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The El Alacrán Cu-Au Deposit: A Hybrid Iron Oxide-Copper-Gold and Carbonate-Replacement Deposit in the Colombian Andes

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The El Alacrán Cu-Au Deposit in NW Colombia is the most explored prospect within the San Matias District (SMD). The genesis of the deposit is controversial because it exhibits mixed characteristics of different deposit models (e.g., IOCG, VMS, and Skarn deposits), besides an evident spatial relationship with nearby porphyry Cu-Au prospects (e.g., Montiel E, Costa Azul). Understanding the origin of the El Alacrán Cu-Au Deposit and its relationship with porphyry Cu-Au mineralization in the regional metallogenic context is critical for the exploration of similar deposits in the western Colombian Andes.

The El Alacrán Cu-Au Deposit lies within a Late Cretaceous intra-oceanic arc formed in an extensional to transpressive tectonic regime upon the Caribbean Large Igneous Province (CLIP). It is hosted in an intermediate to mafic volcano-sedimentary sequence of the Barroso Fm. and intruded by a series of calc-alkaline phreatomagmatic breccias and tonalites (e.g., El Alacrán Oeste Tonalite). The Cu-Au mineralization extends over 1 km north-south and comprises different styles, including stratabound replacement, dissemination, and minor veins. Based upon a detailed petrographic characterization, at least thirteen alteration assemblages have been recognized and interpreted to be formed through three different pathways (A, B, and C; Figure 1): Path A (>79.5 Ma) developed an early barren calc-sodic alteration (albite-apatite-quartz-chlorite) spatially associated with sill intrusions followed by Path B (ca. 79.5 Ma) with abundant magnetite (mushketovite)-quartz-apatite-Fe-rich chlorite-carbonate \pm titanite pyrite \pm chalcopyrite, providing a Fe-Au \pm Cu \pm light REE (Ce-La) IOCG geochemical signature. The incursion of an additional fluid (Path C) between 73 and 68 Ma under a syn-deformation regime produced a calc-potassic alteration assemblage dominated by V-mica (roscoelite composition)-quartz-actinolite-ilmenite-pyrrhotite-chalcopyrite-pyrite-Au, followed by sericite-Mg-rich chlorite-carbonate-quartz-chalcopyrite-pyrite-titanite \pm molybdenite and later by a carbonate-base-metal (CBM) vein alteration producing a Cu-Au-Mo-Zn-Ag-As geochemical signature.

Pb isotopes in sulfides and feldspars suggest a relationship of Path B with a non-porphyry source (e.g., El Alacrán Oeste Tonalite). In contrast, disseminated sericite of Path C yielded a ^{40}Ar - ^{39}Ar age of ca. 68 Ma, slightly younger with respect to U-Pb zircon ages obtained for intrusions associated with porphyry Cu-Au mineralization in the San Matias District (ca. 70 Ma). S isotopes in sulfides (avg $\delta^{34}\text{S}$ \sim 11‰) suggest an important seawater contribution to the ore-forming fluids. Fluid in Path B is consistent with IOCG mineralization, whereas CRD mineralization associated with Path C seems to explain better the variety in mineralogy, isotopic composition, sericite age, and the multiple Au generations identified in the El Alacrán Cu-Au Deposit.

El Alacrán Cu-Au Deposit mineralization is interpreted as the product of a hybrid process between an iron oxide-copper-gold (IOCG) spectrum and a carbonate replacement deposit (CRD) mineralization possibly associated to a porphyry Cu-Au source (Figure 1). The mineralogical and compositional features are comparable to those of well-known Andean IOCG deposits in the Coastal Cordillera province of Peru and Chile. However, dominant seawater ore fluid, a juvenile crust involvement, and the proposed relationship with a porphyry Cu-Au source make it unique respect to other Andean IOCG analogues.

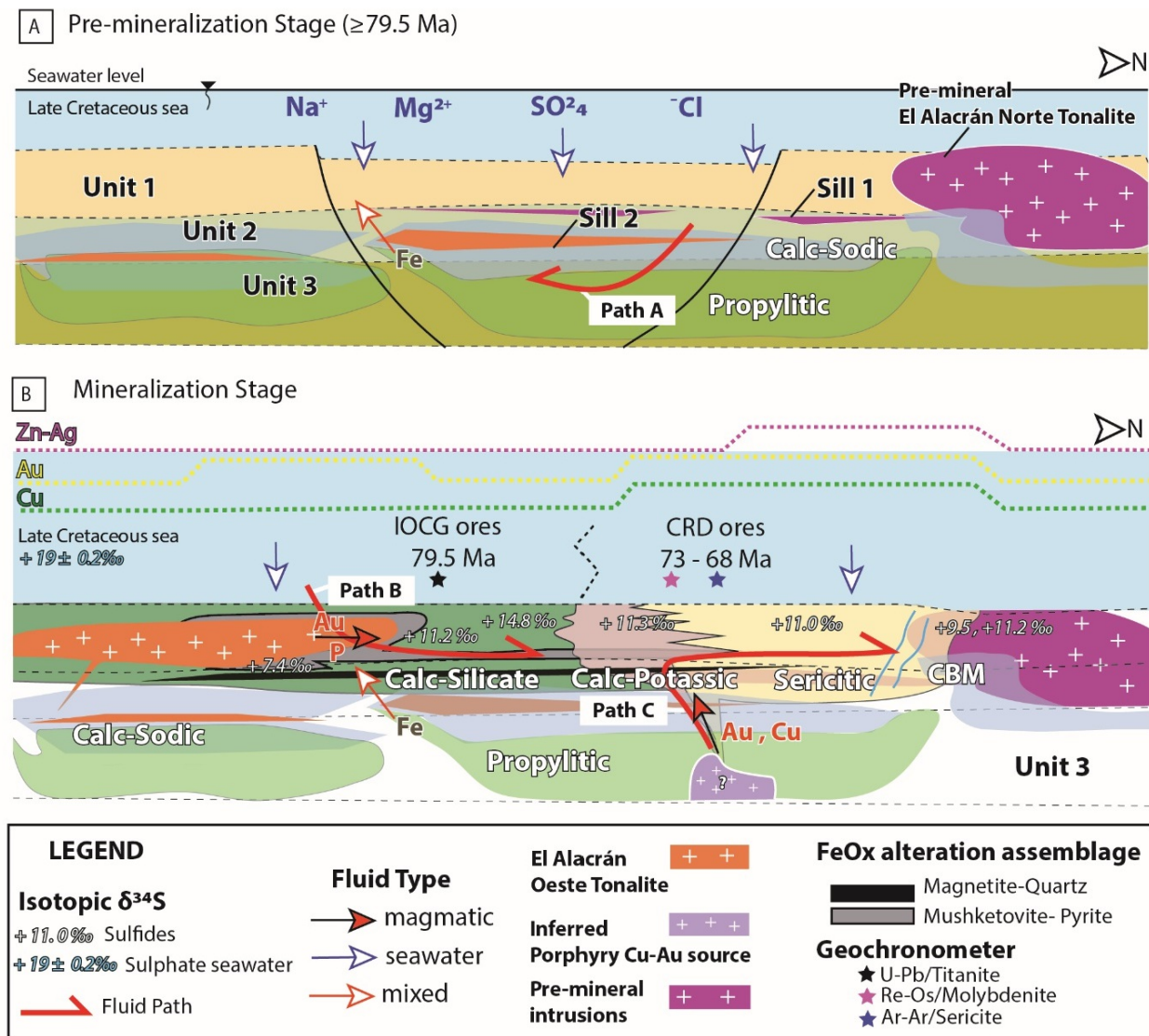


Figure 1. Fluid evolution of the El Alacrán Deposit. A. West-looking schematic diagram of the initial configuration of the El Alacrán Deposit. The schematic diagram shows the El Alacrán Deposit sequence units (Unit 1, Unit 2, and Unit 3), the pre-mineral location of the El Alacrán Norte Tonalite magmatism, and the beginning of the Sill 2 magmatism that led to the formation of the cooling Path A alteration assemblages. B. Mineralizations and alteration assemblages formed from seawater interaction with at least two magmatic fluids; one fluid sourced from the El Alacrán Oeste Tonalite (in Path B) and other sourced from a inferred concealed porphyry source (Px2) consistent with the cooling Path C.