

Toward the continuous series of HgS-ZnS solid solutions: Zn-rich metacinnabar assemblages in the Vorontsovskoe gold deposit, Northern Urals, Russia

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ABSTRACT

A nearly continuous series of metacinnabar–sphalerite solid solutions is reported in assemblages of Zn-rich metacinnabar in gold-bearing carbonate breccias of the Vorontsovskoe gold deposit, Northern Urals, Russia. Metacinnabar occurs as grains containing paragenetic inclusions of realgar, specific thallium-bearing sulfosalts, high-fineness native gold, and various ZnS–HgS minerals, including Zn-bearing metacinnabar, Hg-bearing sphalerite, and pure cinnabar. Selected metacinnabar–sphalerite compositions fall within the $(\text{Hg}_{0.54}\text{Zn}_{0.46})\text{S}$ – $(\text{Zn}_{0.62}\text{Hg}_{0.38})\text{S}$ range. This finding confirms the absence of the long-debated miscibility gap (MG), which was previously constrained to $(\text{Hg}_{0.54}\text{Zn}_{0.46})\text{S}$ – $(\text{Zn}_{0.75}\text{Hg}_{0.25})\text{S}$ in the natural HgS–ZnS cubic system. The compositions obtained within the MG have the following major components ranges (wt%): Zn (17.7–27.3), Hg (50.7–63.6), and S (18.7–22.0). Compositional zoning in Zn and Hg contents is observed in metacinnabar. The core consists of either highly Hg-enriched sphalerite or Zn-enriched metacinnabar, while the rim is composed of low-Zn metacinnabar (3–5 wt% Zn). The Hg/Zn ratio gradually increases from core to periphery. Metacinnabar also contains minor impurities of Mn (up to 1.2 wt%) and Cd (up to 2.6 wt%). Mn is a nearly constant constituent. Based on published compositional data on sphalerite–metacinnabar from 38 localities, Mn is considered an indicator for these minerals in Vorontsovskoe. Zoned Zn- and Mn-bearing metacinnabar formed during cooling (from <350 °C to <200 °C) of late-stage hydrothermal fluids enriched in chalcophile Tl–Cu–Zn–Hg–As–Sb–S elements. Our study suggests that a complete series of ZnS–HgS solid solutions may be found in hydrothermal systems with a relatively high-temperature formation regime (>250 °C). In addition, Zn–Mn-bearing metacinnabar is a metastable phase in the Zn–Hg–Mn–S system. Mn is considered a stabilizer for metacinnabar, a natural counterpart of β -HgS, which is a prospective zero-gap semiconductor.

Keywords: Zincian metacinnabar, mercurian sphalerite, HgS–ZnS solid solution, Hg–Zn–Mn–S system, sulfide, Vorontsovskoe, Northern Urals, Russia