The "boring billion":
What's about Proterozoic porphyry copper deposits?

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Université de Lorraine
GeoRessources
NANCY, FRANCE
Precambrian porphyry deposits

25 largest porphyry copper-molybdenum deposits... Precambrian
Secular distribution of porphyry deposits
Scarcity of Proterozoic porphyry deposits

1. Meso- to Neoproterozoic
   - the Boring billion

2. Paleoproterozoic porphyry deposits
   - Gaoua district, West African Craton

Goldfarb et al. 2010
Most of the porphyry deposits formed in the upper few kilometers of crust, in tectonically active environments and at plate boundaries.

Richards, 2013

Secular distribution of porphyry deposits
Meso- to Neoproterozoic: the Boring billion

 الحقوق غير متساوية
Secular distribution of porphyry deposits
Meso- to Neoproterozoic: the Boring billion

- OROGENIC GOLD

- uneven preservation
  - Plate motions
    - the supercontinent cycle,
    - the tectonic settings,
    - the depth of formation.

Goldfarb et al. 2010
Secular distribution of porphyry deposits
Meso- to Neoproterozoic: the Boring billion

 saldo-term secular changes in the Earth System.

Modern-Style plate tectonics
Secular distribution of porphyry deposits
Meso- to Neoproterozoic: the Boring billion

- long-term secular changes in the Earth System.
- Mantle depletion rate
  dramatic reductions or temporary cessations of subduction
Secular distribution of porphyry deposits
Meso- to Neoproterozoic: the Boring billion

long-term secular changes in the Earth System.

⇒ Geochemical features

Magmatic-hydrothermal processes within an evolving Earth: Iron oxide-copper-gold and porphyry Cu ± Mo ± Au deposits

Jeremy P. Richards* and A. Hamid Mumim**
*Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada
**Department of Geology, Brandon University, 270 18th Street, Brandon, Manitoba R7A 6A9, Canada

Richards and Mumim, 2013
Secular distribution of porphyry deposits
Paleoproterozoic porphyry deposits

Intergent Plate Tectonics?
Paul G. Silver, et al.
Science 319, 85 (2008);
DOI: 10.1126/science.1148397

Convergent margins

<table>
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<th>Ore type</th>
<th>3 Ga</th>
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<td>Orogenic gold</td>
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<td>Paleoplacer and placer gold</td>
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<td>Porphyry copper</td>
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Goldfarb et al. 2010
Secular distribution of porphyry deposits

Paleoproterozoic in Earth evolution

Reddy and Evans, 2009
Paleoproterozoic porphyry deposits

India: 2.5 Ga

Sinclair, 2007
Paleoproterozoic porphyry deposits
The Fennoscandian shield: 1.8-1.9 Ga

Metallogeny and tectonic evolution of the Early Proterozoic
Skellefte district, northern Sweden

P. Weihe, J. Bergman and U. Bergström

Sinclair, 2007
Paleoproterozoic porphyry deposits
The West African craton: 2.16 Ga

Sinclair, 2007
Paleoproterozoic porphyry deposits

The Gaoua district

- SW Burkina Faso
- Boromo-Goren greenstone belt

Le Mignot et al., 2017
The Gaoua district

Volta Resources, now B2Gold

🌟 Copper-gold porphyry occurrences
🌟 Gold-only occurrences

22 Mt at 0.29% Cu and 0.33 g/t Au

Total resource estimate:
Gold: 98.6 t inferred and 7.5 t indicated
Copper: 912,000 t inferred and 64,000 t indicated copper resources

(SRK Consulting Ltd., 2013).

Le Mignot et al., 2017
Paleoproterozoic porphyry deposits
The Gaoua district

- Paleoproterozoic porphyry deposits
- Gaoua district
- Nb/Th, Zr/Nb ratios
- ARC, N-MORB, Oceanic Plateau basalts
- Diorite, Andesite, basalt-andesite
- Cu% (> 0.3)
- Hydrothermal breccia
- Base of oxydation
Paleoproterozoic porphyry deposits
The Gaoua district

Brecciated diorite with triangular cavities composed of Cp1
Paleoproterozoic porphyry deposits
The Gaoua district

Brecciated diorite with triangular cavities composed of Cp1

Reworked mineralized breccia affected by D1
Paleoproterozoic porphyry deposits
The Gaoua district

Brecciated diorite with triangular cavities composed of Cp1

Reworked mineralized breccia affected by D1

D1 shear band with carbonate alteration halo
Paleoproterozoic porphyry deposits
The Gaoua district

Late oblique D2Ga shear bands crosscutting the altered diorite

Brecciated diorite with triangular cavities composed of Cp1

Reworked mineralized breccia affected by D1

D1 shear band with carbonate alteration halo

2.48 g/t Au and low Cu
Paleoproterozoic porphyry deposits
The Gaoua district

<table>
<thead>
<tr>
<th>Host rock</th>
<th>Porphyry Cu</th>
<th>S1-Shearzone</th>
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<tr>
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<td>Plagioclase</td>
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<td>K-Feldspar</td>
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<td>Tellurides of Au, Ag, Pb and Hg</td>
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<td>Fluoro-apatite</td>
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STAGE 1: PORPHYRY

STAGE 2: LODE-GOLD EVENT

Le Mignot et al., 2017
Paleoproterozoic porphyry deposits
The Gaoua district

Stage 1: Porphyry

Re-Os age 2164±25
MSWD=1.3

Le Mignot et al. 2017
Paleoproterozoic porphyry deposits
The Gaoua district

Gold solubility limit

Porphyry deposits

Orogenic deposits

LA-ICP-MS spectra

Ni, Cu, Au, Pb, Sb

Le Mignot et al. 2017
Superposition of Orogenic Gold on a Porphyry Occurrence
Paleoproterozoic porphyry deposits
The Gaoua district

Correlation between:
1. the Boromo-West greenstone belt stratigraphy,
2. SW Burkina Faso geodynamic environment,
3. deformation history.
Proterozoic porphyry deposits

Take home message

✓ Share the same features of Phanerozoic porphyry deposits
  lower grade, lower tonnage, scarcity of alteration

✓ Scarcity during Paleoproterozoic times, absent during Meso to Neo-Proterozoic,

✓ Primary features often obscured by later mineralization event(s)
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