# Optimization of Cut-Off Grade in Open-Pit Mines Considering Spatial and Temporal Dimensions: A CASE STUDY

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Keywords: cut-off grade optimization, mixed-integer linear programming (MILP), mining production scheduling, open-pit mining.

# ABSTRACT

Determining cut-off grades throughout a mine’s life is essential for strategic open-pit mining plans and significantly affects the project’s Net Present Value (NPV). Traditional approaches, such as Lane's algorithm and its extensions, have been widely applied, while Direct Block Scheduling (DBS) offers implicit cut-off grade determination over time. However, DBS faces computational challenges in large-scale cases, often requiring heuristics or metaheuristics to mitigate these limitations.

This study presents an optimization model to determine cut-off grades, integrating spatial and temporal dimensions. Using tonnage-grade distribution curves for predefined phase-benches, the model is formulated as a mixed-integer linear programming problem that maximizes the mining plan’s NPV. The optimization identifies critical and marginal cut-off grades for each phase-bench and period, considering operational constraints like precedence, mining rates, and processing capacities.

Applied to a real-world mine in northern Chile, the model showed a substantial NPV improvement compared to baseline methods, which only incorporate fixed critical and marginal cut-off grades. Furthermore, including additional cut-off grade alternatives per phase-bench led to further NPV increases, demonstrating the model's capacity to unlock greater economic value.

The proposed method solves all scenarios within an hour, emphasizing its computational efficiency and practicality for large-scale applications. It positions itself as a viable alternative to DBS, eliminating reliance on heuristics. Additionally, its low computational requirements enable it to optimize mining and processing capacities, provided the mining phases are predefined.

This framework offers a robust, efficient tool for enhancing decision-making in open-pit mine planning, balancing economic objectives and operational feasibility.