Copper deposits in Chile: the 'apparent' Pb-Re paradox

C. Freydier
J. Ruiz
Department of Geosciences, Gould Simpson Building, University of Arizona, Tucson, AZ 85721, USA

R. Tosdal
Department of Geological Sciences, Snee Hall, Cornell University, Ithaca, NY 4853, USA

F. Munizaga
Departamento de Geologia, Universidad de Chile, Santiago, Chile

The well-exposed copper deposits of Chile offer an excellent opportunity to study metallogenetic processes in continental arcs. Along this convergent plate margin, magmatic activity has spanned more than 200 Ma. Distinct epochs of copper mineralization accompanied magmatic and tectonic activity. The three most notable periods are: (1) 150–100 Ma, (2) 42–30 and (3) 10–5 m.y. ago. Between 150 and 100 Ma the most important type of copper mineralization was in stratabound ore deposits, known as mantos, that are either hosted by volcanic rocks or more complex volcanic-sedimentary sequences; these deposits formed from circulating fluids driven by magmatic or tectonic activity. The larger porphyry copper deposits are linked directly to magmatic activity, and formed between 42-30 Ma in northern Chile or between 10–5 Ma in central Chile. The exception is the Andacollo porphyry deposit, which is approximately 100 Ma old. Pb isotope work (Tosdal and Munizaga, 1996) indicates that crustal Pb dominates the ore deposits, and that the Pb represent varying mixtures of two different Pb sources. One source is a radiogenic high $^{207}Pb/^{204}Pb$ crust component whereas the other source is a low $^{207}Pb/^{204}Pb$ and more 'oceanic' source. Pb in the Jurassic and Miocene deposits have a larger component of the high $^{207}Pb/^{204}Pb$ that Cretaceous deposits, which are dominated by the 'oceanic' Pb (Fig. 1a). These data are contrary to Re-Os isotopic data wherein Cretaceous deposits, including manto and the single porphyry copper deposit, have higher Re (Fig. 1b) and $^{187}Os/^{188}Os$ isotopic ratios than the Cenozoic deposits. At face value, the Re data would suggest a lesser participation of a crustal component during the genesis of the youngest deposits.

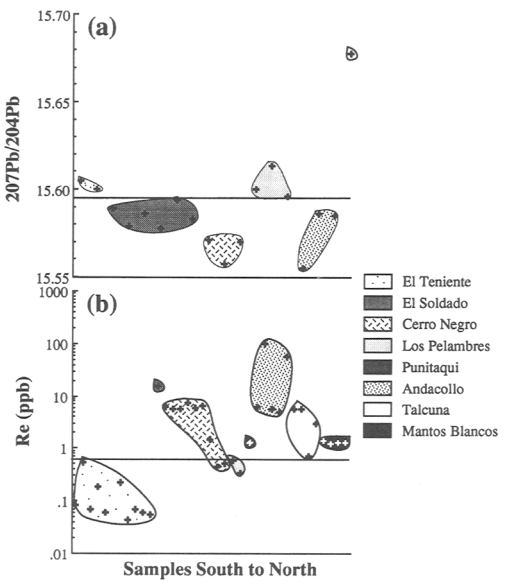

FIG. 1. (a) $^{207}Pb/^{204}Pb$ *vs* location of samples from south to north. Two groups are present, the first with $^{207}Pb/^{204}Pb > 15.595$ and the second with $^{207}Pb/^{204}Pb < 15.595$. (b) Re (ppb) *vs* location of samples from south to north. Two groups are present, one with low Re (< 0.6 ppb) and the other with high Re contents (> 0.6 ppb).

This apparent paradox can be explained by a depletion in Re during the melting of the base of the crust in the earlier stages of magma genesis, explaining the high Re contents in the older deposits and the lower ones in the young deposits. The Pb isotopes are not affected by this depletion, and since the mid-Cretaceous as the crust thickened, basement contributions becomes more important, leading to higher $^{207}Pb/^{204}Pb$ ratios.

References

Tosdal, R.M. and Munizaga, F. (1996) *Denver, Geol. Soc. America abstracts with program*, A154.