Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35844

In situ Pb-Pb and Lu-Hf dating of aeschynite reveals principal ~430 MaNb mineralization at Bayan Obo

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The Bayan Obo deposit in China is the world's largest REE deposit and also represents one of the most significant Nb endowments. Despite decades of study, the timing and genesis of Nb mineralization at the Bayan Obo deposit remain poorly constrained. This is due to the deposit's complex, multistage geological evolution spanning over one billion years and the presence of more than 30 Nb minerals. To reconstruct the temporal framework of Nb mineralization, we carried out systematic *in situ* Pb–Pb and Lu–Hf dating of aeschynite, the most important Nb mineral, accounting for >30% of the Nb resource of the deposit. Twelve aeschynite samples from various ore types were selected for SIMS Pb–Pb dating. Among them, 11 samples yield consistent ages between 402 ± 43 and 449 ± 56 Ma, with a weighted mean of 429 ± 11 Ma. The remaining aeschynite sample yields an age of 291 ± 55 Ma. Three additional aeschynite samples were selected for LA-ICP-MS/MS Lu–Hf analyses. They also yield consistent ages ranging from 420 ± 48 to 435 ± 39 Ma. Our new aeschynite ages, in combination with published geochronological data, indicate that the principal Nb mineralization at Bayan Odo occurred in the early Paleozoic, coincident with the newly identified ~430 Ma carbonatite dikes throughout the mining area. The Nb mineralization is most likely controlled by carbonatite-derived hydrothermal fluids. The pre-existing Nb mineralization was locally reworked or remobilized by regional Permian (~270 Ma) granite plutonism.