DECLINING FORTUNES WITH FOUR-D

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ABSTRACT

The bulk of the Central Zone deposit at Great Central Mines' Bronzewing Project is to be mined by underground methods. The initial decline design proposal incorporated a deep box cut close to the processing plant with a long decline to the initial underground stopes. A significant capital cost was estimated. A pit optimization study using Four-D was undertaken to investigate if a pit shell could be produced, close to the top of the underground stopes, which would reduce the length of decline access and hence capital cost. The study was successful and the Central Portal Pit has, to date, resulted in above budget gold production.

INTRODUCTION

The Central Zone forms part of the Bronzewing Gold Project which is located about 130 kilometres by road north of the town of Leinster. Gold mineralisation was first identified in auriferous laterites overlying a major bedrock gold deposit now known as the Discovery Zone. An aggressive exploration programme by Great Central Mines rapidly identified further areas of gold mineralisation in the North Eastern Laterite, Western and Central Zones.

Current reserves at Bronzewing have been reported by Great Central Mines, as at December 31st 1994, 9.2 million tonnes at 4.2 g/t (cut grade estimate) or 5.6 g/t (uncut grade estimate). Reserves are to be mined from the North Eastern Laterite, Discovery Zone and Central Zone open pits and from the Central Zone, Western Zone and Discovery Deeps by underground methods. The Bronzewing Project represents one of the most significant gold discoveries in recent years.

Non lateritic gold mineralisation located to date is totally obscured by deep transported alluvial deposits and a thick layer of leached clays derived from intense weathering of the bedrock. In the Central area the transported alluvial cover is 6 to 25 metres thick. Intense weathering has generally reduced the bedrock to saprolitic clays to a depth of 50 to 70 metres below the surface. Highly weathered and oxidised rock extends for a further 10 to 20 metres, with completely fresh rock not being encountered until a depth of 100 to 120 metres.

Gold mineralisation at the Central Zone consists of a flat lying laterite hosted deposit which overlies a major series of auriferous shear zones in weathered and unoxidised bedrock. In bedrock, gold mineralisation and associated alteration occur mainly in shear zones within a sequence of mafic igneous rocks. High gold grades occur in the bedrock gold mineralisation.

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PROJECT SCOPE

The bulk of the bedrock gold mineralisation at Central Zone is to be mined by underground methods. Access to the deposit is to be provided by a decline. The initial decline proposal was for a box cut, located near the processing plant, to provide a portal, followed by a decline down to the location of the initial mining stopes. Due to the deep weathering profile at Bronzewing, the proposed box cut would involve mining of a significant tonnage of waste in order to reach fresh bedrock at a depth of approximately 120 metres. Capital costs of the order of $6 million were estimated for the box cut option.

As an alternative strategy, a pit optimization study was carried out using Four-D in order to determine if a open pit could be developed, reaching fresh bedrock, which could be used to establish a portal for a shortened decline. The key goals of the study were as follows:

- To identify an open pit which reaches to fresh bedrock (at 100 metres depth).
- The pit design parameters should take into account the necessary wall angles, based on geotechnical studies, to provide a long term, stable configuration.
- The cost of developing the pit and associated decline should be significantly lower than the box cut option.
- The pit shell should closely approximate to a workable design.

This paper described the approach taken and results obtained form the pit optimization study.

A series of pit optimizations were carried out in order to achieve the key targets summarised above.

FULL MODEL PIT OPTIMIZATION

A pit optimization model in Four-D format was produced from a block model developed using the Vulcan mining software package. The model used cut gold grades. A cost matrix was developed using mining and processing cost parameters compiled by GCM technical staff. The resultant mining and processing cost adjustment factors were built into the Four-D model using the facilities of the reblocking programme, FDRB.

The initial pit optimizations were carried out on the full Central Zone block model. The Four-D optimization model had dimensions of 1250 metres in the easting direction, 1500 metres in the northing direction and 500 metres in the vertical direction.

The model was reblocked to a 20 metre cubic optimization block size wherein each optimization block could contain up to 64 regularised 5 metre cubic Vulcan model blocks. During the reblocking process the number of ore parcels was reduced to the limit of 50 parcels by the Four-D process of combining parcels with the most similar grade. In this manner, grade smoothing is reduced to the absolute minimum. Wide experience of running pit optimizations with both reblocked models and original models has indicated that the reblocked models produce results with essentially the same precision as the full size models but with a time saving of several orders of magnitude. The Four-D pit optimizations were carried out on Unix workstations to maximize processing speed and hence to minimize the time required to undertake the optimizations. The reblocked model contained some 118,000 optimization blocks.

Table 1 displays the overall slope angles used in the initial pit optimization.

ZONE	DIRECTION			
	North	East	South	West
Upper 90 metres	42°	35°	34°	38°
Below 90 metres depth	48°	48°	48°	48°

Table 1: Overall wall angles for initial pit optimization

The initial pit optimization, using the entire model, produced a pit, at a gold price of $550/oz, which reached a total depth of 280 metres. The pit was accessing mineralised zones which were to be mined by underground methods.

RESTRICTED MODEL PIT OPTIMIZATION

In order to remove the influence of the high grade mineralised zones on the pit optimization, a revised Four-D model was produced in which all blocks in the resource model greater than 220 metres below the surface were omitted.

Initial pit optimizations were carried out using exactly the same cost, recovery, slope parameters and MCOSTM increments as the initial full model pit optimization. The pit optimization results file contained two sets of pits as follows:

- Pits which only reach the base of the flat lying laterite zone (20 metres deep at the base case gold price).
- Pits which reach the base of the truncated resource model (220 metres deep at very high gold prices).

Two key conclusions could be drawn from this initial restricted model pit optimization:

- The depth to which pits were developed was extremely sensitive to the gold price and hence cut off grade.
- The switch from very shallow pits to pits which are too deep occurs very abruptly.

In order to determine if it was possible to induce Four-D to produce an optimum pit shell with a base close to the target depth of 100 metres, a series of pit optimizations were carried out in which both the gold price and MCOSTM increment were varied. In particular, a very small MCOSTM increment was used (0.0005) to produce as many pits as possible between specific gold price ranges.

After several iterations, the target was achieved and an optimum pit shell was produced which reached approximately 95 metres below the ground surface. The incremental pit shells still contained changes in pit depth such that two adjacent incremental pit shells had bases at 95 metres and 195 metres depth.

The target pit shell was actually optimum for a gold price of approximately AUS$700 per ounce. In order to determine the tonnes and grade of ore, the stripping ratio and likely operating cashflow,

financial analyses were carried out using FDAN and a base case gold price of AUS$550 per ounce. At this gold price the target pit shell contained some 130,000 tonnes of ore at a cut grade of 2.8 g/t with a stripping ratio of 23 : 1. An indicated operating cashflow (exclusive of any capital or pre-production costs of AUS$1.7 million), was estimated using FDAN.

MODEL REFINEMENT AND SENSITIVITY STUDIES

The restricted model pit optimizations had identified an area within the Central Zone deposit where a pit shell could be generated to the target depth and which contained sufficient resources to generate an operating cashflow surplus.

GCM technical staff then initiated an intensive programme of data acquisition in order to refine the robustness of the portal pit database. Activities included:-

- Additional close spaced drilling.
- A significant number of check large diameter diamond drilling to confirm reverse circulation drill intersections used in the resource model development along with the large number of diamond drill holes.
- A series of geotechnical drill holes logged by geotechnical consultants.

The resource model was recast incorporating the additional drilling data. A revised set of slope parameters were determined paying particular attention to the ground conditions predicted to occur in the vicinity of the pit walls and the requirement for high stability during an extended mine life. The revised overall pit slopes are summarised in Table 2. Operating costs were also reviewed and adjusted.

DIRECTION	OVERALL WALL ANGLE
North	34°
East	33°
South	30°
West	40°

Table 2: Overall wall angles for revised pit optimization

A Four-D optimization model was produced using the revised resource model and a maximum vertical extent of 200 metres. An optimum pit shell was produced, using the same approach as described above, which reached a depth of 100 metres. When a gold price of AUS$550 per ounce was used to interrogate the results file with FDAN, the pit contained approximately 240,000 tonnes of ore at a grade of 1.9 g/t with a strip ratio of 20 : 1. The potential cost benefits of processing low grade ore were not addressed in this initial analysis. The operating cashflow from the pit produced a small loss.

A full pit design was produced using the Four-D pit shell as a guide. A revised and much shortened decline was also designed to access the underground stoping blocks.

Once the pit design was produced, detailed scheduling of run of mine and low grade ore was undertaken by GCM technical staff.

CONCLUSIONS AND POST SCRIPT

The pit optimization study had successfully achieved the key aims:

- To identify an open pit which contains sufficient resources to cover the cost of pit development.
- To shorten the amount of decline required to access the underground stoping blocks.

The study indicated that the cost of providing access to the Central Zone underground reserves could be reduced by approximately $4.5 million.

At the end of January 1995 the Central Portal Pit had been mined to a depth of 79 metres with production of 305,000 tonnes at 1.7 g/t for 16,600 ounces compared with ore reserve estimates of 260,000 tonnes at 1.3 g/t for 10,700 ounces to the same depth.

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