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Strategic Mine Schedule Optimisation

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ABSTRACT

This abstract describes long term mining schedule optimization approach that may be suitable for complex marginal projects and is based on modern scheduling techniques.

The techniques are an attempt to solve limitations of the Lerch Grossman algorithm that became an industry standard. The algorithm (designed in 1964-1965) is used to define economic viability of a pit by outlining the ultimate pit using economic and mining parameters.
Then mine scheduling is done based on nested shells approach where the same LG algorithm is used to define nested pits with different revenue factors. Somewhere in the process a cut off grade (or series of cut off grades) is calculated to define what material should go to the plant.
A deficiency of Lerch Grossman and fixed cut-off grade(s) is the lack of the concept of time hence no concept of constraints related to the time while mining, as any industrial process, is always constrained by a bottle neck.

It gets even more complicated when a mining project has several alternative processes for the same ore. For example when it has fresh and oxide Cu in the same block (Katanga mineralization style). The solution for pit optimization often requires a customised routine in the optimization software.

A flexible cut-off grade taking into account opportunity costs (Lane, 1988; Rendu 2014) could partially solve the problem and would allow to subordinate other parts of mining enterprise to the constraint/bottle neck. But it means introducing complexity into scheduling process. And introduction of several processing streams increases number of required cut-off calculations dramatically.

The proposed approach is based on using economic value of each block and apply constraints to physical throughput units in the system. Thus it allows to avoid using the proxy of economic value such as cut-off grade. The model is then run through an integer linear programming algorithm to optimize the schedule trying to achieve maximum NPV. The approach was initially described by Thys Jonson in 1968.
The constraints can be defined in different units and applied in parallel. For example, a total mining capacity in tons, plus total crushing capacity in BWi (energy), oxide ore capacity (in tonnes), total deleterious elements content (in tonnes) in a period and other parameters can be defined simultaneously. The ultimate goal is to get a schedule with maximum NPV.

Limitations of the approach are the consequences of its advantages – the resulting schedule is strategic in nature and will require further analysis and design work, and sometimes what is the most economic solution in long term is not always what a company may require right now. An example of the latter may be a cash strapped miner that would prefer to sacrifice long term NPV to this year's cashflow.