ANNEXURE 7.9

Preliminary Report on Future Long Hole Stoping Operations at Boschfontein Shaft, Rustenburg Section, Rustenburg Platinum Mines

K.A.Rhodes: 02 August 2000
PRELIMINARY REPORT ON FUTURE LONGHOLE STOPING OPERATIONS AT BOSCHFONTEIN SHAFT, RUSTENBURG SECTION, RUSTENBURG PLATINUM MINES.

BACKGROUND
In late 1998/early 1999 longhole stoping trials were carried out on UG2 reef at Union Section. A Tamrock Solo H606 RA electro-hydraulic production drill rig drilled the long holes; this machine was leased to Union as part of a larger fleet of equipment being operated at the Declines. Notwithstanding certain successful aspects of these trials it was clear that the Solo rig, being primarily a machine for long hole ring drilling in large open stopes, was not the ideal equipment for narrow tabular orebodies for long hole stoping. At this time Tamrock were developing a low profile drill rig, the P-Low 1F for chrome mines in South Africa and it was believed that this basic model could be re-designed specifically for long hole stoping operations in narrow platinum reefs.

The re-designed rig, model P-Low LC10, commenced trials at Boschfontein, Rustenburg Section, early in 2000 in terms of a six month trial period during which time the machine was leased to Amplats in terms of a contractual agreement. The trial is now complete (end July 2000) and in terms of the contract a decision has now to be made by Amplats on whether to purchase the machine or not taking cognizance of the understanding that if the trial KPI’s (key performance indicators) were achieved then Amplats undertook to purchase the machine.

In general it would appear that expectations have been met specifically in terms of stoping width control; accuracy of drilling long holes; very good hangingwall and footwall conditions in the stoping area; no necessity for persons to enter the stopeed out workings. These parameters therefore allow mining operations to be carried out from grid development on the reef horizon which greatly enhances safety.

This report now sets out a motivation for the continued use of long hole stoping (LHS) at Boschfontein.

INTRODUCTION
LHS trials at Boschfontein have taken place on the Merensky reef horizon and have been restricted to the extraction of certain pillars which had been left after
TM3 mining. Only 16500m² remain in these pillars and operations can only continue for 6-8 months if LHS continues. It is then proposed to switch LHS mining to the UG2 reef horizon which has not been previously mined at Boschfontein. Notwithstanding the different geotechnical conditions of the two reef horizons it is proposed that (following discussions with Amplats R&D managers) the original Boschfontein layout on Merensky will be assumed for UG2 subject to further confirmation (or otherwise) by the Amplats Rock Engineering Consultant.

**LAYOUT**
The layout (same as for Merensky) for the UG2 planning is shown in Annexure 1. In this layout the major parameters are as follows.

- **Drilling Declines (DD’s)** advanced on true dip (10°) are 3,2m wide x 1,6m high set out at 34,2m centre to centre.
- **Holing Raises (HR’s)**, into which the long holes are drilled by the P-Low 10C rig, are 1,5m wide x 1,0m high and are conventionally developed. Considerations will be given to the mechanisation of this work. HR’s are situated between DD’s and are also 34,2m centre to centre.
- **Access Strike Drives (ASD’s)** are developed immediately above strike pillars (4 metres wide) and provide for 20 metres (skin to skin) of stope between the strike pillars and ASD’s. Dimensions of ASD’s are 3,2m wide x 1,6m high.

**GRID DEVELOPMENT**
In a stoping block of 600m² (15m x 20m x 2), refer to Annexure 1, grid development requirements can be calculated as follows.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD’s</td>
<td>34,7m</td>
<td></td>
</tr>
<tr>
<td>DD’s</td>
<td>24,0m</td>
<td></td>
</tr>
<tr>
<td>HR’s</td>
<td>24,0m</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>82,7m</strong></td>
<td></td>
</tr>
</tbody>
</table>

In terms of the above m²/m grid development is therefore 7,26.
TONS AND GRADE
In a 600m² block the following tons (without any overbreak) will be generated.

<table>
<thead>
<tr>
<th>Place</th>
<th>M²</th>
<th>Metres Advanced</th>
<th>Tons/m²</th>
<th>Tons/m</th>
<th>Tons Generated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stope</td>
<td>600</td>
<td></td>
<td>2,81</td>
<td></td>
<td>1687</td>
</tr>
<tr>
<td>ASD’s</td>
<td>34,7</td>
<td></td>
<td></td>
<td>17,36</td>
<td>602</td>
</tr>
<tr>
<td>DD’s</td>
<td>24,0</td>
<td></td>
<td></td>
<td>16,56</td>
<td>397</td>
</tr>
<tr>
<td>HR’s</td>
<td>24,0</td>
<td></td>
<td></td>
<td>5,29</td>
<td>127</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2813</td>
</tr>
</tbody>
</table>

Tons/m²(stope) = 4,60

Based on a channel grade of 5,60g/ton over 74cms and SG’s of 3,8 and 2,75 for UG2 chrome and pyroxenite respectively the following overall grade can be estimated.

<table>
<thead>
<tr>
<th>Place</th>
<th>Tons</th>
<th>Grade g/ton</th>
<th>Content grams</th>
<th>Overall grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stope</td>
<td>1687</td>
<td>5,60</td>
<td>9447</td>
<td></td>
</tr>
<tr>
<td>ASD’s</td>
<td>602</td>
<td>2,90</td>
<td>1746</td>
<td></td>
</tr>
<tr>
<td>DD’s</td>
<td>397</td>
<td>3,04</td>
<td>1207</td>
<td></td>
</tr>
<tr>
<td>HR’s</td>
<td>127</td>
<td>4,46</td>
<td>566</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2813</td>
<td></td>
<td>12966</td>
<td>4,61</td>
</tr>
</tbody>
</table>

Assumed grade is 4,6g/ton.

PRODUCTION
In order to determine the production tonnage from a single LHS rig it has been assumed that drilling performance will be 5000 metres/month (supported by previous trials). The drilling pattern is expected to be two rows of holes 100cm between holes in the same row and 50cms between rows; holes being drilled staggered. The drilling performance of 5000m/month will then provide for 2500m²/month/LHS rig. Tons/month are then calculated at 11721 [2500 ÷ 600 x 2813] say 11750 TPM to provide for grade estimate. In summary then one LHS rig will support 11750TPM at 4,6g/ton.
COSTS
Stoping and development costs have been estimated at R49.47/ton milled for total on reef operations. Refer to Annexure 2 for details.

OVERALL SHAFT HEAD COSTS
UG2 shaft head costs for LHS can be summarised as follows.

<table>
<thead>
<tr>
<th></th>
<th>R/Ton Milled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoping and Development</td>
<td>49.47</td>
</tr>
<tr>
<td>Tramming</td>
<td>8.72</td>
</tr>
<tr>
<td>Hoisting</td>
<td>5.31</td>
</tr>
<tr>
<td>Pumping</td>
<td>0.20</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>0.00</td>
</tr>
<tr>
<td>Support</td>
<td>0.00</td>
</tr>
<tr>
<td>Hostel</td>
<td>4.00</td>
</tr>
<tr>
<td>Power</td>
<td>9.20</td>
</tr>
<tr>
<td>CARA</td>
<td>3.69</td>
</tr>
<tr>
<td>Services</td>
<td>33.91</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114.50</strong></td>
</tr>
</tbody>
</table>

The LHS cost of R114.50 compares to conventional UG2 costs at Paardekraal of R119.03 or a reduction of the order of 3.8%.

CONCLUSIONS
This exercise shows that a reduction in costs at 3.8% is likely coupled with an improvement in grade of about +6%. The overall improvement in profitability is therefore of the order of 10%.

It should be stated further that the method is clearly safer than conventional stoping and also represents a definite step forward towards the overall goal of mechanised mining and therefore if any improvement in viability can be achieved it is considered worthwhile to pursue the concept.

It is therefore recommended that the present rig at Boschfontein be purchased and that further work is carried out both on the Merensky reef (the remaining reserves) and subsequently on the UG2 reef when a final more definitive report could be prepared.
SYNTHETIC ON REEF COSTS OF TRACKLESS LONG HOLE STOPING AT BOSCHFONTEIN

These synthetic costs have been prepared in terms of the following parameters.

**Layout**
As defined in Annexure 1 and same as Merensky.

**Fleet of Equipment**
P-Low 1F face rig
P-Low 10C longhole rig
Licence Mining low seam roofbolter
EJC 115 LHD

**Operational Labour**
- LHS Rig: 4
- Face Rig: 2
- Face Pump: 2
- LHD: 2
- R/Bolter: 2
- Face Preparation: 4
- Blasting: 4
- Team Leader: 2
- PTV: 1
- Water Jet: 2
- **Total:** 25

**Operating Shifts**
Standard 11 shift fortnight.

**Maintenance of TM3 Equipment**
OEM

**Supervision**
Up to panel supervisor only
**DIRECT COSTS: LONG HOLE STOPING AND ON REEF DEVELOPMENT**

<table>
<thead>
<tr>
<th>Item</th>
<th>R/Ton Milled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining Labour</td>
<td>12.76</td>
</tr>
<tr>
<td>OEM Maintenance</td>
<td>13.13</td>
</tr>
<tr>
<td>Replacement of Fleet Costs</td>
<td>7.24</td>
</tr>
<tr>
<td>Drill String</td>
<td>3.79</td>
</tr>
<tr>
<td>Blasting</td>
<td>3.65</td>
</tr>
<tr>
<td>HR Development</td>
<td>6.38</td>
</tr>
<tr>
<td>Support</td>
<td>1.26</td>
</tr>
<tr>
<td>Water Jetting</td>
<td>1.26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49.47</strong></td>
</tr>
</tbody>
</table>
VOLUME 4

ANNEXURE 7.10

Mechanisation Options for Bafokeng Rasimone Mines

K.A.Rhodes: 17 September 2000
DRAFT

MECHANISATION OPTIONS FOR BAFOKENG RASIMONE MINES

Background
Bafokeng Rasimone Platinum Mines (BRPM) has been developed as a narrow reef conventional mine employing a downdip stoping method with a planned stoping width of 0,90metres. If there is now a need to change to totally mechanised operations at BRPM there are certain options available to management and they can be set out as follows; such operations by definition will be carried out on the reef horizon and will necessitate an increase in reef mining width to accommodate the mining equipment and therefore the head grade may be lower.

Mechanised Options
An acceptance of an increased mining (stope) width and a totally on reef mining operation (possibly with a footwall gathering haulage system) the available options for mechanisation would be room and pillar (or bord and pillar); long hole stoping (reef) mining; long hole resue mining. In all cases the planned on reef mining width would be of the order of 1,70 metres.

- Room and Pillar/Bord and Pillar
  This method of mining is proven and common in South African mines specifically chrome mines and has also been introduced at Kroondal Platinum and Bleskop (Rustenburg Section) and is planned for both Stylidrift and Waterval. All the above mines and/or projects relate to the exploitation of chrome reefs (LG6/6A and UG2) except for Stylidrift. At the chrome operations some separation of reef and waste can be carried out underground because of the visible difference between reef and waste. At Stylidrift the proposed mining will take place in the transition zone where a greater mineralised width occurs enabling mining operations to be planned for 2,00 metres. However at BRPM mining operations are taking place in the Rustenburg series where values occur in a narrow channel close to the top reef contact (TRC) of the Merensky reef. Any such mechanised pillar mining method will therefore cause a significant drop in head grade.

- Long Hole Stoping (LHS)
  This method of mining has recently been on trial at both Union Section (UG2) and at Boschfontein (Rustenburg Section). Specifically at Boschfontein, on the Merensky reef where certain pillars have been extracted, it has been proven that long holes (up to 15 metres) have been drilled of sufficient accuracy to enable narrower reef channels to
be mined than with conventional stoping. LHS is therefore an option for BRPM.

- **Resue Long Hole Stoping (RLHS)**
  In this system it is proposed to utilize long hole drilling techniques in a resue method of mining: instead of drilling holes in the reef channel (as at Boschfontein) long holes would be drilled in the bottom section of face below the reef and this waste portion would be blasted away from the advancing face thus allowing the top section of the face (reef) to be blasted down in a separate operation and loaded out as reef. The method therefore provides the working height for machines to operate on the reef horizon but leaves waste underground. It is less dependent on long hole drilling accuracy and such drilling takes place in waste with a simple operation for reef recovery; grade control therefore will be improved over the standard LHS method.

**Concluding Comments**
Notwithstanding that all the three methods defined above are perceived to be practical, the viability of each would have to be tested by means of a detailed feasibility comparison; nevertheless the following comments are believed to be relevant.

- In terms of a room and pillar method on Merensky with only a narrow mineralised channel, the opening up of the stoping width to accommodate (low profile) mechanical equipment cannot be perceived to be viable due to the fall in head grade because there would be almost no value in the bottom section of the face. The only means of improving grade with this method would be to apply resue mining where all blasts in rooms/bords would be subject to a double cut operation; in this way the top section would be blasted and loaded out as reef and the waste left underground. Nevertheless this would still cause heavy dilution as it would only be practical to partially clean out the waste in the bottom cut.

- The trials with the LHS method at Boschfontein have proved the accuracy of drilling long holes (up to at least 15 metres) with the new modified P-Low drill rig. Notwithstanding this success the final cleaning of the (planned for) unsupported face still has practical problems which must still be addressed. Further there is a risk that grade will be affected if reef is left in the hanging wall after the long hole blast. It is for these reasons that a method, whereby long holes are drilled in the bottom (waste) section of the face, is proposed thereby providing the opportunity to recover the top (reef) section of the face in a simple operation; this method being resue long hole stoping (RLHS).
• The RLHS system is a new proposal and there has been no previous feasibility exercise to assess its viability. The basic concept of this method can be outlined as follows.

- Grid development would be carried out on true dip providing that it does not exceed 10°. Declines to accommodate the long hole production rig would be developed at say 27 metre intervals; 20 metres of face, (say) 4 metre wide pillars and 3 metre wide decline. A slot or sill drive would be driven between the declines; see Figure 1.

- The bottom section of the face would be drilled from the decline by means of long holes drilled on strike up to the dip pillar. Operations would proceed up dip and the waste would be blasted away from the advancing face. See Figure 2.

- The upper section (reef) of the face would be drilled in an up dip direction with a face rig operating on strike. See Figure 3.

- After blasting down the reef loading would take place by LHD probably to a conveyor.

- The exposed hanging wall would be bolted before the next part of the cycle (face drilling) would be allowed to commence.

**Recommendations**

The following recommendations can be made related to any proposed mechanisation of mining operations at BRPM.

• Carry out a pre-feasibility exercise for mechanised on reef mining. This exercise will compare the new proposal of up dip rescue long hole stoping (RLHS) with open long hole stoping (LHS) and room and pillar mining (or bord and pillar).

• On the assumption that the pre-feasibility exercise can demonstrate the viability of a mechanised option for BRPM a layout for a trial can be drawn up which could form part of a new 5 year plan for the total mine.

• Following completion of the above compile a new 5 year plan for BRPM.
Notes:
- Holings between stopes through pillars can be effected as required.
- Pillar dimensions and spans are provisional pending rock engineering requirements.
- AD's are say 3m (wide) x 2,0m (high).
- Sill drive dimensions to be determined.
FIGURE 2

WASTE RESUE

Direction of Mining ➔

Dip ←

AD

WASTE FILL

Long holes drilled in bottom section of the face

AD

Plan

REEF

WASTE

Section
FIGURE 3
REEF RECOVERY

Direction of Mining

Waste fill

Updip holes drilled in reef

Plan

REEF

WASTE

0.8 m

1.2 m

Passage for mechanised equipment

Section