

Society of Economic Geologists (SEG)

Advancing Science & Discovery

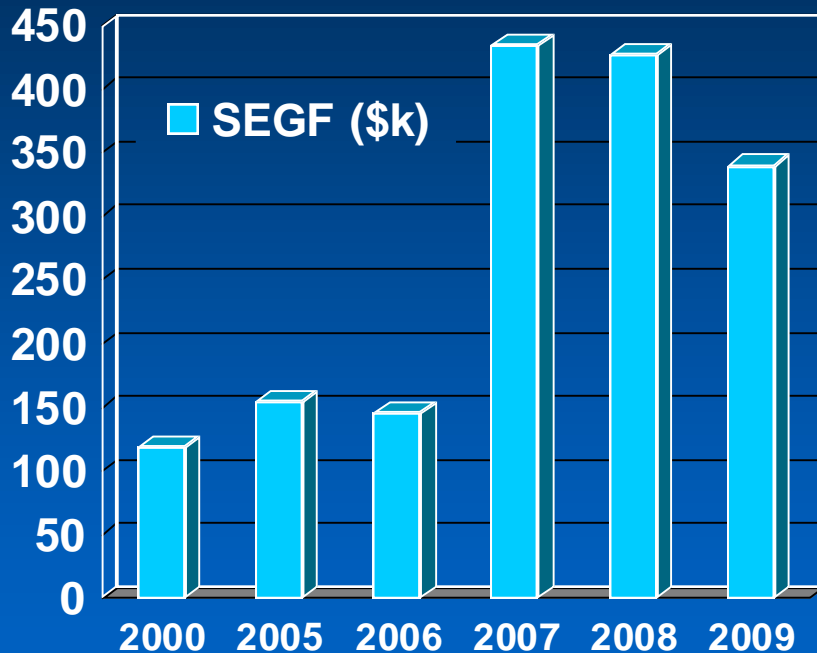
- Representing 5400 members in 100 countries
 - Members from industry (~2/3) and research (~1/3)
 - Advance the science of economic geology
 - High-quality conferences, seminars, publications (*Economic Geologists*)
- Assists in development of all economic geologists
 - Short courses, workshops, field trips
 - Provides a network of colleagues; promotes excellence
- Student support
 - An introduction to the profession
 - Network and mentors
 - Many educational and funding opportunities



www.segweb.org

SEGF investment in students worldwide

Levels: 2000, 2005-2009



*Keystone 2006 Wealth
Creation conference*

SEG membership

	members	students
'00	3501	314 (27 ch)
'10	5260	937 (44 ch)



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Gold Discoveries in the Americas: Challenges and Opportunities

Jeffrey Hedenquist, Ottawa (*President, SEG*)
Antonio Arribas (Newmont), Chico Azevedo (Gold Fields),
Rich Goldfarb (USGS), and Richard Sillitoe (UK)

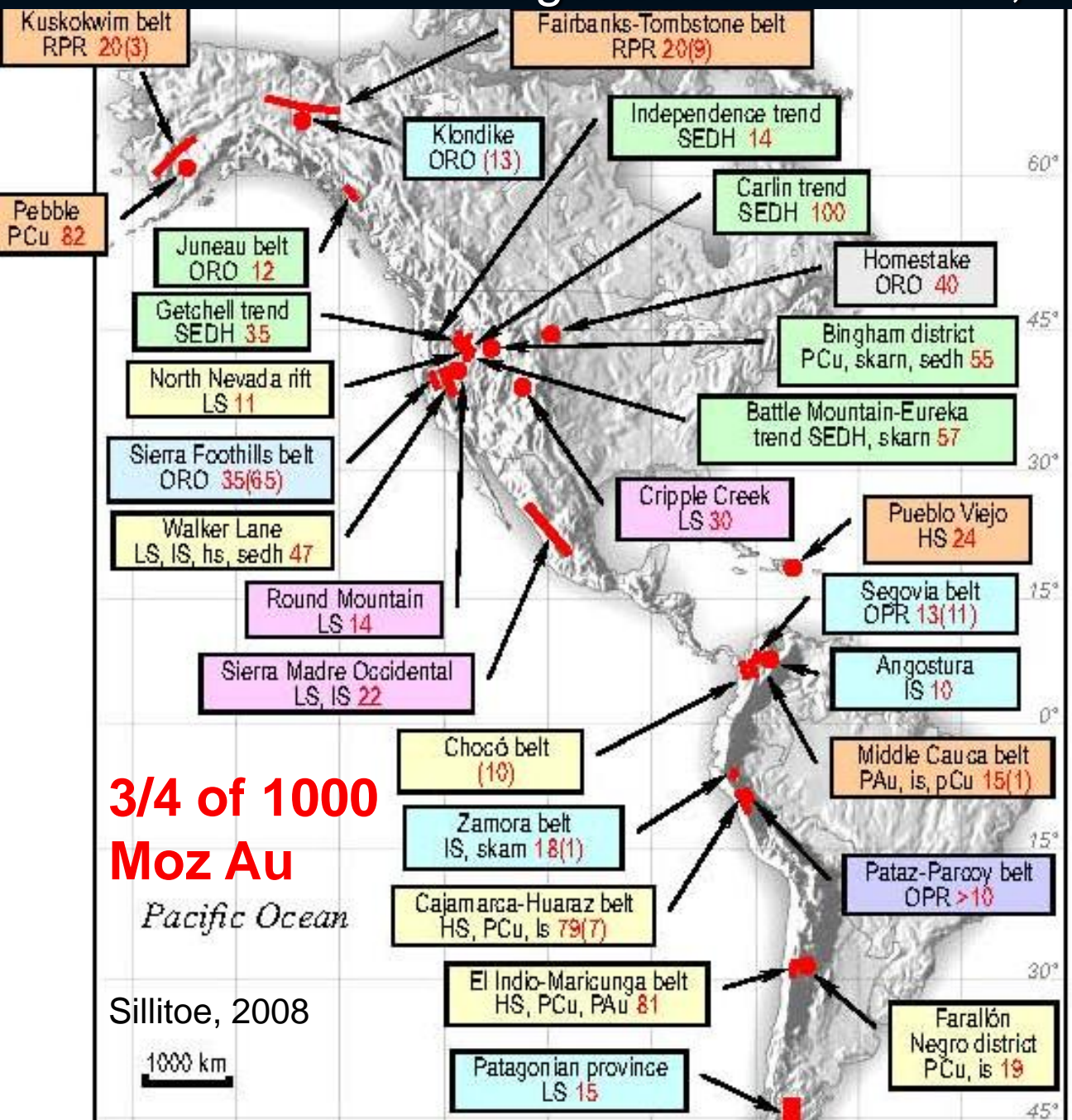


Alto Chicama, Peru

Outline

- Gold deposits of American Cordillera
 - Styles, distribution, importance, tectonics
- Orogenic and intrusion-centered dominate
- Au deposit discoveries, 1970-2008 (21st C)
- Southern Peru trend
 - Discoveries, and deposits, grow
- South America update

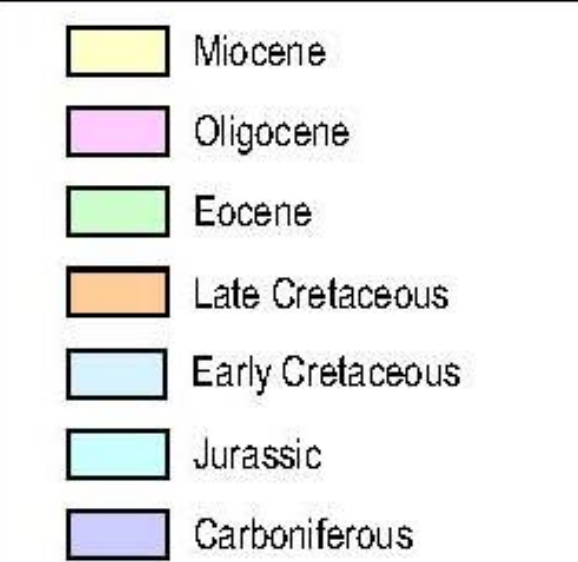
>10 Moz belts: Heterogeneous distribution, styles, ages, location!



SEDH	Sediment hosted
ORO	Orogenic
RIR	Reduced pluton related
OIR	Oxidized pluton related
PCu	Porphyry Cu-Au
PAu	Porphyry Au
SKARN	Skarn
HS	High-sulfidation epithermal
IS	Intermediate-sulfidation epithermal
LS	Low-sulfidation epithermal

(NB Abbreviations for major deposit upper case)

57(5) Contained Au (placer Au), in million oz



3/4 of 1000 Moz Au
Pacific Ocean

Sillitoe, 2008

1000 km

Gold Deposits $\geq 150t^*$

(≥ 5 Moz)

OROGENIC

24 >500t
6 >1000t

Muruntau	5290t
Ashanti	2070t
Golden Mile	1984t
Nataika	1376t
Homestake	1237t
Telfer	1005t

IOCG

1 >500t
1 >1000t

Olympic Dam	1905t
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IRGS

0 >500t

SKARN

0 >500t

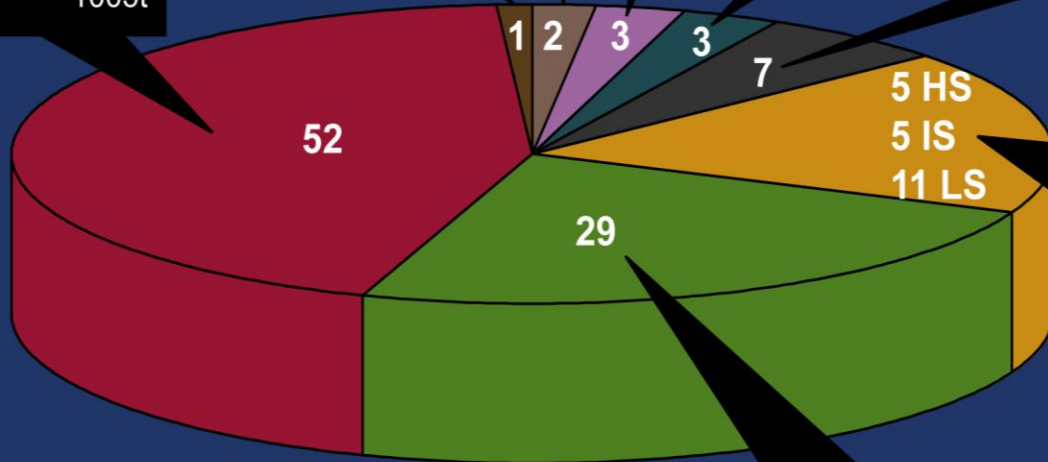
VMS

0 >500t

CARLIN

5 >500t
2 >1000t

Betze Post	1539t
Pipeline/Cortz	1029t



HIGH SULFIDATION EPITHERMAL

3 >500t
2 >1000t

Yanacocha	1320t
Pueblo Viejo	1242t

INTERMEDIATE SULFIDATION EPITHERMAL

0 >500t Several Mexican Ag-Au

LOW SULFIDATION EPITHERMAL

4 >500t
1 >1000t

Ladolam	1306t
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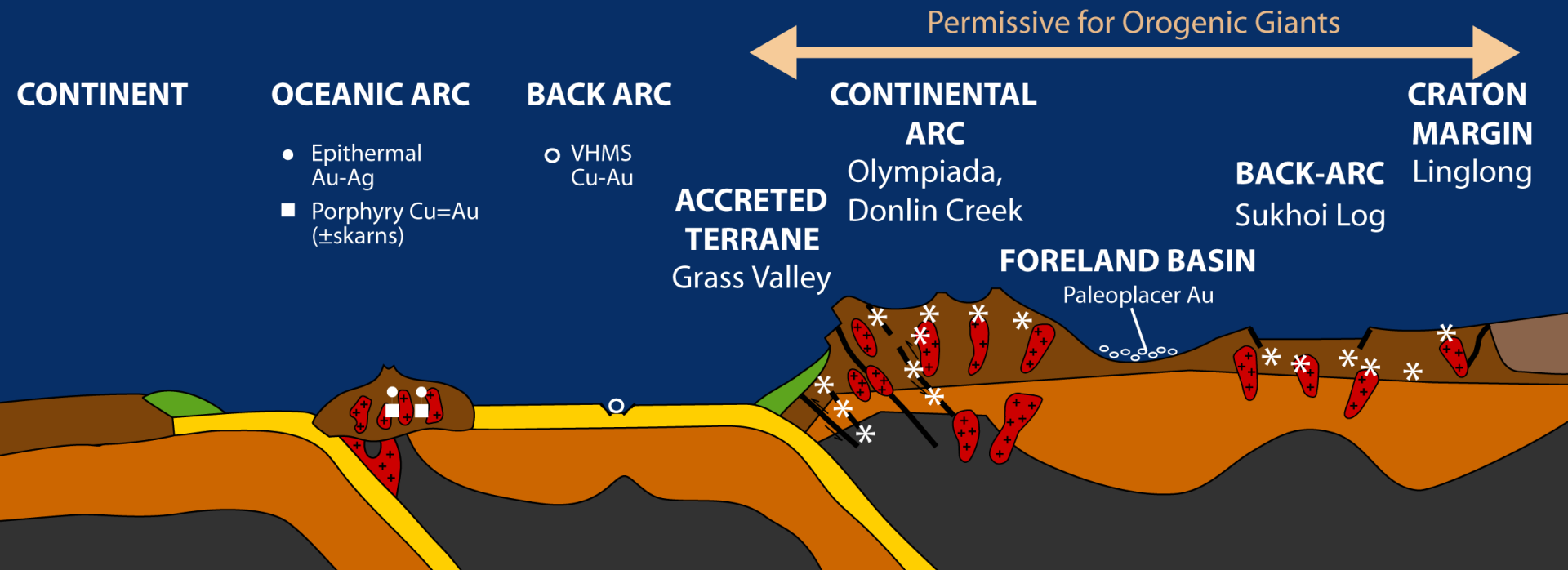
PORPHYRY

10 >500t
4 >1000t

Almalyk	2798t
Grasberg	2604t
Pebble	2541t
Bingham	1603t

Total Deposits = 119
* does not include Paleoplacers

Tectonic Settings of Orogenic Gold



- Gold in the fore-arc, arc and back-arc:

- 20-200 m.y. younger than host rocks, deep metamorphism

- Gold correlates with changing stress/transpressive reactivation

- Highest uplift rates adjacent to transpressive 1st order faults

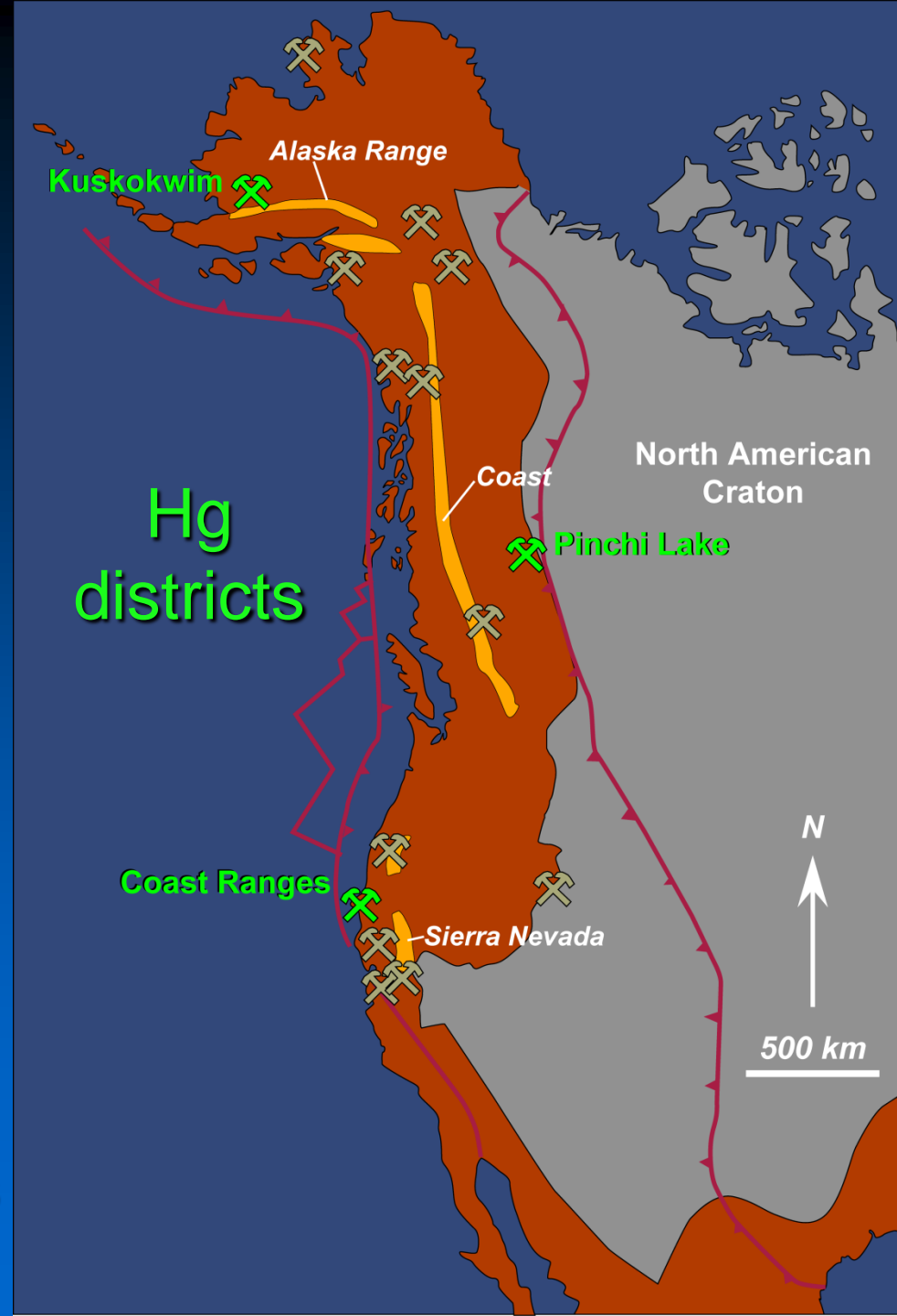
Cordilleran Mesozoic Gold Belts:

Ores in Accreted Arcs,
Marine Sequences, and
Overlap Assemblages

KEY REGIONAL EXPLORATION TARGETS

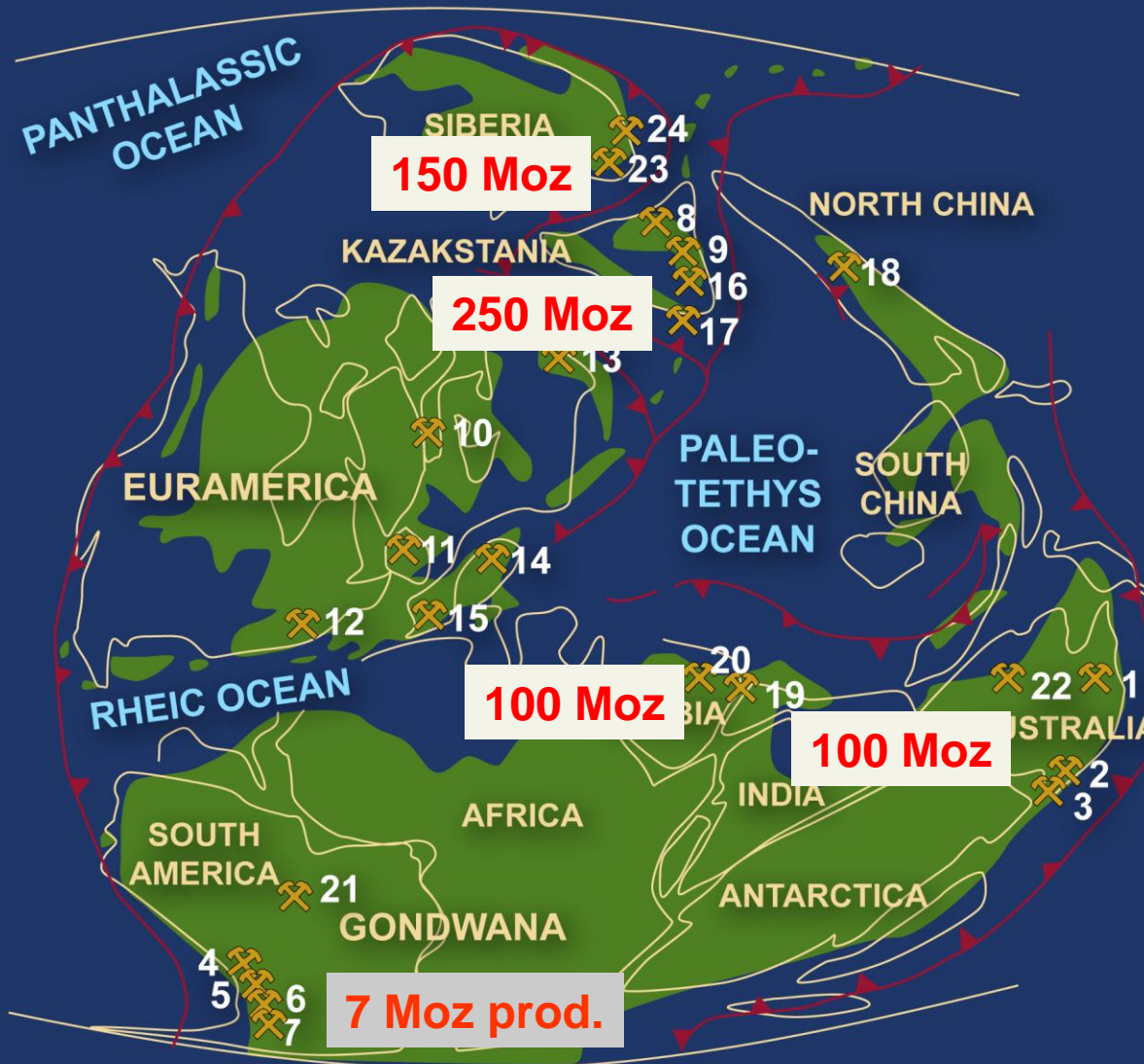
- 1) Major structure
- 2) Metamorphic grade
- 3) Physical or chemical trap

Hg: tops of young orogenic ores



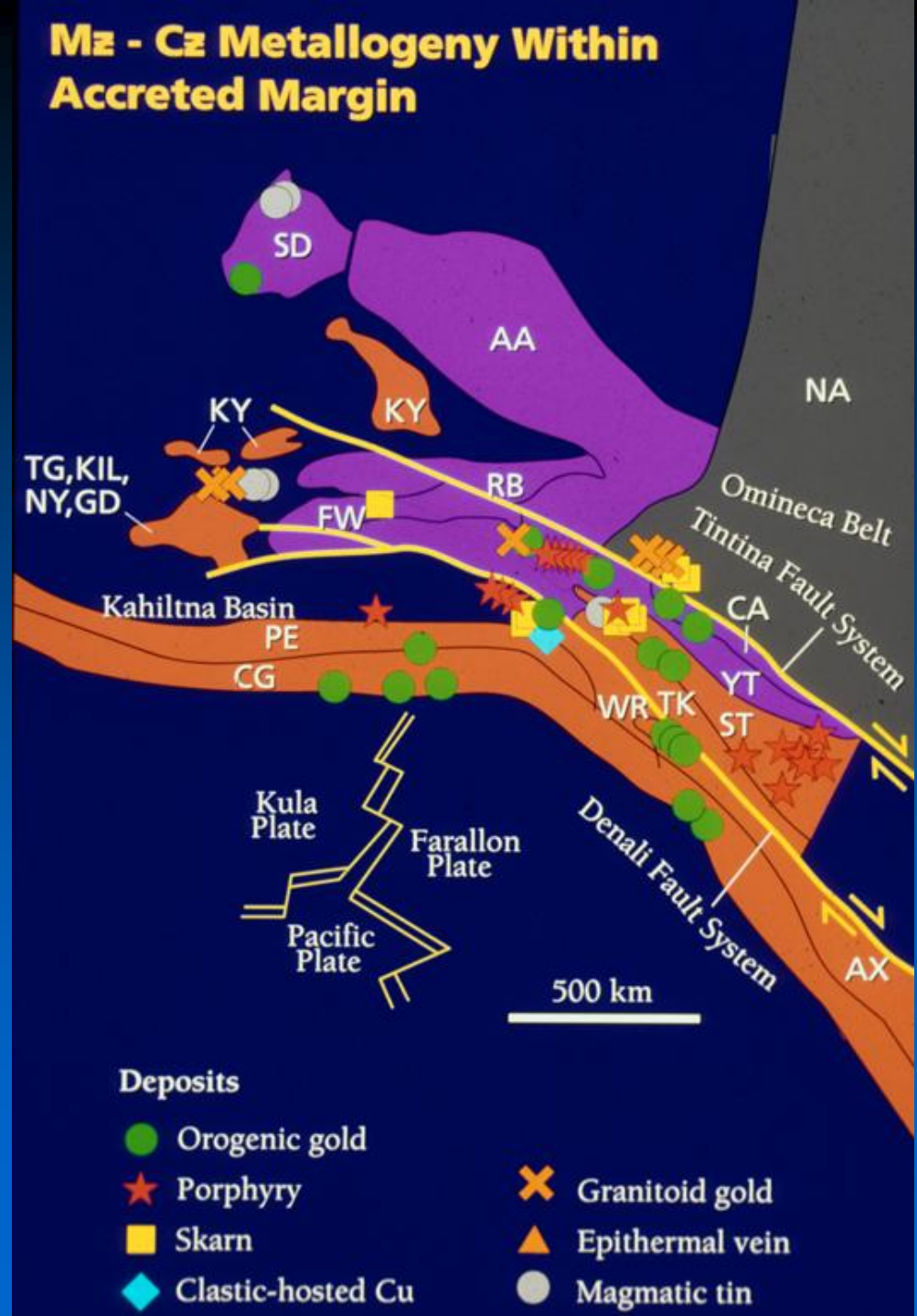


Paleozoic Orogenic Gold



1. Thomson fold belt
2. Lachlan fold belt
3. Westland, S. Island, N.Z.
4. Pataz
5. Ananea
6. Amayapampa
7. Sierra Pampeanas
8. Northern Kazakhstan
9. Altaids
10. Caldonides
11. Meguma
12. Carolina slate belt
13. Central Ural Mtns.
14. Bohemian Massif
15. Iberian Massif
16. Eastern Tian Shan
17. Western Tian Shan
18. Northern China Craton
19. Arabian-Nubian Shield
20. Hoggar Shield
21. Brasilia fold belt
22. Tefler
23. E. Sayan
24. Baikal

Numerous deposit styles juxtaposed in space



Intrusion-centered deposits: tectonic setting

CONTINENT

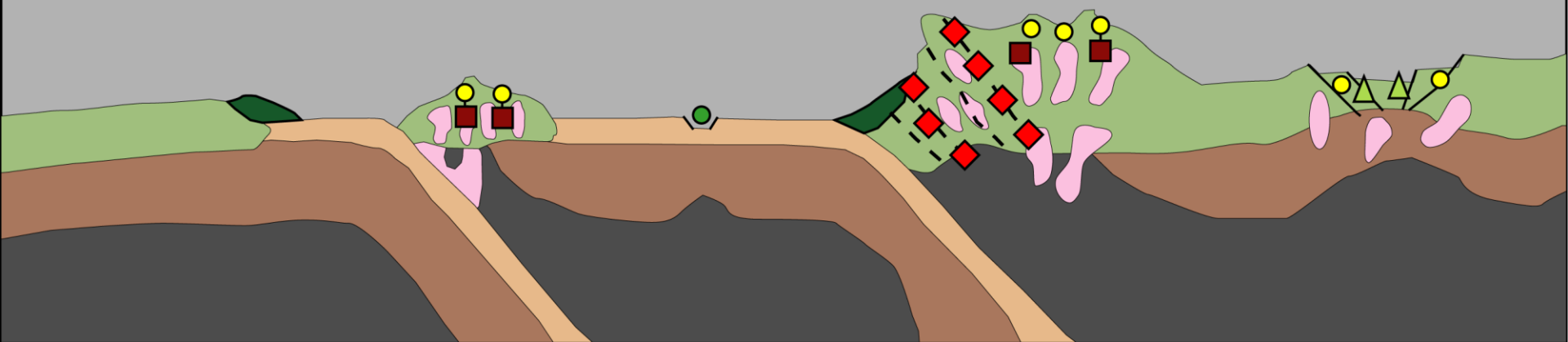
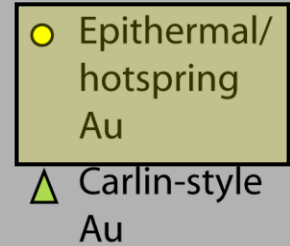
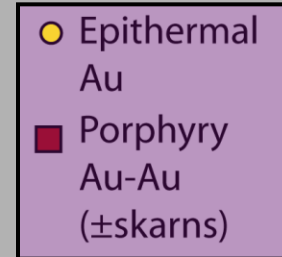
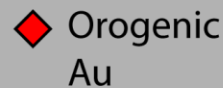
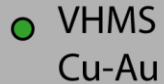
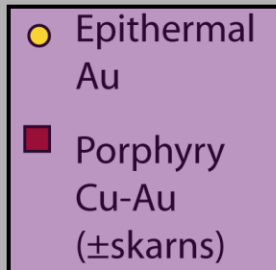
OCEANIC
RIDGE

BACK
ARC

ACCRETED
TERRANES

CONTINENTAL
ARC

BACK-ARC
EXTENSION



■ Accretionary wedge

■ Continental crust

■ Granitoids

■ Oceanic crust

■ Subcrustal lithosphere

■ Asthenosphere

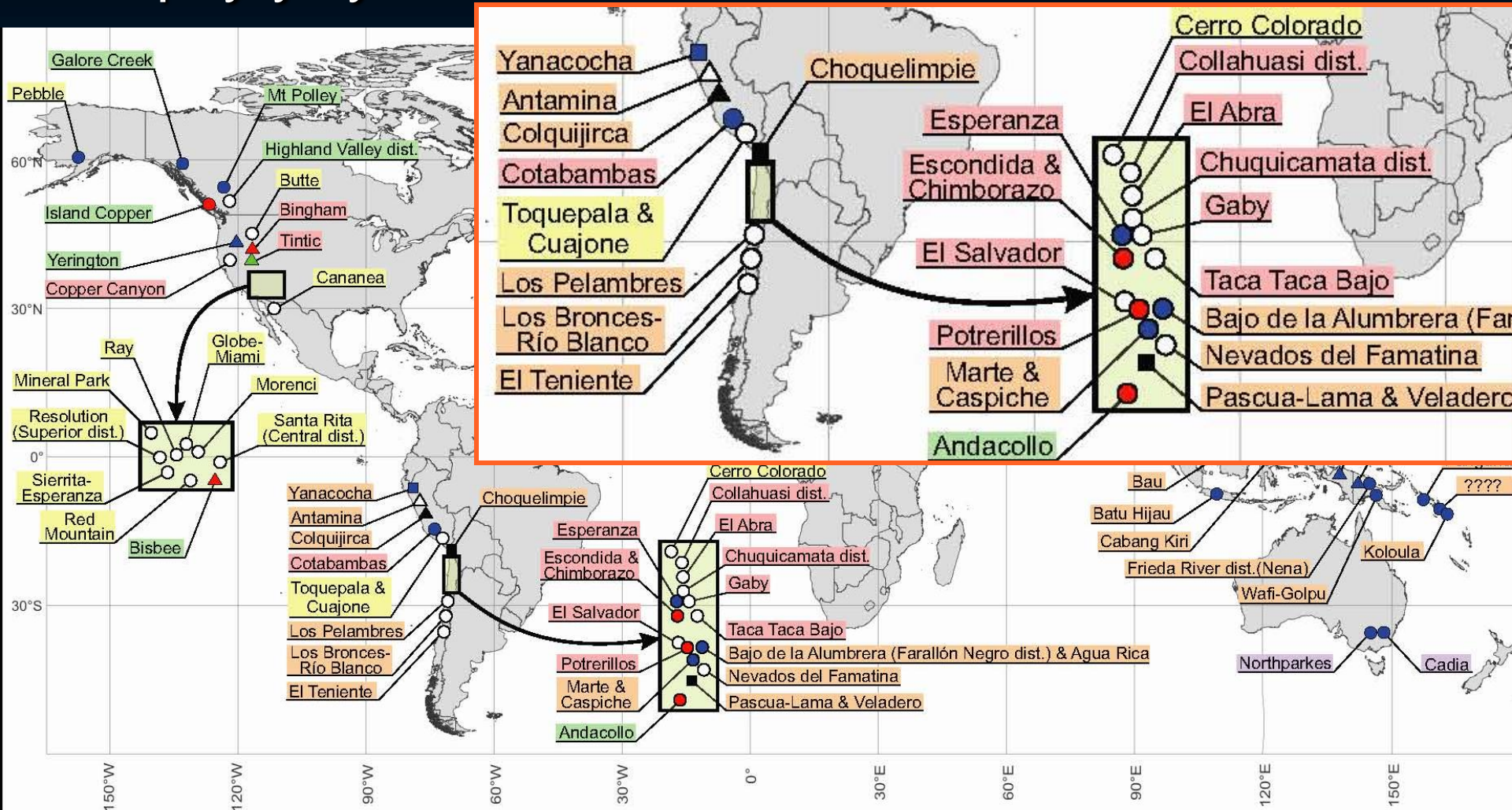
--- Compressional fault thrust

— Extensional fault

after R. Goldfarb, from Groves et al., 2005

Porphyry systems of the Americas

Sillitoe, 2010



Principal metals

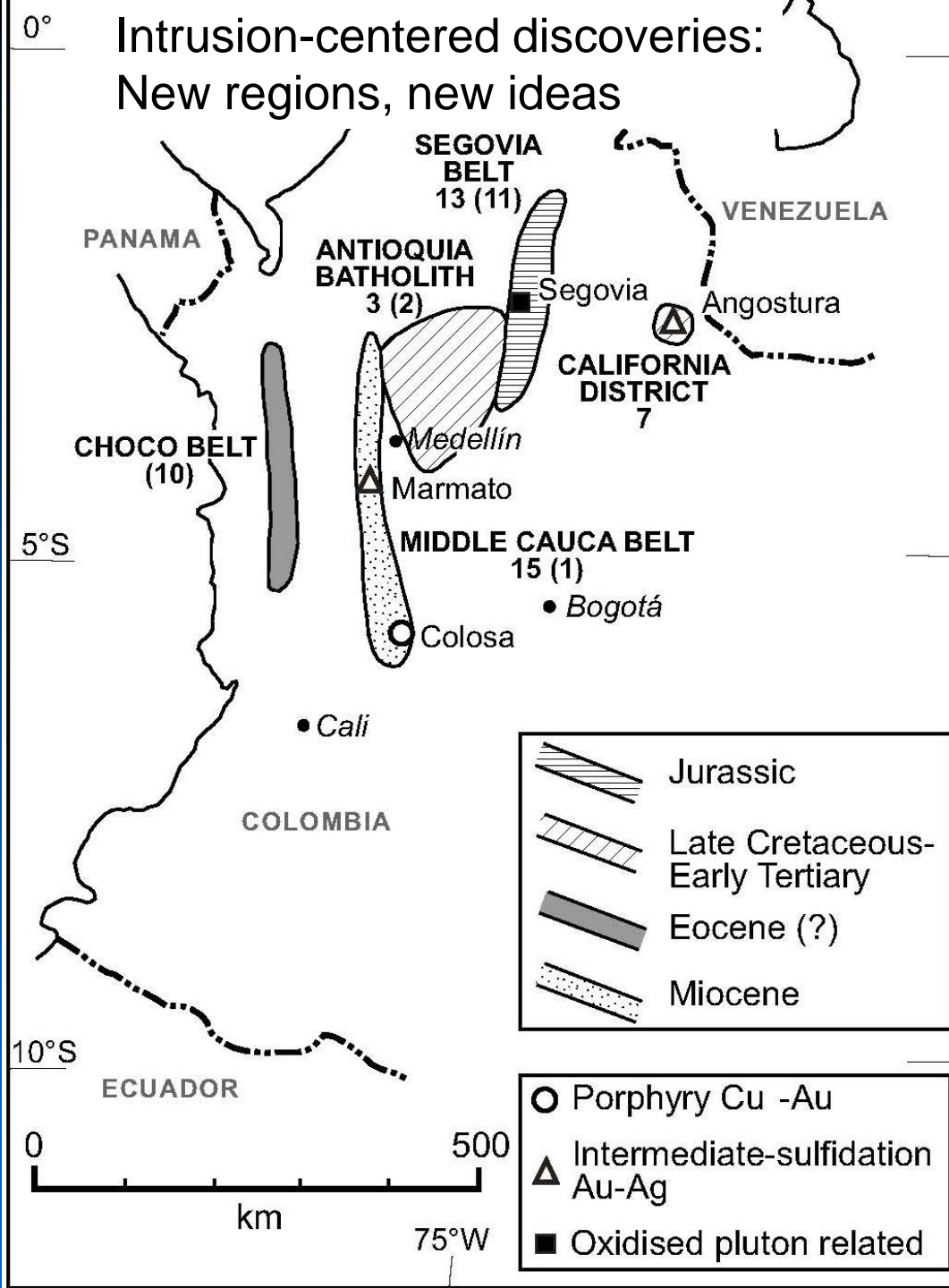
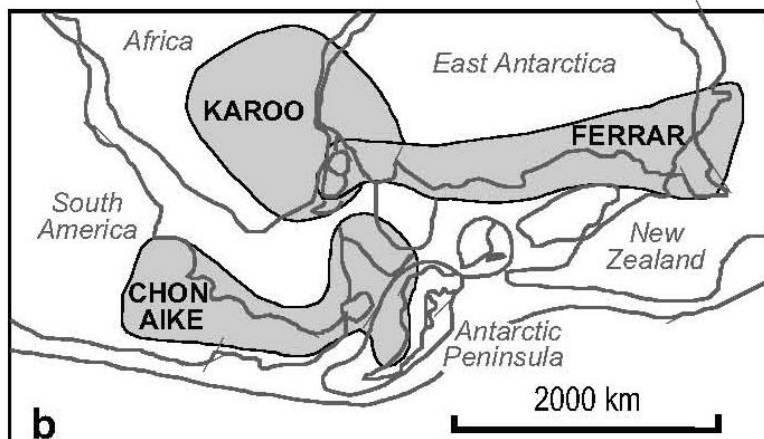
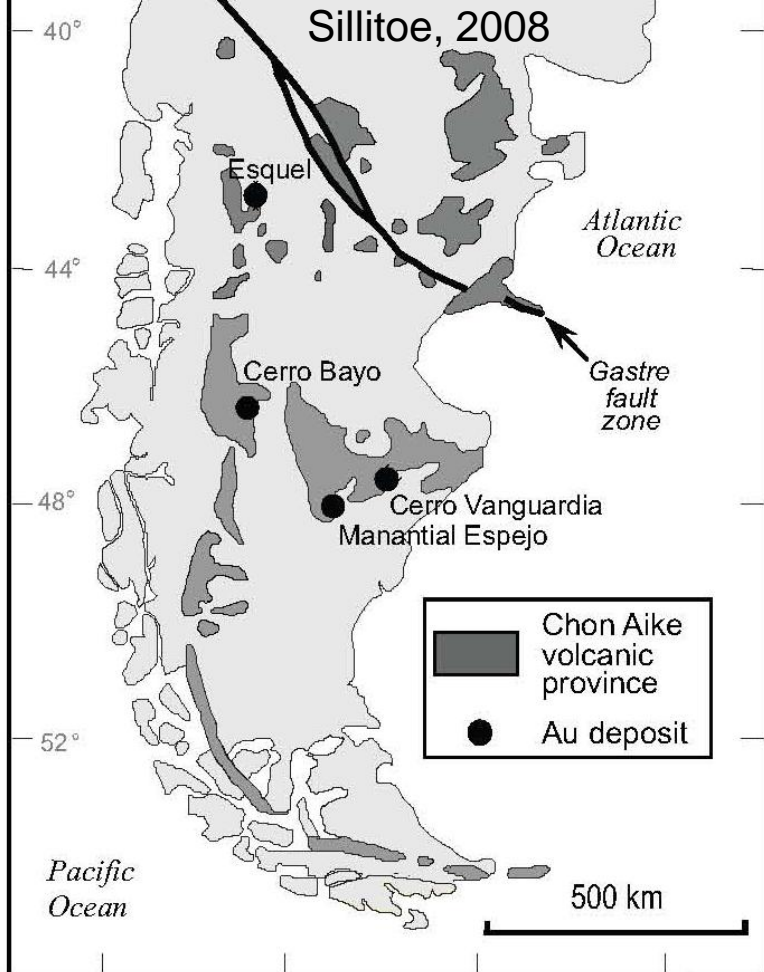
- Cu-Mo
- Cu-Mo-Au
- Cu-Au
- Ag-Pb-Zn-Cu

Deposit type

- Porphyry
- △ Porphyry + major skarn/
carbonate replacement
- High sulfidation
epithermal ± porphyry

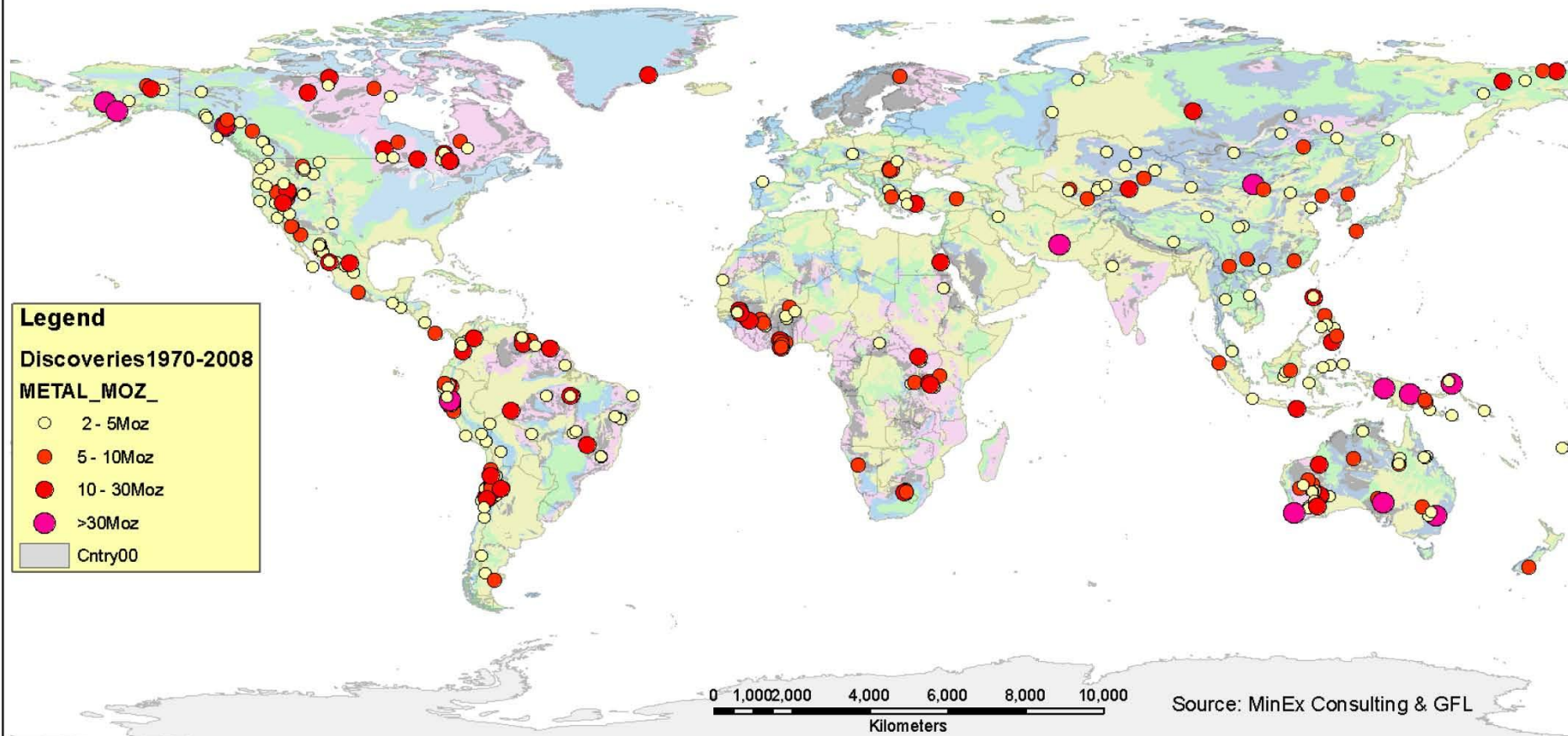
Age

- Pascua Miocene-Pleistocene
- Gaby Eocene-Oligocene
- Globe Late Cretaceous-Paleocene
- Bisbee Late Triassic-Early Cretaceous
- Oyu Tolgoi Late Devonian-Carboniferous
- Cadia Ordovician

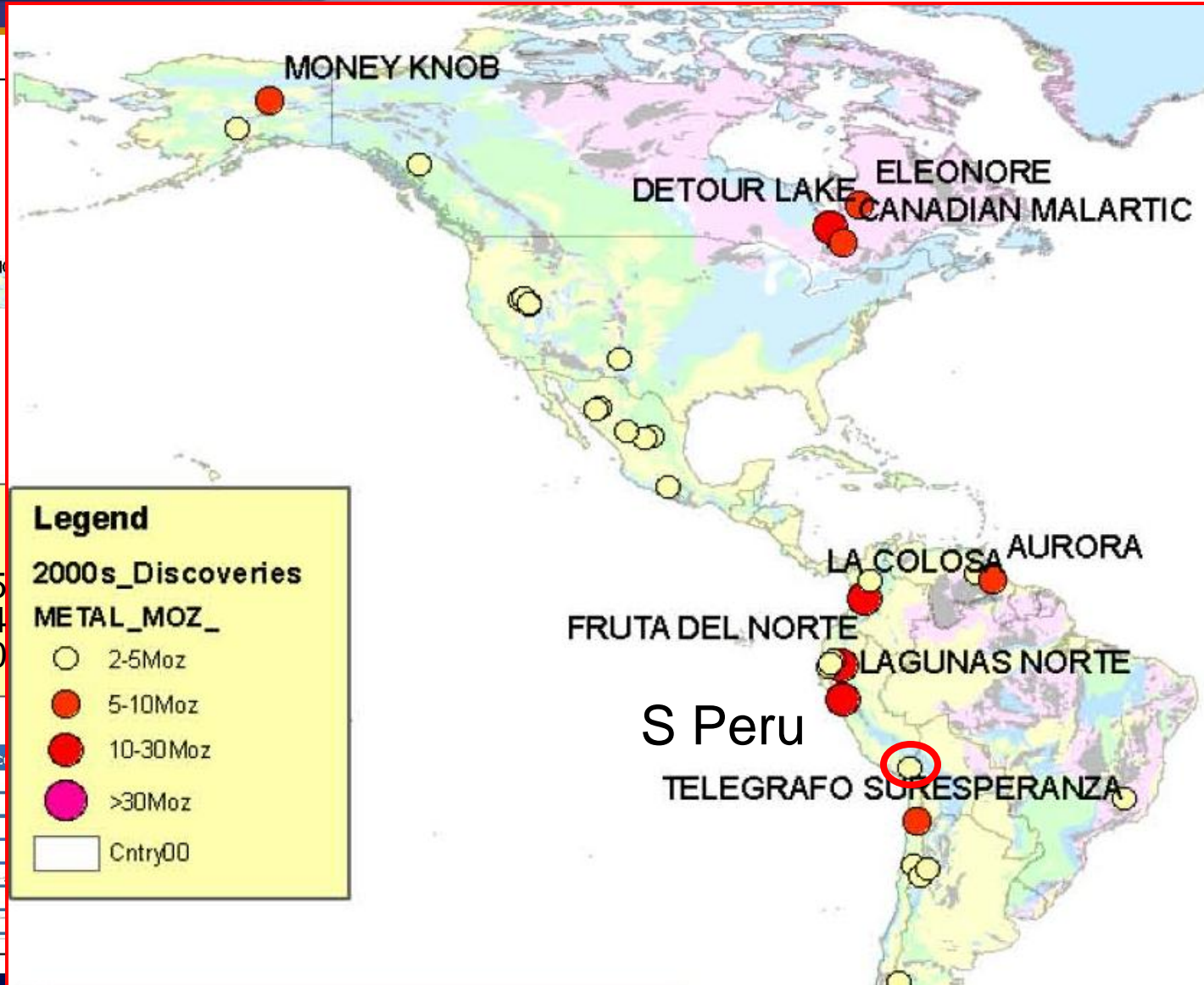




Gold discoveries by size for the period 1970 to 2008



Maps the known gold belts – but



Legend

2000s_Discoveries

METAL_MOZ_

○	2-5Moz	7,5
●	5-10Moz	5,4
●	10-30Moz	1,0
●	>30Moz	
□	Cntry00	

Region	Disc
Africa	
Asia	
Australia	
Europe	
Latin America	
North America	
SW Pacific	

Legend

2000s_Discoveries

METAL_MOZ_

○	2-5Moz
●	5-10Moz
●	10-30Moz
●	>30Moz
□	Cntry00



Traditional developed areas poorly represented

Late Miocene high-sulfidation epithermal gold deposits of the Aruntani district, southern Peru

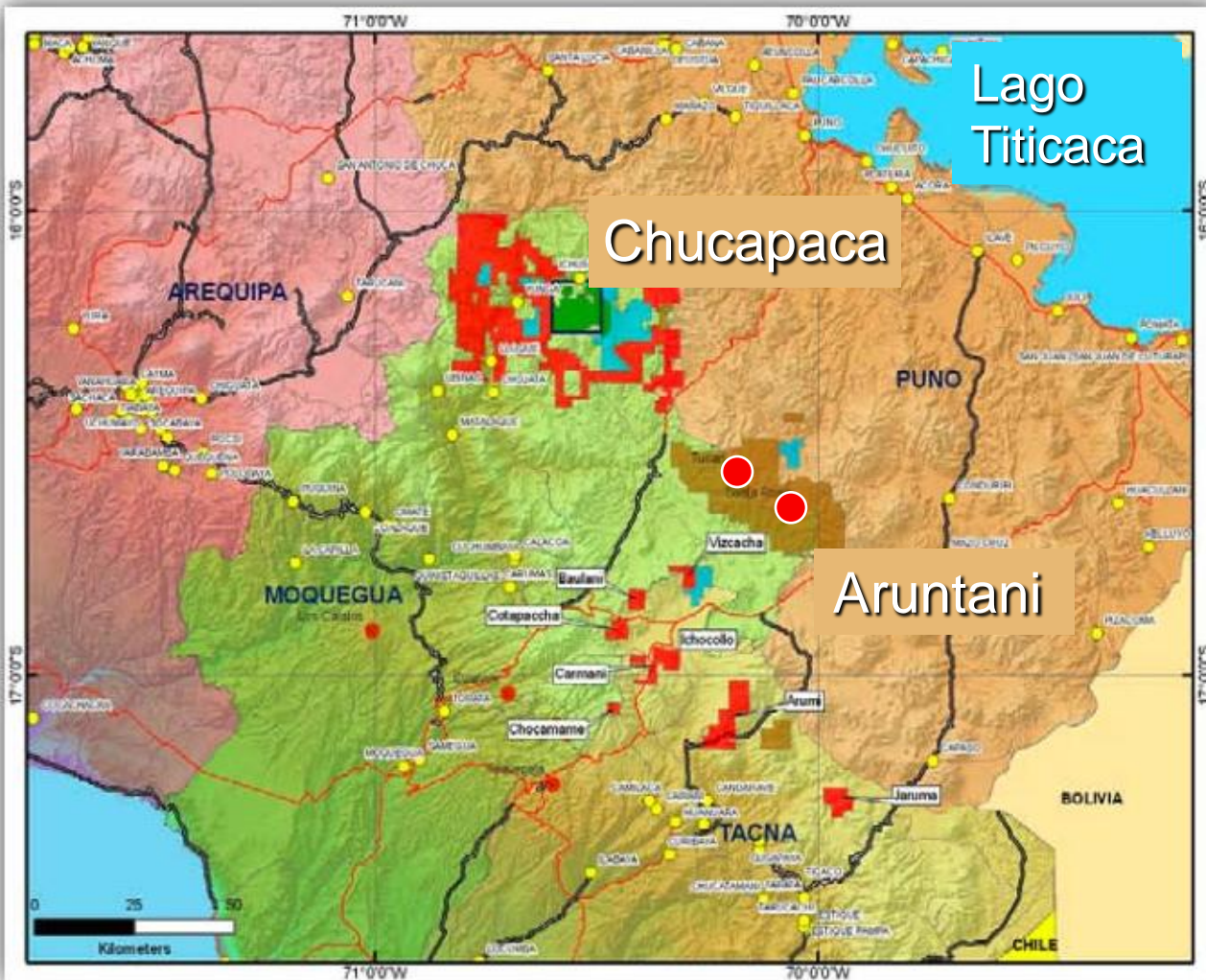
Recent discovery of a new ore type
in an abandoned mining district

Dante Loayza and Jorge Barreda (Aruntani SAC),
Alvaro Crósta, Wolfgang Morche, and Jeffrey Hedenquist

**Discovery of Santa Rosa (1997/2002, 0.4 Moz Au) led to Tucari (2000/2004, 2+ Moz)
Reawakened interest in region...**



Tucari, 2002: 5000 m

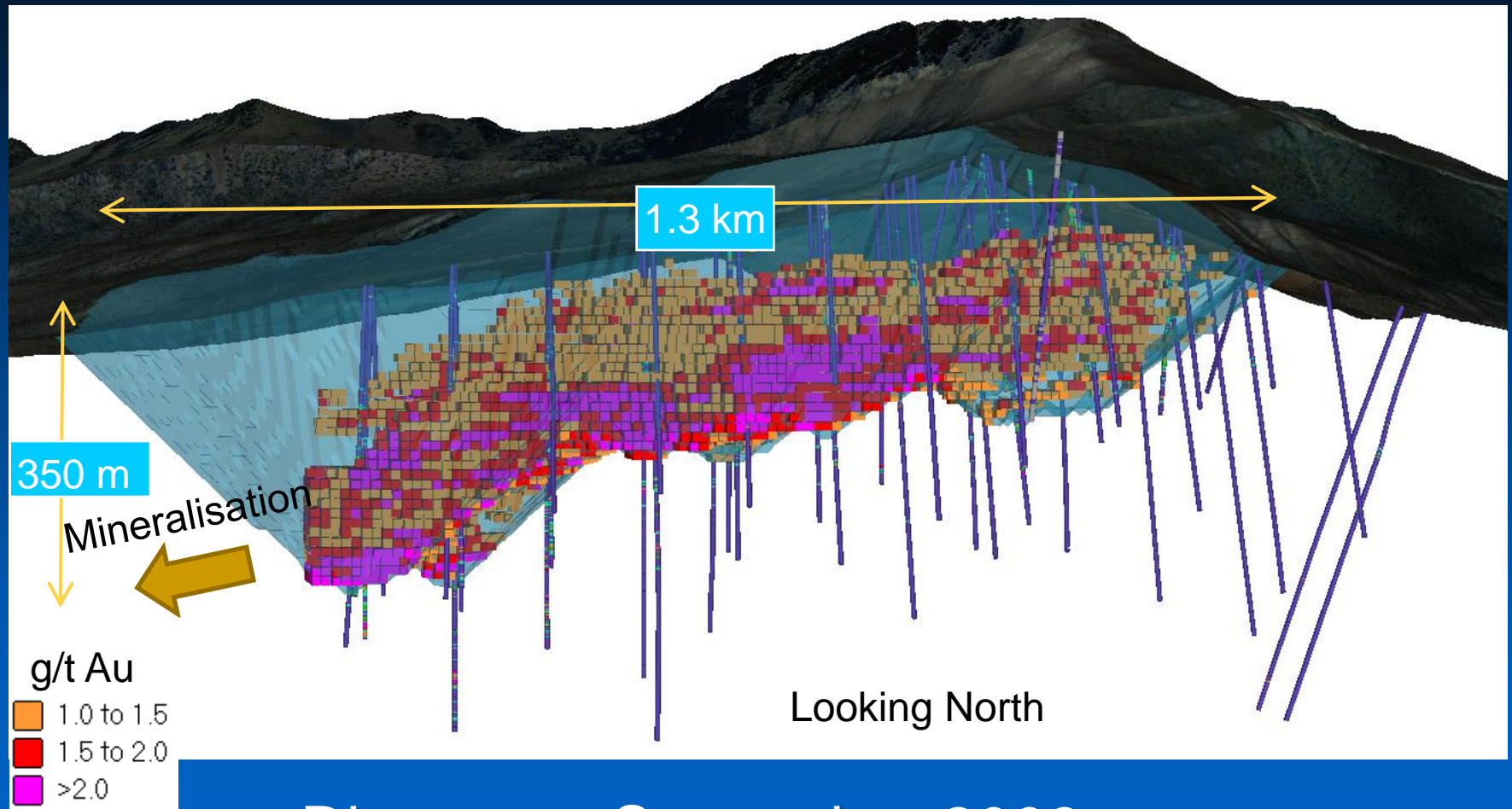


- MINING CONCESSIONS**
- Canteras del Hallazgo – 12,700Ha
 - Gold Fields – 94,100Ha
 - Buenaventura – 18,400Ha
 - Aruntani

- SYMBOLY**
- Main Road
 - Back Road
 - Dirt Road

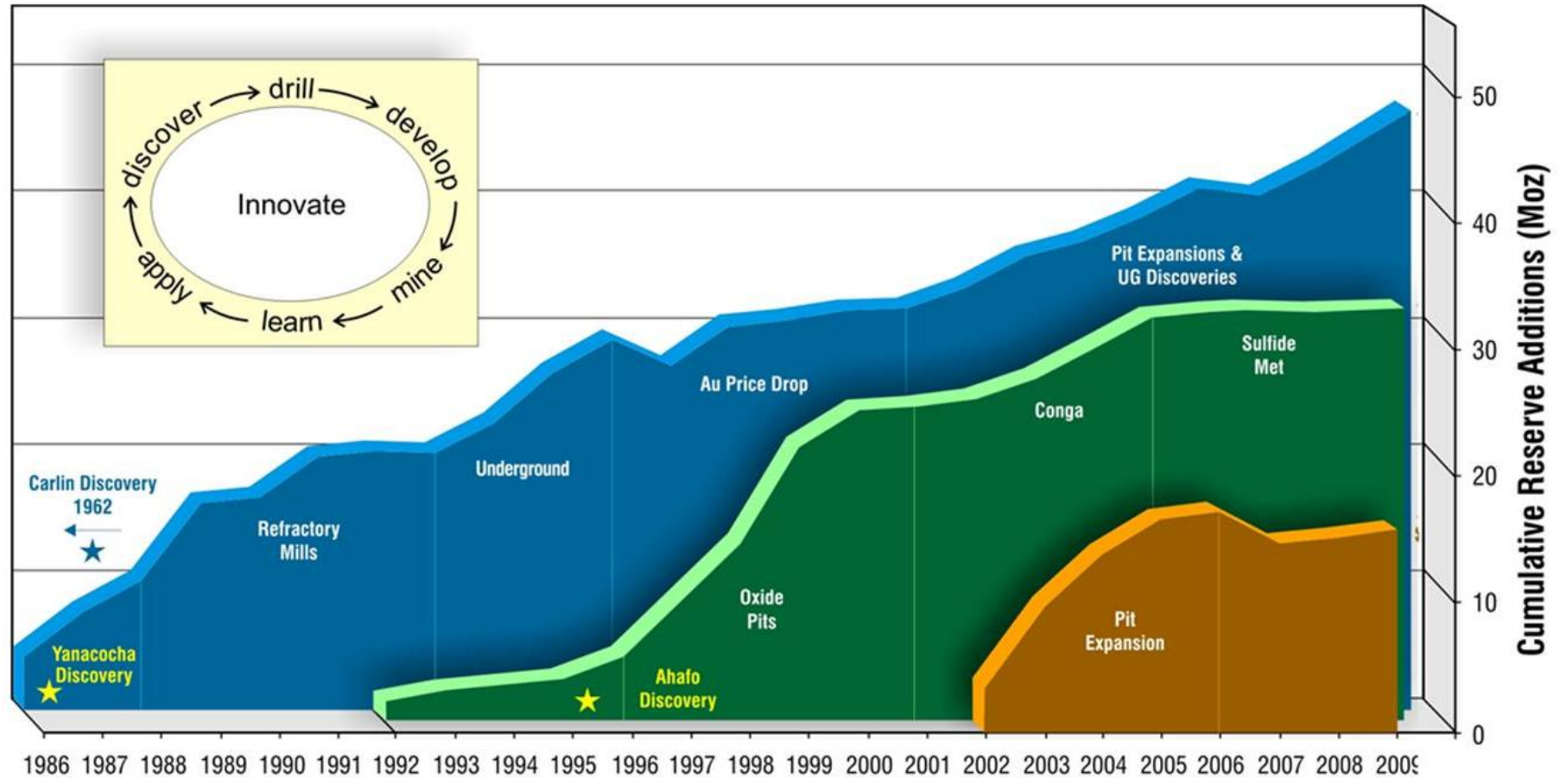
Gold Fields 51% (operator) and Buenaventura 49%

Canahuire resource model & pit shell: Chucapaca JV



- Discovery, September 2008
- Resource, May 2010: 5.8 Moz Au eq.

An experienced team and innovative culture results in the countinuous addition of reserves in world class districts (year-on-year, after production)



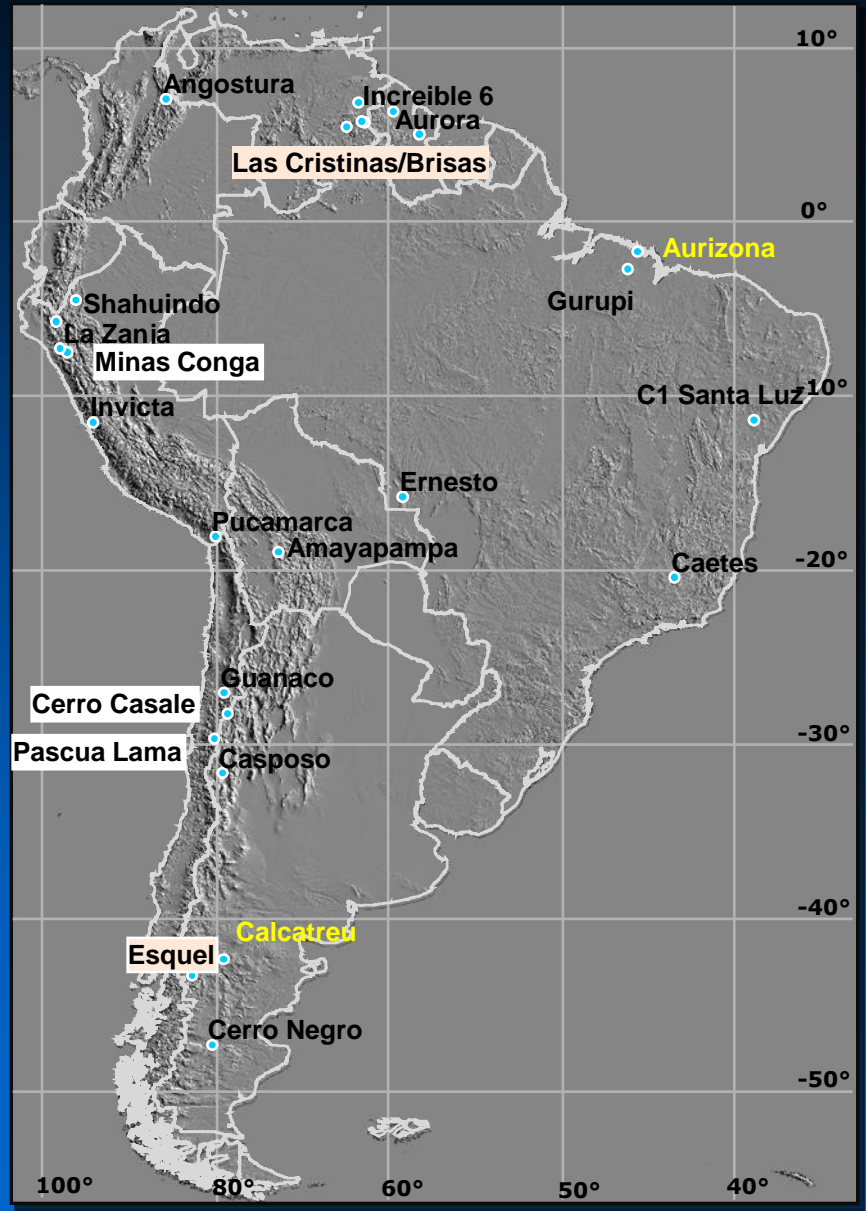
- Carlin Trend
- Yanacocha District
- Ghana

South America – Active Au projects

Feasibility and Pre-Production
Total resources >500,000 oz Au
(Source MEG)

Minas Conga: 700k oz/y, \$2.9 B
Pascua Lama: 775 k oz/y, \$2.95 B
Cerro Casale: 1,050 oz/y, \$4.2 B

Inactive projects:
Las Cristinas/Brisas, Esquel



South America – Au projects: target outline and resource development phase

26 Gold projects with total resources > 2 M oz Au (Source MEG)

Most recent discoveries:

La Colosa: 12.2 M oz @ 1.0 g/t Au

Condor (FdN): 11.8 M oz Au @ 9.1 g/t Au

Caspiche: 24.2 M oz Au @ 0.5 g/t Au+0.2% Cu

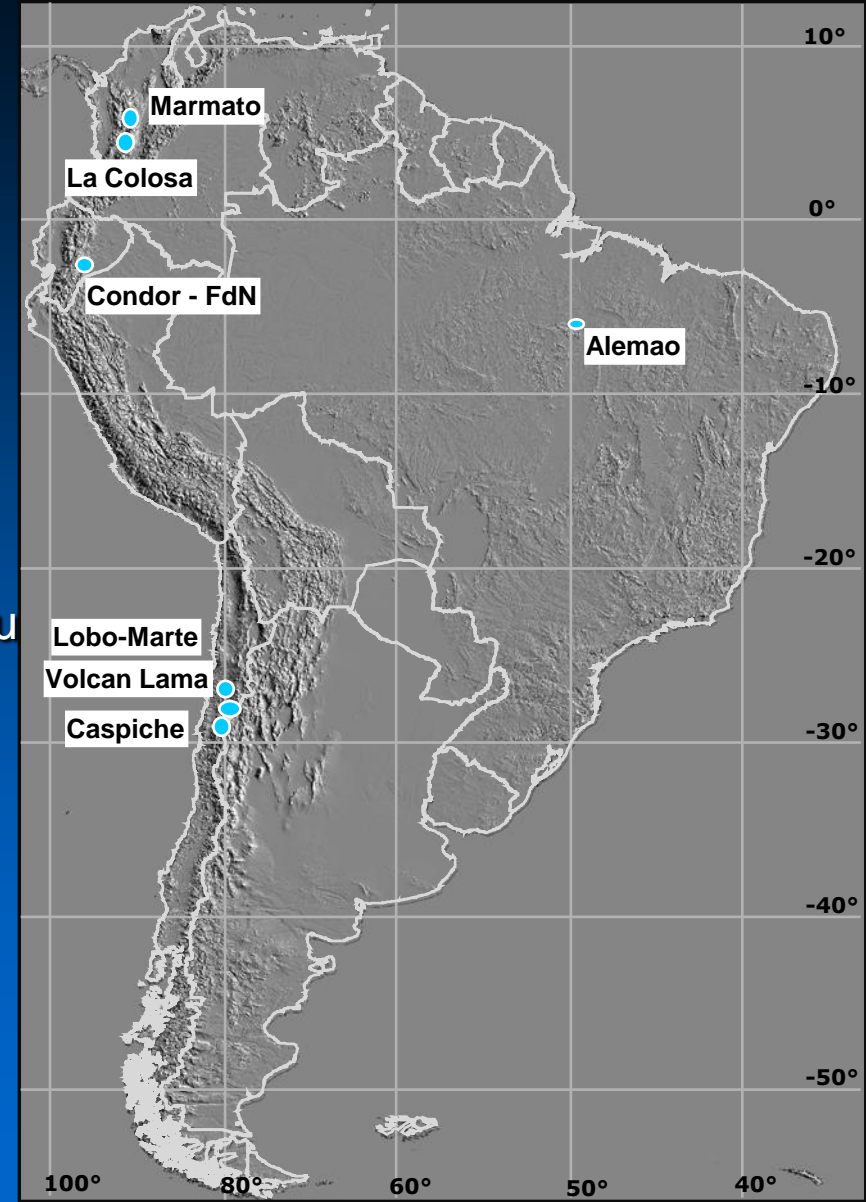
Other world class deposits:

Marmato: 9.7 Moz Au @ 0.96 g/t Au

Alemao: 4.4 Moz Au @ 0.86 g/t Au+ 1.3% Cu

Lobo-Marte: 6.5 Moz Au @ 1.1 g/t Au

Volcan: 11 Moz Au @ 0.9 g/t Au



Summary

- Gold deposits of American Cordillera
 - Strong endowment of many styles
 - Heterogeneous belts
 - Potential to define new belts
- Challenges: geological
 - New regions, more cover
- Opportunities
 - Deposits being found, lateral thinking

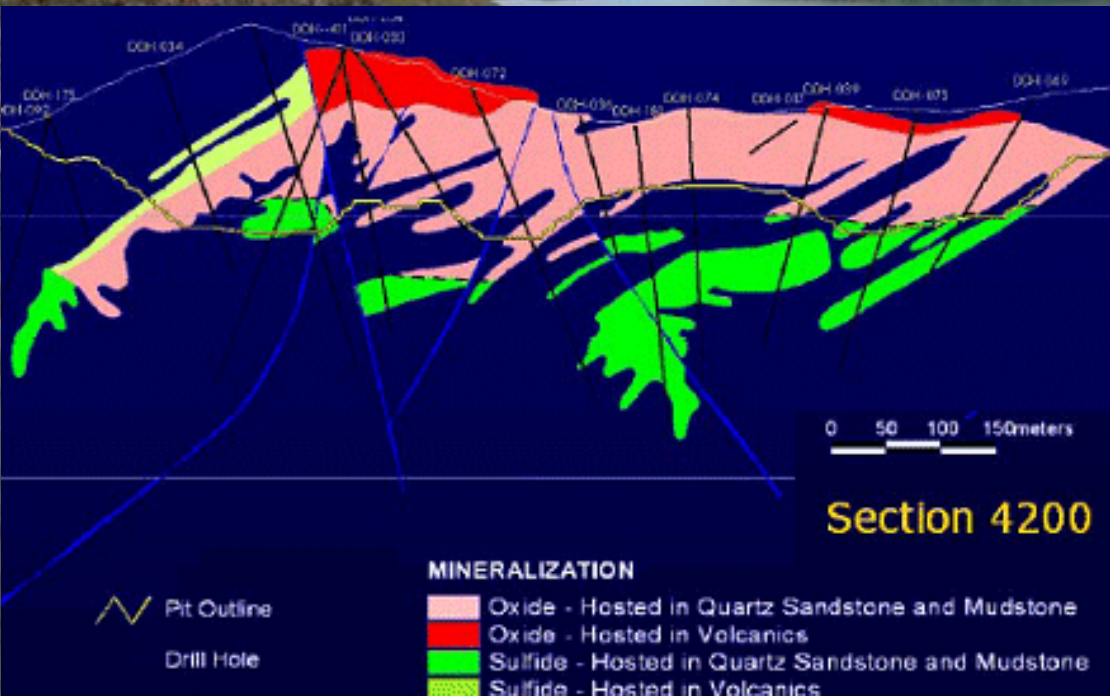
Alto Chicama, Peru

BLEG; 10.5 Moz resource, 2003

Lagunas Norte, 1.24 g/t Au, >206 Mt ox


Chimu quartzites

Calipuy volcanics




Mutual exclusivity of the MAJOR regions of gold and copper deposits of the Cordillera

Source(s) of heterogeneity?



QuickTime™ and a
decompressor
are needed to see this picture.



QuickTime™ and a
decompressor
are needed to see this picture.

- 
- >10 Moz Au in 22 belts, 5 giant deposits
 - <5% of Cordillera, 3/4 of 1000 Moz Au
 - 3 compressive belts, >40% of world's Cu

Grade (g/t Au)

