Quality or Quantity? Do you understand your orebody?

A Ebbels, Principal Consultant, SRK Consulting

This article was first published in The AusIMM Bulletin, December 2014.

Introduction

The past decade has seen mining costs spiral and in the last two years the commodity prices have been volatile. The mining industry is now, once again, focusing on costs and gone are the days that any ore is good ore or metal at any cost.

The current economic climate has created an environment that is being experienced for the first time by many operational engineering and geology staff. When the commodity prices are high, orebodies are forgiving of additional expenditure than in harder times when every dollar spent has to be justified to ensure that operations are profitable.

This article explores the simple changes that mine planning and production engineers can implement to improve their designs and ultimately improve the bottom line. The worked examples in the article will explore the impact on the bottom line that simple changes can have through practical examples comparing an over-engineered ("Rolls Royce") design to an optimized design and the impact that poor geological information can have on profitability.

While some of these changes seem obvious to those with experience of tougher times, a review of several mines and mine designs within Australia show that understanding of the economics of orebody is lacking by many planning engineers. The designs are "Rolls Royce", but unsustainable in the lower grade orebodies at the lower commodity price.

Geology

Mine geology has the ability to make or break a mine. If the geological interpretation is not well understood, the flow on effect to the mine design, the processing plant and potentially the end product will result in a lower profitability than expected.

The accuracy of the information that a geologist supplies the mining engineer is important from the grade estimation through to the location of structures within the mine. Lower than planned grades will result in lower profit or even a loss. The misinterpretation of the location or severity of structures may lead to higher costs due to additional ground support and delays in production. The geologist can only estimate from the data collected, so ensuring that the geological data is collected ahead of when required and is available to be included in the interpretation and incorporated into the design process is critical to the success of a mine. Grade control drilling, time allowance for assaying and interpretation should be included as activities in the mine schedule.

The following worked exampled (Example 1) shows the impact that a 10% decrease in the mine grade can have on the economic viability of a stoping level.

Example 1

The worked examples in this paper are based on the mine design shown in Figure 1.

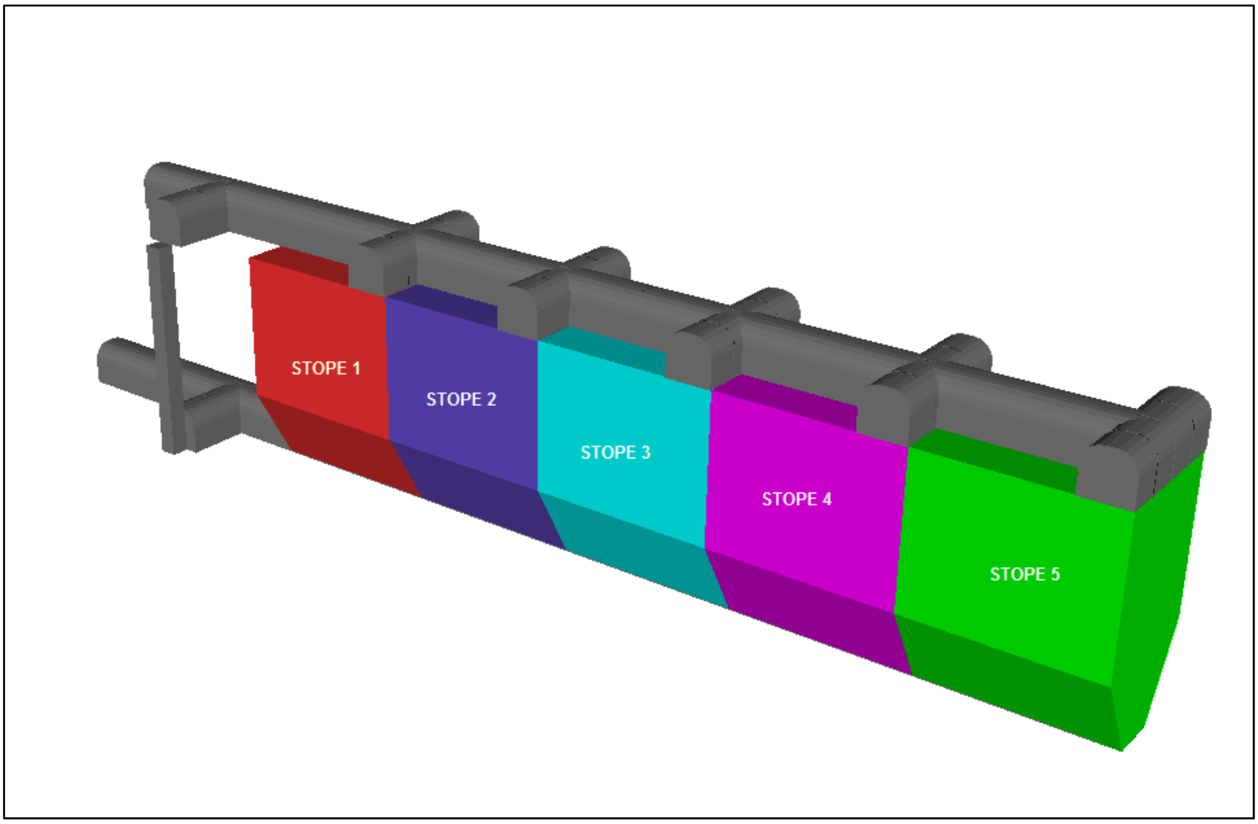

Figure 1: Worked Example Design 1

The worked example assumes that the mine design has not changed, but the grade of all the stopes has been reduced by 10%. The calculations are based on a total operating cost of AUD110 /t, copper price of AUD7,200 /t. Table 1 and Figure 2 show the impact the reduction in stope grade has on the profitability of the level. The profitability of the level is reduced by approximately 45% (AUD1.4 M) without the cost of capital being included. A 5% reduction in grade reduces the profitability by 32%.

While the level is still quite profitable, the impact of the reduction in grade is considerable. If the mine had an annual production of 1 Mtpa and there was a 10% reduction in grade, then there is the potential for the profit for the year to have reduced by almost half the budgeted profit, if the grade reduction was across the whole deposit.

Table 1: Summary of impact of lower grade on potential profit

Stope	Tonnes	Original Copper Grade (%)	New Copper Grade (%)	Original Revenue (AUD M)	New Revenue (AUD M)	Cost (AUD M)	Original Profit (AUD M)	New Profit (AUD M)
Stope 1	20,000	2.4	2.2	3.02	2.72	2.20	0.82	0.52
Stope 2	20,000	1.9	1.7	2.43	2.18	2.20	0.23	-0.02
Stope 3	20,000	2.6	2.3	3.27	2.94	2.20	1.07	0.74
Stope 4	20,000	2.2	2.0	2.77	2.49	2.20	0.57	0.29
Stope 5	20,000	2.1	1.9	2.64	2.38	2.20	0.44	0.18
Total	**100,000**	**2.2**	**2.0**	**14.12**	**12.71**	**11.00**	**3.12**	**1.71**

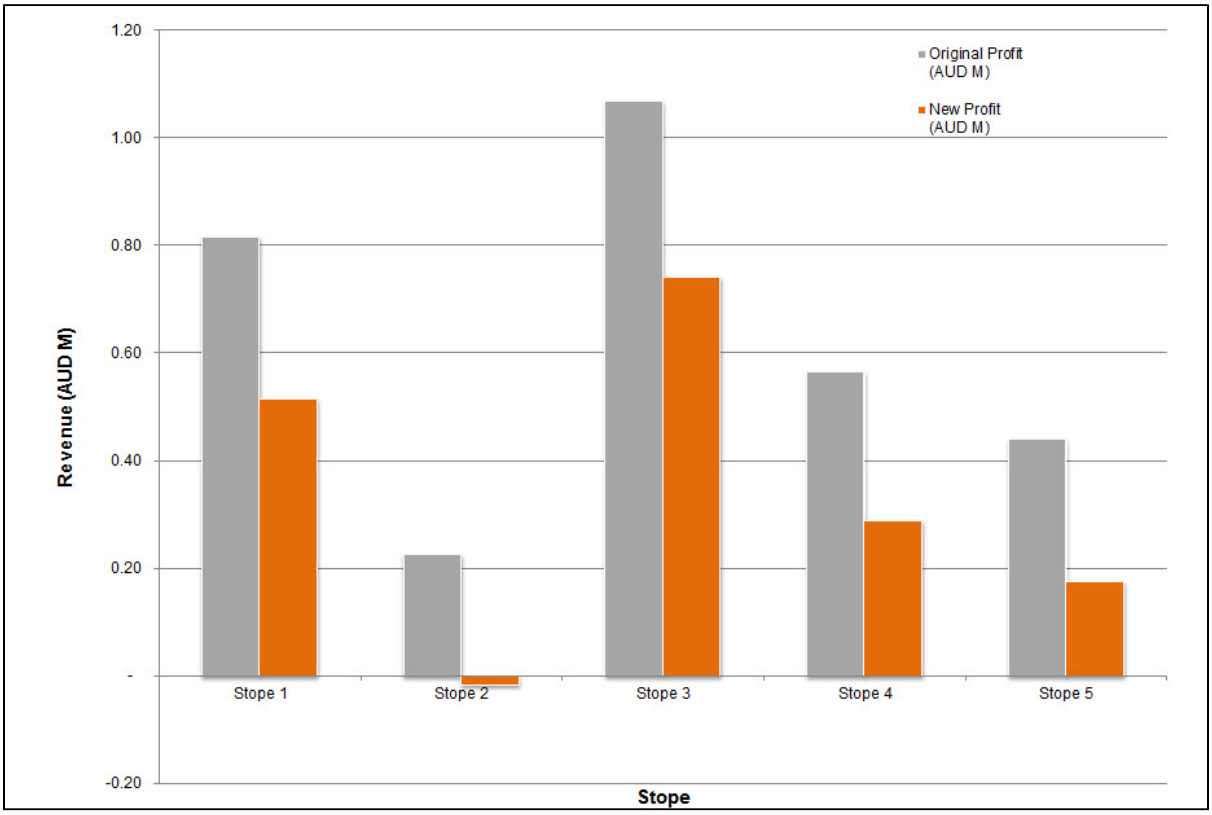

Figure 2: Impact of change in grade to potential profit

Mine Design

The mine planning engineer has the ability to influence the profitability of a company by designing and implementing robust and optimized stope designs. In the recent "mining boom", the author has observed management focus to increase the output of the mine in pursuit of increases to the bottom line. The high commodity prices masked the less than optimum designs being implemented and created an environment that meant that the orebodies were very forgiving of over engineering of the mine design. Operations were more focused on the metal or ounces produced rather than the cost of production.

In tougher times, mine planning engineers were required to ensure that their designs are robust and optimized, the author has observed a loss of rigour in the planning process from forgiving commodity prices. Planning engineers should consider the following when undertaking their designs:

- Are there ways that infrastructure can be used for the next stope?
- Can the development layout be changed so that development is minimized?
- Can the sequencing be changed to minimize the amount of development required?
- Are there cost savings to be made in the blast design without impacting on stope productivities?
- Can waste rock be placed in the stope to minimize the amount of cemented fill required?
- Can operational practices be altered to assist changes to the designs?

The list above is by no means an exhaustive list, but some of the areas that are likely to have the biggest impact on costs.

The following worked example (Example 2) shows the impact of a "Roll Royce" design versus a prudent design and the impact that it has on the stope economics.

Example 2

Design 1 and Design 2 are shown in Figure 1 and Figure 3 respectively. The capital and operating costs and revenue for the two designs have been calculated using the assumptions in Table 2.

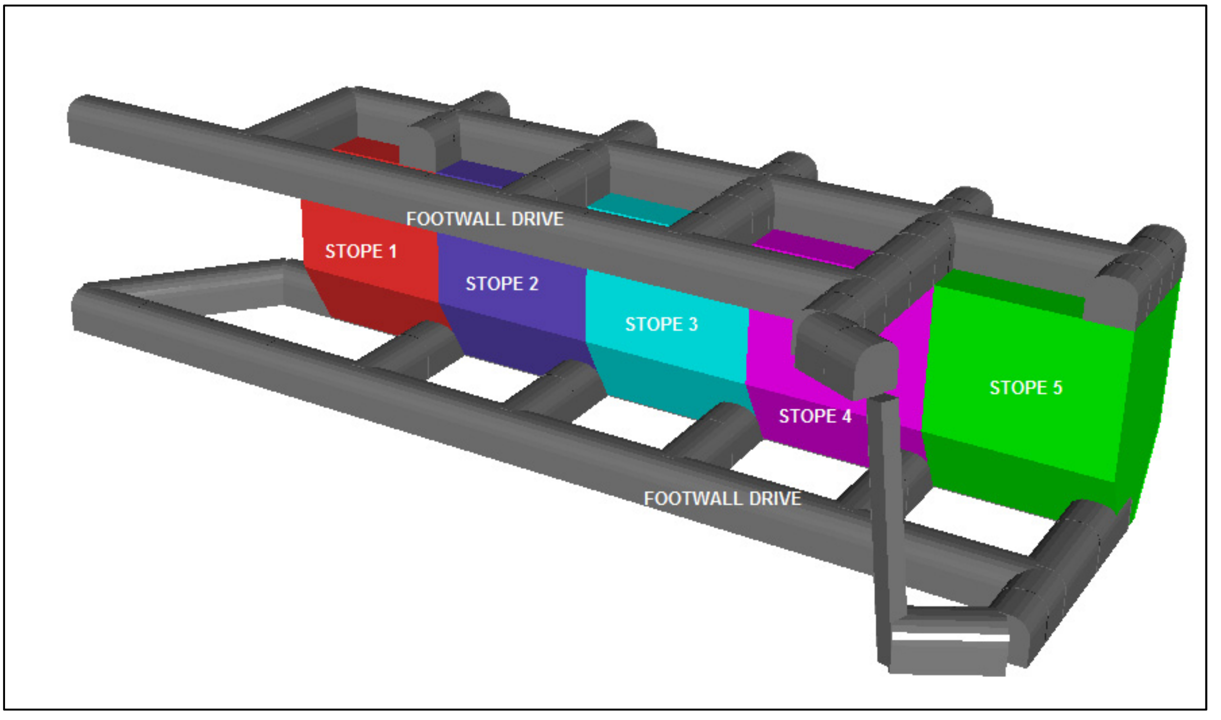

Figure 3: Worked Example design with footwall drive (Design 2)

Table 2: Assumptions applied

Item	Unit	Cost
Development Cost	AUD/m	7,000
Stoping Cost	AUD/t	65
Processing Costs	AUD/t	10
Administration	AUD/t	15
Sales and Marketing	AUD/t	8
Metallurgical Recovery	%	90
Payable metal	%	97
Copper Price	AUD/t	7,200

Using the original tonnes and grade from Table 1, the calculations for Design 1 and Design 2 are shown in Table 3 and Table 4 respectively. Figure 4 presents a comparison of the results for both the designs.

The calculations in Table 3 and Table 4 show that the introduction of a footwall drive reduces the profitability of the level by AUD2.56 M, resulting in the level making a loss. What the footwall drive does is allows the flexibility of mining more than one stope on the level at a time, better ventilation of the haulage drive which would reduce delays to the production and reduces the impact of operational delays on production. The question is: Are these advantages worth the additional AUD2.56 M that is required to be spent?

Table 3: Design 1 calculations

	Development		Costs						
	Operating (m)	Capital (m)	Development (AUD M)	Production (AUD M)	Processing (AUD M)	Administration (AUD M)	Sales & Marketing (AUD M)	Total Costs (AUD M)	Profit (AUD M)
Stope 1	60	21	0.57	1.30	0.20	0.30	0.16	2.53	0.49
Stope 2	59	21	0.56	1.30	0.20	0.30	0.16	2.52	-0.13
Stope 3	59	21	0.56	1.30	0.20	0.30	0.16	2.52	0.25
Stope 4	59	21	0.56	1.30	0.20	0.30	0.16	2.52	-0.26
Stope 5	59	21	0.56	1.30	0.20	0.30	0.16	2.52	0.12
Total	**296**	**105**	**2.81**	**6.50**	**1.00**	**1.50**	**0.80**	**12.61**	**0.47**

Table 4: Design 2 calculations

	Development		Costs						
	Operating (m)	Capital (m)	Development (AUD M)	Production (AUD M)	Processing (AUD M)	Administration (AUD M)	Sales & Marketing (AUD M)	Total Costs (AUD M)	Profit (AUD M)
Stope 1	100	65.6	1.16	1.30	0.20	0.30	0.16	3.12	-0.10
Stope 2	91	58.6	1.05	1.30	0.20	0.30	0.16	3.01	-0.62
Stope 3	91	63.6	1.08	1.30	0.20	0.30	0.16	3.04	-0.28
Stope 4	91	63.6	1.08	1.30	0.20	0.30	0.16	3.04	-0.78
Stope 5	91	63.6	1.08	1.30	0.20	0.30	0.16	3.04	-0.40
Total	**464**	**315**	**5.45**	**6.50**	**1.00**	**1.50**	**0.80**	**15.25**	**-2.18**

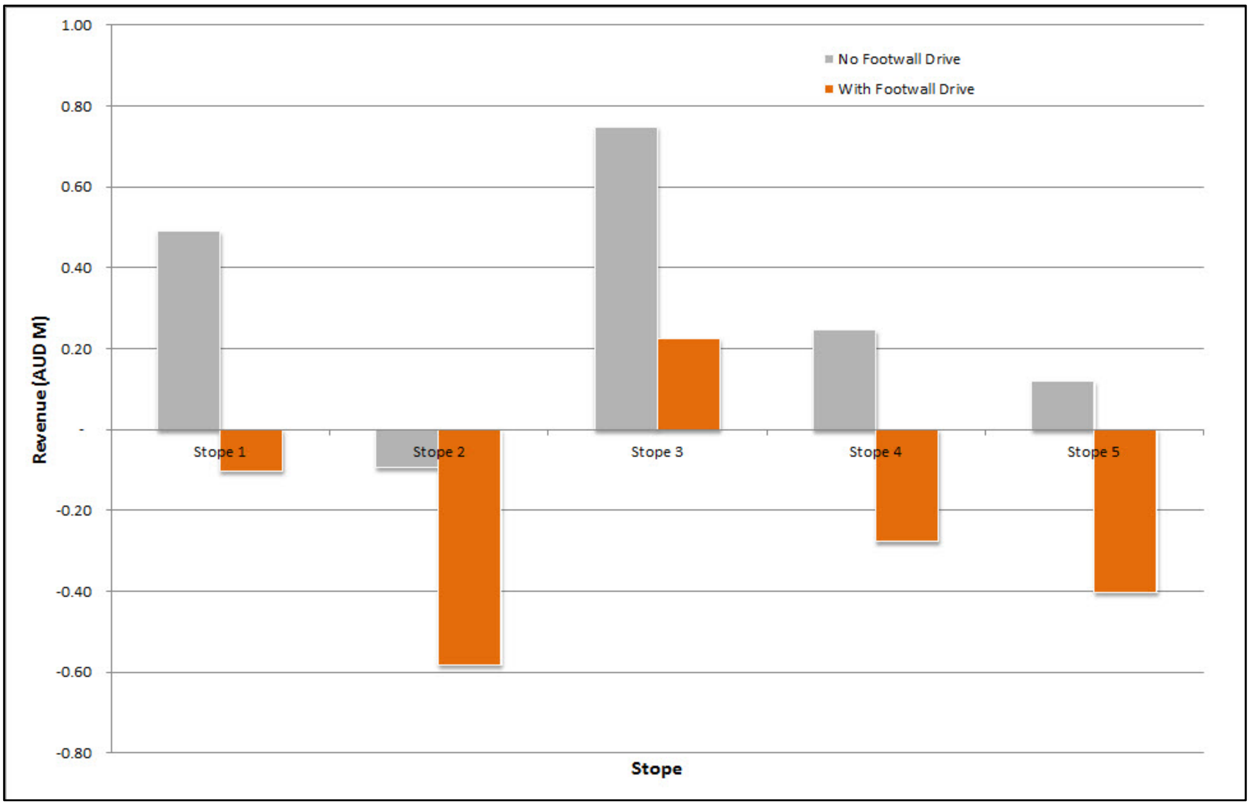

Figure 4: Comparison of the results for Design 1 and Design 2

Conclusions

The author has observed the mining industry change its focus to a more cost driven approach. It is important the mine geologist and the mine planning engineer understand that they have a big influence on the profitability of the mine in their day to day work and that it is not just “cost-saving” projects that will impact the bottom line.

Ensuring that enough geological information is available to inform the mine planning process and the mine planning process looks at the profitability of each stope being mined and ensures that the design is robust and satisfies the objectives without being “Rolls Royce” will ensure that the profitability of mine remains when the commodity price are lower and the “cream” is realized when the commodity prices increase and that the value of the orebody is not being destroyed.