

Cenozoic Magmatism, and Copper Deposits in Chile

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Fig. 1 The Disputada pit at the Rio Blanco-Los Bronces porphyry copper deposit.

Porphyry Copper in Chile:

- Largest concentration in the world.
- 400 million tons present in 50 porphyry deposits
- 9 of the 16 giant (>10 million tons) porphyries are in Chile.
- 3 of the largest (El Teniente, Rio Blanco-Los Bronces and Chuquibambilla) with > 50 million tons in deposits.
- Annual production 4.6 million tons representing 37% of world production.

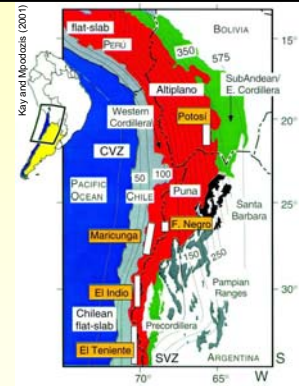


Fig 2. Contours showing Benioff zone of subducting Nazca plate. Regions >3000m (SVZ & CVZ) in red and foreland fold-thrust belt (Sub-Andean/E. Cordillera) in green.

Copper in Chile is the form of Porphyry deposits.

What is a porphyry copper deposit?

A large, low-grade stockwork to disseminated deposit of copper which may also contain minor molybdenum, gold, and silver, commonly in a granitic host rock.



Fig. 3 Chalcocite (copper ore) with Covellite and Pyrite from Butte, Montana. Most common ore is Chalcopyrite.

Porphyry Copper Deposits of North and Central Chile

- *Porphyry deposits of copper classified as:* Cu, Cu-Mo, and gold rich
- Time span of porphyry deposit: Early Cretaceous to Pliocene.
- Time span with most deposits: Eocene to Oligocene (54.8 to 23.8 mya).
- 90% of Andean copper emplaced in the Cenozoic.

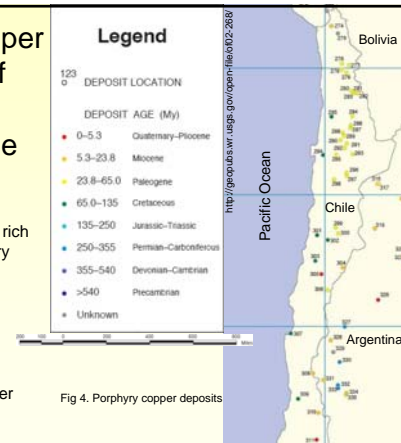


Fig 4. Porphyry copper deposits

Magmatism

- Nazca subducting under South American plate.
- Causing magmatism and crustal shortening.
- Copper deposits in extinct volcanic belts underlain by thickened continental crust (50-70 km).
- Fold & thrust belt forms in the east – Eastern Cordillera
- Initially steeper - starts to shallow at 25mya.

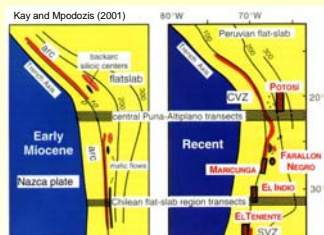


Fig. 5 Depth changes in Benioff zone. Red line is for arc volcanic front. Mafic and silicic backarc centers are also shown.

Magmatism Cont.

- Reasons for Nazca plate flattening:
 - Increase in convergence rate – b/w 25-5 mya rate was 14cm/yr.
 - Younger & warmer Nazca had greater buoyancy.
 - Extended subduction leads to flattening (subduction present for 200 my).
 - Subduction of hotspots (Juan Fernandez & Easter-Nazca).

Magmatism Cont.

- In Chile the angle is approx. 30° and in north and south subduction is steeper.
- Result - magmatism moves east. Erupted volumes decrease towards east.
- Magmatism goes from mafic/silicic to andesitic to dacitic.
- Andesitic volcanism ends by 9 mya and by 5 mya magmatism ends in Chile.

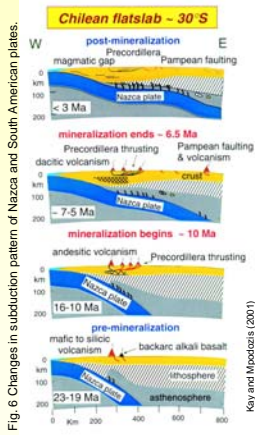


Fig. 6 Changes in subduction pattern of Nazca and South American plates.

Key and Moore (2001)

Mineralization

- Hypogene copper mineralization (caused by ascending hydrothermal solutions associated with magmatism).
- Mineralization accounts for porphyry deposits.
- As many as 9 different epochs of mineralization in Chile.
- Moving east – mineralization belts become younger (early Cretaceous to early Pliocene).

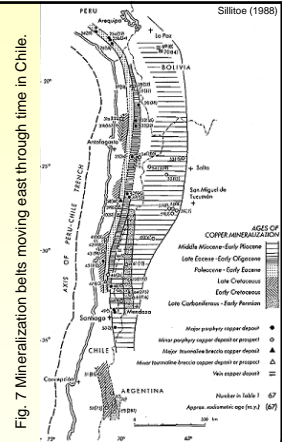


Fig. 7 Mineralization belts moving east through time in Chile.

Sillitoe (1988)

Mineralization Cont.

- In Chile mineralization occurs predominantly due to andesitic volcanism (Farellones Formation).
- Occurs in magmatic-hydrothermal breccia as well as fault related breccia and fractures.
- Mineralization also occurs in sedimentary deposits.
- A body can be enriched multiple times accounting for very rich and economically viable deposits in Chile.
- Mineralized copper is either in the form of oxides (malachite) and sulfides (Chalcopyrite).



Fig. 8 Toquepala Copper Mine, Southern Peru

Analogue to North America

- Laramide Orogeny
 - Andean type continental margin.
 - Copper in plutons (Arizona) from magmatic arc.
 - Colorado mineral belt – no copper and due to local magmatism.
- Cenozoic Volcanism
 - Challis Magmatic Belt - Idaho/Montana
 - Copper in veins
 - Tuscorora Magmatic Belt (43-37 mya) – Nevada and Utah
 - Porphyry copper deposits

Porphyry Copper Deposits in Arizona “Copper Belt”

Fig. 9 Porphyry copper deposits in Arizona.

<http://geopubs.wr.usgs.gov/open-file/of02-268/>

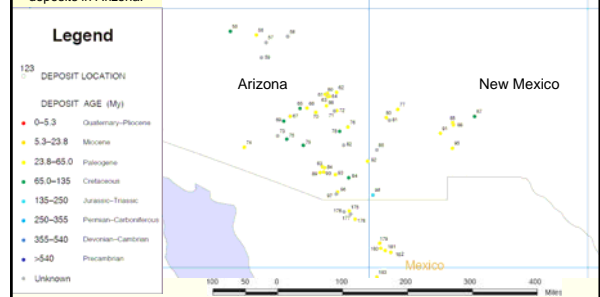




Fig. 10 Bingham Copper Mine in the Oquirrh Mountains, southwest of Salt Lake City, UT. This porphyry mass intrudes Pennsylvanian sediments; the ore contains about 1% copper. Photo taken in 1966.

References

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Questions?



Fig. 11 Chalcocite associated with quartz.