**An Intelligent Decision Support System Framework for Continuous Economic Optimization of Underground Critical Raw Materials Mining Projects**

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**Keywords:** Techno-Economic Uncertainties, Digitalization, Decision Support System, Underground Mining, Critical Raw Materials

**Abstract:**

Economic instability has led to substantial obstacles to critical raw material (CRM) extractions worldwide, suspending or discontinuing numerous projects. In addition to fluctuating market prices, economic instability arises from the unexpected discontinuities and differentiated geotechnical and rock mechanic properties of ore bodies. Furthermore, excessively optimistic assumptions about production volumes, processing and recovery rates during the mine planning phase cause significant economic vulnerability. Adverse economic circumstances during the operation phase hinder CRM extraction projects' feasibility and profitability, especially underground operations where uncertainties and costs are naturally high. The application of digital technologies in several mining operation sectors has reduced risks. However, using artificial intelligence (AI), machine learning, predictive analytics, real-time data, and other relevant digital technologies in mine planning and optimisation is still minimal. A framework with integrated digital technologies is required to support the decision maker during the operational phase of the underground mining projects to handle unexpected economic scenarios and optimise the project to attain feasibility in CRM extractions.

A novel AI-driven decision-support system (DSS) framework is proposed in this study to continuously evaluate underground CRM mining projects' economic viability. Upon integrating AI with machine learning technologies, this framework evaluates and optimises crucial operational parameters, such as mining methods, ore grade, recovery rates, and production schedules. Moreover, the framework has used predictive algorithms and historical, currently available mining operational data to provide a dynamic model that aids decision-making over the mining project's life. By addressing technological and economic concerns, the framework enables decision-makers to evaluate the effects of different operational changes and choose options that support long-term CRM extraction objectives. Through constant updating of data and the creation of real-time economic scenarios, the framework helps the new and ongoing mining project to quickly adjust to changing market conditions, improving operational efficiency and economic resilience.