Geochemical and micro-textural fingerprints of boiling in pyrite

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Several studies have shown that pyrite composition and textures are valuable tools to elucidate the evolution of hydrothermal systems. However, linking the chemical and textural features of pyrite with a single physico-chemical process, e.g., boiling versus non-boiling events, remains elusive and challenging.

Here we examine how pyrite geochemical and micro-textural features relate to pyrite-forming process at the active Cerro Pabellon Geothermal System (CPGS) in the Altiplano of northern Chile. We integrate EMPA and LA-ICP-MS data with micro-textural observations of pyrite and associated gangue minerals recovered from a ~500 m long drillcore that crosscuts the argillic, subpropylitic and propylitic alteration zones in the CPGS. Additionally, we carried out a Principal Component Analysis (PCA) to understand and interpret the internal structure and chemical variability of the pyrite data.

Pyrite formed during vigorous boiling is characterized by high concentrations of As, Cu, Pb, Ag and Au in comparison to Co and Ni. These pyrites have irregular forms and areas with clustered pores and abundant micro- to nano-inclusions indicating a formation by rapid crystallization. In contrast, pyrite formed under gentle boiling to non-boiling conditions is characterized by a higher concentration of Co and Ni, and lower concentrations of As, Cu, Pb, Ag and Au. Texturally, these pyrites form aggregates of euhedral and “clear” pyrite crystals with scarce pores and mineral inclusions suggesting formation under more steady physico-chemical conditions.

These results show that pyrite not only records the chemical evolution of hydrothermal fluids, but can also provide critical information related to physico-chemical process such as boiling and phase separation. The notable relation between the chemical and micro-textural features of pyrite with its formation conditions in the CPGS highlights the potential of this mineral as a vector to mineralization in low- to intermediate-sulfidation epithermal systems.