Volcanic Strata-Hosted Gold Deposits in Quaternary Volcanoes: The “Sandwich-Style” Model

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Contents

Very shortened version of 1 hour presentation for exploration company looking for epithermal Au deposits in Kamchatka, Russian Far East

-Focused for African geology students

-Basics
  volcanoes
  “sandwich-style” model for Au exploration
Various types of volcanic rocks around the Pacific coasts of Asia and the Americas
One of the best studied in the northern Andes

Expells 0.5 kg of gold per day
to the atmosphere in its fumaroles.

It is probably depositing more than 0.06 kg Au/day in the volcanic edifice.
If such rates remain constant, a moderately sized gold deposit (>200 tons of contained Au) may form in only 10,000 years.

If an equivalent amount is left behind in porous volcanic rocks, a short lapse of hydrothermal activity may produce large Au deposits.
These observations do not take into account moments of great activity and explosive vulcanism, when fumarolic activity increases and several type of hydrothermal breccia are formed.
Quaternary vulcanism due to active subduction on the edges of plates
Bimodal volcanism produces stratovolcanoes.

= monotonous layers of lava and pyroclastic material (ash + tuffs)
Various types of ore deposits are generated within bimodal volcanic edifices.
Volcanic Rock Main Parameters

1. Cementation

2. Porosity
   = amount of voids in volume of rock

3. Permeability
   = measure ease of fluid flow through substance
   related to amount of connected pores

4. Reactability
   Depends on:
   - Rock chemistry
   - Available surface to react

Determine aquifers or aquicludes
Red-altered basaltic lava

well-cemented
not porous
impermeable
=Aquiclude
Pumice with lithics

permeable
porous
abundant surface to react with
= Aquifer
Andesitic lava

Notice abundant elongated open vugs

porous permeable lots of surface to react cooling joints enhance permeability = Aquifer
Welded tuff

well-cemented
not porous
impermeable
= Aquiclude
Eroded volcanoes don’t expose their mineralized carapace.
What would happen if we made a volcanic edifice like this blow up?

From Lasnicka, 1988
2002 eruption of Reventador volcano, Ecuadorian Andes.
What if the explosion took place sideways?

From Lasnicka, 1988
Maar in Colombian Andes with significant gold disseminations related to intrusive breccias exposed by volcanic explosion.
Caldera lake in the same maar.
Northernmost volcano of Andean Cordillera.
Disseminated Au in breccias of volcanic edifice exposed by cataclysmic eruption.
From Hedenquist, Arribas & Gonzalez-Urien, 2002

Kaolinite ± alunite ± native S – opaline silica (steam-heated alteration)

“SANDWICH” MODEL

Chlorite-calcite ± epidote
Smectite/mixed-layer clay ± chlorite
Crustified quartz/chalcedony-carbonates ± adularia ± barite/fluorite

Water table
Paleosurface
Hot springs
Sinter Terrace

Chalcedony blanket

Less permeable

Vein ore

Permeable lithology

Disseminated ore

Less permeable
Vertical section controlled by drillholes, with sub-horizontal pyroclastic layers

Round Mountain mine, Nevada
Mineralization and Alteration at Round Mountain mine, Nevada
"SANDWICH" MODEL

Kaolinite ± alunite ± native S – opaline silica (steam-heated alteration)

Paleosurface

Hot springs

Sinter Terrace

Water table

Chalcedony blanket

Disseminated ore

Vein ore

Sericite/illite ± adularia

Chlorite-calcite ± epidote

Smectite/mixed-layer clay ± chlorite

Crustified quartz/chalcedony-carbonates ± adularia ± barite/fluorite

Permeable lithology

50-100 meters
Cerro Bravo Volcano (literally “fierce mountain”) 
Dome and five concentric calderas 
4000 m.o.s.l., Colombian Central Cordillera
5 concentric calderas and a central, young dome
Cerro Bravo volcano
In axis of Andean Cordillera.

Another Quaternary volcanic system studied by the author.

Contains important epithermal Au dissemination associated with tuff layers limited by andesite lava aquicludes.
Mineralization in
>8 porous, permeable, pumice-rich pyroclastic layers

High sulfidation epithermal system
Alunite conforms large portion of matrix in breccias & mineralized tuffs.

Northern Andes Volcano*
Lateral explosion opened large window of mineralized breccia pipes & epithermal mineralization hosted by interlayered pyroclastics & lavas.
Morphology of lateral explosion
Northern Andes volcano*
Tabular lava and pyroclastics
Northern Andes volcano*
Aspects, exposed diatreme
Northern Andes Volcano*

Various diatremes within pyroclastic layer
Northern Andes Volcano

Various diatremes within pyroclastic layer

Diatreme 1

Diatreme 2
Stockworks in pyroclastic sequences. 3-D stereoscopic image.
Goethite around fractures enhanced by weathering
Stockwork. Most of rock was clay altered
Moving out in same stockwork.
Stockworking over a diatreme. +4 discrete Au-mnzg events.
Moving out in same stwk. All surface here is mineralized.
Moving away still more. 1.6km vertical exposure.
Sandwich-style Au mineralization in series of lavas + pyroclastics

Northern Andes Volcano*
Conclusion

Porous, permeable volcanic strata (pyroclastics) limited by impermeable strata (lava layers or welded tuffs) provide a good trap for epithermal Au mineralization.

= “Sandwich-style” mineralization
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