Aspects of Lachlan Orogen Magmatic Arc Cu-Au-Ag Exploration with lessons from the Pacific rim

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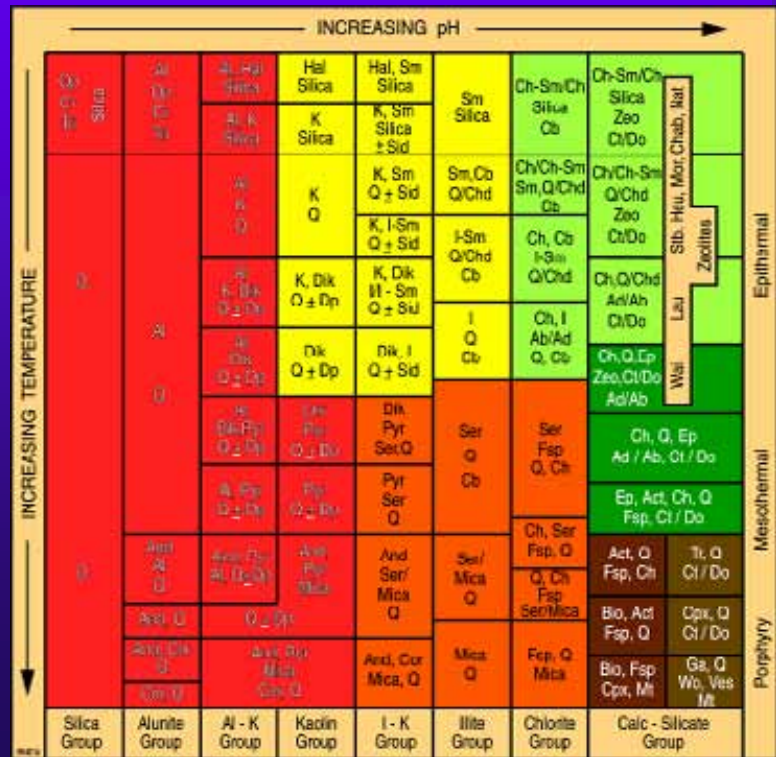
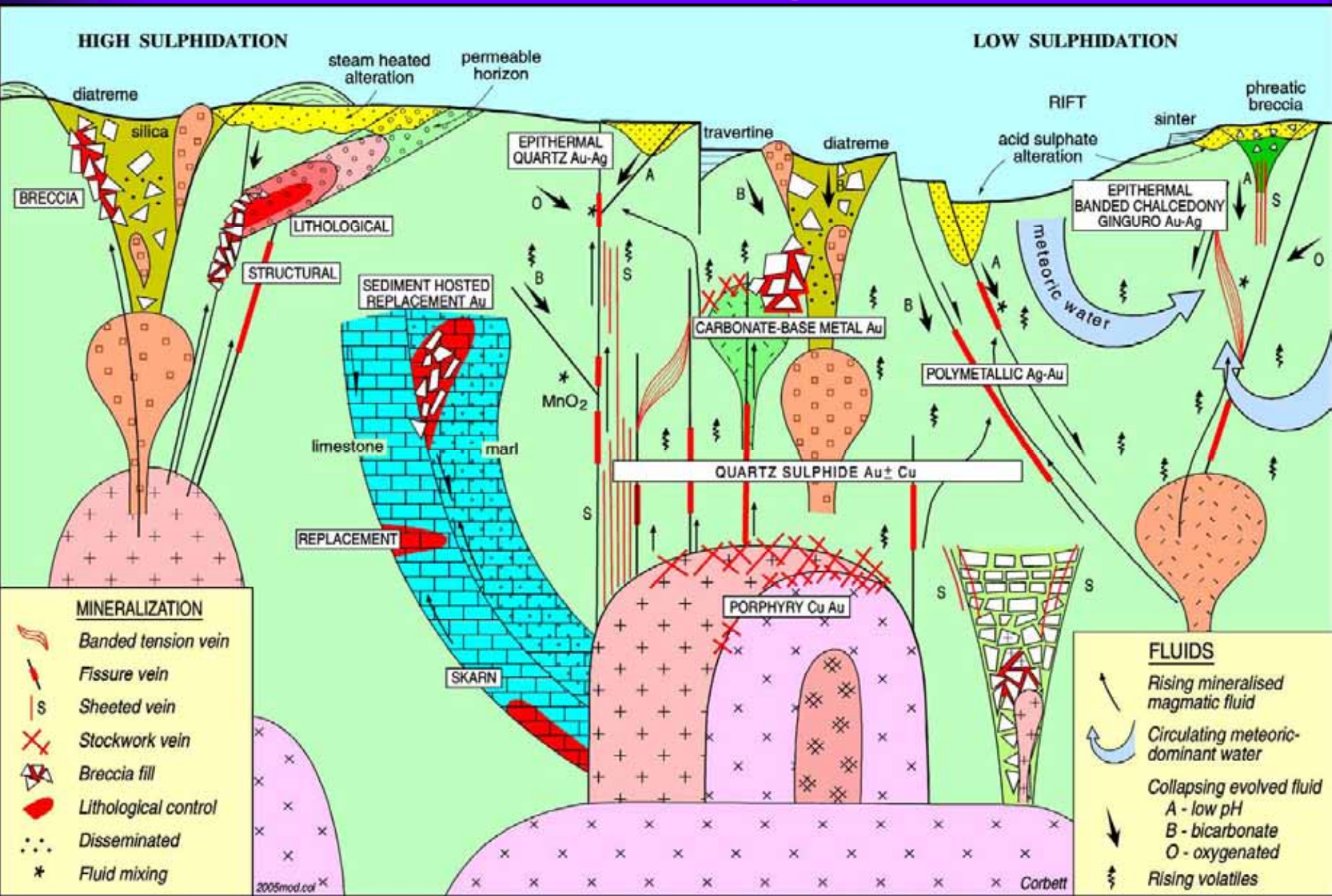
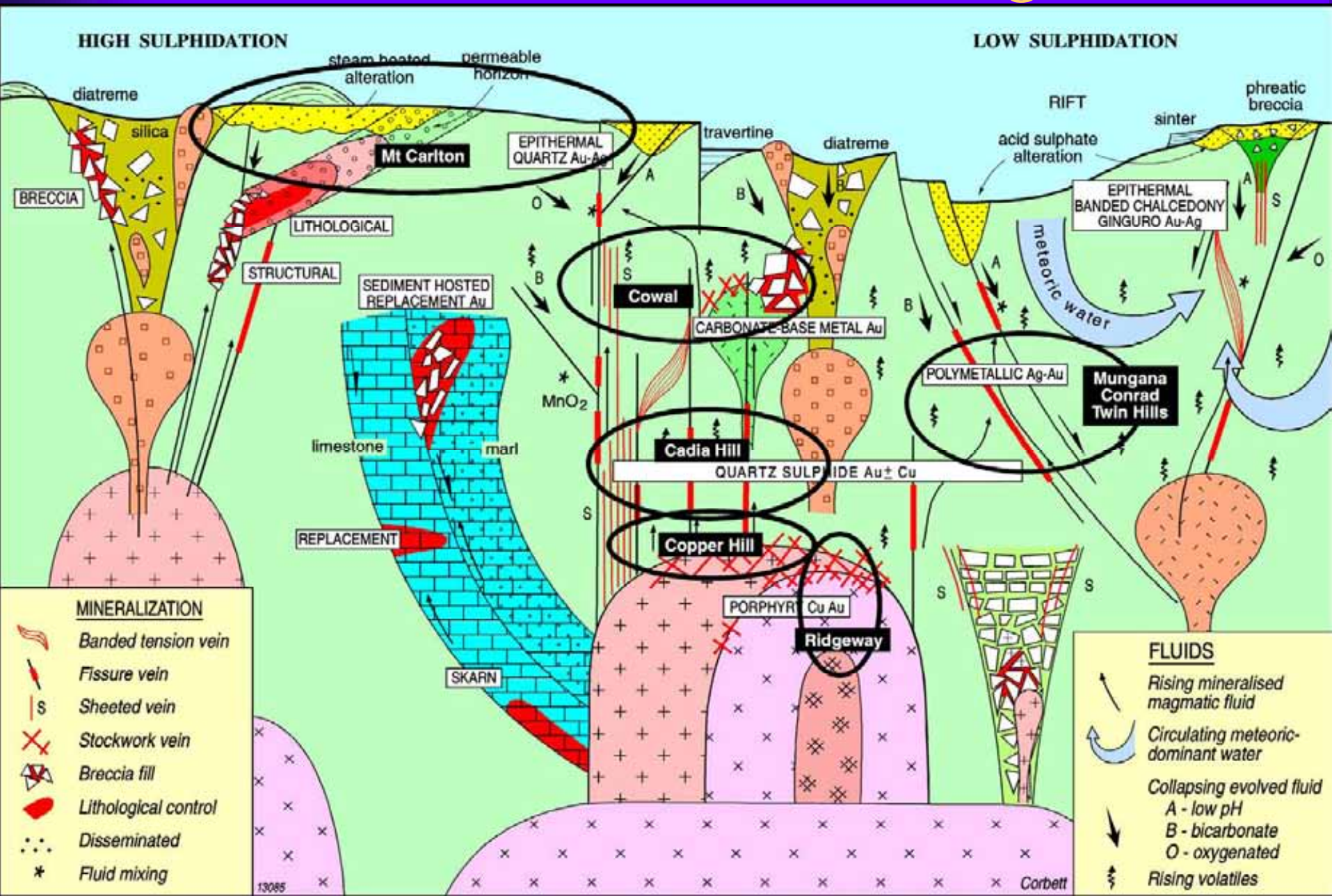
Terry Leach Symposium 2008



Model for Pacific rim magmatic arc Cu-Au

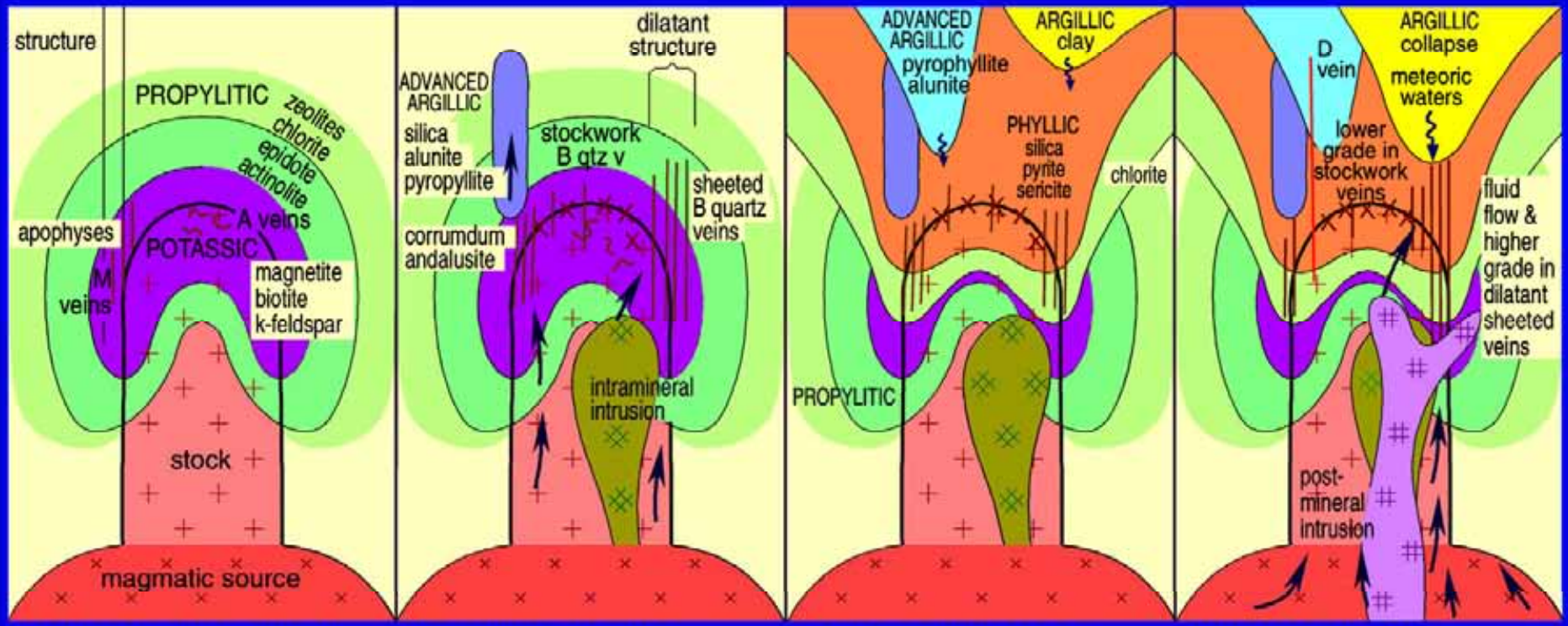


Mines & Wines Lachlan Orogen



STAGED PORPHYRY Cu-Au EVOLUTION

EARLY → LATE



Intrusion emplacement and heat transfer.

Initiation of A & M quartz vein formation and early mineralization

B quartz vein formation and continued prograde alteration.

Exsolution of magmatic volatiles.

Cooling and overprint of retrogrde alteration.

Continued collapse, mineralization, D vein formation & post-mineral features.

12464

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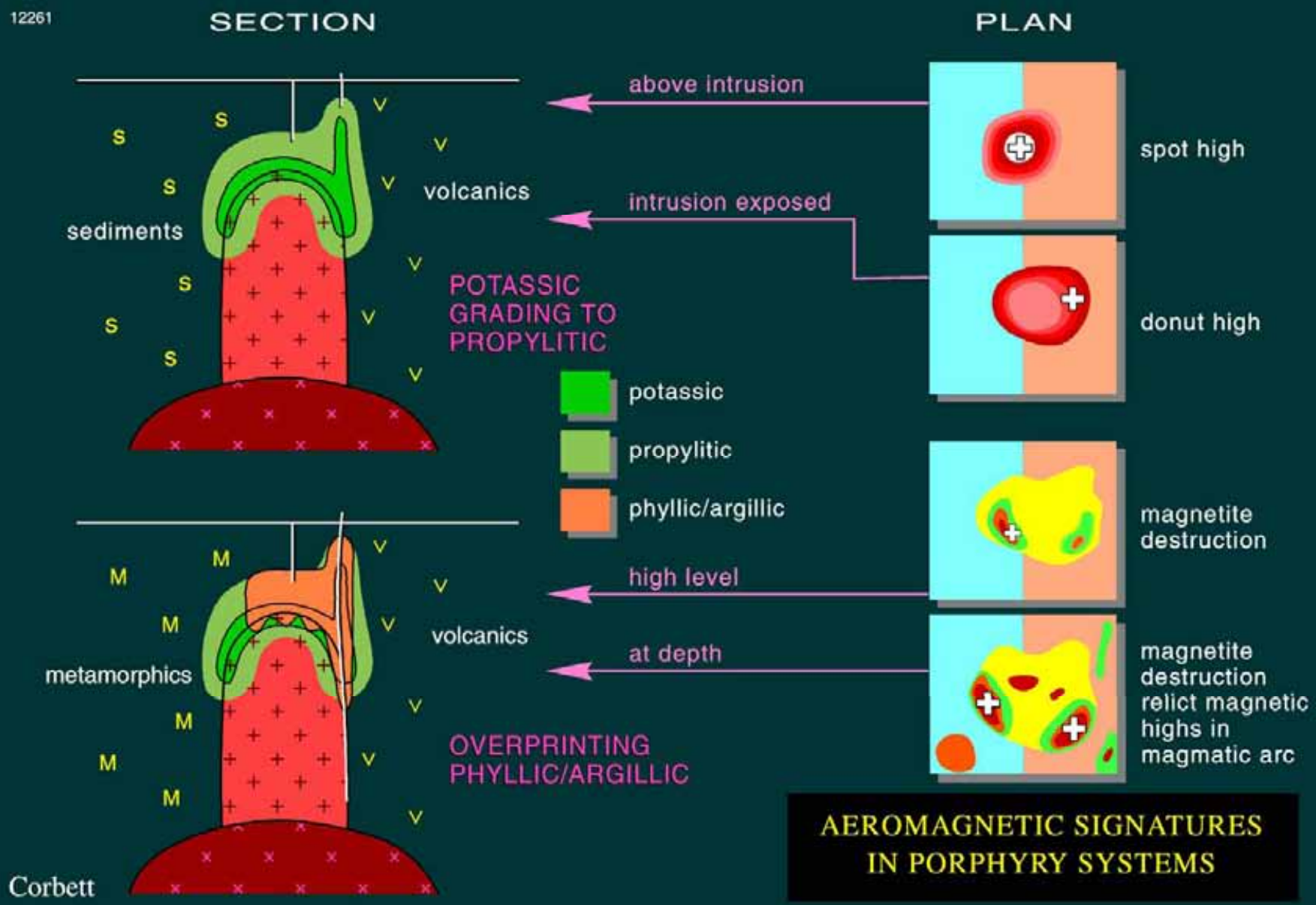
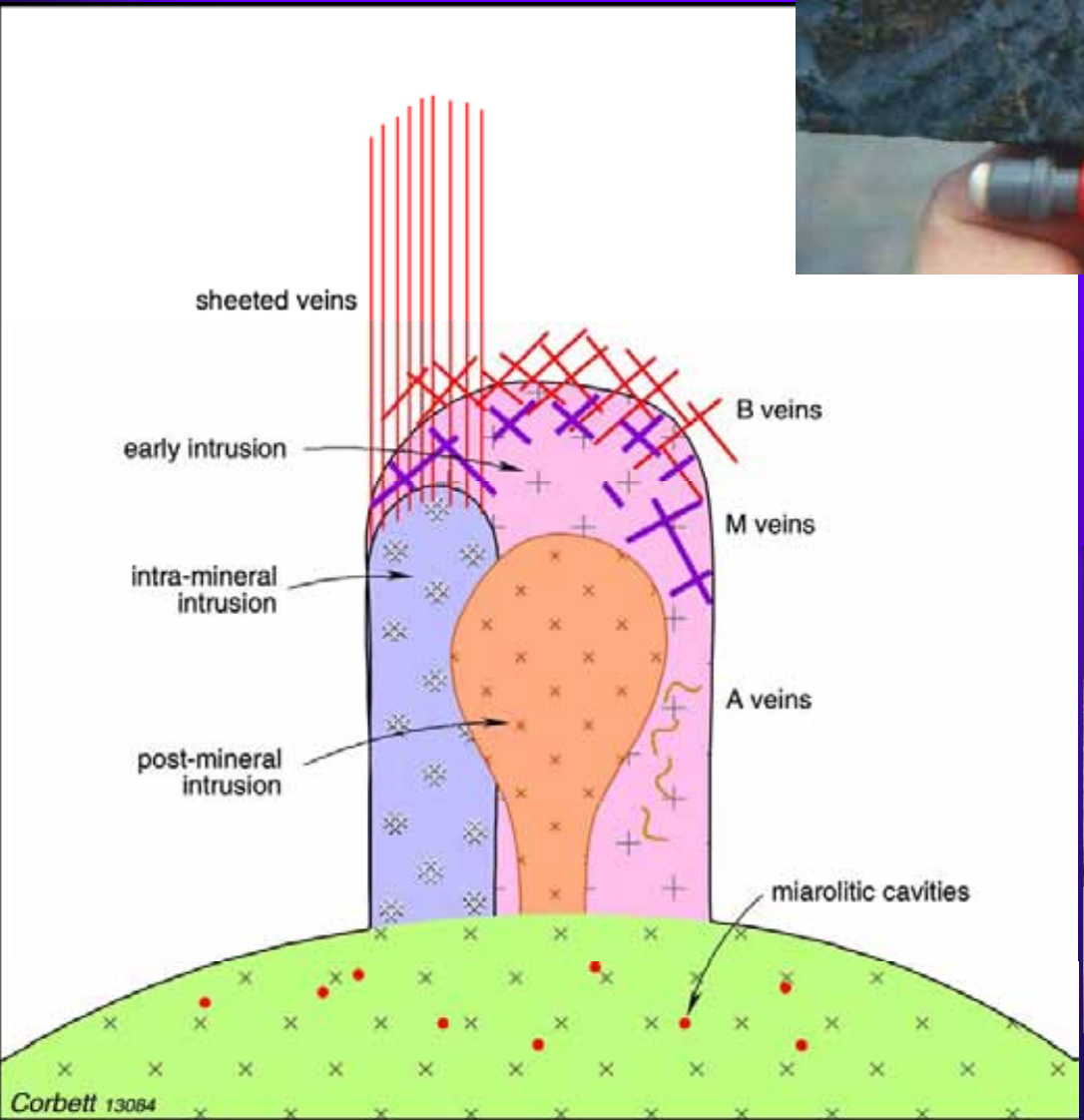
Magnetite destruction by phyllic (sericite) alteration overprint (of potassic alteration)

Overprinting alteration and magnetics



Overprinting intrusions and veins

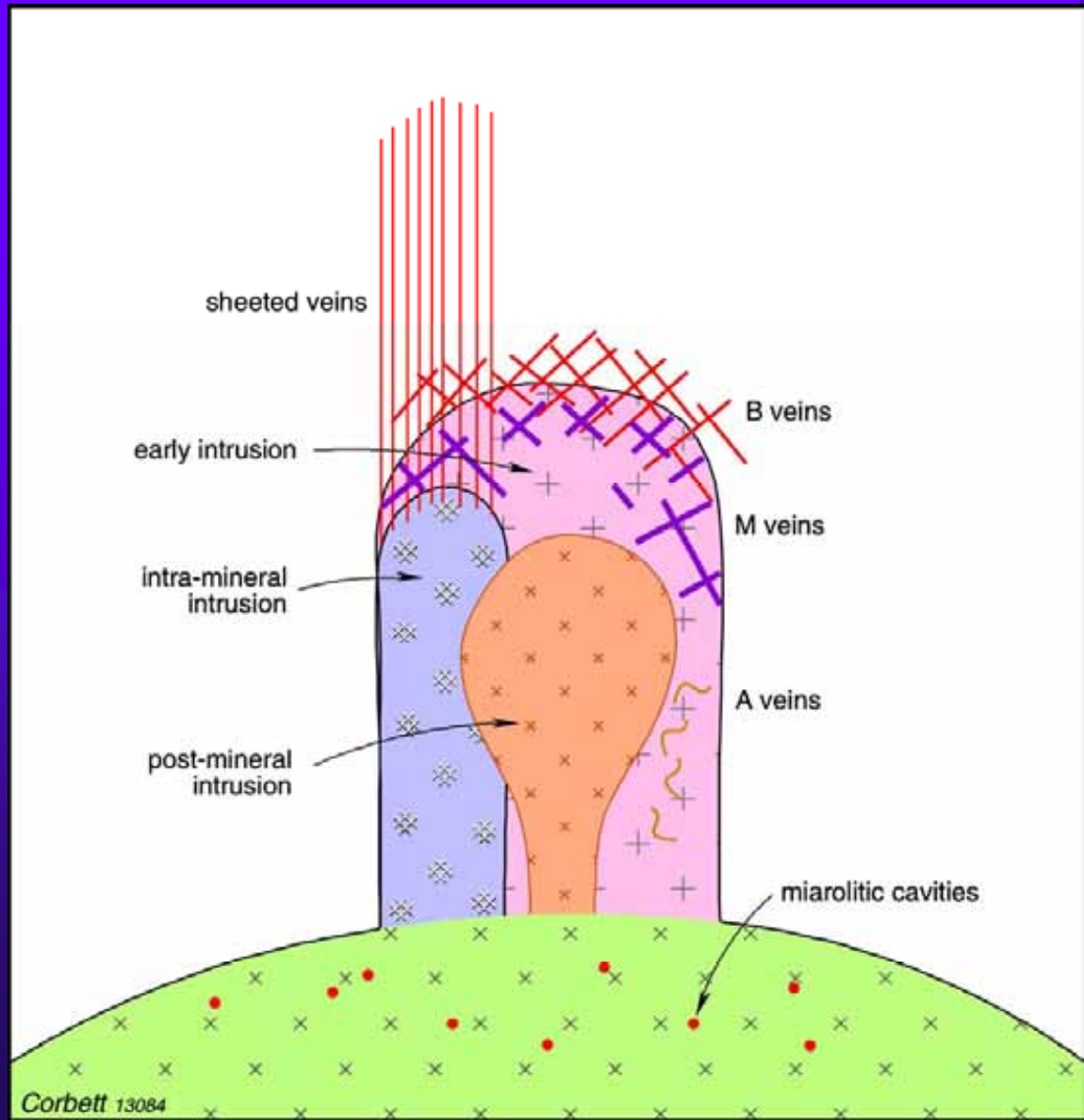


Ridgeway, Straya

Rio Grande, Argentina

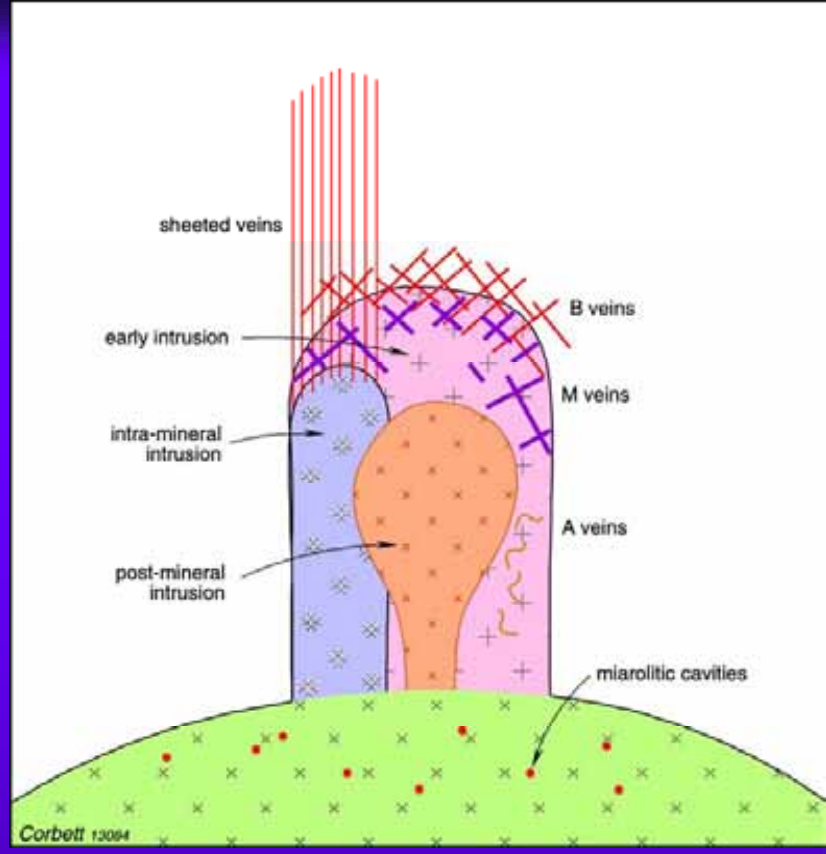
Overprinting intrusions

Fluid evolution and levels in Porphyry Cu-Au



Wall rock porphyry

Cadia Australia



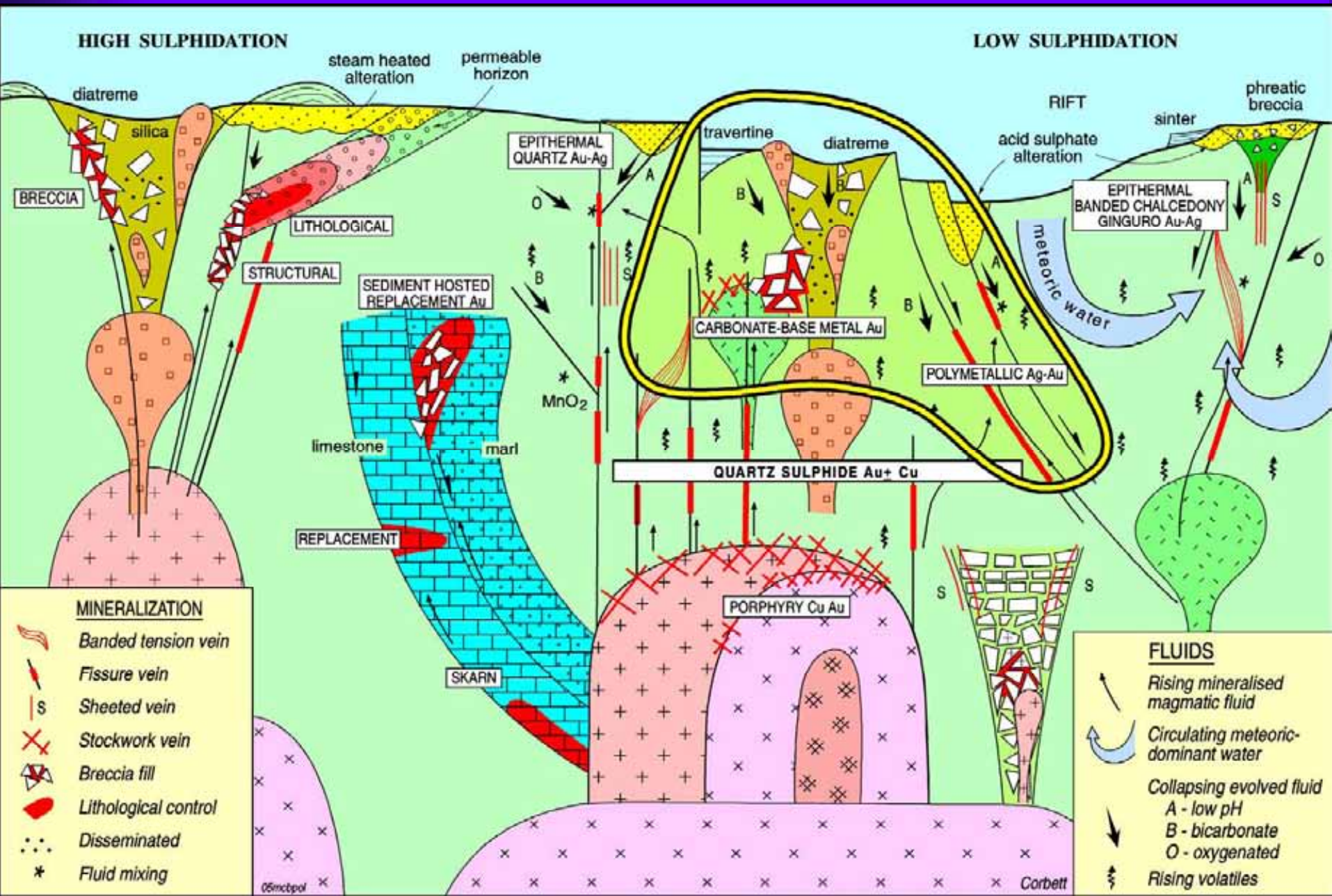
Maricunga Belt, Chile

Gaby, Ecuador

Porphyry - wall rock porphyry Exploration implications

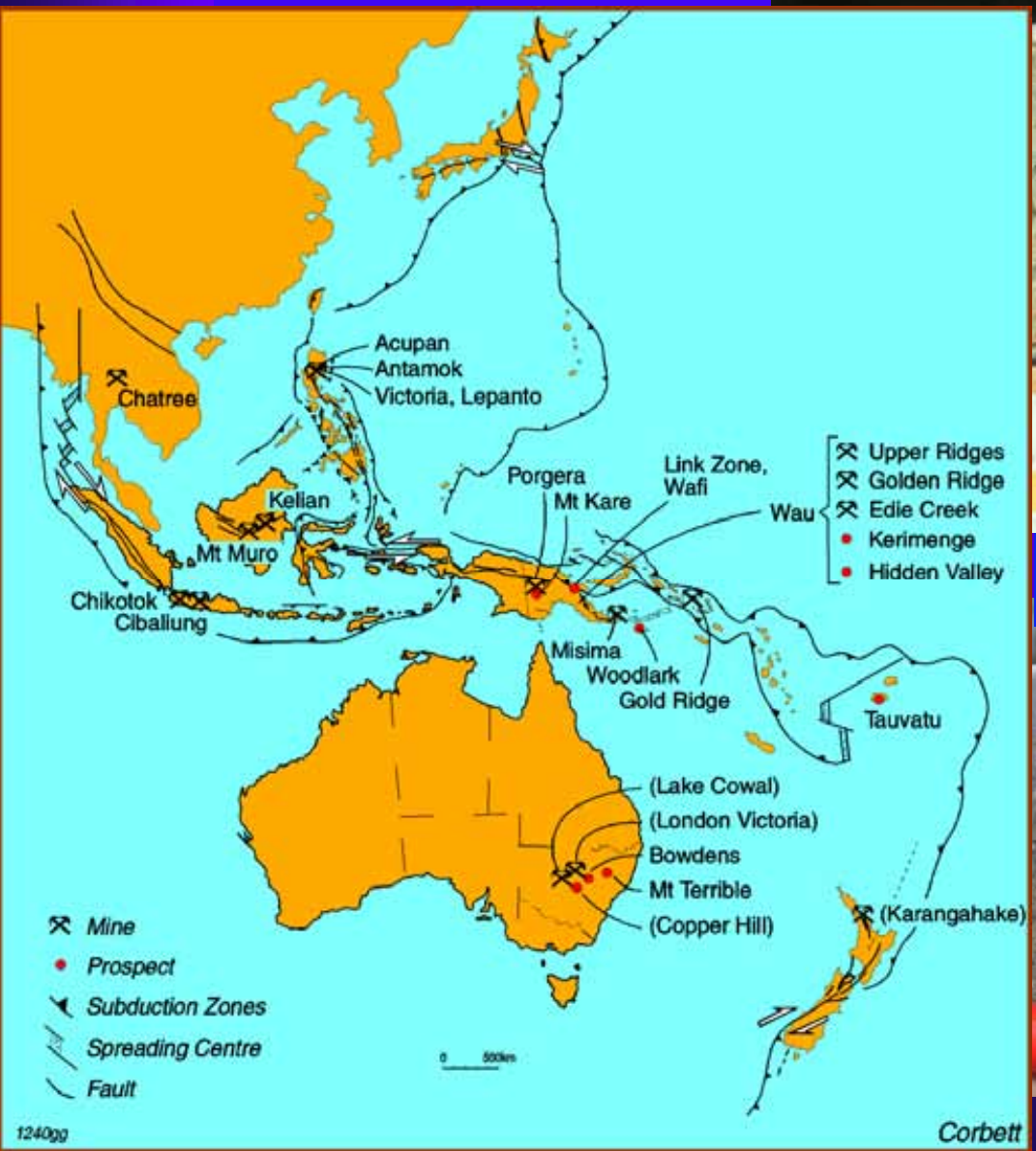
- Highest value targets
- Complex overprinting relationships increase metal grade
- Position in the anatomy is critical (late barren intrusions)
- Structural control to sheeted veins important

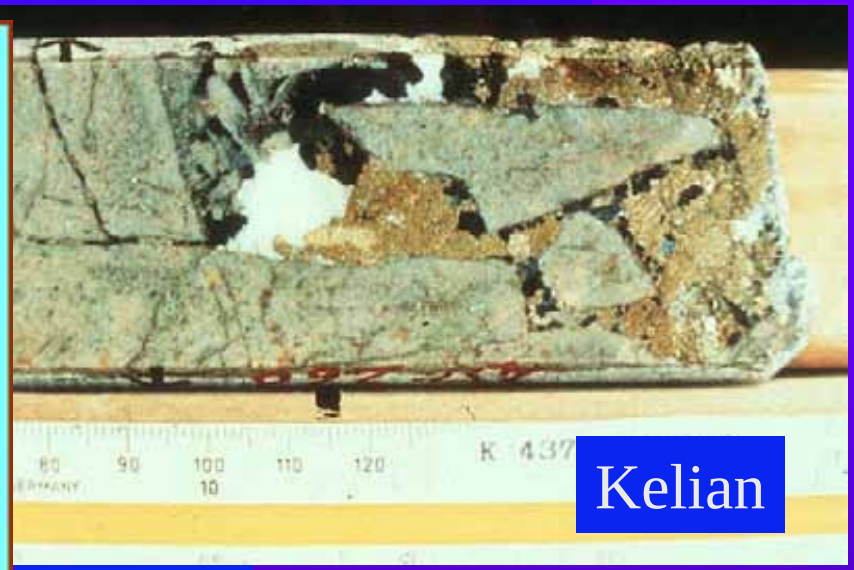
Carbonate-base metal Au



Carbonate-base metal Au –

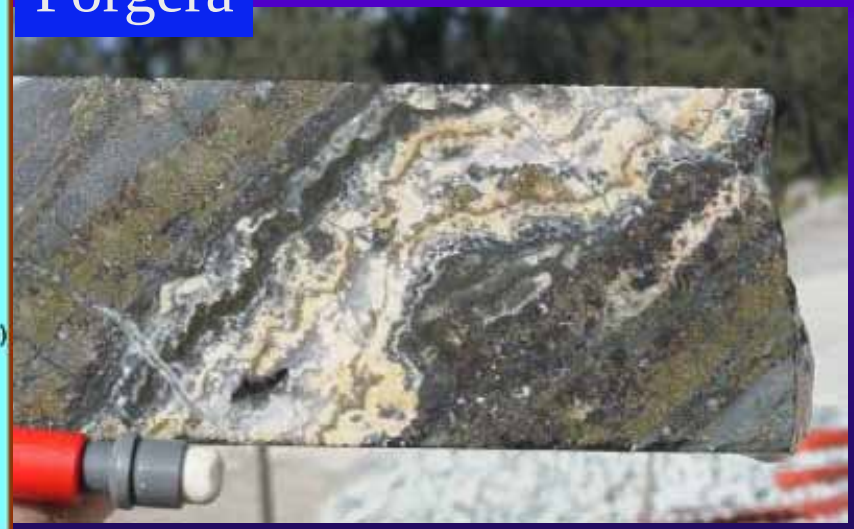
Leach and Corbett, 1993, 1994, 1995; Corbett and Leach, 1998



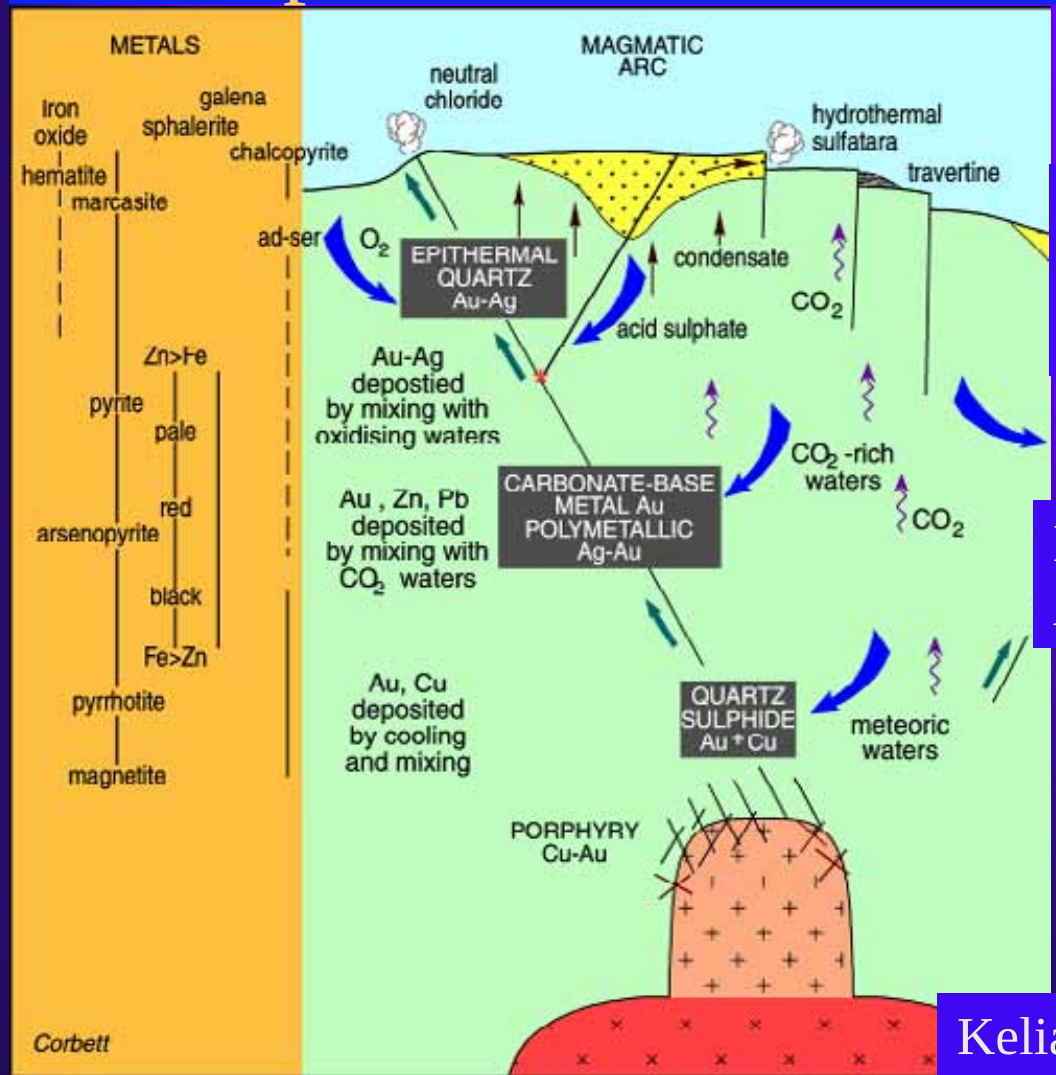


Kelian

Porgera



Polymetallic Ag-Au – carbonate base metal Au sphalerite zonation



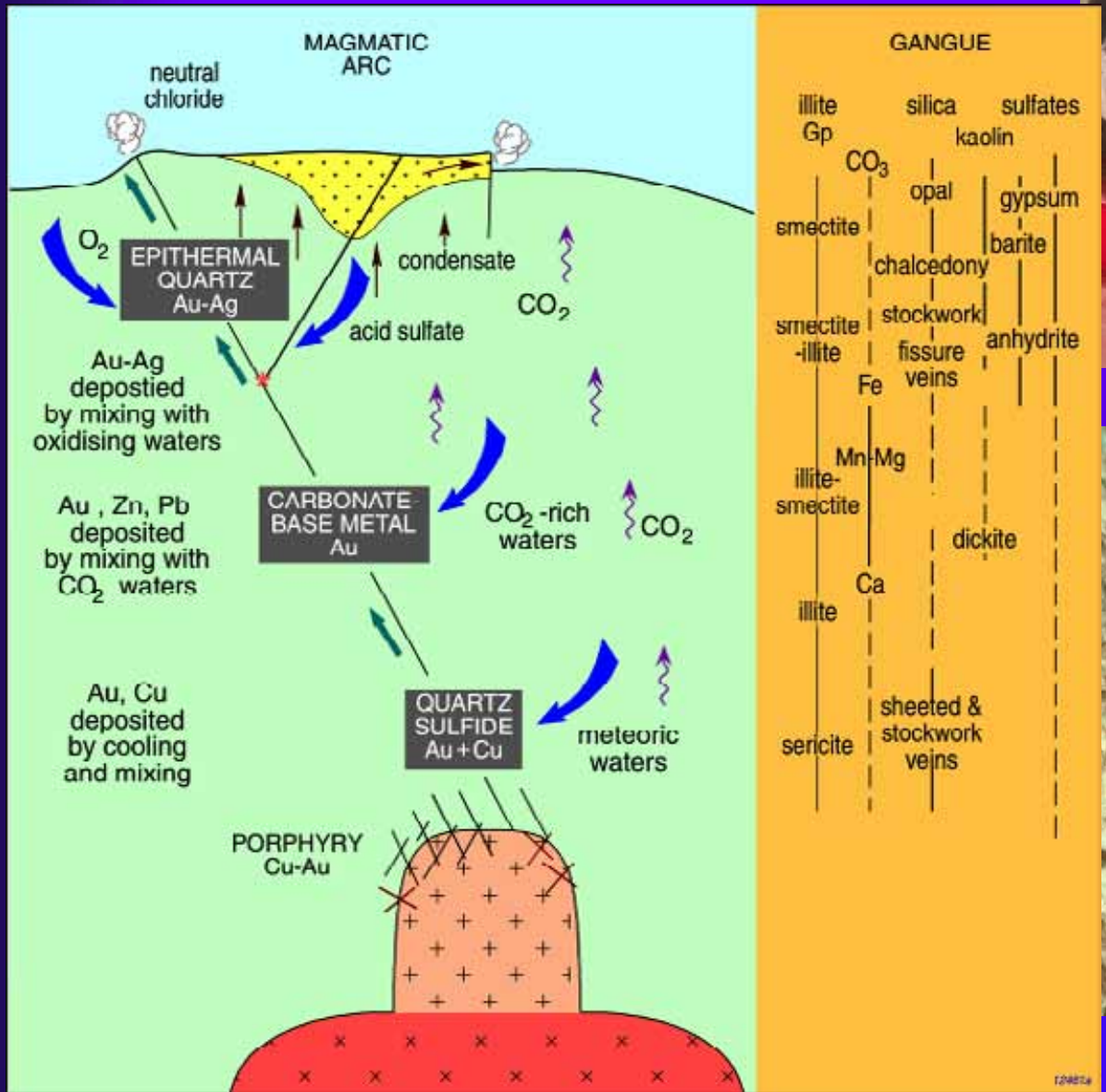
San Martin Peru

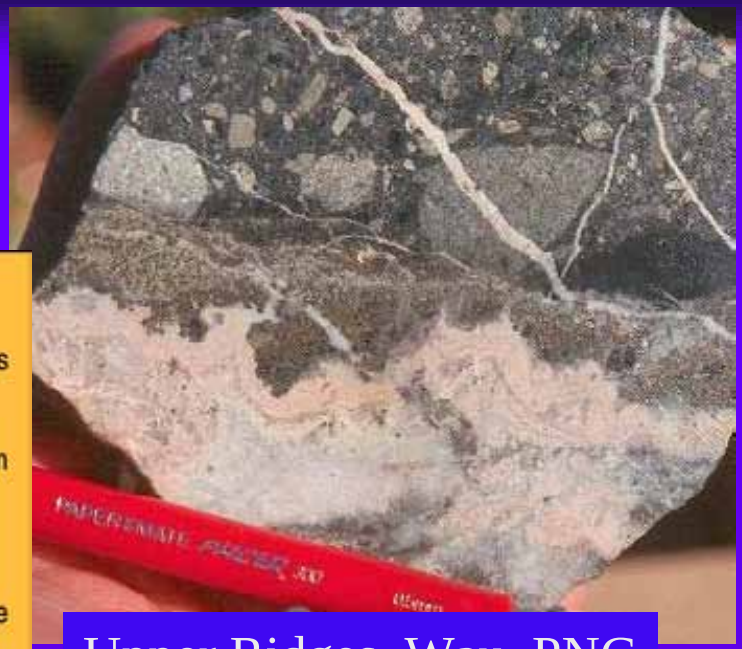
Kumrock, Kamchatka, E. Russia

Bowdens, Australia

Kelian, Indonesia

Carbonate base metal Au – carbonate types



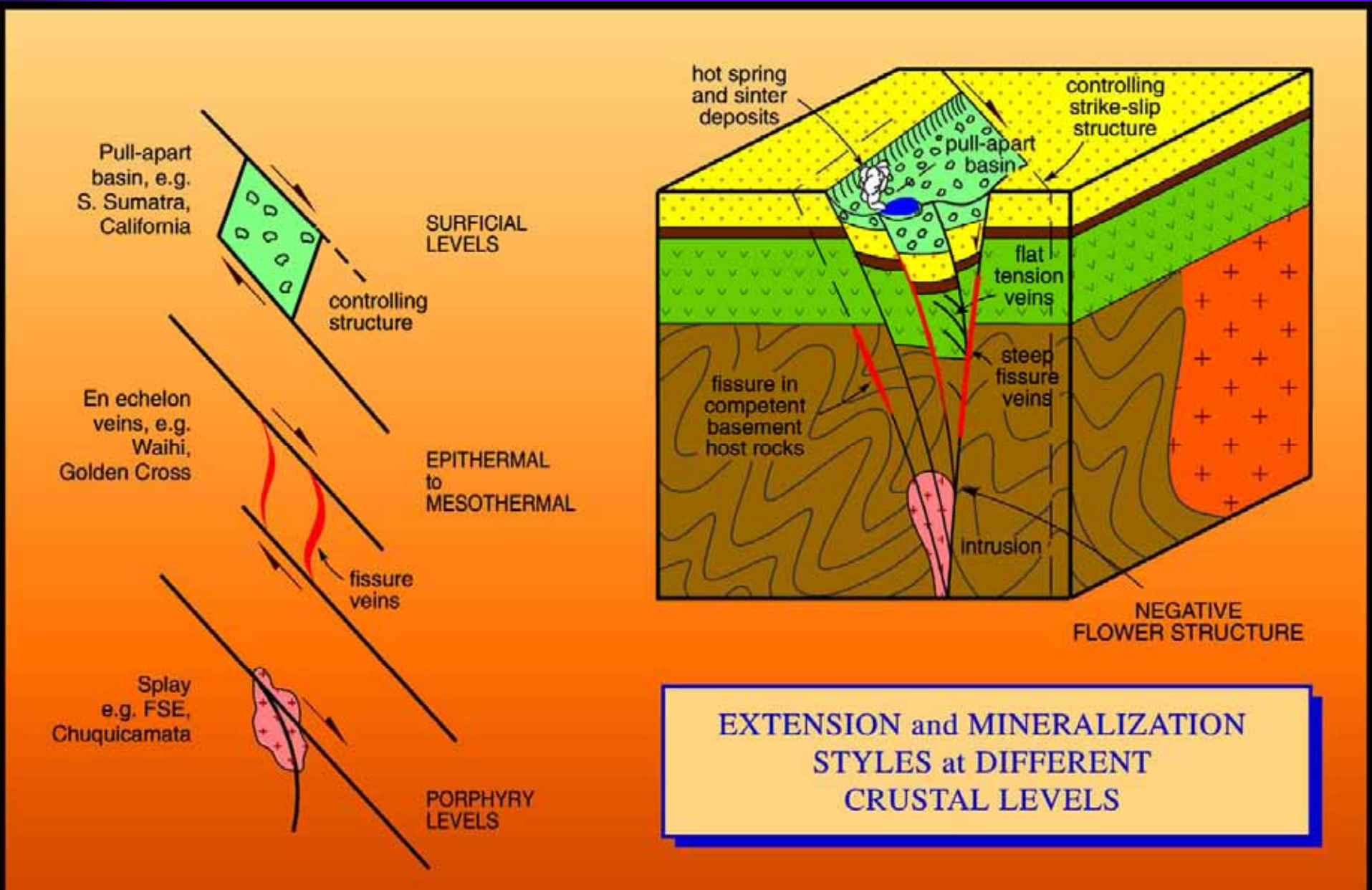


Upper Ridges, Wau, PNG

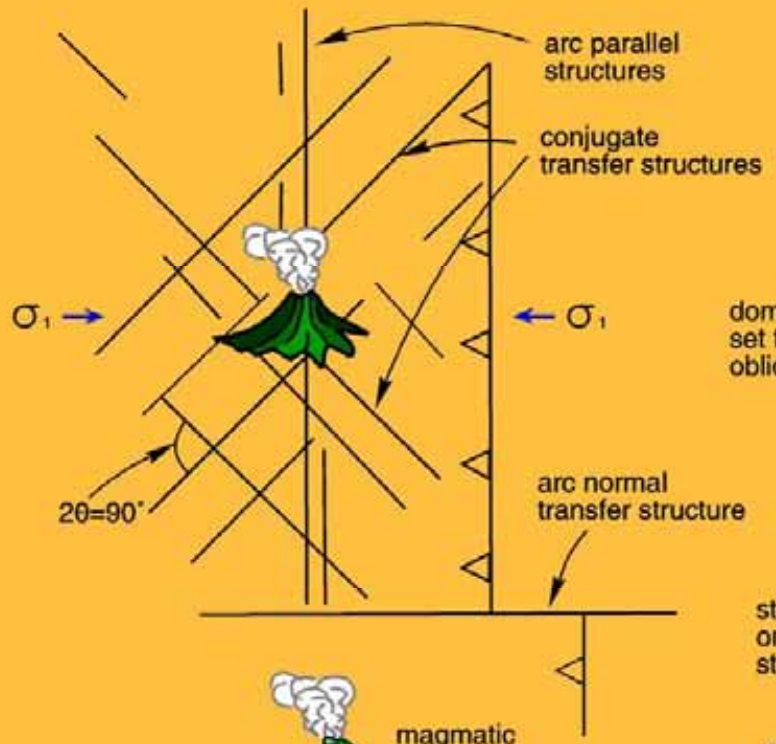
Mt Kare, PNG

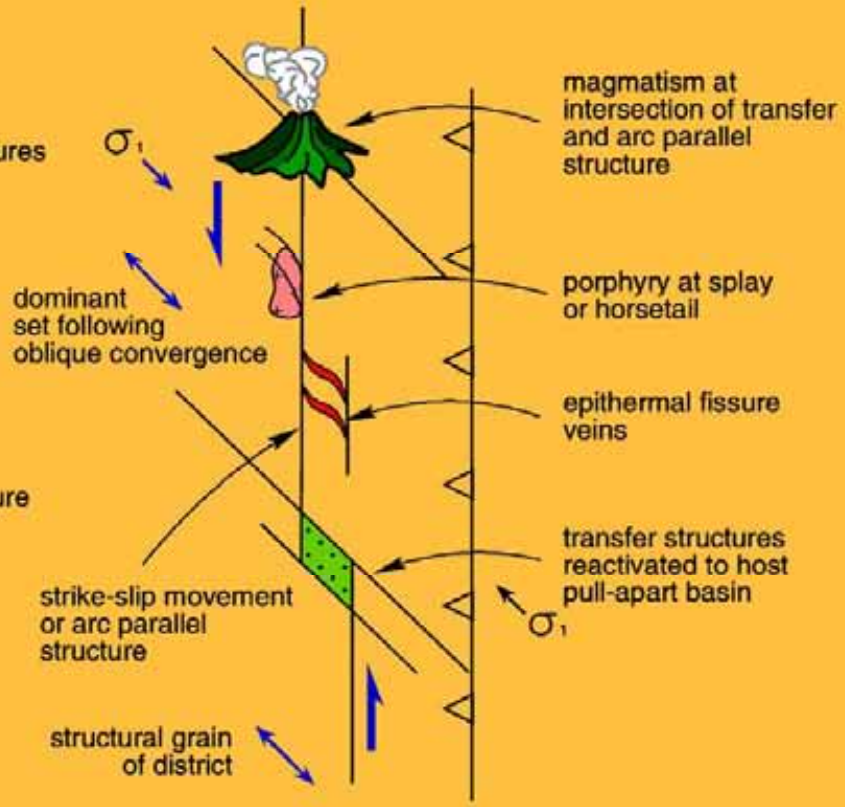
Cowal-
Carbonate -base metal Au

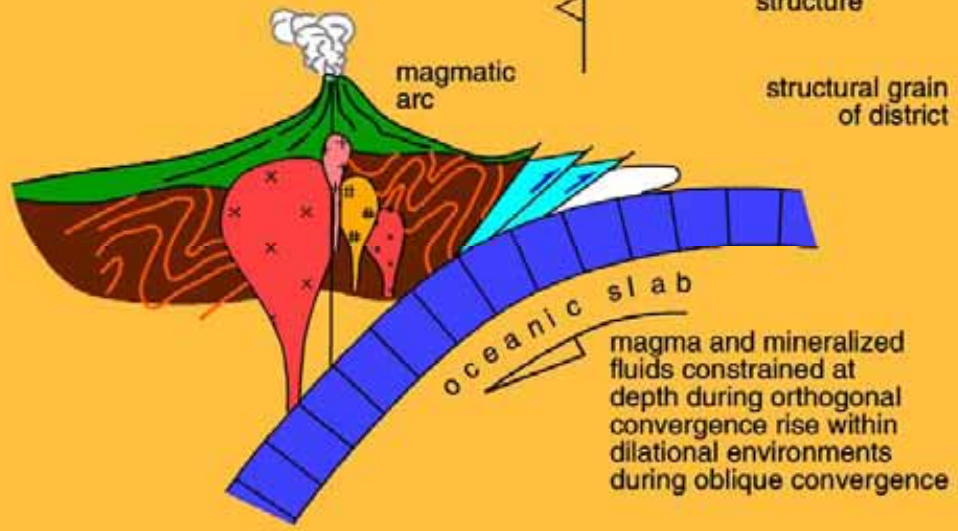
Cowal pull-apart basin fractures



Changes in convergence as a trigger







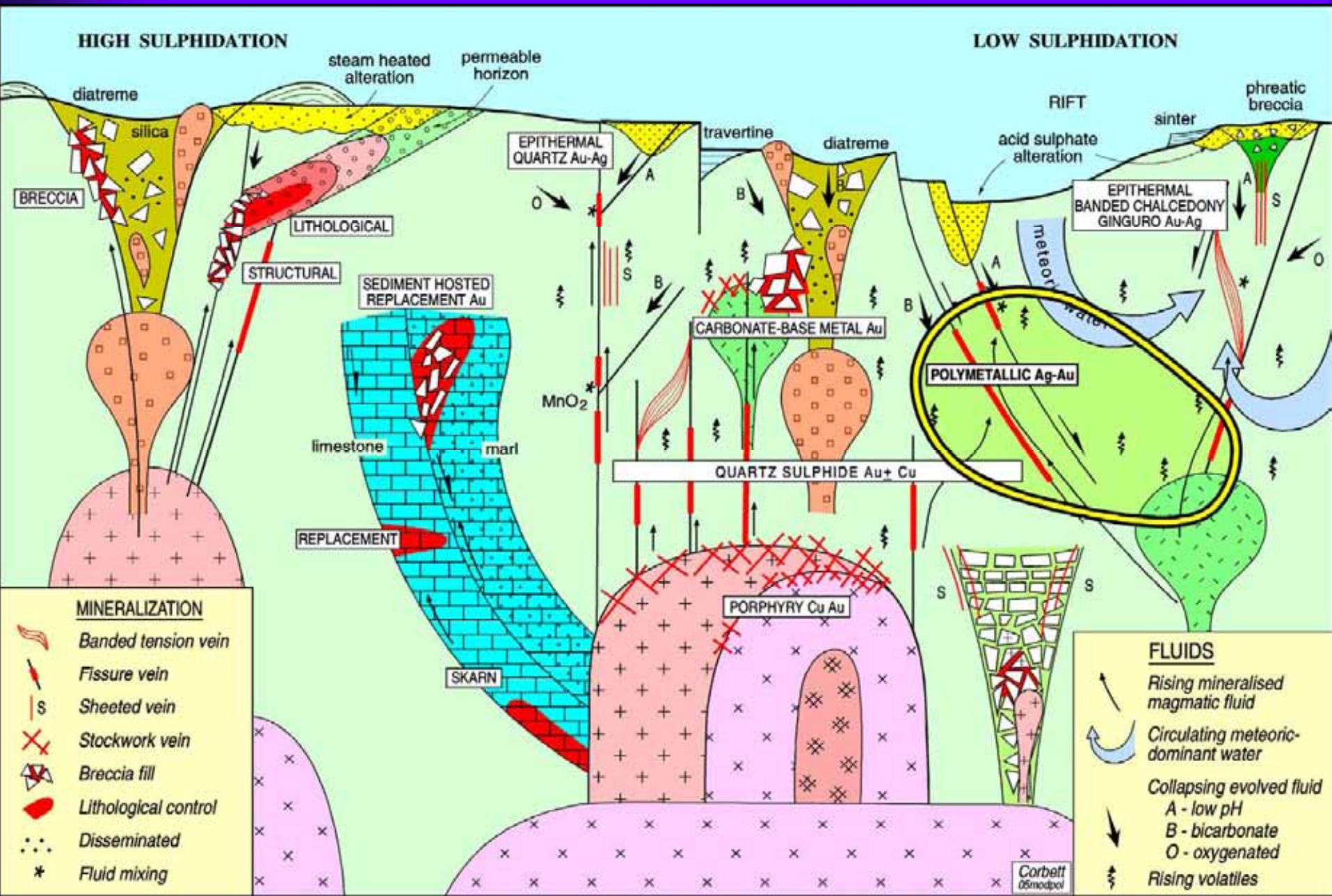
CONJUGATE TRANSFER STRUCTURES, MAGMATISM, AND CHANGES FROM ORTHOGONAL TO OBLIQUE CONVERGENCE

Carbonate-base metal Au Exploration implications

- Most prolific Au producers in the SW Pacific rim
- Au with zoned Zn>Pb and carbonate
- Irregular Au distribution & variable metallurgy
- Local overprinting bonanza Au
- Structural control to bleed fluids from magmatic source

Porgera

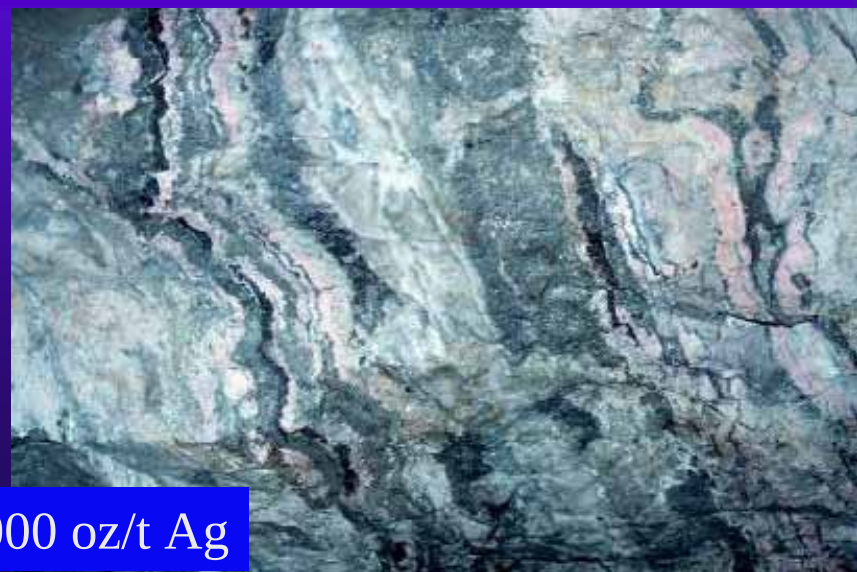
Polymetallic Ag-Au



Andean Polymetallic Au-Ag

Arcata, Peru

Caylloma, Peru



1000 oz/t Ag

Polymetallic Ag-Au Mexico

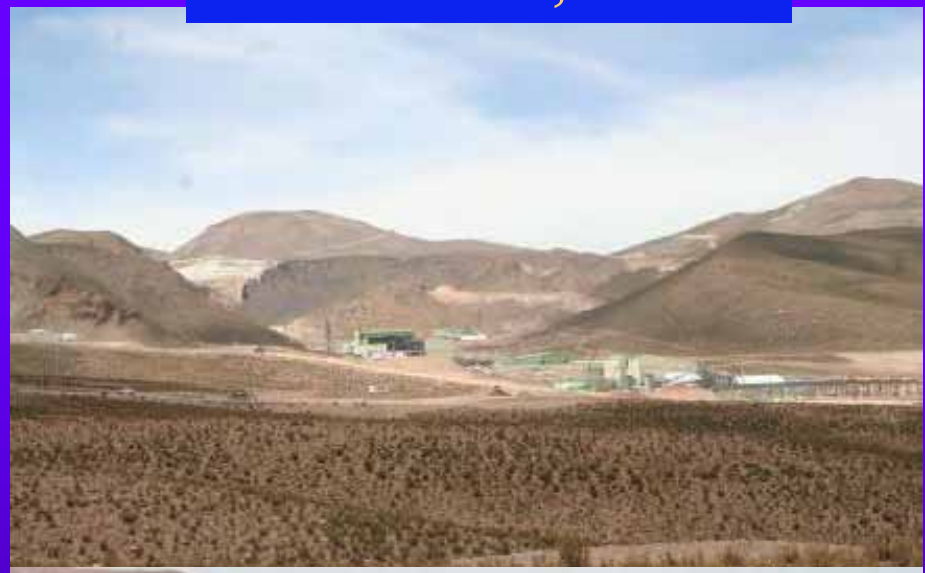
Fresnillo

Palmarejo

Polymetallic Ag-Zn-Pb

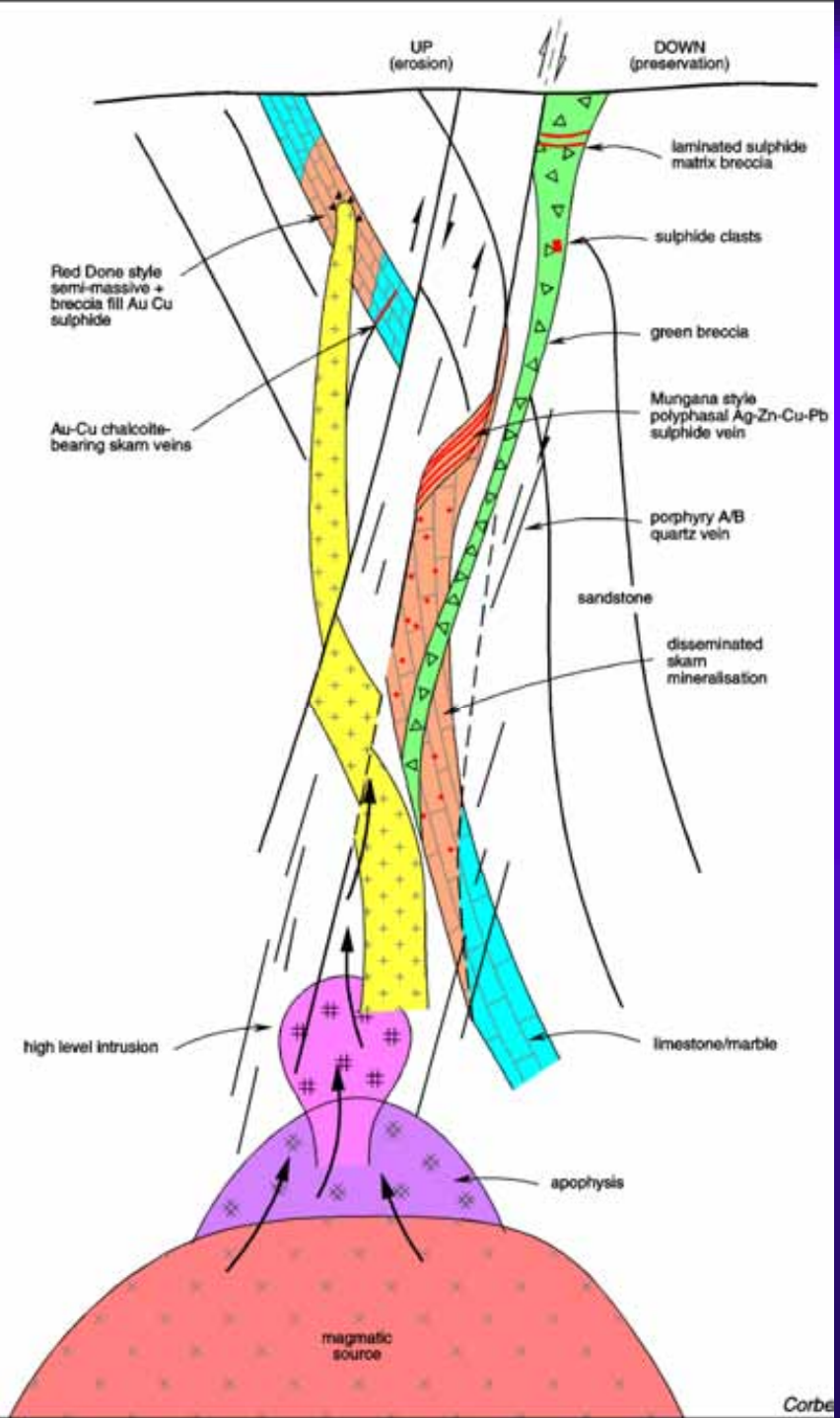
Corani, Peru

San Cristobal, Bolivia



Zonation in polymetallic Ag-Au

- Tops – white (Zn-rich) sphalerite, siderite, elevated precious metal grades, Ag>Au
- Bottoms – black (Zn-poor) sphalerite, chalcopyrite

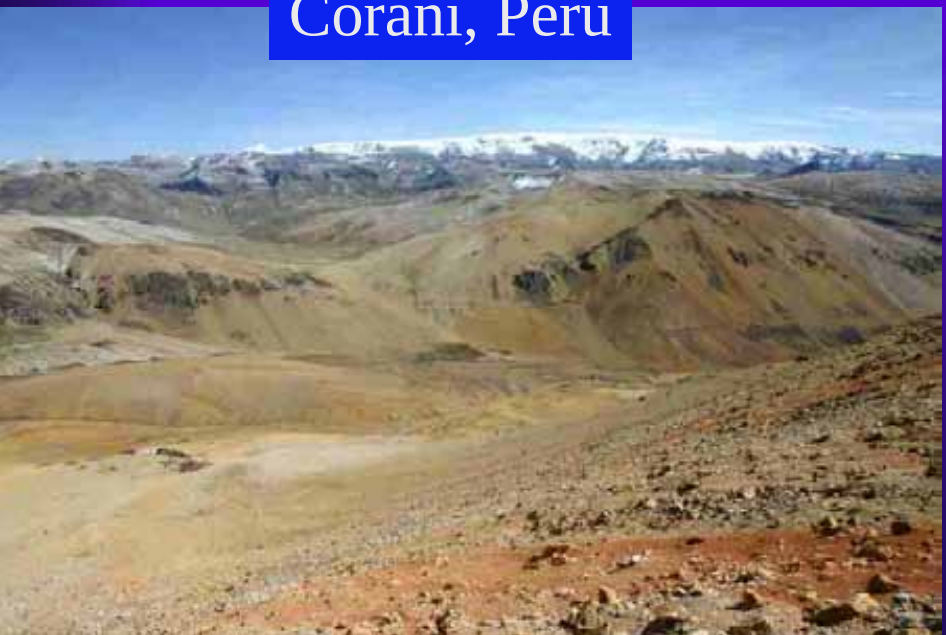

UP
(erosion)
DOWN
(preservation)
laminated sulphide
matrix breccia
sulphide clasts
Red Done style
semi-massive +
breccia fill Au Cu
sulphide
green breccia
Mungana style
polyphasal Ag-Zn-Cu-Pb
sulphide vein
Au-Cu chalcolite-
bearing skarn veins
porphyry A/B
quartz vein
sandstone
disseminated
skarn
mineralisation
high level intrusion
limestone/marble
apophysis
magmatic
source

Mungana

Polymetallic Ag-Au (Pb-Zn-Cu)

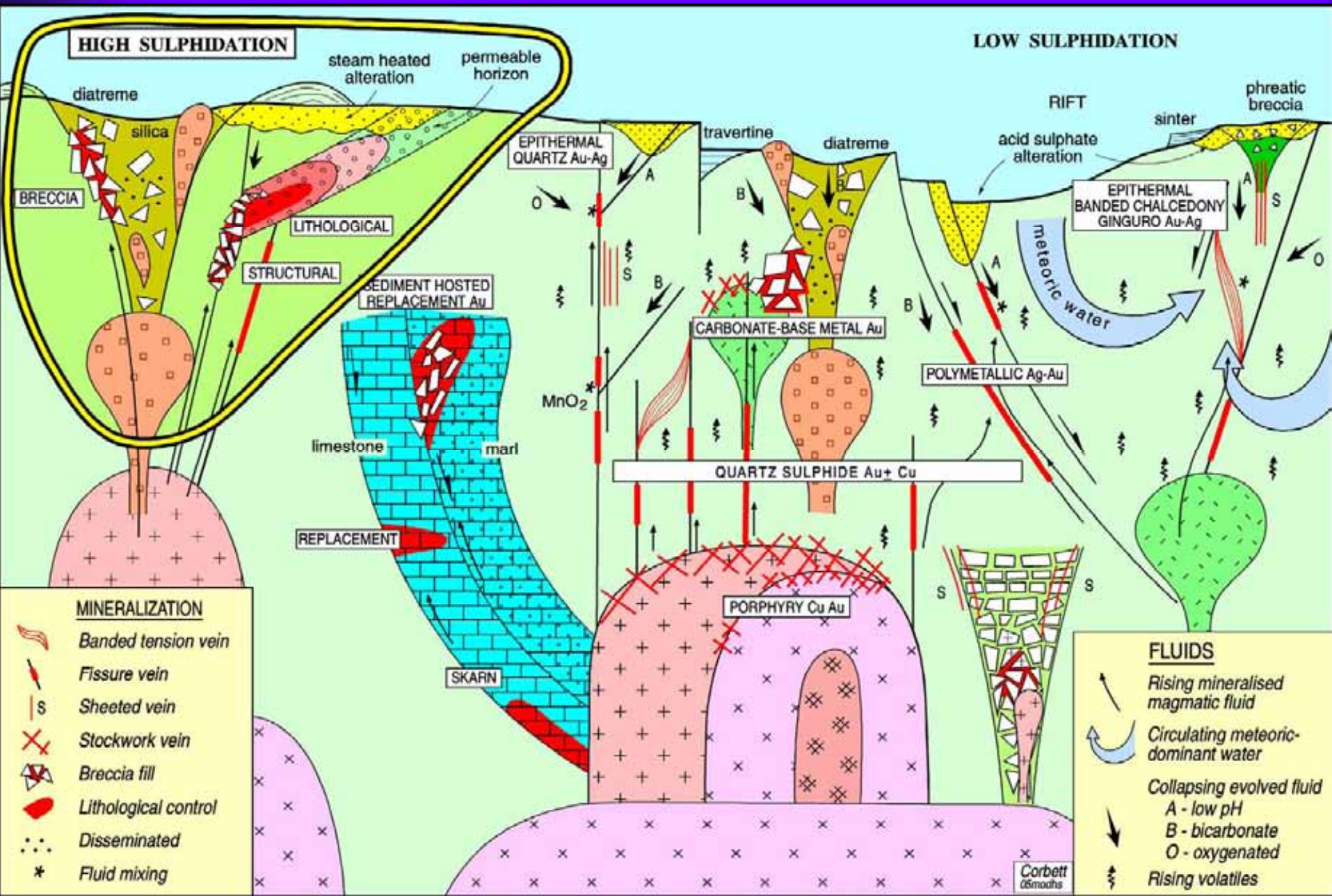
- Overlooked by the majors or many years but company makers for juniors
- Ag>Au
- Spatially zoned with bonanzas in lower temperatures
- Multiple control to ore shoot development

Corani, Peru

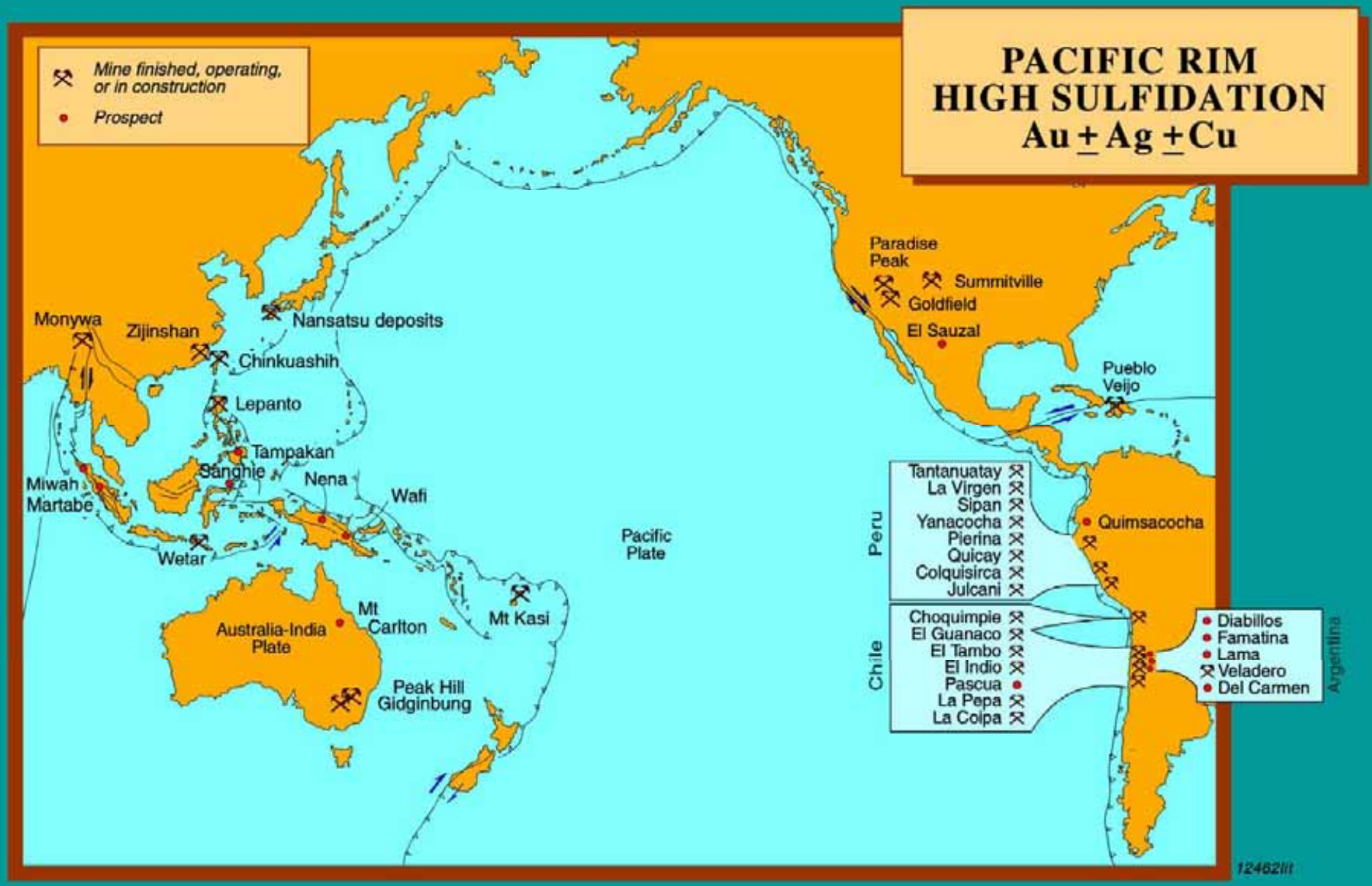


Palmarejo, Mexico

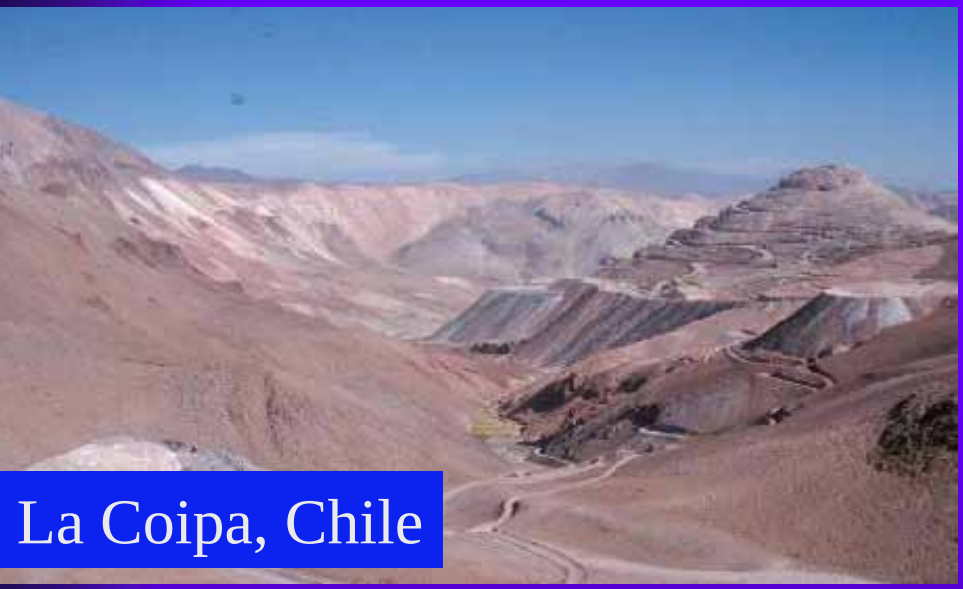
High sulphidation epithermal Au ± Cu± Ag



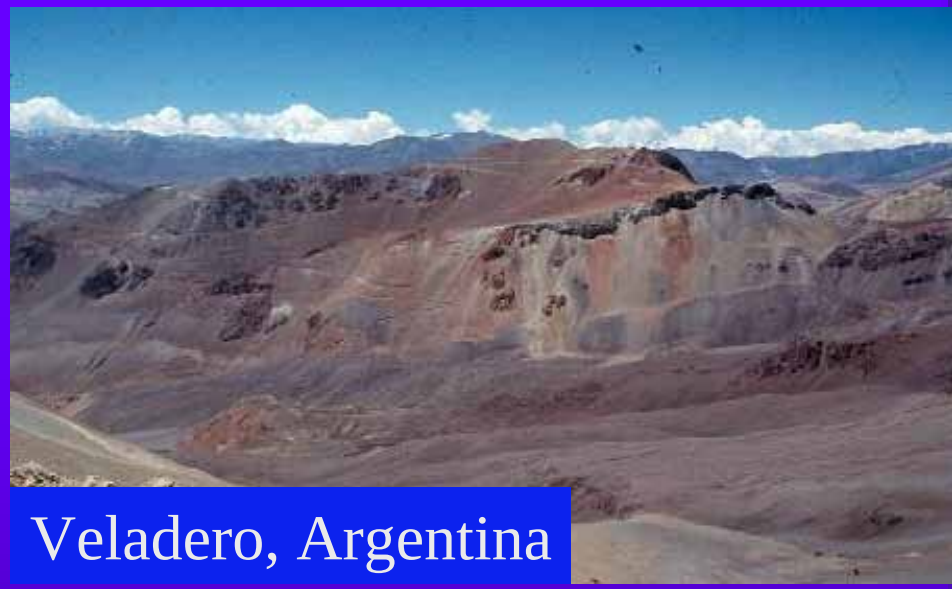
High sulphidation Cu-Au



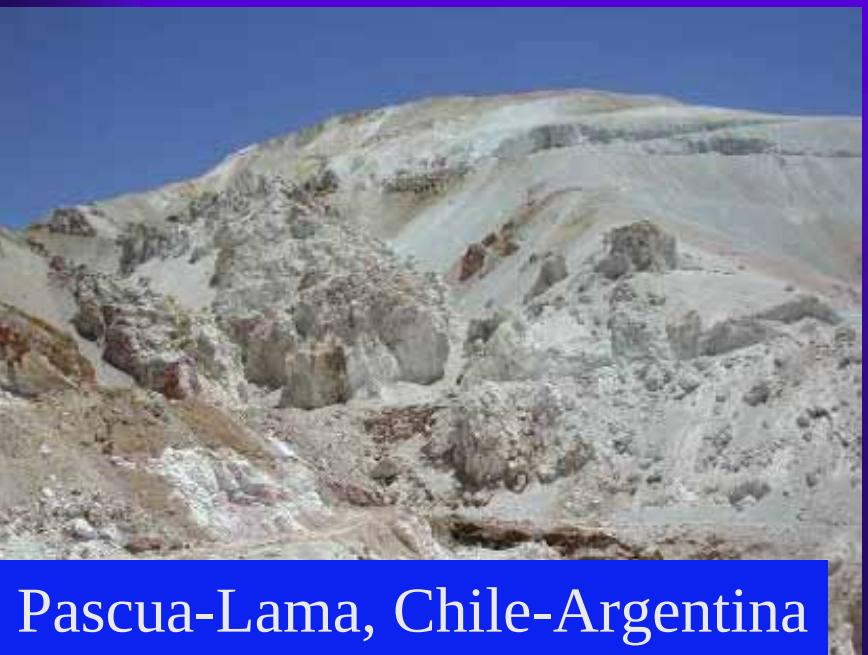
Andean high sulphidation Au-Ag



La Coipa, Chile

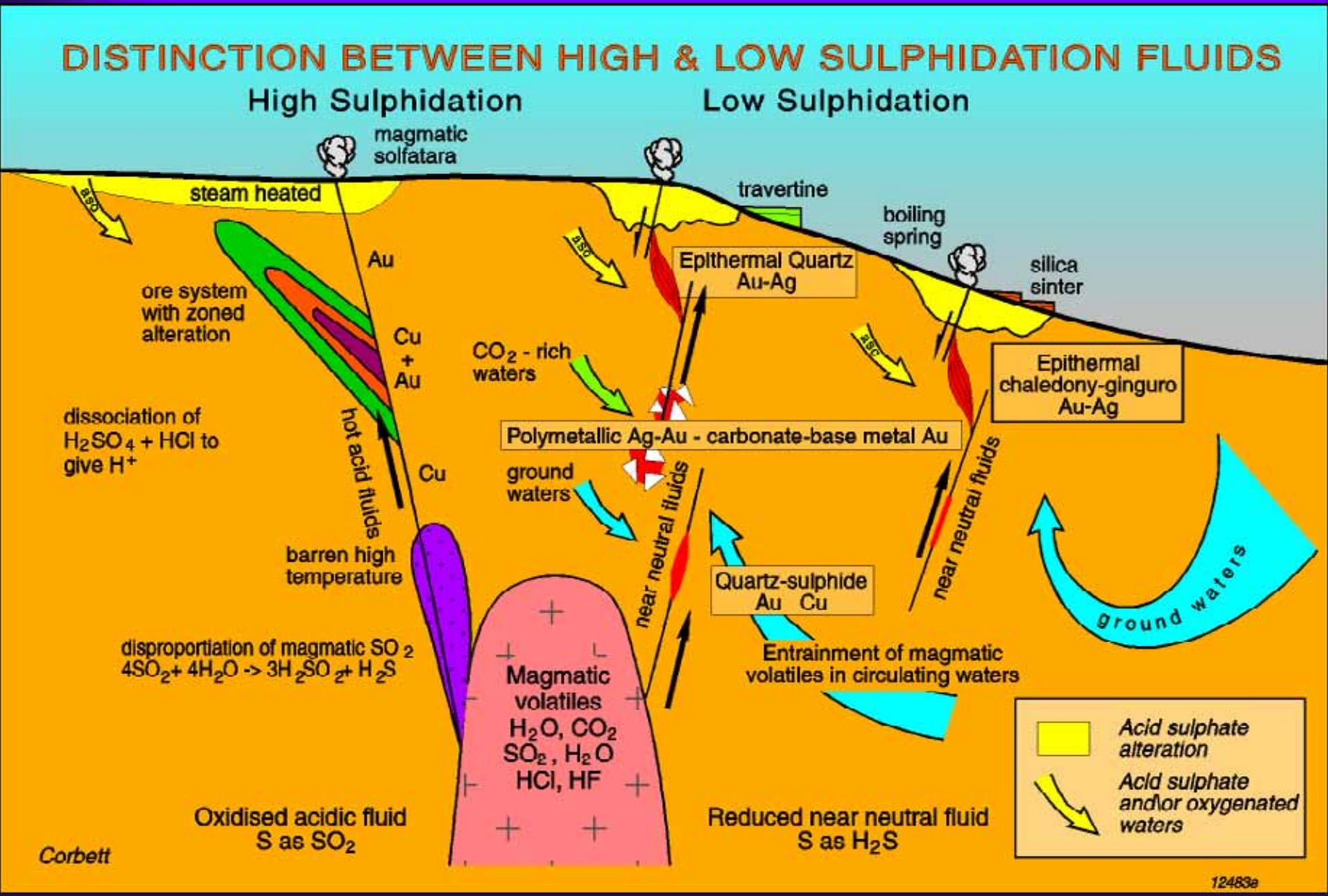


Veladero, Argentina



Pascua-Lama, Chile-Argentina

Yanacocha, Peru


DISTINCTION BETWEEN HIGH & LOW SULPHIDATION FLUIDS
High Sulphidation
Low Sulphidation
magmatic solfatara
steam heated
ASC
travertine
boiling spring
silica sinter
Au
ore system with zoned alteration
Cu + Au
Epithermal Quartz Au-Ag
CO_2 - rich waters
Epithermal chaledony-ginguro Au-Ag
dissociation of H_2SO_4 + HCl to give H^+
Polymetallic Ag-Au - carbonate-base metal Au
hot acid fluids
Cu
ground waters
near neutral fluids
barren high temperature
Quartz-sulphide Au Cu
near neutral fluids
ground waters
disproportiation of magmatic SO_2
$4SO_2 + 4H_2O \rightarrow 3H_2SO_4 + H_2S$
Magmatic volatiles
H_2O, CO_2
SO_2, H_2O
HCl, HF
Entrainment of magmatic volatiles in circulating waters
Acid sulphate alteration
Acid sulphate and/or oxygenated waters
Oxidised acidic fluid
S as SO_2
Reduced near neutral fluid
S as H_2S
Corbett
12483a

High sulphidation
Zoned acid alteration

CENTRAL
HOT ACID

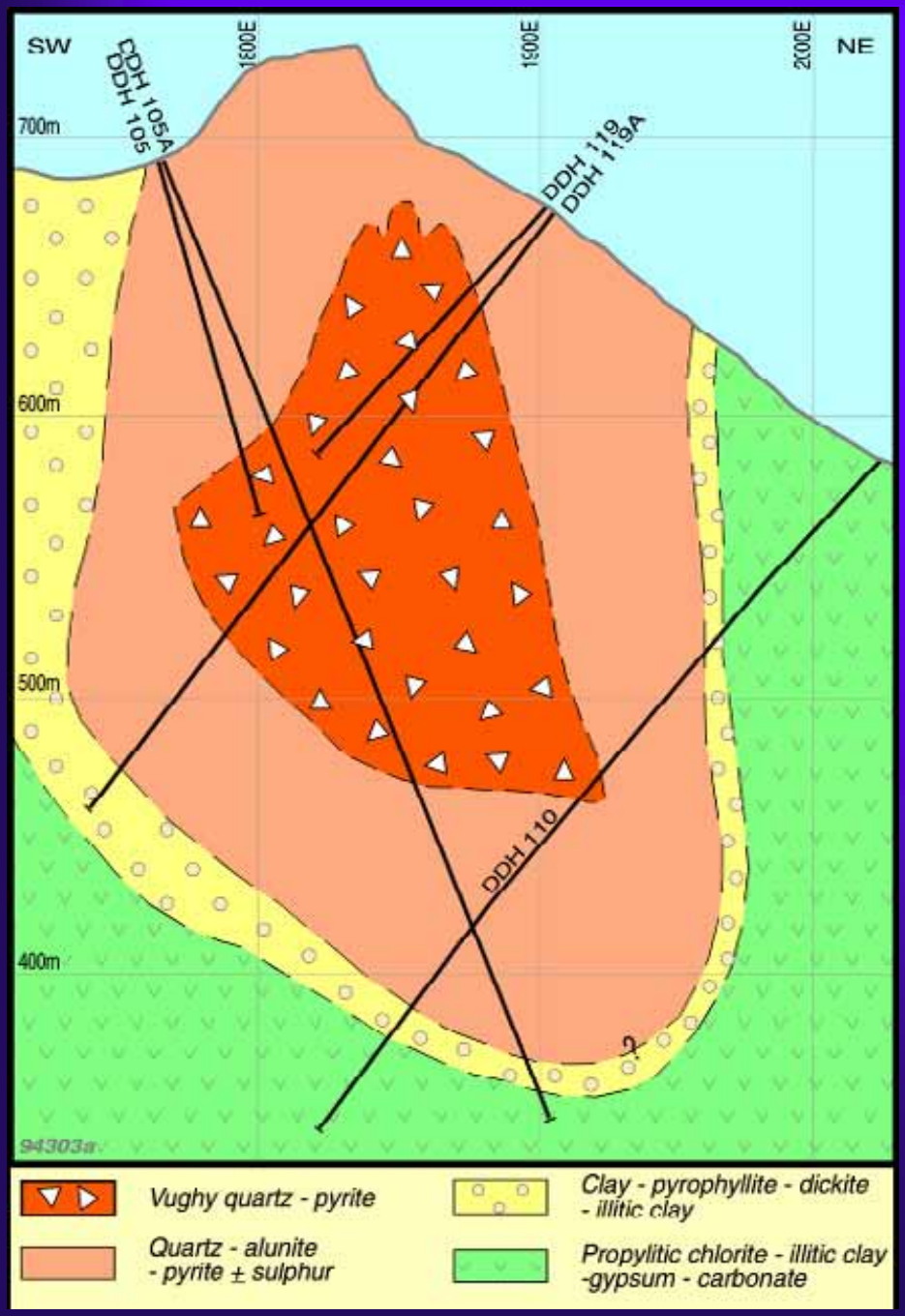
Alunite

Pyrophyllite-diaspore

OUTER
LESS ACID

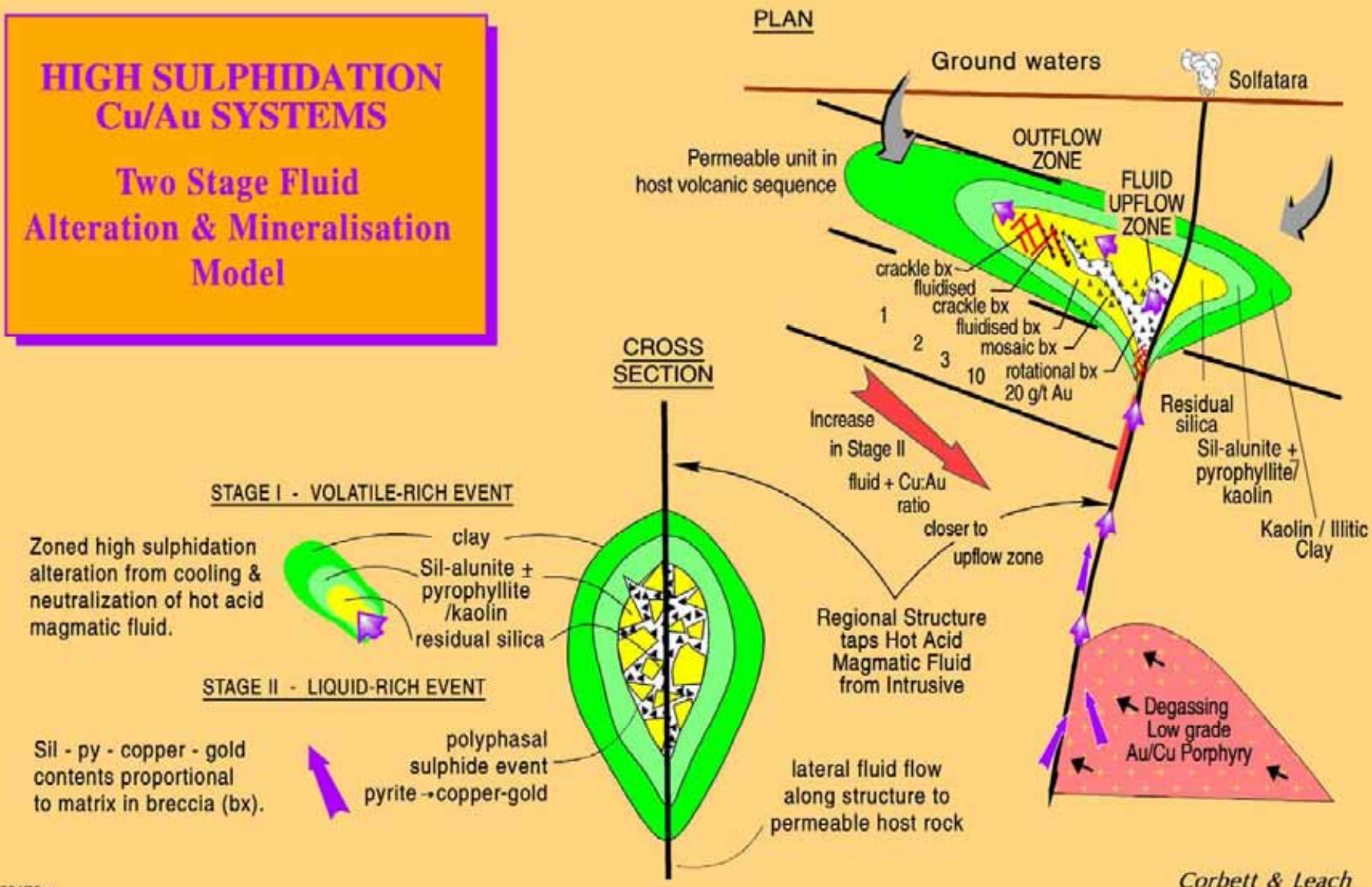
Dickite-kaolinite

Alteration cross section - Nena, PNG



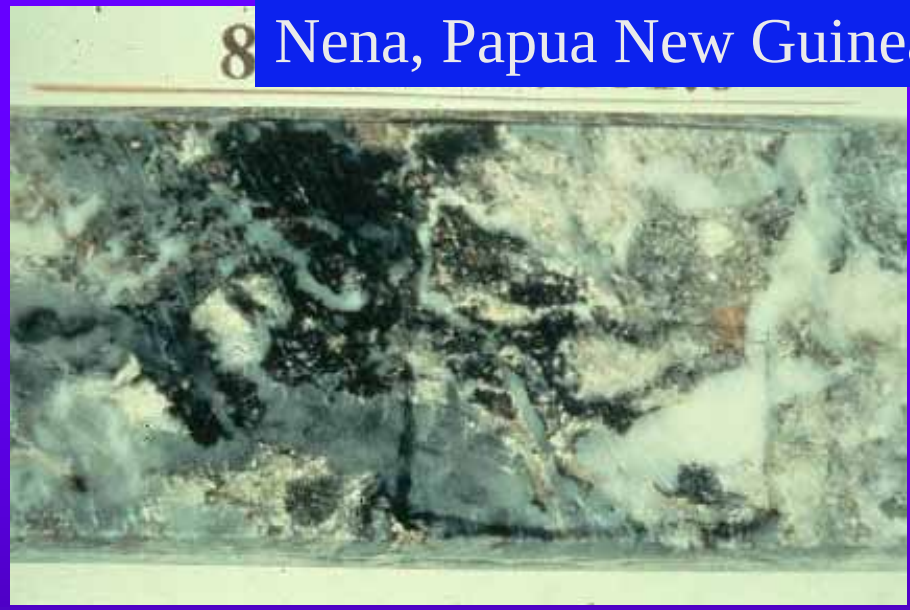
HIGH SULPHIDATION Cu/Au SYSTEMS

Two Stage Fluid Alteration & Mineralisation Model

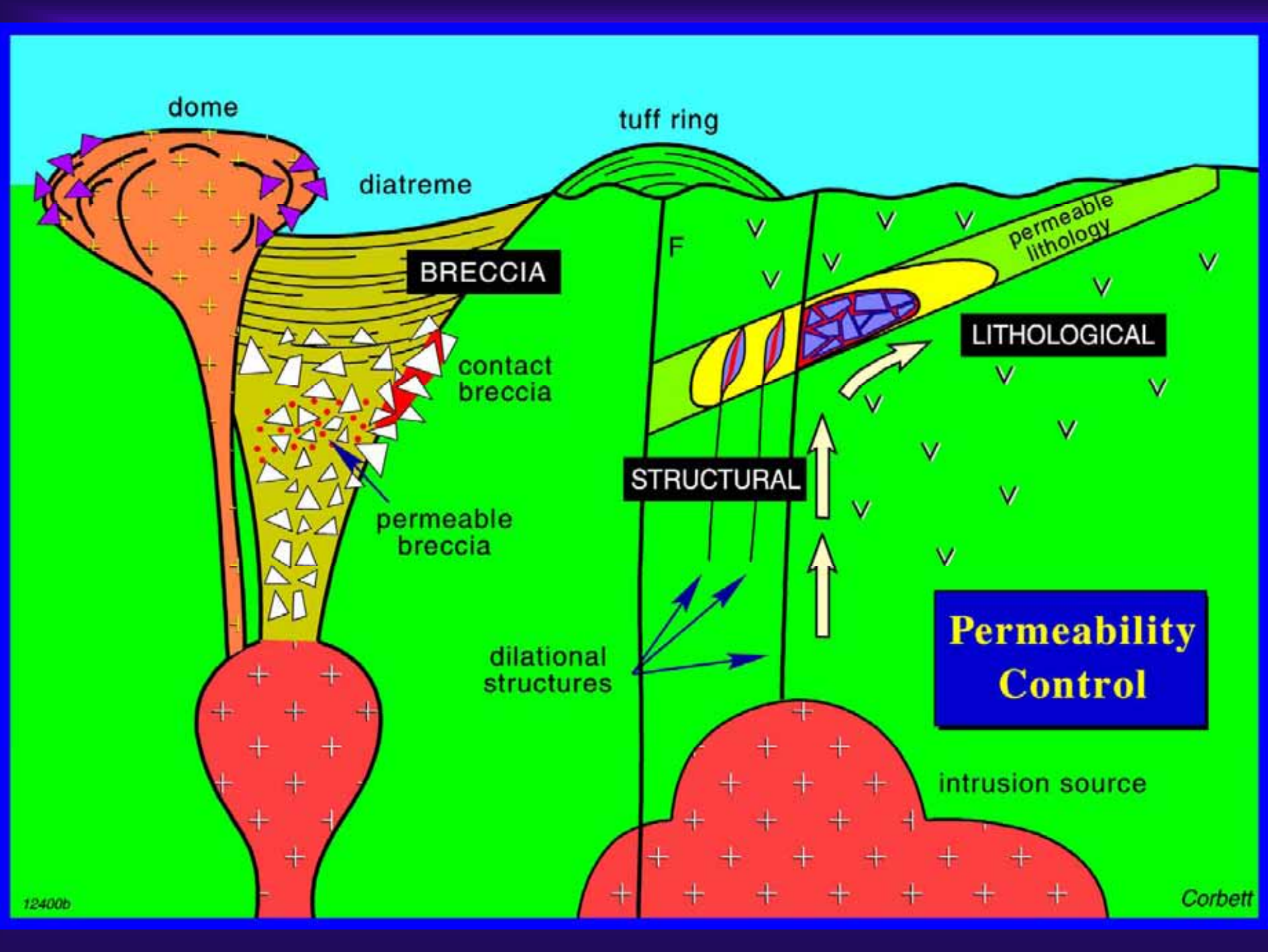


High sulphidation mineralogy

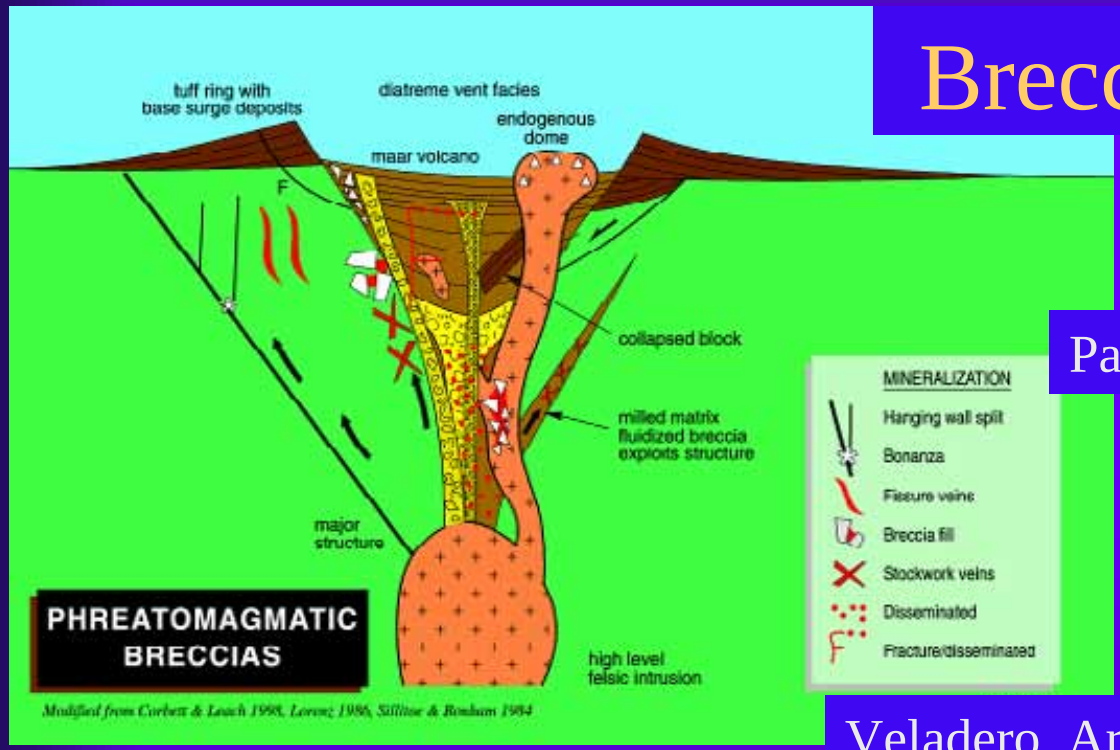
El Indio, Chile



Nena, Papua New Guinea


dome
tuff ring
diatreme
BRECCIA
contact breccia
permeable breccia
F
permeable lithology
LITHOLOGICAL
STRUCTURAL
dilational structures
Permeability Control
intrusion source
12400b
Corbett

Breccia



Pascua, Chile

Veladero, Argentina

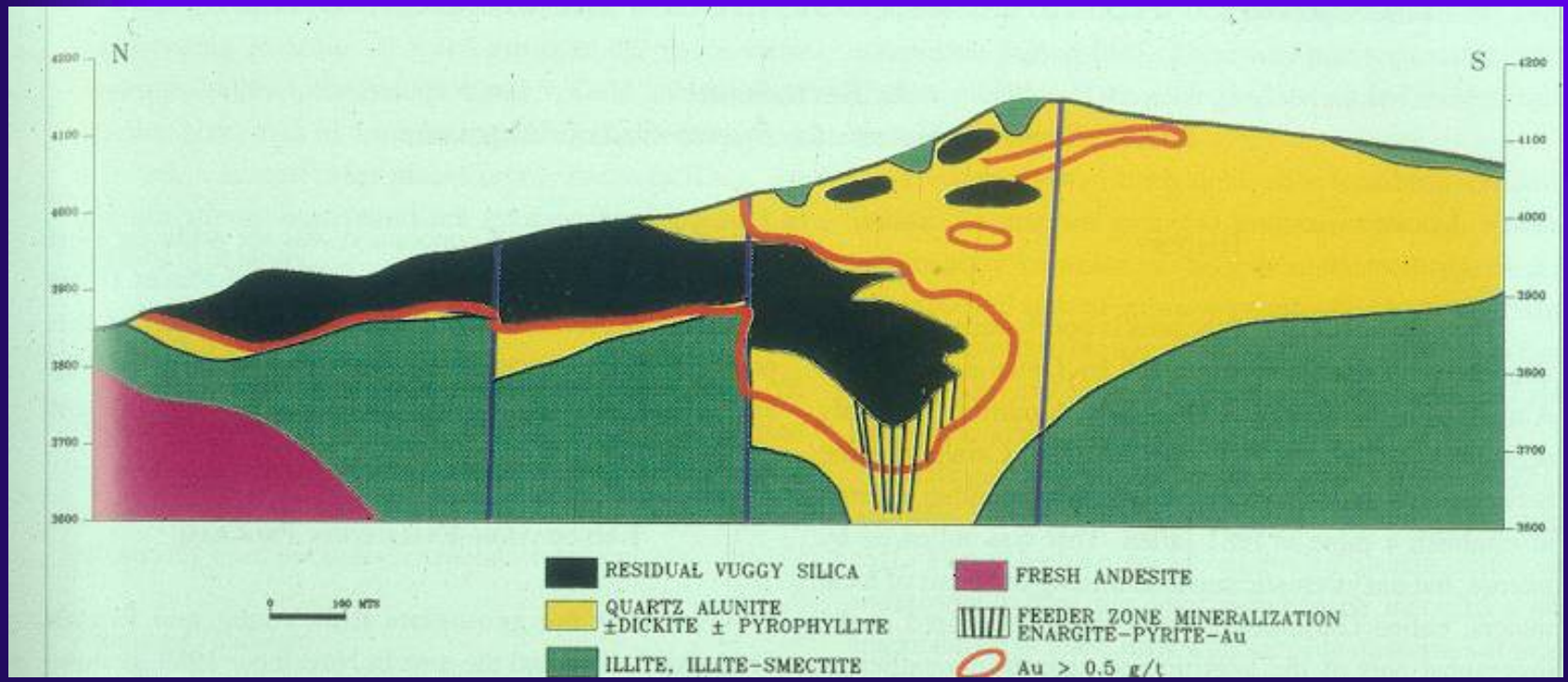
Lepanto, Phillipines

Yanacocha, Peru

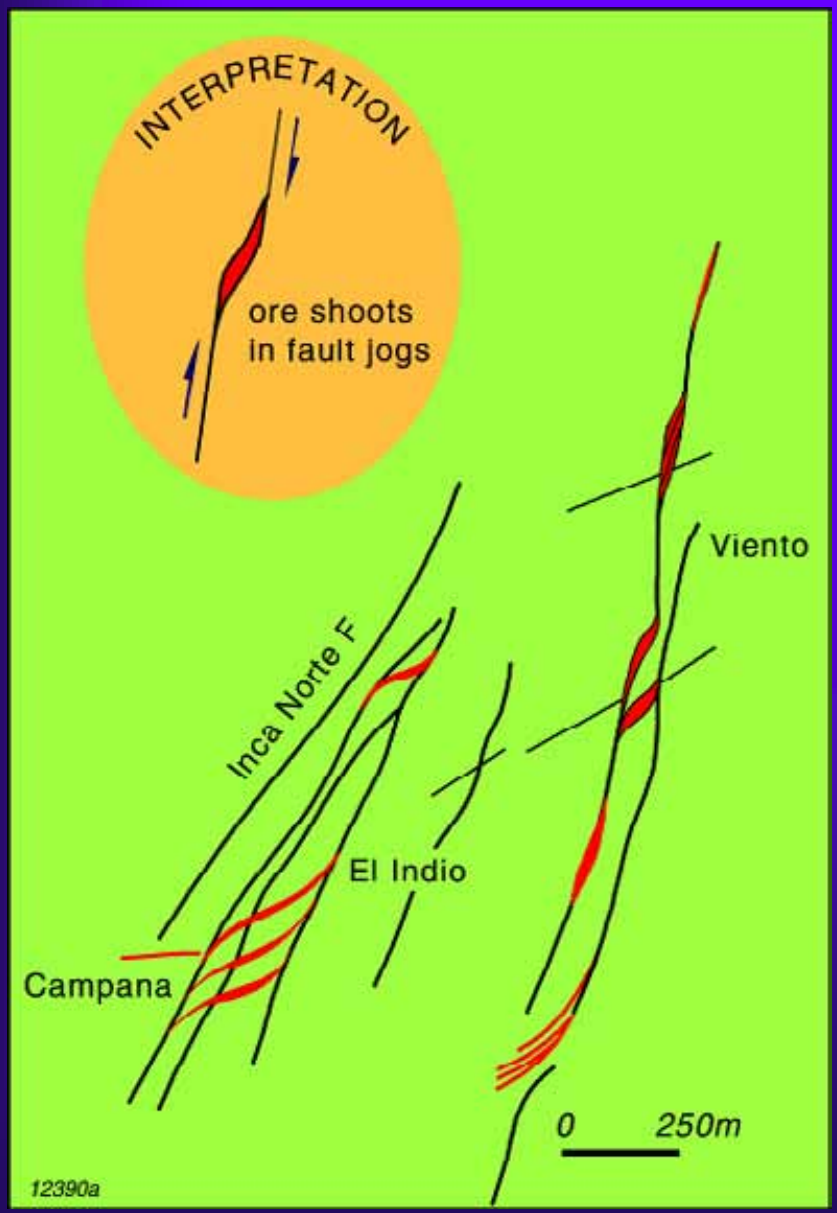
Lithological Control – Pierina, Peru

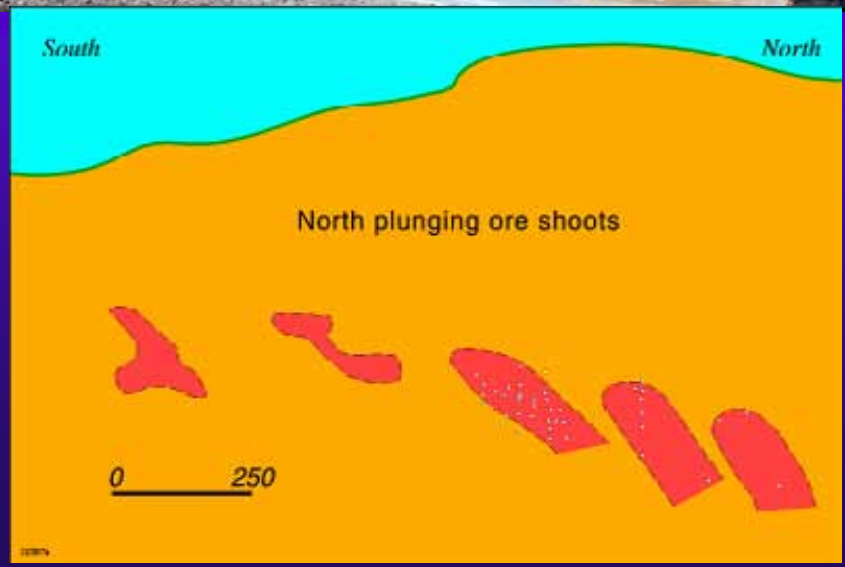
Vughy silica altered ignimbrite

Long Section.Volkert et al 1998



Structural control - El Indio, Chile





Mt Carlton

Polybasite
9Ag2S.Sb2S3

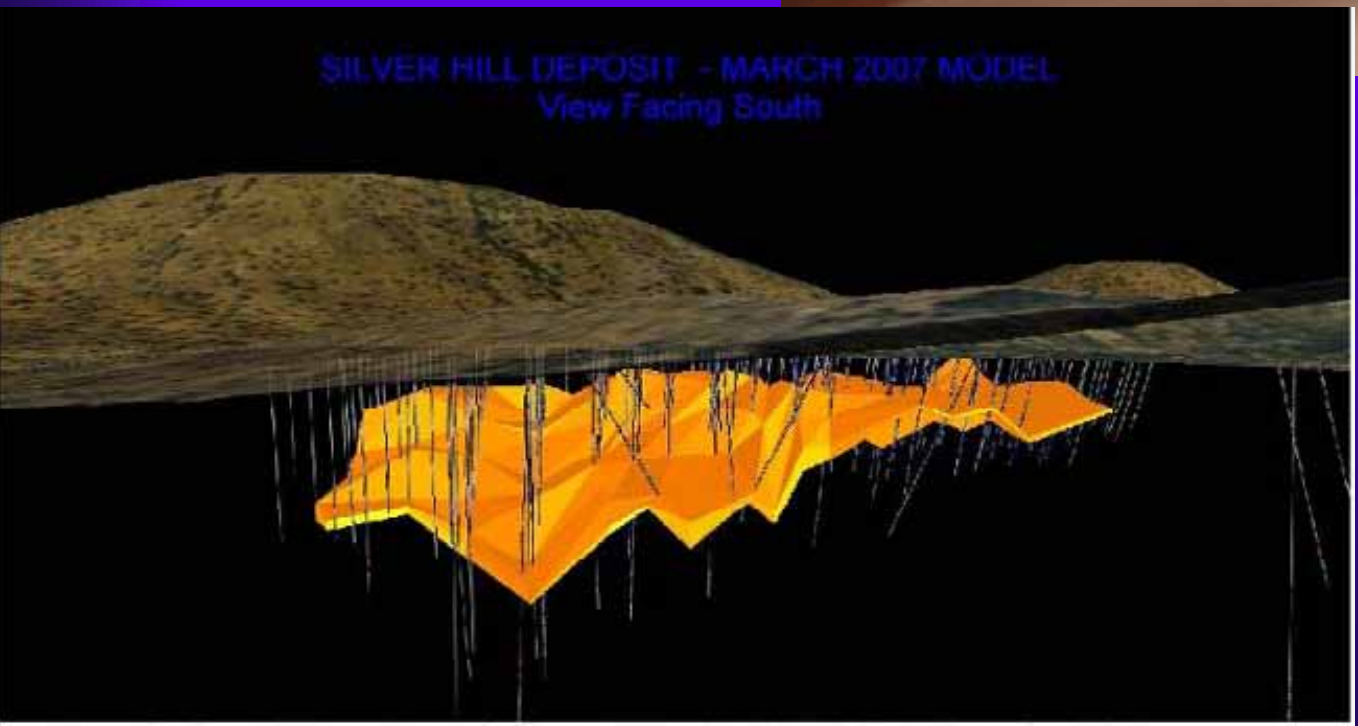
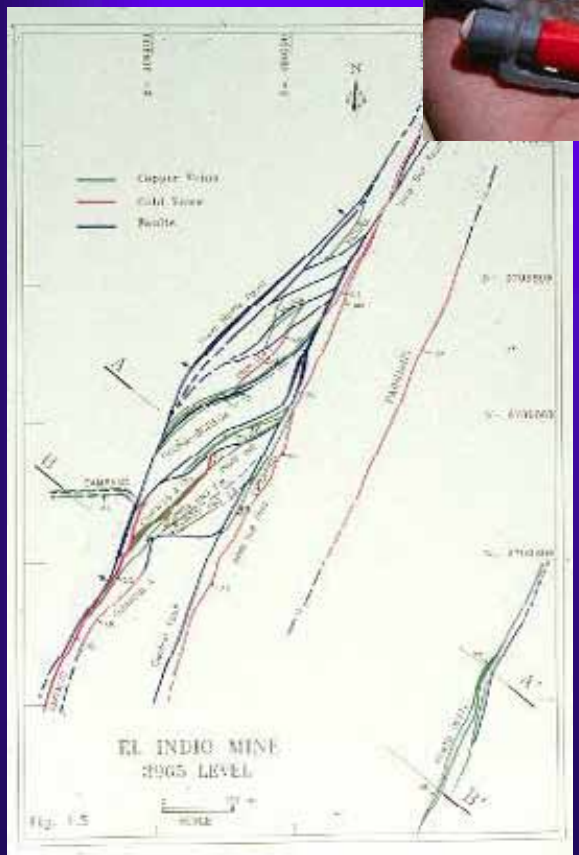


Figure 3: Silver Hill Deposit Model – March 2007, with all drill holes to December 2006.

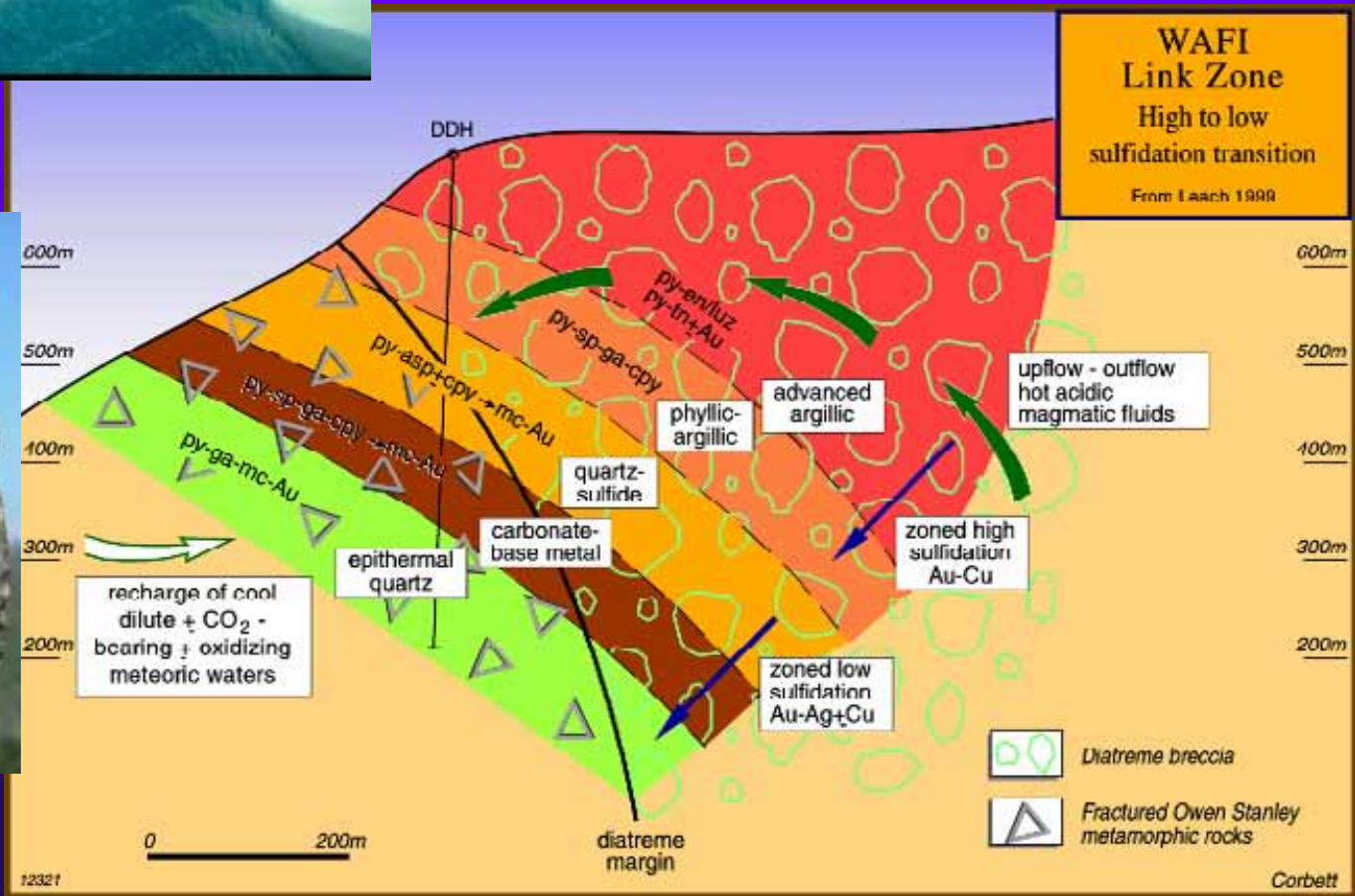
El Indio Chile

Low Sulphidation



High Sulphidation

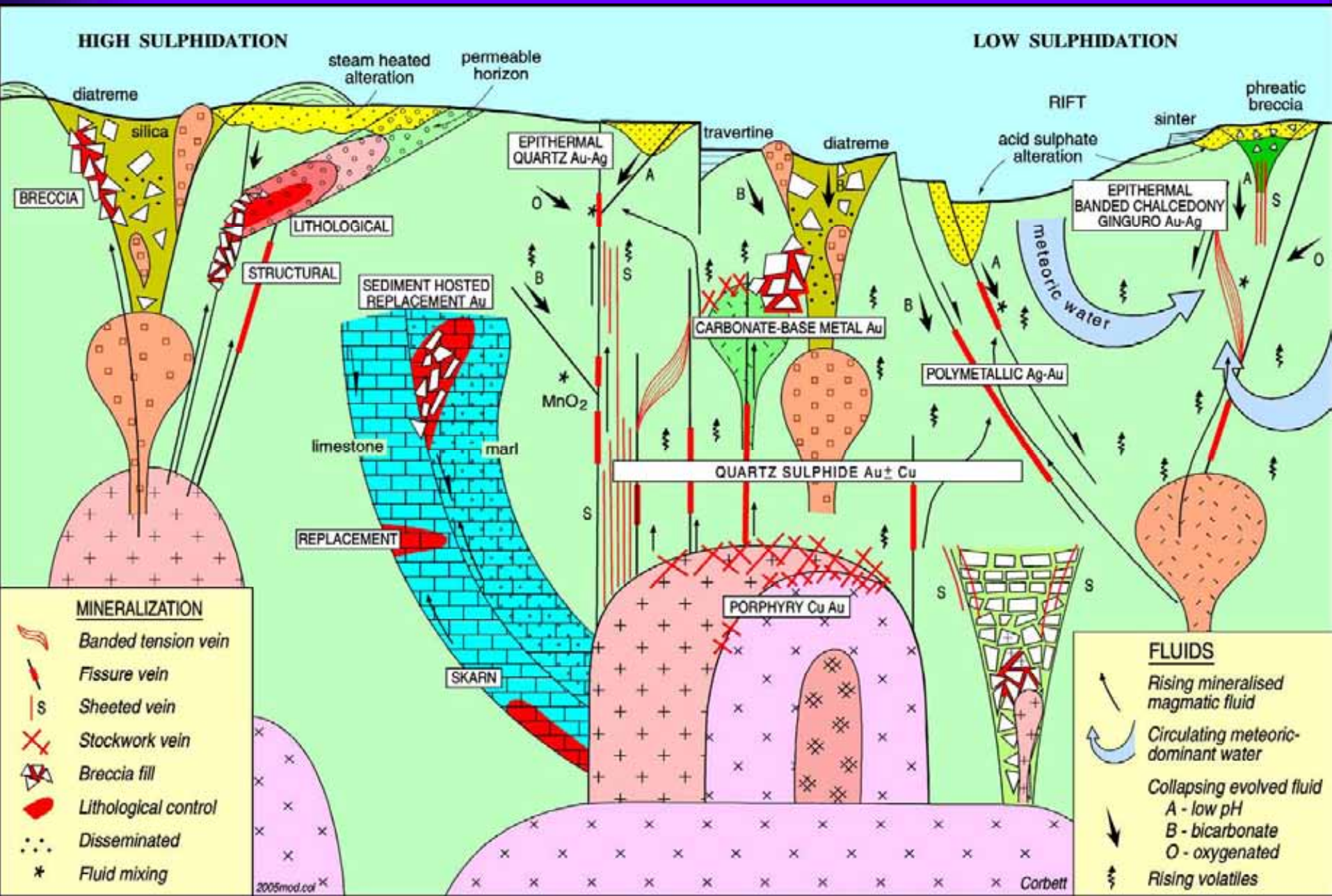
Wafi, Papua New Guinea
Transition to low sulphidation
from Leach, 1999



High sulphidation Exploration Implications

- Zoned alteration & permeability controls
- Often poor metallurgy & low Au grade
- Better Au grade & metallurgy with temporal & spatial transition to lower sulphidation
- Caution with barren advanced argillic alteration

Model for Pacific rim magmatic arc Au



Good prospecting!!