
Stockpiles – Optimizing a Global Limit

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Abstract

The usual effect of optimizing cut-offs on a given mining schedule is to raise cut-offs early to ensure that high grade material can be processed earlier to bring increased revenue forward - where it has greater economic benefit. Without stockpiles, lower grade material that is still economic to process (but not as financially rewarding as higher-grade material) will be dumped. If stockpiles can be used, then this material can be saved for the time when mining cannot supply sufficient ore to the mill to keep it fully occupied, or mining has finished. Space for the stockpile can sometimes be a problem. When a global limit on stockpile space exists, it is not simply a matter of dumping the excess material. The optimization process will adjust the cut-offs to maximise the Net Present Value (NPV) of the mine, which also reduces the amount of material dumped.

Introduction

Choosing a cut-off has evolved from the simplistic (illustrated by Lane, K. F. 1997, p.2) to methods he pioneered which now take into account the effect of time on the value of money (*op. cit.*, p.57).

The process of optimising cut-offs involves a life-of-mine plan that varies the cut-offs over the life of the mine to increase the value (NPV) of the mine. The process takes a mining schedule and adjusts the cut-offs to process the greater revenue bearing material sooner rather than later since a dollar earned today is worth more than the

same dollar earned later (*Peirson & Bird, 1981 p.109*).

It is worth emphasising at this point that cut-off optimization can only be performed in situations where the mining capacity is not a limiting factor. Where the processing plant is able to take all the material from the mining operation there is no point in rejecting any material above the marginal cut-off.

While the cut-off optimization process still improves the value of the mine even though processable material is dumped, an even greater return can be made by saving the ore above the marginal cut-off (but below the optimized cut-off) for later processing. This stockpiled material, (*defined by Lane, K.F. 1997, p.71*) as "Intermediate grade", can be used to smooth out gaps in the mining supply to the mill, and/or keep the mill going for a time after mining has ceased.

The Problem

Some locations do not have an unlimited area in which to stockpile the rejected intermediate grade material. In such a situation, the amount of material that can be stockpiled must be limited to a global maximum, even though the available area can be used for stockpiles of different grades, different rock-types and different quantities.

Without an optimizing process, when the stockpile is full, new material to be added must be discarded. An optimizing process

will limit the amount of “useful” material that we would otherwise have to dump.

An Example

Using some test data (diskette available if requested) a base scenario is presented with step-wise changes being made in each successive scenario to clearly identify the effect of those changes in each scenario.

Base Case Scenario

The base case for this illustration has a 20 million tonne (mt) per year mining limit

and a 2.5 mt/year processing limit. As you can see from the graph below, the mining limit is only reached in period 5. This data was chosen to clearly illustrate the effect of stockpiles on cut-off optimization, not how well the mining schedule was planned!

There is no cut-off optimization in this scenario and the NPV of the mine is \$175,631 (in thousands). Most of the time, the limiting factor is the processing, which must be the case if cut-off optimization is to reap any benefit.

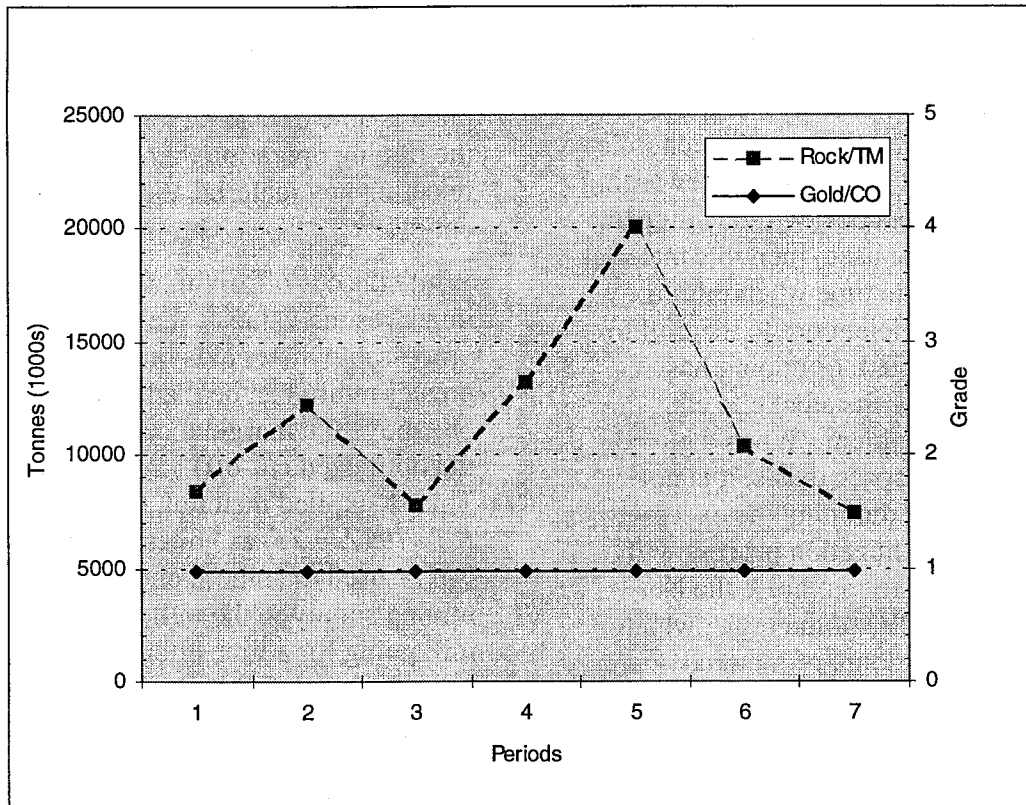


Figure 1: Base Case Scenario – Marginal Cut-off

Optimised Cut-off Scenario

The only change between this scenario and the base case scenario is that the cut-off has been optimized to maximise the NPV of the mine.

Notice that the heavy mining that was in period 5 of the base case has now been brought forward to period 4. This has occurred because the intermediate grade ore

in the first three periods has been rejected in favour of reaching more quickly the richer ore in later periods. Even though the intermediate grade ore has been thrown away in this scenario, the value of the mine has still increased 6.9% to \$187,668 (1000s) because revenue has been brought forward.

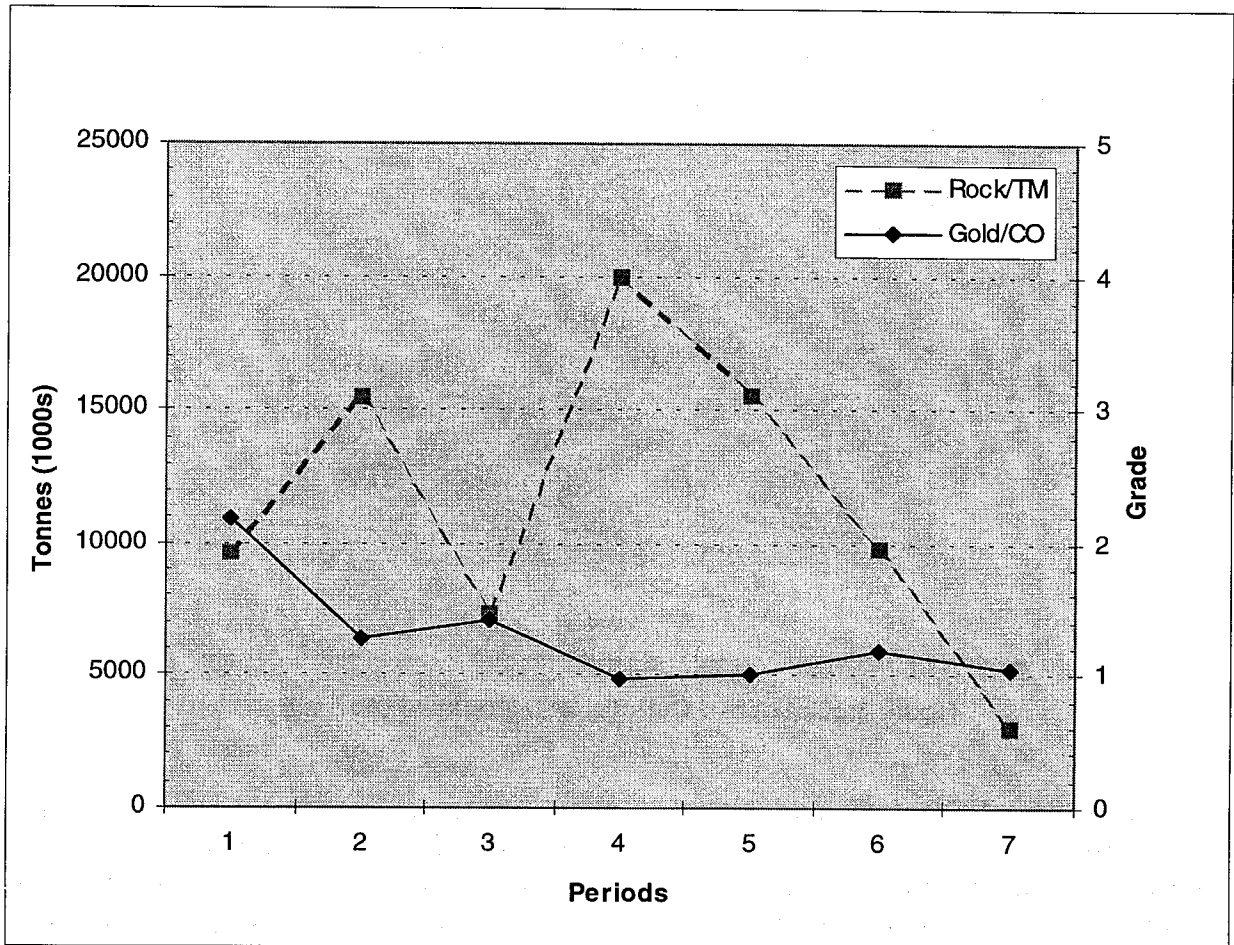


Figure 2: Optimized Cut-offs (no stockpile)

Optimized Cut-off with Stockpile Scenario

In this scenario, we save the intermediate grade ore that was rejected in the previous scenario to a stockpile for processing at a later time. The stockpiled material will be processed if the mining limit has been reached but there is still processing capacity available, or if there is still stockpile material available when the mine is finished.

A stockpile recovery factor of 90% and a stockpile re-handling charge of 50c/tonne

are included to simulate the penalty involved in using a stockpile. These factors are included in both scenarios involving a stockpile.

Because intermediate grade ore is saved for later processing, the cut-off optimization algorithm is more aggressive in reaching the best material as fast as possible. This has the effect of bringing the cash-flow even further forward, and in this example, results in a 9.3% increase from the Base Case Scenario to \$191,922 (1000s).

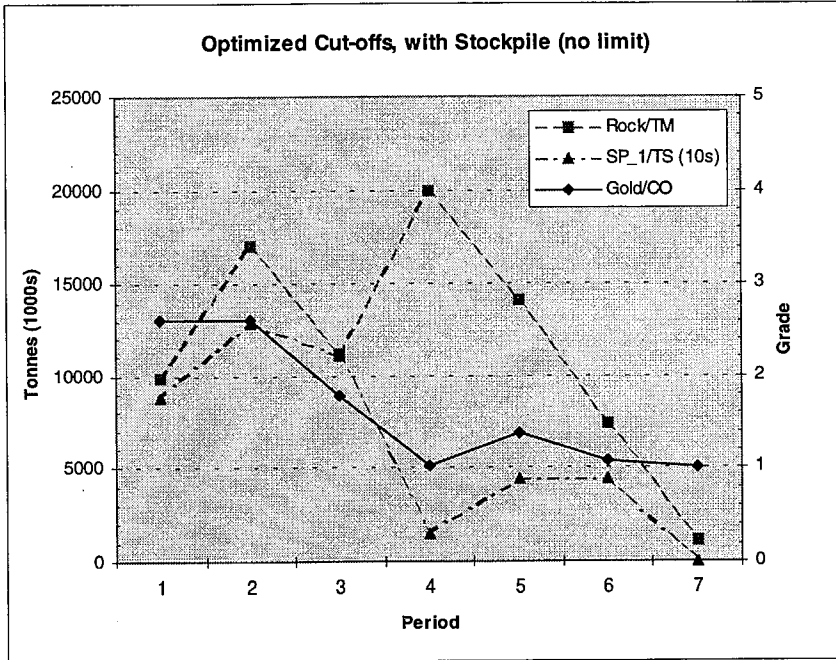


Figure 3: Optimized Cut-offs, with Stockpile (no limit)

Optimized Cut-off, Stockpile and Global Limit Scenario

We now come to a situation where the change we impose on the scenario has a negative effect on the mine's NPV. By imposing a global limit on the amount of material that can be placed on the stockpile,

we are constraining Opti-Cut's freedom in the cut-off optimization process. We know, therefore, that the final result will not be as good as an unconstrained optimization, but the results bring their own surprise.

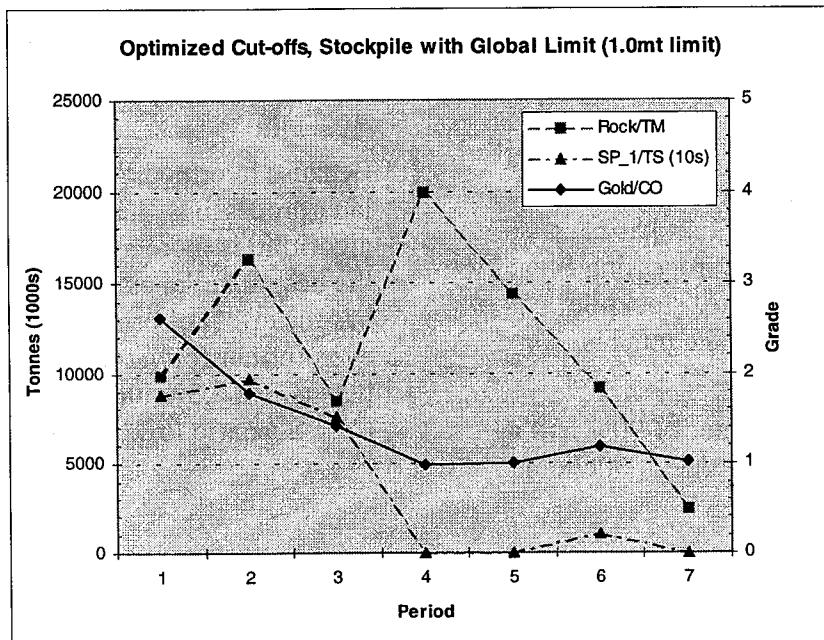


Figure 4: Optimized Cut-offs, Stockpile with Global Limit (1.0 mt limit)

In this example, we have used a stockpile global limit of 1.0 million tonnes. In studying the result, we discover that the global limit has not just “capped” the stockpile, throwing away material once the global limit has been reached, but that the optimization has been redone to ensure that the best material is kept for processing.

While it is not obvious in the above graph, it can sometimes appear in these summaries that the stockpile total stays significantly below the global limit. In these situations, the intra-period peaks have been smoothed out of the summary information.

Summary

The NPV of the four scenarios is presented below.

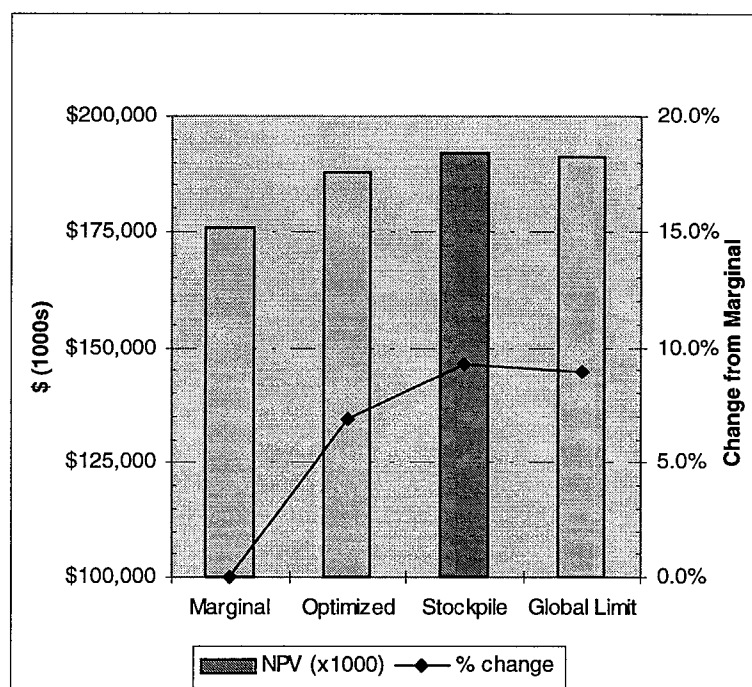


Figure 5: Cut-off Scenarios Compared

This is perhaps the best indication yet that Cut-off Optimization is *not high-grading*, but a whole-of-life schedule where adjusting the cut-offs during the life of the mine can allow a mine operator to improve its value.

Conclusion

Cut-off optimization can improve the value of a mine, but in the process, some economically viable ore will not be processed unless stockpiles are used. By adding stockpile(s), this ore is saved for later processing which boosts the value of the mine even further. Some mine sites,

however, do not have the luxury of stockpile sites as large as an unrestrained, cut-off optimized mine plan would need. By incorporating a global limit on the stockpile size, the Opti-Cut Cut-off Optimization process re-optimizes the whole-of-life mine schedule which minimises the value of ore not processed and still maximises the NPV of the mine.

Acknowledgements

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References

Lane, K F 1997. *The Economic Definition of Ore: Cut-off Grades in Theory and Practice* (Reprinted with updates and improvements), Mining Journal Books, London.

Peirson, G, Bird, R, 1981. *Business Finance, 3rd Edition*, McGraw-Hill, Sydney.