Porphyry Cu-Au mineral systems in Argentina – the next exploration frontier

CONICET

Nora Rubinstein

ARGENTINA

Accreted terranes - arc, back arc, extensional magmatism - marine/continental basins

Precious metal:
HS
LS
PC
Distal epithermal (Au)
Orogenic gold
IRGS

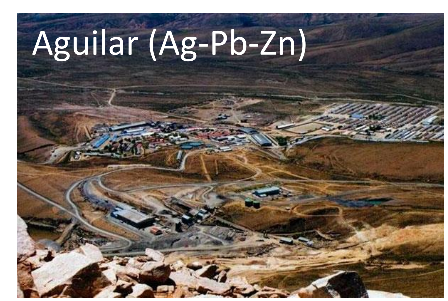

Cerro Vanguardia (Ag-Au)

Critical elements:
Salars (Li-B)
Pegmatites
Greisen
Polymetallic veins
Five element deposits


Olaroz (Li)

Base metals:
SEDEX
PC
VMS
Skarns

and…


Aguilar (Ag-Pb-Zn)

ARGENTINA

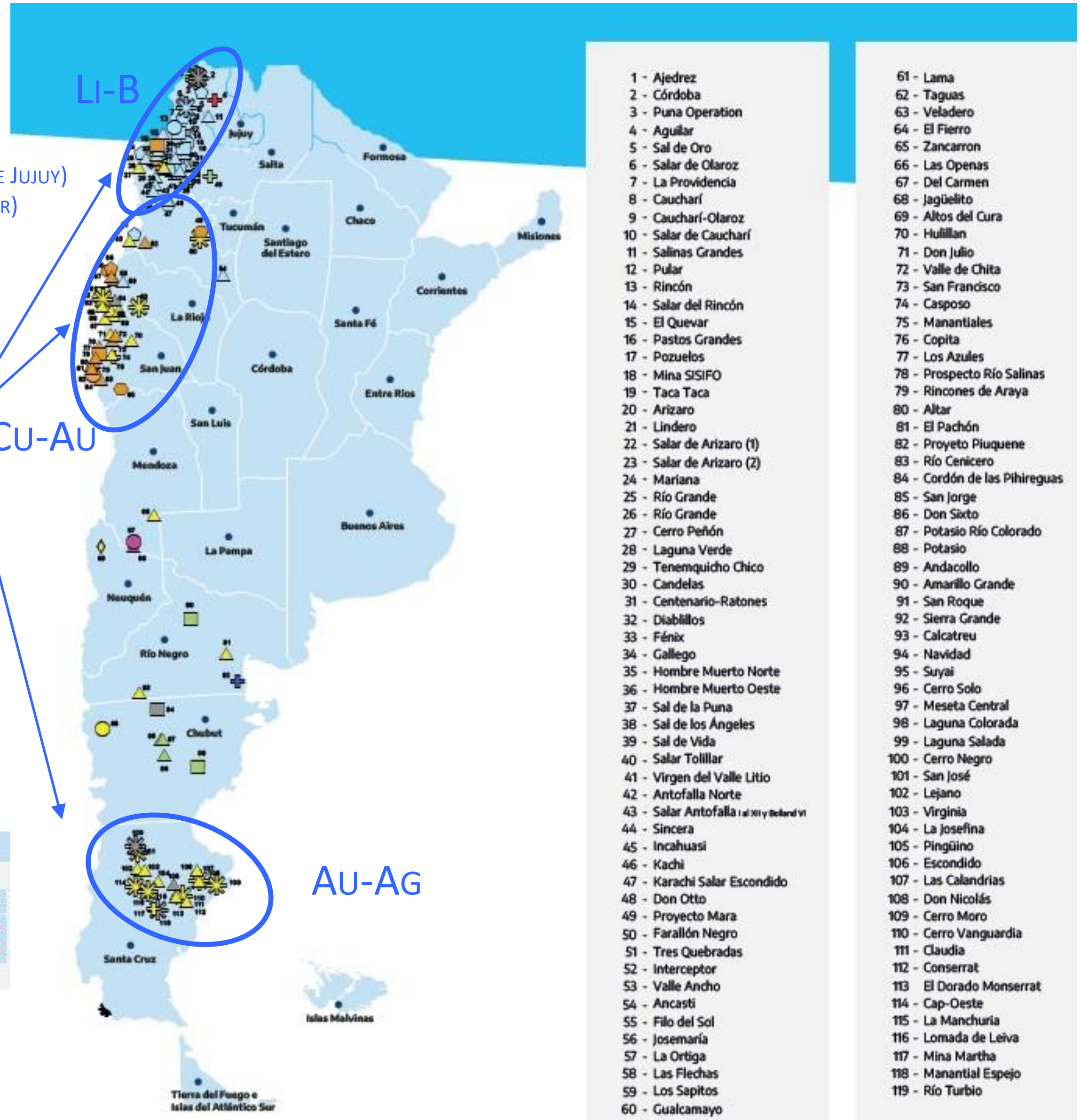
Status of mining projects

Li: 3 mines in operation (Cauchari, Fenix, Sales de Jujuy)
B: 3 mines in operation (Tincalayu, Sijes, Provenir)

Li: 77000t/y (4th world producer)
B: 600Kt/y (4th world producer)

Au-Ag: 10 mines in operation (Lindero, Veladero, Co. Vanguardia, Gualcamayo, Martha, San José, Co. Negro, Don Nicolás, Lomada de Leiva, Manantial espejo)

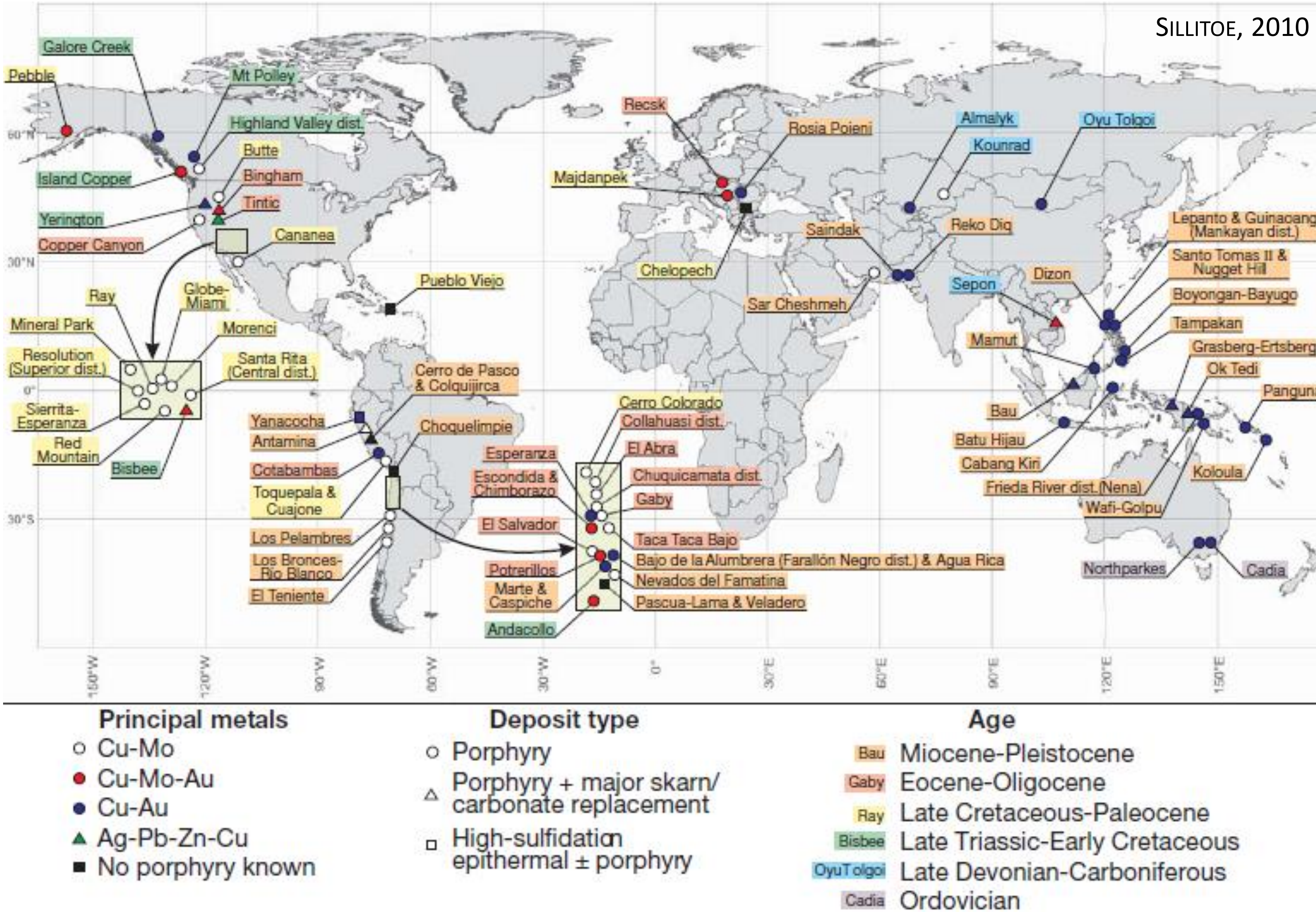
Veladero: 480Koz Au (2022)
Co. Vanguardia: 170 Koz Au -3.7 Moz Ag (2022)
Co. Negro: 278Koz (2022)



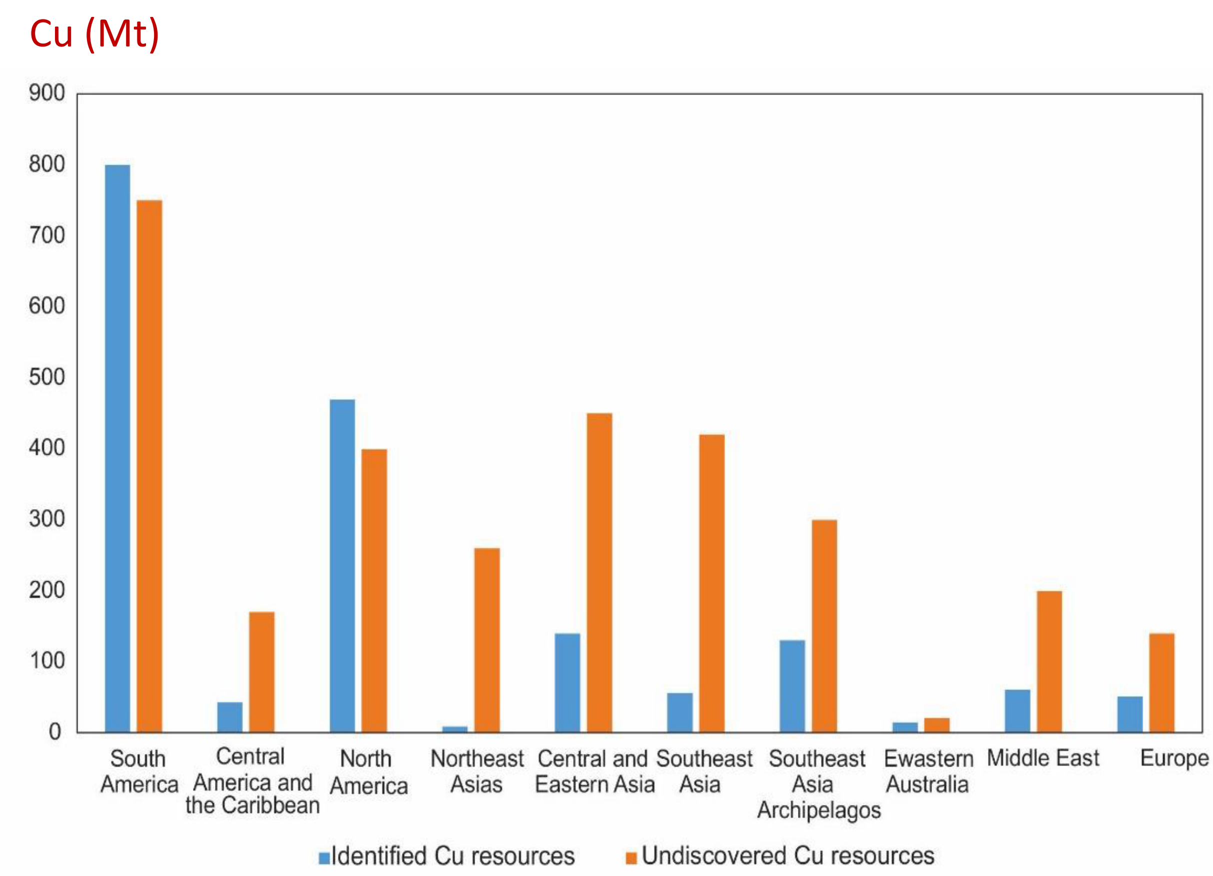
Ministerio de Desarrollo Productivo
Argentina

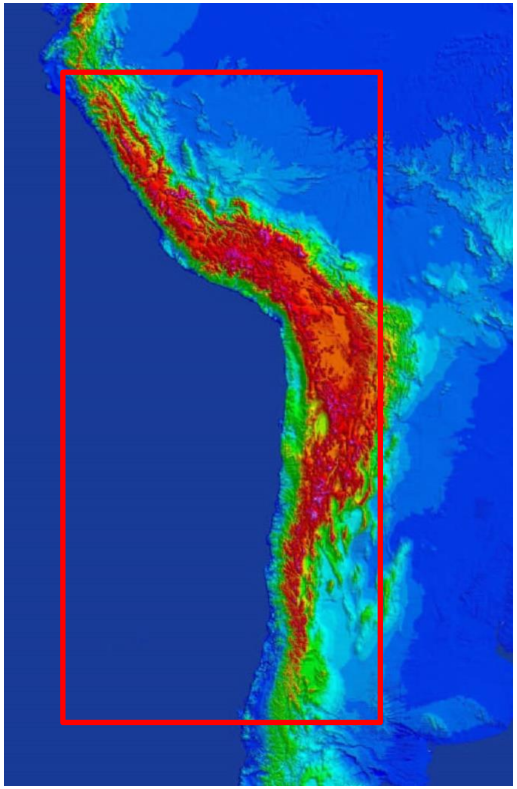
PCD in the word

SILLITOE, 2010



Central Andes: The largest Cu endowment worldwide





Hammarstrom et al., 2019

PCD of the Central Andes

- Emplaced during declining orogenic conditions marked by crustal thickening, surface uplift, and rapid exhumation.
- In orogen-parallel belts developed during defined metallogenic epochs:

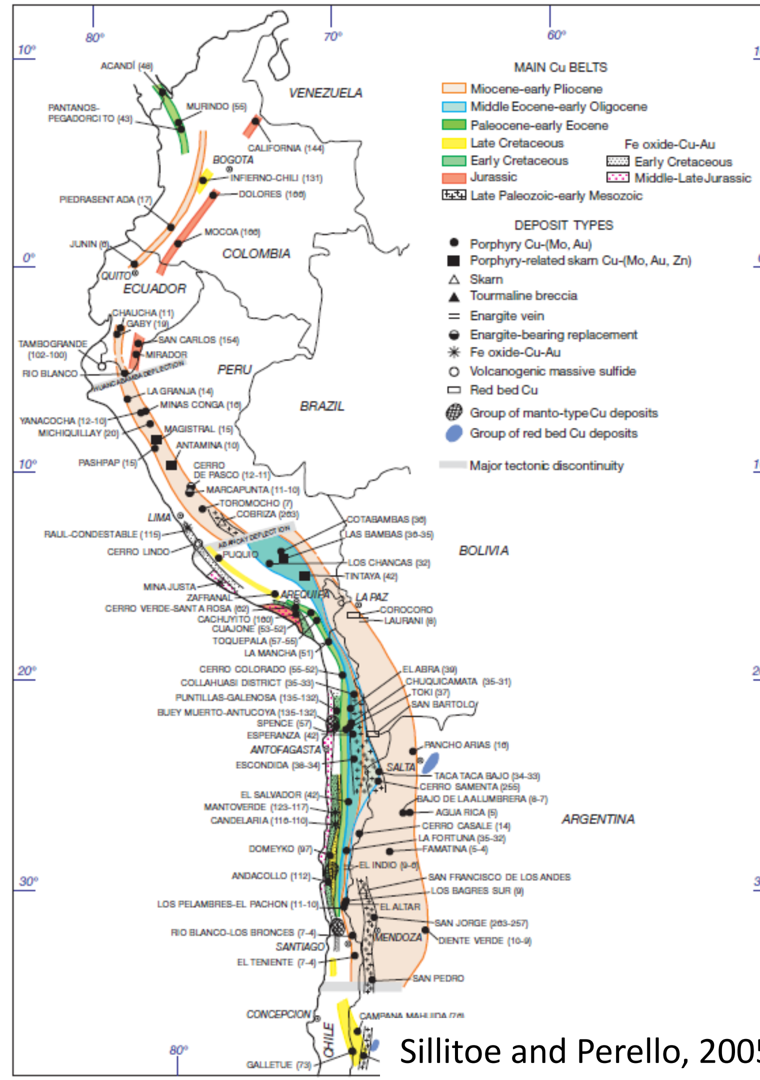
  Paleozoic to early Mesozoic

  Middle to late Mesozoic

  Paleocene to early Eocene,

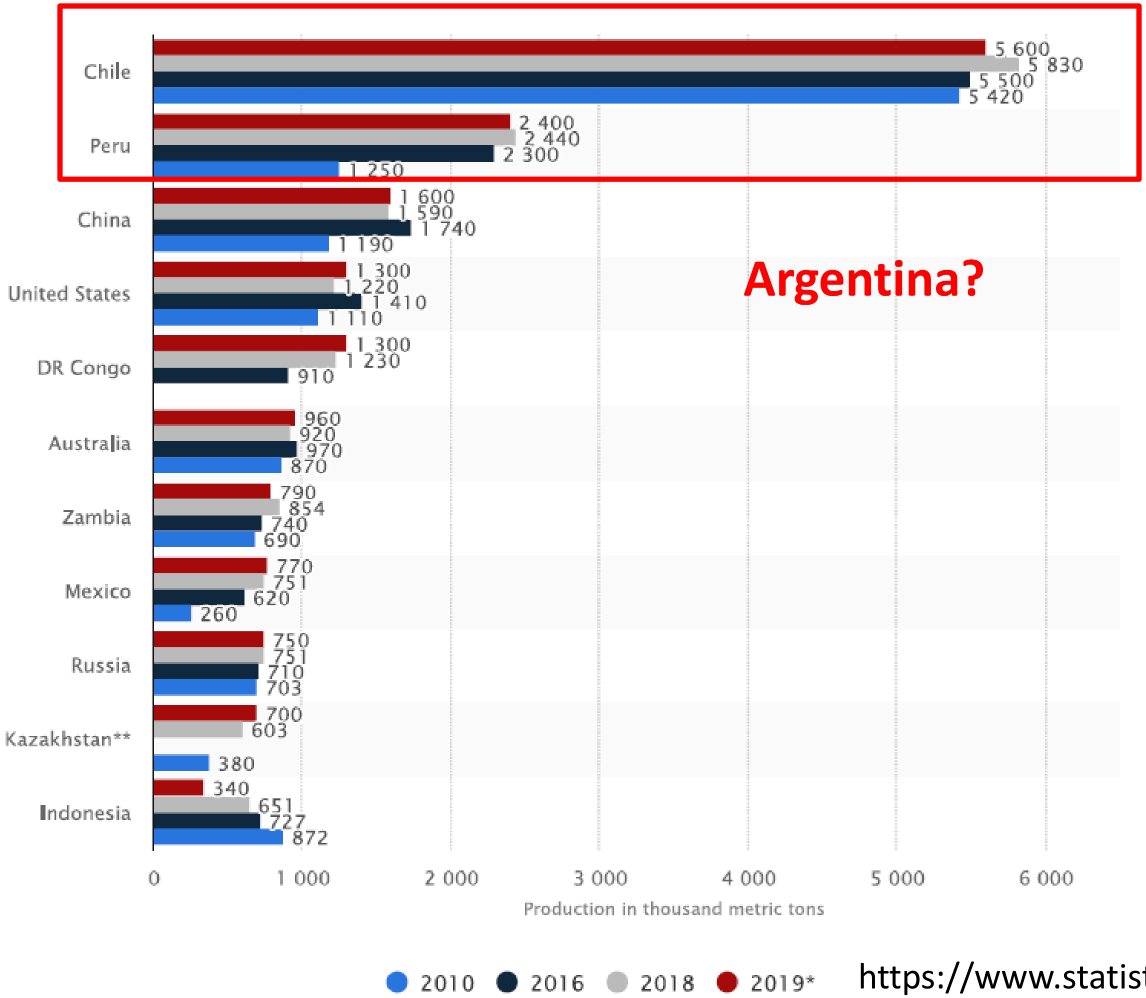
  Middle Eocene to early Oligocene

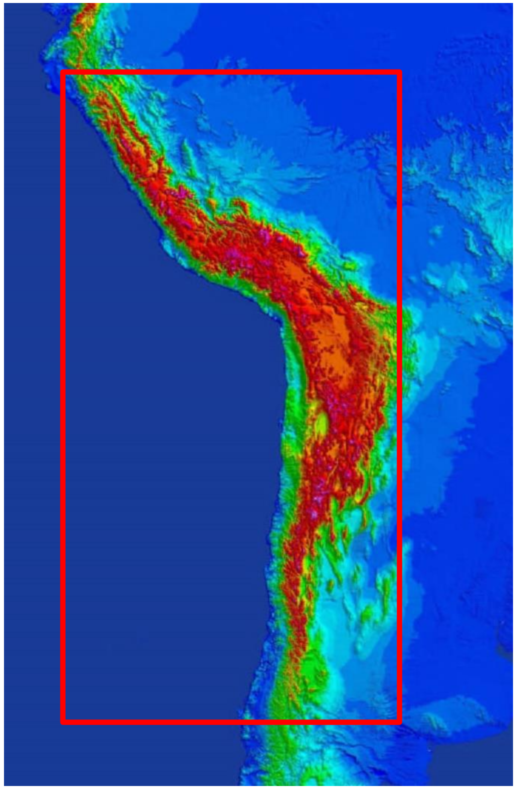
  Miocene to early Pliocene



Sillitoe and Perello, 2005

Central Andes: The largest Cu endowment worldwide





https://www.statista.com/

PCD of the Central Andes of Argentina

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Porphyry CU deposits in the Central Andes of Argentina: An overview

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Geodynamic setting
Metallogenic characteristics
Geological controls
Metallogenic belts
Endowment

ABSTRACT

Porphyry Cu deposits are the world's most important source of Cu and the Central Andes of South America hold some of the largest Cu resources worldwide. In Argentina many porphyry-type deposits and prospects with different degrees of exploration straddle along ~1500 km of the Central Andes. The review and analysis of the tectono-magmatic, metallogenic and economic data of the better-known deposits and prospects allow to define the controls of porphyry-type mineralization and the metallogenic epochs and belts which in turn indicate the potential for porphyry-type mineralization in some relatively poorly explored segments of the Central Andes.

Slab shallowing (particularly linked to the subduction of aseismic ridges) and associated eastward arc migration/expansion appears to be a favorable geodynamic scenario for Paleozoic and Cenozoic mineralizing magmatism which show variable adakitic signatures probably as a result of a progressive crustal thickening. In this context the V/Sc and especially the Sr/Y ratios are a useful tools for assessing magma fertility. Major WNW-trending deep crustal pre-Andean structures controlled the inland migration of the magmatism and are a first order control on porphyry emplacement during these epochs of magmatic activity.

There are five favorable metallogenic epochs linked to the arc magmatism in Argentina: Permian, Upper Cretaceous-Eocene, late Eocene-early Oligocene, late Oligocene-early Miocene and Miocene-Pliocene. The Permian and Upper Cretaceous-Eocene metallogenic epochs are represented by a small number of deposits with low metal (Cu–Mo–Au) content; however, the extension of the magmatism of both epochs suggests they are

Metallogenic epochs

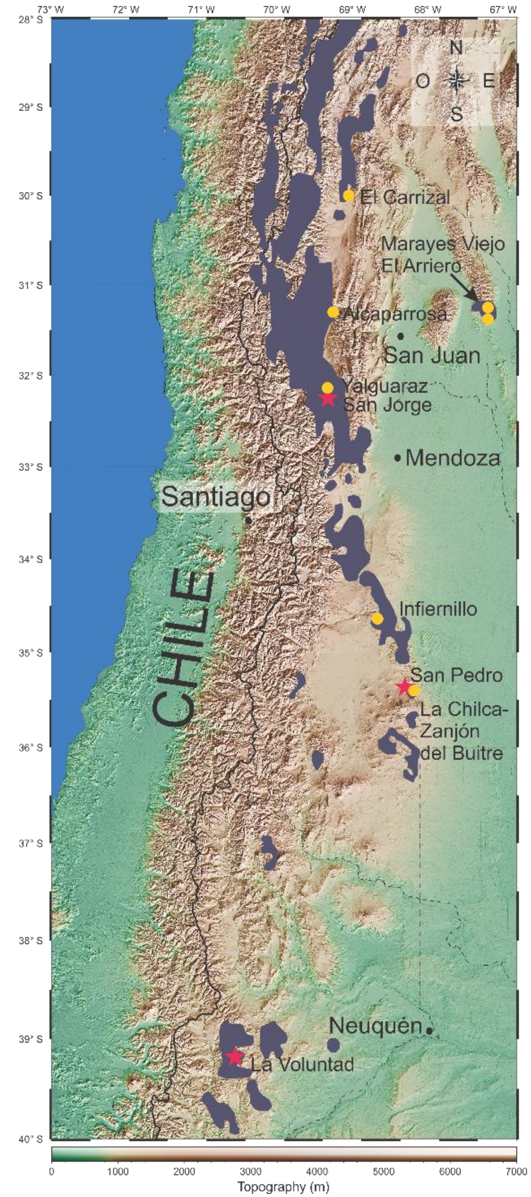
- Permian
- Upper Cretaceous-Eocene
- Late Eocene-early Oligocene
- Late Oligocene-early Miocene
- Miocene-Pliocene

Permian metallogenic epoch

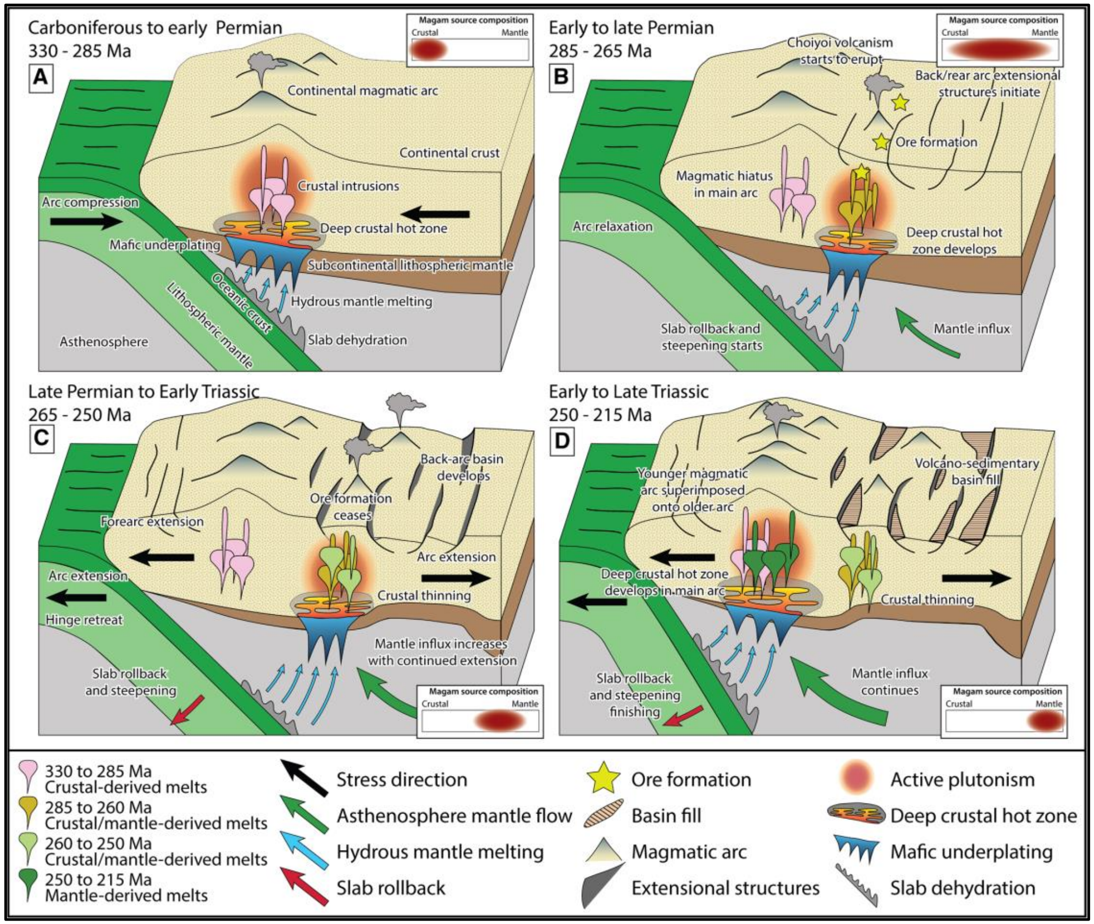
The PCDs of this epoch are linked to the lower section of the Choiyoi Magmatic Cycle (early Permian) which has a typical arc signature.

South of 31° this magmatic arc shifted to the east due to a progressive shallowing that produced crustal thickening resulting in an adakite-like signature.

By the late Permian - early Triassic slab rollback induced back arc extension producing magmas with a transitional to intraplate signature (upper Choiyoi section).



Permian metallogenic epoch



Poole et al., 2020

a) Magmatic arc in a compressional regime. Intrusion of dominantly crustal-derived magmas.

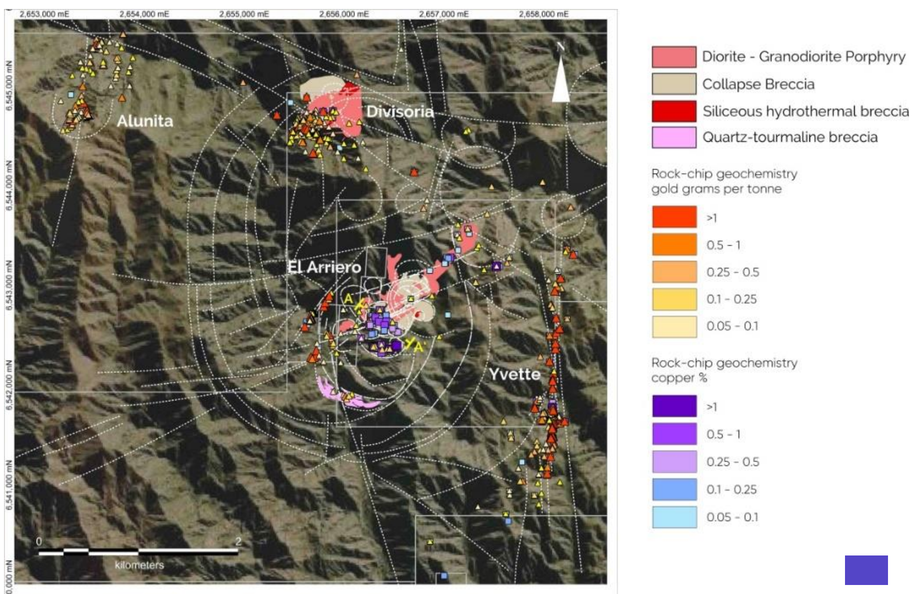
b) Magmatism arising in a backarc as the arc relaxes. Synchronous emplacement of crustal and mantle-derived magmas.

c) Continuation of extension with back-arc basin development and slab rollback.

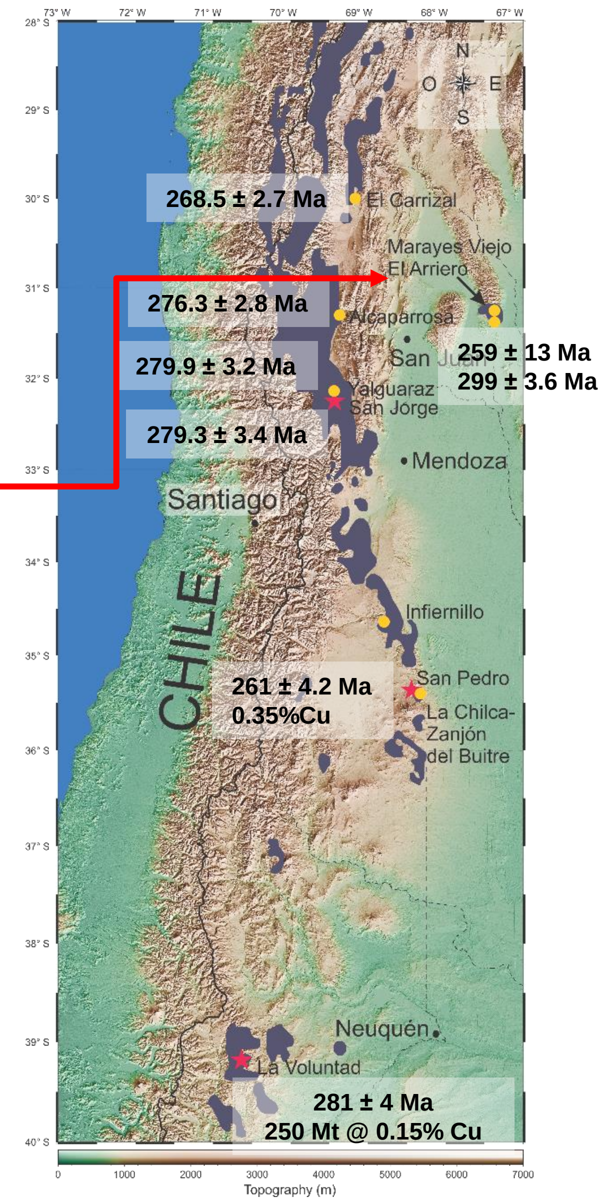
d) Magmatism migrates back westward into the main arc as extension wanes. Magmas with a mantle-derived signature

Permian metallogenic epoch

This metallogenic epoch is represented by a small group of PCDs conformed by mid-size deposits and a few prospects with different degrees of exploration.



https://www.royalroadminerals.com/projects/santo-domingo



Permian metallogenic epoch

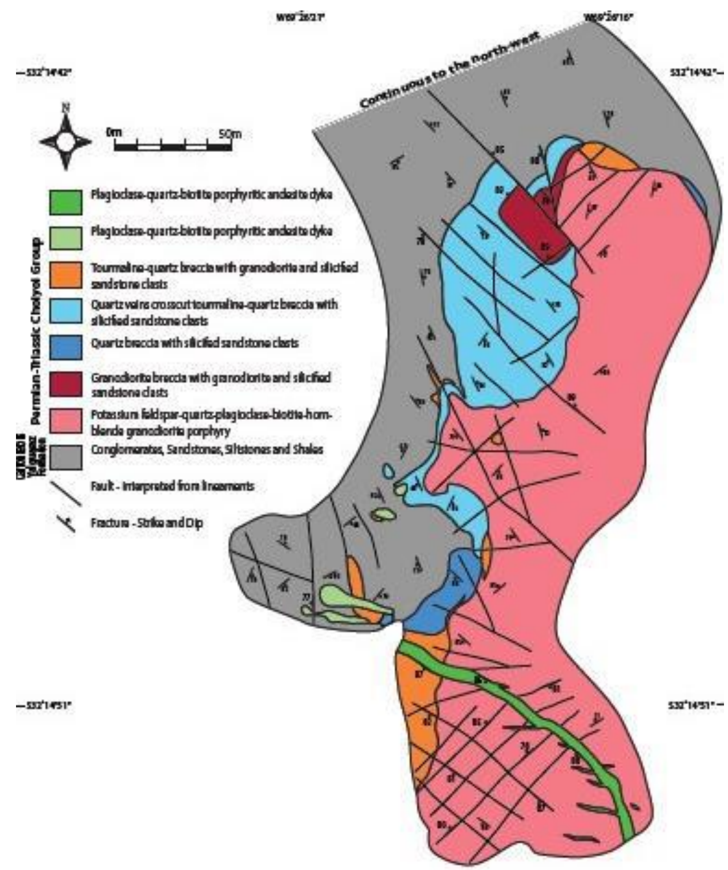
San Jorge

Associated to a Permian porphyritic granodiorite (279.3 ± 3.4 - 280.5 ± 3 Ma).

In Devonian - Carboniferous sedimentary sequences.

Chalcopyrite in the granodiorite and in tourmaline-(quartz) breccias, both with associated potassic (biotite+ K-feldspar + quartz) alteration and in structurally controlled phyllic alteration belts affecting the sedimentary sequences.

The tourmaline breccia was formed by medium T (~400°C), low salinity (<10 wt % NaCl eq.) magmatic fluids.



Poole et al., 2017

Permian metallogenic epoch

San Jorge

A PFS Cu project with 194 million tons of ore containing 900,000 tons of contained copper and 1.03 million ounces of gold https://solwaygroup.com/

Provincial Law 7722 (Mendoza province): Prohibition of the use of toxic chemical substances (e.g. cyanide, mercury, sulfuric acid) in the metalliferous mining processes of prospecting, exploration, exploitation and/or industrialization of metalliferous minerals obtained through any extractive method.

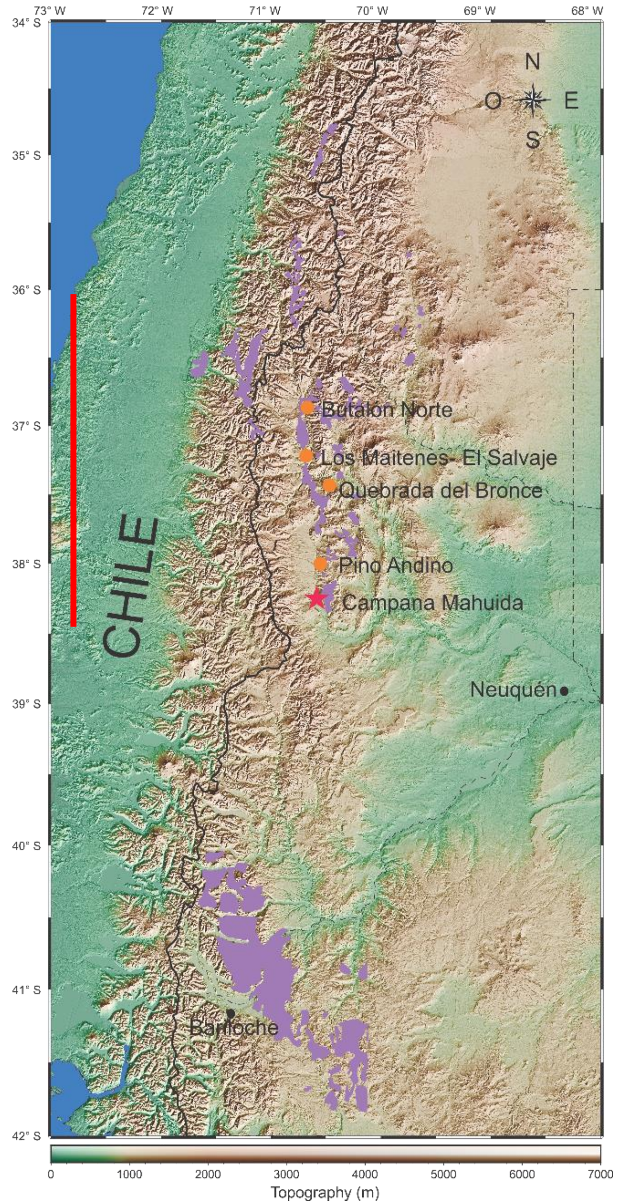
Upper Cretaceous - Eocene metallogenic epoch

The magmatism of this epoch is represented by sequences between ~74 and 40 Ma with the subvolcanics bodies restricted to the ~36°-38.5°segment.

During the late Paleocene-Eocene the convergence turned to oblique with a low subduction rate resulting in a poorly developed magmatic arc that shifted to the east.

Coeval magmatic sequences show contrasting geochemistry (calc-alkaline and intraplate) and magmatic gaps resulting from the passage of the Aluk-Farallón ridge by Late Cretaceous.

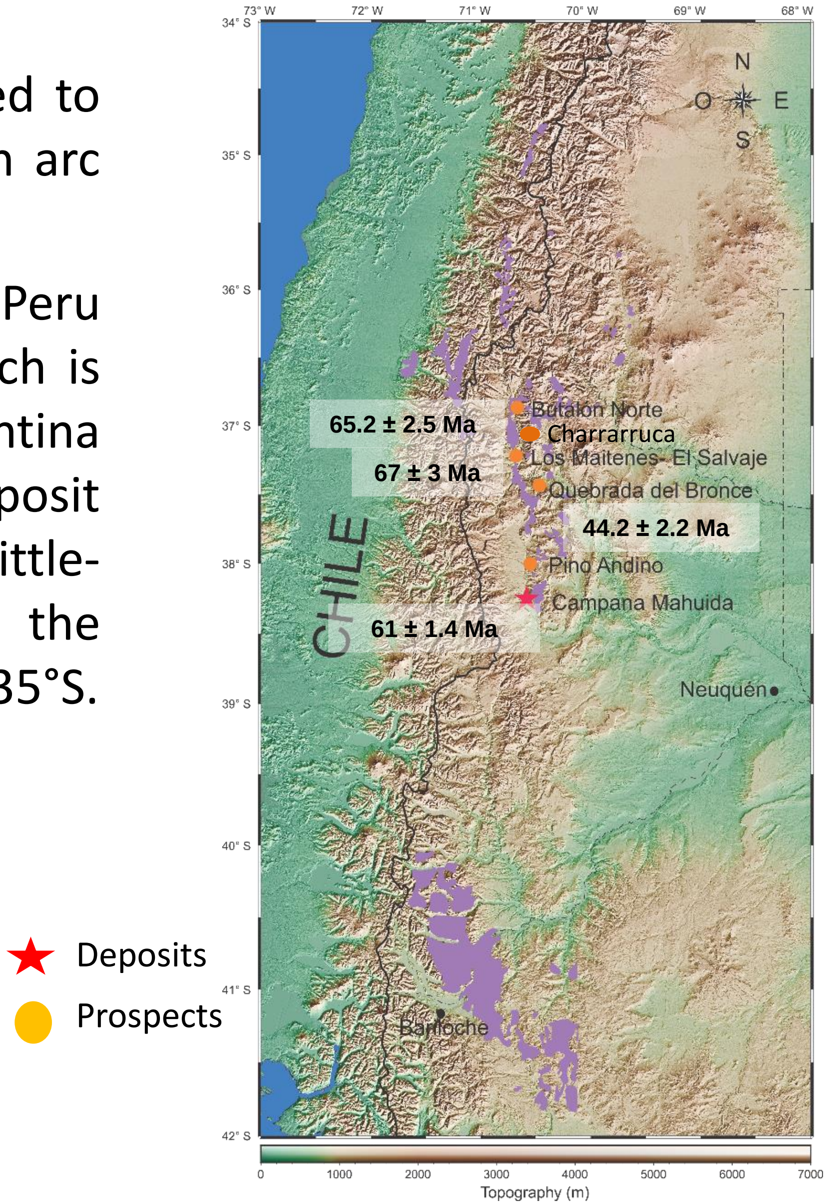
Magmas equilibrated at low P conditions (low Sm/Yb).



Upper Cretaceous - Eocene metallogenic epoch

The PCDs of this epoch are linked to andesitic subvolcanic bodies with arc signature.

Unlike in the Central Andes of Peru and Chile, this metallogenic epoch is poorly represented in Argentina where it includes just one deposit with resources and very few little-known prospects located in the Southern Central Andes south of 35°S.



Upper Cretaceous - Eocene metallogenic epoch

Campana Mahuida

Associated to an andesitic stock (61.0 ± 1.4 Ma).

Emplaced in Jurassic continental sedimentary sequences.

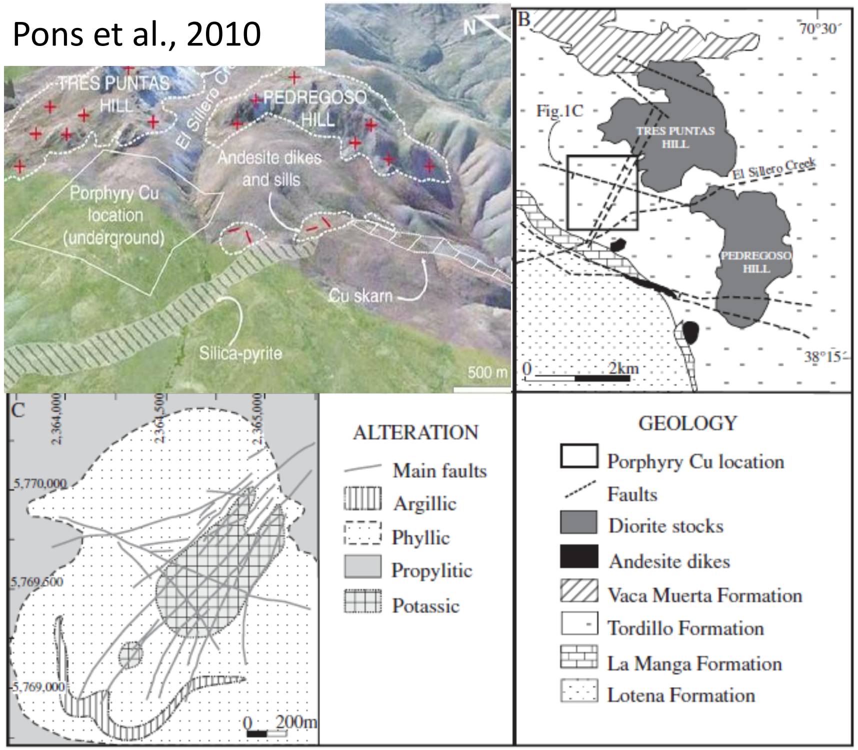
A potassic core (biotite + K-feldspar ± magnetite) overprinted by a chlorite-rich zone related to the mineralization of chalcopyrite ± bornite ± molybdenite ± Au.

Phyllic alteration overprints the potassic and propylitic alteration.

Fluids of the potassic stage had high T (>550°C) and salinities (28-75% NaCl eq.).

40 Mt (measured + indicated + inferred) @ 0.49% Cu with a cut-off grade of 0.15%

Pons et al., 2010



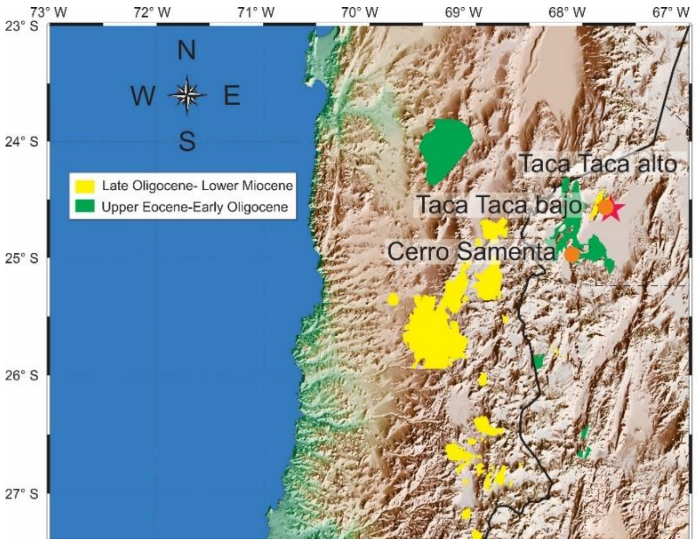
Late Eocene – early Oligocene metallogenic epoch

PCDs of this metallogenic epoch are linked to the Early Oligocene magmatism in the southern Puna.

During the Paleocene–Early Eocene the volcanic arc axis was located in the Central Valley of Chile and moved progressively eastwards due to a slab shallowing.

From 40-35 Ma shortening was focused to the western Puna and from 35-30 Ma to the eastern Puna.

Uplift of Puna plateau started at ~ 25 Ma due to crustal thickening produced by horizontal shortening of the softened lithosphere.

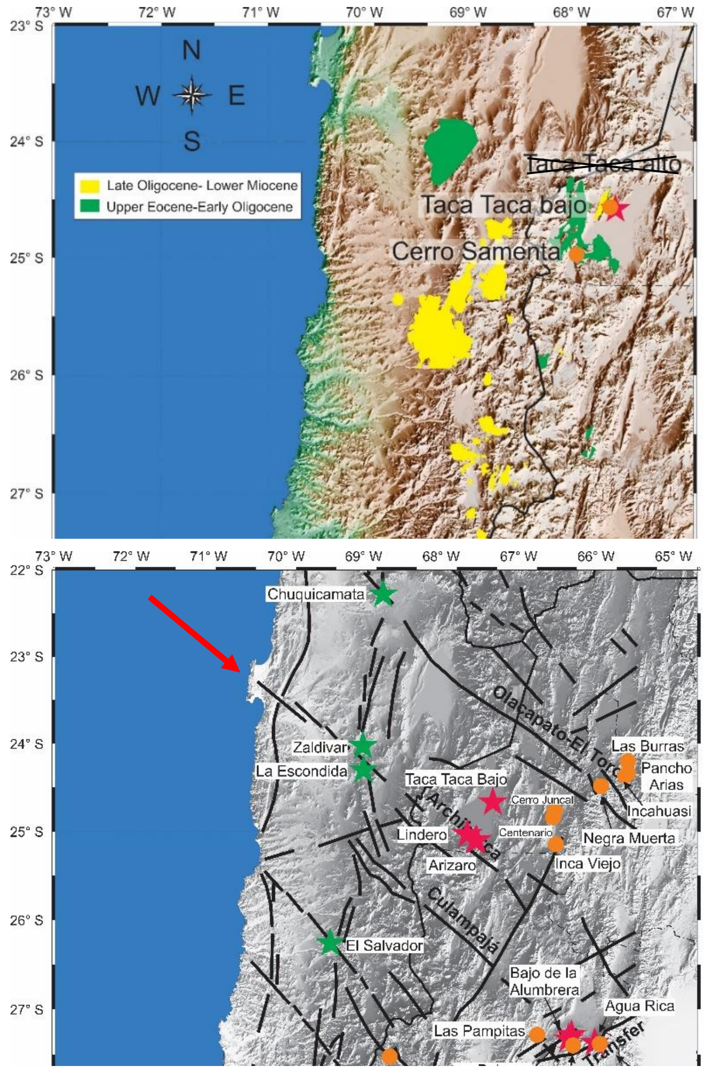


Late Eocene – early Oligocene metallogenic epoch

This metallogenic epoch developed some of the largest Cu resources in the world.

It is a prominent epoch in Chile and Perú but it is poorly developed in Argentina where it includes the Taca – Taca Bajo deposit and one prospect in the Puna region.

PCDs of this epoch in Argentina and Chile are controlled by the Archibarca regional lineament



Late Eocene – early Oligocene metallogenic epoch

Taca-Taca Bajo

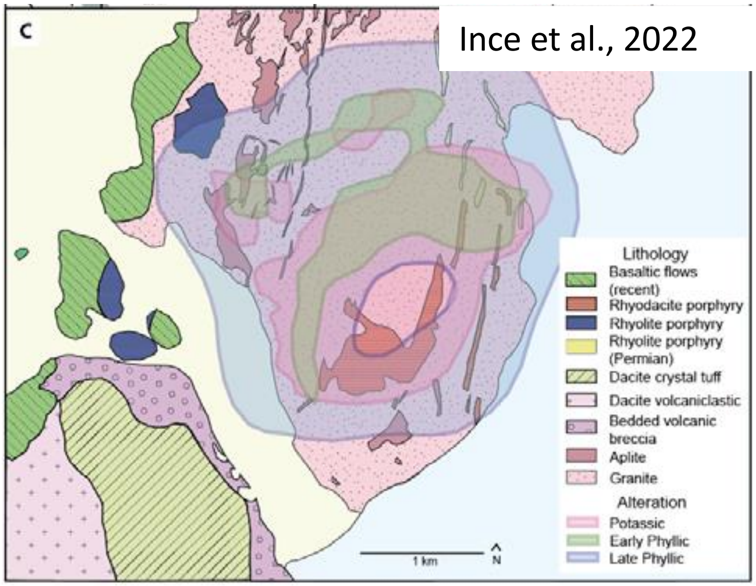
Associated to rhyodacitic porphyry dikes (30.5±0.3 – 29.3±0.4 Ma).

Emplaced In an Ordovician granodiorite.

Potassic alteration (biotite + K-feldspar + quartz) with associated molybdenite and minor chalcopyrite and bornite.

Early phyllic alteration (phengite) with associated chalcopyrite, bornite and molybdenite and late phyllic alteration (muscovite) with associated chalcocite and minor chalcopyrite, both overprinting potassic alteration.

Supergenic enrichment blanket up to 300 m thick with chalcocite (and Au).

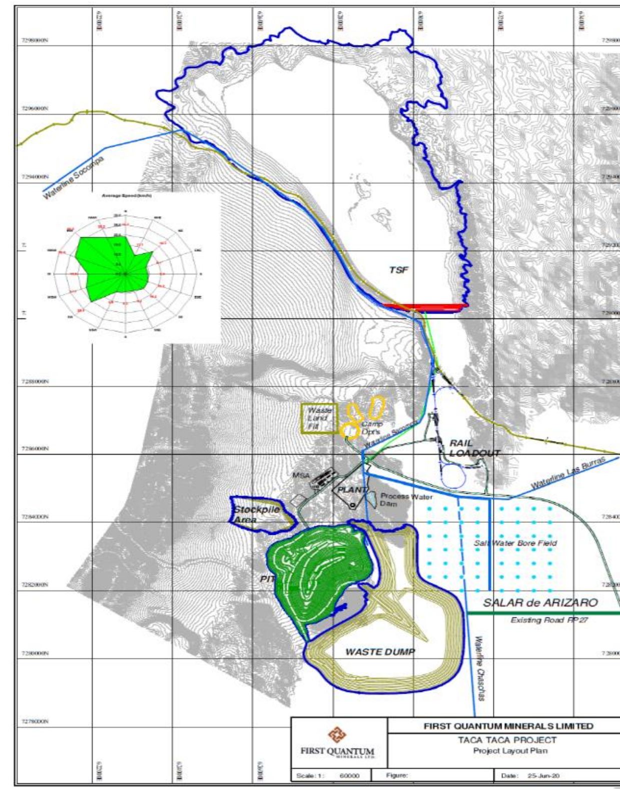


29.14±0.12 Ma
(Re/Os in molybdenite)

Late Eocene – early Oligocene metallogenic epoch

Taca-Taca Bajo

A PFS Cu project with 2023.3 Mt @ 0.43% Cu, 0.09 g/t Au and 0.012% Mo (measured + indicated) and 716.9 Mt @ 0.31% Cu, 0.05 g/t Au and 0.009% Mo (inferred). https://www.first-quantum.com/



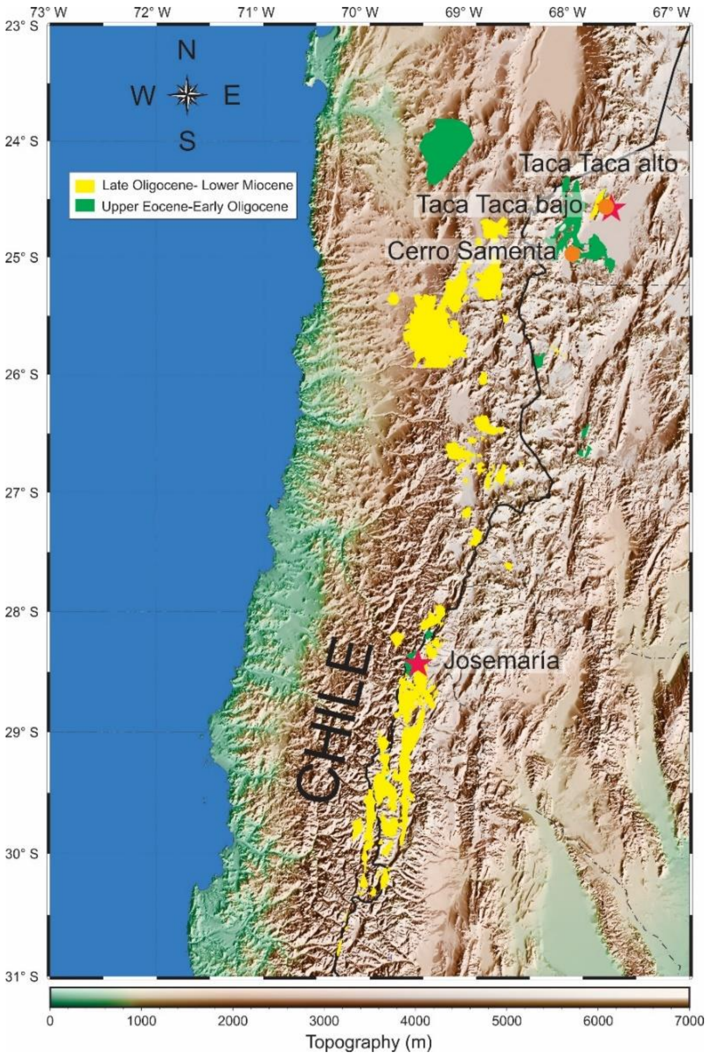
Layout of the proposed Project site NI 43-101 Technical Report, 2021

Late Oligocene – early Miocene metallogenic epoch

PCDs of this metallogenic epoch are linked to the Late Oligocene magmatism in the Frontal Cordillera.

During the late Oligocene to the early Miocene (~27-21 Ma) the volcanic arc was constructed just after the change from slow and very oblique to fast and nearly normal convergence.

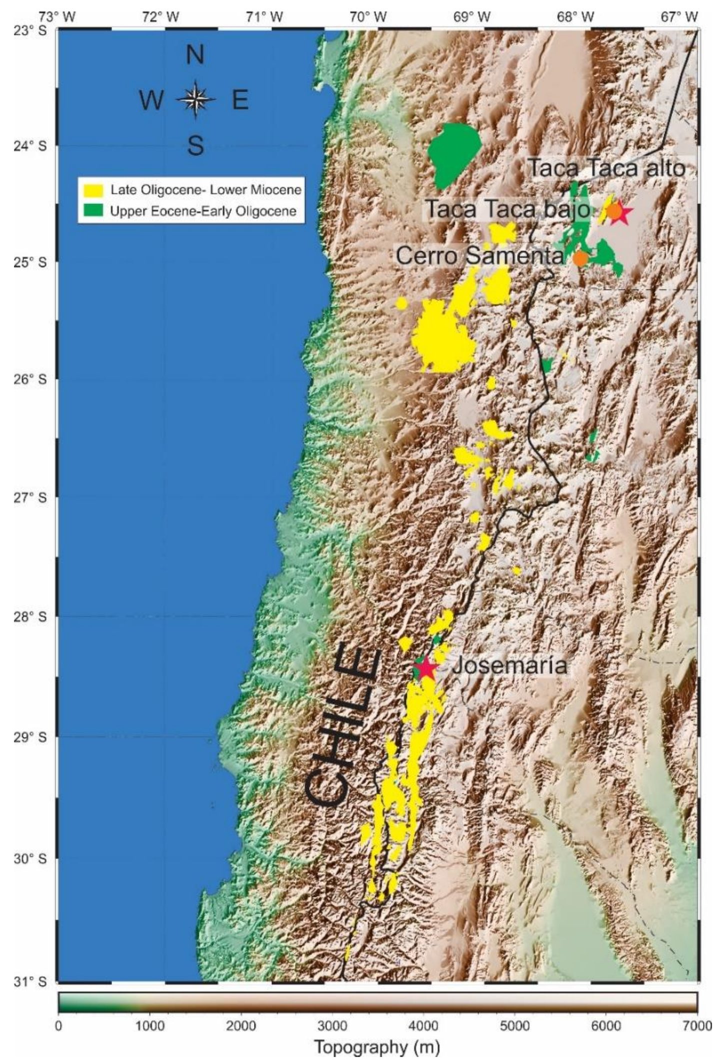
The magmatic activity is largely confined to the arc and near-back arc region and included calc-alkaline and tholeiitic arc volcanics.



Late Oligocene – early Miocene metallogenic epoch

Calc-alkaline volcanic units correspond to medium-to high-K andesites and dacites with typical arc-like signatures and REE pattern indicating equilibration with pyroxene and amphibole-bearing residual assemblages in normal to slightly thickened arc crust.

Tholeiitic rocks include basaltic to mafic andesitic flows, dikes, sills, and volcaniclastics units with geochemical characteristics consistent with a low-pressure, pyroxene-dominated residual mineralogy.



Deposits

Prospects

Late Oligocene – early Miocene metallogenic epoch

Josemaría

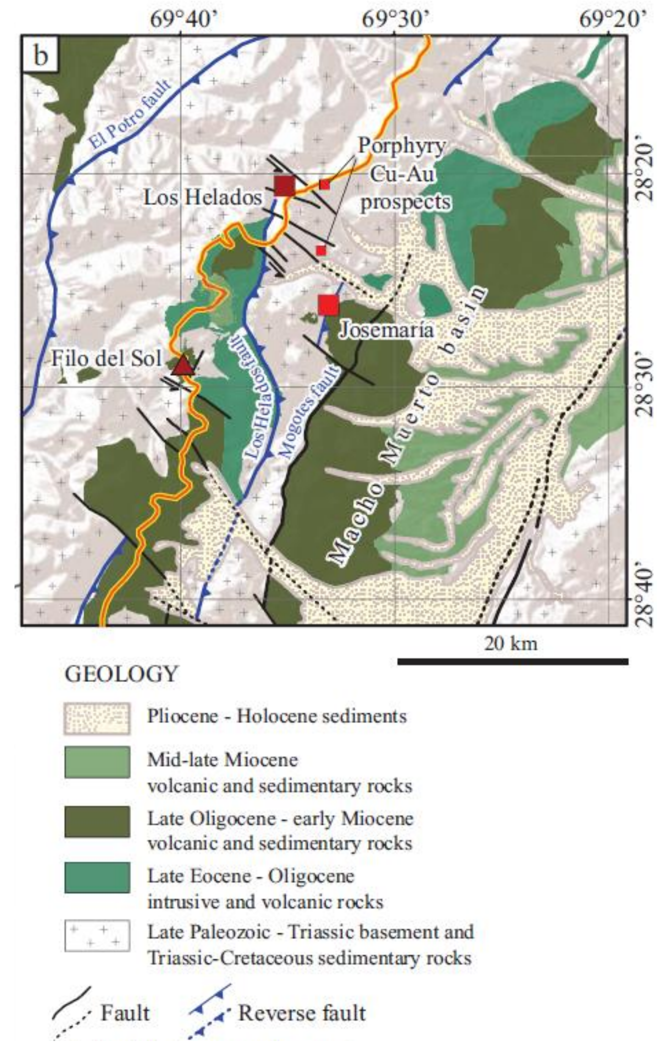
Associated to multiphases dacite porphyry intrusions (24.98–24.66 ± 0.04 Ma).

Emplaced at the contact between Permo-Triassic rhyolitic volcanic and tonalitic plutonic rocks.

Potassic alteration (biotite + K-feldspar) with associated chalcopyrite, minor bornite and molybdenite overprinted by chlorite-sericite alteration with associated chalcopyrite.

Sericitic alteration with pyrite + chalcocite + bornite ± covellite ± tennantite ± enargite.

Advance argillic alteration with an ore paragenesis similar to that of the sericitic alteration.

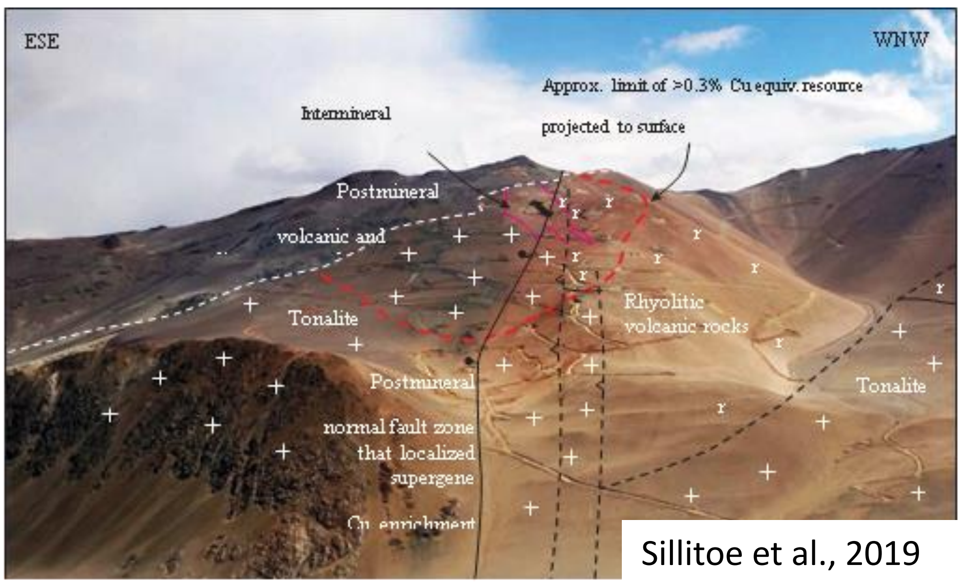


Sillitoe et al., 2019

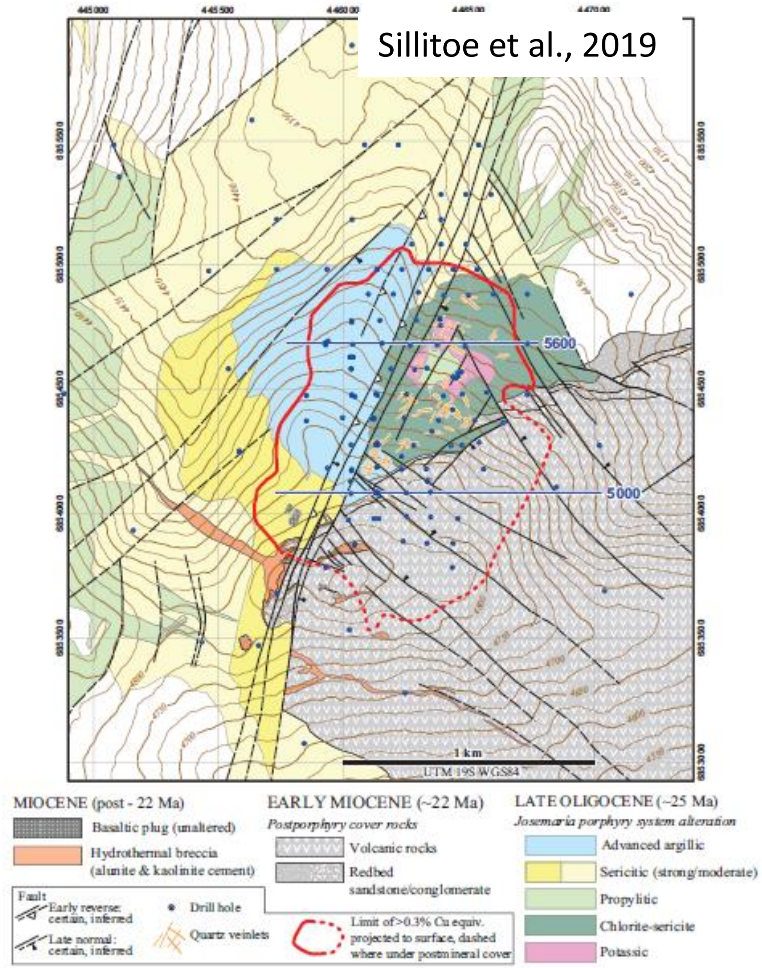
Late Oligocene – early Miocene metallogenic epoch

Josemaría

A Cu project at FS status with 1159 Mt (measured + indicated) @ 0.29% Cu and 0.21 g/t Au, and 704 Mt (inferred) @ 0.19% Cu, 0.10 g/t Au and 0.8 g/t Ag. https://lundinmining.com/



Sillitoe et al., 2019



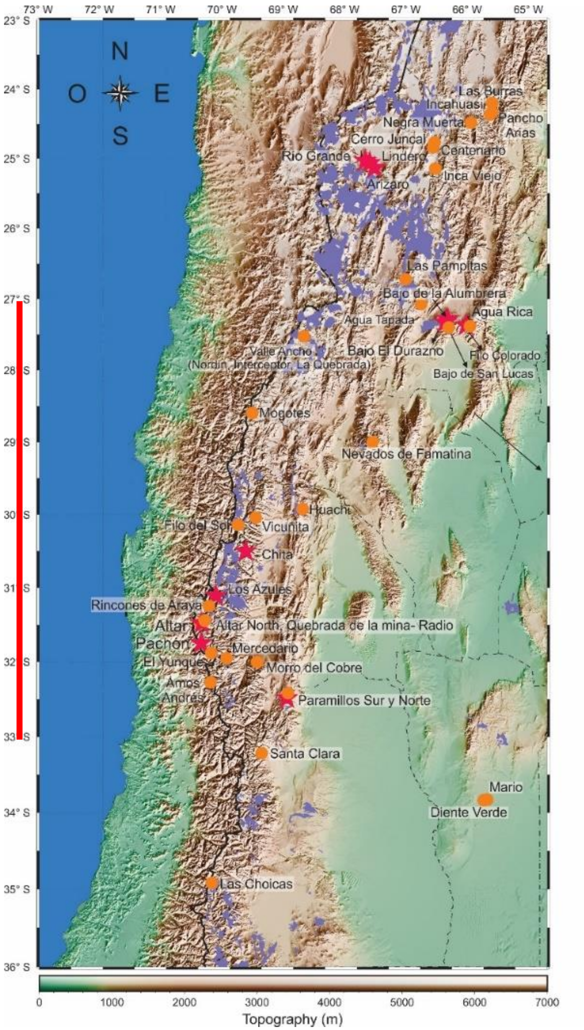
Sillitoe et al., 2019

Miocene – Pliocene metallogenic epoch

PCDs of this metallogenic epoch are linked to the Miocene-Pliocene arc magmatism that produced large volumes of dacitic-andesitic volcanic rocks.

By ~20 Ma changes in rate and direction of convergence of the plates led to a transition from an extensional to a compressional tectonic regime, shallowing and frontal arc migration.

By the late Miocene changes in the geodynamic scenario are linked to the collision of the Juan Fernández Ridge (JFR), particularly in the Pampean flat slab segment (27° -33°).

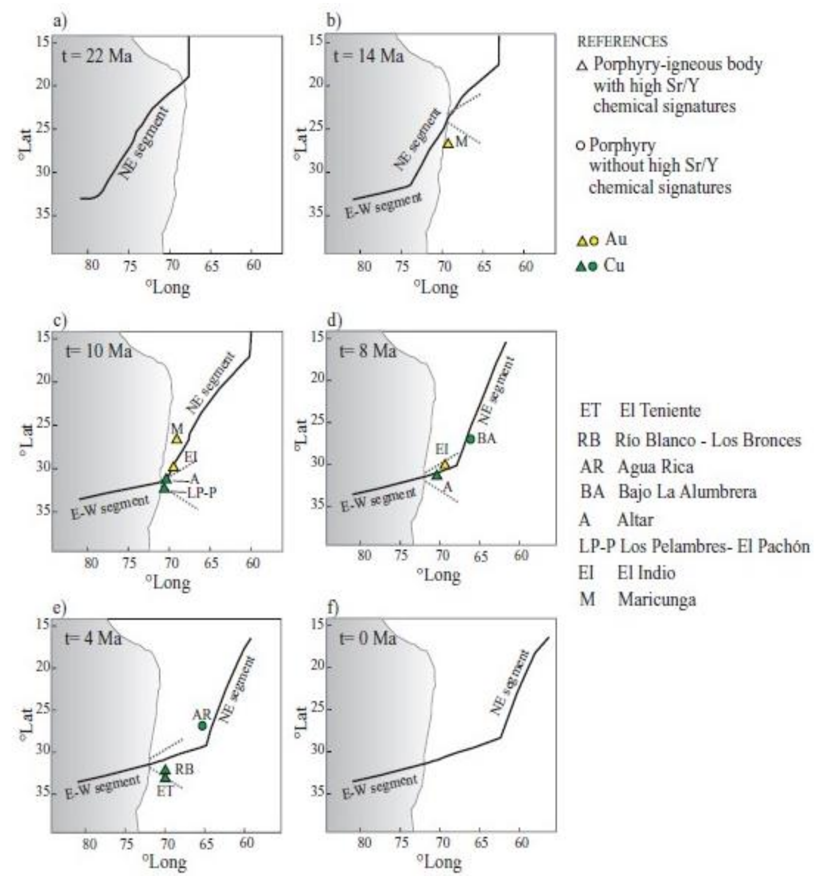


Miocene – pliocene metallogenic epoch

The arrival of the JFR produced the shallowing of the downgoing Nazca plate, an increase in the compressional regime and the subsequent crustal thickening and eastward arc migration.

The NE arm of the JFR arrived at the northern Puna ~24°S at ~10 Ma, and 2 Ma later at Sierras Pampeanas ~27°–27°30’ S (Agua Rica - La Alumbrera area)

The EW trending arm arrived at the Main Cordillera ~31°- 32°S at ~ 10 Ma (Pachón – Los Azules).



Maydagán et al., 2014

Miocene – pliocene metallogenic epoch

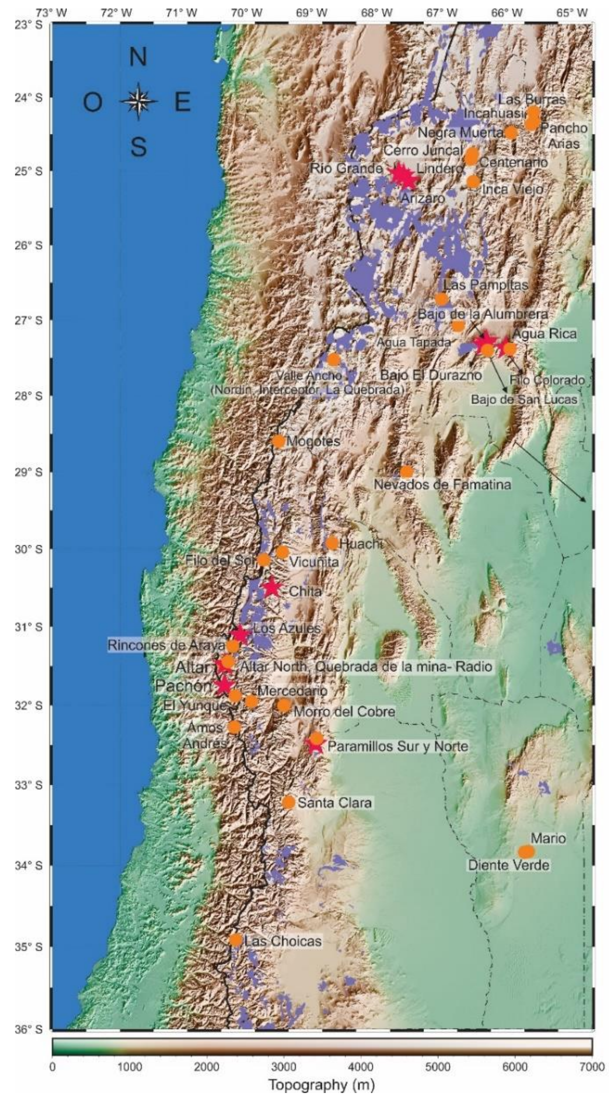
Puna: PCDs are linked to the early Miocene (~15 Ma) high-K calc-alkaline andesitic magmatism with back arc affinity. Magmas evolved under a normal thickened crust.

Flat-slab segment (arc): PCD are linked to the late Miocene calc-alkaline andesitic-dacitic magmatism. Magmas evolved under a thickened crust.

Flat-slab segment (backarc):

PCDs linked to the late Miocene high-K calc-alkaline to shoshonitic andesitic-dacitic magmatism with a geochemistry reflecting moderate shallowing.

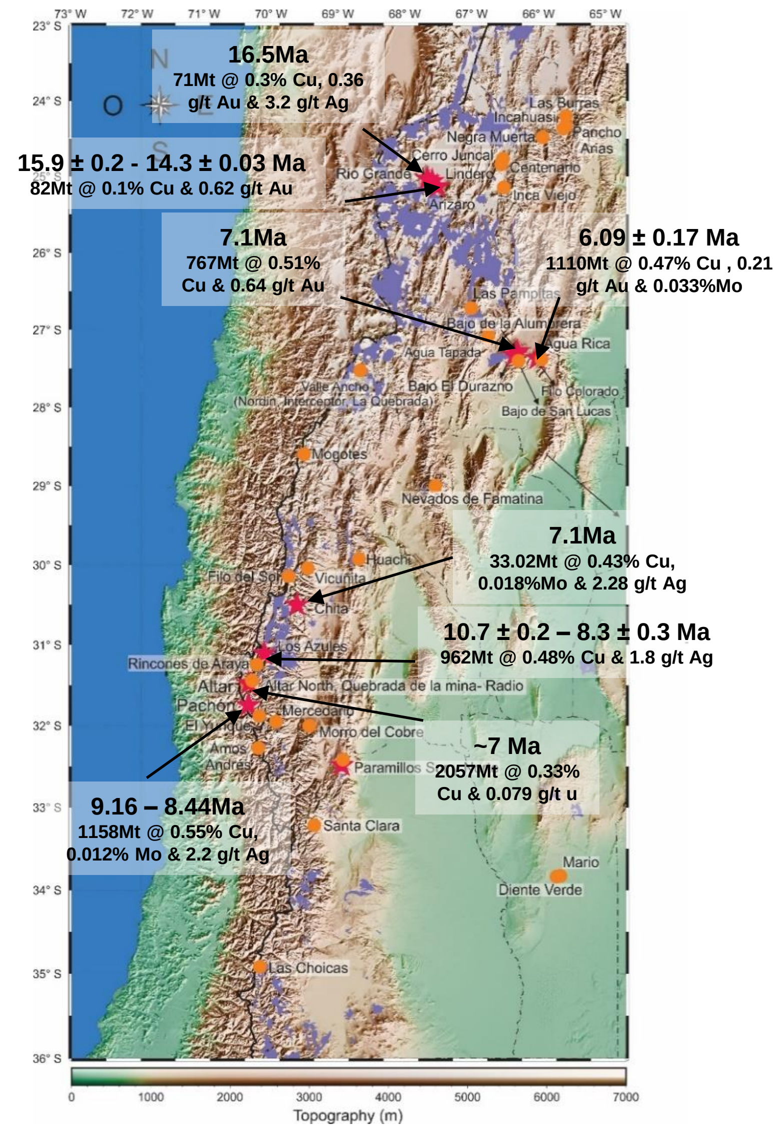
PCD linked to the early Miocene (~17-12 Ma) calc-alkaline andesitic-dacitic magmatism. Magmas evolved under a thickened crust.



Miocene – Pliocene metallogenic epoch

This is the economically preeminent metallogenic epoch because of the large number of deposits and prospects occurring in different clusters in Puna, in the Andean Cordillera and the back arc region.

Some of the PCD are world class deposits (e.g. El Pachón, Los Azules, Agua Rica and La Alumbrera).



Deposits

Prospects

Miocene – pliocene metallogenic epoch

Los Azules

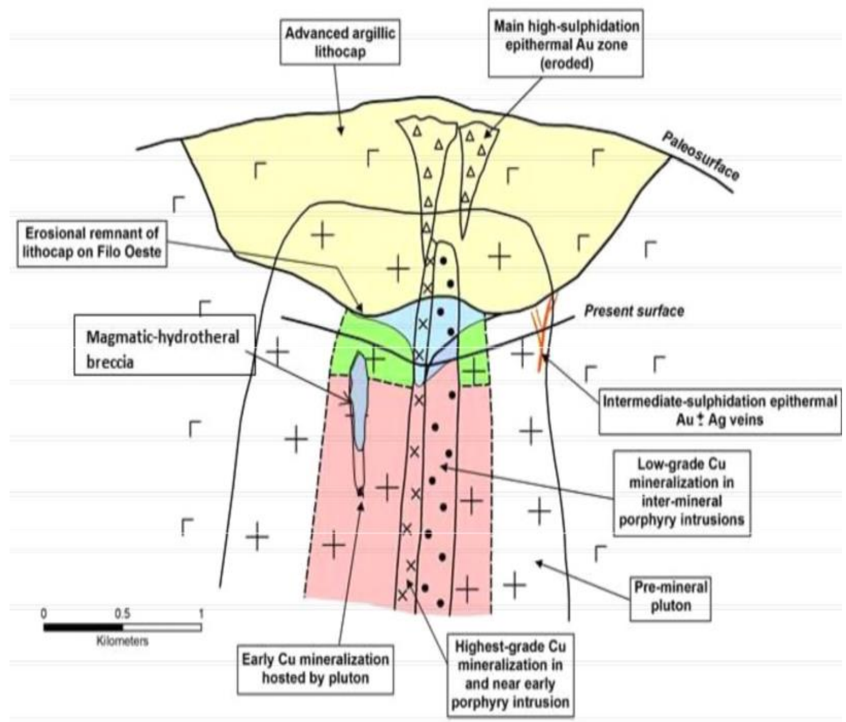
Associated to porphyritic quartz diorite dikes (9.2 Ma ± 0.2 Ma) intruding a quartz diorite pluton (10.7 ± 0.2 Ma).

Chlorite-magnetite alteration with chalcopyrite in the upper levels grading into potassic alteration (K-feldspar + biotite) with chalcopyrite and bornite at depth.

Intermineral porphyry dikes and magmatic-hydrothermal breccias.

Late sericitic alteration with pyrite + chalcopyrite.

High-grade enrichment blanket with chalcocite and covellite

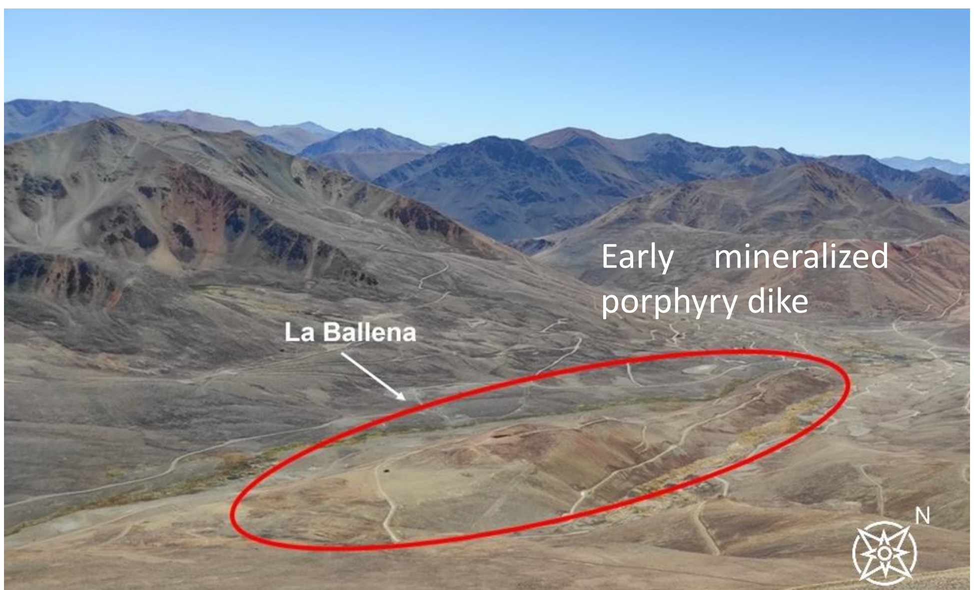


7.8 ± 0.04 Ma (Re/Os in molybdenite).

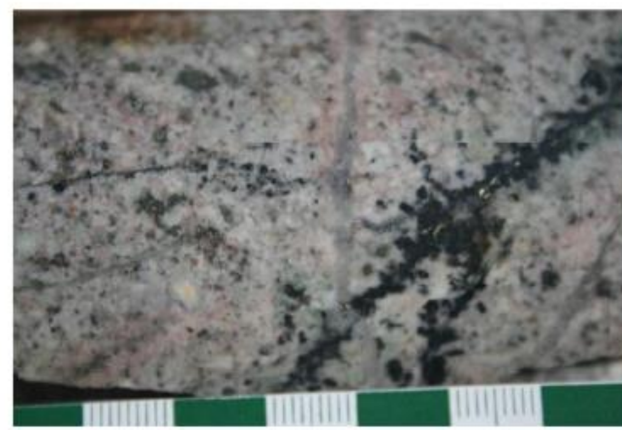
Miocene – pliocene metallogenic epoch

Los Azules

A PFS Cu project with 1235.3 Mt @ 0.4% Cu (indicated), 10 Moz Ag and 0.46 Moz Au (indicated), and 4509.3 Mt @ 0.31% Cu (inferred)



Quartz-anhydrite-chalcopyrite A vein with a K-feldspar halo



Biotite-chalcopyrite EDM vein cut by a quartz –chalcopyrite A vein.

Miocene – pliocene metallogenic epoch

Farallón Negro mining district

Stage 1 (**9.5–8.0 Ma**): Mainly basaltic - andesitic volcanism, El Durazno porphyry

Enriched} mantle-derived magma

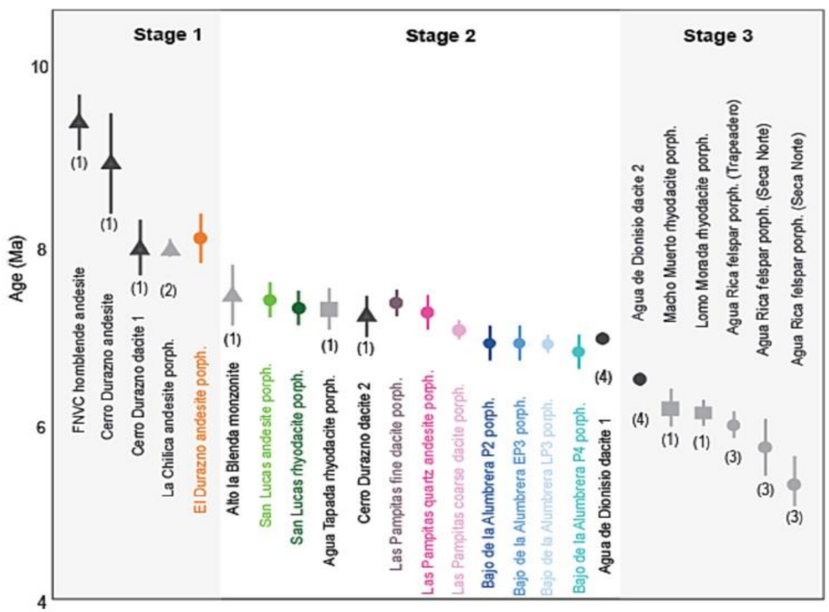
Localized extension

Stage 2 (**7.5–6.8 Ma**): Bajo de la Alumbrera, San Lucas, Las Pampitas porphyries

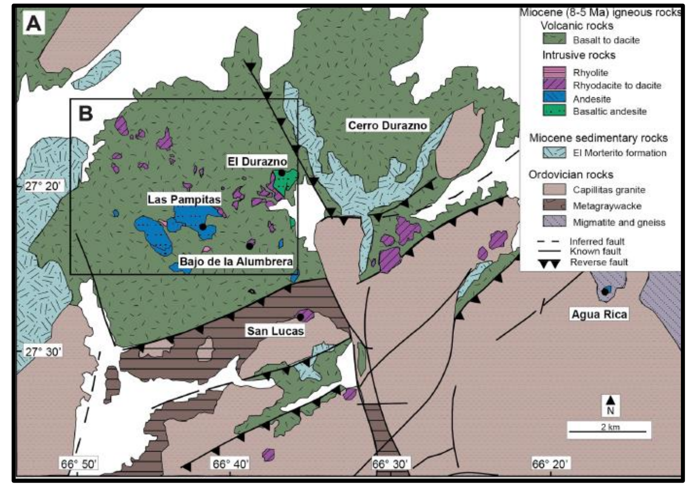
Mixed mantle-derived and supracrustal source

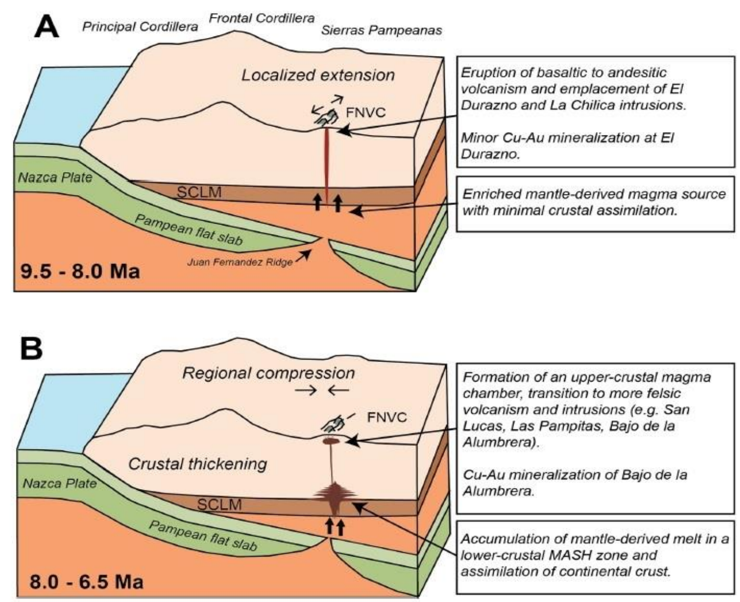
Regional compression - - peak of shallowing

Stage 3 (**6.5–5 Ma):** Agua Rica - Trampeadero and Seca Norte porphyries



Ince et al., 2023





Miocene – pliocene metallogenic epoch

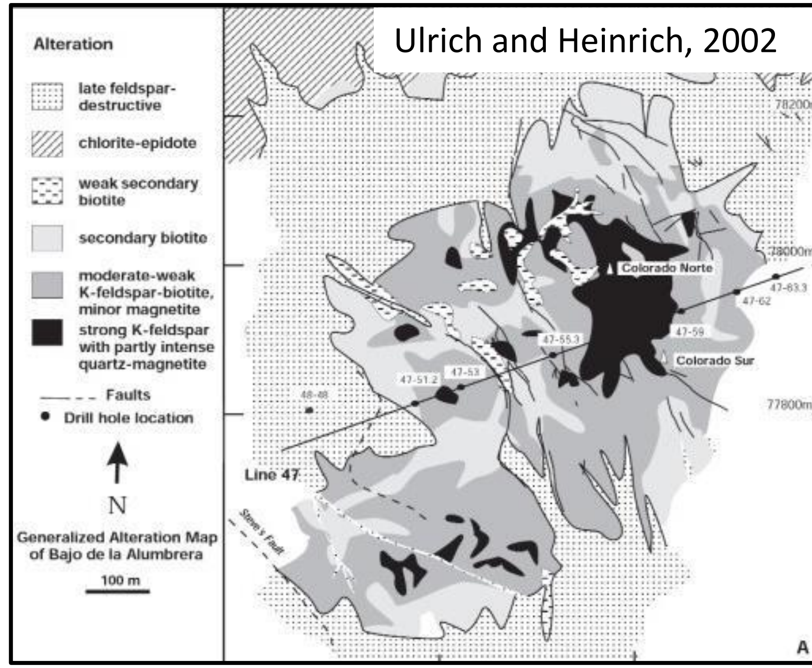
Bajo de la Alumbrera

Centered in a cluster of small porphyry stocks (P2, EP3, LP3, P4) emplaced into andesites of FNVC.

The mineralizing event is associated with porphyries P2 and EP3.

Strong potassic alteration (quartz-magnetite) core surrounded by a moderate potassic alteration (biotite - K-feldspar - quartz ± magnetite ± anhydrite) halo and external propylitic alteration.

Phyllic-argillic alteration (sericite + quartz + pyrite ± kaolinite ± illite) overprinted the potassic and propylitic zones.



Ulrich and Heinrich, 2002

Chalcopyrite + Au + bornite + pyrite + molybdenite associated to potassic alteration

7.089 ± 0.025 Ma (Re/Os in molybdenite)

Miocene – Pliocene metallogenic epoch

Bajo de la Alumbrera

A world class Cu-Au deposit mined between 1997 and 2020

Historic mineral resources of 767 Mt @ 0.51% Cu and 0.64 g/t Au

El Durazno (2 km north of Alumbrera) with 93 Mt (measured + indicated) @ 0.15% Cu and 0.41 g/t Au, and 56 Mt (inferred) @ 0.14% Cu and 0.33 g/t Au was mined in 2015 - 2018.

Miocene – Pliocene metallogenic epoch

Agua Rica

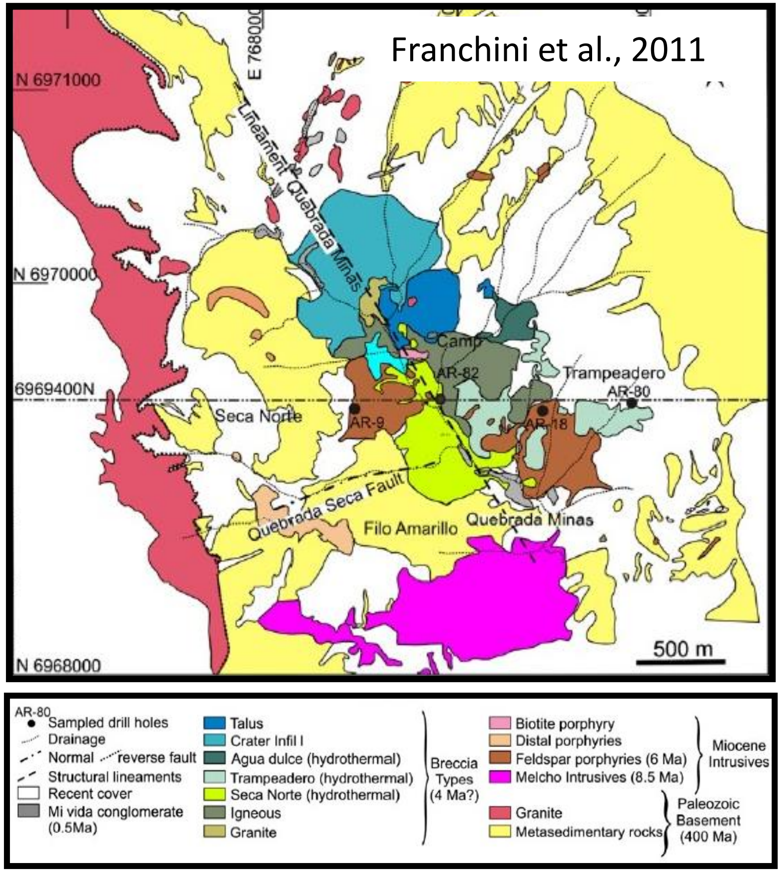
Premineral syenodiorite - monzonite intrusions.

Synmineral feldspar porphyries (6.09 ± 0.17 Ma to 5.41 ± 0.25 Ma) with potassic alteration (biotite + K-feldspar + quartz) and chalcopyrite + molybdenite ± bornite mineralization.

Hydrothermal breccias and phyllic alteration with molybdenite in veins.

Telescoped advanced argillic alteration (4.88 ± 0.08 Ma, K/Ar in alunite) with covellite ± enargite ± Pb/Bi sulfosalts ± Au, Ag.

Supergene enrichment with covellite ± digenite (3.94 ± 0.05 Ma, K/Ar in alunite).



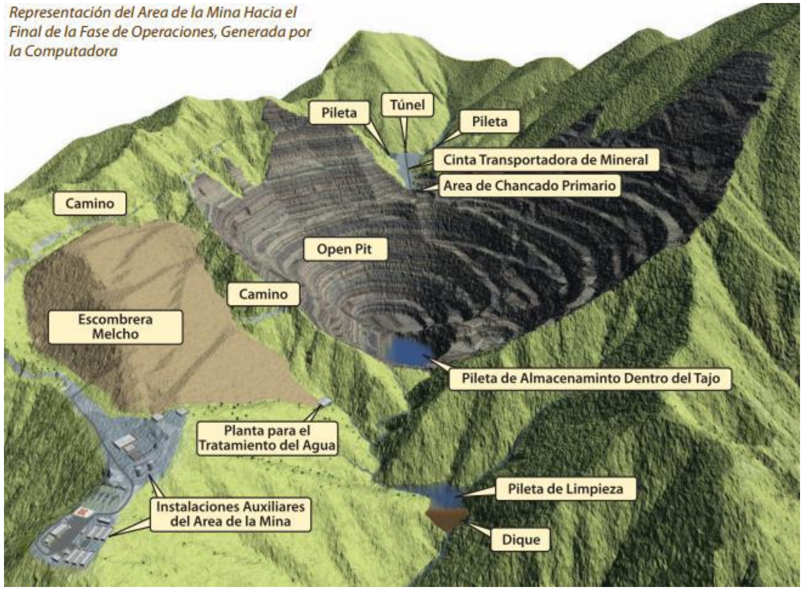
5.61 ± 0.03 Ma
(Re/Os in molybdenite)

Miocene – Pliocene metallogenic epoch

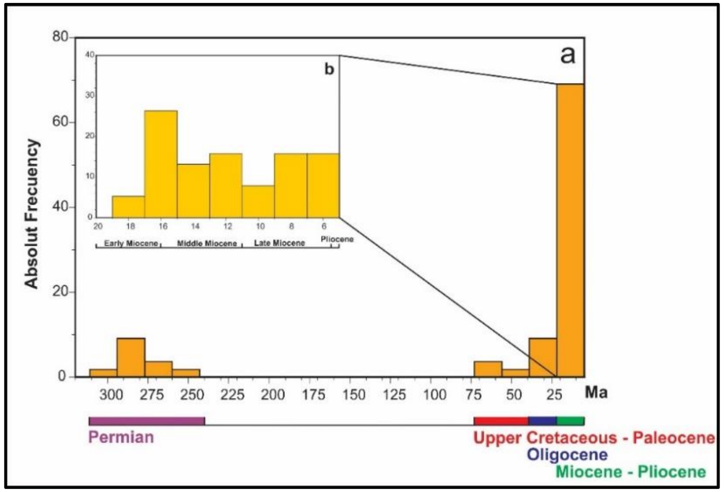
Agua Rica

A Cu-Au project at PFS status with 1110 Mt @ 0.47% Cu, 0.21 g/t Au and 0.033% Mo (measured + indicated) and 651 Mt at 0.34% Cu, 0.12 g/t Au and 0.034% Mo (inferred)

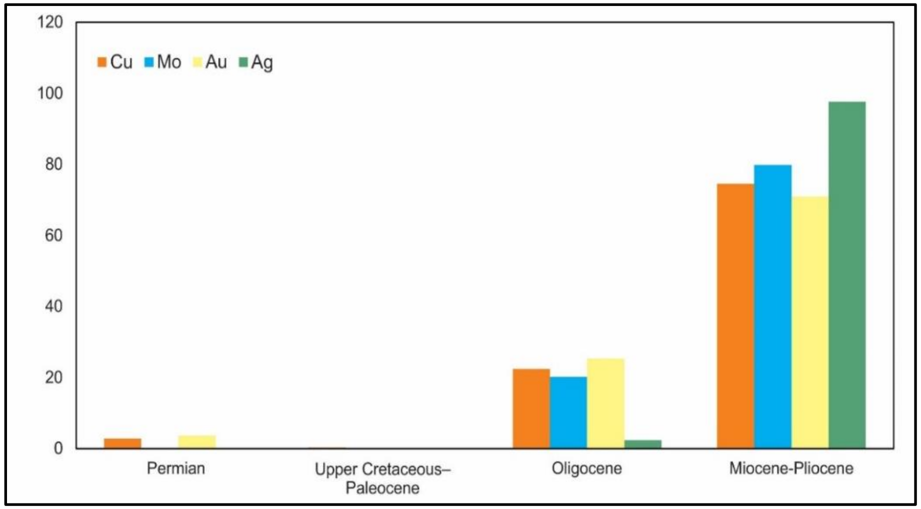
Mara project (Minera Agua Rica LLC Argentina and Minera Alumbrera Ltd. https://www.proyectomara.com.ar/



Metallogenic epoch and metal endowment



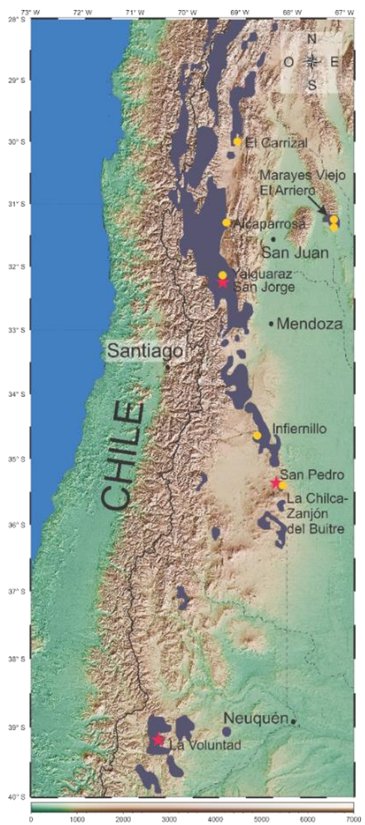
Age distribution of the mineralizing magmatism

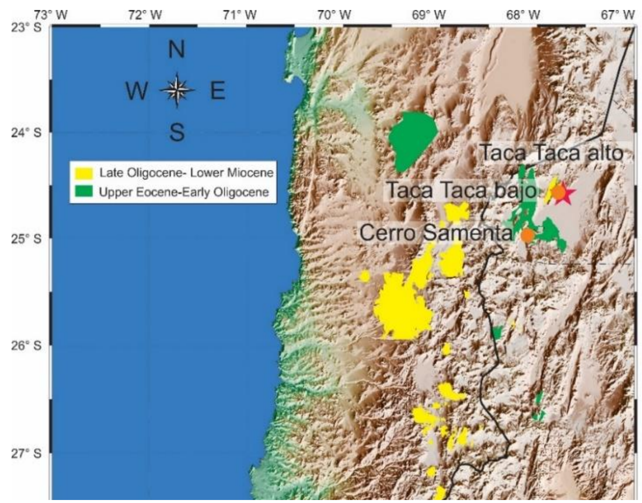


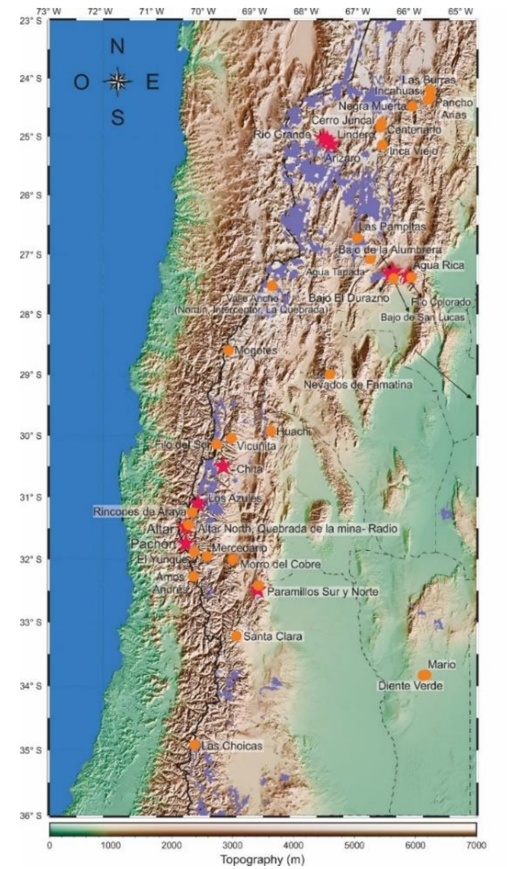
Distribution (%) of metals by metallogenic epoch

Geological controls of PCDs

- Arc migration/expansion is recorded in Argentina in the Gondwanan magmatism, in the Oligocene magmatism in Puna and in the Miocene magmatism in Puna and the Pampean flat-slab segment

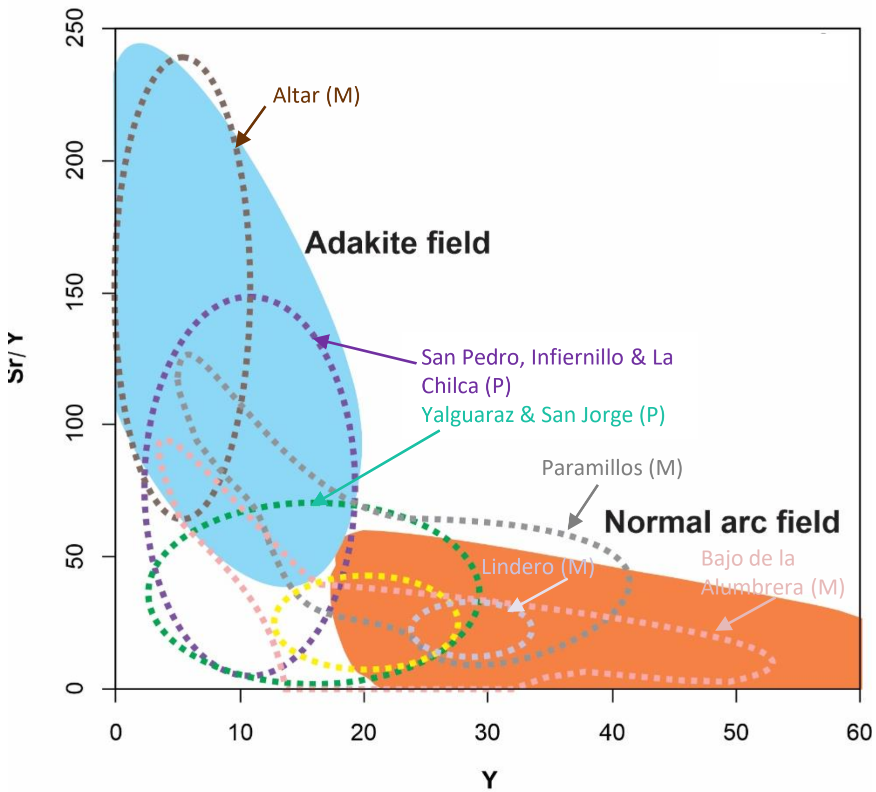


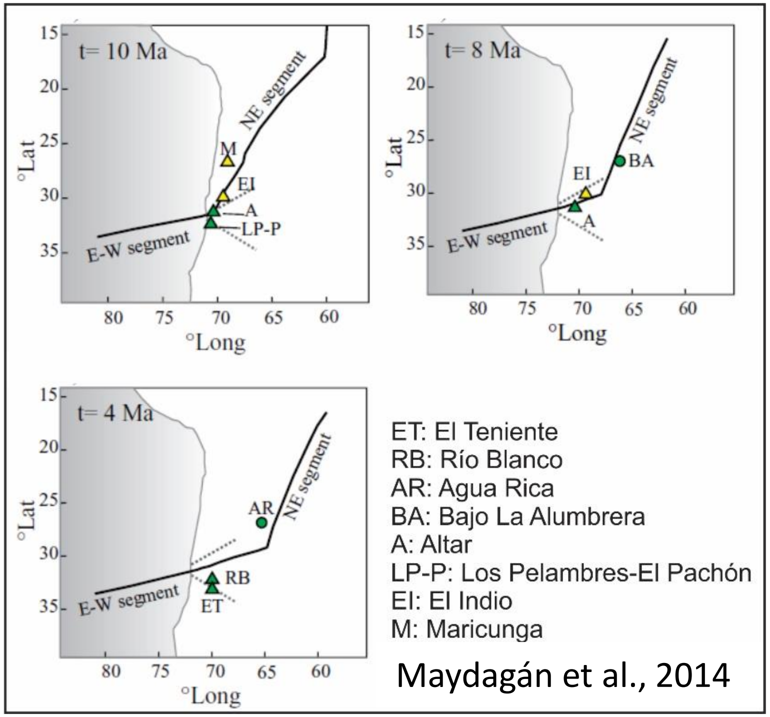




Geological controls of PCDs

- The Permian mineralizing magmatism displays adakitic signature whereas the Miocene mineralizing magmatism shows variable adakitic signatures.
- The emplacement of some of the high productive Miocene PCDs in Argentina coincides with the passage of an aseismic ridge.

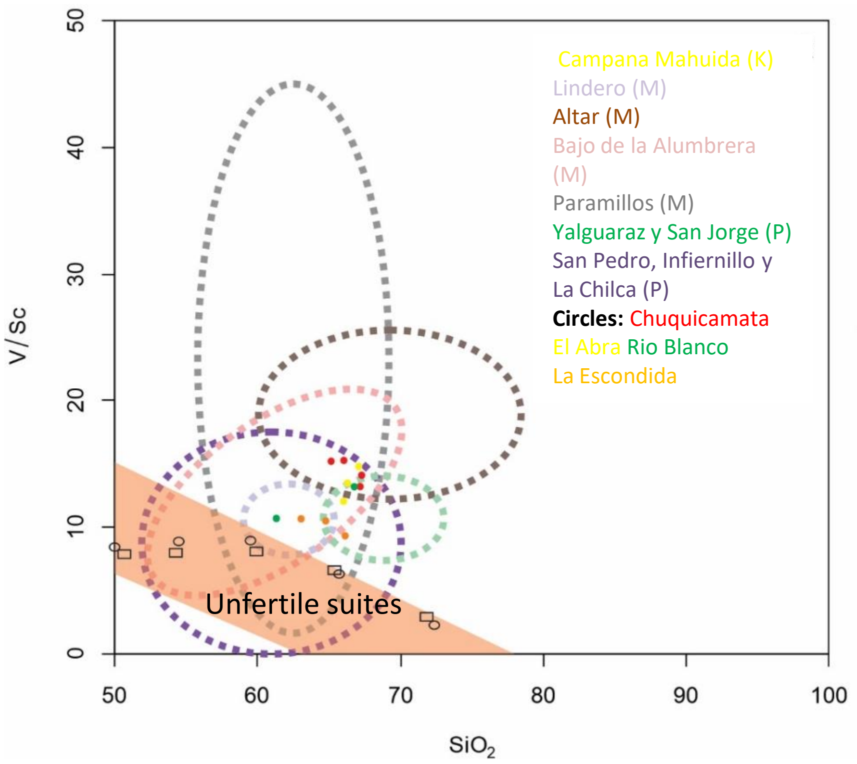


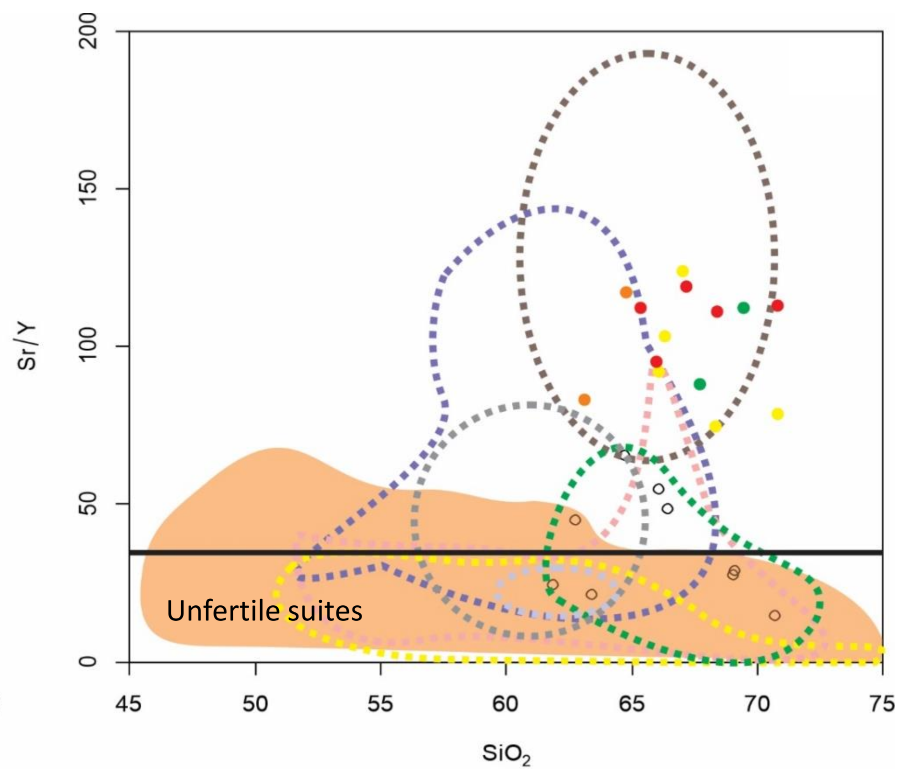


Maydagán et al., 2014

Geological controls of PCDs

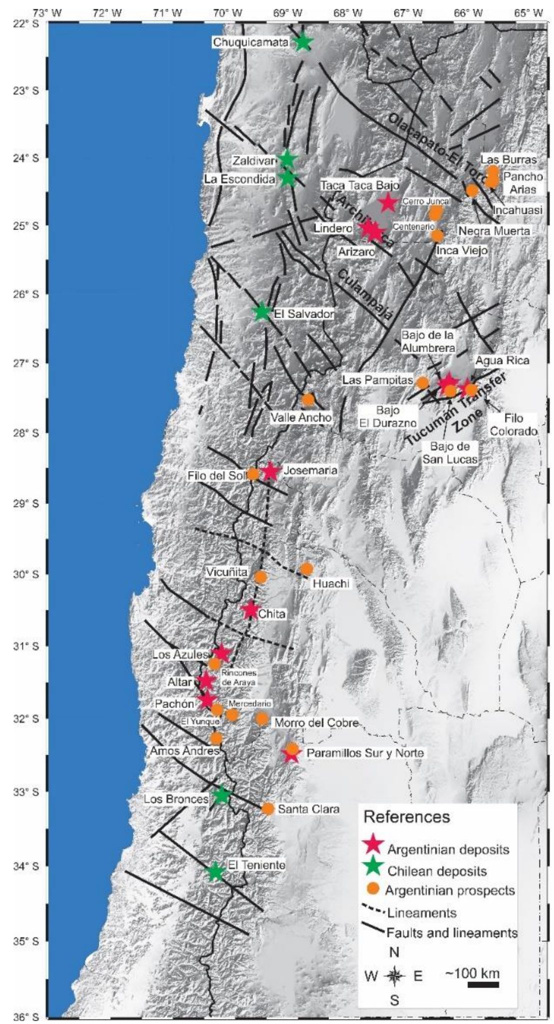
➢ The Permian and Miocene mineralizing magmatism from flat-slab settings with associated crustal thickening show higher V/Sc than Cenozoic barren volcanic suites and high Sr/Y (>35 distinctive of fertile suites).





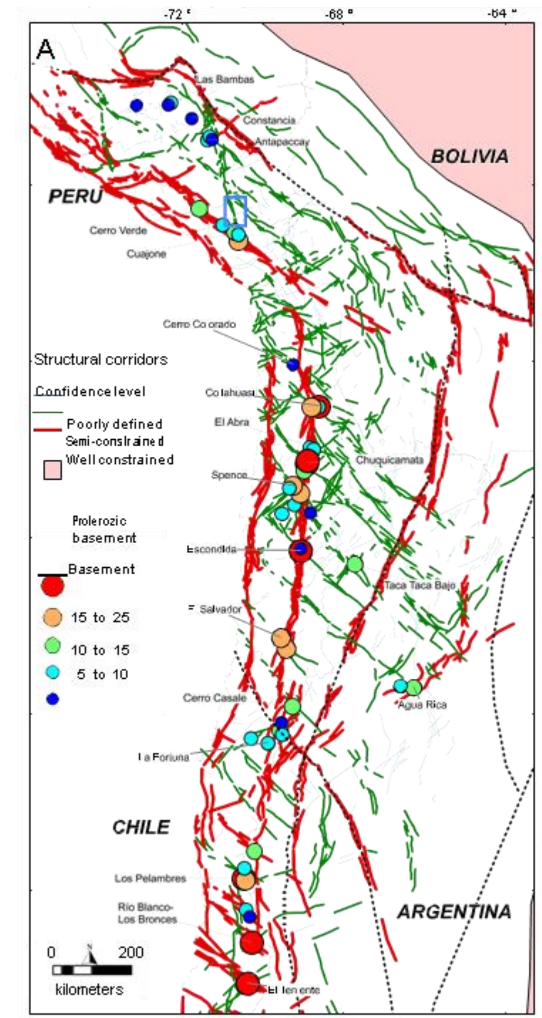
Geological controls of PCDs

- Intersections between WNW lineaments and arc-parallel structures operated as first order control in PCDs emplacement.
- WNW lineaments are deep crustal pre-Andean structures reactivated during the Cenozoic which provided pathways for magma ascent.
- Link between PCDs and waning orogenic settings.



Chernicoff et al., 2002; River Herrera et al., 2012; Oriolo et al., 2014

Farrar et al., 2023



Geological controls of PCDs

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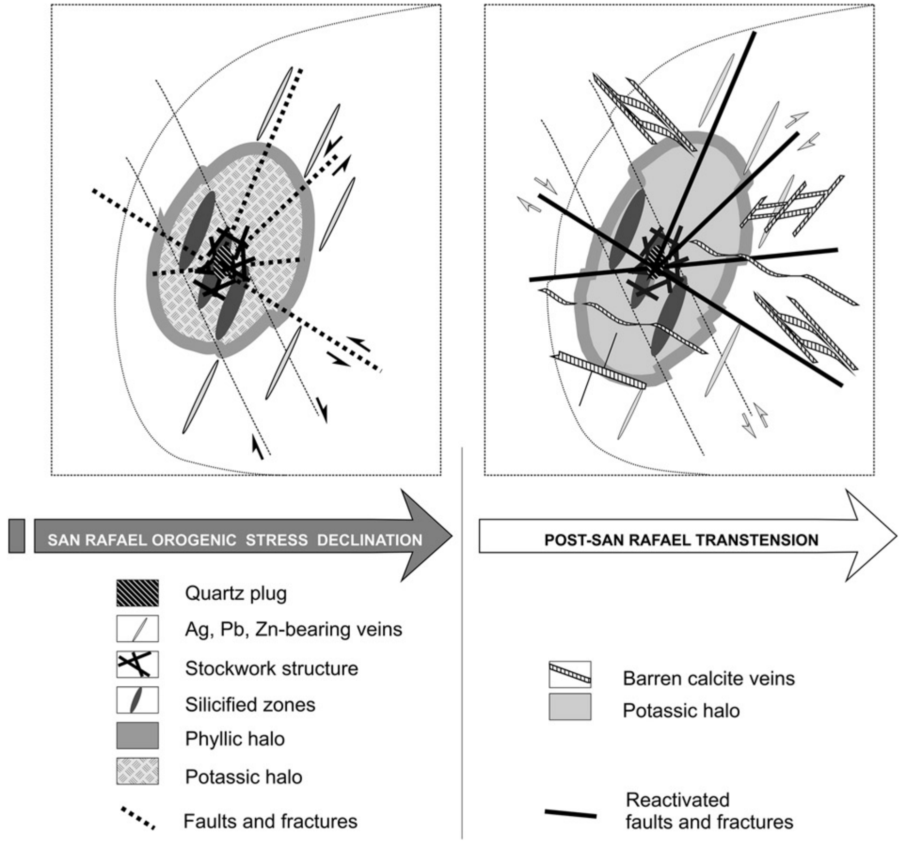
Japas et al., 2013

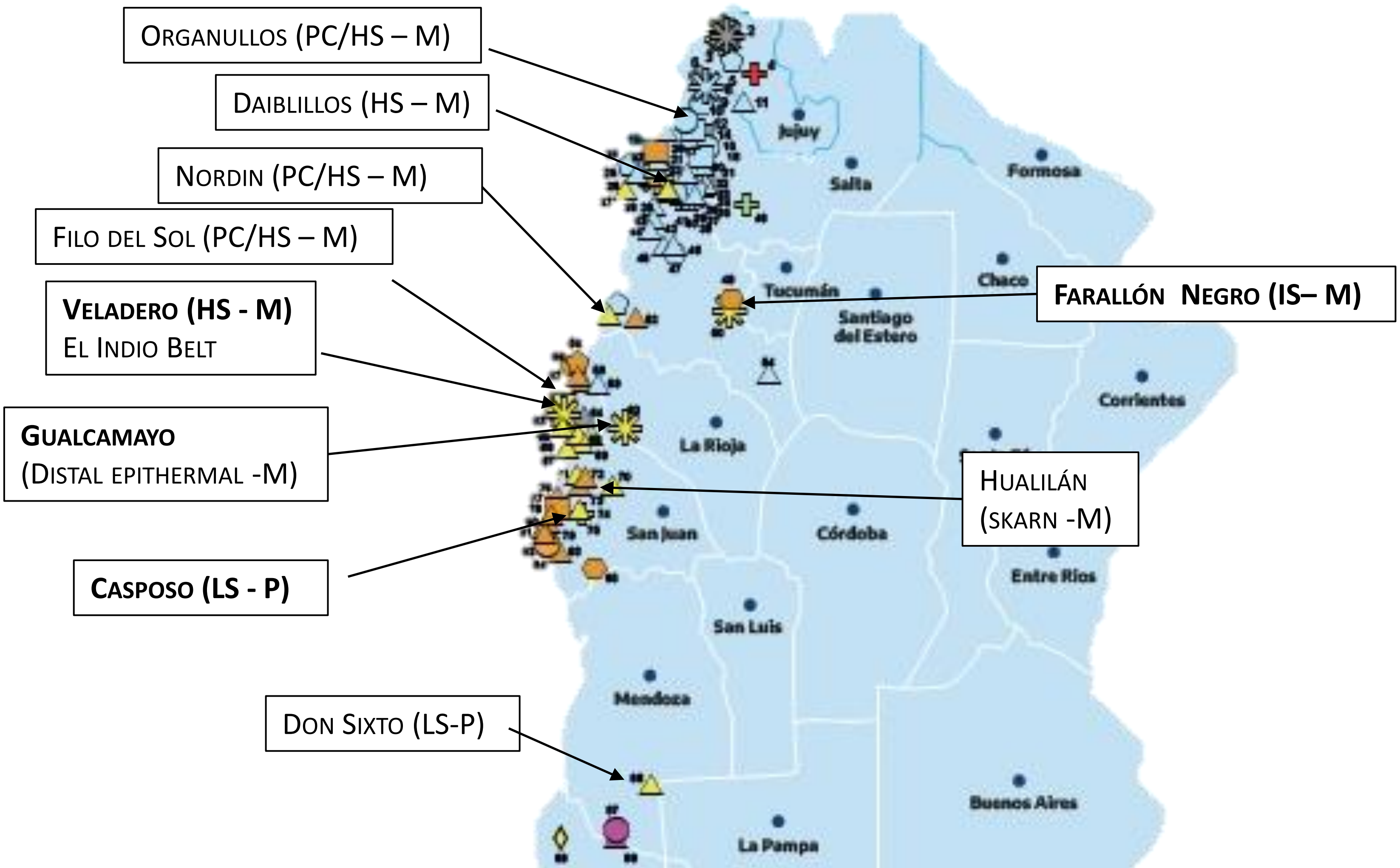


Change in the tectonic regime

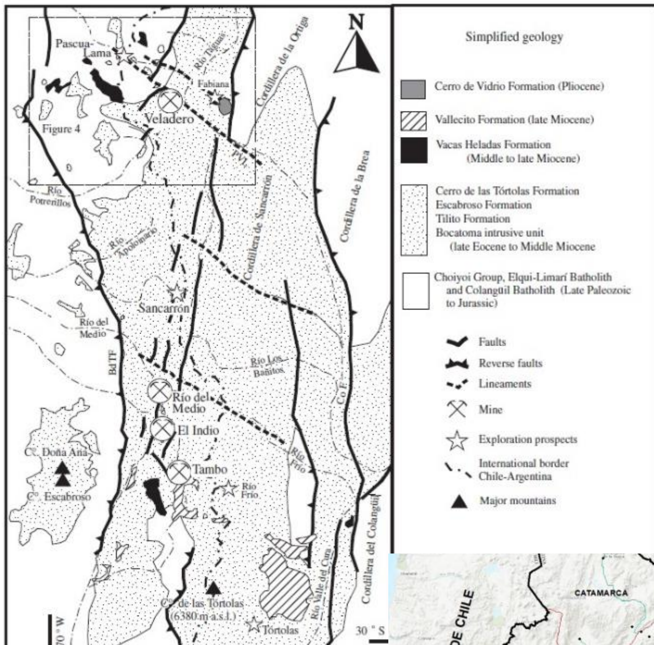
NNE tensional to shear extensional fractures, and WNW and NNW transpressional ss

NW tensional and WNW and NNW transtensional ss

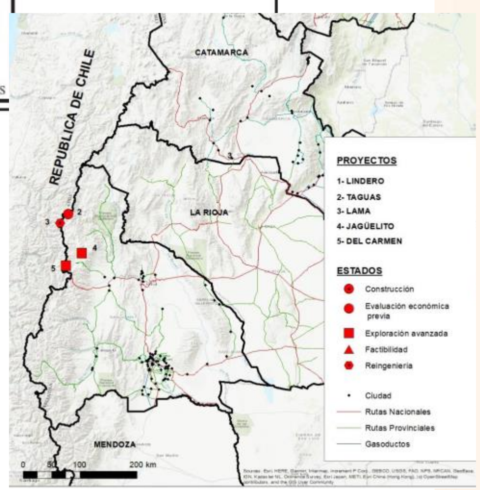
Au epithermal deposits in the Central Andes

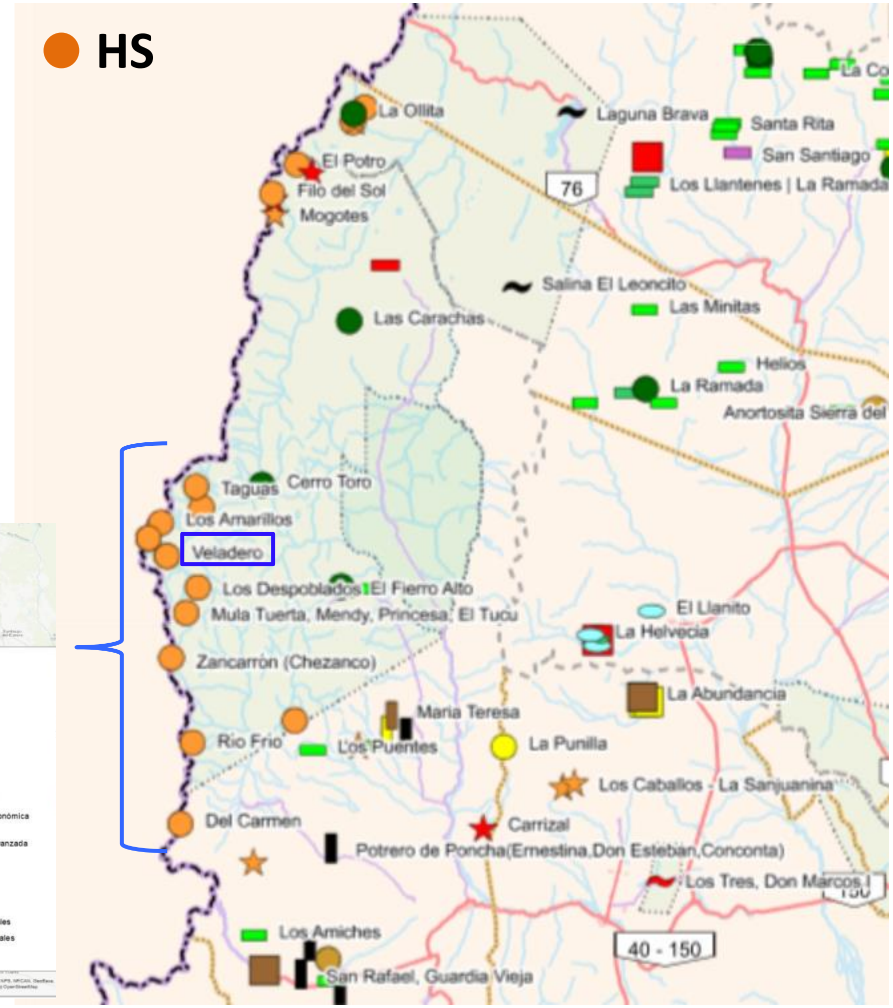


HS Au deposits - El Indio Belt

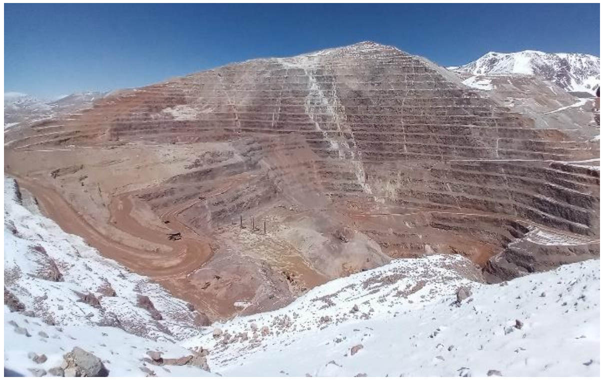


Charchaflié et al., 2007





HS Au deposits - El Indio Belt



Veladero

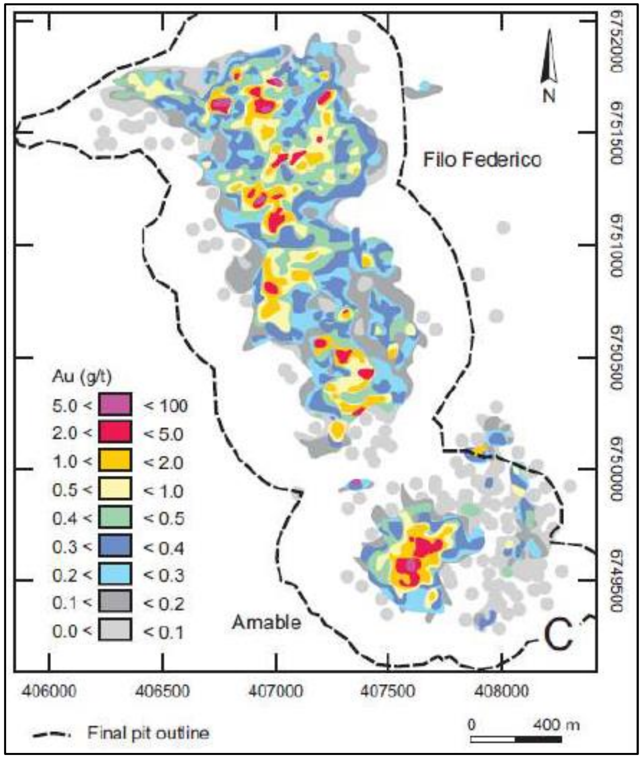
Operating since 2005 (Barrick-Shandong).

10,442.783 oz Au & 19,826.769 oz Ag (12/2022).

Related to a Miocene diatreme-dome complex.

Disseminated mineralization (10.9-10 Ma Ar/Ar in alunite).

Au, calaverite, petzite, pyrite (chalcopyrite, bornite, sphalerite, molibdenite).



HS Au deposits - El Indio Belt

Lama

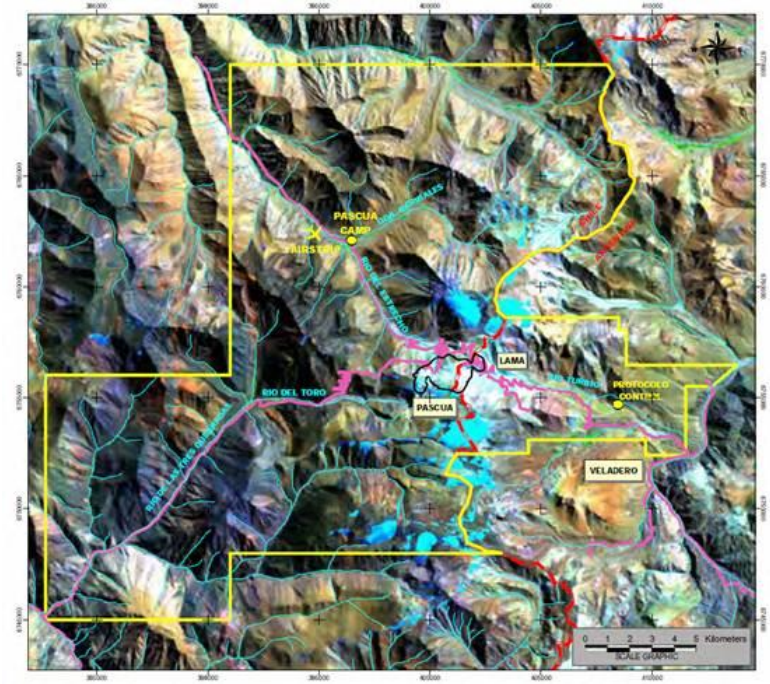
FS status.

Permian volcanic host rocks intruded by Miocene (8.8 Ma) dioritic dikes.

Veins, breccias (9 Ma, K/Ar in alunite)

Pyrite, enargite, Au, acantite, muthmannite, proustite, pyrargirite.

21.3 Moz of measured and indicated Au resources (2019)



Resources and Reserves

RESERVES	Tonnage (Mt)	Grade			Metal Content*	
		Au (g/t)	Ag (g/t)	Cu (%)	Au (oz)	Ag (oz)
Measured	42,81	1,86	57,21	0,10	461,520	27,561,450
Indicated	391,73	1,49	52,22	0,08	3,380,90	230,201,300
Inferred	15,4	1,74	17,83	0,05	155,340	3,090,500

* the metal content expressed corresponds to the portion on the Argentinean side of the project (Lama).
Source: Technical Report 2011-03-31. Barrick Gold Corp.

https://www.barrick.com/English/operations

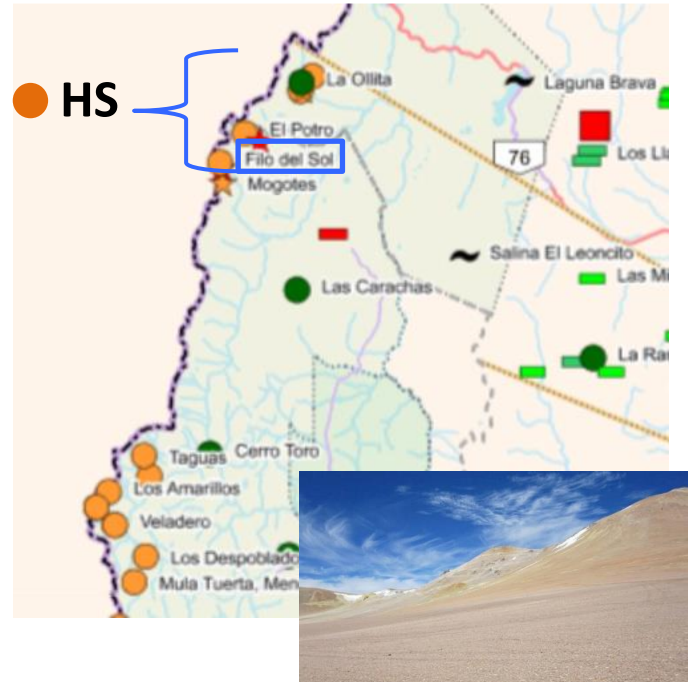
HS Au deposits – Vicuña belt

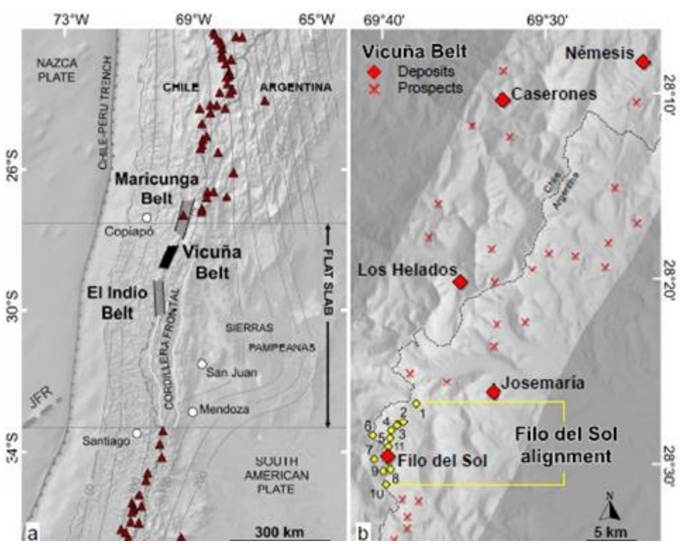
Filo del sol (Lundin-BHP)

Middle Miocene (~15 Ma) dioritic dikes.

Porphyry Cu-Au and telescoped epithermal Cu-Au-Ag mineralization (~14.7 to 14.4 Ma Re/Os in molybdenite).

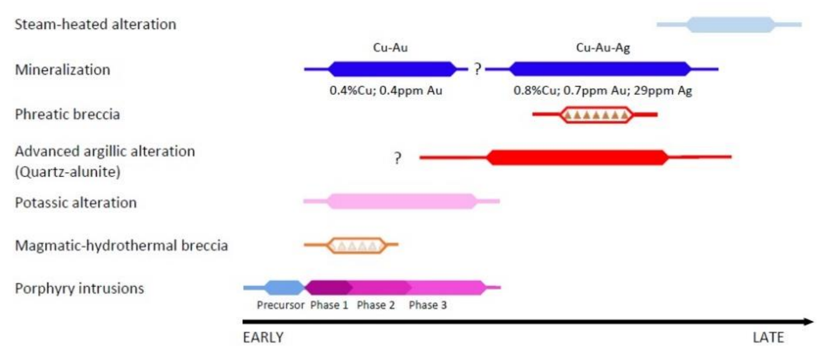
425.1 Mt (indicated) + 175.1 Mt (inferred) @ 0.33% Cu & 0.32 ppm Au.





1) Gemelos
2) Maranceles
3) La Bonita
4) El Viejo,
5) Refugio,
6)Ventana
7) Los Colorados
8) Vicuna,
9)Tamberias
10)Flamenco
11) Aurora

Perelló et al., 2023



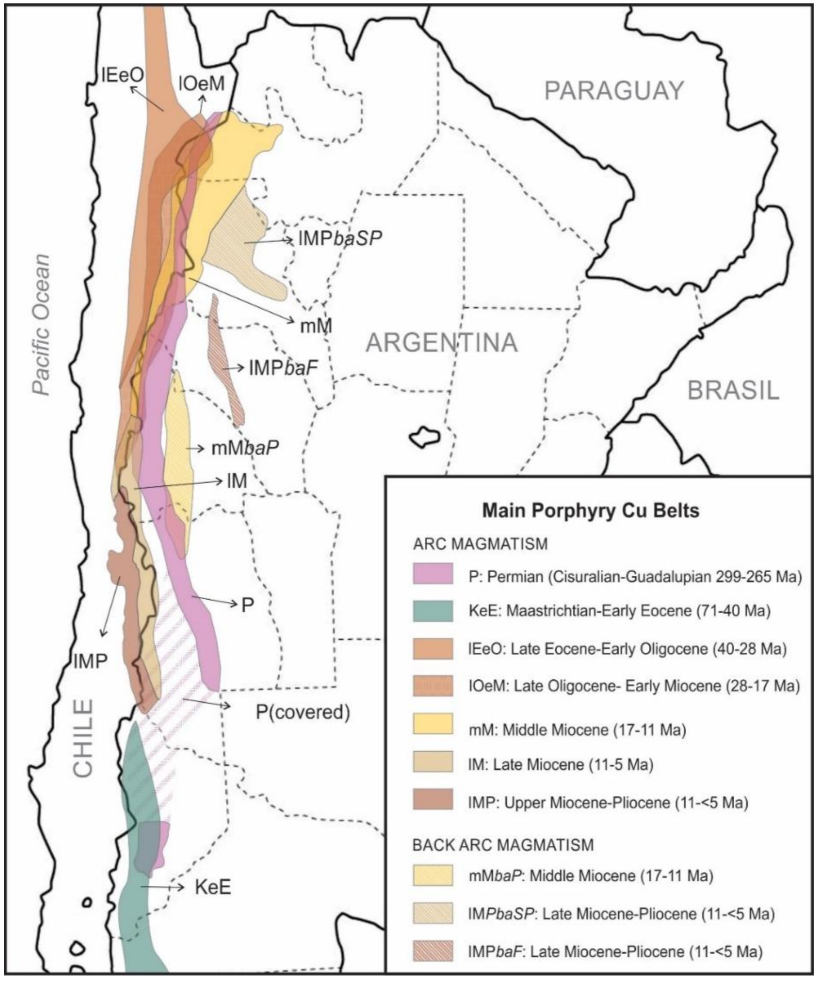
PCDs metallogenic belts

Global Mineral Resource Assessment Project (U.S.G.S. Survey, Cunningham et al., 2008)

Probabilistic estimate of the number of undiscovered mineral deposits that may be present within identified tracts of land in the Andean region.

Allowed to identify areas that have potential for undiscovered mineral resources using geology, geochemistry and geophysics available information, and previous exploration results in the context of quantitative statistical models.

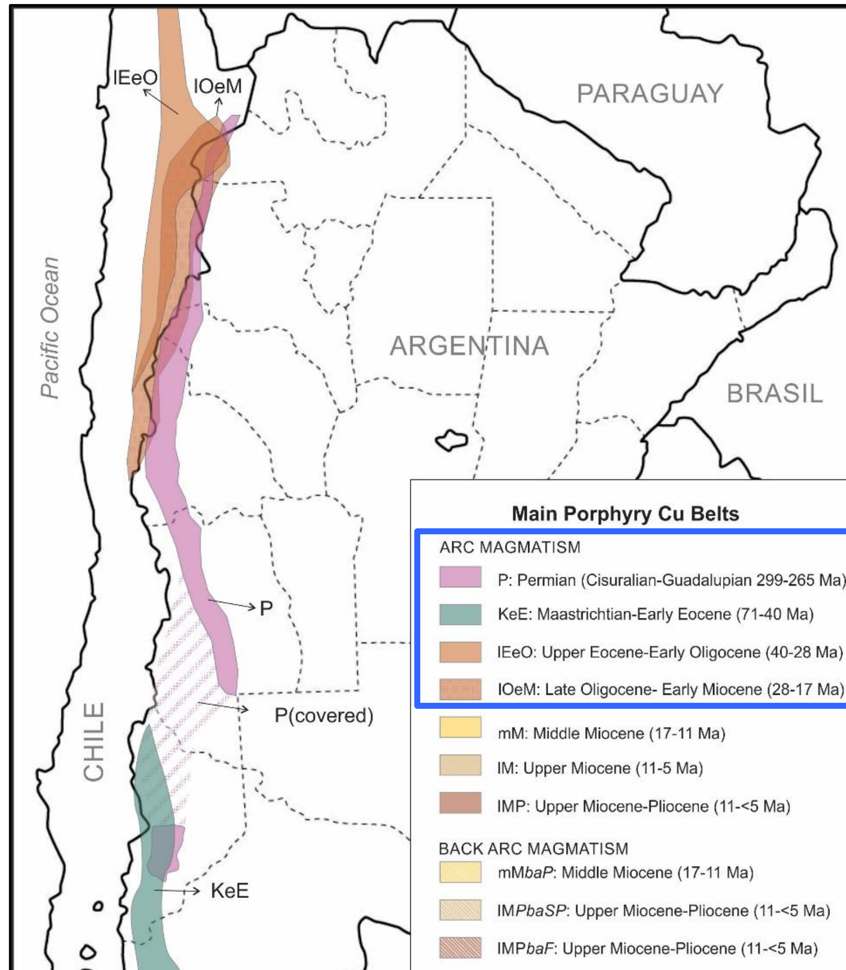
The tracts are areas in which the geology is permissive for PCDs.



PCDs metallogenic belts

Available geochronology, tectono-magmatic scenario, favorability of the magmatic arcs, and permissive defined tracts

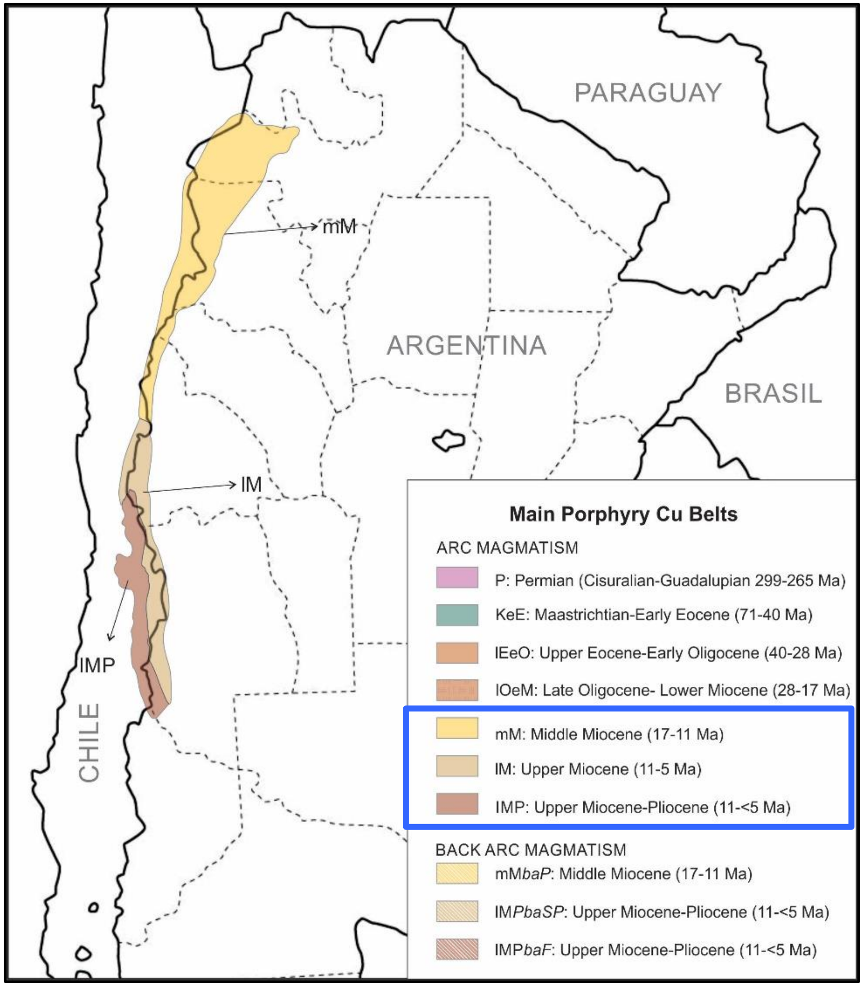
- ✓ Permian Puna-Frontal Cordillera /Neuquén basement belt (P) - San Jorge
- ✓ Upper Cretaceous–Eocene Neuquen belt (KeE) – Campana Mahuida.
- ✓ Late Eocene-Early Oligocene Puna belt (lEeO), mostly in Chile –Taca.
- ✓ Late Oligocene-Early Miocene Puna-Frontal Cordillera belt (lOeM) – Josemaría



PCDs metallogenic belts

Available geochronology, tectono-magmatic scenario, favorability of the magmatic arcs, and permissive defined tracts

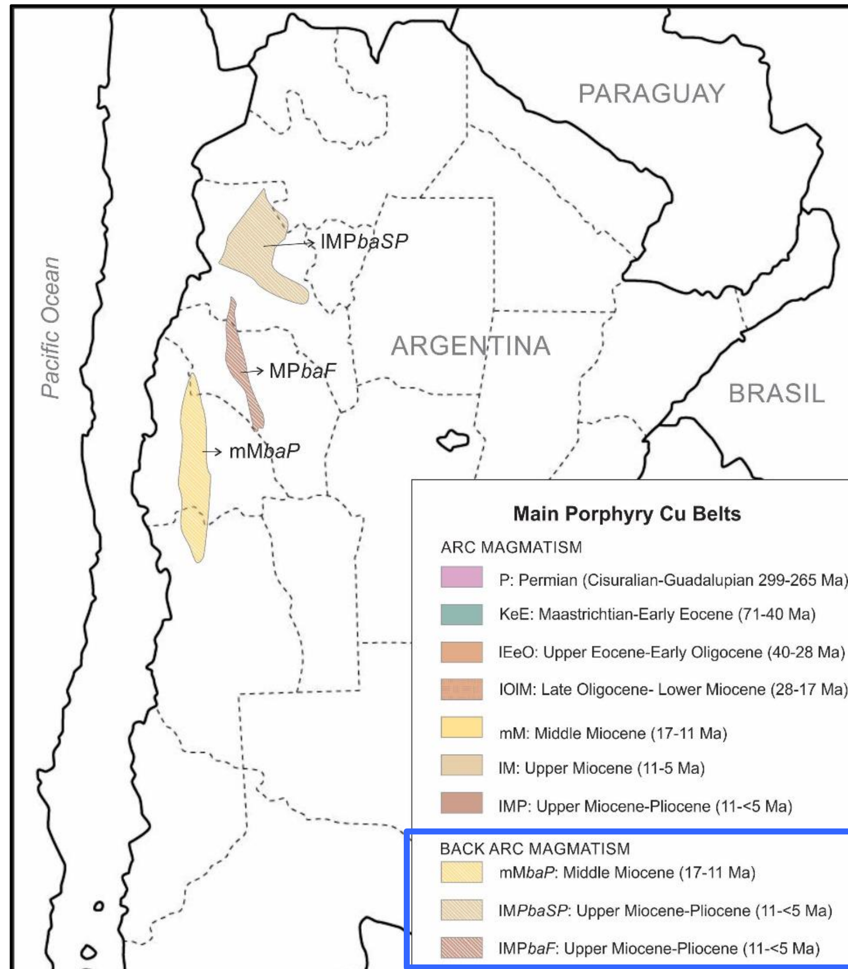
- ✓ Middle Miocene Puna-Frontal Cordillera belt (mM)
- ✓ Late Miocene Cordillera belt (lM) – Los Azules
- ✓ Late Miocene-Pliocene Cordillera belt (lMP), mostly in Chile.



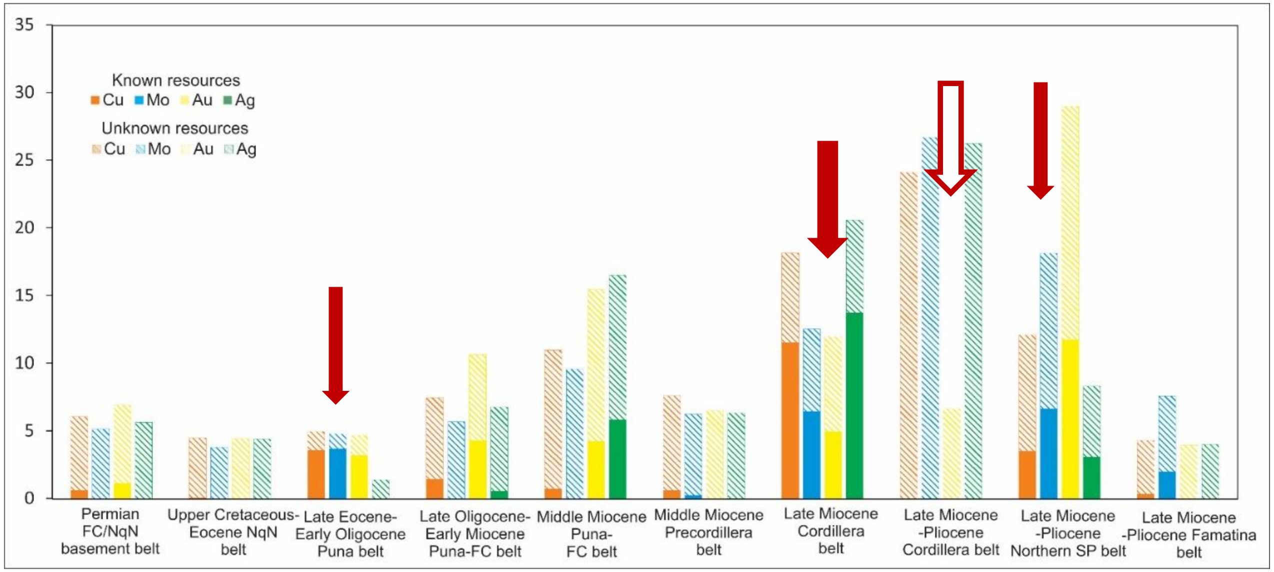
PCDs metallogenic belts

Available geochronology, tectono-magmatic scenario, favorability of the magmatic arcs, and permissive defined tracts

- ✓ Late Miocene-Pliocene Northern Sierras Pampeanas belt (lMPbaSP) – La Alumbrera.
- ✓ Late Miocene-Pliocene Famatina belt (lMPbaF).
- ✓ Middle Miocene Precordillera belt (mMba).



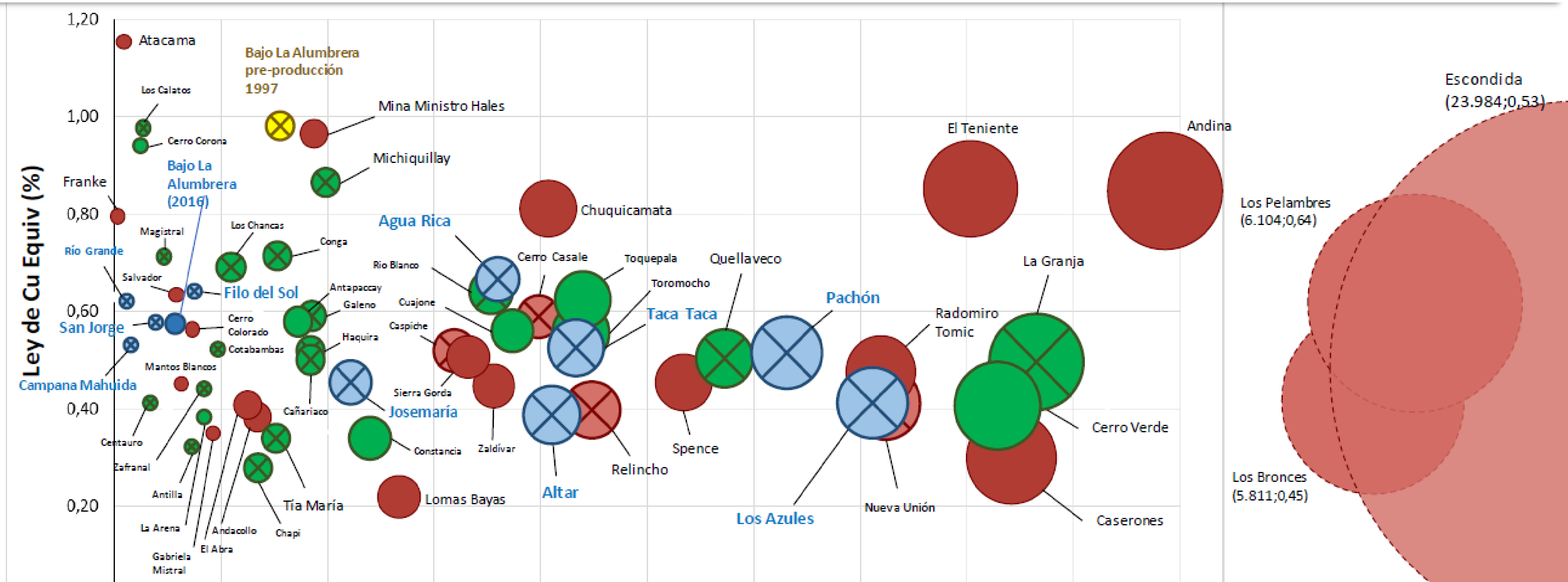
PCDs resources

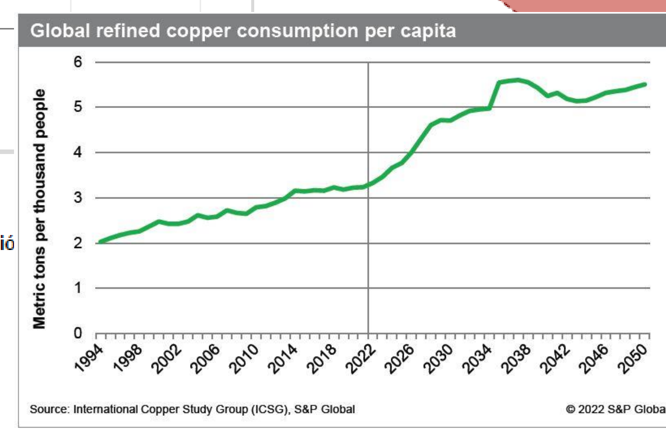


EMINERS Version 3.0, Economic Mineral Resource Simulator (Duval, 2012)

USGS TRACT	BELT	ID	AREA (km²)	TOTAL KNWON RESOURCES				UNDISCOVERED RESOURCES				TOTAL ENDOWMENT			
				Cu (Mt)	Mo (Mt)	Au (t)	Ag (t)	Cu (Mt)	Mo (Mt)	Au (t)	Ag (t)	Cu (Mt)	Mo (Mt)	Au (t)	Ag (t)
SA16a/bPC	Permian Puna-Frontal Cordillera-Neuquen basement belt	P	91,000	2.07	0.00	79.31	0.00	18.00	0.46	430.00	5,800.00	20.07	0.46	509.31	5,800.00
SA15PC	Upper Cretaceous–Early Eocene Neuquen belt	KeE	80,000	0.20	0.00	0.00	0.00	15.00	0.36	340.00	4,700.00	14.80	0.34	326.00	4,500.00
SA11PC	Late Eocene-Early Oligocene Puna belt	lEeO	2,429	11.90	0.33	234.14	0.00	4.50	0.10	110.00	1,400.00	16.40	0.43	344.14	1,400.00
SA12PC	Late Oligocene-Early Miocene Puna-Frontal Cordillera belt	lOeM	13,000	4.70	0.00	313.79	563.20	20.00	0.51	470.00	6,400.00	24.70	0.51	783.79	6,963.20
New 13a/cPC	Middle Miocene Puna-Frontal Cordillera belt	mM	59,500	2.38	0.00	310.99	5,976.19	34.00	0.86	830.00	11,000.00	36.38	0.86	1.140.99	16,976.19
SA14aPC	Middle Miocene Precordillera Belt	mMba	21,721	2.10	0.02	0.00	0.00	21.00	0.52	480.00	6,500.00	25.20	0.56	480.00	6,500.00
SA13bPC	Late Miocene Cordillera belt	lM	30,000	38.20	0.58	363.72	14,185.32	22.00	0.55	520.00	7,000.00	60.20	1.13	883.72	21,185.32
SA14bPC	Late Miocene-Pliocene Cordillera belt	lMP	3,800	0.00	0.00	0.00	0.00	80.00	2.40	490.00	27,000.00	80.00	2.40	490.00	27,000.00
SA14cPc	Late Miocene-Pliocene Northern Sierras Pampeanas belt	lMPbaSP	24,084	11.56	0.59	858.71	3,152.00	17.00	0.44	390.00	5,400.00	40.12	1.63	2,140.72	8,552.00
SA14dPC	Late Miocene-Pliocene Famatina belt	lMPbaF	57,790	1.10	0.18	0.00	0.00	12.00	0.32	290.00	4,100.00	14.20	0.68	290.00	4,100.00
TOTAL			**383,324**	**74.21**	**1.70**	**2,160.66**	**23,876.71**	**243.50**	**6.52**	**4,350.00**	**79,300.00**	**332.07**	**9.00**	**7,388.67**	**102,976.71**

Porphyry Cu-Au mineral systems in Argentina – the next exploration frontier?

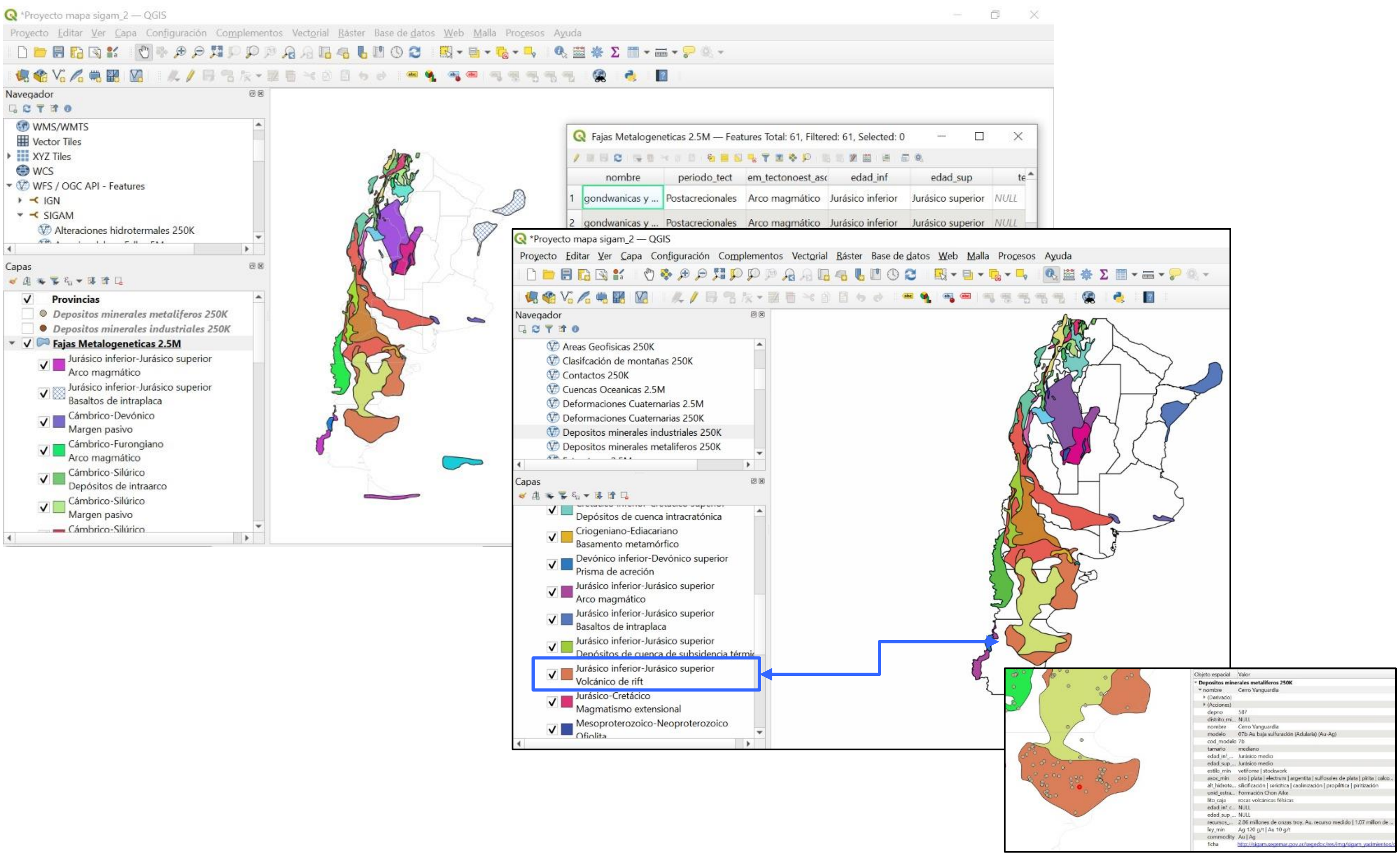




SIGAM

(Mining, Environmental and Geological Information System)

https://sigam.segemar.gov.ar/




THANK YOU!
narubinstein@gmail.com