

Vapor as a medium for the transport of metals: Implications for ore deposit modeling

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Despite increasing evidence to the contrary, most economic geologists still assume that hydrothermal ore deposits form exclusively from aqueous liquid. However, analyses of fluid inclusions in porphyry systems show that the vapor can contain ore-forming concentrations of metals, and that to varying degrees some metals, e.g., Cu, favor the vapor over the coexisting brine.

Although most partitioning experiments have shown that Cu, Zn, Ag, Au and Fe strongly favor the brine, recently reported experiments involving sulfur showed a preference of Cu for the vapor. The solubility of Cu, Ag, Au, and Sn in vapor has been investigated at sub-critical temperatures in the HCl-H₂O system, and that of Mo in pure water vapor. Models developed from these experiments, which assume that the dissolved species have the form, MeCl_m.nH₂O, predict metal concentrations in the vapor approaching those required by an ore fluid, but substantially lower than those measured in vapor-rich fluid inclusions from ore deposits. Metal solubility experiments in sulfur-bearing vapor are now in progress.

Considering that vapor is the dominant fluid in high level magmatic hydrothermal systems, and fluid inclusion and experimental evidence that Cu partitions preferentially into the vapor, we argue that vapor can be the principal agent of metal transport in some porphyry copper systems. We further argue that high sulfidation epithermal deposits closer to the earth's surface are also formed by this vapor. Early in the evolution of these latter systems the vapor condenses, producing acid-sulfate and vuggy silica alteration, and in some cases Cu-As-Au-Ag mineralization. In other cases, this mineralization is later, after the site of magmatic fluid exsolution has receded to greater depth. Vapor separating at this stage cools along a P-T path above the critical curve of the system, causing it to contract to a liquid from which precious metals subsequently deposit.

Transport of elements by high-temperature and highly oxidized gases from Colima Volcano

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Colima volcano is the most active volcano in Mexico. Before November 1998, when a new eruption started (it still is going on), we have succeeded to sample condensates, natural incrustations and silica tube sublimates from a 800°C fumarole and a 600°C thermal ground. Some results have already been published [1, 2]. Here we report new findings and review all the data obtained. The main difference of Colima gas vents before the 1998 eruption from other well studied volcanoes with strong high-temperature fumarolic jets (Kudryavy, Momotombo, Merapi, Satsuma-Iwojima, Showa-Shinzan) was a very diffuse emission of a hot air + magmatic gas mixture from the whole surface of the former summit dome. Therefore, the mineral set deposited on the inner wall of the silica tube was quite different from minerals of "common", reduced volcanic gases. We found V- and Te-sulfates, which have never been found inside silica tubes and in natural incrustations before. Native gold has been observed in natural incrustations at other volcanoes, but never in silica tubes. The deposited "pneumatolitic" material in silica tubes is close in chemical composition to a rich "high-sulfidation" ore body of precise metals. The observed distribution of metals along temperature gradient is in a good agreement with the modeled distribution using the SOLVGAS computer code with a modified thermodynamic data base. The redox-control of the variability of mineral phases is discussed in detail; in particular, the cause of the V- and Te- enrichment and the absence of "common" Mo and Cd phases in Colima sublimates. The REE abundances and distribution is also discussed.

References

- [1] Taran Y.A., Bernard A., Gavilanes J.C., Africano F. (2001) *Appl. Geochem.* **15**, 337-346.
- [2] Taran Y.A., Bernard A., Gavilanes J.C., et al (2000), *JVGR* **108**, 245-264