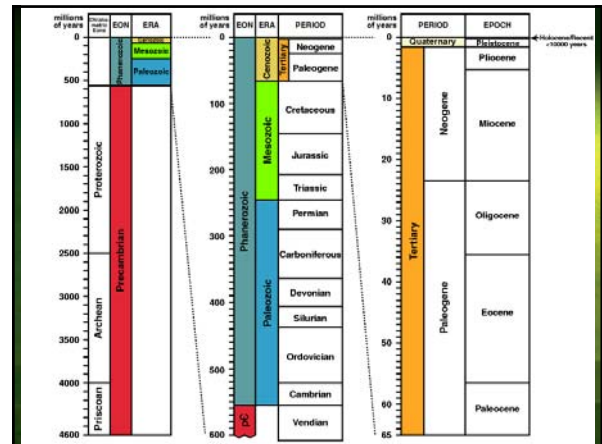


Cenozoic Magmatism and Mineral Deposits: Peru

Sarah Black
Jay Zambito
Chaudhry Ahmed



Cenozoic Tectonic Setting



http://www.ucmp.berkeley.edu/geology/tecall1_4.mov

Early Cenozoic

K/T Boundary 66 Ma



<http://www.scotese.com/>

Overview

- Notable deposits:
 - Peru: Gold and Silver
 - Chile: Copper
 - Bolivia Mineral Belt
- What types of magmatism/tectonic settings helped to create these mineral deposits?



Cenozoic Cordilleras

- Two main cordilleras
 - Occidental (west)
 - Oriental (east)
- Main volcanic activity today is located in Cordillera Occidental

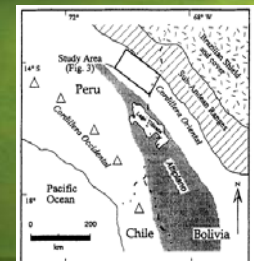
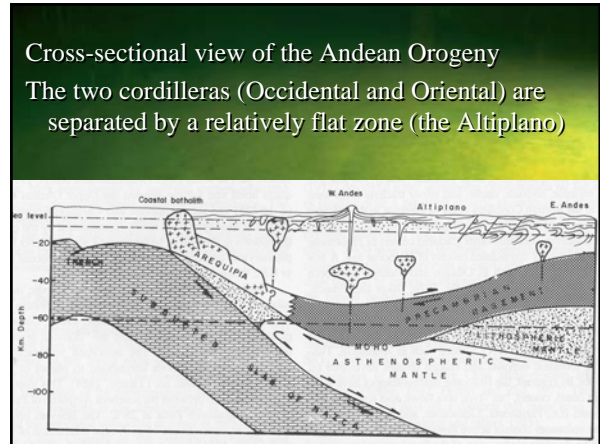
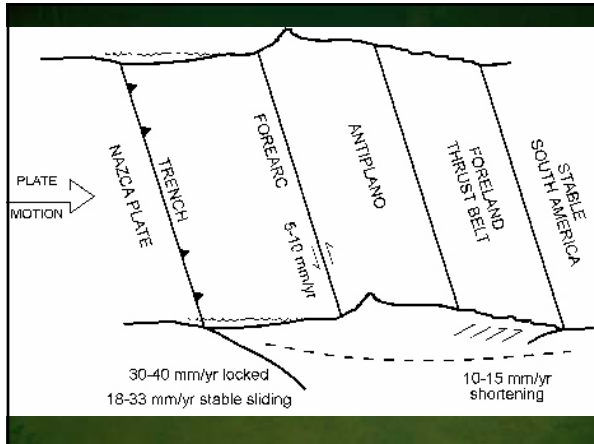


Figure 1: Index map showing major physiographic/tectonic provinces of the Central Andes and the location of the study-area (Fig. 3) in southern Peru.

Sandeman et al. (1996)



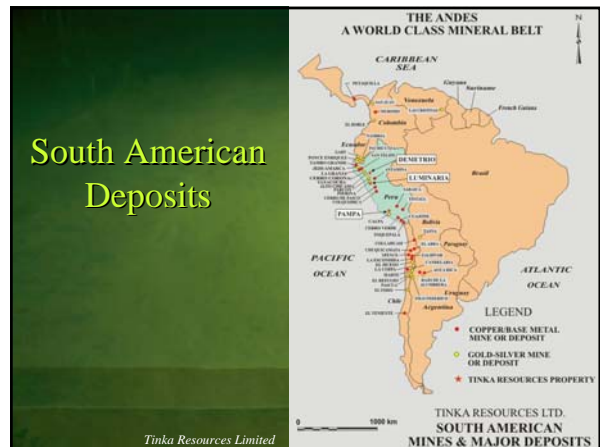
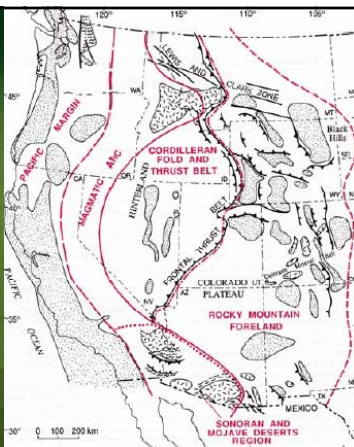
- ### The Subduction Situation
- Early Cenozoic: slow convergence
 - Steeply dipping Nazca plate
 - Subduction zone moves closer to Pacific-Nazca Ridge, causing younger, more buoyant crust to be subducted
 - Shallower angle of subduction
 - Magmatism moves further inland and becomes wider
 - Exerts upward forces on the overlying continental crust
 - *Pilger 1984*

Cordillera Oriental (East)

- Few Cenozoic sed. rocks
- Volcanics different from the typical calc-alkaline Andean volcanics (Cordillera Occidental)

CENOZOIC	Age (Ma)	Stages	Cordillera Oriental	Name and thickness
	0	Quaternary	G	Shoshonitic volcanoes (S)
0	Pliocene	A	Alluvium (A)	Alluvium (A)
5	Miocene	G	Glacial deposits (G)	Glacial deposits (G)
5	Miocene	M	Macusani Volcanics (M)	Macusani Volcanics (M)
5	Oligocene	CF	Cayconí Fm. (CF)	Cayconí Fm. (CF)
38	Oligocene	Hiatus		
65	Eocene	VF	Vilquechico Fm. (VF)	Vilquechico Fm. (VF)

- ### Eastern Cordillera
- Two-mica, corderite-, and biotite-bearing volcanics
 - Usually associated with high K calc-alkaline basalts
 - North American Analog: Similar to the two-mica volcanics in the Sonoran and Mojave Desert Region



Economic Geology of Peru

- Mined for Cu, Pb, Zn, Ag, Au, Fe
- All notable mining areas are within the cordillera



Peru: Gold and Silver Deposits

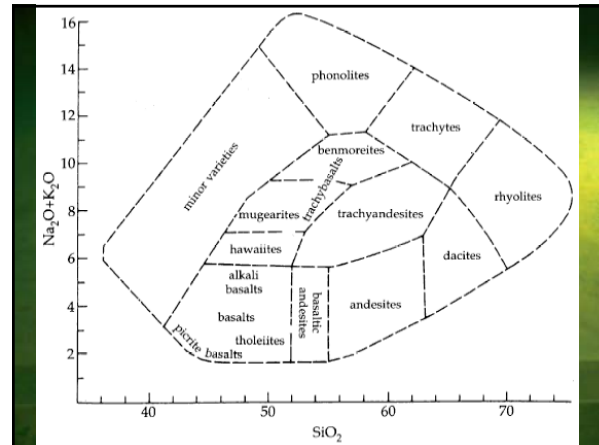
- 2003: Peru ranked as 2nd Ag and 6th Au producer
- Hydrothermal mineral deposits
- Notable deposits:
 - Arcata, Caylloma, and Orcopampa (each has produced over 40 mil. oz of Ag, and 100,000 to 1 mil. oz of Au), and many, many more
 - Deposits mostly in Tacaza Group (possibly also in Barroso group)



Uplifted limestones in the Andean range near the Pachapaqui mining area, Peru

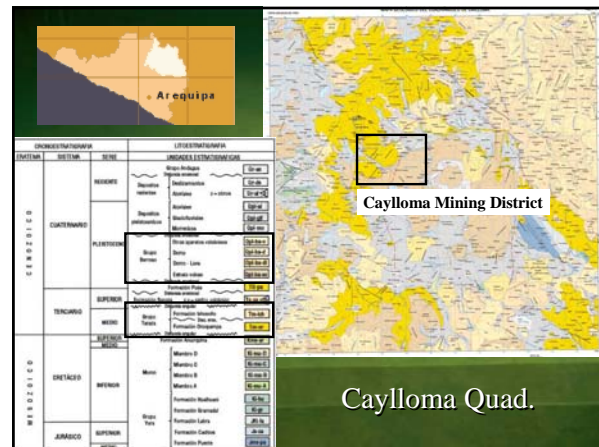
Tacaza Group

- Lower part mainly sed rx
 - coarse congl. -> interbedded ss and volcanic mudstones
- Two volcanic packages
 - Lower package: similar to underlying sed package, but with layers of tuffs and flows
 - Upper package: bedded flows, breccias, andesitic tuffs, dacite and rhyolite lenses



Barroso Group

- Andesites and Dacites with pyroclastics
- Broken into two formations:
 - Malmanya Fm (andesite, dacite) and Vilcarini Fm (PF's and lava sequences – evolved lavas)
- Veins with Au and Ag mineralizations
 - Also Pb, Zn, Cu
- Have found conflicting reports about the economic value of the Barroso Group (Fletcher et al. 1989)



Mineral Deposit Formation

- Do not appear to be from sills or laccoliths
 - Very little alteration, and rarely mineralized
- Proposed formation model: (Fletcher et al. 1989)
 - Hot Tacaza lavas set up convection cells and circulate hydrothermal fluid
 - Hydrothermal fluid leeches materials from lava piles and deposits them along fracture zones

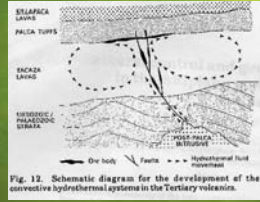
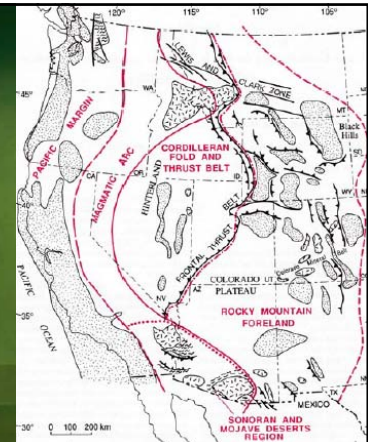


Fig. 12. Schematic diagram for the development of the convective hydrothermal system in the Tertiary volcanism.

North American Analogs

- How does this compare to North America?
- Sonoran and Mojave Desert Regions
 - Increased buoyancy of crust induces crustal flexure; 2-mica deposits

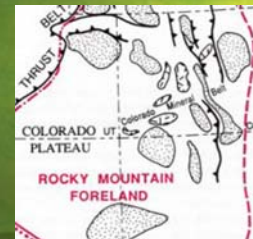


- Migration of Magmatism
 - Three active volcanic zones in the Andes (north, central, south) broken up by areas of inactivity
 - Shallower subduction causes magmatic zones to move to the north and south; central area becomes inactive



North American Analogs

- Colorado Mineral Belt
 - Gold and Silver deposits
 - Water circulating through rocks leeches elements and deposits them back out



North American Analogs

- Au and Ag deposits in Sonoran and Mojave Desert Regions
 - Porphyry deposits containing Cu, Pb, Zn, Au, and Ag



References

- Andean America Mining Corp www.andeanamerican.com/projects/santa_rosa.htm
- Arcturus Ventures Inc. http://www.arcturusventuresinc.com/projects_peru.html
- Fletcher et al. "Structural control and genesis of polymetallic deposits in the Altiplano and Western Cordillera of southern Peru." *Journal of South American Earth Sciences* 2(1): 1989: 61-71.
- Goldfarb et al. "Orogenic gold and geologic time: a global synthesis." *Ore Geology Reviews* 18 (2001) 1-75.
- Instituto Geológico Minero y Metalúrgico <http://www.ingemmet.gob.pe/publicaciones/index.htm>
- International Minerals Corporation http://home.globalcrossing.net/~emc/news_releases/pr_03-05-15.html
- Nelson, E.P., Colorado School of Mines http://www.mines.edu/fs_home/enelson/
- Pilger, R.H., "Cenozoic plate kinematics, subduction and magmatism: South American Andes." *Journal of Geological Society London* 141 (1984) 793-802.
- Sandeman et al. "A critical appraisal of the Cayóni Formation, Crucero Basin, southeastern Peru." *Journal of South American Earth Sciences* 9 (1996) 381-392.
- Steinmuller et al. "Modern hot springs in the southern volcanic Cordillera of Peru and their relationship to Neogene epithermal precious-metal deposits." *Journal of South American Earth Sciences* 14 (2001) 377-385.
- Sultan Minerals Inc. <http://www.sultanminerals.com/s/Projects.asp>
- Tinka Resources Limited <http://www.tinkaresources.com/projects.shtml>

Questions?

