American Mineralogist, Volume 100, pages 852–860, 2015

Atom probe tomography of isoferroplatinum

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Abstract

Here we apply the relatively new analytical technique of atom probe tomography (APT) to a naturally occurring isoferroplatinum grain (Pt_3Fe) from northern California to constrain its origin and the nanoscale distribution of trace elements within the grain. Each analysis detected the positions of 10 million atoms in three dimensions with sub-nanometer spatial resolution. The (111) atomic planes are clearly resolved and their orientation was confirmed by electron backscatter diffraction (EBSD). The elemental concentrations of all elements (Pt, Fe, Ir, Ni, Rh, Ru, and Cu) determined from the APT mass/charge spectra are within 2 standard deviations of electron microprobe analysis (EMPA) of the grain. The isotopic abundances determined by APT matches NIST standard compositions over a wide range of concentrations, down to 100 ppmw. Nanoscale areas free of minor and trace elements are present throughout the sample. These could be due to the random distribution of atoms. Alternatively, the Pt-Fe phase diagram indicates that order-disorder precipitates of an $L1_2$ structure could have formed as the isoferroplatinum cooled from magmatic temperatures (Nose et al. 2003). The trace element free areas could be such precipitates, which would support a high-temperature igneous origin for the isoferroplatinum, rather than formation during low-temperature serpentinization. The results highlight the unique capabilities of APT and the potential utility of knowing the location and identity of atoms in nanometric volumes.

Keywords: Atom probe tomography, isoferroplatinum, platinum group alloy, precipitate, order-disorder, core-shell