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Multi-isotope (S, C, O and Sr) approach to the genesis of the Picachos Cu-(Ag) manto-type deposit, North-Central Chile

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The Coastal Cordillera of Northern Chile. The Picachos deposit is hosted by the Arqueros/Quebrada Marquesa volcanosedimentary Formations (Berriasian-Albian). It comprises numerous small copper mines and working sites (e.g., Picachos, Leoncito, Flor del Bosque, La Ñipa). Mineralization consists in stratabound manto-type bodies and veins. 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. Silver has been found associated with polybasite–acantite. Mineral resources are estimated at >25 Mt @ 1-2 %Cu and 25 g/tAg. A multidisciplinary approach to unravel the genesis of the Picachos deposit has been performed including core logging, petrography, SEM-EDS, EMPA, whole-rock geochemistry, Raman spectroscopy and, stable and radiogenic isotope (S, O, C, Sr) studies. Petrography and whole-rock geochemistry reveal that organic matter-rich limestones deposited in a shallow marine basin are strongly silicified and that mineralization ore grade could be up to 20 %Cu and 140 g/tAg. Raman inspection indicates a maximum temperature of 240±5°C. $d^{34}S$ values suggest a polygenic sulfur source for the deposit (-22 to -4‰), where bacteriogenic sulfide predominates with minor input of magmatic sulfur (-2 to +4‰) and in lesser extent of sulfur from sulfate reduced seawater (~12‰). $d^{13}C$ values obtained from calcites associated with mineralization (-5 to -2‰) indicate that calcite carbon has an isotopic signature between igneous and sedimentary carbonate. In contrast, the $d^{18}O$ of calcite have wide ranges extending towards a $d^{18}O$-rich composition (12 to 25‰). It is not clear whether the C-O composition of calcites depends on the thermal effect on isotopic fractionation between calcite and mineralizing fluids or on the incorporation of sediment-derived $d^{18}O$-rich components. The $^{87}Sr/^{86}Sr$ values of calcite are close to those of the igneous rocks and sedimentary rocks, therefore the ore forming fluids are inferred to have been equilibrated with the associated volcanosedimentary rocks. The Picachos Cu-(Ag) structurally/lithologically controlled deposit was formed by a mineralizing fluid resulting from the interaction between a hydrothermal fluid and the volcanosedimentary sequence.