

# Union Reefs Gold Mine Expansion

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### Abstract

Whittle 4D software was used at the Union Reefs Gold Mine in the Northern Territory as a key component of an evaluation process to determine the type, timing and scale of a major processing plant upgrade.

### Introduction

Acacia Resources Limited owns and operates the Union Reefs Gold Mine near Pine Creek in the Northern Territory. Mining commenced in September 1994 in the Crosscourse Pit and the process plant was commissioned in January of 1995 at a nominal rate of 1.25 Mtpa. This was increased through debottlenecking various aspects of the plant, resulting in actual throughput for 1995 of 1.5 Mt and for 1996 of 1.7 Mtpa.

The initial mine plan called for an upgrade to mill grinding power late in 1997 to maintain throughput as harder primary ore became the main feedstock. A project team consisting of site operations personnel was formed in January 1996 to evaluate options for the upgrade. Whittle 4D software had been purchased for use on site in 1995 and it was agreed by the team that it would be one of the primary tools used to evaluate the upgrade options.

Two key questions were to be answered. What would the nature of the upgrade be? A second ball mill, an AG/SAG mill or a rod mill? Secondly what should the upgraded throughput be? The original 1.25 Mtpa rate had already been superseded in oxide and transitional ore, however projections for fresh ore were that the plant would reduce to 0.9 Mtpa, so what rate would be appropriate for fresh ore?

### Costs

Because Union Reefs is in operation and has experience of two of the three main ore types (weathered, transitional and fresh), it was intended to make as much use as possible of real data.

### Processing plant

In the processing plant, weathered and transitional ore had been milled and real operating data and costs were available for all aspects of the plant. Of particular interest was power usage from which actual work indices for weathered and transitional material could be determined and compared with feasibility numbers. No fresh ore had yet been milled so feasibility testwork was used, however it was considered that this would be conservative after review of feasibility data for weathered and transitional feed.

Other key data related to gravity and leach circuit recoveries, and the general performance of the wet plant, in particular consumables consumption. Maintenance costs were also able to be based on historical performance.

A metallurgical engineering study was commissioned in January 1996 to determine capital and operating costs for a range of upgrade option types and throughputs.

### Mining

Load and haul costs were defined in the current contract down to a depth of about 85 metres and were extrapolated below that increasing by 5% each 20m. Some assumptions were made to estimate drill and blast costs regarding patterns used and the proportion of wet blasting needed.

Grade control costs proved more difficult to extrapolate because this was a rapidly developing area of activity, with considerable work being done on instituting a new conditional simulation based method of grade estimation. Other administrative and mining cost overheads were based on historical performance.

### Geotechnical

With the exception of structural mapping and a geotechnical review of the performance of the pit walls from the limited exposure available in early

1996, no substantial geotechnical work had been done since the feasibility study. Overall slopes were determined using the initial pit design and ramp layout and the recommended batter angles from the geotechnical review.

### Resource modelling

The project commenced in September 1994 with a geological resource (at June 30<sup>th</sup>, 1994) of 11.4 Mt @ 2.4 g/t Au and a mining reserve of 8.8 Mt @ 2.2 g/t Au.

Limited resource drilling was done at Union Reefs during the period from 1993 until mid 1995, when a small program was undertaken beneath the Crosscourse and Union North pits.

By early 1996 it was apparent that problems existed in the original inverse distance squared (ID<sup>2</sup>) resource model used. Remodelling was done which included all drilling to the end of 1995 to produce a revised ID<sup>2</sup> recoverable resource model. This was available in early May 1996.

A substantial exploration drilling program had been commenced in early 1996 which was focussed on depth, strike and lateral extensions to the Crosscourse Pit. In July 1996 a Multiple Indicator Kriged recoverable resource model was completed which included all drilling to May 1996.

This model was then updated in October 1996 by another Multiple Indicator Kriged recoverable resource model which included all drilling to early September 1996.

Nearly as much drilling again was completed in 1996 as had been done at the time of the feasibility study in 1993. Resources at the end of September 1996 were 19.1 Mt at 1.96 g/t.

### Training

Effective training for new users of Whittle 4D has been found to be critical to their ability to then proceed on their own. In our case, Tom Tulp was brought to site in January 1996 to provide training in the use of 4D. Site based training was done so that it would occur within the operational environment that future work would occur in, using the hardware and facilities that would be available.

It was not until May 1996 however that an updated resource model became available. Because of this delay Tom was engaged at site again for a refresher session. This was extremely valuable and further served to underline the need for not just training but

also the need to develop and maintain a high degree of familiarity with the software. It is only by extensive use and experimentation with as many aspects of the software as possible that users become comfortable, confident and competent in its use.

### Education

This new found confidence had then to be transferred to the other members of the evaluation team, who were from various disciplines and who possessed varying degrees of exposure to project optimisation techniques. It was critical that all involved were comfortable with the reliance placed upon 4D. Again, having an experienced 4D user such as Tom Tulp available was invaluable, because he was able to talk with many people on site and answer at first hand their questions about the use and application of 4D.

Extensive interaction was also necessary with the various members of the team to establish appropriate formats and methods of transfer of cost data and operating parameters.

To be using 4D in such a situation is an extremely interesting and rewarding experience because of the broad exposure that is gained to all aspects of the project. The Whittle 4D process becomes a focal point, drawing together data from all departments, much of which remains contained within the respective disciplines at a day to day operational level.

### Optimisation and analysis

#### ID<sup>2</sup> Model

The initial work done on this model allowed the team the opportunity to gain experience using Whittle 4D and to explore options in presenting and interpreting results. Four optimisations were done on combinations of high and low operating costs and high and low gold prices. Analysis was done by running a range of Milling Rates (1.2, 1.6, 2.0, 2.4 and 2.8 Mtpa) for each of the four cost/price scenarios. No scheduling was done within FDAN.

Graphs were generated showing the Present Value against Pit Shell and Incremental / Cumulative Ounces against Pit Shell. Various other combinations of parameters were graphed showing each of the scenarios as a separate data series. This enabled the relativity between the scenarios to be easily observed. Parameters included Milled Tonnes, Present Value, Milled Grade, Cost per Ounce and Net Ounces. Material below the

marginal cutoff grades was presented as Rejected Tonnes and Rejected Grade and these were particularly useful in highlighting how much of the resource was actually utilised in each scenario. Analysis runs using dilution and mining recovery factors showed clearly the fundamental importance of the geological modelling which underlies all of the optimisation work.

From this work some initial conclusions were able to be drawn regarding throughput, annualised gold production, mine life and costs. Review of the appropriate optimised shells using FDPR showed where lack of drilling data limited the pit base and this was used in planning further drilling.

Through an iterative process of continual review and analysis, experience was gained in using the 4D software and appropriate methods were defined to assist in making the information derived as useful as possible to members of the evaluation team.

### MIK model

By July 1996 the first Multiple Indicator Kriged resource model was completed. The metallurgical engineering study had identified the two upgrade alternatives (a ball mill or a SAG mill, running in parallel with the existing ball mill) and initial operating and capital cost estimates were available. The range of fresh milling throughputs was now narrowed down to between 1.4 Mtpa and 2.0 Mtpa.

For operational reasons optimisation work from this point was done by consultants under site supervision. Six sets of optimisations were carried out, Ball Mill at 1.6 and 2.0 Mtpa and SAG Mill at 1.4, 1.6, 1.8 and 2.0 Mtpa. At this stage of the evaluation, the SAG Mill route seemed to have a substantial operating cost advantage and more emphasis was placed on possible SAG options.

There was little overall variation in ore tonnages in the optimal pits between the different runs. The SAG Mill options contained slightly more tonnes than the Ball Mill options at the same rates.

The sensitivity of the pits to gold price was gauged by graphing the ore tonnage against the pit shells at different prices. These showed two substantial step increases at lower prices and the curves flattened off above the base case gold price. This was identified as the effect of the indicator cutoffs chosen to place blocks into the Whittle model excluding lower grade material that became economic at higher prices.

Mill type and throughput options were compared to assess their respective impacts on cash costs, mine life, annual gold production, total ounces and net cash. In each case grand total summaries were extracted and averaged over the respective mine life.

A basic financial comparison of the options was tabulated. After application of all respective costs there was little difference between the Ball and SAG options at the same rates. After consideration of financial and technical issues the Ball mill option was selected as the most appropriate upgrade route.

In early October 1996, a second MIK recoverable resource model containing drilling results to mid September was completed which substantially upgraded the available resource. Further optimisation work using this model was done offsite. The Ball Mill option was evaluated at a revised range of throughputs to provide the site based team with information to identify the most appropriate mill throughput rate.

### Conclusion

Over the course of the expansion evaluation project many factors that influenced the effectiveness of the use of Whittle 4D at Union Reefs Gold Mine were observed. They include:

- The importance of training for Whittle 4D users.
- The need for all providers, users and customers of the Whittle 4D process to be comfortable with the Whittle 4D methodology.
- The importance of understanding the relationship between the general mining software used and the Whittle 4D software which greatly influences the ease with which data can be transferred between the two.
- The critical importance of validating and understanding the resource model used.
- The use of a recoverable resource model which removed the need for the use of mining recovery and dilution factors.
- The advantage of having the Whittle model(s) generated as a part of the overall resource modelling process.
- Necessity for an orderly method of recording the generation of Whittle 4D files.
- Necessity for a methodical approach to control the generation and use of input data from a variety of sources.

- Value of standardised spreadsheets and graphs for calculation and display of results.
- Value of an external audit of the optimisation process.

Union Reefs Gold Mine experienced a period of consolidation in terms of operational performance in mining and milling and a substantial and rapid increase in geological resources during the expansion evaluation process. At times this made the process difficult, but the use of Whittle 4D served to provide a sound foundation from which an appropriate choice could be made.

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