Chemical form of palladium and 3D distribution of Pt-group minerals in Norilsk ore deposits

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Norilsk ore deposits in Russia are one of the largest sources of Pt-group elements (PGEs) in the world. Palladium (Pd), the economically important critical element, one of the main metals mined in Norilsk, is found either in Pt-group minerals (PGMs) or as a trace element in pentlandite, \((\text{Fe},\text{Ni})_9\text{S}_8\) \(^1\). 2D distribution and high concentrations of Pd (up to 5 wt.% in pentlandite) in these minerals were recently demonstrated in Norilsk ores (Fig. 1) \(^2\). However, the trapping mechanism of Pd during the growth of sulphides and the nature of its incorporation into pentlandite are still under debate. It is generally accepted that PGEs can incorporate in sulphide minerals in form of separate atoms, metal clusters or as individual microscopic PGMs \(^3, 4\). So far, no direct evidence on Pd substitution in pentlandite is provided. Moreover, distribution of Pd on the atomic scale in PGMs is also unknown. In the present study we determine the chemical forms of Pd in natural pentlandite and PGMs from Norilsk ore deposit by combining synchrotron-based micro X-ray fluorescence (\(\mu\)XRF) and high energy-resolution X-ray absorption spectroscopy (HR-XAS). The spectroscopic measurements are complemented by 3D micro computed tomography (\(\mu\)CT) combined with spectral CT \(^5\). Synchrotron-based HR-XAS shows the atomic bonding environment of Pd in pentlandite, and common PGMs. In addition, we present a 3D distribution of chemically different PGMs and their relations with sulphide minerals. The new 3D data allows for an improved genetic model of the formation and enrichment of PGMs in the Norilsk ores. These results will help to develop more sustainable mining and the supply of PGEs, economically important critical metals.

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