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## Partitioning of trace elements between hydrothermal fluids and pyrite

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Pyrite is the most abundant sulfide on Earth and can host a large variety of trace elements including Au, Co, Mo, Cu, Pb, As, Se, Te, Bi and Sb. Trace element variations in pyrite have been used to study various processes during ore formation, to reconstruct paleo-seawater composition and to understand hydrothermal systems. Furthermore, element enrichment in pyrite can reach high enough concentrations that pyrite itself becomes an ore mineral and can be mined. For example, the enrichment of Au in As-bearing pyrite can reach up to several thousand ppm in the giant Au deposits of the Carlin trend (Nevada, USA). In this case the coupled partitioning of Au and As is considered to be an ore forming process<sup>1</sup>. The high variability of trace elements in pyrite makes it potentially a powerful tool for the reconstruction of fluid compositions in hydrothermal settings. Nevertheless, the lack of partition coefficients of trace elements between hydrothermal fluids and coexisting/newly forming pyrite hinders a wider use of pyrite as a fluid proxy. Also, the underlying processes controlling the incorporation into the crystal structure and the interplay of different trace elements during partitioning are not well understood.

Here, we present results of hydrothermal batch experiments at 200°C studying the partitioning of Co, Cu, Pb, Se, Bi, As and Sb between aqueous solutions and newly formed pyrite. We use the replacement of siderite to crystallize euhedral pyrites large enough to be measured by LA-ICPMS for their trace element content<sup>2</sup>. The initial trace element concentration in the experimental fluid varied from 0.1 to 10 ppm. To study the influence of As in pyrite on the D values, As concentration in the experiments was varied independently, whereas all other tracers had a constant ratio.

Concentrations of trace elements in hydrothermal pyrite range between 10 ppm and 1200 ppm, and depend strongly on the initial fluid composition. Partition coefficients for Sb and Se are in the range of 20-300. Co, Cu, Pb, Bi have lower but more variable D values ranging from 0.1 up to 50. Almost all studied elements show a high compatibility in the pyrite structure, replacing most likely either S (i.e. Se, Sb) or Fe (i.e., Co, Cu, Bi, Pb) in the crystal lattice. Unlike Au, partitioning of studied trace metals is not coupled to the As concentration of newly formed pyrite. Nevertheless, D values of Co, Cu, Se and Sb from experiments with a high concentration of trace elements (i.e., 10 ppm) decrease compared to D values from experiments done at lower concentrations (i.e. 0.1 and 1 ppm). This behavior indicates either a solubility limit of the particular element in the pyrite structure or results from an over-occupation of the potential crystal sites by other trace elements.

The partition data from our experiments will help to unlock the potential to use the pyrite composition as a proxy for hydrothermal fluids.

References:

<sup>1</sup> Kusebauch et al., (2019) *SciAdvances*; 10.1126/sciadv.aav5891

<sup>2</sup> Kusebauch et al., (2018) *Chemical Geology*; 10.1016/j.chemgeo.2018.09.027