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Age of Mineralization of the Candelaria Fe Oxide Cu-Au Deposit and the Origin of the Chilean Iron Belt, Based on Re-Os Isotopes

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Abstract

Re-Os isotopes are used to determine the age of iron oxide Cu-Au mineralization at Candelaria, Chile, and to explore possible genetic links with the batholithic intrusions in the area. Re-Os ages calculated from molybdenite are 114.2 ± 0.6 Ma and 115.2 ± 0.6 Ma, and they are interpreted to represent the age of mineralization. These ages are consistent with previously reported ages for biotite alteration that range from 114 to 116 Ma.

An isochron calculated by Re/Os ratios from hydrothermal magnetite and sulfides constrains an initial $^{187}Os/^{188}Os$ ratio of 0.36 ± 0.10. The initial $^{187}Os/^{188}Os$ ratio for sulfide from Bronce mine, a small satellite of the Candelaria orebody, is 0.33 ± 0.01. These values are broadly similar to the calculated initial $^{187}Os/^{188}Os$ ratio for magmatic magnetite in nearby batholithic rocks that range from 0.20 to 0.41. The relatively radiogenic initial $^{187}Os/^{188}Os$ ratio represents a mixture of mantle and crustal components in the ores and batholitic rocks. The similarity in initial $^{187}Os/^{188}Os$ ratio of the ore and magmatic oxides suggest that the granitic plutons could be the source of metals in the Candelaria district. These data are consistent with the existence of a significant magmatic fluid component in the hydrothermal system as suggested by previously published work.

In order to establish a regional perspective, we analyzed ore minerals from other Chilean deposits of the iron oxide (Cu-U-Au-rare earth elements [REE]) class. Magnetite from the Manto Verde iron oxide Cu-Au deposit has Os and Re concentrations of 11 to 17 parts per trillion (ppt) and 4 to 6 parts per billion (ppb), respectively. The initial $^{187}Os/^{188}Os$ ratio is approximately 0.20 and is similar to that of ore minerals from Candelaria and of the Early Cretaceous batholithic intrusions. These data indicate a similar metal source for the mineralization at Manto Verde and Candelaria.

Magnetite from three magnetite-apatite deposits of the Chilean iron belt have Re concentrations between 0.8 and 3 ppb and Os concentrations between 11 and 76 ppt. Calculated initial $^{187}Os/^{188}Os$ ratios of these magnetites range from 1.2 to 8.4 and are distinctly different from those of the iron oxide Cu-Au deposits. The cause of the comparatively high radiogenic signatures in the magnetite-apatite ores is probably related to fluid interactions with (i.e., leaching) the surrounding sedimentary rocks during their genesis. In contrast to the iron oxide Cu-Au systems, the Os in magnetite-apatite ores could be derived from sedimentary rocks. This evidence suggests that predominantly basin-derived, nonmagmatic brines formed these magnetite-apatite deposits.