

## The effect of magma composition on the genesis of hydrothermal gold and copper ore deposits

Z. ZAJACZ<sup>1</sup>, J.H. SEO<sup>2</sup>, P.A. CANDELA<sup>1</sup>, P.M. PICCOLI<sup>1</sup>  
AND C.A. HEINRICH<sup>2</sup>

<sup>1</sup>Laboratory for Mineral Deposits Research, University of Maryland, College Park, MD 20742

<sup>2</sup>Institute for Geochemistry and Petrology, ETH Zurich, 8092 Switzerland

Intermediate to mafic magmas are often suggested to be the source of metals in porphyry and epithermal Cu, Cu-Au and Au ore deposits. In order to evaluate this premise, we conducted experiments to study the solubility of Au and Cu in high-temperature vapors (1000 °C and 150 MPa) to assess the efficiency of Au and Cu transfer by volatiles exsolving from andesitic to basaltic melts. Our data show that Au hydrosulfide complexes supersede Au chloride complexes at these conditions, and that the stability of gold hydrosulfide complexes is significantly increased by the presence of minute concentrations of KCl or NaCl. For example, at an  $fO_2$  of 0.6 log unit below the Ni-NiO buffer (NNO) and a fixed  $fH_2S$  of 13.2 MPa, the addition of 0.5 m KCl to the  $H_2O - H_2S$  vapor increases the solubility of Au from  $90 \pm 20$  (1  $\sigma$ ) to  $1600 \pm 220$   $\mu g/g$ . Therefore, magmatic volatiles that are simultaneously characterized by high  $H_2S$  and alkali chloride activities are the most susceptible for Au transfer.

The behavior of Cu contrasts with that of Au at these conditions because of the low stability of Cu hydrosulfide complexes. At an  $fO_2$  of NNO-0.6 log units, the solubility of Cu (at a reduced Cu activity of 0.01) as  $CuCl^0$  is higher in dilute chloride-bearing vapors ( $176 \pm 14$   $\mu g/g$  at 0.5 m NaCl), than it is in  $H_2S$ -rich, chloride-free volatiles ( $39 \pm 8$   $\mu g/g$  at  $fH_2S=10.4$  MPa). As opposed to the behavior of Au (the solubility of which significantly drops at the  $H_2S$  to  $SO_2$  transition), the solubility of Cu significantly increases with increasing  $fO_2$ . The relative role of Cu chloride complexes, and Cu complexes formed with oxidized sulfur species at high  $fO_2$  ( $\sim NNO+2$  log units) is under investigation.

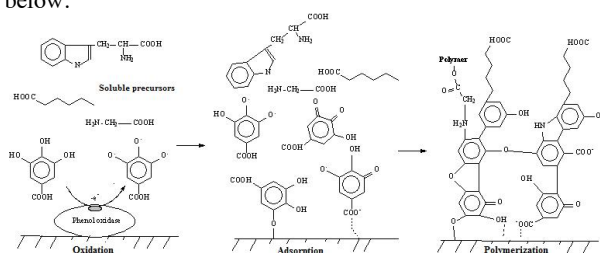
Many of the largest known hydrothermal Au deposits occur in association with alkaline mafic magmas, which are the most likely to release volatiles simultaneously rich in  $H_2S$  and alkali-chlorides, while porphyry Cu deposits are typically associated with oxidized magmas. Therefore, a clear link can be established between magma types and the occurrence of hydrothermal Au and Cu deposits via understanding the solubility of these metals in high-temperature vapors.

## Formation of humin and humic acids by surface precursor polymerization: Implications to primitive and well-developed soils

A.G. ZAVARZINA

Faculty of Soil Science, Moscow State Univ, 119991 Moscow, Russia (\*correspondence: zavarzina@mail.ru)

A considerable fraction of mineral-bound organic matter in soils is represented by high molecular weight (50-100 kDa) humic acids and non-extractable humin. The origin of such high molecular weight compounds on mineral surfaces can not be explained simply by adsorption since migration of polymeric material to adsorption sites should be limited by its low solubility. We argue therefore that polymeric humic-mineral compounds are formed *in situ* in mineral soil horizons. One of the possible mechanisms is heterophase polymerization of low molecular weight and thus soluble precursor material on/near the surface of catalytically active solid phases (so-called adsorption or boundary polymerization). In the recent review we have summarized available data supporting this concept and provided an experimental evidence for the key role of immobilized phenol oxidases and solid matrix in accelerating polymerization process [1]. The proposed reactions sequence leading to formation of humic acid-like polymers and non-extractable organic matter (humin) on the mineral surfaces is shown below.



**Figure 1:** Formation of humic acids and humin by surface/boundary polymerization.

Surface polymerization can be of primary importance for the long-term carbon sequestration in illuvial and surface humus horizons of soils in cold and temperate humid climate. We are going to present experimental data supporting this hypothesis. The special emphasize will be given to lichen-induced humus formation by surface polymerization mechanism.

[1] Zavarzina (2009) *Soil Enzymes*, in press.