Comparison of Stochastic vs Deterministic Open Pit Mine Production Schedule Optimisation using Mixed Integer Linear Programming with Conditional Orebody Simulations

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# ABSTRACT

Stochastic optimisation creates robust production schedules by solving for mining locations and processing destinations over time to maximise discounted cash flows while accounting for both orebody uncertainty and variability. Conditional simulation inputs provide a model of uncertainty by creating multiple equally likely orebody realizations conditional to existing drillhole information. Each simulated orebody realization also models the variability of selective mining unit grades.

A new stochastic optimisation model is presented which maximises Net Present Value (NPV) by simultaneously solving for mining sequences, process cut-offs, stockpiling, and blending over time. The new model strictly adheres to mine and process constraints for each orebody realization without relying on arbitrary penalty functions. The model is formulated as a Mixed Integer Linear Program (MILP) with conditionally simulated orebody realizations as the key geostatistical input.

The stochastic optimisation model can be simplified to allow deterministic optimisation with deterministic geostatistical inputs that can capture orebody variability but do not capture the uncertainty displayed by conditional simulations.

The stochastic optimisation model can also be simplified to allow stochastic evaluation of existing mine plans created via deterministic optimisation or any other process. Stochastic evaluation with conditional simulation inputs captures the effects of orebody uncertainty and variability to enable risk analysis to answer questions such as: what annual production ranges are likely? or what NPV uncertainty might be expected?

Stochastic optimisation, deterministic optimisation and stochastic evaluation of open pit mine production schedules are compared using a gold mine case study. Significantly higher NPV is seen from stochastic optimisation with conditional simulation inputs vs deterministic optimisation with Ordinary Kriging inputs. However, when orebody variability and mining selectivity are accurately captured in deterministic geostatistical inputs via an Indicator Kriging, Localized Conditional Simulation or similar process, deterministic optimisation yields long term open pit mine plans that are very similar to stochastic optimisation solutions.