Advanced Hydrogeological Modeling and Sensitivity Analysis to Optimize Dewatering and Characterize Water Flow at the Mingomba Cu Deposit

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This research applies advanced 3D geological modeling and hydrogeological simulation techniques to support dewatering strategy design during shaft development at the Mingomba Cu deposit on the Copperbelt (explored and developed by KoBold Metals). Leveraging Petrel, a software widely used in the oil and gas sector, the study demonstrates how cross-disciplinary technologies can be adapted to mineral development, enabling high-resolution characterization of groundwater flow in structurally complex and fracture-dominated environments. Stratigraphic and structural datasets from geotechnical boreholes are integrated into a dynamic simulation framework, where hydraulic properties are assigned using the Kozeny-Carman relationship, and Darcy’s Law governs transient flow across heterogeneous stratigraphic units.

Innovative computational workflows underpin the project’s methodology: Monte Carlo simulations are employed to quantify uncertainty in key parameters such as permeability, porosity, and pressure response. Additionally, a sensitivity analysis identifies which variables exert the most influence on model outcomes, providing actionable insights to prioritize future data collection and optimize the value of new measurements. This targeted approach enhances the robustness and predictive power of the simulation, especially in scenarios of operational uncertainty.

Model calibration draws upon geostatistical methods and historical analogs from the adjacent Konkola mine, where previous dewatering campaigns led to increased near-surface permeability due to subsidence. Scenario-based planning supported by the model enables just-in-time dewatering localized at active mining fronts, helping to minimize risk and improve development efficiency.

This work exemplifies how technological innovation, including the repurposing of petroleum industry tools and probabilistic analysis, significantly enhances decision-making in mineral development. In particular, this modeling framework contributes to the efficient and responsible extraction of critical minerals like copper to enable the global energy transition. It reflects the broader trend of integrating computational methods across scales to transform how we discover, develop, and manage next-generation mineral systems.