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Optimizing In-Situ Mineral Recovery: Sustainable Rock Preconditioning with Slow-Releasing Energy Material Agents

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Extended Abstract

The escalating demand for minerals, driven by global population growth and expanding markets, underscores the inefficiencies of traditional mining techniques, particularly their high energy consumption and environmental footprint [1]. In-situ Mineral Recovery (IMR) emerges as a promising, sustainable alternative, leveraging leaching reagents to extract minerals directly from deep ore deposits [2]. Despite its potential, the viability of IMR faces significant environmental challenges, especially concerning groundwater contamination and the permeability of host rocks [3]. This study investigates the application of a slow-releasing energy material agent (SREMA), a non-explosive expansive material, as an environmentally friendly solution for rock preconditioning, aiming to enhance IMR's feasibility and applicability across various mining and engineering contexts.

Our comprehensive analysis focuses on the hydration dynamics, effects of admixtures, and mechanisms of fracture initiation and propagation of SREMA. The study underscores SREMA's potential to improve rock fracturing efficiency by controlling fracture propagation, supported by insights from swelling theory and crystal growth [4, 5]. Through detailed experiments and analyses, we demonstrate how SREMA can be tailored to optimize performance in IMR processes, addressing key factors such as expansive pressure quantification, water content, temperature, and chemical composition.

Key findings from our research reveal that SREMA can significantly enhance rock fracturing by managing the initiation and control of fractures. This capability is crucial for creating an interconnected fracture network for efficient mineral extraction in deep underground conditions [6]. We explore the influence of various admixtures on SREMA's hydration process and its subsequent expansive pressure, providing a deeper understanding of the material's behaviour under different environmental conditions.

Furthermore, our study highlights the importance of developing SREMA with specific properties tailored for IMR applications. These properties include optimal viscosity, flowability, and water resistance, essential for ensuring the material's performance in the harsh conditions encountered during deep underground mining [7]. By addressing these factors, SREMA can significantly mitigate environmental issues associated with conventional rock preconditioning methods, contributing to more sustainable mining practices.

Our findings suggest that SREMA when properly formulated and applied, can effectively reduce the environmental impact of IMR by minimizing the risk of groundwater contamination and enhancing the permeability of host rocks. This advancement represents a significant step forward in the field, offering a more eco-friendly and efficient approach to mineral recovery.

However, the study also acknowledges the necessity for further research to optimize SREMA performance and explore new applications. Future work should focus on enhancing the material's properties, understanding long-term environmental impacts, and developing advanced models to predict SREMA behaviour in various geological settings. By addressing these challenges, we can pave the way for more sustainable and effective mineral recovery processes, aligning with the growing demand for environmentally responsible mining practices.

In conclusion, this study presents SREMA as a viable solution for enhancing the feasibility and sustainability of IMR. By improving rock fracturing efficiency and mitigating environmental concerns, SREMA holds significant potential for

advancing the field of mineral recovery. Continued research and development are essential to fully realize its benefits and ensure its successful implementation in diverse mining and engineering applications.

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