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Characterizing the magmatic-hydrothermal and orogenic origin of the Pogo Gold Deposit, east central Alaska

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Pogo gold deposit within the Tintina Gold Province (east-central Alaska, USA) is not only known for world-class gold exploration but also holds potential for sourcing the critical minerals Bi and Te. Gold occurs within quartz veins as native gold, intergrowths with Bi-Te minerals, and micro- and nano-scopic inclusions in arsenopyrite ("invisible Au"). The origin of the mineralizing fluid in Pogo remains a subject of significant debate. Stable isotopes from ore-stage carbonate minerals suggest a magmatic-hydrothermal source [1], which is corroborated by the geochronological constraints that suggest mineralization contemporaneous with mid-Cretaceous felsic intrusions (107–93 Ma). Re-Os molybdenite dates from the main Liese zone lode veins are much older (~104 Ma) than mica ^{40}Ar-^{39}Ar ages in the vein alteration assemblage (96–91 Ma). However, hydrothermal monazite and xenotime chemistry from the amphibolite facies host rock suggests an orogenic fluid [2], potentially related to peak regional metamorphism at ~116 Ma. On-going cathodoluminescence study indicates that Pogo was an orogenic Au deposit, subsequently overprinted and upgraded by intrusion-related fluids.

To resolve the mineralizing fluid-source controversy, this study utilizes a machine learning (ML) framework by analyzing high-dimensional global geochemical datasets of magmatic-hydrothermal deposits and orogenic deposits from the Critical Minerals in Archived Mine Samples Database and Alaska Geochemical Database. First, we employed Self-Organizing Maps (SOM) to perform unsupervised neural clustering on 10 pathfinder trace elements in host rocks. Here Pogo samples exhibit a dual affinity, showing geochemical similarity with both orogenic and reduced intrusion-related deposits (IRGS) clusters.

Subsequently, a supervised ML classifier (XGBoost) was trained on the same database of pathfinder elements from known global IRGS and orogenic deposits, effectively distinguishing between these two deposits. When applied to Pogo sample analyses, the model categorized >60% samples as IRGS with the rest classified as orogenic. SHAP values demonstrate Au-Bi-Te-As signature as a robust genetic indicator. These findings provide strong evidence for a magmatic-hydrothermal Cretaceous mineralization event overprinting an earlier orogenic Au deposit at Pogo. Our study offers a novel ML tool for fingerprinting cryptic fluid sources of complex gold-bearing mineralized systems.

References:

[1] Morishita & Rogers (2025) *Minerals,* 67.

[2] Taylor et al. (2024) *Miner Deposita,* 949–967.