PLANNING FOR A TRACKLESS ACCESS STOPING OPERATION

IN NARROW REEF CONDITIONS

K A RHODES

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SYNOPSIS

The trackless access stoping operation for narrow reef conditions recently introduced at Cooke 2 Shaft, Randfontein Estates Gold Mining Company, Witwatersrand, Limited is discussed in the paper.

In the north-eastern portion of the Cooke 2 lease area the UEIA Reef is flat and lies immediately above the 95 Level elevation and these conditions were therefore considered to be highly favourable for the introduction of trackless equipment on the reef horizon utilizing the concept of the trackless access/gathering haulage system for narrow reef conditions.

The trackless access system will show a reduction in working costs for reason that footwall waste development is reduced significantly; the operation will be considerably more efficient in the use of labour (specifically non-specialist labour); can be expected to be a safer operation than a conventional operation.

Additional profits can therefore be expected to be generated due to the reduction in working costs; an increase in reef hoisting (reef hoisting replacing the waste tons which would be hoisted from a conventional operation).

It is realised that dilution could be a main area of concern for a trackless mining operation in narrow reef conditions. However, in the planning of the operation described in the paper considerable attention has been given to this matter and in terms of the proposed cycles for development and stoping operations, it is confidently predicted that dilution will be controlled and will not be excessive.
1. **INTRODUCTION**

During late 1984 a proposal to introduce trackless mining equipment to the reef horizon in narrow reef conditions at Cooke 2 Shaft, Randfontein Estates Gold Mining Company, Witwatersrand, Limited was motivated.

The main objectives of the proposal were to reduce markedly the footwall development which would be necessary for a conventional scattered mining operation; reduce labour complements generally and specifically with regard to ancillary operations; to provide for a safer operation.

The proposal was approved in early 1985 and the initial development for the trackless operation commenced immediately.

2. **GEOLOGY**

The area of UEIA Reef to be exploited lies in the north-eastern portion of Cooke 2 lease area between the so-called C 15 and C 17 dykes and extends from workings being currently mined above the 95 Level elevation to the mineral rights boundary to the East. The reef in this area is almost flat, dipping at less than 5° in the north-west and flattening to 0° in the middle of the block before climbing again in the south-east to form a very low profile basin. Although this basin is heavily faulted these faults have in general throws of only 1 metre to 3 metres; three major faults occur in the block. The channel width of the reef is of the order of 110 cms.

**Figure 1** shows a transverse section across the basin and **Figure 2** indicates the geographic location of the area.
3. METHOD OF MINING

3.1 Selection of Mining Method

Because the UEIA Reef in the area is flat (0-5°) and lies only 5 metres above the 95 Level elevation it was considered impractical to mine the area from 95 Level by conventional methods, and therefore the original planned development layout provided for a development programme on 101 Level with all orepasses in excess of 60 metres and certain development being carried out on 95 Level for top access; an alternative layout would be the introduction of an interlevel which would reduce the total orepass development but would necessitate the operation of an additional level. In both cases the waste development would be excessive. The development layouts for these alternatives are shown in Figure 3 (101 Level and 95 Level only); Figure 4 (101 Level with an interlevel).

The total (waste) metres to be developed, waste tons to be trammed for both alternatives are summarised as follows.

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<th>Metres</th>
<th>Waste Tons</th>
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<td>Alternative 1 (No interlevel)</td>
<td>18 000</td>
<td>304 000</td>
</tr>
<tr>
<td>Alternative 2 (With interlevel)</td>
<td>14 000</td>
<td>265 000</td>
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The costs of this development were estimated in January 1985 terms as R7,0 million for Alternative 1 and R5,6 million for Alternative 2.

It was axiomatic therefore that a trackless operation on the reef horizon which would obviate the necessity for either of the above development programmes must be a viable alternative; the proposed alternative method of mining will now be considered.
3.2 Proposed Trackless Operation: Concept

The geology of the reef (as previously detailed) in relation to the layout of the levels (close proximity of the reef horizon) were such that the introduction of the trackless access/gathering haulage concept should be considered as a practical and viable alternative method of mining.

It was planned that an access ramp from 95 Level would be developed onto the reef horizon and from such access all operations were to be carried out on the reef horizon with trackless equipment. Final tramming operations would take place on 101 Level where a streamlined gathering rail haulage was under construction.

Waste development would be at a minimum with an increase in reef hoisting capacity being realised, generating increased profits from the additional revenue (reef hoisting replacing waste hoisting).

4. MINE DESIGN

4.1 Production Parameters

The maximum production rate from the operation was planned at 50 000 tons per month on a double shift basis. If it is assumed that mineable reserve is of the order of 3.5 million tons the life of the operation can be expected to be six years. In terms of the production build-up the planned production rate of 50 000 tons per month would be achieved in late 1986.

4.2 General Mining Layout

Development on the reef horizon consists of access roadways which traverse the basin; the maximum distance between access roadways is 150 metres. From these roadways at 40 metre intervals, access stope drives (A.S.D's) are developed down dip of the strike (approximately -5°). Water accumulations are pumped out from the face of the A.S.D's.
The access roadways are developed 4.5 metres wide and 3.0 metres high; the dimensions of the A.S.D's are 3.5 metres wide and 3.0 metres high.

At intersections of access roadways and A.S.D's it will be essential to strip hanging wall in order to establish the necessary height for truck loading.

The general layout is shown in Figure 5 which details the access roadways; the detailed panel layout is shown in Figure 6.

There is no footwall development except for the extension of the 101 Level footwall haulage (shown in Figure 5).

4.3 **Rock Mechanics Recommendations**

The general support system (crush pillar and stick) employed at Randfontein Estates Gold Mine remains unchanged for this operation except for the addition of dip crush pillars to the strike crush pillars normally developed adjacent to the conventional A.S.G's.

Since the introduction of the crush pillar and stick system at Randfontein Estates Gold Mine very few panels have been lost due to the failure of the hanging wall; any such failures being due to geological features parallel to the line of strike pillars. Notwithstanding that these failures have caused minimum production losses such a failure over the access roadways of the proposed trackless system would be unacceptable as these roadways are the arterials of the system. Dip crush pillars have therefore been included to prevent major hanging wall failure over these roadways and these pillars can be expected to support faults, slips in any given orientation.

The immediate support installed in the access roadways and A.S.D's is cement grouted shepherd crooks; 1.8 metres long. However at the junction of the access roadway and A.S.D (where hanging wall stripping is to be carried out), the support will be 25 mm full column resin grouted rebar 2.7 metres long.

The support system described is depicted in Figure 7.
4.4 **Ventilation**

The total volume of air required to ventilate the area is calculated at 160 m³/sec., representing 45% of the total air available in the eastern ventilating district of Cooke 2; this quantity of air will provide for an output in excess of the 50,000 tons per month (planned output assuming double shift operation) with a possible re-entry period of two hours.

Initial design requirements include the installation of booster fans to ensure constant air volumes throughout the mining area.

Although coursing of the ventilation along the stope faces will be practised it will be necessary to introduce air jet fans to ventilate the face of the A.S.D's.

5. **CYCLE OF OPERATIONS**

In terms of the general layout the distance between access roadways is 150 metres and A.S.D's are developed in opposite directions from the access roadways; the maximum advance (theoretical) of any A.S.D is therefore 75 metres.

5.1 **Development on Reef**

All access roadways and A.S.D's will be drilled by twin boom electro-hydraulic drill rig. The cut will be drilled in the bottom section of the face (in waste) and blasted separately from the top section (reef); refer to dilution control aspects. All blasting operations will use Nonel L.P.D's (length of round will be 3.8 metres).

5.2 **Stope Drilling and Blasting**

Conventional face drilling techniques will be practised (pneumatic jack hammers). However experimentation has commenced with a hydraulic rig unit; the use of hydraulic machines for face drilling must be considered if the efficiency of this operation is to be improved.
Face blasting operations will be conventional using fuses, although trials are presently ongoing with Nonel accessories.

5.3 *Stope Face Cleaning*

The blasted rock on the stope face will be cleaned by face winch in the conventional manner; cleaning into the A.S.D. All reef from the A.S.D will be cleaned by L.H.D unit (3.8 m³) and trammed back to the access roadway intersection and loaded into the dump truck (24 ton capacity).

When L.H.D's load into trucks on the reef horizon in close proximity to the working face (and this is important if L.H.D traming distances are to be minimised) it becomes essential to introduce the E.O.D bucket (ejector bucket). Integral to the E.O.D bucket is a hydraulically operated hinged pusher plate which allows the L.H.D to load in the horizontal position. Therefore an E.O.D bucket on an L.H.D unit allows for the loading of a larger truck; a reduced roadway height for any given truck. Refer to Figure 8.

In a narrow reef operation these factors provide for obvious advantages; a large truck can be introduced to the arterial roadway (access roadways) provided that cognizance is taken of roadway dimensions for waste control.

Further advantages of the E.O.D bucket are as follows:

(a) The bucket ejects the load across the truck bowl and will therefore optimize the truck fill factor.

(b) The increased reach of the bucket (refer to Figure 8) means that the L.H.D does not load in close proximity to the truck and therefore truck damage can be obviated. Alternatively the loss of time when manoeuvring close to the truck in order to avoid damage can also be eliminated thereby improving cycle times.
6. DILUTION CONTROL ASPECTS

The operation of trackless equipment on the reef horizon in narrow reef conditions demands that consideration must be given to the dilution aspects of the operation.


In all roadways (access roadways and A.S.D's) it is planned to blast waste in a separate operation and tram the waste to a waste tip initially and, later, following the geographic expansion of the workings, to a worked-out A.S.D to be packed.

The use of an L.H.D. unit for tramming waste in a separate operation is considered to be a practical method of ensuring that waste can be kept out of the reef orepasses; in conventional operations this is not the case with scraper units operating in an A.S.G. When waste is packed underground by L.H.D units, control can be exercised over this operation because the waste packed in a worked-out drive can be seen and measured during and immediately following the operation.

In order to maximize waste packing in worked out drives, a bulldozer will work in association with the L.H.D. unit and ram the waste to hanging wall elevation.

Following cleaning out of the waste portion of the face the top section (reef) will be blasted and trammed as reef.

Notwithstanding the L.H.D's provide for selective loading and dumping of waste and reef in the underground workings it is vital that management introduces control procedures which must be adhered to if dilution control is to be achieved.
Figure 9 shows how the waste and reef are blasted separately in access stope drives and Figure 10 shows a profile of the L.H.D unit cleaning an access roadway (or A.S.D) with a stoping width of 120 cms. Theoretically it is possible to clean out the bottom section (waste) completely, but for planning purposes it has been assumed that only 60 % of the waste will be actually trammed as waste, with the remaining 40 % waste trammed as reef causing dilution.

Waste dilution during this reef development can therefore be calculated as follows:

**Access Roadway Development**

Distance between Access Roadways = 150 m

Access Roadway Width = 4,5 m

Access Roadway Height = 3,0 m

Stoping Width (assumed) = 1,2 m

Therefore:

Ore Reserve tons generated = 495 tons

for 1 metre Access Roadway advance

Development waste portion of

Access Roadway per metre advance = 22,3 tons

Waste trammed as reef. = 40 %

Therefore:

Dilution is;

\[
\frac{22,3 \times 40\%}{495} = 1,80 \%
\]
**A.S.D Development**

Panel length (centre to centre between A.S.D's) = 40 m

A.S.D Width = 3.5 m

A.S.D Height = 3.0 m

Stoping Width = 1.2 m

Therefore:

Face tons blasted per metre advanced by A.S.D = 132 tons

Waste portion of A.S.D advance = 17.3 tons

Waste trammed as reef = 40 %

Therefore:

**Dilution is:**

\[
\frac{17.3 \times 40 \%}{132} = 5.2 \%
\]

Total dilution is therefore:

\[
1.8 \% + 5.2 \% = 7.0 \%
\]
In addition to the above, it may be necessary to establish turning points and passing points for dump trucks and other vehicles if a one-way traffic system is not available in all cases. Further, tipping points must be established at the junctions of access roadways and A.S.D's. The total waste generated from these sources can be shown to be of the order of 1% (theoretically calculated in Figure 11 at 0.87%), if such waste is allowed to be trammed as reef.

It can be shown (theoretically) that all waste blasted on the reef horizon can be packed in worked-out drives provided that access to such drives is still available; calculations are as follows:

**A.S.D's**

Assume stoping width = 1.20m  
Waste portion is therefore = 1.80m  
Width of A.S.D = W m  
40% of waste portion is trammed as reef (assumed in previous calculations) and 60% of waste portion is therefore trammed as waste.  
Waste (volume) per metre is therefore = 60% x 1.80 x W  
= 1.08 W m³

**Access Roadways**

Ore Reserve generated by  
1 metre advance in access roadway = 495 tons  
Tons blasted per metre advance in A.S.D = 132 tons  
Therefore 1 m advance in A.S.D requires 0.27 metres advance in the access roadway (assuming access roadway development is totally pay).