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Experimental determination of the phase relations of Pt and Pd antimonides and bismuthinides in the Fe-Ni-Cu sulfide systems between 1100 and 700 °C

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Abstract

The stability relations of Pt and Pd antimonides and bismuthinides in the Sb- and Bi-bearing Fe-Ni-Cu sulfide systems have been experimentally determined at temperatures between 1100 and 700 °C in evacuated silica tubes. Both PtSb and PdSb are stable as immiscible liquids at temperatures above 1100 and 1000 °C, respectively. The Fe-Ni-Cu-sulfide melt that coexists with the immiscible antimonide melt can dissolve up to 3.8 wt% Sb at 1100 °C, whereas monosulfide solid solution (mss) dissolves very low amounts of Sb over the entire 1100–700 °C temperature range. The liquidus of Pt-antimonides and Pd-antimonides are above 980 and 750 °C, respectively. Bismuth does not form immiscible melt at 1100 °C but may partially partition into a vapor phase at 1050 °C. The Pt- and Pd-bismuthinides crystallize directly from immiscible bismuthinide melt only after crystallization of the sulfide melt into intermediate solid solution (iss). Insizwaite ($PtBi_2$) and froodite ($PdBi_2$) are stable at 780 and 700 °C, respectively. At the last stage of evolution of Sb-bearing magmatic Fe-Ni-Cu sulfide melts, Sb will form immiscible antimonide melt that will extract Pt and Pd from the sulfide melt. During cooling, Pt and Pd-antimonides will crystallize directly from the immiscible antimonide melt, and Pt-phases will form at higher temperatures relative to Pd-phases. Bismuth will partition into vapor phase and concentrate into a low-temperature melt in hydrothermal and porphyry systems that scavenge precious metals. The Sb and Bi (like Te) will be highly incompatible at moderate degrees of mantle partial melting.

Keywords: Platinum-group minerals, antimonides, bismuthinides, experimental study, sulfide system, phase relations