Fixation of sulphur during framboidal pyrite development in a petroleum reservoir in Cretaceous volcanics in the Andes: implications for Cu metallogenesis

P.G. Collins[1], R. Boric[1], N.S.F. Wilson[2], and M. Zentilli[1]

1. Department of Earth Sciences, Dalhousie University, Halifax, NS B3H 3J5, Canada <pgcollin@is2.dal.ca> ¶ 2. Geological Survey of Canada, 3303-33rd St. NW, Calgary, AB T2E 0Z5, Canada

El Soldado, Chile, is a giant strata-bound copper deposit hosted in Lower Cretaceous basalts and rhyolite. Previous work suggested that copper was concentrated preferentially where hydrothermal copper-rich solutions replaced pre-existing, low-temperature, diagenetic pyrite, which is generally associated with bitumen (solidified petroleum). This model implies that the mineralizing hydrothermal phase did not supply sulphur to the system; sulphur would have been inherited from the diagenetic sulphides. Doubt remains on whether some deep zones with massive crystalline pyrite veins, and massive chalcopyrite, bornite, and chalcocite

ores, could represent a net input of sulphur from hydrothermal, magmatically-derived sources. To answer this question, massive sulphide assemblages are being studied by microscope, microprobe, and sulphur isotope analysis.

All new samples studied so far show petrographic evidence of pre-existing diagenetic pyrite, including deep massive pyrite veins and massive-crystalline copper-rich ores. Diagenetic pyrite is characterized by framboidal structures of ca. 16μm diameter or smaller. Framboids consist of microcrysts of pyrite, <2 μm in size, organized in spheroidal aggregates. In this deposit, the framboids developed mostly within liquid petroleum, now solid bitumen. Although controversial, the general consensus is that framboids may grow with bacterial involvement, and that their spheroidal shape is determined by colloidal-scale magnetic and electric properties of their precursor iron monosulphides. A range of stages of development of massive crystalline aggregates is observed in the samples: individual microcrysts, framboids, framboid clusters, recrystallized megacryst overgrowths, and banded concentric zones.

If there was an influx of homogenized, magmatic-related sulphur one would expect that the $\delta^{34}S$ would be close to zero ‰. However, available sulphur isotope data to date show a wide variation in $\delta^{34}S$ values, thus supporting low-temperature fractionation, which is compatible with the wholesale fixation of sulphide sulphur with the aid of sulphur-reducing bacteria in a degrading petroleum reservoir at a few kilometres depth in the crust, at temperatures within or below the oil window. The incursion of sulphate- and iron-rich meteoric or basinal fluids may have provided the raw materials; reduction of sulphur produced H_2S, which combined with iron in solution and formed iron monosulphides in framboidal aggregates within mobilized petroleum. Thermal metamorphism led to recrystallisation and consolidation of original framboids into crystalline pyrite aggregates.