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From hydrothermal fluids to mineral deposits – development of a new internally-consistent geochemical-thermodynamic model of Pb-Zn-Ag-Au-As-Sb systems

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Hydrothermal ore deposits are large metal enrichments in the Earth's crust and the formation of world-class deposits requires highly efficient extraction of metal from large volumes of source rocks, efficient transport by hydrothermal fluids and localized and effective metal precipitation.

Fluid-mineral interactions are essential processes that lead to the formation of world-class ore deposits such as magmatic-hydrothermal porphyry Cu-Au-Mo, epithermal Ag-Au-As-Sb deposits and sediment-hosted Pb-Zn deposits.

The geochemical-thermodynamic modeling of the fluid processes that are driving ore deposit formation and hydrothermal alteration, is a powerful approach for the development of next-generation ore system models.

For this purpose, robust thermodynamic datasets are an essential prerequisite to accurately simulate metal and mineral solubilities and fluid-mineral reactions. The aim of this work is to develop a new internally-consistent geochemical-thermodynamic model for hydrothermal transport of Pb-Zn-Ag-Au-As-Sb systems which will extend significantly the existing, recently developed dataset of the system Na-K-Ca-Mg-Al-Si-C-Cl-O-H ([1], [2]).

This dataset will then be applied to numerically simulate the first-order geochemical processes that control the formation of sediment-hosted exhalative and carbonate-hosted Pb-Zn deposits but also of epithermal Ag-Au-As-Sb deposits. The modeling adresses key questions related to formation of globally important ore deposit types, namely the relative role of reduced acid and oxidized brines in sediment-hosted Pb-Zn systems, the link between exhalative carbonate-hosted Pb-Zn deposits and the effect of the metalloids As and Sb on the hydrothermal transport of Pb, Zn, Ag and Au.

Critically evaluated experimental solubility and spectroscopic data for Pb-Zn-Ag-Au-As-Sb are used for global fitting of the standard Gibbs energy of aqueous species to derive a consistent thermodynamic model for hydrothermal metal extraction, transport and precipitation by using the GEMS3 and GEMSFITS software.

The poster presentation will focus on new results of the ore metals Pb and Zn.

[1] – Miron G.D., Wagner T., Kulik D.A., Heinrich C.A., 2016, Internally consistent thermodynamic data for aqueous species in the system Na-K-Al-Si-O-H-Cl, Geochimica et Cosmochimica Acta, 187, 41-78

[2] – Miron G.D., Wagner T., Kulik D.A., 2017, An internally consistent thermodynamic dataset for aqueous species in the system Ca-Mg-Na-K-Al-Si-O-C to 800 °C and 5 kbar, American Journal of Science, 317, 754-805