



Porphyry deposits: Secondary enrichment,
breccias; exploration methods

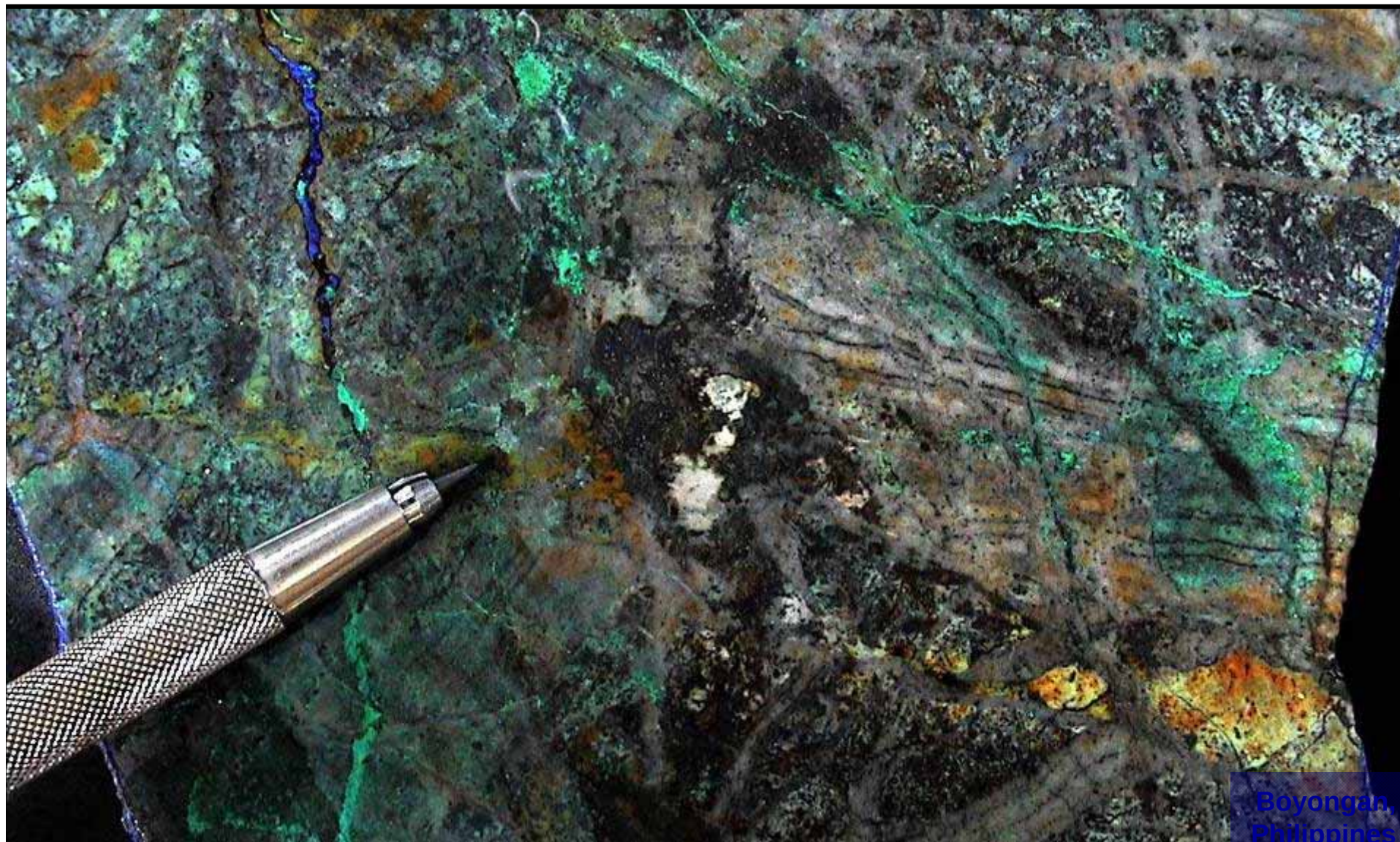
斑岩矿床 次生富集 角砾岩 勘探方法

Tourmaline – pyrite – chalcopyrite-cemented breccia, Sierra Gorda, Chile



Supergene Mineralisation

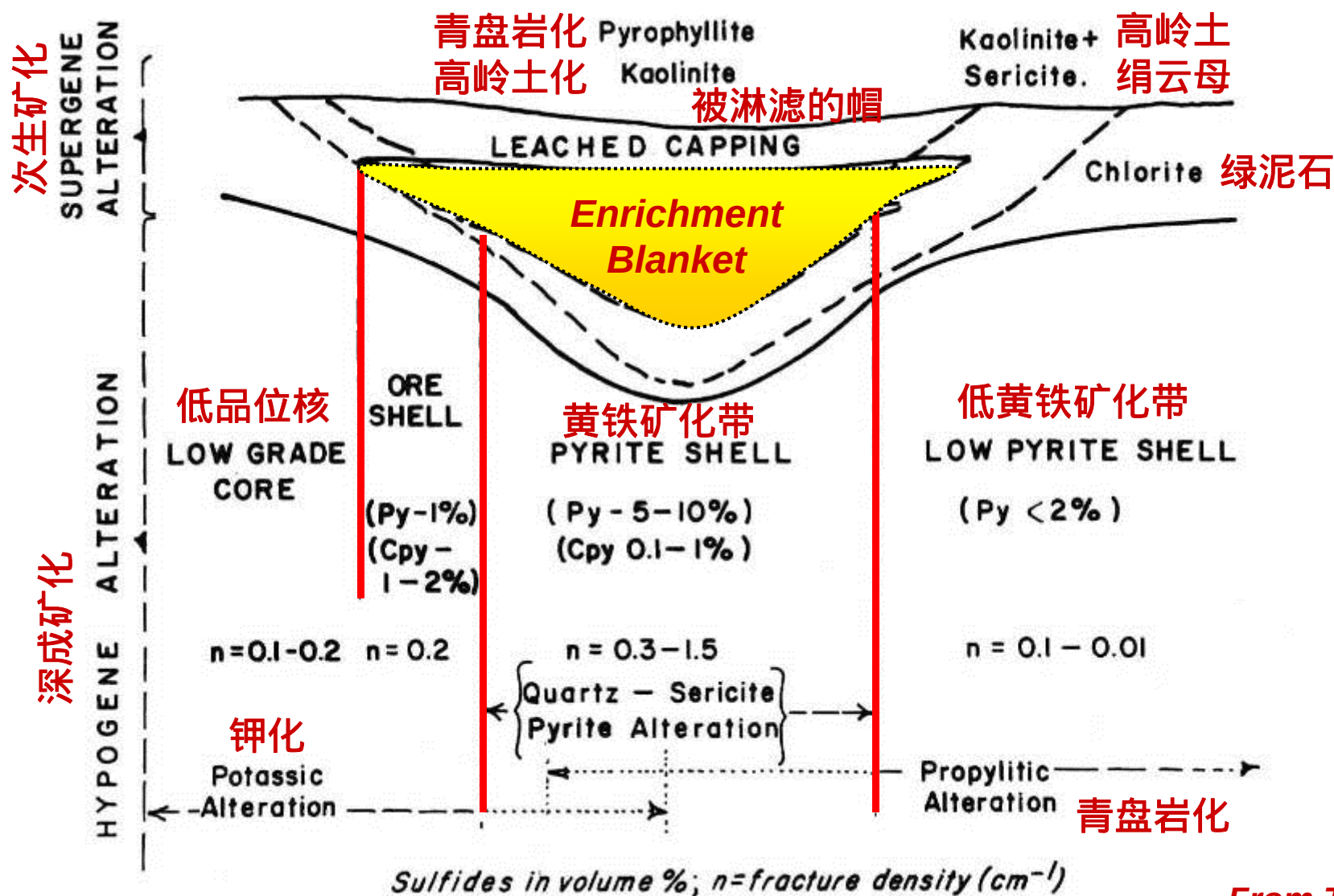
次生矿化





Idealised supergene enrichment blanket

次生富集层的理想模式



From Titley, 1982

Examples of Fe minerals in leached caps

淋滤盖层中的Fe矿物实例

Overburden
覆盖层

Hematitic cap
赤铁矿盖层

Chalcocite ore
辉铜矿矿石

Cuajone, Peru





Examples of Fe minerals in leached caps

淋滤盖层中的Fe矿物实例



Jarositic leached cap in a highly pyritic Ag-Au bearing epithermal system, Bolivia

富黄铁矿含Ag-Au浅成热液矿床 中的黄钾铁矾淋滤层

Goethitic leached cap above a pyritic Sn-Ag porphyry system, Bolivia

含Sn-Ag黄铁矿 斑岩体系上的针铁矿淋滤层



Identifying residuals minerals in leached caps

淋滤盖层中的残留矿物的鉴别

Limonites 褐铁矿:

- From Peterson and Chavez (2002).



Hematite 赤铁矿

Goethite 针铁矿

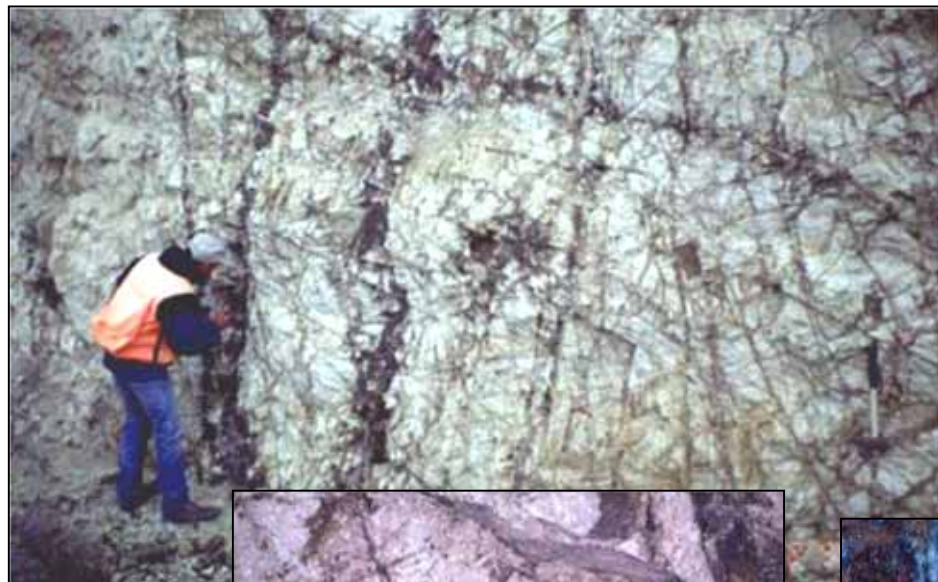
Jarosite 黄钾铁矾

- Iron oxide characterization chart for comparing smudges from leached outcrops and drill holes intervals
氧化铁特征图，用于对比淋滤过的露头 and 岩心中的氧化物
- Mixtures of red hematite, goethite and jarosite will produce gradational colors as shown in the standard box
混合红色赤铁矿、针铁矿及黄钾铁矾，会产生象标准图标中一样的颜色等级
- Note that the standard smudges are derived from leached capping environments and represents XRD analyzed end-member iron oxides
注意，标准的氧化物色谱来源于淋滤层环境，代表经XRD分析了的铁氧化物端元组分



Examples of Cu minerals in leached caps

淋滤盖层中的Cu矿



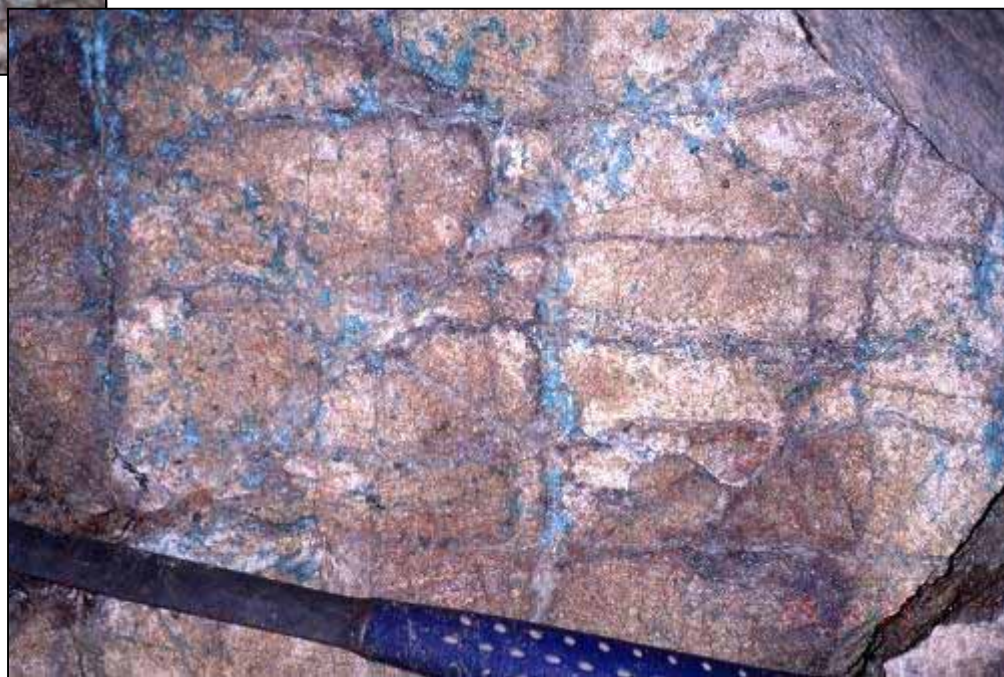
Neotocite on fractures in phyllic altered quartz monzonite porphyry, Quellaveco, Peru

绢英岩蚀变石英二长斑岩裂隙中的硅锰矿



Brochantite along oxidised qtz-cp veins in quartz monzonite porphyry Quellaveco, Peru

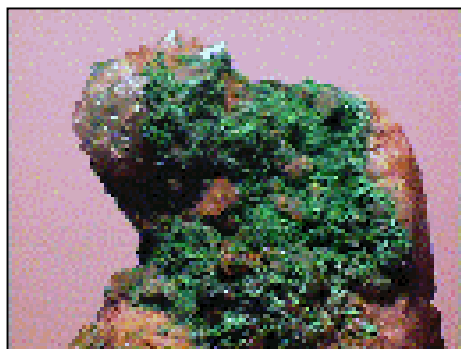
氧化脉中的水胆矾





Examples of Cu minerals in leached caps

淋滤盖层中的Cu矿石

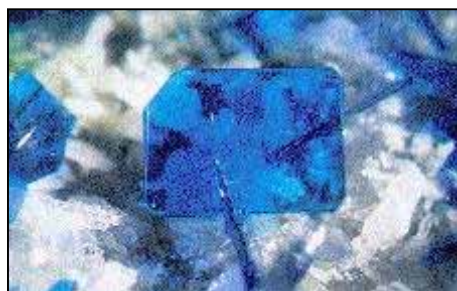


Antlerite



Turquoise 绿松石

**Native Cu
自然铜**



Azurite 蓝铜矿



Azurite on fractures from in-situ oxidation of chalcocite, Escondida, Chile



Breccias in Magmatic - Hydrothermal Systems

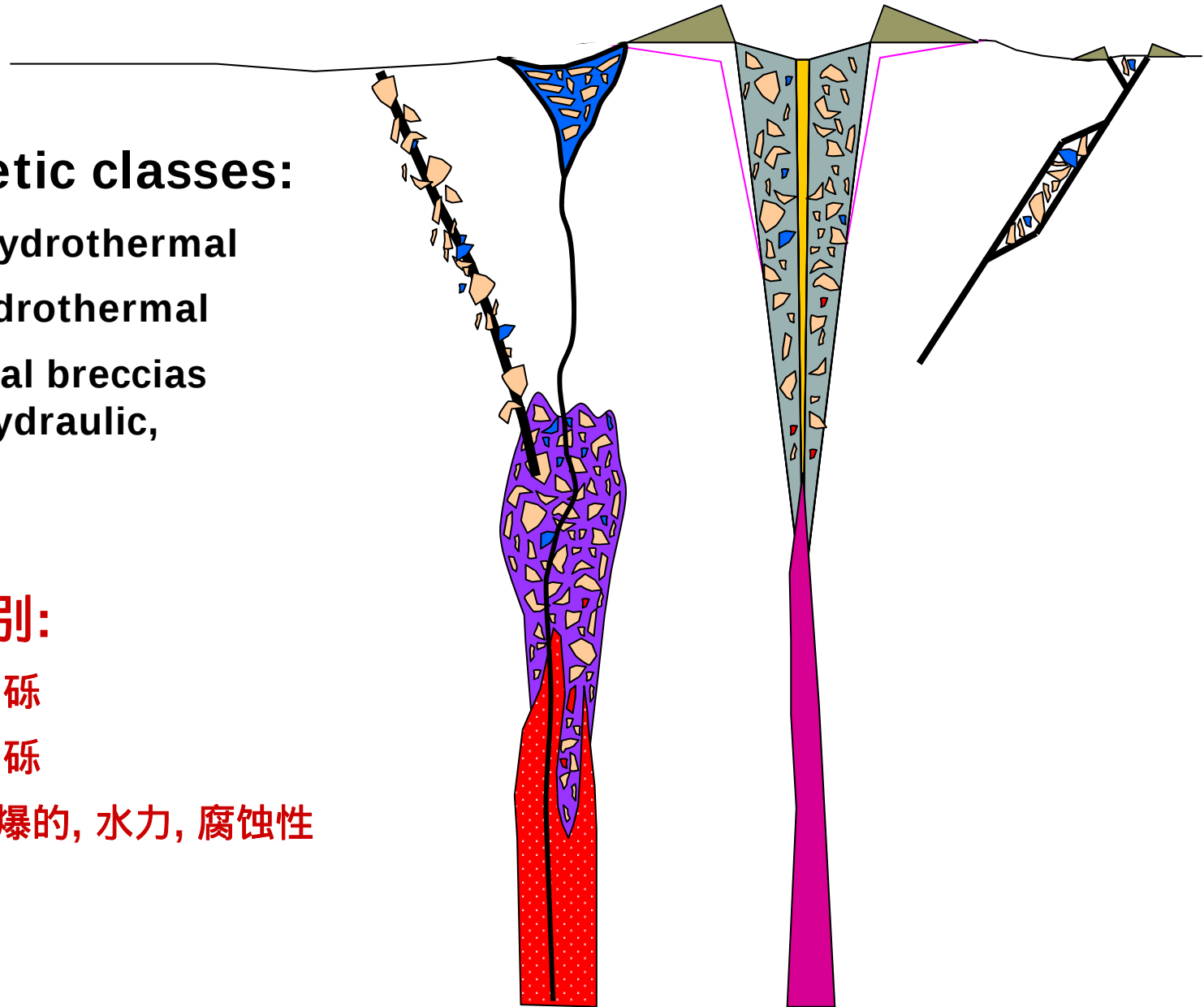
岩浆 - 热液系统中的角砾岩

Major genetic classes:

- Magmatic-hydrothermal
- Volcanic-hydrothermal
- Hydrothermal breccias (phreatic, hydraulic, corrosive)
- Tectonic

主要成因类别:

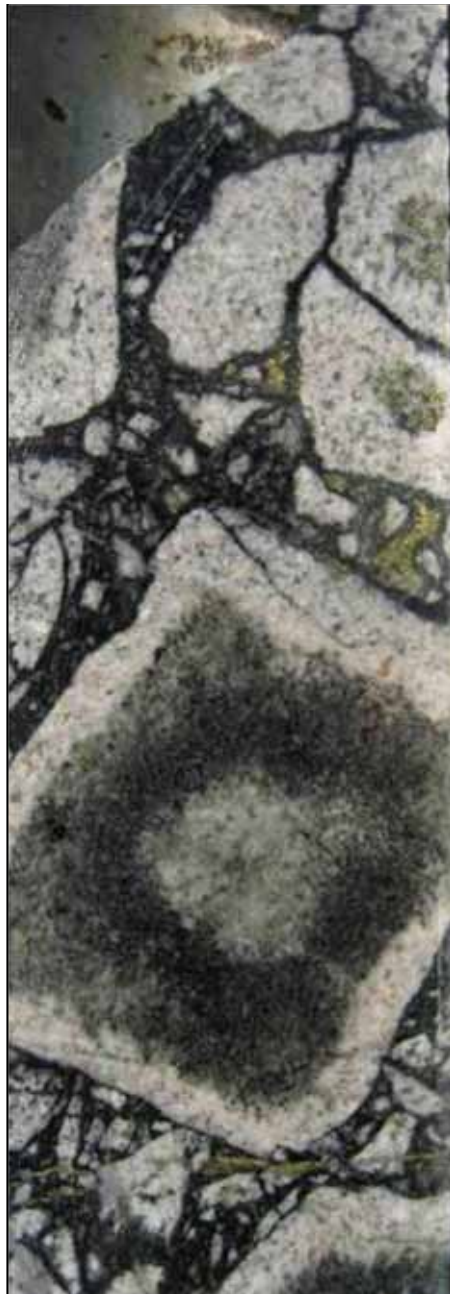
- 岩浆 - 热液角砾
- 火山 - 热液角砾
- 热液角砾 (隐爆的, 水力, 腐蚀性的)
- 构造角砾



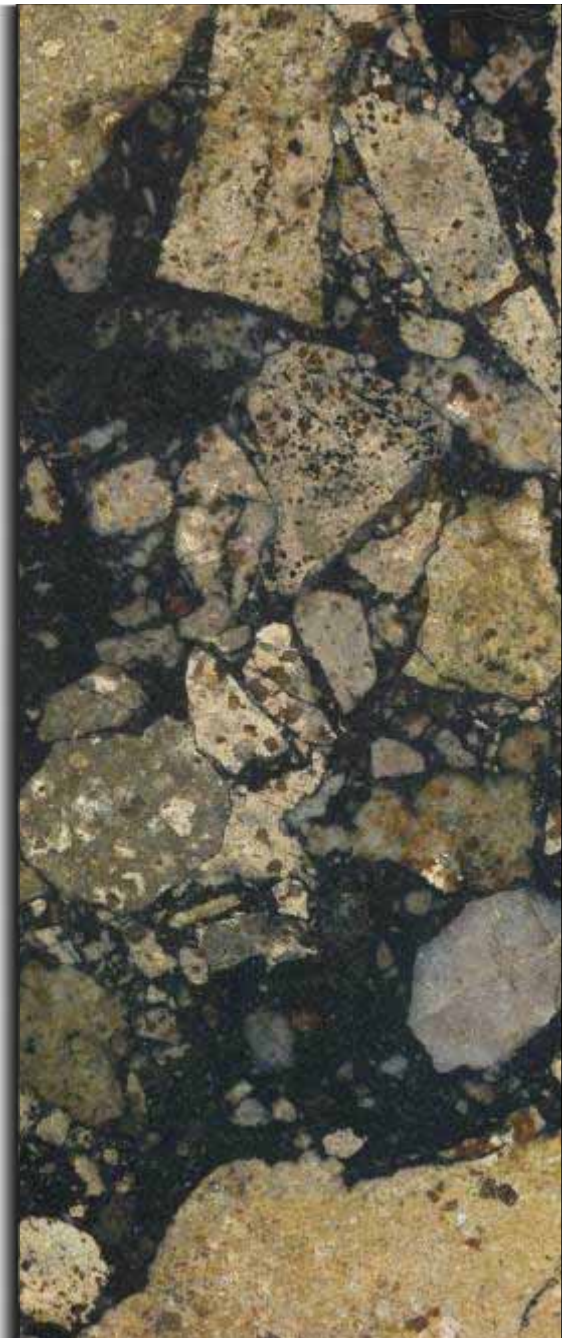
Magmatic- hydrothermal breccias

岩浆 – 热液角砾

- Generated by explosive fluid release from crystallising porphyry 由流体从正在结晶中的岩浆爆发性地释放造成
- Angular clasts - implies limited clast transport & abrasion 有棱角的碎屑 – 说明碎屑搬运和磨圆很有限
- High temperature alteration rinds (*clasts*) and altered matrix 碎屑有高温蚀变边和蚀变的基质
- Sulfide cement 硫化物胶结



Tourmaline-
chalcopyrite cement,
Rio Blanco



Polymict tourmaline
breccia, Sierra Gorda, Chile

Sulfide Mineralisation Styles 硫化物矿化类型

Clast alteration
蚀变碎屑

Cement
胶结物

Vein
矿化脉

- Hydrothermal cement 热液胶结
- Alteration of matrix 岩石蚀变
- Alteration of clasts 碎屑蚀变
- Cross-cutting veins 交切脉体

Tourmaline breccia,
Río Blanco, Chile



Breccias in Hydrothermal Systems

热液体系中的角砾岩

2 – Phreatomagmatic breccias

岩浆蒸气作用角砾岩

- Clastic matrix & milled clasts
碎屑状基质和磨碎的碎屑
- Surficial and subsurface deposits

在地表及地下均有角砾岩形成

- Bedded and massive breccias

成层的和块状构造的角砾岩相

- Venting of volatiles to surface

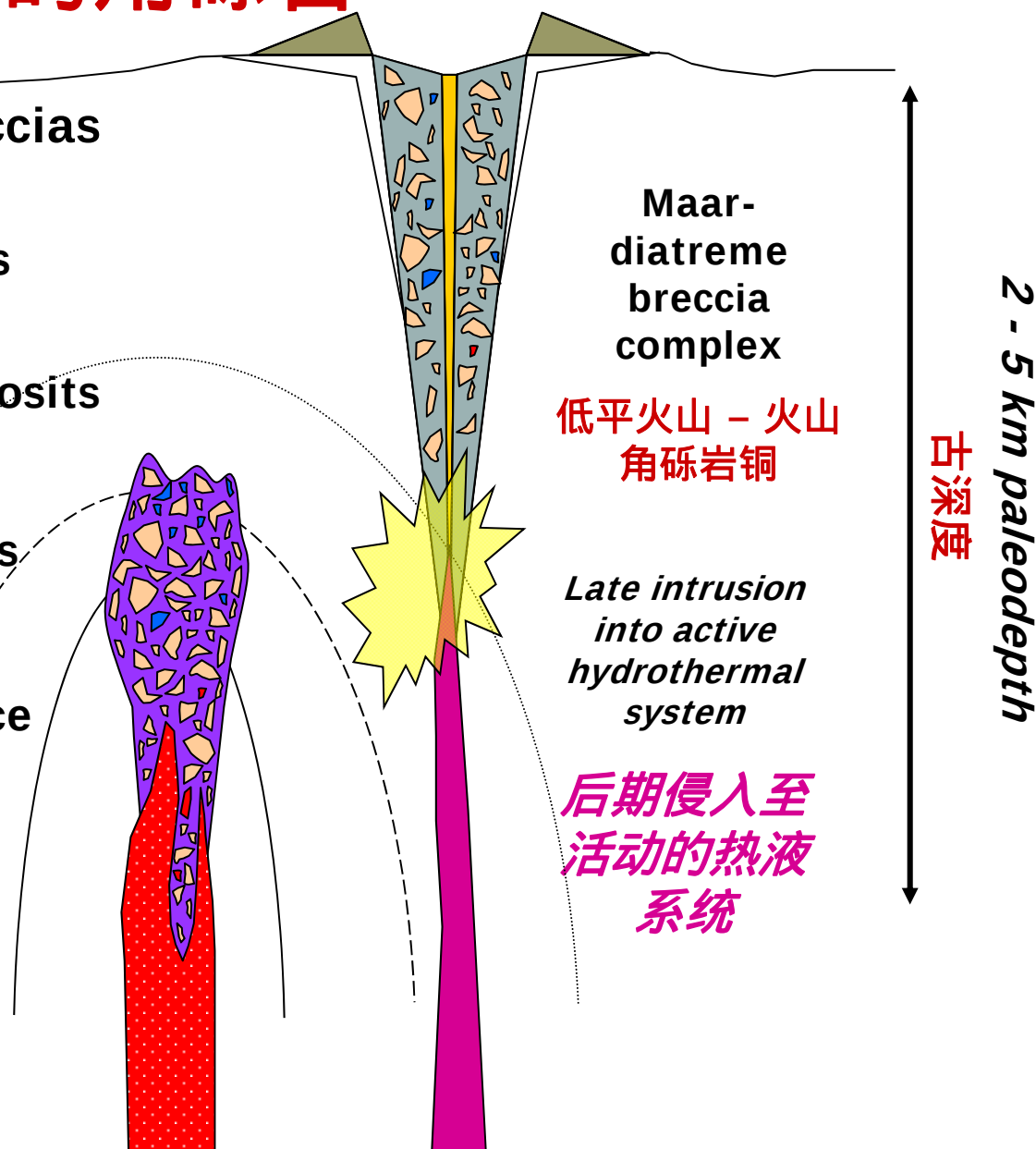
挥发份排出到地表

⇒ *death of a porphyry deposit*

斑岩矿床成矿作用停止

⇒ *shortcut to the epithermal environment*

形成浅成环境的捷径



Volcanic-Hydrothermal Breccias – Nature's Drillholes

火山 – 热液角砾岩：自然界的钻孔



Capillitas diatreme, Fallon Negro district, Argentina



Diatremes 角砾岩筒

Diatremes are downward-tapering, cone-shaped breccia bodies (paleovolcanic vents) that can exceed 2km depth

角砾岩筒是向深部变细的圆锥形角砾岩体（古火山喷发通道）。
可深达2公里

- phreatomagmatic and phreatic explosions 蒸汽岩浆爆破和蒸汽爆破
- filled by volcaniclastic debris and collapsed wall rocks 被火山碎屑岩碎石和崩塌的围岩充填
- subsurface conduits beneath maars 低平火山口下的通道



USGS photo by R Russell, 1977



USGS photo by D. Dewhurst, 1990 100 m



**Purumbete Maar, Victoria, Australia:
truncated low angle cross-bedding
(base-surge deposits)**

Late-stage diatreme breccia at Acupan Au-Ag mine, Philippines
菲律宾 Acupan 金银矿的晚期火山角砾岩筒



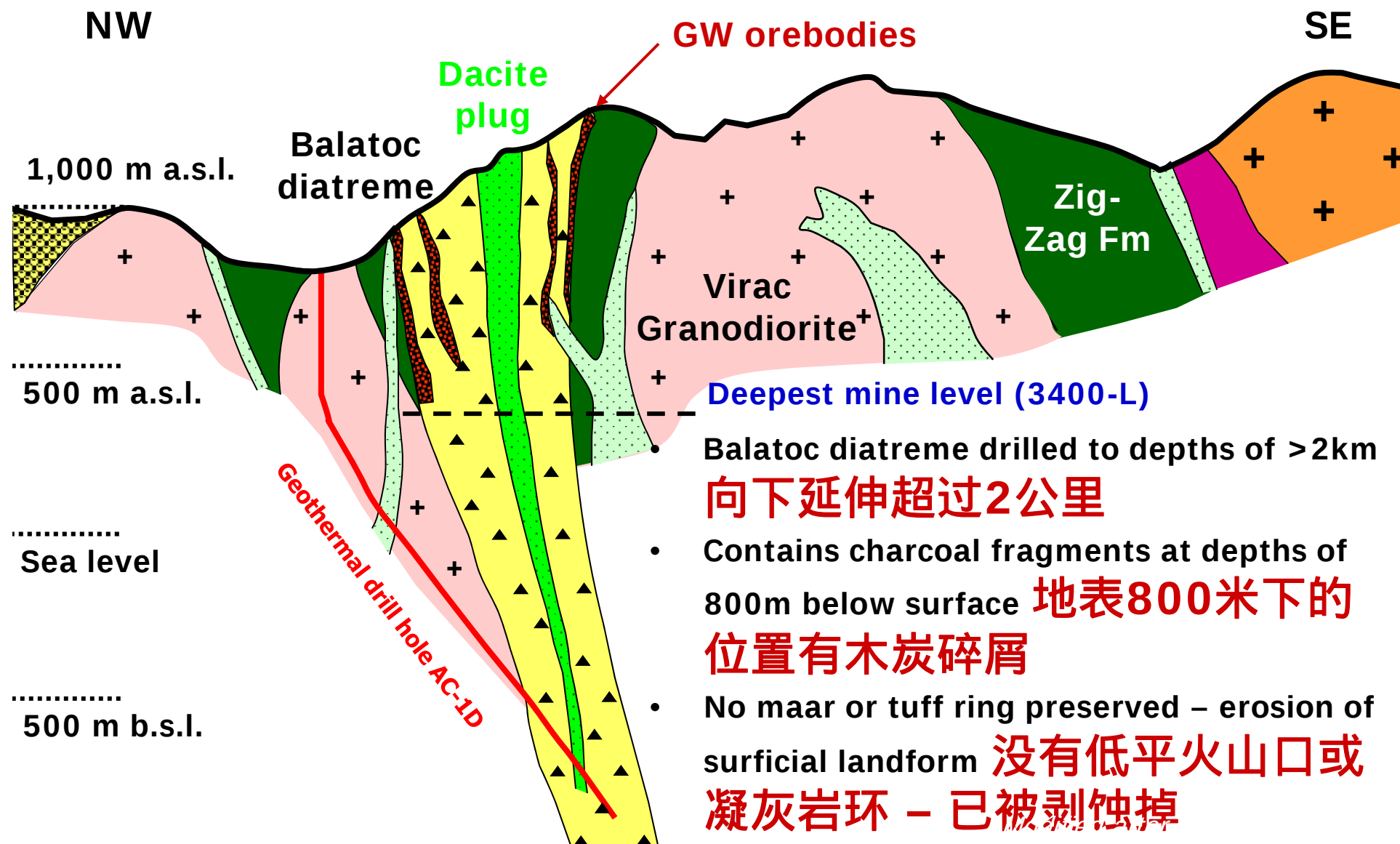
Sericite-chlorite altered
polymict matrix-rich breccia,
Acupan Gold Mine, Philippines

Chalcopyrite clast in
polymictic matrix-rich
breccia, Amacan, Philippines



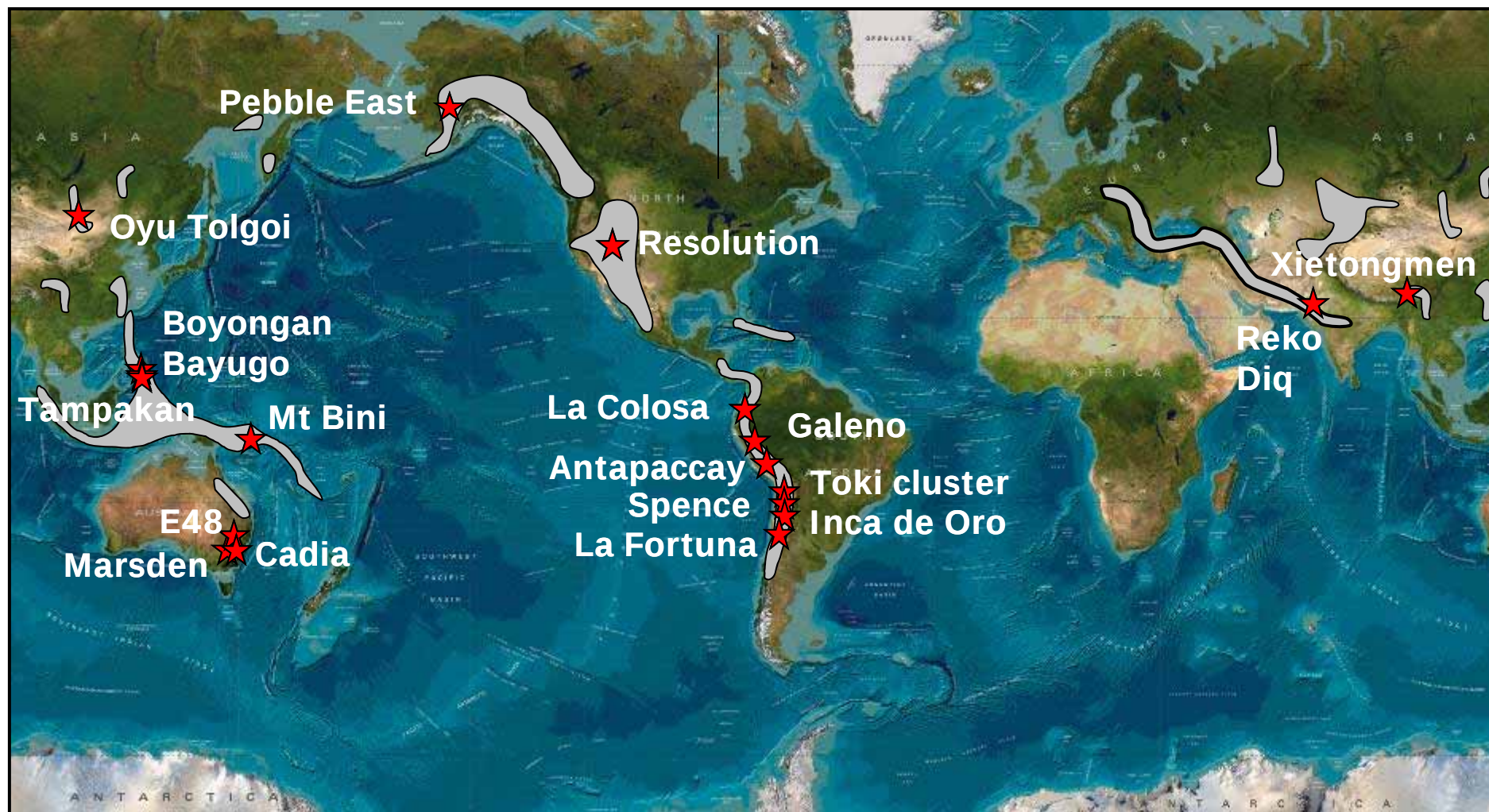
Balatoc diatreme – Acupan, Philippines

Balotoc角砾岩筒, Acupan, 菲律宾





Porphyry deposit discoveries since 1992 自1992年以来发现的斑岩矿床



Map source: <http://www.gebco.net>

Porphyry discoveries since 1992

自1992年以来发现的斑岩矿床

- More discoveries have been made in covered geological settings than in the past 与过去相比更多的新发现是在有盖层的地质环境中
 - *e.g., Spence*
 - *Toki*
 - *Cadia East*
 - *Pebble East*
 - *Hugo Dummett*
- These covered deposits are mostly being discovered in near-mine (*brownfields*) areas rather than virgin (*greenfields*) areas 这些矿床大多数是在已有矿山周围发现的，在新区发现的较少。

Biotite alteration halo in albite-sericite altered quartz monzonite porphyry, E48, NSW





Exploration 勘探

Explore near known systems thoroughly

在查明系统附近进行全面勘查

Regional-scale structures

区域尺度构造

Geophysics: aeromagnetics, IP

地球物理：航磁，IP

Geochemistry: soil, stream, rock chip, RAB

地球化学：土壤，水系，岩石碎片，RAB

Aeromagnetics - North Parkes, NSW

Gravity - North Parkes, NSW



Exploration 勘探

Intrusive geochemistry and geochronology
岩体地球化学和年代学

Alteration mapping 蚀变填图

Breccias 角砾岩

Drilling 钻探

Exploration Drilling - Cadia Far East, NSW