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Strata-Bound Cu-(Ag) Deposits in the Jurassic La Quinta Formation, Northern Colombia

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Strata-bound copper-silver deposits have been historically mined in northern Colombia; nevertheless, there has not been extensive research dealing with the nature and origin of the mineralization. These Cu-(Ag) deposits are hosted by Jurassic rocks from the La Quinta Formation, which consists of a thick pile of continental red sandstones and siltstones that are interbedded with tuffs, basaltic lavas, and rhyolites. The mineralization is divided into two main styles: (i) native copper and silver, which occur as veinlets and in amygdules hosted by strongly altered flow-top basaltic lavas, and (ii) veins and breccias with matrix of bornite-digenite-chalcocite (silver rich)-hematite ± chalcopyrite hosted by gray siltstones. Alteration associated with the mineralization is characterized by four distinct mineral assemblages. They are in chronological order of formation: (1) albite ± quartz ± epidote, (2) local K-feldspar, quartz, (3) epidote-quartz-prehnite ± chlorite ± clinozoisite, and (4) calcite. The copper mineralization is exclusively linked to the calc-silicate alteration (3). Widespread supergene oxidation has produced cuprite ± delafossite and ± paramelaconite after native copper, whereas the copper sulfides have been converted to malachite-chrysocolla ± azurite and minor covellite and goethite. Mass balance calculations within alteration zones indicate that the concentrations of Zr, W, Sn, Nb, Ta, and REE are constant, suggesting that these elements were the least mobile during hydrothermal activity, whereas these rocks show a relatively depletion of Mg, Na, K, Ba, and Rb. On the other hand, there is a net gain of Ca, Fe, Al, Ti, Sr, Cr, V, Cu, Ag, and Pb, which is in agreement with the observed alteration mineralogy (widespread calc-silicate alteration) and evidences the influence of the host rocks in the composition of the hydrothermal fluids. Mineral chemistry and fluid inclusion data indicate a range of low temperatures (140°–210°C) and moderate to low salinities for the fluids responsible for mineralization. According to the geochemical data and the mineral assemblages, the hydrothermal system was characterized by near-neutral pH and moderately oxidized fluids, where copper was probably dissolved during extensive albitization and transported as chloride complexes; reaction between the host rocks and the copper-bearing fluid is presumably the mechanism responsible for copper deposition.