Some benefits arising from the establishment of a mining infrastructure prior to the commissioning of the shaft

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Synopsis

The predevelopment and preparation of a total infrastructure in a deep level mining environment, prior to the shaft system being commissioned has major advantages. This paper intends to indicate these advantages and outline an understanding of the disadvantages. These benefits can be classified in three basic groups: the financial and timing advantages, a knowledge of the ore body and the development of required technology to meet the design parameters.

The required technology in many aspects was still to be developed prior to successful application. Stemming from the technological evolution are some secondary advantages which will be described in each of the groups. Safety and health considerations and some practicalities made some of the new technology redundant prior to the actual application. In each case the actual achievements and the anticipated benefits will be indicated to allow the reader to distinguish clearly between planned and actual achieved advantages.

Introduction

The South Deep project is part of Western Areas Gold Mining Company Limited situated on the West Rand region of Gauteng Province. Currently being sunk are the two 9m diameter shafts from surface to an ultimate depth of 2800 m concurrent with the shaft sinking, while the development of infrastructure, the development of ore reserves and the extraction of the entire shaft pillar is in progress. Mining of the shaft pillar requires backfill material with special properties. A plant for this purpose only is currently producing stiff backfill material from crushed waste and classified tailings which is pumped to the excavated stopes.

Developing and shaftsinking rates of approximately 530 m and 140 m per month respectively allow for the planned commissioning of the complex during August 2000. Once the commissioning is complete, mining will take place from two reef horizons on either side of the shoreline—being the mechanized mining of the massive orebody and conventional mining of the VCR reserves to the west of the shoreline. In order to allow the extraction of the wide orebody a destress cut at the lowest most payable horizon of the massive orebody must lead the operation to allow a stress environment equivalent to mining depths of 1200 m and vertical stresses at the range of 20 to 35 MPa. Having tested at low production rates from a total pre-developed orebody the mining methods employed will now develop a significantly rapid tonnage buildup phase to bring the mine up to the planned production of 180 000 t per month.

Continuous deepening and exploration of the mine will continue by means of a triple decline system situated at the centre of gravity of the orebody and permit the opening up of 3 to 5 new mining levels at 50 m vertical intervals, which will ultimately link up with a sub-vertical shaft system. Good positional efficiency will be derived from the underground installed cooling plants inclusive of air scrubbing and condenser facilities. Hydroelectric power and its accompanying plant will also be installed underground and utilized on conventional mining applications both for VCR and EC destress mining. Intensive drilling programmes from the development and destress horizons, inclusive of sacrificial development, will allow a 25 m by 25 m grid pattern for the drilling programme. From this data a comprehensive Data mine model linked to a design and scheduling package will allow for the optimization of all mining design parameters, being measured continuously against the influence of 3D stress models and environmental considerations.

Through pre-installed telemetering leaky feeder cables continuous communication from a central control room allow for on-line vehicle dispatch and work organizing to ensure proper

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fleet utilization and ore blending. Establishing a new mine in a climate of declining profits, reduced capital expenditure per ton milled and increased workplace turmoil regarding labour and the socio-political environment in which the mining industry currently operates calls for some special business benefit from such a project. This paper describes these factors and benefits giving the edge to proceed with confidence.

Economic background

Seen in the light of a declining industry where the total gold output reduces by 7% annually owing to both reduced tonnage production and a smaller yield inhibits the potential for new mining projects.

In such an environment the capital expenditure potential is drastically reduced as indicated in Figure 1. The graph representing the South African gold mining industry indicates the inability of gold mines to utilize capital. Expressed in Rand per ton milled the negative trend is very evident. To allow investment in new projects of this nature calls for extraordinary features and advantages that will allow significant benefits that will not only perform better than the direct market competitors but also outperform the general high-risk investment opportunities in the marketplace.

Increased costs and low productivity lead to ever-increasing paylimits which reduces the gold reserves and at the same time the average grade of the existing reserves is declining. This environment is well known amongst mine management currently and therefore makes the challenge that much more outstanding.

The advantage that South Deep has in being a pre-developed unit outweighs these negative indicators by having at their disposal the information required to attract investors with confidence. Timeous and pre-planned action in most eventualities is possible within the framework of electronic media and advanced software packages allowing optimization in terms of ore extraction. Not only does this allow optimal tonnage flow but also the possibility of blending ore from all sources to maximize extraction of the orebody.

Considering that only 10% to 14% of the total envisaged working cost over the life of the mine is capital it emphasizes the major advantage stemming from doing it correctly the first time round. With this background it is clear that significant preparatory work can be done concerning the mining method and the deployment of equipment to ensure the cheapest and most efficient working arrangement.

Figure 1—Capex per ton milled in 1997, real terms

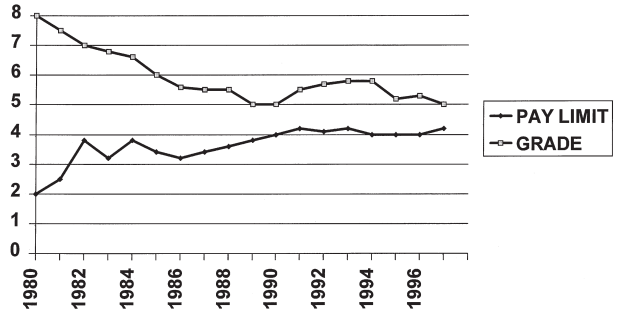

Figure 2—Pay limit and yield comparison

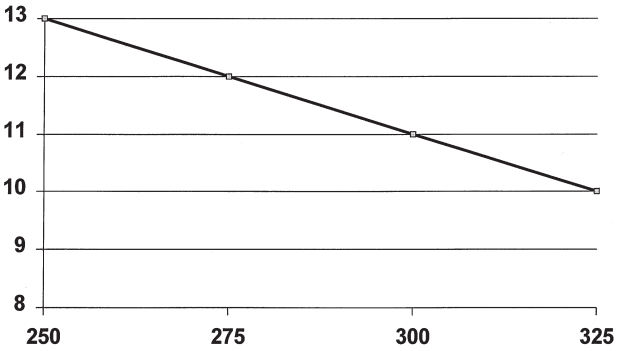

Figure 3—Capital expenditure as a percentage of total w/cost

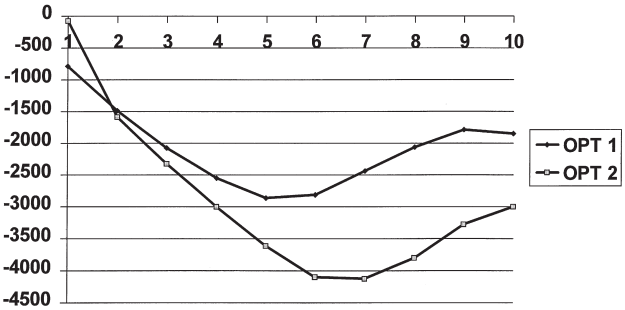

Figure 4—Cumulative NPV (10 years)

Net cash advantage

The estimated budget for the total project amounts to R2,7 billion in 1994 terms, to be spent over a period of 7 years, with returns from the 8th year onwards. When compared with the same discounted cashflow of the opposing project the major benefit allows for a 36% positive increase in cashflow. In the example given in Figure 4 the two options being compared are, pre-development and post-development after shaft commissioning, option 1 and option 2 respectively. It is important to realise that if the finance mechanism does not allow for early recovery of Capex this is no longer a viable project.

Time saving

Predevelopment

Predevelopment of the total infrastructure required to support a mining rate of 180 000 tons prior to the shaft being commissioned shortens approximately 3 years in the life cycle of the

project preparation, resulting in the full benefit income generating potential during that phase. During phase 1 of the project all four of the working levels of the mine will be fully developed and equipped, including the ore crushing and handling facilities. All workshops and facilities not only will be completed and commissioned, but also manned and examined in the period leading up to commissioning.

Positional efficiency

Once the major service excavations are in place in an underground environment the full benefit of positional efficiency can be made, which will anticipate drastic reduced working costs over the life span of the project. Excavations in this category will include cooling plants and associated plants including of hydroelectric power installations. During the same period it will be possible to establish an experimental stope where mining methods can be researched and developed fully.

Ore reserve stockpiling

The critical path for the buildup is very dependent on the destress mining operation which by design will be on the lower most-payable reef horizon and opening up at a 45 degree angle in front of the massive mining that will follow. The infrastructure required to support the destress will also be available for the massive mining, with the added advantage that detailed information will be derived from the development and the drilling program at ultimately a 25 m grid pattern. It is planned to have available, at all times at least 24 months of proven ore reserves. Secondary benefits that will be gained can be summarized as follows.

Information on the geology of the orebody

The ability to forecast and pre-plan the extraction of the ore-body based on the amount of information received has major benefits in the optimization of this process. Data models of the detailed orebody of the mine are in existence and are being updated from the inputs received from seismic studies, sampling, bore holes and mapping information. These models form the cornerstone of the design in other packages ensuring optimization when considering the total scope of variables. The major benefits of a solid data base, prior to the mining of an orebody, are the ability to be pro-active and to make full use of the flexibility offered by alternative scenarios evaluated in artificial intelligence software packages. The financial benefit derived from high levels of confidence on the reserve are the rates at which the gold expressed per ounce in the ground is valued in excess of those less confident.

The development of new technology

The development of new technology, with the installation of the required backup systems, allows the automation of the sampling and gold analysing on the working face to make turn around times of valuation information as short and as accurate as possible

Shaft pillar extraction at the depths of mining envisaged in this project will mean that a shaft pillar will be sized according to the design parameters and it will end up being approximately 1000 m by 1000 m. Not only is this not practical but will also lock up a major portion of the reserve, which cannot be tolerated.

Research and development in this field have led to the installation of an underground crushing and screening plant to deliver the crushed product of waste rock to the mixing section to be mixed with classified plant tailings and then pumped to the paddocks in the stope. Filling in the stope covers 65% of excavated volume making it possible to have very small closures in the extracted area with the result that the shaft is stable over its mining life, but at the same time does not lock up any of the reserve till the end of the mine's life.

During the development phase it became abundantly clear that no technology existed to fill the volumes excavated during the process of shaft pillar removal, making it necessary to develop sufficient confidence in the pumping technology of backfill material. This same technology now has the ability to allow simple, safe and economical support of the destress cut at higher stoping widths, exceeding 2m.

Major successes in applying this approach have not only proved the technology but at the same time has opened a window of perception when in years to come it will be required as a prerequisite to permit mining at these depths.

Typical criteria that will influence the choice and ensure optimization are:

- Population
- Inventory
- Local manufacturing
- Maintainability
- Supplier support
- Operational simplicity
- Capital cost
- Life cycle cost
- Production rate
- Availability
- Technical specification
- Safety & ergonomics.

Mining methods

Mining will be either a conventional longwall type operation on the VCR and destress horizons or a combination of drift and/or cut and fill mining. The latter being accessed by means of a zigzag ramp or rubber-tyred vehicles at an 8 degree inclination, allowing access to a boxcut across the reef bands. On strike to both sides of the boxcut are drifts up to 70 m in length, from where the mining will take place. Each of the mined-out drifts will be filled with CCT material and the process will repeat itself in the horizontal and vertical plane till the total package is mined out. Other methods such as vertical crater retreat or multi-reef conventional mining will still be evaluated and the most promising method implemented by the time increased production targets are to be met.

Having the opportunity to experiment with the potential of each of the above-mentioned methods allows the scope to optimize on the basis of set parameters such as working cost, extraction rates and the extent as well as the types of mechanization required. The ability of a new mine to build a production profile of this nature relies on the confidence in the mining method and the extent to which preparatory work has been done.

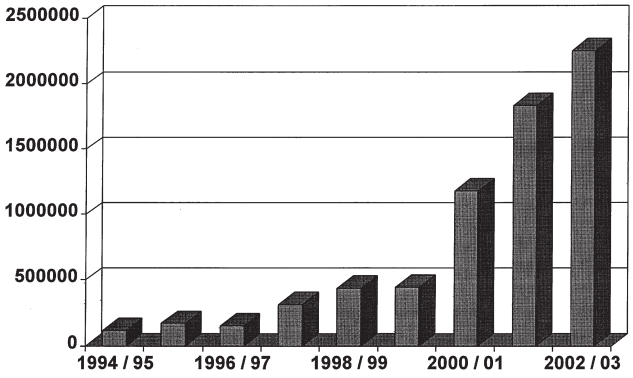

Figure 5—South Deep, milled tons

Production profile

After the commissioning of the shaft complex the production buildup is very rapid when cognisance has been taken of the factors discussed in this paper. Clearly, the real benefit is the ability to take full advantage of such a pre- prepared infrastructure and detailed planned operation, with all aspects pre-examined and tested in keeping with the required buildup.

Summary

The South Deep project would not have been a viable proposition if the financing mechanism was not based on sound principles as summarized here.

The ability to benefit from the available information.

- ➤ Modelling the design and evaluating the results to optimize.
- ➤ Placement of infrastructural and ore reserve developments in positions that will maximize their use in future.
- ➤ Satisfying a multitude of variables for optimal extraction through the use of computer models and artificial intelligence-based systems.

Using all available time efficiently.

- ➤ Pre-development of both infrastructural and ore reserve excavations.
- ➤ Pre-development and installation of applicable technology.
- ➤ Experimental work to maximize mining methods.
- ➤ Application of new technology on a small scale without major disruption during the development phases.
- ➤ Removal of the shaft pillar at depth prior to the shaft intersection.

Net cash advantage.

- ➤ Some funding of the project from the extraction of the shaft pillar and other destress operations.
- ➤ A rapid buildup after commissioning of the shaft complex ensuring lower levels of risk.
- ➤ A higher level of confidence in the project which will attract investment from the market place.
- ➤ Reduced cost of capital due to continuous contribution.

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