Controls on the Formation of Porphyry Copper and Gold Deposits

Massimo Chiaradia

Department of Earth Sciences, University of Geneva (Switzerland)

massimo.chiaradia@unige.ch

http://www.unige.ch/sciences/terre/
Cu-rich versus Au-rich porphyries

Cu-rich $\rightarrow$ calc-alkaline, thick crust, syn-subduction setting (Andean-type)

Au-rich $\rightarrow$ alkaline to cal-alkaline, thinner crust (island to transitional arcs), post-subduction to extension, but also calc-alkaline, thick crust, syn-subduction setting (Andean-type)

Cu-rich versus Au-rich porphyries

Chiaradia (2020) Gold endowments of porphyry deposits controlled by precipitation efficiency
Nature Communications 11:248 |
https://doi.org/10.1038/s41467-019-14113-1
Cu endowment in Cu-rich versus Au-rich porphyries

Same Cu endowment controls in Cu-rich as in Au-rich porphyries (magma volume & ore process duration) → the difference concerns Au!

Chiaradia (2020) Gold endowments of porphyry deposits controlled by precipitation efficiency Nature Communications 11:248 | https://doi.org/10.1038/s41467-019-14113-1
Cu-rich versus Au-rich porphyries: a petrogenetic control?

- Higher Au contents in alkaline than calc-alkaline magmas? (e.g., Rock and Groves, 1988)

- Higher fluid-melt $\text{AuK}_D$ values in alkaline than in calc-alkaline magmas?

- Higher Au precipitation efficiency in alkaline than in calc-alkaline systems?

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Higher Au contents in alkaline magmas?

**calc-alkaline systems**

Maximum gold endowment in Au-rich porphyry deposits

**alkaline systems**

Maximum gold endowment in Au-rich porphyry deposits

**Chiaradia (2020)**

* Nat. Comm.

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**Figure c**

Exsolvable Au (tons, 50% efficiency)

- N = 1583
- Mean: 14300
- Median: 14350
- 10% percentile: 10800
- 90% percentile: 17800

**Figure d**

Exsolvable Au (tons, 50% efficiency)

- N = 984
- Mean: 31500
- Median: 30500
- 10% percentile: 17000
- 90% percentile: 49000

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Cu-rich versus Au-rich porphyries: a petrogenetic control?

• Higher Au contents in alkaline than calc-alkaline magmas? (e.g., Rock and Groves, 1988)

• Different fluid-melt $^{\text{Au}}K_D$ values in alkaline and calc-alkaline magmas?

• Higher precipitation efficiency in alkaline than in calc-alkaline systems?
Different fluid-melt $^{\text{Au}}K_D$ values in alkaline and calc-alkaline systems?

$K_D^{\text{Cu}} = 2 - 100$

$K_D^{\text{Au}} = 10 - 100$

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Different fluid-melt $^{\text{Au}}K_D$ values in alkaline and calc-alkaline systems?

Alkaline magmas $K_D^{\text{Au}}$ fluid melt = 10-100

Calc-alkaline magmas $K_D^{\text{Au}}$ fluid melt = 10-100

$K_D^{\text{Cu}} = 2-100$

$K_D^{\text{Au}} = 10-100$

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Cu versus Au precipitation efficiency

Au precipitation efficiency ~15 times better in Au-rich than in Cu-rich porphyry systems (in both cases Au precipitation efficiency is less than for Cu)

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Cu versus Au precipitation efficiency: depth control?

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A tectonic control?

Chiaradia (2020) Gold endowments of porphyry deposits controlled by precipitation efficiency Nature Communications 11:248 | https://doi.org/10.1038/s41467-019-14113-1

Chiaradia (2015) Crustal thickness control on Sr/Y signatures of recent arc magmas: an Earth scale perspective. Scientific Reports 5 : 8115 | DOI: 10.1038/srep08115

Increasing crustal thickness

![Graph showing correlation between crust thickness and Sr/Y ratio across different regions.](image)
## Cu-rich versus Au-rich porphyries

### Cu-rich porphyry deposits
- Build-up of large magmatic systems (1000-2000 km$^3$) at high pressure (>0.4 Gpa) and for long time (>2.5-3 Ma)
- Favoured by long-lasting compression during subduction in thick continental arcs
- Transfer of magma to upper crustal levels during timescales of ore-forming processes
- Multistage mineralization (0.0x-≤2 Ma): longer time = higher Cu tonnage

### Au-rich porphyry deposits
- Increased Au precipitation efficiency $\rightarrow$ shallow depth and higher stability of gold complexes in magmatic fluids associated with alkaline rocks
- Favorable geodynamic setting (post-subduction, extension, island arcs $\rightarrow$ shallow depth)
- Multistage mineralization (0.0x-≤1 Ma): longer time = higher Au tonnage