EXPERIMENTAL DETERMINATION OF THE PARTITIONING BEHAVIOR OF SILVER BETWEEN VARIOUS SULFIDE PHASES AND ELECTRUM

by J. Lynn Youell

Advisors: Professor P.A. Candela and Dr. P.M. Piccoli

Silver is always a component of magmatic ore bodies (Robb 2005) at a percentage appreciably greater than gold. However, research in porphyry –type deposits has traditionally focused on the distribution of the more profitable copper, gold and molybdenum constituents. Likewise, epithermal deposits sometimes form in association with porphyry deposits and are an important source of ore because of the higher concentration of precious and base metals typically associated with these deposits. In both porphyry and epithermal type deposits, silver grades are often higher than gold. At Far Southeast- Lepanto, the Ag:Au ratio is approximately 5:1 by wt. (Hedenquist et al. 1998) and 7:1 at the Bingham Canyon porphyry copper deposit. Renewed interest in silver, and the high concentrations found in epithermal deposits inspire research into the distribution of silver .

In this study I determined the distribution of silver between sulfide phases and electrum. These data can be used to model and predict factors which can enrich and restrict the formation of a silver-rich epithermal deposit. Since research is lacking as regards the partitioning of silver between sulfide phases and electrum, I have based my research on experimental methods and outcomes in gold distribution conducted by Simon et al. (2000) and experimental determination of the solubility of electrum by Gammons and William-Jones (1995) using concentration quotients;

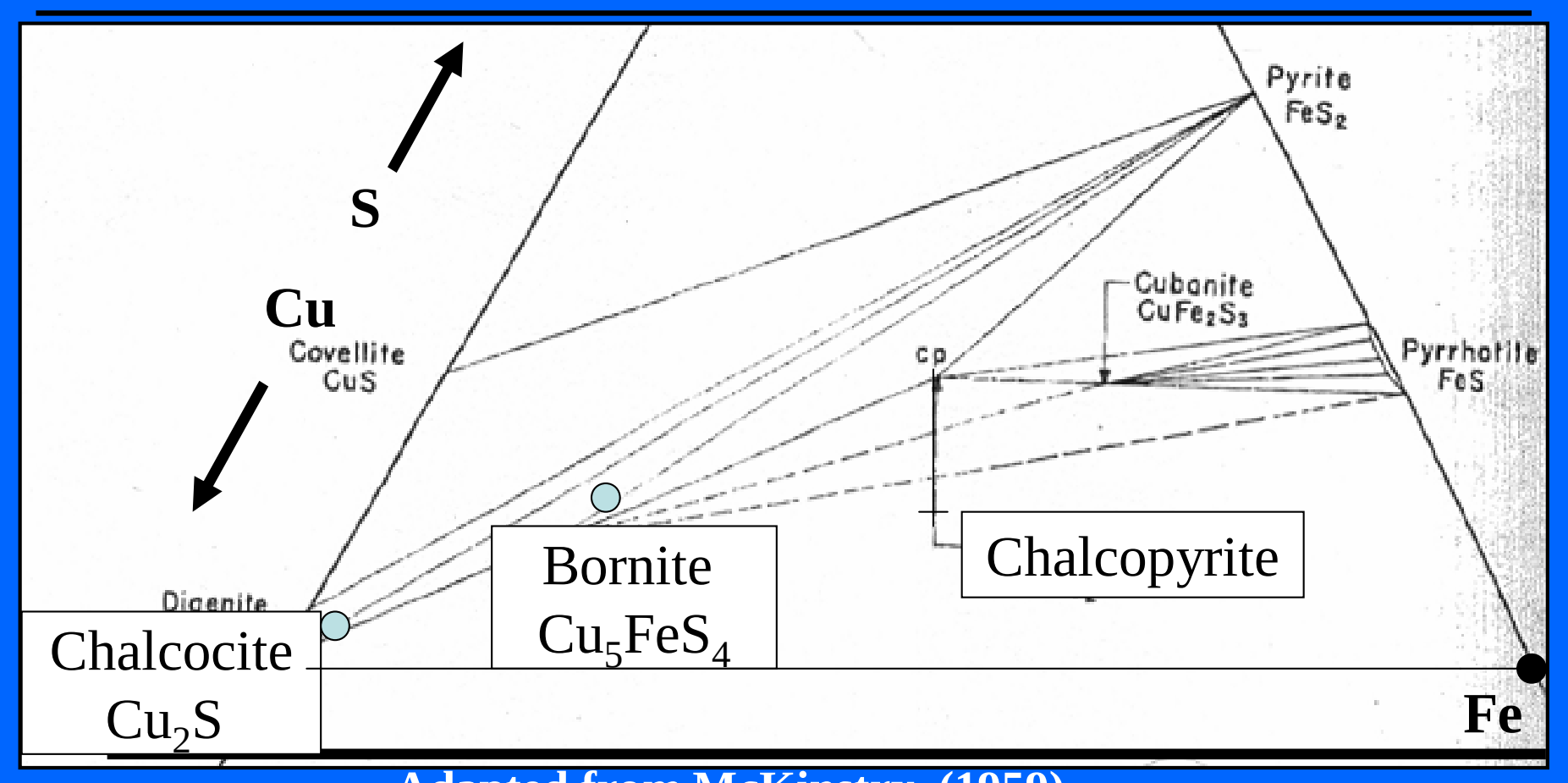
$$K = \frac{\text{xsulfideAg *xmetalCu}}{\text{xsulfideCu *xmetalAg}} \quad \text{and} \quad K = \frac{\text{xsulfideAg *xmetalAu}}{\text{xsulfideAu *xmetalAg}}$$

In order to relate my data to the hydrothermal realm, I will employ the data from Gammons and Williams-Jones (1995) for the exchange of silver and gold between electrum and chloride-bearing aqueous solutions.In effect, I am taking my Log K values and interpreting them in the context of the experimental hydrothermal environment(Gammons and Williams-Jones 1995), the paired porphyry copper-gold environment of Far Southeast-Lepanto, and a median porphyry copper deposit The null hypothesis is: **the partitioning of silver into copper-iron sulfides during the formation of a porphyry copper deposit will be insufficient to poison the formation of a shallow silver-rich epithermal deposit.** I tested the null hypothesis by using my experimental concentration of electrum as the normalizing factor by which I compared the hypothetical concentration of silver and gold in the epithermal ore forming fluid for Far Southeast-Lepanto deposit, a hypothetical median porphyry deposit and an ore fluid derived from Gammons and Williams-Jones research in silver gold exchange. The outcome of these experiments failed to support my null hypothesis.

Null Hypothesis

The partitioning of Ag into Cu-Fe sulfides will be insufficient to poison the formation of a more distal epithermal deposit.

Silver will partition in favor of a chalcocite - bornite solid solution relative to a metal phase at levels similar to those of gold as demonstrated in Simon et al. (2000) on the basis of their similarities on the periodic table.



Adapted from McKinstry, (1959)

Mineral Assemblages in the Cu-Fe-S System

$$K = \frac{x^{sulfide}_{Ag} * x^{metal}_{Cu}}{x^{sulfide}_{Cu} * x^{metal}_{Ag}}$$

for copper-silver exchange

$$K = \frac{x^{sulfide}_{Ag} * x^{metal}_{Au}}{x^{sulfide}_{Au} * x^{metal}_{Ag}}$$

for silver-gold exchange

Prepared Silica Glass Tubes

Experiments

Sealed Silica tubes

Lindberg box furnaces/chromel-alumel thermocouples

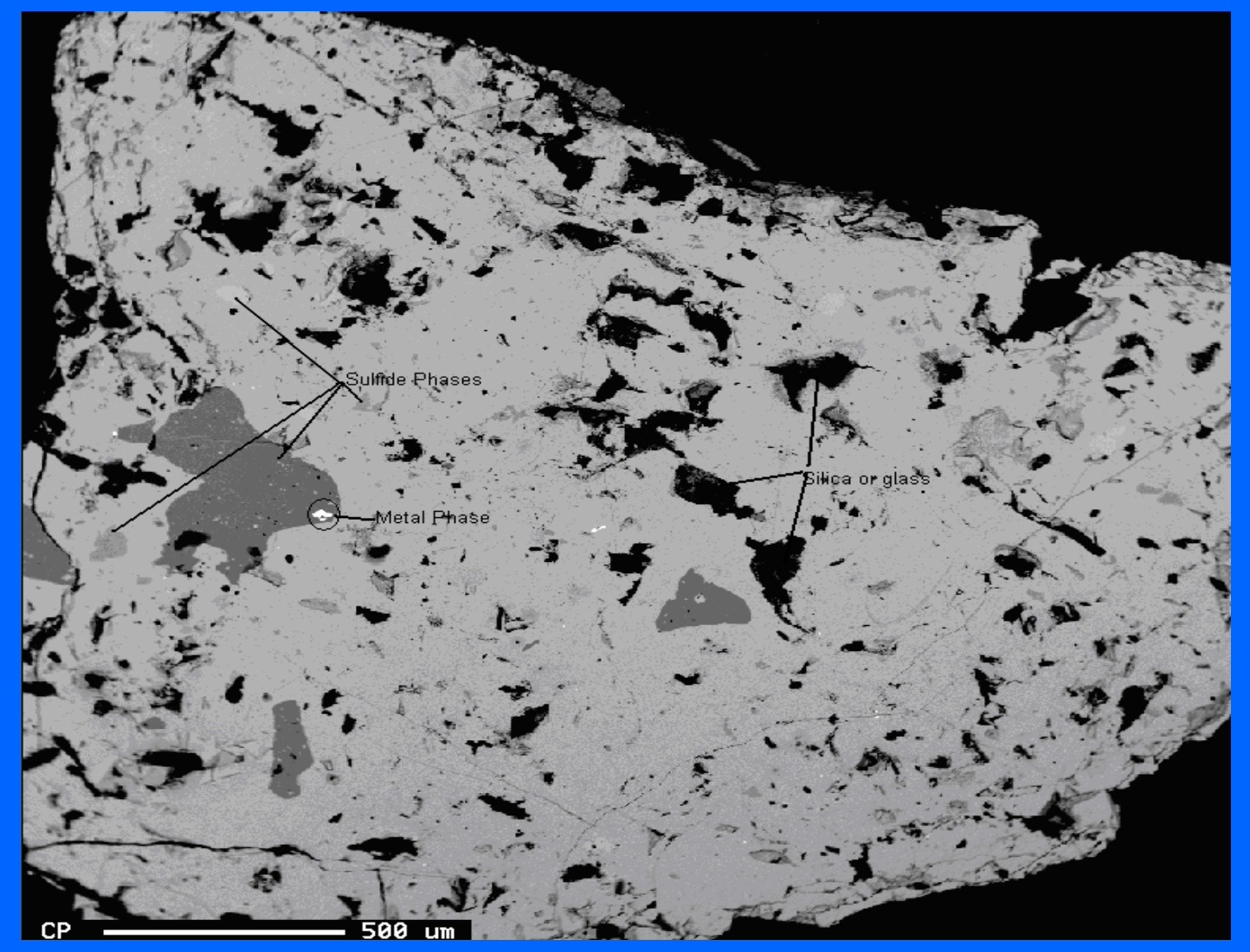
Run durations: 7-56 days

600ºC, and vapor pressure of the assemblage

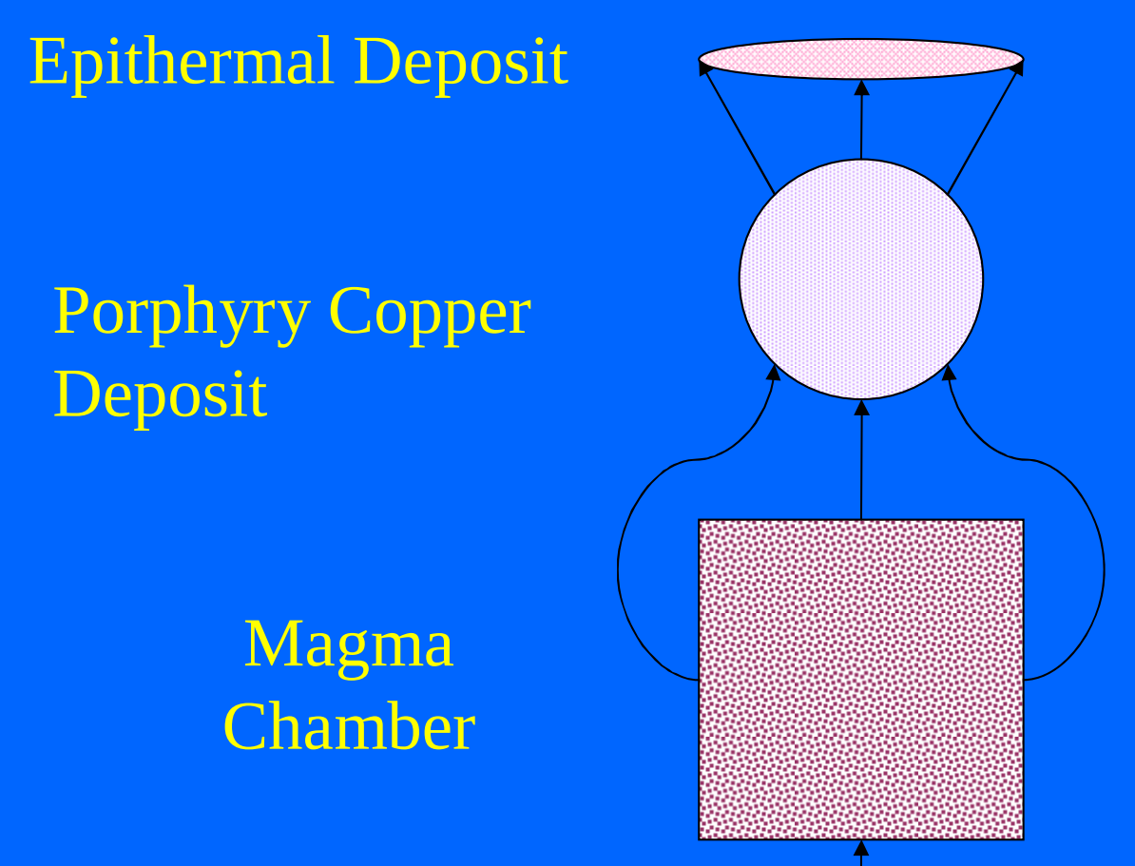
Starting materials- bornite:gold foil:acanthite = 15:10:4 mg

Analyses by EPMA: analyzed electrum for Au, Ag, Cu and Cu-Fe sulfide phase for Au, Ag, Cu, S, Fe

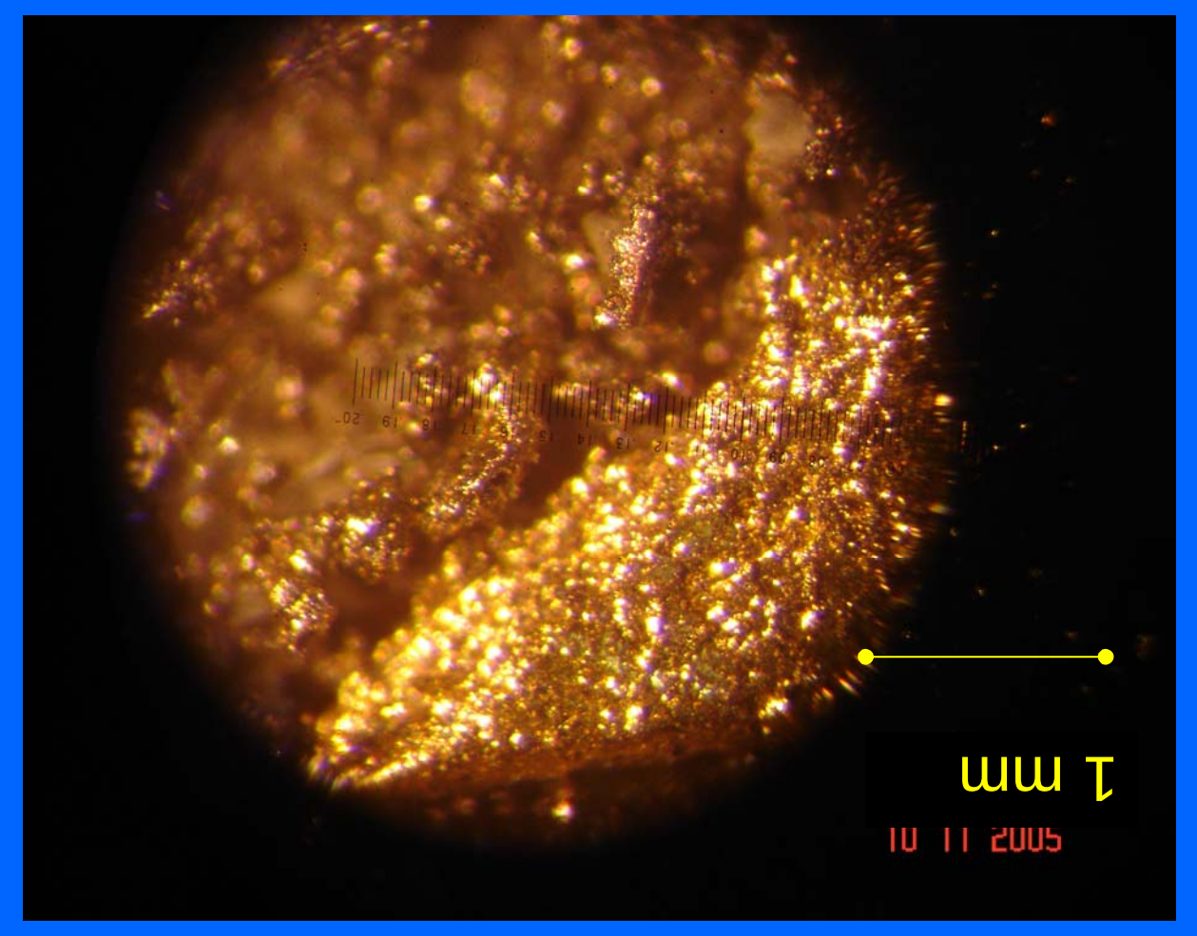
Run Products Ready for Polishing



Backscatter- electron image



Simplified schematic of a paired porphyry/epithermal deposit. Arrows indicate the general path of fluid flow.



Run Product @ 50x magnification

My Goal:

Experimentally test the extent to which (silver added as acanthite) will partition between chalcocite - bornite solid solution and electrum (Au-Ag solid solution).

Calculate equilibrium exchange constants.

K values Cu-Ag	Log K Cu-Ag	K values Ag-Au	Log K Ag-Au
0.0198	-1.70	1218	3.09
0.0165	-1.78	20291	4.31
0.0115	-1.94	1255	3.10
0.0087	-2.06	1597	3.20
0.0617	-1.21	2420	3.38
0.1928	-0.71	2353	3.37
0.1361	-0.87	377	2.58
0.1603	-0.80	1050	3.02
0.1642	-0.78	3258	3.51
0.0853	-1.07	480	2.68
1.47	0.17	561837	5.75
0.348	-0.46	12875	4.11
0.190	-0.72	55890	4.75
0.137	-0.86	1977	3.30
0.012	-1.93	2101	3.32
0.011	-1.95	176	2.25
0.013	-1.90	316	2.50
0.012	-1.94	373	2.57
0.030	-1.52	1065	3.03
0.026	-1.59	4924	3.70
0.010	-2.01	143	2.16
0.019	-1.71	745	2.90
0.023	-1.64	2565	3.41
0.026	-1.59	2025	3.31
0.020	-1.71	1453	3.16
0.017	-1.76	1217	3.09
0.012	-1.92	681	2.83

	Mean	σ
Log K $^{Cu-Ag}$	-1.36;	± 0.585;
Log K $^{Ag-Au}$	3.27	±0.763