HIGH ENERGY BLASTING DELIVERS MINING AND MILLING IMPROVEMENTS AT MT RAWDON

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HIGH ENERGY BULK EXPLOSIVES AND MINE TO MILL FOCUS – THE MT RAWDON STORY
G WALLACE AND D MORTON. PRESENTED AT *THE NINTH AUSIMM OPEN PIT OPERATORS' CONFERENCE 2016*

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CASE STUDY - HIGH ENERGY BLASTING DELIVERS MINING AND MILLING IMPROVEMENTS
EVOLUTION MT RAWDON, QLD, AUSTRALIA

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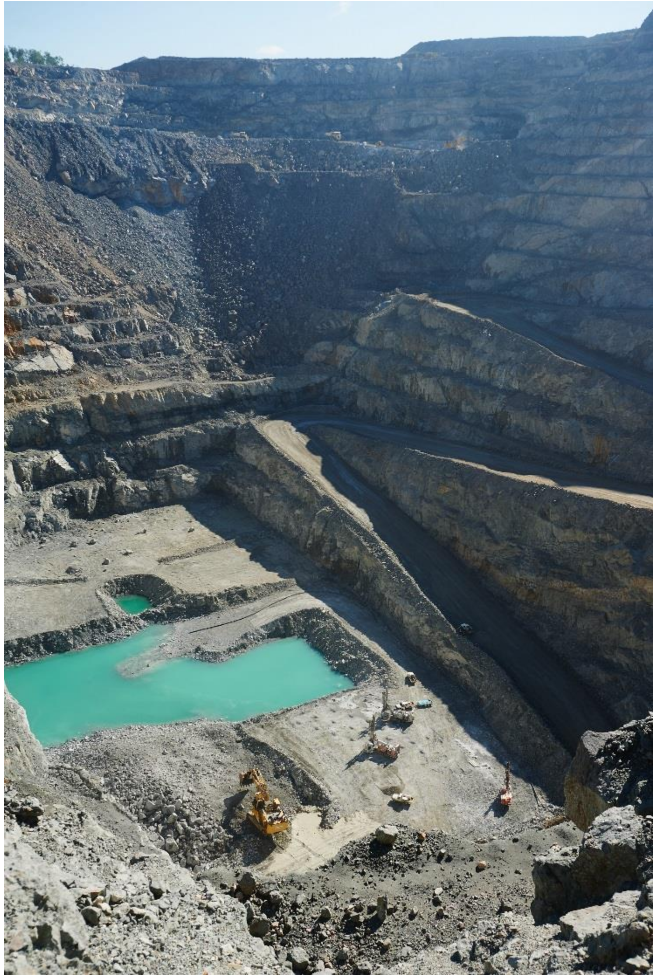
A QUEENSLAND GOLD MINING SUCCESS STORY

- Mt Rawdon is an open pit gold mine located 75 Km south west of Bundaberg in Queensland.
- It is owned by the Evolution group, a leading growth-focused company and Queensland's largest gold producer.
- Mt Rawdon is a low grade mine (0.71-1.0 g/tonne) yielding approximately 100,000 oz of gold p.a.
- Mining production is derived from a single open pit, utilising conventional drill and blast, load and haul methodologies, mining 10-15m benches.
- At current estimates, mining is scheduled to continue until FY23, with a remaining life of mine strip ratio of 1.8:1.



BUILDING TRUST THROUGH LONG-TERM COLLABORATION

- Orica has worked with Mt Rawdon since the site's commencement in 1998.
- Both parties have collaborated on a number of blasting related, business improvement initiatives.
- In 2014, Mt Rawdon began investigating initiatives to deliver higher mill throughputs without any significant capital expenditure or modifications to the existing processing plant.
- Orica provided a Technical Solutions Engineer for a two month period to investigate this opportunity and cover a leave absence of a site engineer.

UNCOVERING MILL THROUGHPUT BOTTLENECKS

- No ‘Burning Bridge’
- No avenue for significant capital spend
- Variability in mill feed – opportunity to increase throughput
- Consider ‘Mine to Mill’

MINE TO MILL THINKING…

- Throughput increases are possible by applying more blast energy, essentially by **reducing feed size through blasting and leaving less work for the comminution circuits** (Brent et al, 2013., Ziemski, 2011, Workman & Eloranta, 2003).
- **53% of energy used on a mine site is consumed by the comminution circuit, with only 2% being consumed by drill and blast (Smith, 2013).**
- If single variables or geological domains are reviewed in isolation, the original objective of improving profitability is often forgotten and replaced by the pursuit of technical perfection and data for data’s sake.

STAGE 1 – PRACTICAL ANALYSIS OF MILL THROUGHPUT

- Historical analysis revealed a relatively high variation between different material types.
- Throughput depended on ore type, sometimes throughput was balanced, however other ore types constrained throughputs by up to 30%.
- Based on this analysis of the mill, the two primary objectives for the project were defined as:
  - Increasing the percentage of sub 13mm material (fines) in the feed
  - Controlling the proportion of intermediate size material to keep the SAG recirculation below 70tph

- It was decided to fire groups of blasts at different powder factors, initially in the volcaniclastics and silicified dacite domains. These are harder ore types that have historically shown to overload the SAG mill.

STAGE 2 - INCREASED POWDER FACTOR NOT SUCCESSFUL ON ITS OWN

WHAT DID WE TRIAL:

- Double powder factor blast using standard products and a tighter pattern with side by side comparison to standard practice.

WHAT WAS THE KPI:

- Muckpile image analysis.
- Mill performance :throughput (t/hr), specific energy (kWh/t) and SAG mill recirculating load.

WHAT DID WE SEE:

- **The results from this trial did not meet the initial predictions**
- **Increased damage to the blast perimeter, resulting in large blocks in the muckpile.**
- **Oversize vs Fines = no net gain in fragmentation (marginal throughput reduction of 4 tph).**

WHAT WAS THE NEXT STEP:

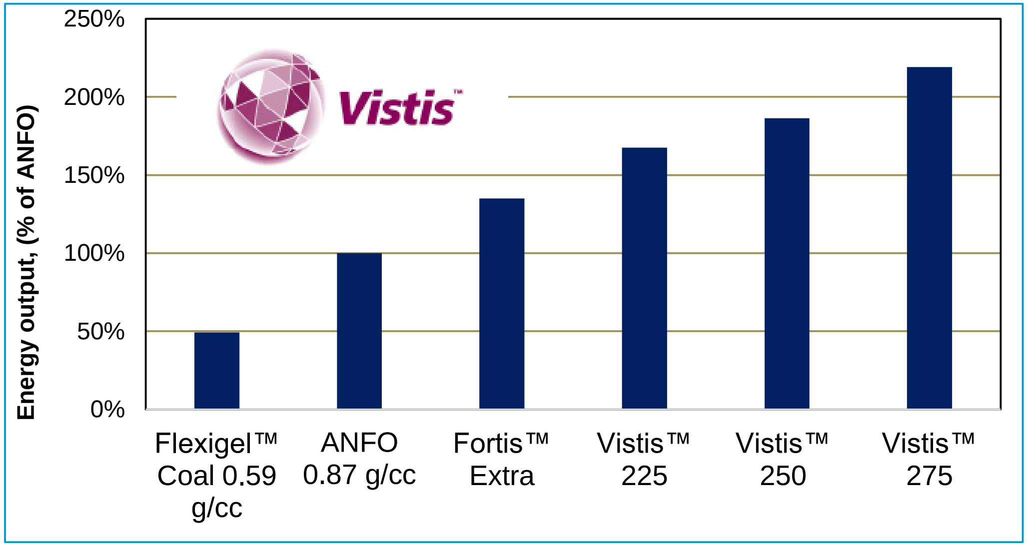
- A section of the muckpile without any oversize was isolated and fed to the plant - mill responded favourably to the high fines content
- This suggested that benefits could be realised if the oversize from back-break could be controlled.
- Inherent tight mining conditions and drill capacity constraints meant high energy blasting using tighter patterns would not be sustainable at Mt Rawdon.
- **<u>Another approach needed to be found</u>**

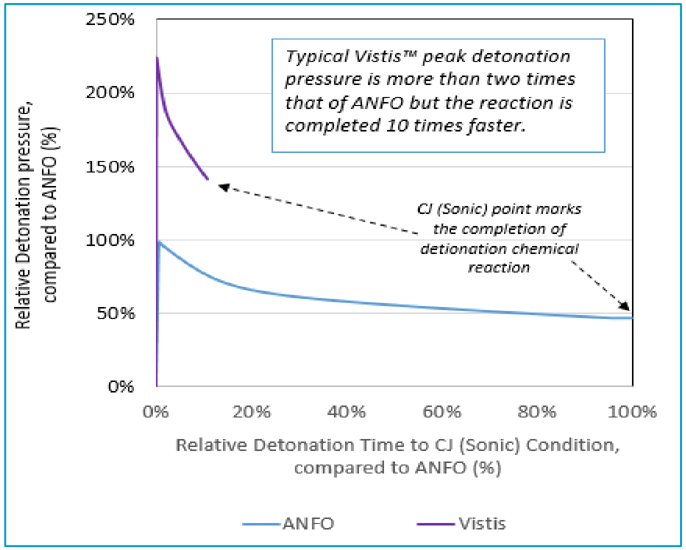
Parameter	Unit	Base Case	High PF Trial 1
Drill Size	(mm)	165	165
Bench Height	(m)	15	15
Burden	(m)	5	3.5
Spacing	(m)	5.8	4
Subdrill	(m)	1	0.6
Stemming	(m)	3.5	3.5
Bulk Product		Fortis Ad.	Fortis Ad.
Product Density	g/cc	1.2	1.2
Powder factor	(kg/m^3)	0.74	1.48
Energy factor	(MJ/m^3)	1.81	3.63

NEW APPROACHES TO HIGH ENERGY BLASTING

- Vistis™ high energy bulk explosive can be used to achieve high energy factors without decreasing blast hole spacing and increasing drilling requirements.
- The product could provide two benefits:

1. Higher blast energy factors would be achieved without increasing the number of holes. Vistis™ 250 high energy explosive at a density of 1.35g/cc yields a 55% increase in blast energy without changing any other parameters
2. Very high detonation pressures produced by Vistis™ would increase the 'pre-conditioning' (Michaux & Djordjevic 2005) or 'microcracking' (Neilson & Malvik) within the ore. This reduces the inherent strength and increasing the grindability of the ore by damaging intact rock particles.





STAGE 3 - INCREASING FINES WITHOUT EXTRA DRILL CAPACITY

WHAT DID WE TRIAL:

- Direct product swap to Vistis™ 250
- A 55% increase in explosive energy per cubic metre
- High energy blast paired with a conventional blast within each of the available ore domains.

WHAT WAS THE KPI:

- Each blast pair - mined and milled independently
- Control plant parameters and measure.

WHAT DID WE SEE:

- **Vistis™ 250 blasts - significantly finer, more consistent fragmentation**
- **Initial trials did not deliver a sustained increase in mill throughput overall.**
- **The trial methodology ended up limiting the plant too severely, removing its ability to react to the feed as it usually would.**

WHAT WAS THE NEXT STEP:

- **To take advantage of the dramatic change in fragmentation and achieve increased milling efficiency we had to consider taking a holistic view towards the the way the plant was operated**

SAG feed comparison between Vistis™ 250 blast 1 (left) and baseline (right**)**

STAGE 4 - A HOLISTIC REVIEW OF MILL THROUGHPUT

It was obvious that Vistis™ 250 was delivering a substantial change in fragmentation, however there was yet to be a sustained mill throughput increase to match. Rather than trying to isolate all the variables and focus on the change in blasting only, the solution required a holistic review. Collectively, the mine and the mill had to determine what the true bottlenecks were, then see how the finer feed could be combined with other initiatives to help alleviate them. A comprehensive review with site stakeholders indicated four key initiatives:

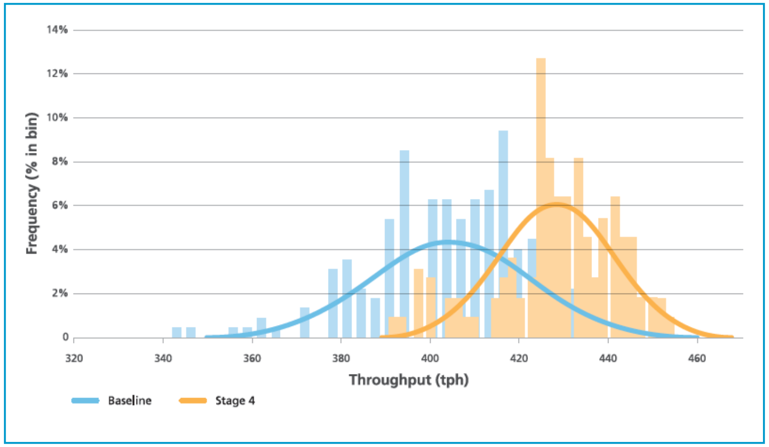
1. **Provide a larger, more consistent feed volume**
2. **Change the ROM stacking and plant feed strategy**
3. **New KPI's, procedures and operator training**
4. **Better primary crusher maintenance planning**

COMBINING LEARNINGS AND WORKING ‘MINE TO MILL’ DELIVERED SAVINGS

- Trial Analysis: 109 operating shifts, 550,724 tonnes of material processed.
- Baseline period: 223 operating shifts, 1,074,818 tonnes of material.
- Over the Stage 4 analysis period, the **mill throughput increased 5.9%** against the baseline.
- The **specific energy, a ratio of power consumption per tonne of material processed, decreased by 7.3%.**
- **SAG recirculation, expressed as a percentage of pebble crusher feed to fresh feed, decreased from 17.4% to 13.8%.**

Parameter	Unit	Incremental Tonnes Ex Pit	Incremental Tonnes LG SP
Incremental Head Grade	(g/t)	1.00	0.40
Additional Ounces	(oz)	5,900	2,178
Gold Price	(AUD/oz)	1,400	1,400
Processing Costs	(AUD)	$1,120,268	$1,120,268
Mining/Rehandle Cost	(AUD)	$ 530,935	$ 91,450
Drill Blast Cost	(AUD)	$ 1,182,387	$ 1,182,387
Total Additional Cost	(AUD)	$ 2,833,589	$ 2,394,105
Additional Revenue	(AUD)	$ 8,267,948	$3,125,891
Annualised Net Position	(AUD)	$ 5,434,359	$ 731,786

Annualised financial analysis of Stage 4 project, comparing a best case and worst case scenario



WHAT ABOUT WASTE?

- After seeing how significant the change was in the original Vistis™ 250 blasts, there was an investigation as to whether Vistis™ 225 could be used to expand patterns in waste and ultimately reduce the total cost of drill and blast.
- Depending on the geological domain, patterns were expanded between 45% and 60%, with no adverse impact on dig rates from this expanded pattern.
- Naturally this resulted in a lower net drill and blast cost, however perhaps more significantly, the mine was able to unconstrain their drill fleet and increase the productivity of the mine.

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THE FINAL RESULTS WERE COMPELLING

- 12 months of trialling & testing various techniques – learnings in each new phase.
- Orica's Vistis™ 250 high energy bulk explosives was the most effective way to increase fines.
- The mine to mill initiative is much more than any one technical or physical change & only achieved by working as a site wide team.
- This true overarching mine to mill mentality, enabled by the use of Vistis™ 250 high energy bulk explosive, resulted in a sustained **throughput increase of 5.9% and a decrease in specific energy of 7.3% over the course of the trial**.
- The economics of the project have been tested and show a very profitable outcome if the current head grade of 1.0g/t can be maintained.
- With patience and vision from all parties concerned, the results are clearly worth the investment.

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THANK YOU & QUESTIONS

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