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Thallium geochemistry in the metamorphic Lengenbach sulfide deposit, Switzerland: Thallium-isotope fractionation in a sulfide melt

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Abstract

The Lengenbach (Switzerland) Pb-As-Tl-Zn deposit was formed from a sulfide melt at about 500 °C during Alpine metamorphism, but details on its formation and especially the source of the metals are still under debate. In this study we present two sample sets to address these questions:

(1) MC-ICP-MS analyses of thallium isotopes in sulfides, sulfosalts, and melt inclusions from the Alpine metamorphic Lengenbach deposit in the Binn Valley of Switzerland, the non-metamorphic Wiesloch Mississippi Valley-type deposit in Southern Germany, and the Cu- and As-rich mineralization at Pizzo Cervandone about 2 km SW of the Lengenbach deposit, which has been discussed as potential source of the Lengenbach metals.

(2) LA-ICP-MS analyses of micas from the Lengenbach deposit and surrounding country rocks between the deposit and the Pizzo Cervandone to trace potential metal-bearing fluid pathways.

We found that Tl isotope compositions expressed as ε^{205}Tl values in all investigated samples range from -4.1 ± 0.5 to $+1.9 \pm 0.5$. The whole variation can be seen in the Lengenbach deposit alone, which hence records considerable fractionation even during high-temperature processes involving a sulfide melt. This large range of ε^{205}Tl is thought to be caused by nuclear volume-dependent fractionation. Interestingly, the common fahlores at Lengenbach behave differently from all other investigated sulfosalts: based on their heavy isotopic composition together with a low As/S-ratio, they do not seem to be crystallized from the sulfide melt, but are interpreted to have formed from hydrothermal fluids enriched in the heavy Tl isotopes. Although As mobilization in the gneisses and dolomites surrounding the Lengenbach deposit is evident based on secondary arsenites, no traces of such a country rock fluid could be found in fissure micas at Lengenbach. Hence, considerations involving K/Rb, Rb/Tl, As/S, and Pb/Tl ratios in the sulfides and micas imply that the element enrichment in the Lengenbach deposit is either pre-Alpine or related to peak metamorphism, but occurred definitely before mica growth at Lengenbach.

Keywords: Sulfide melt, thallium isotopes, metal sources, sulfosalts