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Incorporation of incompatible trace elements into molybdenite: Layered PbS precipitates within molybdenite

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Abstract

Trace elements in molybdenite can provide important information regarding the composition of ore-forming fluid and the evolution and genesis of ore deposits. However, the occurrence states and behavior of relatively incompatible trace elements (e.g., Pb and Os) in natural molybdenite remain ambiguous. Here, we report an abnormally high enrichment of Pb and layered PbS precipitate within molybdenite grains from the Huanglongpu carbonatite-hosted Mo-Pb deposit in the Qinling orogenic belt of Northern China. High-resolution transmission electron microscopy (HRTEM) and related nanobeam techniques were applied to characterize the occurrence states of Pb within molybdenite at the atomic scale. The results show that up to several weight percent of Pb can be incorporated into the molybdenite structure during initial crystallization, which can lead to the formation of screw dislocations and 3*R*/disordered stacking of S-Mo-S sandwich layers. Observations using a scanning transmission electron microscope also reveal that Pb diffuses from the host molybdenite into the layered PbS precipitates under prolonged electron beam irradiation. Pb-bearing molybdenite tends to transform into a Pb-poor ordered $2H_1$ polytype upon Pb exsolution during cooling. Pb preferentially exsolves along the (001) plane of molybdenite and is stored in structural defects (e.g., dislocation loops) and grain boundaries, resulting in nano-scale Pb heterogeneities in molybdenite. Further coarsening of the exsolved Pb results in the formation of layered PbS precipitates along the (001) plane of molybdenite. This study provides an example of the consequences of the incorporation and exsolution of incompatible trace elements in molybdenite and demonstrates that careful mineralogical examination is required to interpret geochemical data obtained by in situ analysis techniques.

Keywords: Molybdenite, layered PbS, polytype, incompatible trace elements; Applications of Fluid, Mineral, and Melt Inclusions