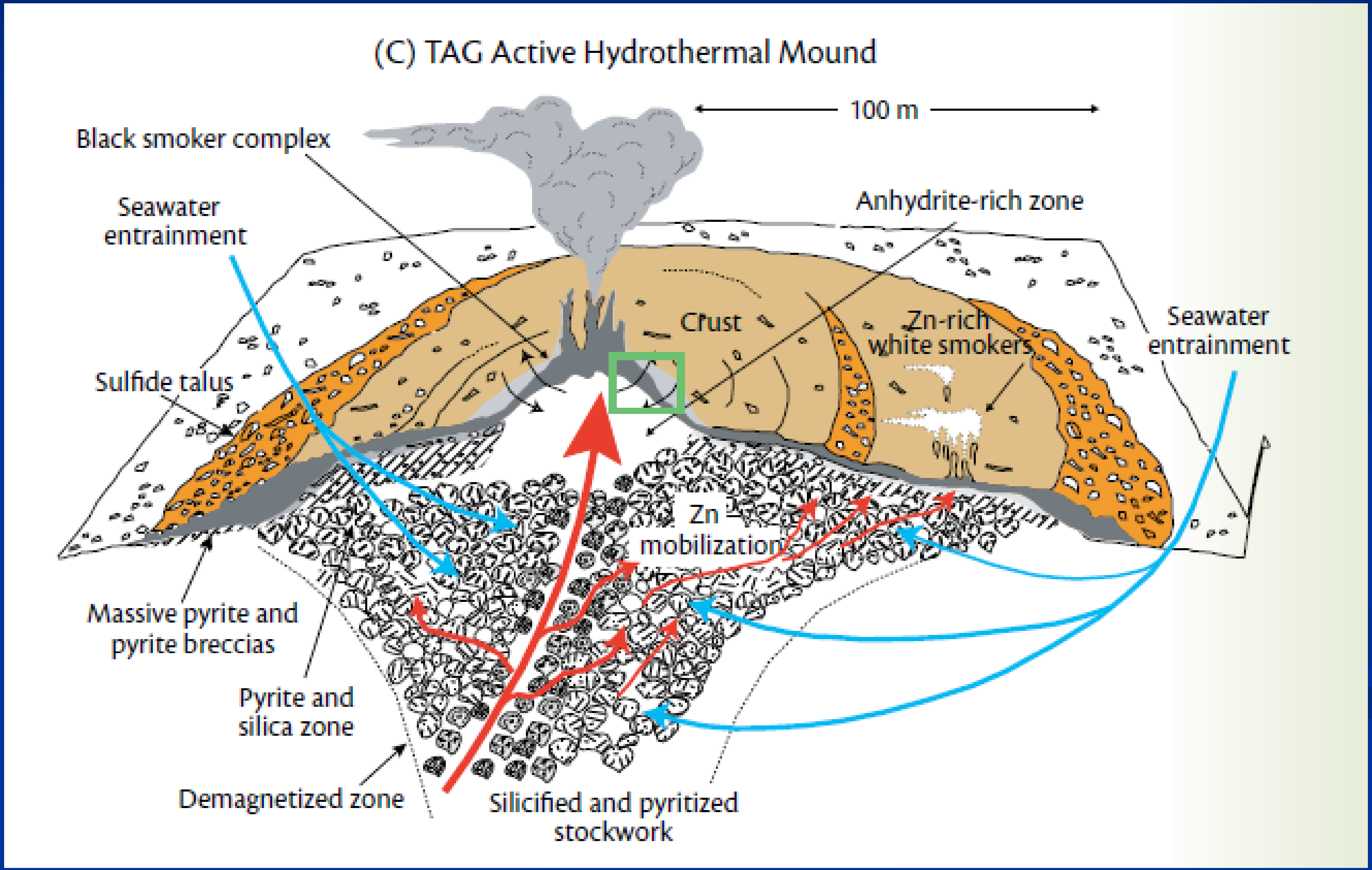
Black smoker chimney and Cu-Zn Sulphides



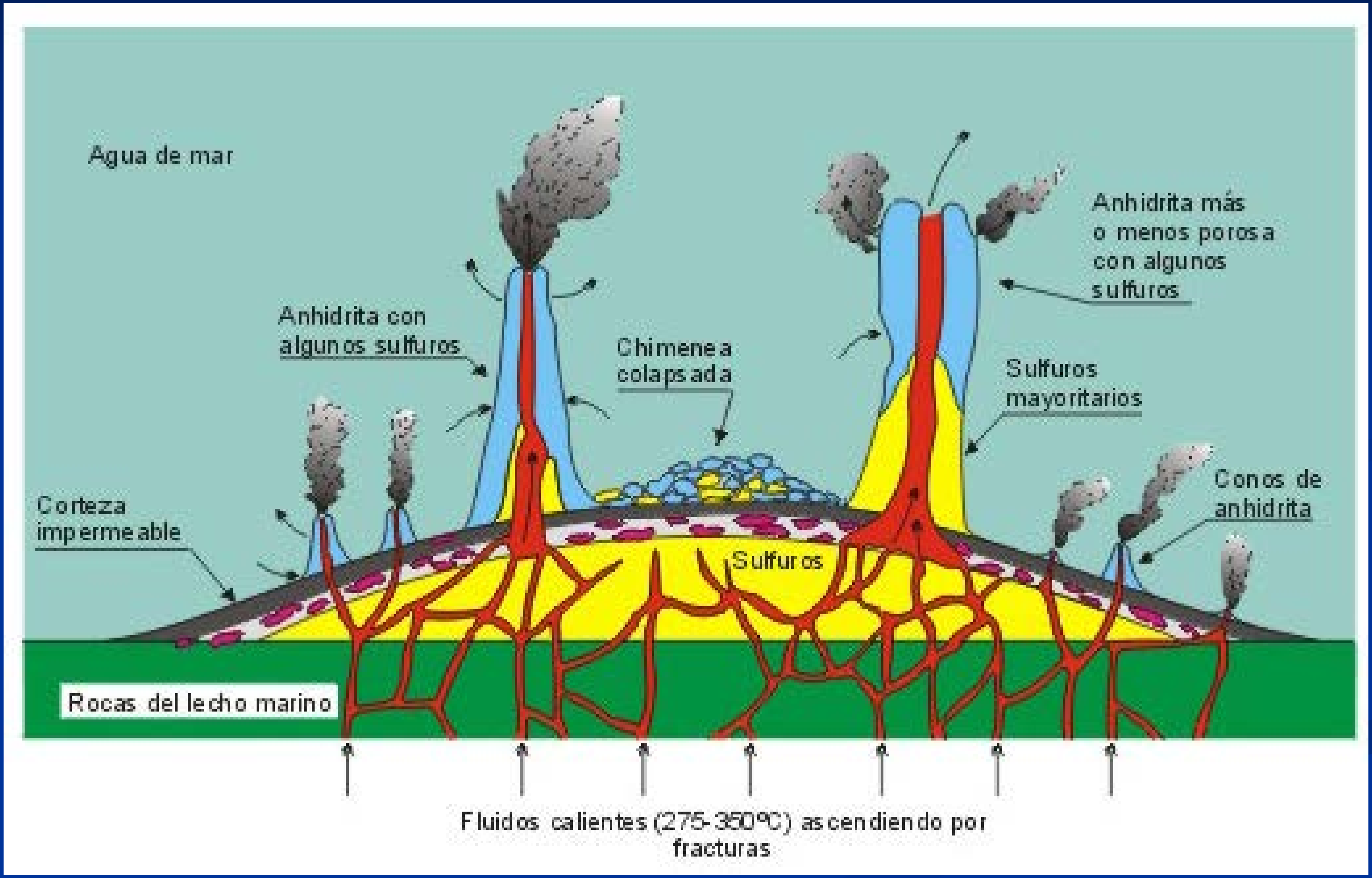
Chimney Development



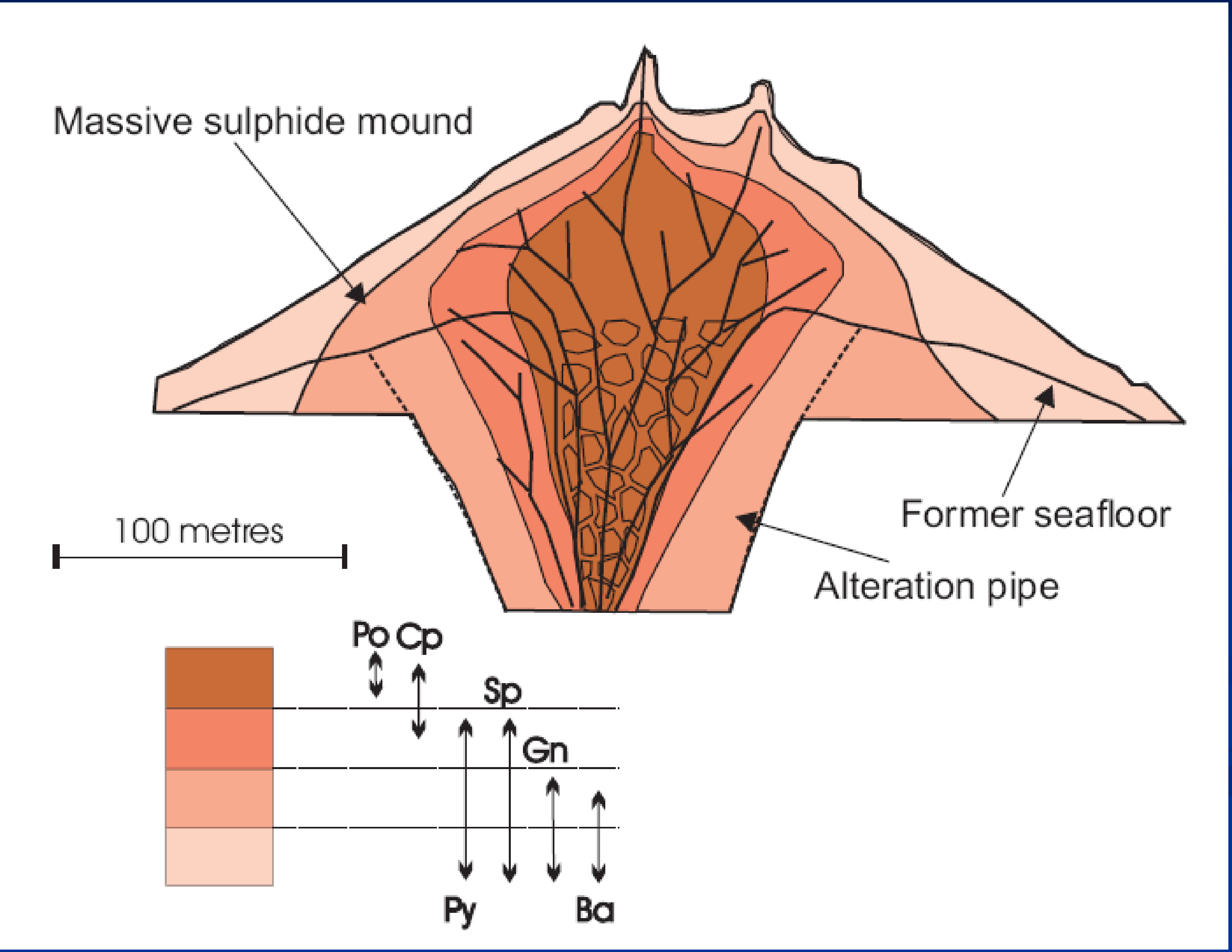
The TAG (Mid-Atlantic Ridge) Hydrothermal Vent Field



Anatomy of a Seafloor Sulphide Mound

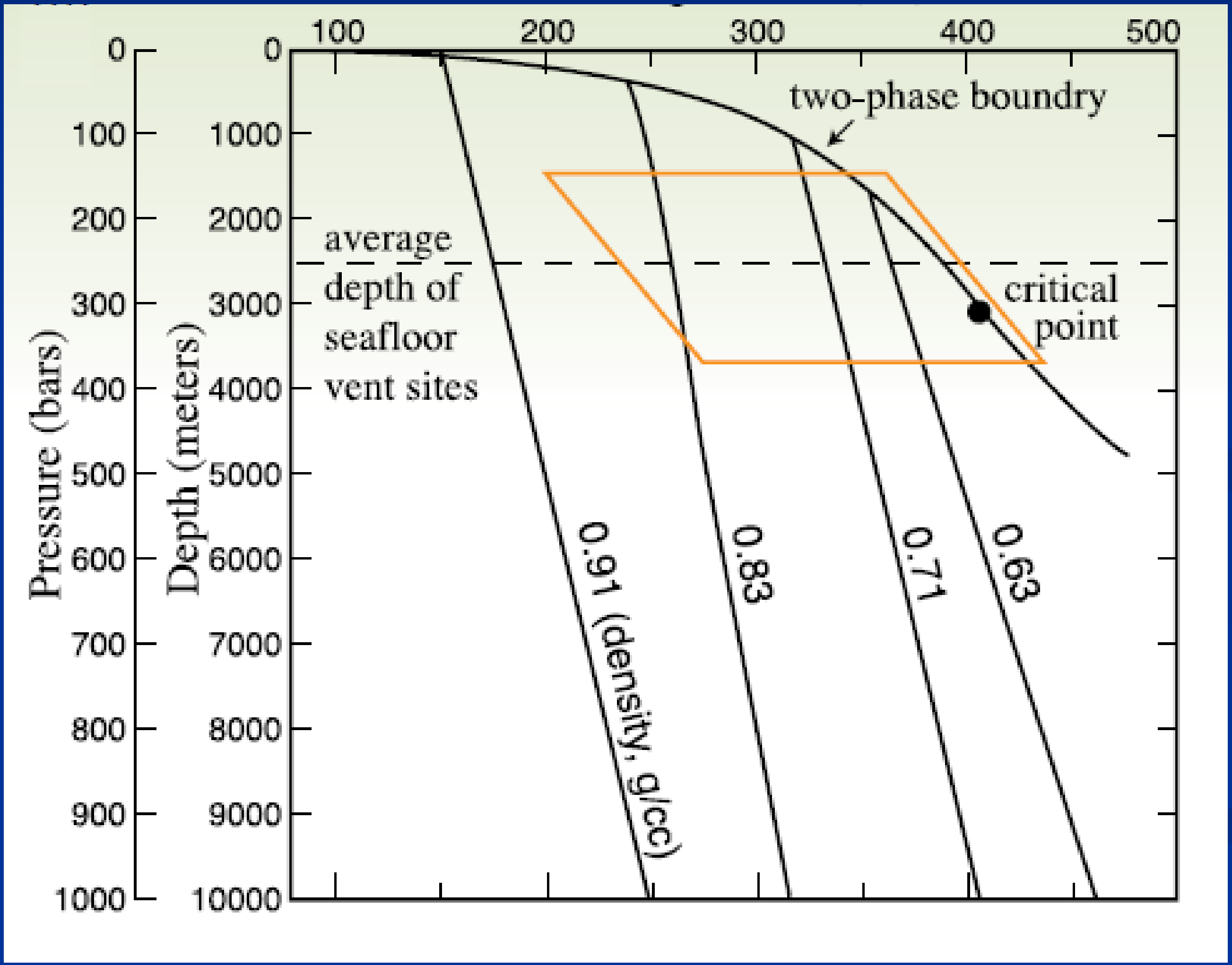


Mound Mineralogy



The State of the Ore Fluid, Liquid or Vapour

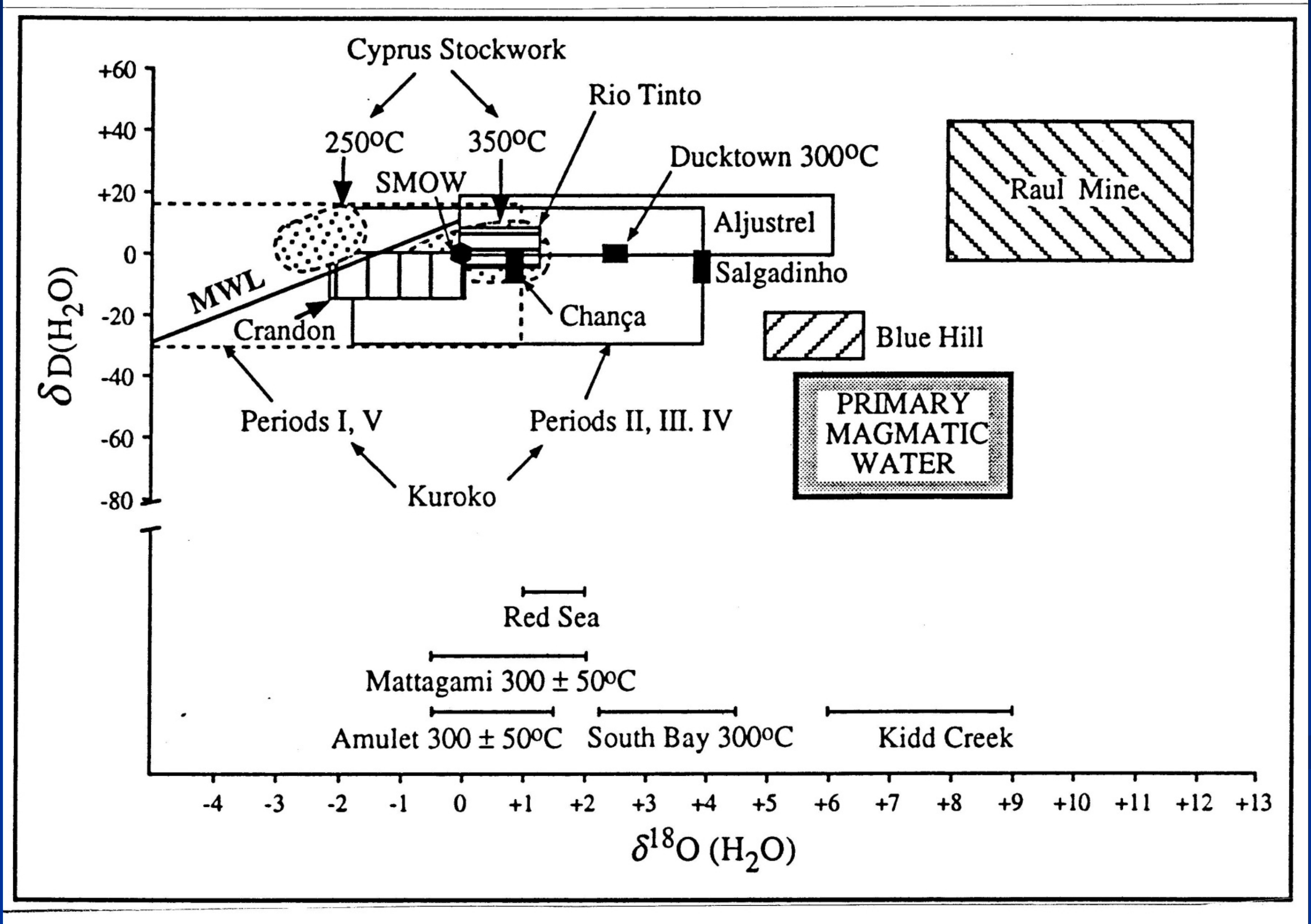
T °C



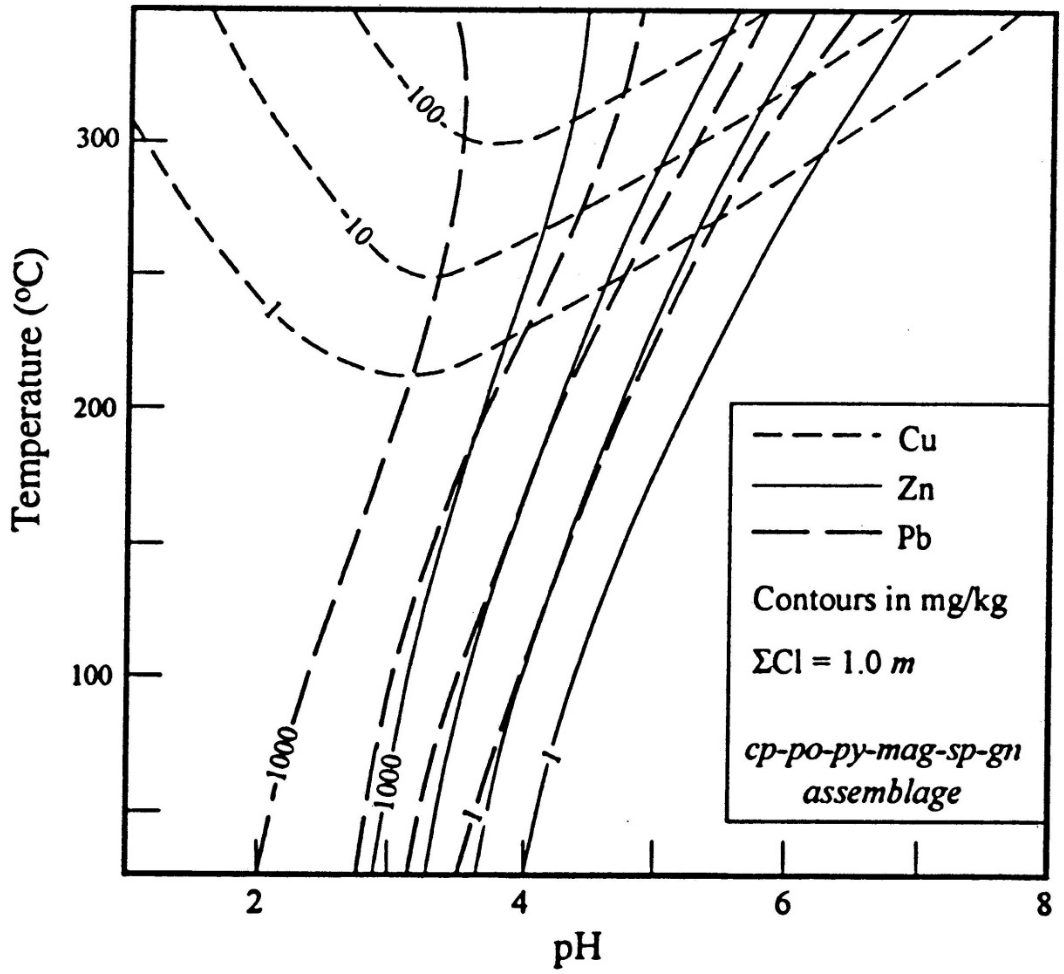
Fluid Compositions

	Kuroko	EPR	SJFR	Seawater
Temp (°C)	320	350	224	2
pH	4.5	3.5	3.2	8.0
Na	17500	9800	18300	10790
K	5000	1000	2020	395
Ca	4400	860	3860	413
Mg	510	< 1	< 1	1280
SiO_2	?	960	1400	10
Cl	40400	17335	38640	19355
SO_4	?	< 1	-50	2745
H_2S	?	221	63	< 1
$\sum CO_2$	8800	282	?	103
Fe	6	100	1045	< 1
Mn	?	34	197	< 1
Zn	3	7	59	< 1
Cu	5	1	< 0.1	< 1
Pb	3	< 1	?	< 1
Ba	?	13	?	< 1

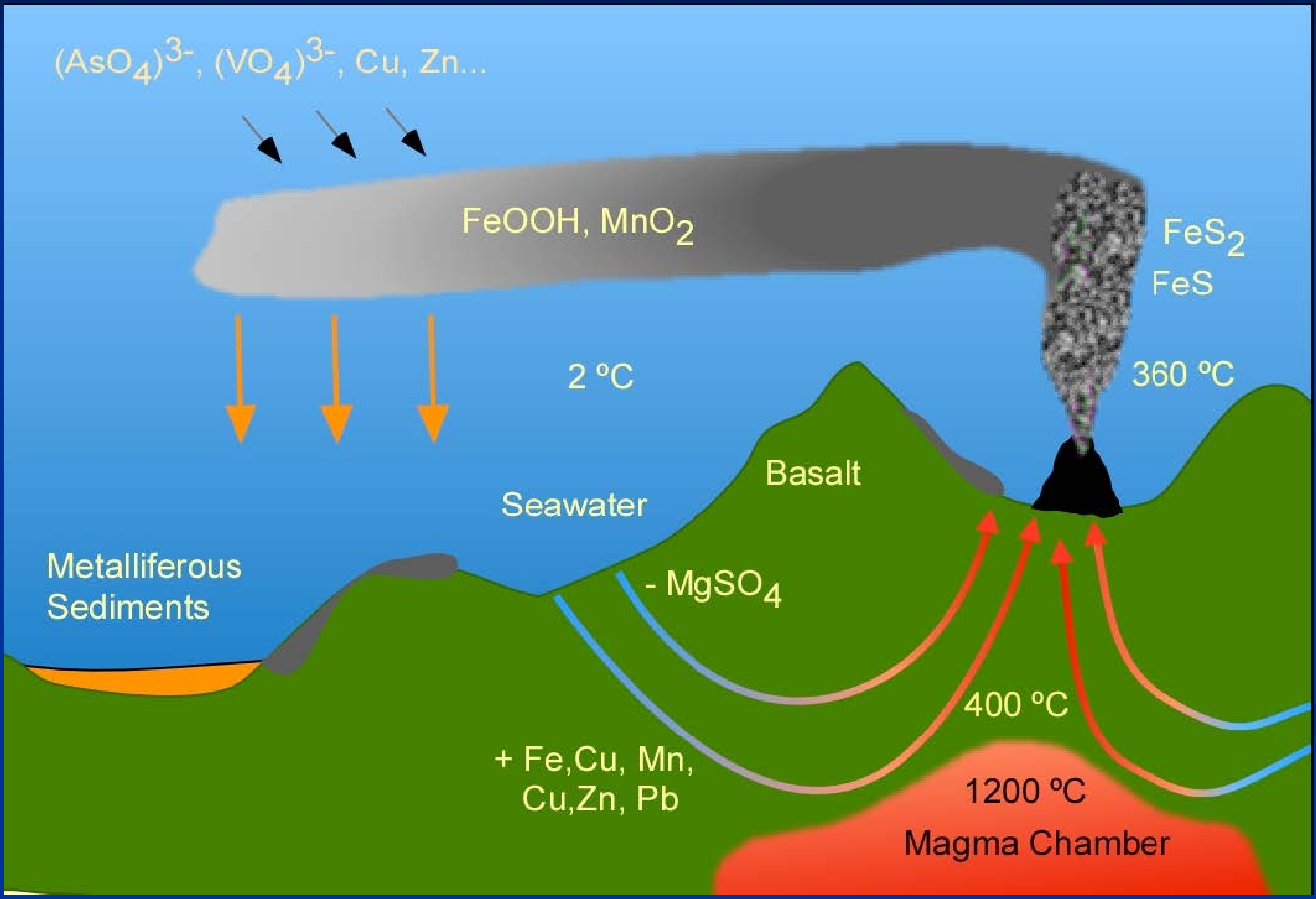
VMS Deposits – Isotopic Data



Controls on Mineral Deposition



Model for VMS Ore Formation



Model for VMS Ore Formation