A long hole stoping system for mining narrow platinum reefs

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Introduction

In South African metalliferous mines, stoping operations are largely confined to narrow, tabular orebodies making mechanization extremely difficult. Limited flexibility in terms of stope width has necessitated drilling by means of hand held, pneumatic rock drills at most of our operations. As the largest producer of platinum in the world, we drill in excess of forty million stope blast holes per annum. Cleaning of the broken ore is also done by conventional means—utilizing scrapers and scraper winches. Conventional methods such as these carry high costs in terms of risk exposure as well as labour intensity.

The purpose of this paper is to describe the development of a long hole stoping system suitable for the narrow platinum reefs. The new system had to be substantially safer and more cost effective than conventional mining. We selected a site that was conducive to mechanized mining and set out the parameters that we considered would meet our requirements. We then conducted a feasibility study to evaluate the conceptualized long hole stoping system in terms of specific goals. An analysis of the proposed system identified the Key Performance Indicators (KPIs). One of the most critical goals was to be able to create a man-free stope. This would mitigate the safety risk associated with normal stoping operations, as well as the inefficiency cost previously referred to.

Other challenges included setting targets for long hole accuracy, stoping width reduction and specific blasting system performance for long hole stoping. We also modelled a critical span that we considered to be inherently safe and to ensure hangingwall stability, throw-blast cleaning and overall system productivity. Anglo Platinum Research and Development and Sandvik Tamrock entered into an agreement for the supply of a specialized long hole-drilling machine. The system was implemented and tested by the mine with the support of the other participants.

The results achieved met our expectations. It was demonstrated that with this method of mining it is possible to have a man-free/support-free stope face and to achieve a reduction in shaft head cost per ton whilst reducing dilution.

Key performance indicators assessed during the trial

- Safety targets
- Mining layout
- Drill rig
- Production targets
- Support requirements
- Explosives requirement
- Services requirement
- Ore removal and cleaning requirement
- Training requirement

Safety targets

All persons involved with the project had to adhere to the mine's safety programmes including the zero-tolerance campaign, and were required to report all hazards observed immediately. Mine personnel and Tamrock carried out a full risk assessment on the drill rig before transporting underground. A further risk assessment was carried out when the machine was in position underground.

Mining layout

See Figure 1 and Figure 2 for a detailed description.

Drill rig

The drill rig was a combination of a Secoma P-Low LC 10 long hole feed and an Axera low profile carrier. The choice of this equipment was made through consultation with Tamrock

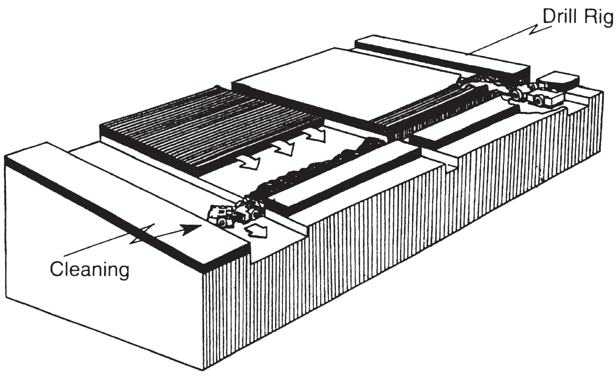

Figure 1—Mining concept—isometric

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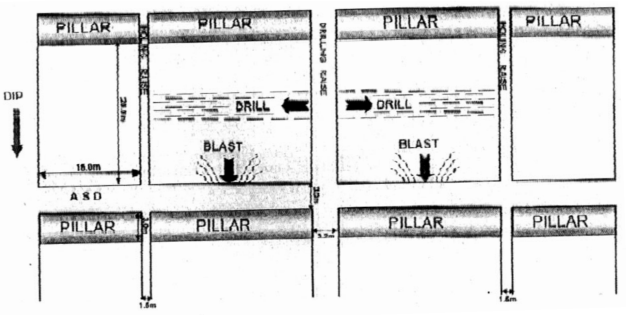

Figure 2—Mining layout

Sandvik. All relevant design perimeters of the area to be mined were taken into consideration.

Production targets

The following production targets were set:

- To optimize face advance (Target of 2 m per blast)
- 125 m drilled per single shift (5000 m per month on a double shift basis)
- 2 500 centares per month or 60 centares per single shift
- Less than 0.5% deflection (75 mm) on 15 m length hole
- System to generate 15% more revenue than conventional mining due to lower dilution
- Shaft head costs expected to be 15% lower than conventional mining
- Zero grade dilution planned at 65 mm mining width. Planned stoping grade of 6.0 g/t
- Sizes of development ends are crucial to make this system profitable (drill raise @ 1.6h × 3.2w m; holing raise @ 1.0 × 1.5 m)—this to prevent excessive waste rock dilution
- System planned as support-free, man-free stope panel environment based on throw-blast-cleaning and a total of 5 people per production panel.

Support requirements

Apart from the installation of roof bolts in the access drives and the use of 4 m strike pillars, the in-stope area was without support. The sequence of mining the blocks was scheduled to ensure that mined out stope spans do not become excessive. Falls of ground in the panel had to be monitored closely in order to make layout changes should the need arise. See Figure 3 of the specific drilling layout for support installation.

An explosives expert from African Explosives Limited, was present during the initial charging and blasting operations. His guidance was critical to demonstrate the method of charging a 15 m long blast hole. Detonating cord was used in conjunction with a train of cartridge emulsion explosives (Magnum 365 mm × 560 mm). (The explosives were transported by means of a Normet utility vehicle to the mining site from surface. At a later stage pumpable emulsion explosives and electronic detonaters will be used to make charging of the blast holes more effective.

Services requirement

- Drilling water with a pressure of at least 6 bar (140l/min.)

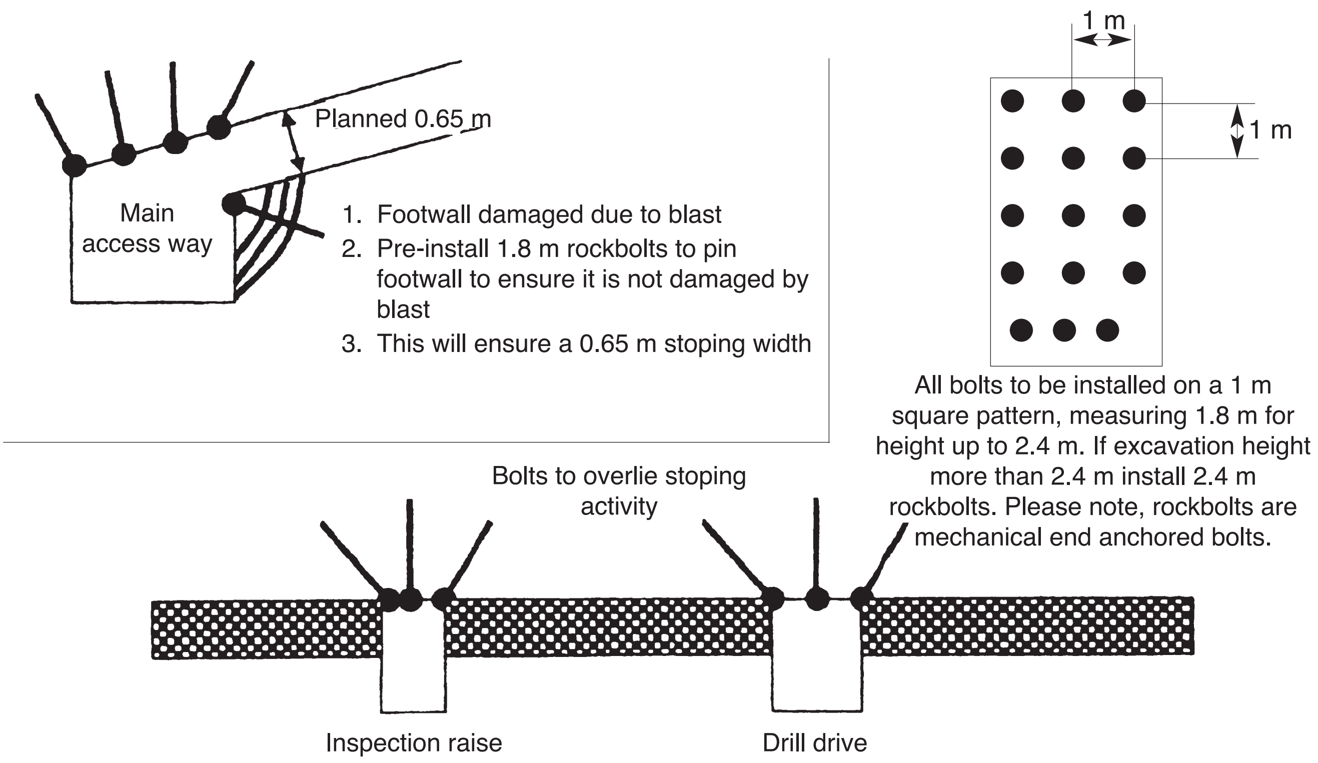

Figure 3—Drilling layout

- Electrical supply: 525V and ±65kW (Pilot wire system)
- Sufficient lighting required
- Mine required technical specifications on the drill rig from Tamrock
- Tamrock had to provide a service technician for the rig maintenance and one operator for the drill rig for a three month trial period.

Operation, ore removal and cleaning requirements

Drilling accuracy was well within the desired 0.5% specified, though drilling rate was slightly slower than anticipated. At an early stage drilling straight holes was shown to be the easy part of achieving the necessary hole accuracy. The difficulty was ensuring that the drill feed was pointed in the correct direction. An angle indicator was mounted on the drill feed that gave a vertical angle read out of 0.01% of slope; setting the horizontal was more complex and involved setting the drill feed relative to survey lines

Throw blasting of stoping ore into the strike loading drive was achieved with broken ore removed by LHD.

The final cleaning of the stope was done by means of water jetting from a remote position in the drilling drive after completion of the blasting process. This practice is consistent with our aim of creating a man-free stope.

Training requirements

Tamrock provided a three-week training period for all relevant engineering and mining personnel. The engineer on the mine had to identify artisans that could be trained as drill rig operators. Due to the complexity of the blasting process, detailed training had to be given to relevant personnel on the correct and safe blasting practices. This training was done by African Explosives Limited.

Project site

The site was situated in the old trackless area of Boschfontein Shaft of Anglo Platinum, Rustenburg Section. The project began in January 2000 and trial work was completed in July 2000. See Figure 4 for more detailed information on the project site.

Project achievement

Safety

During the 6-month project trial period there were no injuries recorded.

Production

	Plan	Actual
Face advance	2 m per blast	1.5 m per blast
Metres per shift	125 m	105 m
Square metres per shift	60 m^2	40 m^2
Hole deflection	75 mm/15 m	45 mm/15 m
Shaft head cost reduction	15%	10.9%
Stoping width	65 cm	45 cm (not optimum)
Holes blasted	7	7
Hole burden	0.5 m	0.45 m
Cleaning water jet	Yes	Achieved
Throwing blasting	Yes	Achieved

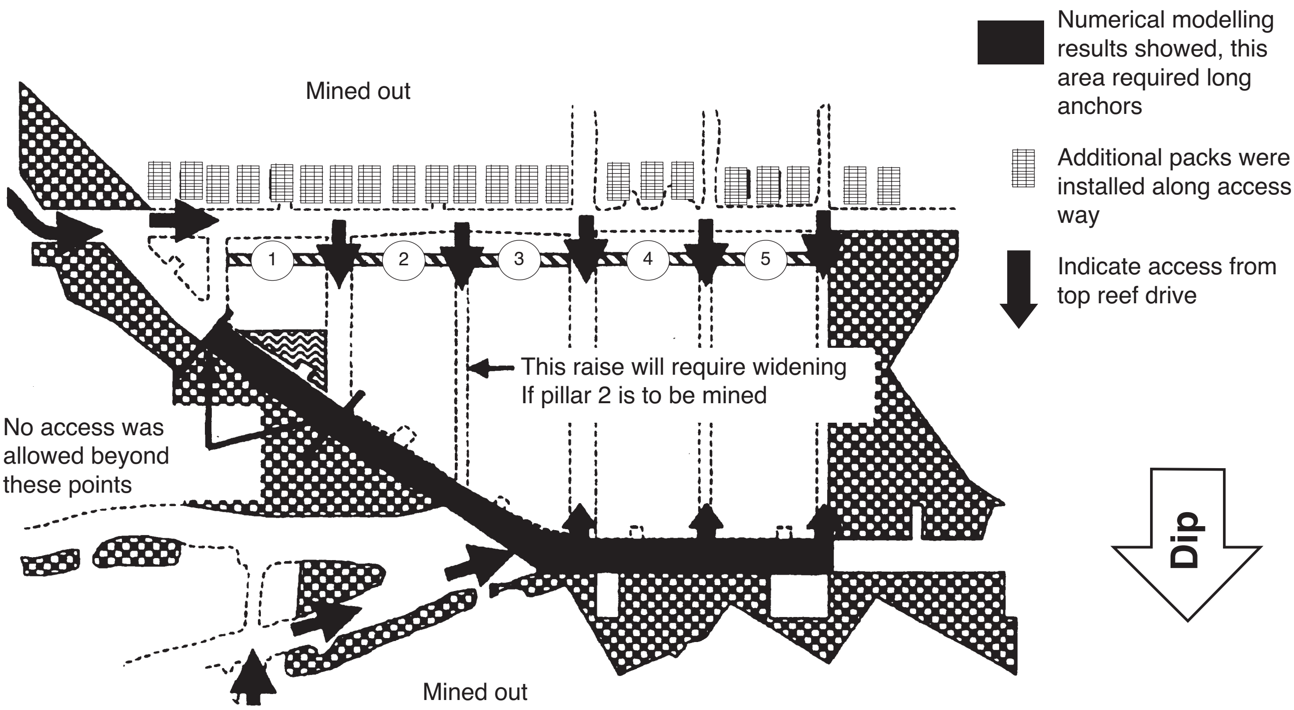

Figure 4—Project Site

Advantages of this mining method

It allows for a low safety and health risk as well as improved working environment. Physical work is reduced and it is easier to motivate the workforce. Another advantage is the improvement in grade due to better control of dilution, as only the channel width of the orebody is mined. This reduces ore transport costs and improves cost efficiency per ounce.

Disadvantages of this mining method

Due to the lack of support in the mined-out areas, careful production planning and rock engineering design is required. Where horizontal fractures exist in the immediate hangingwall, such as the triplets above the UG2 chromitite at Rustenburg Section, critical spans will need to be reduced—this will impact on development replacement rates and therefore also on cost per ounce.

A high-competency workforce with multi-skilled mining and engineering personnel is required. It is probably this issue that is the most challenging—ensuring the operators have the relevant skills is a training issue, ensuring all levels of mine management have the necessary understanding of the new mining process is a paradigm shift.

Conclusions

The results achieved exceeded our expectations. We have demonstrated that narrow, tabular orebodies can be mechanized and perhaps more important, that it is possible to create a man-free/support-free stoping environment. It has significant potential in terms of gaining both scale and learning curve efficience. We are currently establishing a fully integrated mechanized section to take advantage of the significant potential outlined in this document. ◆

Actual achievement January 2001 to July 2001

	Total
Total possible area (m^2)	4.317
Extraction @ 62% (m^2)	2.545
Grade (g/t)	7.00
Stoping width (cm)	99.8
Tons milled	22.182
Ounces	1.655
Revenue (R)	8.627.515
Contract payment	326.725
Stores	469.341
Purchasing long hole drill rig	280.000
Development payment	853.893
Total cost (R)	1.929,959
Shaft Head Cost:	
Direct cost per ton hoisted (R)	87.01
Direct cost per ounce (R)	1.166,14

Economic viability of the project

	Total
Total possible area (m^2)	25800
Extraction @ 62% (m^2)	16000
Grade (g/t)	7.63
Stoping width (cm)	65
Tons milled	32.240
Ounces	4.023
Revenue (R)	20.115.000
Contract payment	579.780
Stores	513.000
Purchasing long hole drill rig	2.400.000
Development payment	2.218.974
Total cost (R)	5.711.754
Shaft Head Cost:	
Direct cost per ton hoisted (R)	80.45
Direct cost per ounce (R)	995.79

Runge donates software to Tuks Mining Engineering Department*

The Department of Mining Engineering at the University of Pretoria (UP) received a donation of software worth US$105,000 from Runge, an Australia-based company.

Runge have through their South African agents, Mineral Resources Management (MRM) Mining Services, donated their full suite of mine-planning and mine business-planning software under full licence to the Department of Mining Engineering. Runge has been providing a service to the mining industry worldwide for over 23 years, and their product has proven itself in the mining industry.

These packages will particularly benefit both under- and postgraduate teaching in surface mining as well as mine design. This donation shows the continued interest that the mining industry has in the Department of Mining Engineering at the University of Pretoria in training world-class mining engineers.

The Department of Mining Engineering forms part of the School of Engineering at the University of Pretoria that offers graduate courses that are not only at the forefront of the various disciplines, but that also equip graduates to be leaders in their chosen professions. The key to the faculty's success is the high premium it places on innovation. This is embodied in our approach to training, training methods and research—but above all, in the wealth-creating attitude nurtured in our students. Therefore, it is no wonder that the faculty is the market leader and that the students who graduate here are known as the *innovation generation*! ◆

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