

Genesis of the Picachos Cu-(Ag) manto-type deposit, North-Central Chile: a multidisciplinary approach

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INTRODUCTION

The Coastal Cordillera of Northern Chile hosts numerous volcanic/sedimentary-hosted stratabound copper deposits termed “manto-type”, forming an economically important cupriferous metallogenic belt in Chile that represents the third largest source of copper of the country (Maureira et al., 2023 and references therein). Two groups of stratabound Cu-(Ag) deposits occur parallel to the Coastal Cordillera (Fig 1A): 1) hosted by the Jurassic volcanic and volcanoclastic sequence of La Negra Formation (e.g., Mantos Blancos, Michilla, Las Luces), and 2) hosted by Lower Cretaceous volcanic and volcano-sedimentary units such as Lo Prado, Veta Negra, Quebrada Marquesa and Arqueros Formations (e.g., El Soldado, Talcuna, Uchumi, Lo Aguirre). Here, a multidisciplinary approach to unravel the genesis of the Picachos deposit has been performed. It includes core logging, petrography, SEM-EDS, EMPA (sulfides), whole-rock geochemistry, Raman spectroscopy (minerals and carbonaceous material) and, stable and radiogenic isotope (sulfides, carbonates) studies.

PICACHOS DEPOSIT GEOLOGY

The Picachos Cu-(Ag) deposit is hosted by the Arqueros/Quebrada Marquesa volcano-sedimentary Formations (Berriasian-Albian; Fig. 1B). These are intruded by Lower to Upper Cretaceous calc-alkaline granitoids and overprinted by very low-grade regional metamorphism and hydrothermal alteration. Cu-(Ag) mineralization consists in stratabound manto-type bodies (10-40m) as well as in mineralized veins of up to 5cm thick. It has a strong lithological and structural control, being specially concentrated in the intersection between marine sequences and NW-trending normal faults. Picachos shows a mineral zonation characterized by an external zone constituted by pyrite ± pyrrhotite and a proximal zone constituted by bornite – chalcopyrite – pyrite – chalcocite ± sphalerite – galena - tetrahedrite/tennantite (Baza et al., 2018; Merinero et al., 2019). Mineral resources are estimated at approximately >25 Mt @ 1-2% Cu and 25g/t Ag.

RESULTS AND INTERPRETATION

Petrography and whole-rock geochemistry revealed that organic matter-rich limestones (locally strongly silicified) were deposited in a shallow marine basin. Mineralization ore grade could be up to 20% Cu and 140g/t Ag. Silver occurs associated with polybasite – acanthite, tetrahedrite – tennantite, bornite and locally galena. Raman spectroscopy of carbonaceous material associated with mineralization indicates a temperature range of 210 to 240°C. The $\delta^{34}\text{S}$ values of sulfides (-22.0 to -4.0‰; Fig. 1C) suggest a polygenic sulfur source, where sulfur from bacteriogenically reduced seawater sulfate predominates with minor input of magmatic sulfur (-2.0 to +4.0‰) and at lesser extent of sulfur from thermochemically reduced seawater sulfate (~12.0‰). The depleted C and O isotopic values of mineralization-related calcites ($\delta^{13}\text{C}$: -5.0 to -2.2‰; $\delta^{18}\text{O}$: +12.6 to 22.0‰) may be explained by an interaction of hydrothermal fluids with the regional organic matter-rich limestones. This interaction has been modeled assuming the isotopic composition of Cretaceous marine carbonates ($\delta^{13}\text{C}$: +3.0‰; $\delta^{18}\text{O}$: +26.0‰) and a

hydrothermal fluid ($\delta^{13}\text{C}$: -12.0‰ ; $\delta^{18}\text{O}$: $+5.0\text{‰}$) at a temperature range of 100 – 240°C with a CO_2 content of 0.1 mole fraction. The estimated composition (C and O) of mineralizing fluids is consistent with a magmatic-hydrothermal fluid mixed with basinal brines equilibrated with organic matter-rich carbonates. The $^{87}\text{Sr}/^{86}\text{Sr}$ values of mineralized calcite veins and host rocks are close to those of Lower Cretaceous igneous and sedimentary rocks, therefore the ore forming fluids are inferred to have been equilibrated with the volcano-sedimentary sequence.

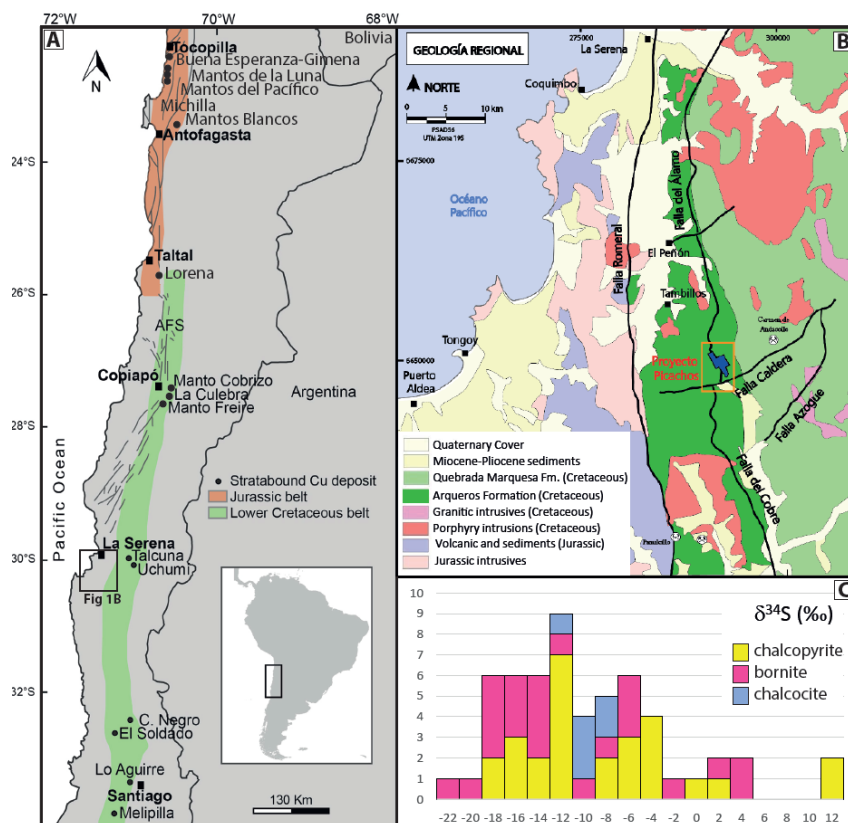


Fig 1. Geology and stable isotope geochemistry of the Picachos Cu-(Ag) deposit. A) Regional geology showing the manto-type deposit belts of northern Chile (Herazo et al., 2020; Maureira et al., 2023). B) Local geology of the Picachos deposit (Modified after Panca, 2015). C) $\delta^{34}\text{S}$ composition of sulfides from the Picachos mineralization. Abbreviations: AFZ = Atacama Fault Zone.

CONCLUSIONS

The Picachos Cu-(Ag) structurally/lithologically controlled deposit was probably formed in Lower Cretaceous times. Mineralizing fluids resulted from a complex interaction between sedimentary/bacteriogenic sulfides and hydrothermal fluids (surficial+basinal) equilibrated with the host rocks. Ore minerals (e.g., bornite, chalcopyrite, tetrahedrite – tennantite) precipitated at a 100 – 240°C triggered by a distally emplaced magmatic intrusion.

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