Whittling away the waste

Ailbhe Goodbody attended Whittle Consulting's Money Mining seminar in London in March, and learned about a fresh approach to optimising mining enterprises

Whittle Consulting is a family business based in Melbourne, Australia, which is represented in South Africa, North America, South America, Asia and Europe and effectively operating worldwide.

The company offers a service called 'enterprise optimisation', a complete approach to extracting maximum value from a mining enterprise. Enterprise optimisation is the culmination of 30 years of development by Jeff Whittle, technical director of Whittle Consulting. The company's vision is to be the global standard for strategic mine planning, and its mission is to transform the economic performance of mining globally. A recent alliance with JKTech in March 2013 added a sustainability framework to the approach.

Whittle Consulting runs Money Mining seminars throughout the year to give a comprehensive briefing on the latest techniques in enterprise optimisation. The London seminar was presented by Gerald Whittle, managing director of Whittle Consulting. He comments: "Mining is a technical business, run by technical people with a focus on the physicals. We need this, but an economic focus is also needed."

Whittle Consulting says that its Money Mining approach can increase the net present value (NPV) of mining properties by 5-35%, regardless of the optimisation done to date to the mine and/or the processing plant. However, Whittle explained that based on 80-100 studies done by the company, the improvement can be anything from 15% to 120%, fundamentally changing economic performance. The goal is to create significant short-term cash gains for all types of mine, without conceding long-term value.

Whittle Consulting has applied its principles at mines such as Kumba Iron Ore's Kolomela project in South Africa

Whittle notes: "Mining is a technical and complex industry – that complexity is what gives us the opportunity."

Whittle Consulting states that most mining companies are not maximising economic values, and are distracted by confusing organisational silo-based objectives that prevent them from seeing the solution that is best for the entire enterprise.

These conventional objectives include maximising reserves, minimising costs, maximising equipment utilisation, maximising recovery, having consistent production/operations, minimising capital outlay and maximising mine life – however, all of these aims can be counterproductive to maximising value.

Over 2,000 mining professionals have participated in the seminars. In addition, Whittle Consulting's methods have been used by a number of companies in the mining industry, including Peabody Energy, BANPU, Gold Fields, Rio Tinto, Kinross, Anglo American, Anglo Platinum, Glencore Xstrata, African Rainbow Minerals, Perseus Mining and Barrick Gold.

THE MONEY MINING WAY

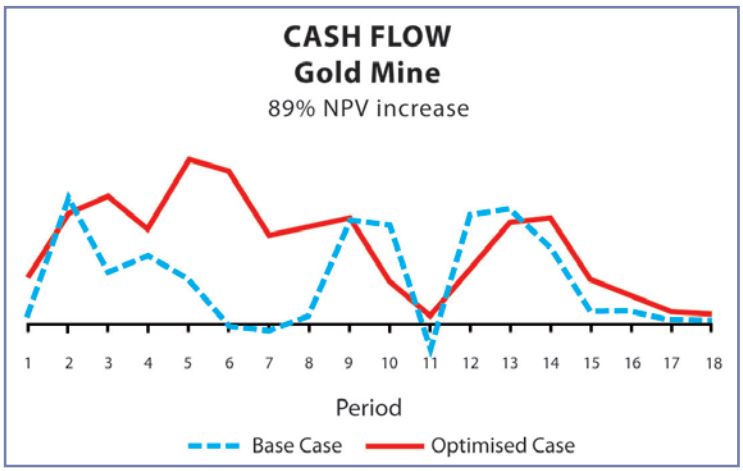
The basic philosophy behind Money Mining is that a mine is a commercial enterprise with the main aim of making money, rather than the main aim being to extract the commodity; without money, a company will not have the opportunity to exist or expand. The focus on tonnes, truck hours and material movement can distract from this aim.

Whittle explains to *MM*: "If you're not making money, why are you doing it? If you're not making money, are you just driving trucks around and picking up rocks for fun, risking the environment and people's safety?"

Money also has a time value; a million dollars is worth more today than ►

"Mining is a technical and complex industry – that is what gives us the opportunity"

In this case, optimising the operation of a gold mine increased its NPV by 89%



it will be worth in a year's time, but many companies ignore this as they make their calculations in constant dollars. The timing of cash spent and generated is very important when evaluating a mining business, which is why Whittle Consulting uses NPV as a basic measure of value.

Bottlenecks are the main hurdle that stops mining companies from getting all the money instantly – if there were no such constraints, a company could mine and process the orebody in one year to get all the cash immediately and to achieve an excellent NPV. As a result, Whittle Consulting states that it is not only the amount of money in an orebody that is important, but also the rate at which the cash can be realised – this is determined by the bottlenecks. Mining companies need to study, understand and manage the economic bottlenecks to maximise the value of the mine.

Enterprise optimisation involves a study of how money/value flows through the system, and what can be done to increase it and speed it up. Generally, the mines do not need any extra capital – just to work better with what they already have to accelerate the flow of cash through the business. The result is a business plan with a significantly better cash-flow profile.

Software allows methodology to be applied in terms of modelling the economic impact of any decisions.

Whittle Programming and its associated software was sold to Gemcom (now Geovia) in 2002, but Whittle Consulting has maintained a partnership with the software company.

"Six Sigma and constancy have no place in strategic mine planning. If the plan is constant, it is not optimal"

THE PLANNING FRAMEWORK

A long-term strategic plan is needed for mining, and capital needs to be optimised to reduce bottlenecks in the system. Many decisions are fixed, but they should be dynamic; in addition, many decisions are made too early, before the options are fully analysed.

Any orebody changes as it is worked through, so the optimal plan changes. As a result, factors such as the strip ratio should not be constant.

The mine plan should change with the orebody – that's where the opportunity and value are. Whittle comments: "Six Sigma and constancy have no place in strategic mine planning. If the plan is constant, it is not optimal."

A decision on one step in the value chain affects all of the others, but they are usually assigned to different departments or silos – such as mining, processing or marketing – so co-operation between the various groups working on a mine is essential. Whittle Consulting states that enterprise optimisation overcomes the analytical challenges in dealing with this.

Net present value

NPV is a basic measure of economic value that is widely used, and reflects the time value of money, including opportunity cost and risk. It is a central tool in discounted cash flow (DCF) analysis. It is not a perfect measurement, particularly in terms of how it accounts for risk and uncertainty, but it is a good starting point.

The advantages of NPV as a measurement unit include:

- Its simplicity – the whole industry understands it;
- It accounts for the time value of money, including opportunity cost and risk; and
- It is good for comparing mining projects that have different timeframes, capital etc.

However, NPV has some disadvantages too, such as:

- The discount rate is subjective (although not arbitrary); for example, riskier projects should have a higher discount rate, but there is no set way to decide on these figures as risk is not tangible;
- It is not great for long-term projects, as it ignores the long-term potential;
- It can be overly simplistic, especially when compared with the science involved in calculating everything else – it is the weakest link in the chain.

Terminology

Whittle Consulting uses the terms 'blue line', 'red line' and 'green line' to describe the different approaches of mining companies.

Blue-line mining is what most mining companies do – the focus is on maximising reserves, minimising costs, maximising recoveries, maximising efficiency and maximising life of mine (LOM). The units are described in physical terms (such as tonnes or ounces) and may not even mention the money. They may have used Whittle software, but not systematically.

Red-line mining is economically optimised; simultaneous, integrated, crossing organisational boundaries, accelerating cash through the bottlenecks. Units are 'net value per bottleneck unit', rather than focusing on the physicals – cash flow, rather than the ore or the commodity. Whittle Consulting has been using this approach for years.

Green-line mining goes up another level, and maximises economics with the social/political/environmental context within which a company operates. It covers sustainability, licence to operate and engagement with all stakeholders.

Whittle Consulting has been carrying this out recently with JKTech. Whittle notes: "It's no use having a great mine plan if the locals are throwing rocks at you."

Case study: Marvin copper-gold project

The Marvin copper-gold project is a hypothetical, but realistic, project that Whittle Consulting uses as an example for mine optimisation. From a mining point of view, the background and how the deposit got there is irrelevant. Whittle says that this fictitious but realistic case was developed so that they can demonstrate clearly the mechanisms involved in optimisation without client confidentiality issues.

The gold is higher grade at the centre of the deposit (over 1g/t), and the gold grade is higher near the surface than at depth. The copper grade is higher to the southeast of the deposit and at depth – it is a typical copper porphyry deposit. The Marvin project NPV is US$1.6 billion, which is the sum of DCFs after approximately US$600 million capital at a 10% discount rate.

The calculations for the base case were all made manually, without the use of software.

While enterprise optimisation is about simultaneous optimisation, looking at the mechanism one step at a time can demonstrate the effect of each. The steps do not have to be in this particular order, as long as there is a plan.

Step 1: Optimised pits

The pit is optimised using the Lerchs-Grossman algorithm; the resulting model is only subtly different in shape, but manual modelling cannot beat software. The pit is almost exactly the same size, but has 10% more ore than the manually calculated pit and a more efficient shape.

Step 2: Optimised phases

Mining benches that are straight across are the worst way to approach a pit, according to Whittle, as this means that the highest mining rate is early in the life of mine (LOM) and the costs are concentrated at the beginning, which is terrible for the NPV. The best-case mining has pushbacks, and a low stripping ratio at the beginning.

An auto-pushback selector and skin analysis is used on the model. In this case, it leads to an 18% smaller pit with different phases selected, and reduces the ore by stopping at shell 12 instead of shell 16. This is because the aim is to maximise the NPV, rather than maximise the ore recovered – continuing past shell 12 affects the NPV, so it should be considered waste rock.

Whittle has worked with Glencore Xstrata on optimising its Mt Isa mines in Queensland, Australia

Step 3: Scheduling

The Milawa scheduling algorithm is used for bench scheduling. It optimises the schedule, taking into account production and economic constraints, while seeking to maximise NPV. It decides which benches in each pushback should be mined in each period, focusing on the phase that currently has the biggest grade.

Milawa can result in large fluctuations in mining rates. While the variable mining rate improves NPV, this idea is not popular with mining engineers as they typically like a constant mining rate. However, a constant mining rate is not the objective – increased NPV is the objective. Whittle comments: "People say it's 'not realistic' – well, it is. Is it not possible, or is it just not what you're used to?"

Step 4: Cut-off grade

Inspired by Ken Lane (1988), this step raises early cut-off to increase production, even if positive margin material is discarded. Marginal cut-off grade is the break-even grade, where revenue equals processing cost. Nothing under this should ever be processed, according to Whittle.

The cut-off grade should be raised above the marginal cut-off, particularly early in the mine life, to increase NPV (if the plant is the bottleneck). There is an 'opportunity cost' of processing low-value ore where there is higher-value ore available in the future. However, the sooner high grade is reached, the more it is worth. The calculations are complicated, though, and software is needed to get it right.

This concept goes against the grain of what geologists and mining engineers are taught. However, if there is limited capacity for production, it should not be wasted it on low-grade ore. Whittle explains: "If you have just spent, for example, US$500 million building a processing plant with a capacity of 4Mt/y, why waste that precious capacity putting material with a margin of US$1/t through it, when you could put more US$30-40/t material through?"

Whittle says that some people think it is mad to drive 2g/t material to the stockpile, but that when the high-grade zone is achieved, that's the time to raise the cut-off grade and put the rest in the stockpile. When the ore is back in the low-grade zone, the company can process the stockpile then. Reducing this bottleneck can result in 50% more revenue, and increases profit from an NPV point of view.

Fewer than 20% of mines are currently using this mechanism, so there is great potential for improvement, according to Whittle.

Step 5: Stockpiles

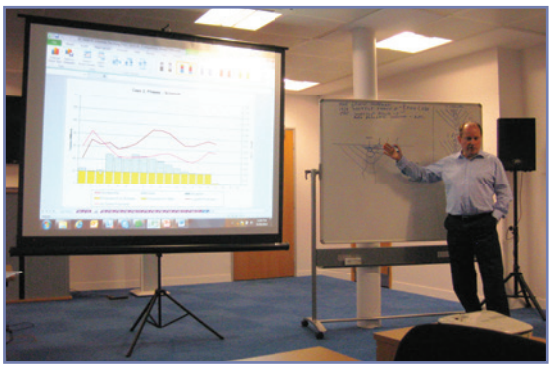
Rather than throwing the lower-grade rock away, some mining companies prefer to stockpile some of it and process it nearer the end of the LOM, which can add 2-5% to the NPV. However, there are re-handling costs and there may be some deterioration, so not all the value will be preserved.

Whittle cautions that projects to process lower-grade material can be misguided – companies may choose to blend it in, expand the plant, add a heap leach or add a concentrator/ore sorter/beneficiation plant, but all of these strategies would get better return if applied to high-grade ore. He adds: "Don't let the lack of stockpiling prevent you from raising the cut-off grade anyway. All the paradigms in the industry cling to lower grades."

"All the paradigms in the industry cling to lower grades"

Marvin facts at a glance

- Copper/gold pit with four phases (pushbacks);
- 60Mt/y mining, max eight benches per year;
- 20Mt/y crush/grind/float;
- Fixed recoveries: Cu = 88%, Au = 60%;
- Producing 28% Cu concentrate;
- 70km, 600,000t/y concentrate pipeline to port;
- Offshore smelter/refinery;
- Gold price US$900/oz (Whittle Consulting made this case study 4.5 years ago – most companies use a fixed price for estimates);
- Copper price US$2.50/lb declining to US$1.50/lb



Gerald Whittle, managing director of Whittle Consulting, explains Money Mining to a London audience

Stockpiles can also lead to significant accounting distortions, as they tie up working capital and remove cash from the balance sheet.

Step 6: Simultaneous optimisation

The conventional mining wisdom is that reserves are estimated first, and then the mine plan is drawn up. However, Whittle declares that it should be the other way around, and that mining companies are focusing on the wrong thing. He comments: "I don't care what the resource is, unlike geologists, engineers and the people who release statements. I care about cashflow and NPV."

Raising the cut-off grade should affect the mine schedule, and changing the mine schedule should affect the phase selection and the ultimate pit.

Geovia's single-pit simultaneous optimisation (SIMO) module, which was released in 2010, can combine steps 1-5 simultaneously for a better calculation – the highest-grade material goes directly to the plant, and it creates several segmented stockpiles. The calculation also considers all periods in the mine life at the same time, and knows when the stockpiled material will be used.

> "The financial success of the project is the fundamental justification for its existence and the security for its survival"

Step 7: Dynamic processing parameters

The Marvin base case assumed that the plant will be run at 20Mt/y, but in reality it could be run faster or slower with a significant impact on the recoveries. There are times when a higher-throughput, lower-recovery option is the best decision for the business.

For example, if material is ground very finely, it will get a lower throughput as it has to stay in the processing stage for longer. Metallurgists will not choose lower recovery, as a general rule. However, if 30% more throughput is achieved and only 5% recovery is lost, that is a 25% improvement.

Whittle says that while cut-off grade is well understood (but less often practised), this very similar mechanism is seldom exploited.

Step 8: Dynamic product specification

The base case also assumed that 28% copper concentrate would be produced, but in fact a range of concentrates could be produced with a significant impact on recovery as well as an effect on transportation of a more or less bulky concentrate product. The benefits of higher throughput are balanced by factors such as shipping costs.

In the Marvin project example, when the copper price is US$2.50/lb, the best solution is a 24% concentration as the benefit of extra recovery outweighs the extra transport cost of the product. However, when the copper price is US$1.50/lb (as it is long-term in this case), the best solution is a 28% concentrate as used in the base case.

The pipeline has become the bottleneck in the system, and the optimiser uses flexibility, at the expense of metal recovery, to get more metal to market through the restrictive pipeline.

A metallurgist would not necessarily recommend a 32% concentrate involving an 8% lower recovery. However, the optimiser has shown this to be the best decision for the business under many circumstances. Maximising recovery is not the objective – it is maximising revenue.

Step 9: Logistics

If the pipeline is the bottleneck in the system, it may be possible to put trucks on for extra capacity. This additional concentrate capacity allows the previous mechanism of processing and product specification to pursue margin rather than throughput. The logistics are more costly, but it is better value overall.

Minimising costs isn't the objective – it is getting the concentrate to port. Increasing costs in this way can massively increase revenue – in the Marvin project example, additional trucking of concentrate at US$30/t adds approximately US$10 million in operating expenditure (OPEX) over two years, but results in trucking up to 300,000t/y in certain years with an added revenue of US$27 million overall.

Step 10: Capital

Enterprise optimisation can determine how much capital is worth spending on each constraint at a mine, simultaneously, while rebalancing the pit, phase, schedule, cut-off, stockpile, processing, product and logistics at the same time.

In the Marvin project example, adding extra mining capacity at US$1.25/t per year adds US$29 million in capital expenditure (CAPEX), while adding extra pipeline capacity at US$20/t per year adds US$8 million in CAPEX. While this is an extra US$37 million capital spend, the mining capacity goes up to 83Mt/y, and the pipeline to 1Mt/y, so trucking is no longer required.

Whittle explains: "What we're doing here is playing the bottleneck game. You should have all the mining equipment you need – don't let it be the bottleneck."

RESULTS

The optimum decisions for the business are often counterintuitive. In the case of the Marvin project:

- The ultimate pit is 18% smaller, and contains less reserves;
- Costs have increased, including the mining cost, plant cost and logistics cost;
- Economic material is discarded/stockpiled and plant recovery is down;
- Capital expenditure has increased by 5%;
- LOM is decreased by three years; but
- The value of the business has been increased by 73.7%.

Whittle says: "None of these decisions would have been made if they were left to the individual managers concerned, as they are counterintuitive, yet together they increase the value of the business significantly. Any of these actions alone would be a disaster – it must be part of a carefully co-ordinated plan."

He adds that the financial success of the project is the fundamental justification for its existence and the security for its survival.

Of the 10 mechanisms involved, many mining companies are optimising only two or three of them separately, and making unsupported decisions on the rest. Whittle Consulting states that the benefits of optimising all of these together remains untapped.

Marvin case-study steps and results

Step	Evolution	Gain (%)	Gain (US$)	NPV (US$)
0	Base case	–	–	$1,598m
1	Pits	7.2%	$115m	$1,713m
2	Phase	6.4%	$102m	$1,815m
3	Mine schedule	4.4%	$70m	$1,885m
4	Cut-off	15.1%	$241m	$2,126m
5	Stockpile	4.6%	$74m	$2,200m
6	Simultaneous	14.1%	$226m	$2,426m
7	Process calib	4.4%	$70m	$2,496m
8	Product spec	5.5%	$88m	$2,584m
9	Logistics	7.1%	$113m	$2,697m
10	Capital	4.9%	$78m	$2,775m
	Total	73.7%	$1,177m	$2,775m