Introduction to Epithermal Gold Deposit

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In the name of God

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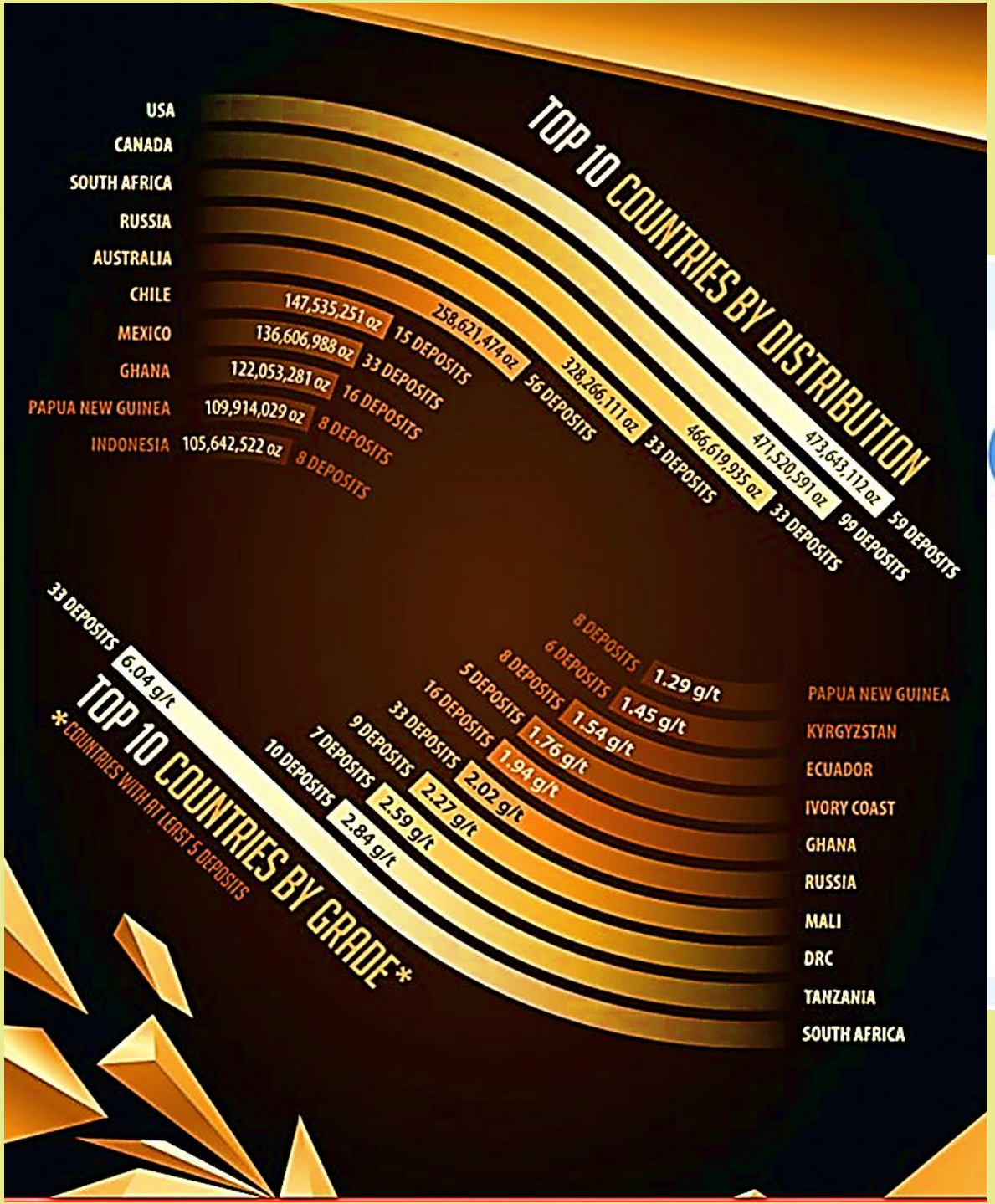
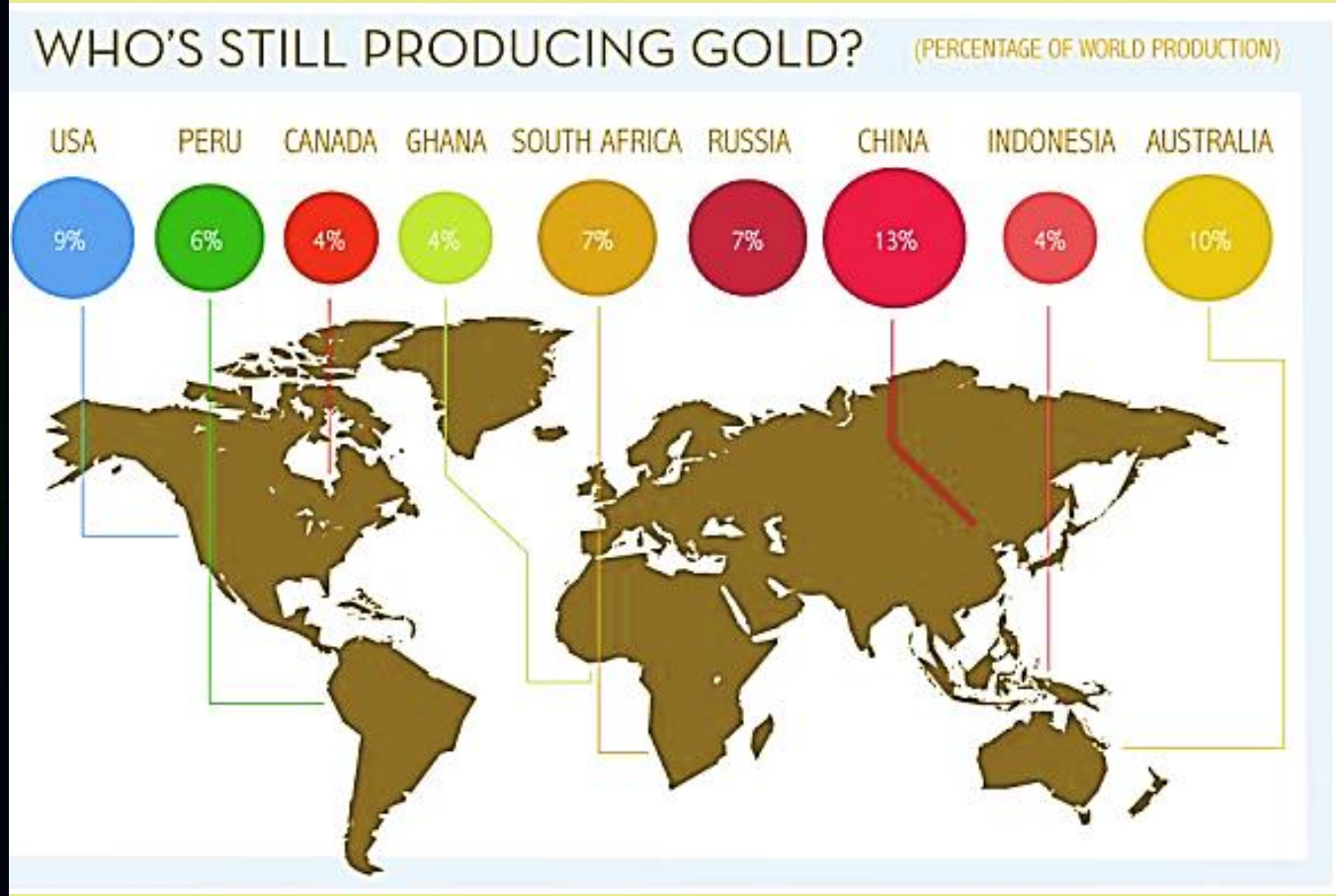
The Map Below Illustrates the Distribution of Gold Production





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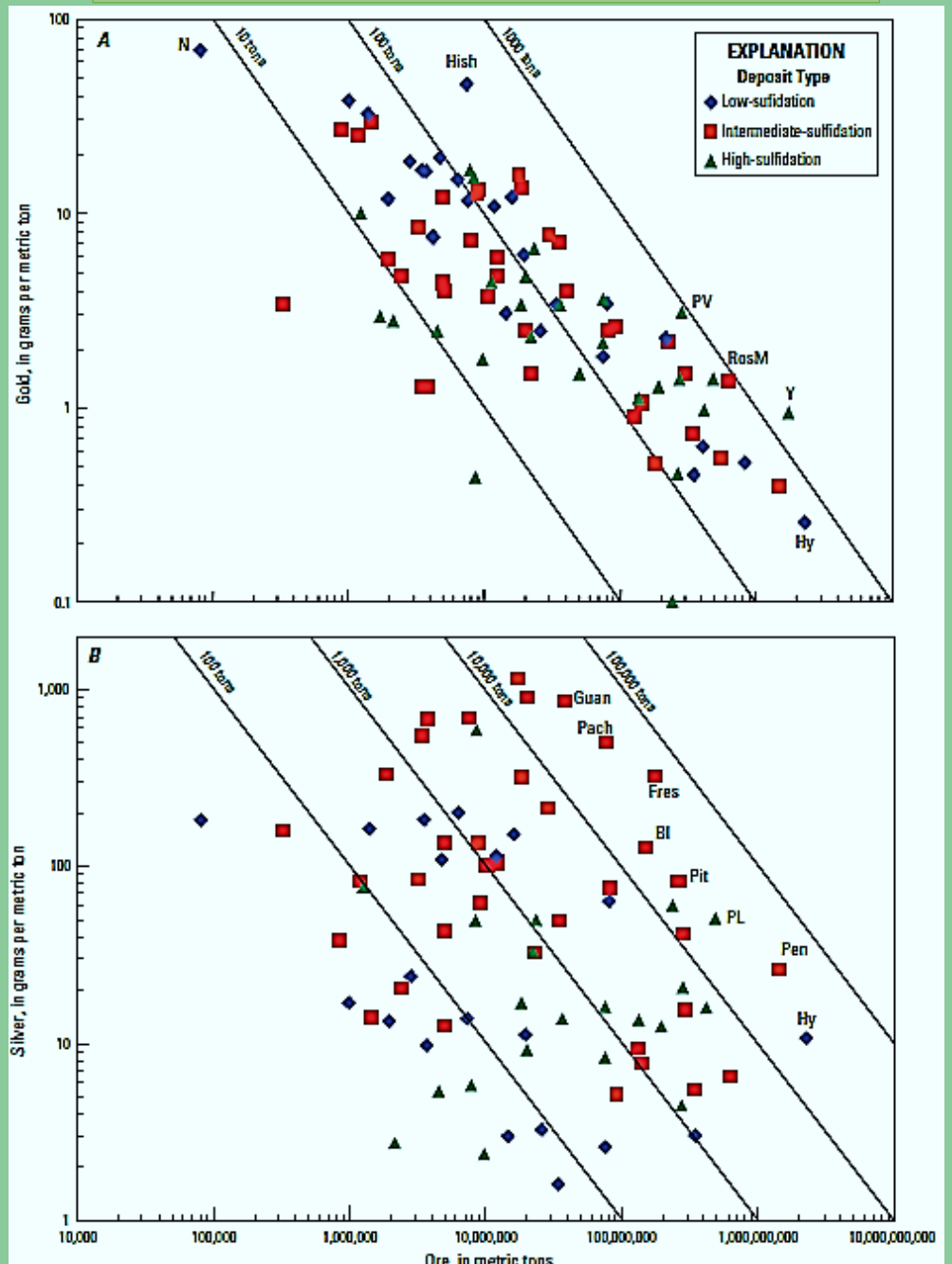
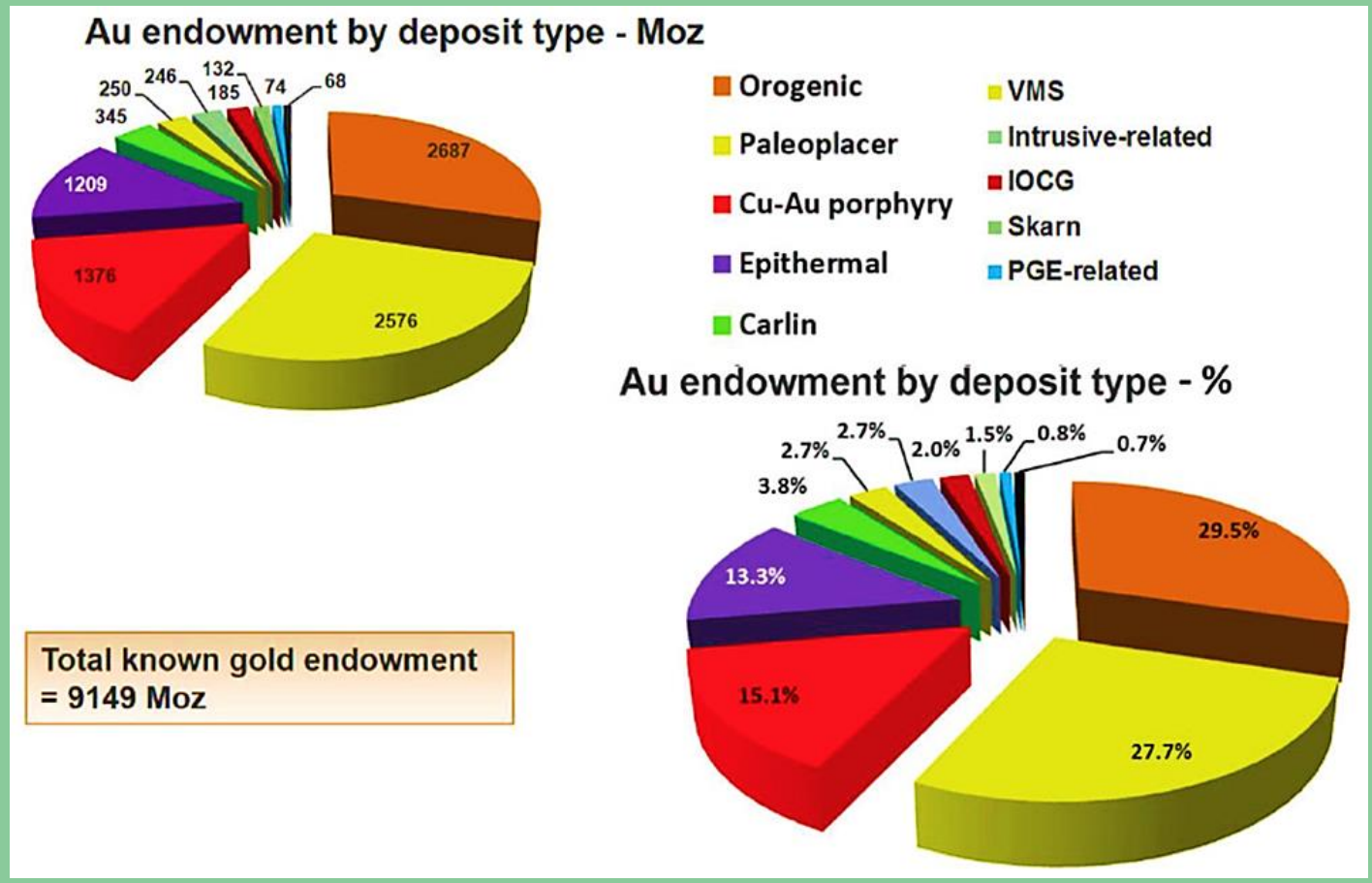
Graphs showing gold (A) and silver (B) grades and tonnages for most epithermal gold-silver deposits



Relative Importance of the different types of gold deposit in overall production between 1984 and 2012



Total known gold endowment = 9149 Moz

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Introduction:

Epithermal mineralization usually at 50 to 250 ° C at the surface and depth of 1000 meters are formed. Groundwater and magma have a fundamental role in this process.

Types of epithermal gold deposit:

3endmember types:

a: High sulfidation bodies: Cu-Au-As, sulfide rich, andesite arcs.

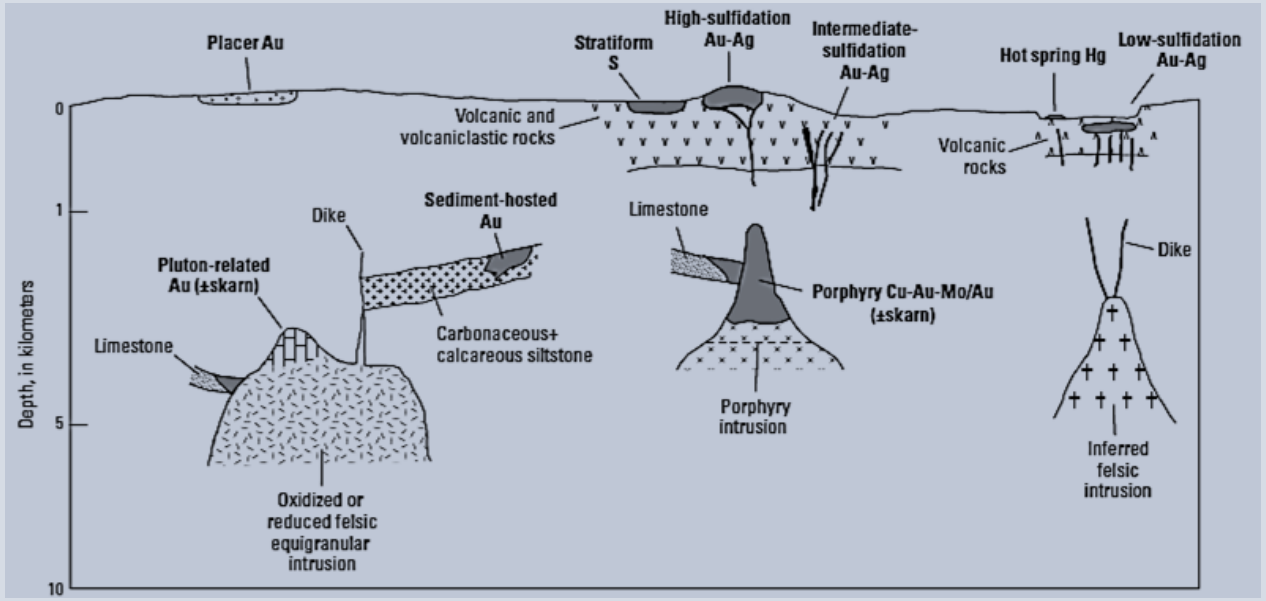
Hosted by lithocaps: advanced argillic zones over porphyry system.

b: Low sulfiddation bodies: Au-Ag bonanzas, sulfide poor.

Ls veins: Au-Ag-Te, sulfide poor; extensional, bimodal.

c:Intermediate sulfidation bodies: Ag-Au(Zn-Pb), sulfide rich.

Zoned and/or complex mineralogy(intrusion related, diatreme



Schematic cross section showing epithermal gold-silver deposits and other related or proximal deposit types. Figure based on Sillitoe (2008). Abbreviations: Ag, silver; Au, gold; Cu, copper; Hg, mercury; Mo, molybdenum; S, sulfur.

Epithermal gold deposits resources:

High sulfidation ores: small reserve

Low sulfidation ores: big reserve

Intermediate sulfidation ores: medium reserve

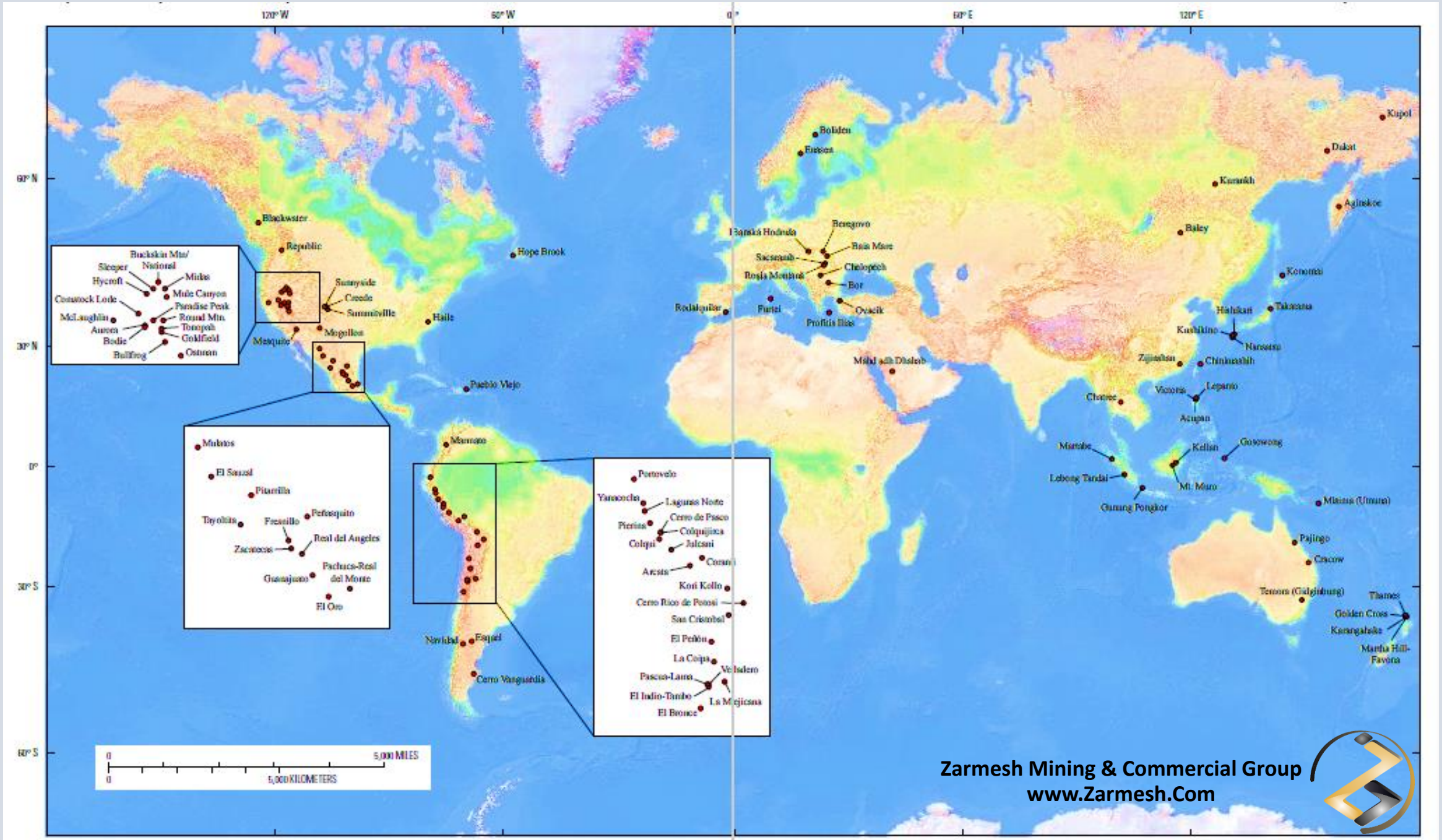
Geochemical Features:

High sulfidation ores: high copper and low Ag/Au

Low sulfidation ores: high zinc, lead and high Ag/Au

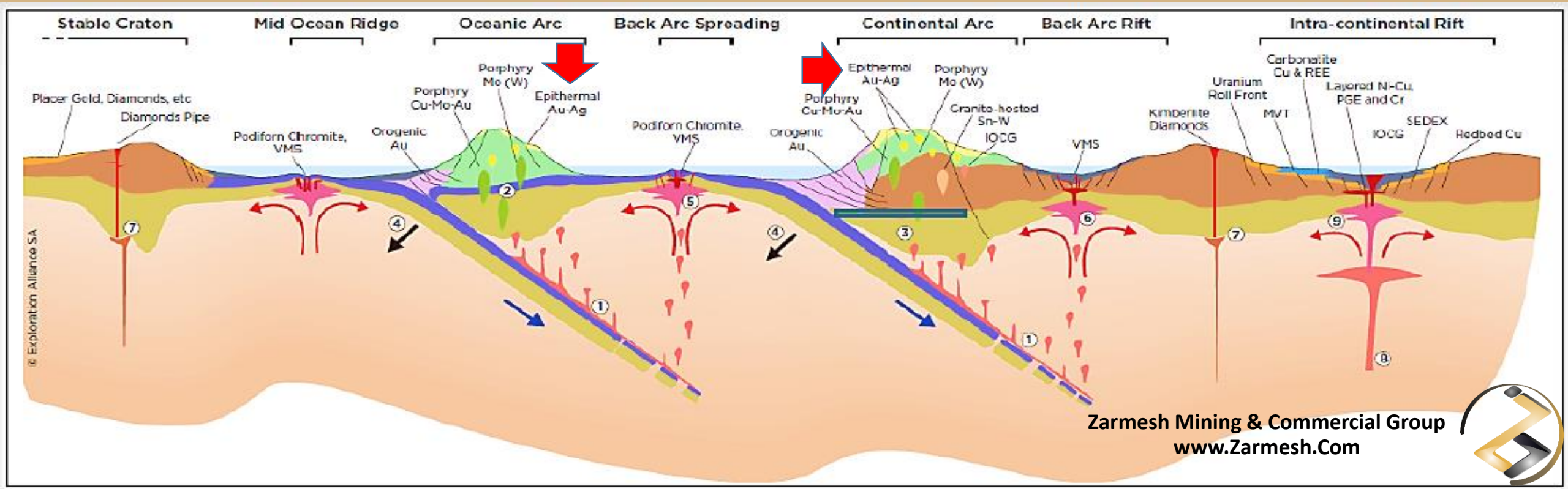
Intermediate sulfidation ores: high zinc, lead and copper ? Ag/Au

Map showing locations of epithermal gold-silver in the world



Geodynamic settings in terms of the supercontinent cycle mineral deposits

Sulfidation state	Igneous rock composition[1]	Tectonic setting
High	Calc-alkaline, andesite-dacite	Magmatic arc in a neutral to mildly extensional stress state; compressive stress state uncommon but serves to suppress volcanic activity
Intermediate	Calc-alkaline, andesite-rhyolite	Magmatic arc in a neutral to mildly extensional stress state; compressive stress state rare
Low	Calc-alkaline, alkaline, tholeiitic bimodal basalt-rhyolite	Magmatic arc undergoing extension leading to rifting; postcollisional rifting



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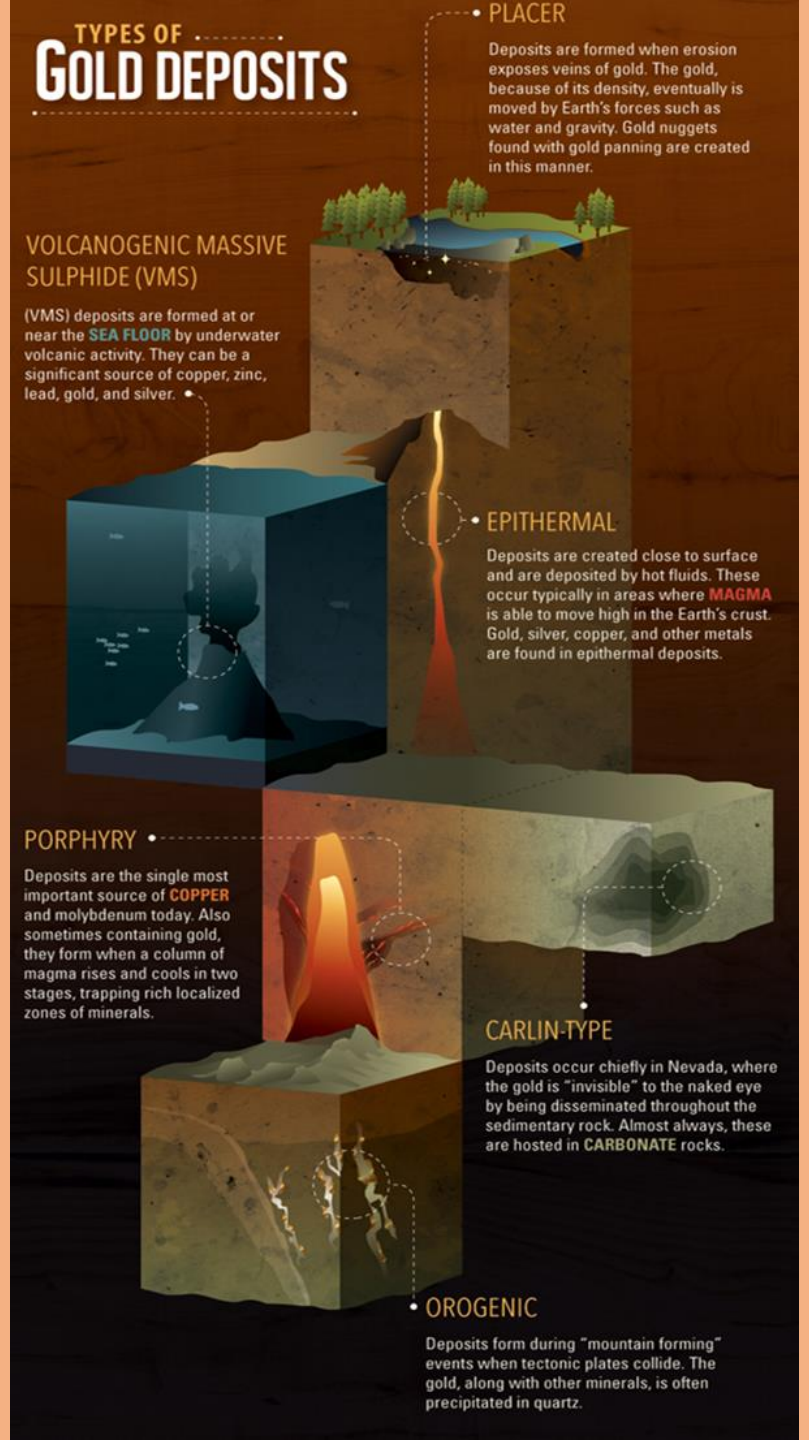
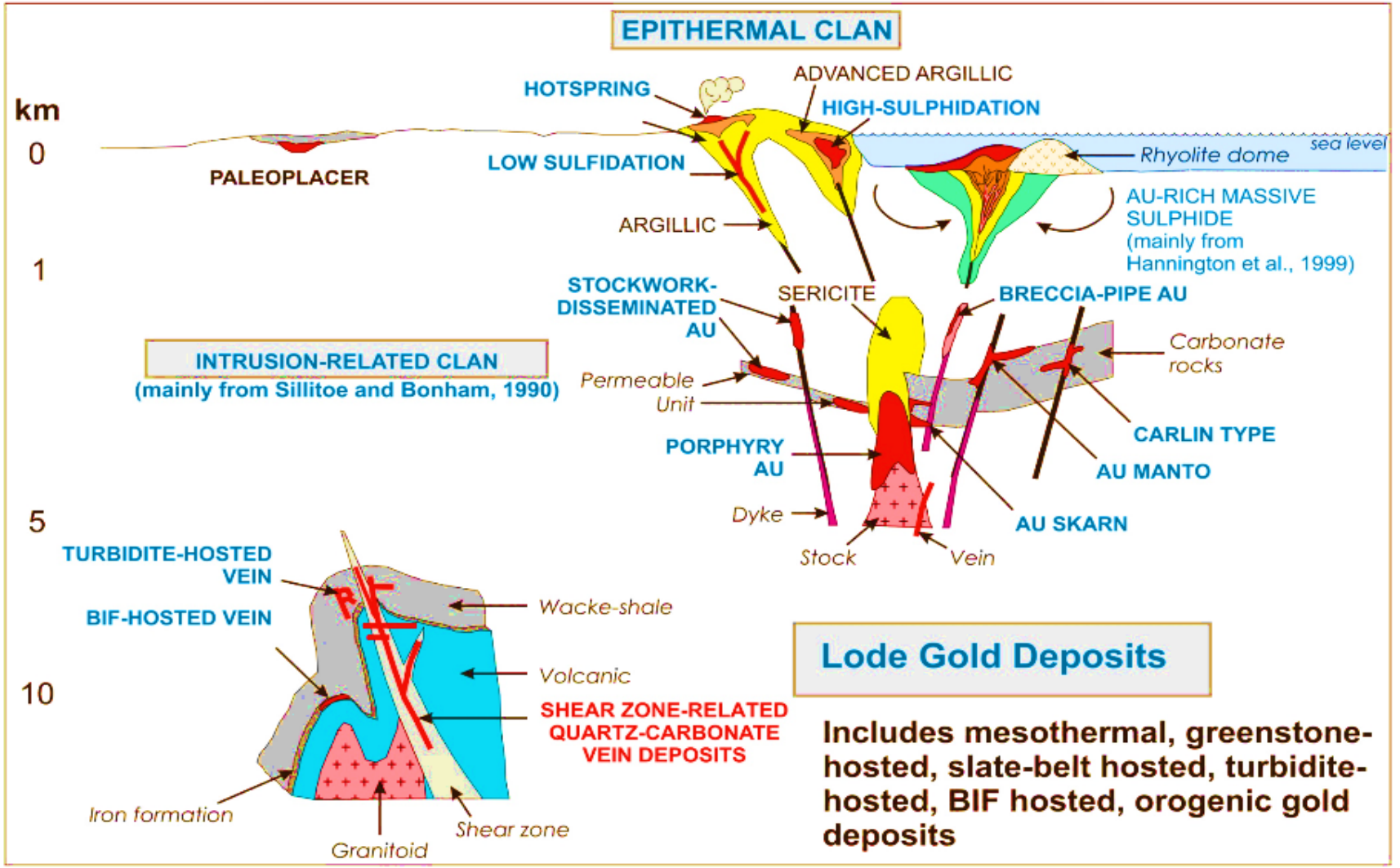
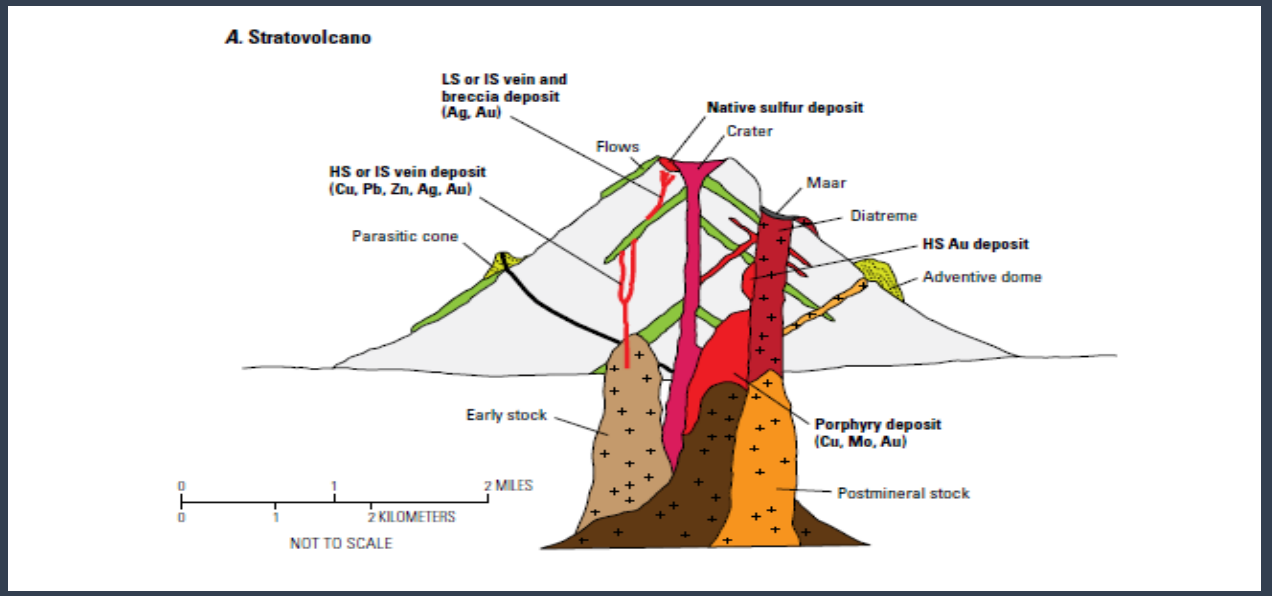


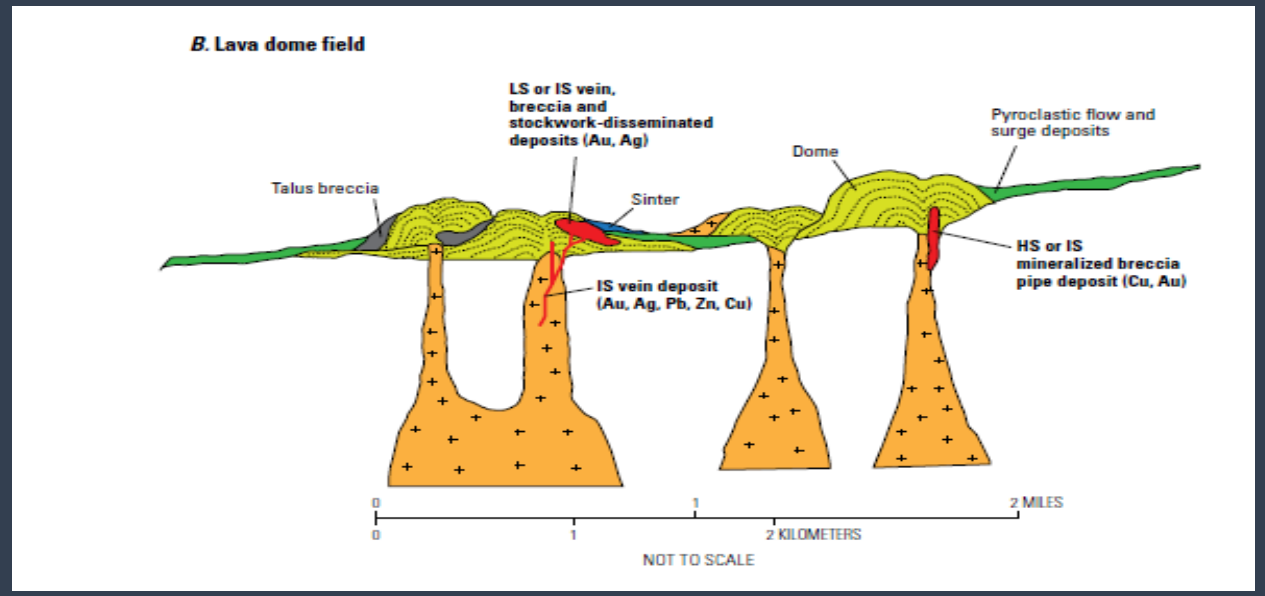
Inferred Crustal Levels of Deposition

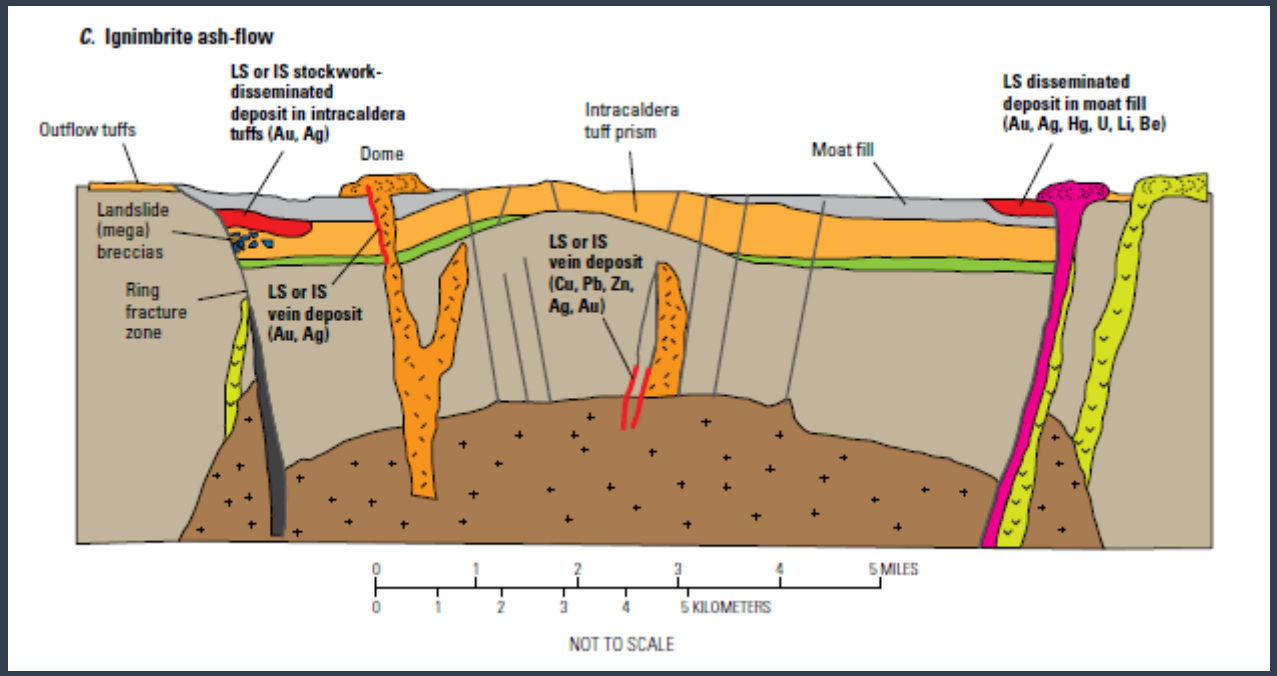


Modified after Dubé and Gosselin (2007)

Schematic cross sections showing volcanic landforms that commonly host epithermal gold-silver and related deposits and principal metals. *A*, Stratovolcano; *B*, Lava dome field; *C*, Ignimbrite (ash-flow) caldera; *D*, Maar-diatreme complex. Figure modified from Sillitoe and Bonham (1984).







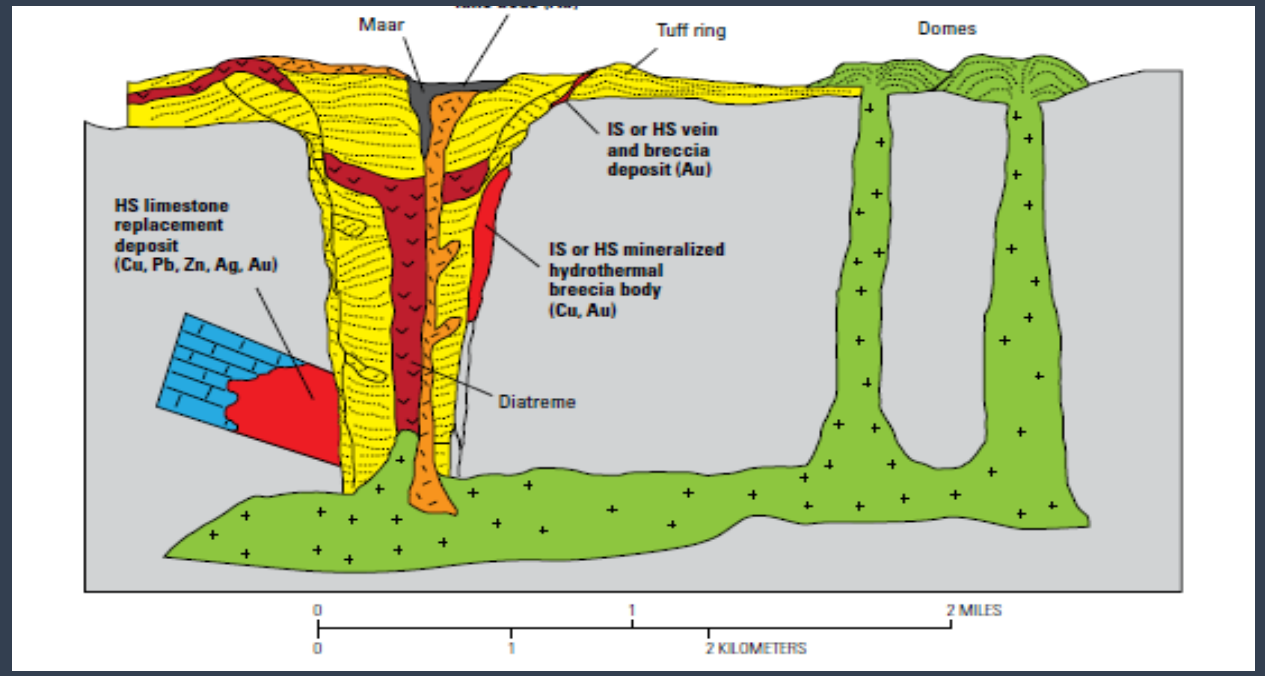
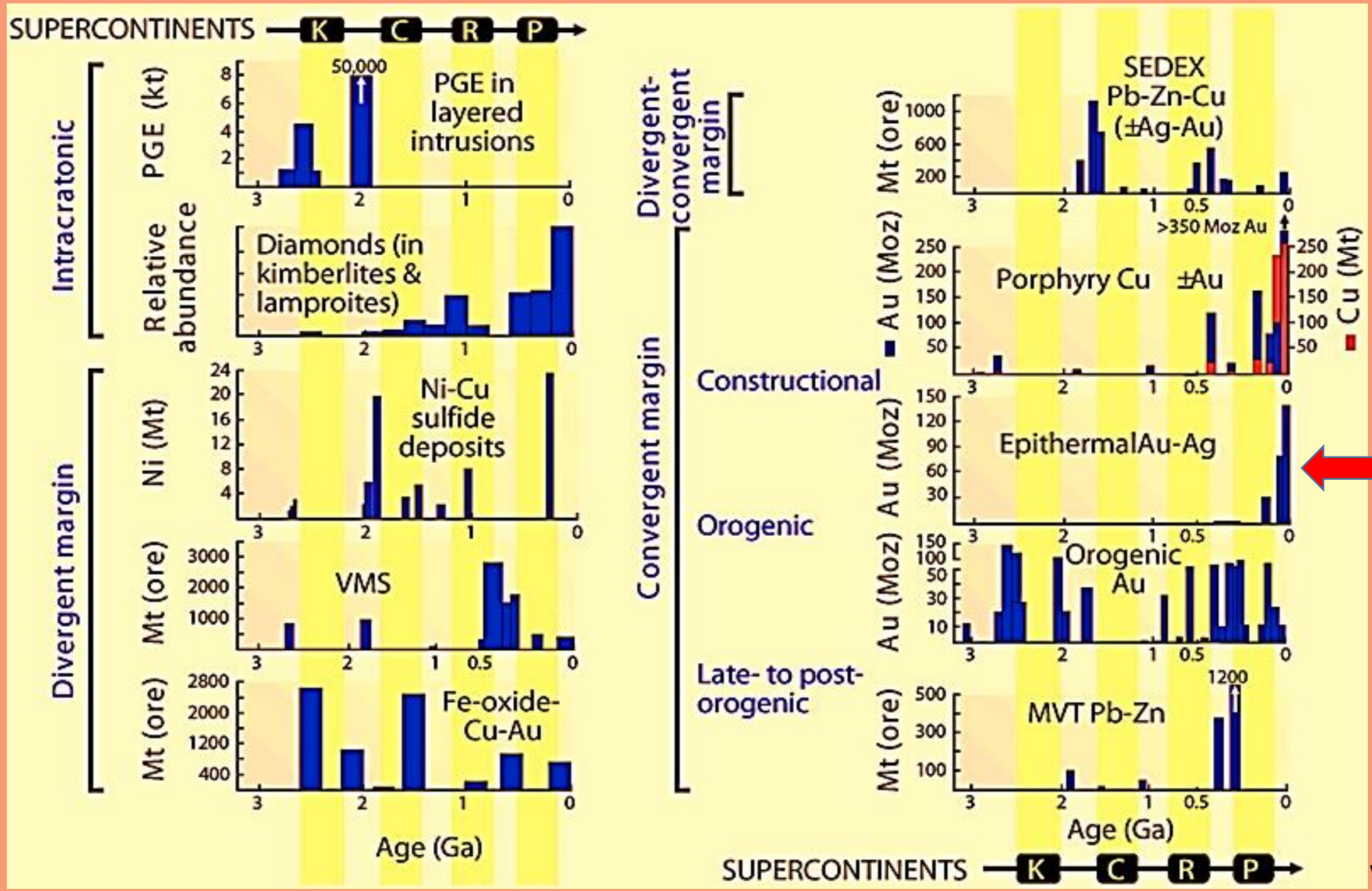
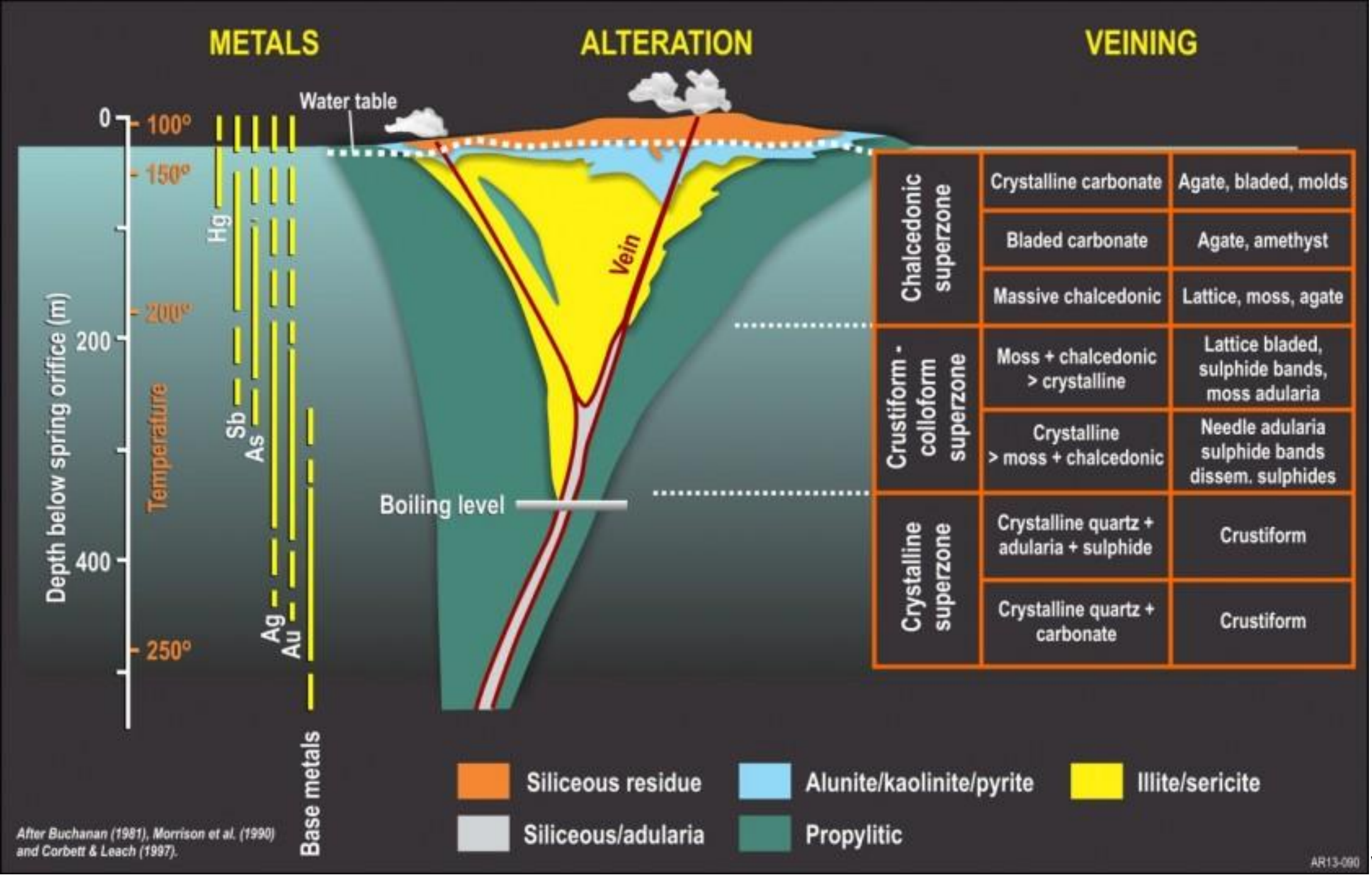


Diagram showing the temporal distribution of deposit types ascribed to broad geodynamic settings in terms of thesupercontinent cycle, as summarized from Figure 1. Temporal distributions are from Groves et al. (2005b) and references therein. K, Kenorland; C, Columbia; R, Rodinia; P. Pangaea



Epithermal gold deposit main characteristic

Parameter	Low Sulphur deposit	High Sulphur deposit
Ore minerals Gold	Gold, pyrite, electrum, sphalerite, galena	Gold, chalcopyrite, pyrite, tellurides, covellite
Gangue minerals	Quartz, Calcite, adularia, illite, carbonates	Quartz, alunite, barite, kaolinite, pyrophyllite
Textures	Veins, and open space filling drusycavities, symmetricalbanding and Colloform	Wall rock replacement,breccias, veins
Deposit characteristics	Cavity veins and stockworks ore common	Disseminated ores and replacement ores commmon
Main metals	Au, Ag, Zn, Pb, and minor Cu, Sb, As, Hg, Se	Au, Ag, Cu, As, and minor Pb,Hg, Sb, Te, Mo, Bi



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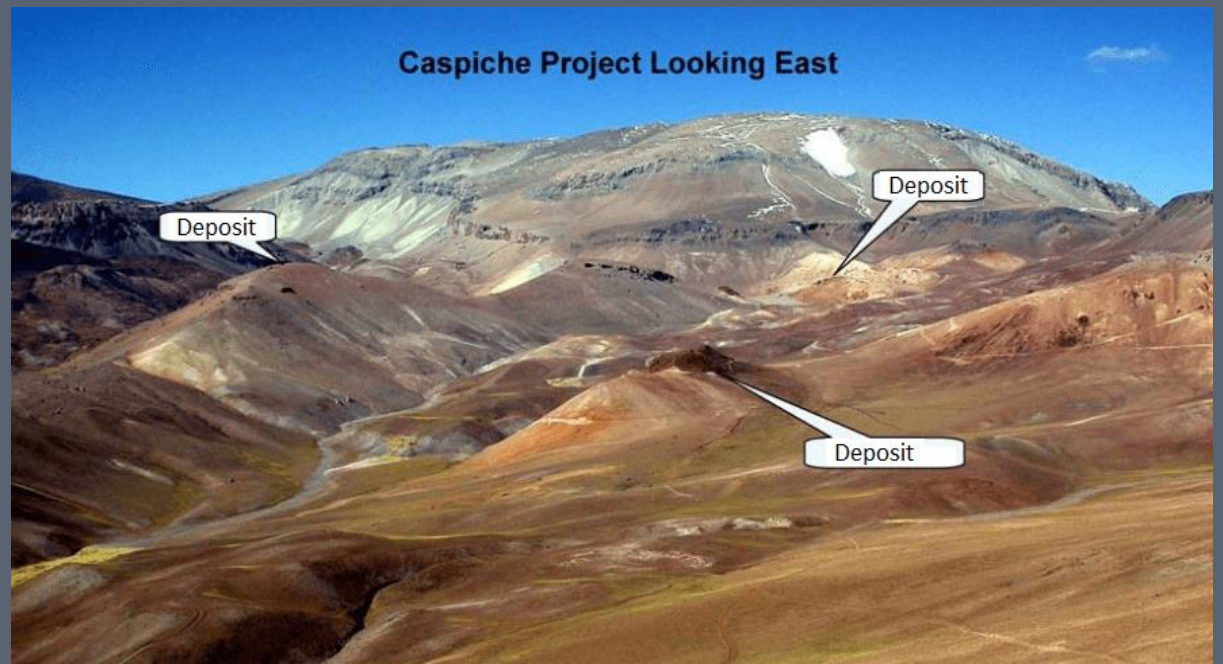
High sulfidation outcrop

Low sulfidation outcrop



Ore minerals

High sulfidation ore

Gold ore high sulfide

High Sulphide vein hosted in advanced argillic altered volcanic.

Intermediate sulfidation ore

Gold& Silver ore

High grade gold and silver ore consisting of lustrous GALENA, CHALCOPYRITE, SPHALERITE from the only operating...

Low sulfidation ore

High-grade gold ore (bonanza-grade gold ore)

Auriferous quartz-adularia rhyolite Native gold (Au) occurs in this rock as colloform bands, partially replaces breccia clasts, and also disseminated in the matrix

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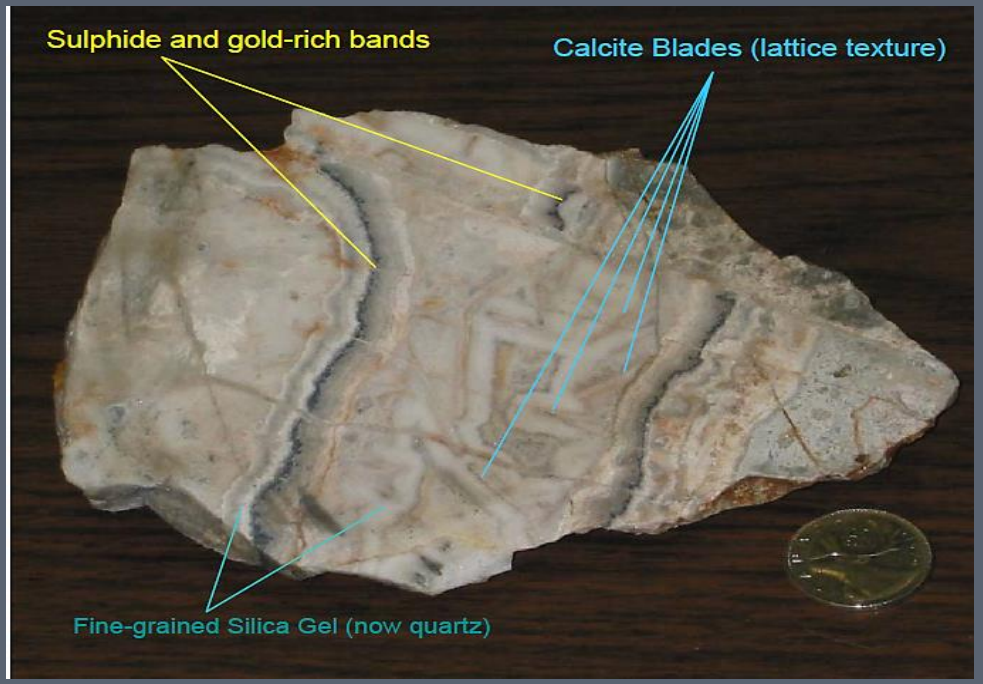
Ore Textures



Alteration	Mineralogy	Occurrence and origin
Propylitic	Quartz, K-feldspar (adularia), albite, illite, chlorite, calcite, epidote, pyrite	Develops at >240°C deep in the epithermal environment through alteration by near-neutral pH waters
Argillic	Illite,smectite, chlorite, inter-layered clays, Develops at <180°C on the periphery and in the shallow epithermal pyrite, calcite (siderite), chalcedony	environment through alteration by steam-heated CO2-rich waters
Adv. Argillic (steam-heated)	Opal, alunite (white, powdery, fine-grained, pseuocubic)), kaolinite, pyrite, marcasite	Develops at <120°C near the water table and in the shallowest epithermal environment through alteration by steam-heated acid-sulfate waters; locally associated with silica sinter but only in geothermal systems
Adv. Argillic (magmatic hydrothermal)	Quartz, alunite (tabular), dickite, pyrophyllite, (diaspore, zunyite)	Develops at >200°C within the epithermal environment through alteration by magmatic-derived acidic waters
Adv. Argillic (supergene)	Alunite, kaolinite, halloysite, jarosite, Fe oxides	Develops at <40°C through weathering and oxidation of sulfide-bearing rocks

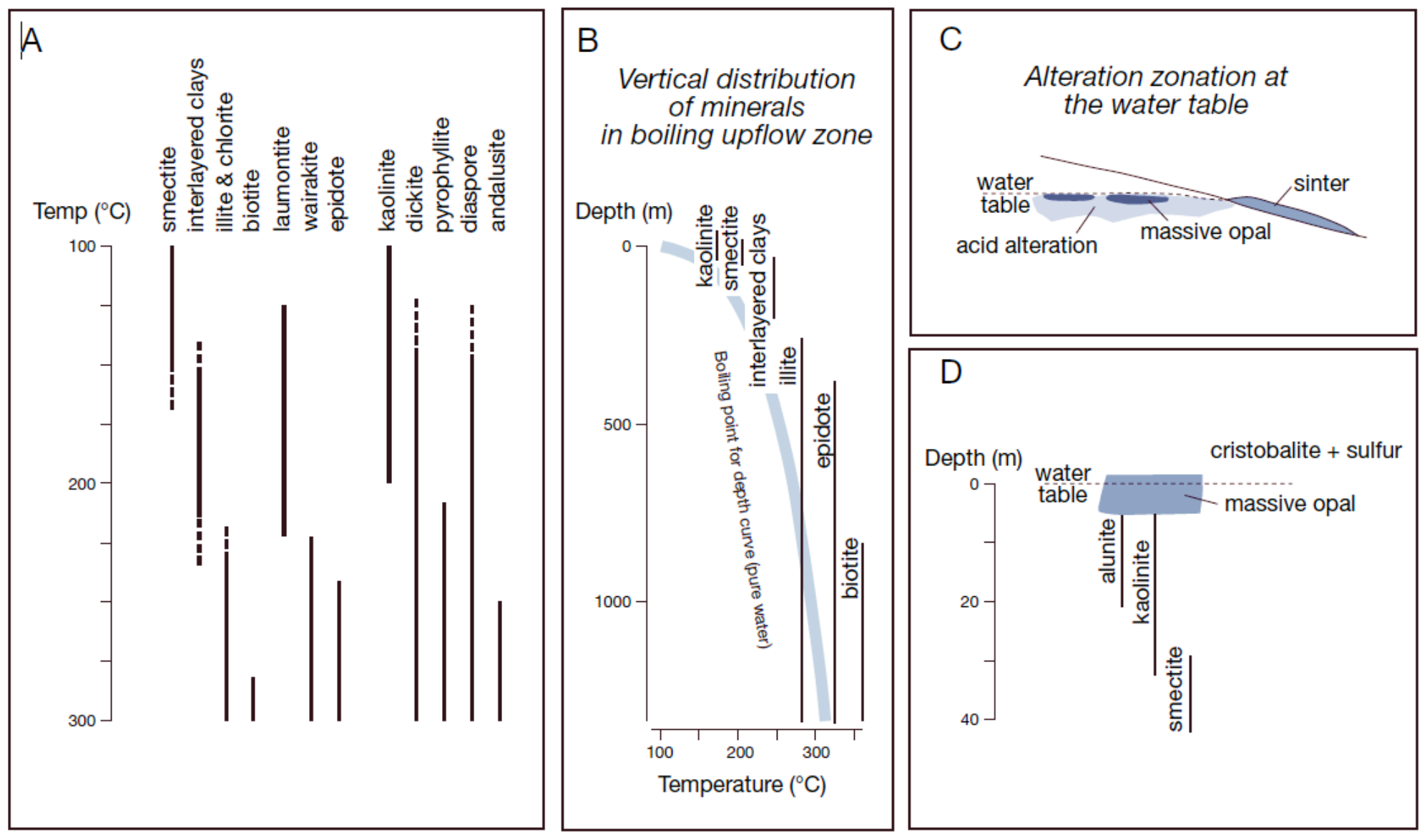


FIG.. Key indicator minerals in epithermal environments. A. Stability range of temperature-sensitive clays, phyllosilicates and zeolites (Henley and Ellis, 1983; Reyes, 1990). B. Vertical distribution of some of the same minerals plotted according to depth, using the hydrostatic boiling curve as the reference temperature gradient. C. Diagnostic hydrothermal minerals forming at the water table, comprising silica sinter where near-neutral pH waters discharge around boiling hot springs and vertically zoned acid alteration (modified from Sillitoe, 1993b). D. Magnification of vertically zoned steamheated acid alteration at the water table (Schoen et al., 1974; immons and Browne, 2000a): cristobalite and sulfur form at and above the water table; tabular massive opal forms at and below the water table; alunite and kaolinite form at and below the water table and the zone of massive opal.

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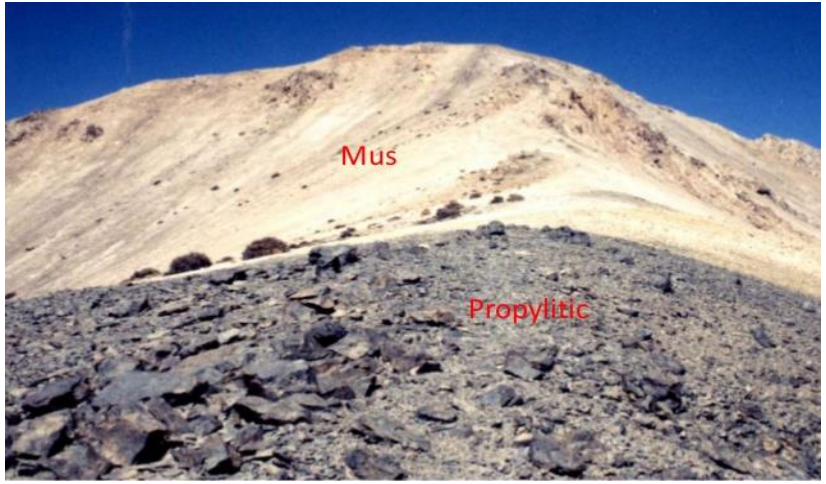
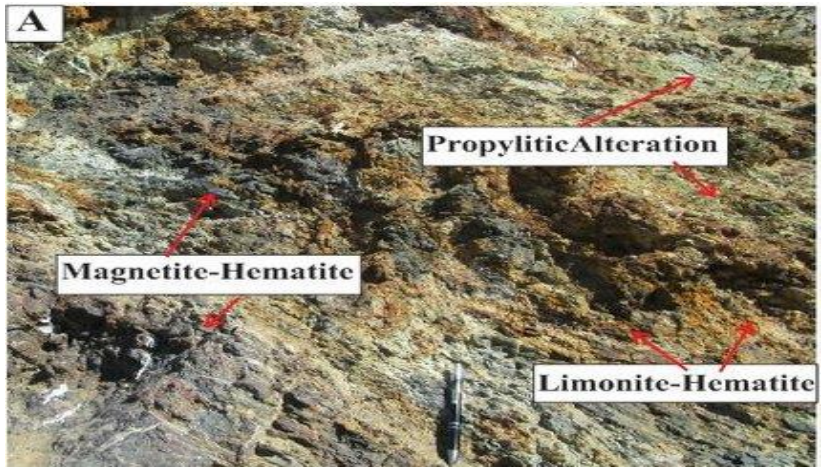
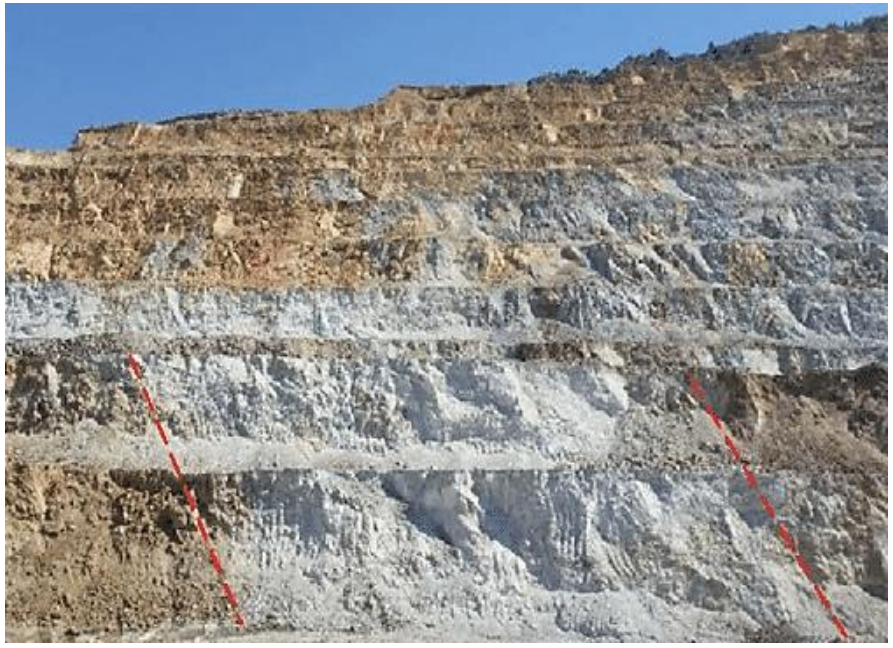
Propylitic Alteration



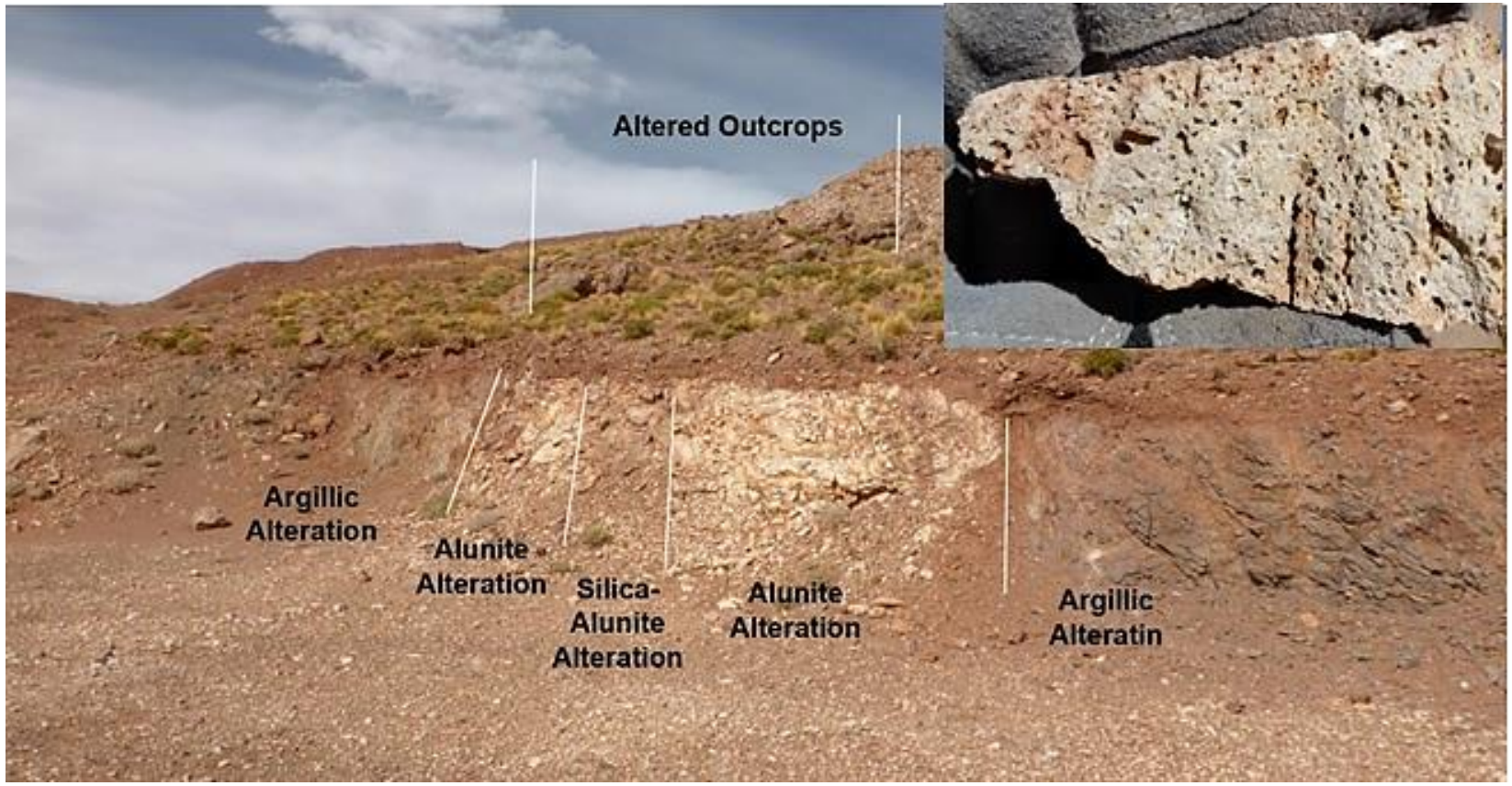


Advanced Argillic Alteration



advanced argillic alteration in an arid setting at Pascua-Lama. from publication: High Sulphidation Gold Deposits.

Alunite Alteration



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Jarosite Alteration

Alteration crust rich in jarosite and other sulfates at El Jaroso Ravine, Sierra Almagrera (SE Spain)

Jarosite samples

Alteration crust rich in jarosite

Jarosite in New Zealand. Credit: Michelle Kotler

Epithermal Au Mineralization and Associated Hydrothermal Alteration in Southern Kyushu

414m (2.54 g/t Au & 1.1 g/t Ag), "Yellow" polymict hydrothermal breccia jarosite-alunita-barite-filled matrix with sub angular vuggy silica altered fragments

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silica sinter

Gangue Minerals In Epithermal Systems

Minerals	LS	HS
Quartz	abundant	abundant
Chalcedony	**common** (variable)	common (minor)
Calcite	**common** (variable)	absent (except as overprint)
Adularia	**common** (variable)	absent
Illite	**common** (abundant)	uncommon (minor)
Kaolinite	rare (except as overprint)	**common** (minor)
Pyrophyllite-diaspore	absent (except as overprint)	**common** (variable)
Alunite	absent (except as overprint)	**common** (minor)
Barite	common (very minor)	common (minor)
Sericite		common
Hematite		common

Bladed Calcite

bladed Barite

Illite

Adularia

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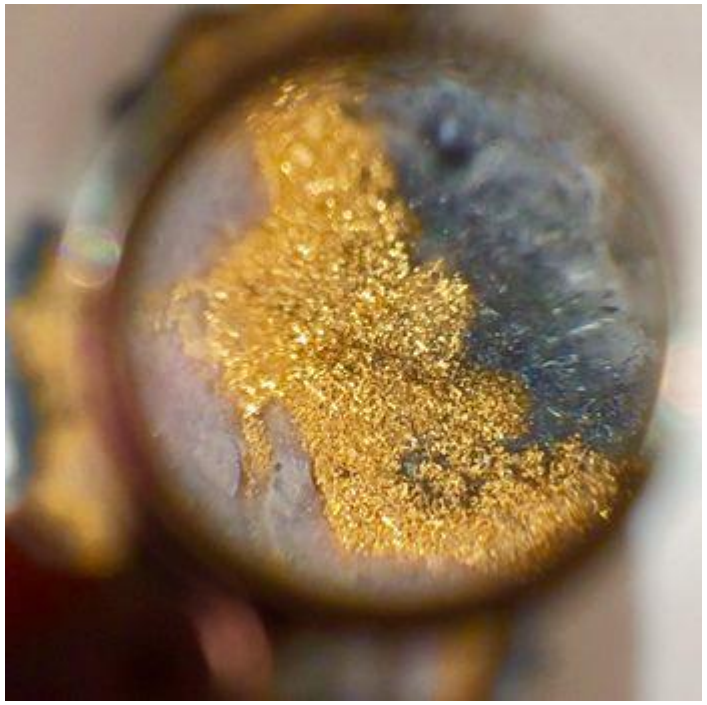
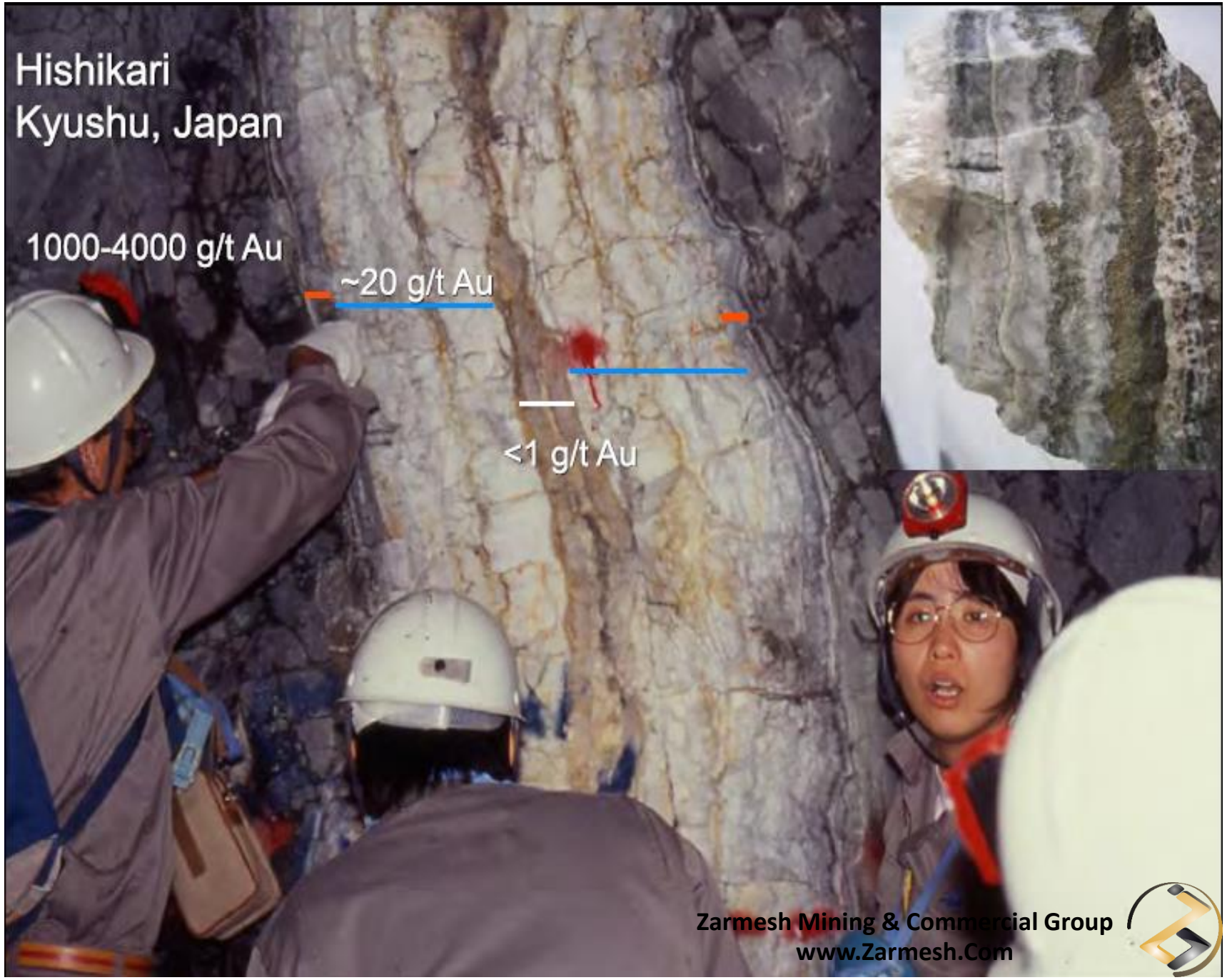
Ore Minerals In Epithermal Systems

Minerals	LS	HS
Pyrite	ubiquitous (abundant)	ubiquitous (abundant)
Sphalerite	**common** (variable)	common (very minor)
Galena	**common** (variable)	common (very minor)
Chalcopyrite	common (very minor)	common (minor)
Enargite-Luzonite rare	(very minor)	**ubiquitous** (variable)
Tennantite-Tetrahedrite	common (very minor)	common (variable)
Covellite	uncommon (very minor)	common (minor)
Stibnite	uncommon (very minor)	rare (very minor)
Orpiment	rare (very minor)	rare (very minor)
Realgar	rare (very minor)	rare (very minor)
Arsenopyrite	**common** (minor)	rare (very minor)
Cinnabar	uncommon (minor)	rare (very minor)
Electrum	uncommon (variable)	common (minor)
Native Gold	common (very minor)	common (minor)
Tellurides-Selenides	common (very minor)	uncommon (variable



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