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Mechanism of mineral transformations in krennerite, Au_3AgTe_8, under hydrothermal conditions

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Abstract

Calaverite, krennerite, and sylvanite are Au-Ag-tellurides with close compositions and related crystal structures. Previous experimental studies show that both calaverite and sylvanite transform to porous "mustard" gold under hydrothermal conditions; however the transformation of sylvanite follows a complex reaction path with several intermediary products, contrasting with the simple replacement of calaverite by gold. Here we report results of an experimental study of the transformation of krennerite, a phase with Ag contents intermediate between those of calaverite and sylvanite.

Krennerite was replaced by Au-Ag alloy under all experimental conditions explored (160 to 220 °C; pH_T ~ 3 and 9; varying availability of oxygen). No reaction was observed at the same temperature under dry conditions. The replacement was pseudomorphic and the resulting Au-Ag alloy was porous, consisting of worm-like aggregates with diameters ranging from 200 nm to 1 μm. The replacement of krennerite proceeds via an interface coupled dissolution-(re)precipitation (ICDR) reaction mechanism. Tellurium is lost to the bulk solution as Te(IV) complexes, and may precipitate away from the dissolution site. In contrast, Au-Ag alloy precipitates locally near the krennerite dissolution site. Overall, the hydrothermal alteration of krennerite is very similar to that of calaverite, but differs from the alteration of sylvanite, for which multi-step reaction paths led to complex products and textures under similar conditions. These striking differences are driven by the competition between solid-state reactions and ICDR reaction in sylvanite. This reflects the fact that a metastable, Ag-rich calaverite nucleates on sylvanite during the early steps of its dissolution, as a result of the close relationship between the structures of these two minerals and the enrichment in Au, Ag, and Te in solution at the reaction front. In contrast, for calaverite and krennerite, no such phase precipitates, and both minerals are transformed in a pseudomorphic manner into Au-Ag alloy.

Keywords: Krennerite, gold, dissolution-reprecipitation, pseudomorphism, replacement