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Modelling the optimum interface between open pit and underground mining for gold mines

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ABSTRACT

The open pit to underground transition problem involves the decision of when, how and at what depth to transition from open pit (OP) to underground (UG). However, the current criteria guiding the process of the OP – UG transition are not well defined and documented as most mines rely on their project feasibility teams' experiences. In addition, the methodologies used to address this problem have been based on deterministic approaches. The deterministic approaches cannot address the practicalities that mining companies face during decision-making, such as uncertainties in the geological models and optimisation parameters, thus rendering deterministic solutions inadequate.

In order to address these shortcomings, this research reviewed the OP – UG transition problem from a stochastic or probabilistic perspective. To address the uncertainties in the geological models, simulated models were generated and used. In this study, transition indicators used for the OP - UG transition were Net Present Value (NPV), ratio of price to cost per ounce of gold, stripping ratio, processed ounces and average grade at the run of mine pad. These indicators were used to compare four individual case study mines; with AngloGold Ashanti's Sunrise Dam Gold Mine in Australia, which made the OP – UG transition in 2004 and hence develop an OP – UG transition model. Sunrise Dam Gold Mine is a suitable mine for providing baseline values because it recently made the OP-UG transition. Only four case study mines were used because it took nine months to generate transition indicators for each case study mine.

A generic model was developed from the results of the four case studies to help mining companies make the OP - UG transition decision. The model uses a set of transition indicators that trigger the decision while recognising the uncertainties in the geological models, future mineral price as well as cost and processing parameters. From the generic model, mines can transition when the margin (gold price to cost per ounce ratio) is greater than 2.0; grade is between 4 g/t and 9 g/t, stripping ratio between 3 and 15 m^3/t and positive NPV depending on the type of deposit. With this model mines can now transition when the critical conditions of the transition indicators (gold price to cost per ounce, grade and stripping ratio) are achieved. The model also uses the set of transition indicators to model the probabilistic nature of the OP-UG interface. The derived generic model will help mining companies in their annual reviews to assess the OP - UG interface and make decisions early enough with regard to transition timing.