Implementation of extra low profile (XLP) mechanized equipment in Anglo Platinum

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Synopsis

The introduction of extra low profile (XLP) mechanized equipment within Anglo Platinum is aligned with the overall New Mining Technologies strategy to focus on continuing modernization of our mining operations` incorporating injury-free production and cost-effective mining technologies.

The method allows for the introduction of a suite of ultra-low profile equipment in narrow reef (1.2 m) stoping operations. For the first time it is now possible to achieve total trackless mechanization at these widths and indications are that XLP mining has the potential to add more value when benchmarked with conventional mining and low profile (1.8 m) room and pillar methods.

Various mine layouts were tested at different sites within Anglo Platinum and the XLP breast mining layout proved to be the most effective. This paper describes the results of the trials at Waterval Shaft and concludes with recommendations on our future strategy on implementation of XLP technology within Anglo Platinum.

XLP room and pillar mining

Background of trials in Anglo Platinum

Bafokeng Rasimone Mine

The XLP equipment suite operating in a room and pillar mining method was first introduced at BRPM South 'D' Decline on the Merensky reef in July 2003. A year later the XLP suite was removed after the mine decided that the effort required and high maintenance costs involved, relative to the continuation of the XLP project, were not worthwhile. Best results achieved with the one XLP suite were 1 007 m²/month in October 2003 (average 747 m²/month).

Waterval Shaft—initial trials

An XLP room and pillar method was introduced at Waterval Central Shaft on the UG2 reef in December 2003. Following achievement of target performance of 2 200 m² with one XLP suite in August 2004 (average 1 420 m²/month); it was decided in December 2004 to prepare two further sections for XLP room and pillar mining at Waterval Central Shaft.

Waterval Shaft—full-scale trials (two XLP sections)

Two separate areas were prepared to fully test the room and pillar method. The decision was based upon the fact that the greater Waterval Shaft was using the same method, and as such there would be minimum change management required.

- *Project scope*—Waterval mine agreement with the OEM was to operate, maintain and manage the XLP project on a rate per ton basis, with the mine retaining ownership and legal responsibility for the project. OEM mining with XLP equipment commenced in May 2005 for a 12-month trial period. Build-up to a steady state production was planned as from September 2005. OEM was responsible for delivering production to the strike belt feeder points. The mine was responsible for hoisting the ore from the XLP sections. The mine was to pay a fixed XLP mining cost to the OEM
- *Mining layout*—the room and pillar layout consisted of 10 m rooms (10 off) with 5 m x 5 m pillars and 10 m ventilation splits. Each section had a strike belt of 1.8 m height for ore handling with the belt distance planned not to exceed 80 m from the advancing face.
- *Planning*—in order to achieve the project target per XLP suite, it was planned to blast 2.2 x 10 m rooms per shift at 1.5 m face advance per blast
- *Project results*—The trial was not successful and was subsequently discontinued in October 2005. Best results achieved in October 2005 with the mine

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 SA ISSN 0038–223X/3.00 + 0.00. This paper was first published at the SAIMM Conference, Rise of the Machines, 14–16 March 2006.

operating a single XLP suite were 1 600 m² and average results achieved for the period May to October 2005 were 800 m²/month.

Learning points

The main objective behind these learning points is that the Anglo Platinum Group will use the best practices and shortcomings identified during this project to ensure that future projects benefit from this experience, with the aim to contribute to successful implementation of new XLP technologies.

- Planning and logistics:
  - Daily supervision and discipline are required to ensure that the cycle of mining is followed and the face shape sequence remains in line. Frequent movement of the XLP drill rig and bolter, with their dependency on electric trailing cables, leads to low equipment utilization when the face shapes are out of line. Sub-standard ventilation as a result of out of sequence face shapes also contributed towards XLP loader breakdowns
  - Method is heavily dependent on the strike belt being kept close to face and face shape sequence being kept in line to avoid excessive tramming distances. Strike belts, which are in excess of 75 m from the face, result in excessive tramming distances, contributing to breakdowns and poor availabilities of the loaders. Planning for XLP belt moves should be included in the mine overall schedule for belt moves
  - Access and in-stope movement requires careful consideration. Dip distances become excessive for machine and personnel travel. The room and pillar layout does not allow for sufficient vehicle and men access points to the workface and does not allow for sufficient space to service XLP vehicles that breakdown at the workface. Supervision is compromised due to the difficulty of travelling in restricted heights for long distances (up to 150 m).
- Production
  - Production limitation per XLP suite without secondary low profile (LP) LHD assistance for XLP loaders due to their production capacity constraints
  - Require sufficient face available to allow a proper drilling, cleaning and bolting cycle activity
  - With no free-face breaking point, best face advance per blast rate achieved was 1.4 m (87%), resulting in production losses.
  - The mine should be responsible for the mining and management, the OEM should do only the XLP equipment maintenance on a contract (rate/hour) basis.
- XLP equipment
  - With the short (10 m) panels and long tramming distances in the room and pillar method, the XLP loader proved to be ineffective with its small payload (2.5 tons needed at least five passes to load) and lack of hauling capability. An option is for the XLP loaders to dump their loads at the closest LP access point/split and LP loaders can then load and tip this ore (double-handling). However, an LP suite of equipment will have to be added to the XLP suite, which in turn will render the room and pillar method too costly
  - The XLP drill rig is not suitable for developing the strike drives of 1.8 m minimum height, and for sliping of the footwall and feeder tipping points. Maximum operating height of the XLP drill rig is 1.6 m and therefore LP or conventional drilling equipment had to be used for this purpose.
- Human resources
  - Shortage of skills was a major contributor to lack of operational performance. Forward planning for XLP skills recruitment and training must be done well in advance of project start-up. Carry 10% over complement labour to cater for shortage, especially when contract labour is being used
  - A simple and achievable bonus system should be introduced from the project start
  - Learning curve for such a new technology is a real issue, both for operators and supervisory personnel. On-the-job instruction and mentoring of individuals is required in order to achieve continuous improvement in project performance
  - A well-motivated team that has a passion to achieve the project targets is a prerequisite for such a new technology initiative.

Successes

- The XLP drill rig and roofbolter achieved the expected operational performance. Individual equipment key performance indicators (KPIs) of 30 holes per hour for the drill rig and 6 bolts per hour for the XLP Bolter were exceeded in the latter part of the trial
- Target stoping height (1.27 m) and head grade (4.04 g/t) was consistently achieved.

XLP room and pillar trial conclusion

The XLP project team found that the room and pillar mining method was inherently difficult to implement in an XLP environment of 1.2 m mining height using current equipment. It was concluded after a detailed evaluation and close-out report, that this mining method should not be pursued any further in Anglo Platinum. It became clear to the project team that the preferred mining method for the XLP technology application is the Breast mining layout, which requires less effort and expertise to apply, yet inherently leads to improved production rates and lower operating costs.

The Waterval room and pillar trial was consequently discontinued in October 2005 and preparations for the XLP Breast mining trial began at Waterval in November 2005.

Waterval XLP breast mining trial

Motivation to change to XLP breast layout

To optimize the face availability and mining cycle in the XLP section, a 5 x 21 m Breast mining layout was adopted instead of the 10 x 10 m room and pillar layout.

The XLP Breast mining layout is preferred for the following reasons:

- Increased face advance rates (up to 1.9 m) due to free (ASD) breaking point
- Stope cleaning is more efficient, 40% throw blasting into advanced strike drives (ASDs) where broken ore is loaded by a large capacity (5 ton) low profile LHD
- Dozer cleaning of remaining stope broken ore is efficient and fast (<2 hours)
- Longer stope panels (21 m) lead to improved equipment utilization and less inter-panel movement
- Comfortable access for men and material via 2 m high ASDs to each panel
- Method is safer as there is less risk of large hangingwall collapse.

Project scope

The mine is responsible for the mining operation and management of the XLP project—to deliver the planned production to the strike belt feeder points at the desired tramming width, head grade and shaft head cost. OEM is responsible for maintaining their XLP equipment on a contract (rate/hour) basis.

The XLP Breast mining trial will continue for a 12-month period from November 2005 to November 2006, after which the project will be re-evaluated and a decision made on the way forward.

Key project objectives

- *Headline objective*—Determine potential performance and operating costs of a mechanized Breast XLP mining system as a guide for future roll-out potential in the Group.
- *Technical objectives*—Deliver sustained high levels of injury-free operational performance at acceptable operating costs when benchmarked against conventional mining performance in Anglo Platinum.

XLP breast mining method—basic mining equation

- *Stoping and development planning*—Establish a typical conventional Breast layout comprising 5 x 21 m breast panels at 1.2 m mining height, each led by an ASD of 4 m wide by 2 m high.
- Base case planning is 2 000 m^2 stoping + 400 m^2 ASDs = 2 400 m^2. Require to blast—1 x 21 m panel per shift x 3 shifts/day = 63 m/day x 18/23 days x 1.77 m advance/blast at a panel advance of 19m/month.
- *Layout requirements*—Maintain ASDs 8 m ahead of the stope faces. Dip raises every 70 m along the full back length (to cater for efficient logistics, namely: access for men, material and ore handling/removal)
  Blast in-stope development to service Breast layout as follows:

ASD:	95 m/month (19 m advance/ASD/month)
Dip raise/winze:	60 m/month (total)

- Drilling and blasting—ASD is carried 2° above strike and stope face is carried on true dip. Use of shock tubes and mechanized drilling at 90° allows throw blasting of at least 40% of ore into ASD. Drill holes are 1.94 m length at a planned face advance/blast rate of 1.77 m. Blasting takes place on day shift and night shift only with a 40 minute re-entry period.
- *Cleaning*—Stope face cleaning is done by XLP dozer where the remaining broken ore (after 40% throw blasting) is pushed into the ASD by the dozer from where it is collected and tipped onto the strike conveyor belt by the LP LHD. Access of the LHD to the strike conveyor is through dip tramming raises spaced 70 m apart on strike. Strike conveyor belt maintained at a maximum of 80 m from the face. Stope sweepings are carried out by the dozer, which is able to clean on dip between the permanent rows of support.
- *Logistics*—Top access to the XLP section is provided for men and material. Access is also available from each ASD and dip raises provided every 70 m on strike. Panel to panel movement of XLP equipment is by travelling up-dip from the stope face (4–6 m face support spacing gap) and out at the top of panel (4 m gap along strike) through the nearest pillar holing into ASD to the nearest dip raise, and entry into new ASD and stope face through down-dip strike pillar holing. The overall face shape must be in line and the cycle of mining strictly adhered to avoid excessive travelling distances of XLP equipment from panel to panel. Planned rate of production requires only one panel to be blasted per shift, therefore only need for XLP drill rig and roofbolter to travel to one panel per shift, preferably to the adjacent panel. Allowance has been made for travelling time from panel to panel for all trackless mining equipment—furthest point of travel is 150 m round travel with a minimum of 20 m, i.e. average 85 m.

XLP breast equipment suite

XLP MKII drill rig	- 1	Stope face drilling
XLP MKII bolter	- 1	Stope face bolting
XLP dozer	- 1	Stope face cleaning
LP axess dev rig/bolter	- 1	Drilling and bolting of all stope development
LP loader	- 2	Loading of all stoping and development
LP utility vehicle	- 1	Loading and transport of all material
LP Jeep	- 1	Men and small material transport
Total XLP section	8	Pieces of equipment

- *Support design*—The leader seam, situated 1.6 m above the UG2 main seam is the predominant parting plane, which must be supported as it also exceeds the 95% fallout thickness criteria. For this purpose the 1.6 m height was incorporated into the support design.

The support consists of three phases of support:

- Bolts are 1.6 m resin coupling bolts at 1.2 m x 1.5 m bolt spacing on strike and dip, respectively, installed within 0.5 m of the face before the blast. This is to ensure the unsupported area after the blast is limited to a maximum of 2.5 m.
  In-stope bolts act as the temporary support to reinforce the hangingwall beam up to the first line of mine poles.
- Mine poles with prestressed jackpots are installed on a 2 m x 2 m square pattern not more than 4 m from the face before the blast and 6 m after the blast. This allows for a wide enough span for the XLP machines to operate in and thereby limits the extent of blast damage on the poles.

Mine poles are installed as the primary support to support either 95% of the fallout thickness or up to the known parting plane, depending on which of the before-mentioned has the greater influence.

- A line of 3 pole cluster packs ise installed every 10 m apart on strike and no more than 20 m behind the face. A line of cluster packs is also installed along the gully and along the top of the panel. Strike pillars, which are left at the up-dip side of the panel, are 9 m x 5 m with pillar holings of 9 m.
  The 3-pole cluster packs serve to bridge the increased unsupported span over the travelling ways along which people and machinery travel, and provide a breaker line of support should a large fall or back break occur.
- *Ventilation*—A minimum volume of 20 m^3/s is required; velocity of 1m/s must be maintained on the stope face to ensure all diesel fumes and diesel particulate matter (DPMs) are effectively removed. Strike ventilation curtain must be maintained at 12 m from the face and pillar holings must be sealed off, leaving only the last one open. Pillar holings not to exceed 18 m from face (9 m pillar and 9 m advance past pillar).

Current XLP breast progress

The change from XLP room and pillar to XLP Breast mining at Waterval Shaft is yielding the desired results. A full suite of XLP equipment (drill rig, roofbolter and dozer) is now proven and performing to expectations. Ramp-up production targets are being achieved and full stoping production is expected to be achieved by March 2006.

Conclusion

It is expected that the XLP Breast mining method under direct control of the mine will produce significantly improved production at acceptable shaft head unit costs.

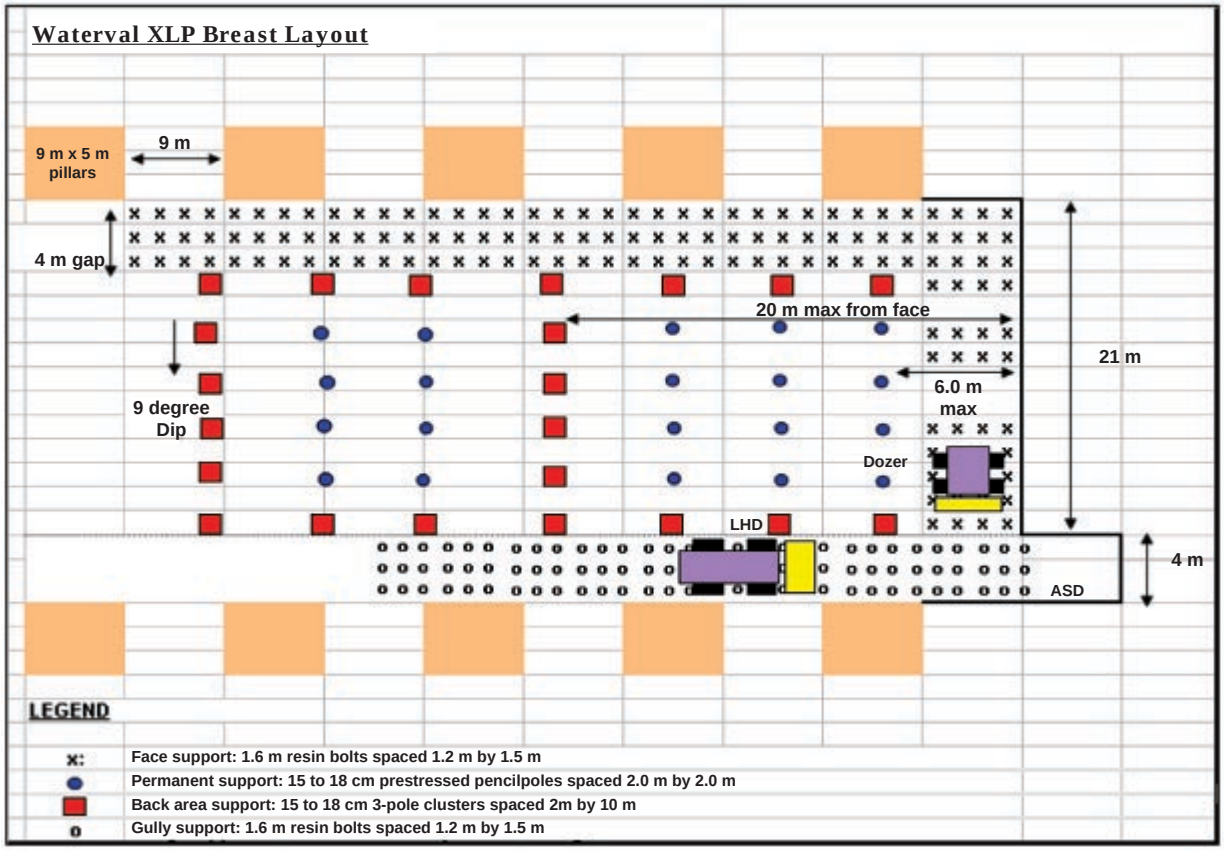
On a like-for-like basis, assuming that we can achieve the plannedXLP numbers, (R/ton shaft head cost and production rate), XLP is more viable than LP, i.e. higher IRR and NPV essentially as a result of higher XLP shaft head grade.

Way forward for XLP in Anglo Platinum

Should the XLP Breast mining project prove successful in terms of the planned safety, productivity and cost benefits, consider roll-out of the XLP Breast mining once the necessary documentation and approvals have been obtained.

Acknowledgements

The author wishes to thank the management of Anglo Platinum for permission to publish this paper and all the persons who assisted in its preparation.



Annexures

A. Basic mining equation—XLP breast mining method

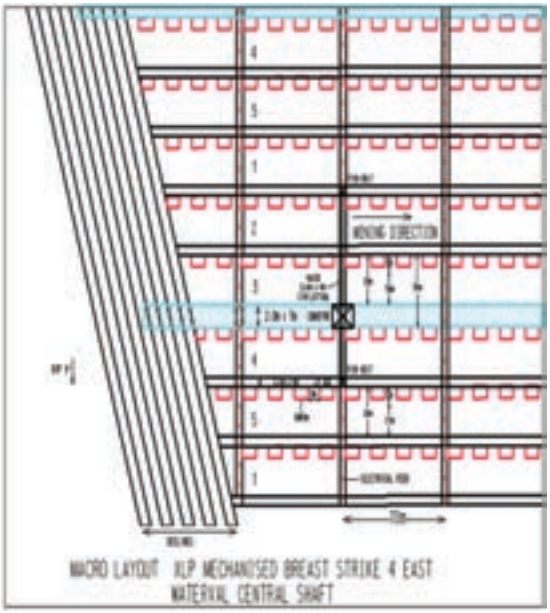
B. Benchmarking

XLP Trial Results per equipment suite per month			
Operation	**Best results**	**Ave results**	**Target**
BRPM (South D) 16 m Rooms R&P Mining (Merensky)	1007 m² (Oct 03)	747 m² (2003)	1200m²
Waterval 10 m Rooms R&P Mining (UG2)	2211m² (Aug 04)	800m² (2005)	2200m²
Townlands 21 m Panels Breast Mining (UG2)	908m² (July 05)	860m² (2005)	1100m² Single shift

C. HR complement

Labour requirements per XLP suite— breast layout	
Maintenance labour breakdown	
Maintenance supervisors	1
Diesel mechanics	8
Auto—electricians	1
Boilermaker	1
Store clerk	1
Data clerk	1
Total maintenance	13
Mining labour breakdown	
Mine overseer	1
Shift supervisor	3
Miners	3
XLP drill rig operators	6
Dev drill rig/bolter operators	6
XLP bolter operators	6
Dozer operators	3
LP LHD operators	6
UV operators	3
Charge up	6
Timber	6
Belt attendants	6
Total mining	55
Total labour	**68**

D. Waterval XLP breast



E. Development of XLP mining equipment

Current status

- *Sandvik mining and construction* (SMC)—MK2 XLP drill rig and roofbolter have been in operation since December 2005 at Waterval Shaft and both these units are performing well. SMC have added a XLP 'Shark' dozer to their current suite and a unit has been tested extensively on a platinum mine since mid-2005.
  SMC XLP suite at Waterval Shaft in a Breast layout
- *RHAM*—MKII XLP crawler mounted XLP suite tested at Townlands Shaft since January 2005. Equipment will be modified and undergo further trials at Townlands Shaft during 2006.
  RHAM XLP suite at Townlands Shaft in a Breast layout
- *DOK-ING*—MKII crawler mounted dozers have been on trial at Townlands and Waterval shafts since January 2006 and are performing well.
  DOK-ING XLP dozer at Townlands in a hybrid Breast layout
- *BOART*—Prototype dozer was tested at Amandelbult 43 East Decline at a semi-steep dip of 18°. Dozer to undergo modifications as per mine user requirements.
  BOART XLP Dozer at Amandelbult 43East in a hybrid Breast layout at 18° dip. ◆

Annexure

Doking MKII dozer at Townlands and Waterval

SMC MKII drill rig and roofbolter at Waterval

RHAM MKII dozer and drill rig at Townlands

Annexure

Waterval XLP breast mining trial—equipment performance (February to June 2006)

	Plan	Actual February–June 2006
XLP drill rig—holes drilled/shift/rig (rated—40 holes/h) (1.5 min/hole; 1.3 m/min)	126 holes/face/shift (21 m face/3.2h)	72 holes/face/shift
XLP roofbolter—1.6 m bolts/shift/bolter (rated—6 bolts/h)	25 bolts/face/shift (21 m face/4.1h)	18 bolts/face/shift
XLP dozer—tons cleaned/shift (rated—31 tons/h) 180 tons/face blasted—40% throw blasting = 72 tons = 108 tons/face/shift	31 tons/h (108 tons/3.5h)	(108 tons/2.4 h) 45 tons/h
LP LHD—tons loaded/shift/LHD (rated—43 tons/h) 80 tons/shift blasted + 65 tons 1 dev/shift blasted = 245 tons/shift / 2off LHD's = 123 tons/shift/LHD	43 tons/h/LHD (123 tons/2.9h)	26 tons/h/LHD (123 tons/4.7h)
LP Axess Dev Drill Rig drilling—rated 24 holes/h (ASD) (Raise) Total 2.87 m/development/shift drilling Bolting—rated 10 bolts per hour (ASD) (Raise) Total 11bolts/shift bolting Total drilling and bolting	39 holes/shift–1.60h 34 holes/shift–1.48 h ASD/Rse–3.08 h 6 bolts/shift–0.72 h 5 bolts/shift–0.65 h aASD/Raise–1.37 h 4.45 h	39 holes/shift 34 holes/shift 2.8 h drilling 6 bolts/shift 5 bolts/shift 1.2 h bolting 4.00 h

XLP = extra low profile stoping equipment
LP = low profile development equipment