

Native tin as solidified molten-metal droplets in a hydrothermal fluid from the epithermal Pukanec deposit (Slovakia)

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ABSTRACT

A find of native tin in deeply weathered material at the Neogene epithermal Au-Ag Pukanec deposit in Slovakia raises the question of transport and reduction to native metal, especially when such a metal requires very strongly reducing conditions. The deeply weathered material contains powdery Mn oxides and clays, with the heavy fraction made of cerussite, smithsonite, nuggets of Au-Ag alloys, and oval nuggets of native tin. During weathering, Au and Ag are mobile and can reprecipitate as native metals. Native tin persists, although it shows signs of weathering to cassiterite. Electron microprobe analyses of native tin document Ni (up to 7 wt%) in a few spots as the only other abundant component. The association of tin with pyrite indicates that tin is primary, but it had to be transported in an inert form through the fluid. The isotopic composition of native tin (expressed as $\delta^{amu}\text{Sn}_{3161\text{A}}$) shows very limited variations between 0.01 and 0.07‰ ($\pm 0.014\text{‰}$), which is close to the expected composition of parent rhyolites, suggesting that the latter were likely the source of Sn. The oval shape of the tin grains and their physical properties (e.g., the low melting point of tin) suggest that tin is transported as metal-melt droplets in the hydrothermal fluid of the epithermal system. Tin must have been reduced before entering the space of the hydrothermal veins, perhaps in the underlying carbonaceous Carboniferous sediments. Reduction of Sn(II) from hydrothermal fluid is unlikely because under such conditions, Fe(II) would also be reduced to native iron. The most feasible explanation for these facts is the local reduction of Sn(II) deep within the hydrothermal system (perhaps in the carbonaceous sediments) and transport as metal droplets to the deposition site.

Keywords: Native tin, Sn isotopes, epithermal veins, metal-melt droplets