Selecting an appropriate decline development advance rate

by S.M. Rupprecht*

Synopsis

Selecting the appropriate development advance rate is important in evaluating the potential of a project. If too optimistic, the project is scheduled to generate revenue much sooner than is practically possible and results in a high internal rate of return (IRR). If too conservative, the project may indicate a low rate of return, which could result in delaying or cancelling a viable project.

This paper looks at the impact of two different decline advance rates applied on a hypothetical gold mine of moderate depth and the impact the two advance rates have on the theoretical cash flow models.

Introduction

One of the key issues facing the planning and evaluation of new projects is the development rate applied to access the orebody. The current investment environment in South Africa and recent boom in commodity prices has seen the introduction of a number of junior mining companies re-evaluating previously 'shelved' projects. However, in many instances, due to the size of the company and the nature of financial backing, it is necessary to minimize capital expenditure and payback period and maximize the return by accessing the orebody in the shortest time possible. This means that decline development needs to be advanced rapidly to create mining infrastructure in the shortest possible time and at the lowest possible cost which will enable high output mining. This rapid access development rate affects directly the bottom line of the project. This paper looks at two different decline advance rates applied on a hypothetical gold mine of moderate depth and the impact the two advance rates have on the theoretical cash flow models.

Background

As a background to selecting an appropriate decline development rate, it is worth noting some of the work that has reviewed the tunnelling process and the effect of advance rates on the net present value (NPV) of the project.

In 1997, MacFarlane documented the relationship between higher advance rates and improved NPV for a project (Table I). The change in NPV is less significant at higher development rates due to the lower rates of opening up the reef horizon.

MacFarlane also investigated various development methods using conventional development as a base case. Trackless methods indicated the greatest change in NPV. It is interesting to note that high capital cost layouts for high advance rates do not necessarily improve the project value. (Table II.)

Van Rooyen (1998) carried out a similar exercise and found similar results. (Table III)

In 1999, the Deepmine Collaborative Research Programme evaluated the effect of advance rates on project net present value (NPV) for different development methods. The work acknowledged the need for mines to develop techniques for safe, cost-effective and rapid access development to orebodies. Table IV indicates the type of equipment used for access development, typical advance rates, and costs. A simple cash flow model was developed to derive an NPV, which indicated that the length of time to carry out the access development was important to the overall economics of the project (Figure 1).

Although the above work supports the principle that rapid access through mechanized

Table I

NPV of different development rates (after MacFarlane, 1997)

Advance rates	Change in NPV—R million
4.5 m/shift	0
9.0 m/shift	26.07
13.5 m/shift	34.98
18.0 m/shift	41.02

* *RSG Global.*

or trackless development methods is the most appropriate manner to improve project value, little reference is made to what is an appropriate development rate or what the net effect is when these targets are not achieved.

DCF comparison of two decline advance rates

A simplified discounted cash flow tabulation for a mining project is set out in Table V and Table VI to demonstrate the effect that the decline development rate has on a project. In this example, a hypothetical gold mine produces 5 343kg per year with the expected selling price of $450/oz at an exchange rate of R7.25 to $1.00 with an initial capital investment of R1000 million (assumed to be the same for both scenarios).

In the first example (Table V), a decline development rate of 120 m per month is proposed. A two year preproduction development period is required before the mine begins production and reaches full production in the fifth year. The hypothetical cash flow model estimates an NPV of R85.6 million at a discount rate of 10% over an 11-year period with an internal rate of return (IRR) of 12.37%.

However, if a more conventional decline development rate of 80 m per month (Table VI) were used, the pre-production period increases to three years with full production achieved year 6. Under these circumstances the simple operational cash flow model indicates that the project is marginally viable with a NPV of R-2.2 million at a discount rate of 10% over a 12-year period with an IRR of only 7.66%.

In the first case, the project cash flow model exceeds a 'hurdle rate' of 10% and would most likely be determined economically viable, whereas, in the second scenario, the project indicates a negative NPV and would be unlikely to get the go-ahead to advance the project.

Selecting the correct decline development advance rate is important in evaluating the potential of a project. If too optimistic, the project is scheduled to generate revenue much sooner than practically possible and results in a high NPV. If too conservative, the project may indicate a low rate of return, which could result in delaying or cancelling a viable project.

Thus, the question is posed—'What is the most appropriate decline development rate to use when evaluating a project?'

Table II

NPV of different development methods (after MacFarlane, 1997)

Method	Change in NPV	Advance rate	Capital expenditure
Conventional	0	Low	Low
Trackless	R23 700 000	Medium	Medium
Mechanized A	R2 320 000	Medium	High
Mechanized B	R20 180 000	Medium	High

Table III

NPV of different development rates (after Van Rooyen, 1998)

Method	NPV—R million
Conventional 80 m/month	2.8
Mechanized 120 m/month	-18.4
Tunnelling 180 m/month	14.1
Tunnelling 220 m/month	13.5

Table IV

Summary of development equipment and associated parameters

Equipment suite	Advance rate	Cost R/metre	Capital	Primary constraint
Conventional	80 m/month	5 000	Low	Cleaning
Semi-trackless	120 m/month	7 000	Medium	Drilling
Trackless	280 m/month	9 000	High	Support
Tunnel boring	500 m/month	12 000	Very gigh	Logistics

Benchmarking proposed development rates

In the South African mining industry many decline development rates are proposed, from as little as 35 m per month to as high as 150 m per month. Often the lower rates are associated with replacement orebodies (brownfield projects); however, in these circumstances the need for high development rates is alleviated by current operations. Higher advance rates are associated with greenfield projects, which are often sensitive to the build-up phase of the project. The

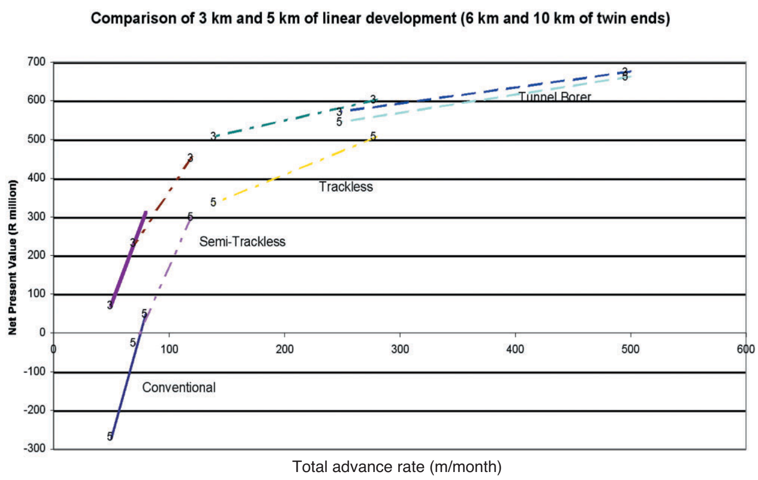

Figure1—Advance rate vs. net present value (Willis, 2002)

Table V

Cash flow model utilizing an increased decline development rate

Increased development rate	**Lucky Friday gold mine—Life of mine cash flow model**							
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**~**	**Year 11**	**Total**
Tons milled (t)	0	0	150 000	900 000	1 200.000	~	1 200.000	9 450 00
Head grade (g/t)	0	0	4.59	4.59	4.59	~	4.59	
Recovery (%)	0.0	0.0	97.0	97.0	97.0	~	97.0	
Yield (g/t)	0.00	0.00	4.45	4.45	4.45	~	4.45	
Gold produced (kg)	0	0	668	4 007	5 343	~	5 343	42 074
Gold price (R000/kg)	105	105	105	105	105	~	105	
Gross revenue (R000)	**0**	**0**	**70 051**	**420 309**	**560 412**	**~**	**560 412**	**4 413 242**
Operating costs (R000)	**0**	**0**	**42 750**	**256 500**	**342 000**	**~**	**342 000**	**2 693 250**
Cash operating profit (R000)	**0**	**0**	**27 301**	**163 809**	**218 412**	**~**	**218 412**	**1 719 992**
Capital expenditure (R000)	(175 000)	(275 000)	(275 000)	(275 000)	–	~	_	–1,000.000
Cashflow (R000)	**–175 000**	**–275 000**	**–247 699**	**–111 191**	**218 412**	**~**	**218 412**	**719 992**
Discounted profit (R000)	**–175 000**	**–250 000**	**–204 710**	**–835 40**	**149 178**	**~**	**84 207**	**85 639**
NPV (R000)	**85 639**							
IRR %	**12.37**							

Table VI

Cash flow model utilizing a conventional decline development rate

Conventional development rate	**Lucky Friday gold mine—Life of mine cash flow model**								
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**~**	**Year 12**	**Total**
Tonnes milled (t)	0	0	0	150 000	900 000	1 200 00	~	1 200 000	**9 450 00**
Head grade (g/t)	0	0	0	4 59	4.59	4.59	~	4.59	
Recovery (%)	0.0	0.0	0.0		97.0	97.0	~	97.0	
Gold produced (kg)	0	0	0	0	4 007	5 343	~	5 343	
Gold price (R000/kg)	105	105	105	105	105	105	~	105	
Gross revenue (R000)	**0**	**0**	**0**	**0**	**420 309**	**560 412**	**~**	**560 412**	**4 343 191**
Operating costs (R'000)	**0**	**0**	**0**	**42 750**	**256 500**	**342 000**	**~**	**342 000**	**2 693 250**
Cash operating profit (R000)	**0**	**0**	**0**	**–42 750**	**163 809**	**218 412**	**~**	**218 412**	**1 649 941**
Capital expenditure (R000)	(50 000)	(250 000)	(250 000)	(250 000)	(200 000)		~		**–1 000 000**
Cashflow (R000)	**–50 000**	**–250 000**	**–250 000**	**–292 750**	**–36 191**	**218 412**	**~**	**218 412**	**649 941**
Discounted profit (000)	**–50 000**	**–227 273**	**–2206 612**	**–219 947**	**–24 719**	**135 616**	**~**	**76 552**	**(2 289)**
NPV (R000)	**–2 289**								
IRR %	**7.66**								

following (Table VII) indicates typical development rates commonly proposed in the South African industry. The majority of projects are planned below 100 m per month with the bulk of the projects targeting 70 to 80 m/month (Figure 2).

Optimizing decline development

In order to achieve the proposed high rates of advance of 120 m to 150 m per month per end for decline development the overall development cycle must be optimized and equipment changes kept to a minimum. The following points should be addressed by potential mine planners when considering decline development.

Drilling and blasting

The drilling cycle accounts for approximately 25% of the available cycle time. Drilling equipment is capable of delivering the required hole accuracy at an appropriate penetration rate and therefore is not seen as a constraint in achieving high advance rate. The following recommendations are made to improve current advance rates.

Blast round design should be based on geotechnical conditions. In poor ground conditions presplitting is recommended as this technique results in less blast damage to the hangingwall and sidewall, which reduces support requirements and the time required for barring.

Table VII

Benchmarking of decline development rates

Project	**Development method**	**Development rate**
Mine A	Semi –mechanized truck	85 m/month
Mine B	Mechanized truck and conveyor	80 m/month
Mine C	Mechanized truck	150 m/month
Mine D	Mechanized—conveyor	90 m/month
Mine E	Mechanized—conveyor	65 m/month
Mine F	Mechanized—Truck	70 m/month
Mine G	Mechanized—Truck	70 m/month
Mine H	Mechanized—Truck	120 m/month
Mine I	Sem-mechanized truck	80 m/month
Mine J	Mechanized—Truck	60 m/month

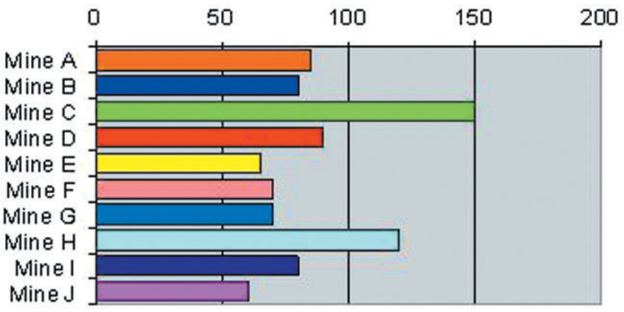

Figure 2—Decline development rates (m/month)

Drill rigs should use auto-parallelism to ensure parallel holes and thereby reduce the number of holes required. The drill rig should be capable of drilling roof support and should be used to facilitate charging up of the top holes. The use of a 'drill master', especially in the earlier phase of the project, is recommended to enable the drill crew to be trained properly and the round optimized.

Drill bits should be monitored to capture drill performance in different geotechnical areas enabling the optimum choice of bits to be made according to rock conditions. The typical critical issues to be monitored are inconsistent quality of drill bits, ground conditions, flushing of holes and identification of geotechnical areas.

The charging procedure represents approximately 10% of the total cycle time. Emulsion is the explosive of choice due to its ease of charging up, insensitivity to water and the fact that it is not transported as an explosive. The shock tube is the preferred initiation system, as the resulting improved initiation sequence leads to better hangingwall and sidewall conditions and fewer oversized rocks. Training and discipline are critical in the charge-up activity.

Cleaning cycle

The cleaning of an end accounts for approximately 30% of the total cycle time. The choice of cleaning equipment is generally based on selecting the largest allowed by the size of the tunnel. The following recommendations are made for rapid access development cleaning.

The maximum size loader suitable to the tunnel dimensions should be used and maximum tramming distance should be restricted to 200 m. Rehandling of rock is not advisable; however, it does promote shorter face cleaning times as rehandling offers a buffer between the LHD and the availability of trucks or conveyors.

Associated activities

There are three main activities to be undertaken, which can be done concurrently. These include equipping, secondary support and cover drilling. The design of the permanent equipment and the secondary support must be fit for purpose. The following are recommendations for these activities when associated with high-speed development:

Permanent equipping should be kept up to date and be installed by a specialist crew, to a standard such that the decline is ready for the designed purpose immediately upon completion of the development phase.

Temporary equipping must be installed to standard and concurrently with the drilling cycle with pipe extensions maintained at a standard distance from the advancing face. Utility vehicles should be used for pipe extensions. Secondary support items should be installed during the drilling cycle.

Cover drilling should be utilized to identify hazards in front of the face.

Project management

A number of softer issues concerned with organization and corporate culture must be addressed before rapid access criteria can be met.

Project management and crew training should receive as much attention as the technical concerns associated with decline development projects. Strong emphasis should be placed on creating the right mindset among the workers and incentive systems should be developed to encourage the development teams. Team building, motivation and appropriate remuneration should be used to improve production rates, safety performance and quality of work. It must be noted that it will take time for any one crew to achieve the maximum possible advance rates. At least a six-month period is required to build a high-speed development crew.

Conclusion

As an international consulting group, RSG Global is often approached to conduct or review project feasibilities for Southern African deposits. One area of concern is the rate of advance used in accessing the orebody. The reader should note that the rates of advance presented in Table VII are planned rates. Benchmarking exercises of actual projects indicate that rates of the order of 80 m per month are appropriate and achievable. Figures above this target rate are generally not consistently sustainable. Recently, a few projects have undertaken to develop their decline development rates in excess of 100 m per month. Whether these projects become the new benchmark upon which the South African mining industry bases it decline advance rates remains to be seen. Until then, decline development rates should remain of the order of 80 m per month; otherwise projects owners run the risk of overvaluing the project.

References

MacFarlane, A.S. Development for Deep Level Rapid Reef Access. South African Institute of Mining and Metallurgy Colloquium Technology for Rapid Accessing the oreBody. July 1997.

Rupprecht, S.M. *et al.* Rapid Access Summary Research Report, Deepmine Collaborative Research Programme, March 2001.

Van Rooyen, C.S. High Speed Tunnelling Project Elandsrand Gold Mining Company, Ltd. *SAIMM Journal,* July 1998.

Willis, R.P.H. and Rupprecht, S.M. The Challenges of Rapid Access Development in South African Deep Level Mines, TAC Canada 2002. ◆