C-Cut Project
Cullinan Diamond Mine
SAIMM Presentation

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Mining Executive
20 July 2017

Photo: Underground at Cullinan: Silo no.2 C-cut project
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Presentation Outline

- Short history timeline & intent
- C-Cut Overview
  - C-Cut scope
  - Geology and Geotechnical
  - RAW & Ground handling Infrastructure
  - Shafts
  - Undercutting and Block Cave establishment
- Milestones, performance and scorecard
- Project challenges
- Contract management lessons learnt

138.57 ct Cullinan white, sold for US$6.5 million FY 2017

121.26 ct Cullinan white sold for $6 million in June 2016
Short History & Timeline

- 1902 Premier Mine Registered
- 1903 Mining Commence – basic open pit mining methods
- **1905 Cullinan Diamond (3106 carats – about 9mbs)**
- 1917 De Beers acquire controlling interest in Premier Mine
- 1932 Mine close during Great Depression,
- 1945 Dewatering of open pit commence
- **1947-1980s UG mining (variations of open benching)**
- 1970 Conventional Block Caving using scrapers
- 1980s UG variations of open stoping
- 1990s Mechanised Block Caving (Post-UC)
- 2001 BCs change to Advance UC
- 2003 Centenary : name change to Cullinan Diamond Mine
- **2007/8 Petra Diamonds purchase CDM**
- **C-Cut declines commence Jan 2010**
- **Undercutting commence in June 2015**
- **C-Cut Steady-state FY 2019**
C-Cut Intent

Project Scope
The project scope & intent is to extend the LOM of Cullinan Diamond Mine beyond 2030. The C-Cut Phase project entails the development, construction and commissioning of a 5,7 hectare Block Cave with a block height of 200m. This entails:

- ca 34,669m of development,
- Deepening Rock hoisting shaft,
- Deepening of Man & Material shaft
- New ground handling system
- Appropriate ventilation system.
**Objective of C-Cut project:**
- Access and exploit deeper undiluted (fresh) kimberlite ore at higher production rate
- Simplify ground handling and access to lower OPEX

**CDM 2008 hand-over:**
- Highly diluted / low grade ore from mostly depleted BCs (LOM to 2014)
- Ground handling system from 805mbs to 500mbs TOS and 541mbs Loading Level
C-Cut Overview
Petra Diamonds Limited: CDM C-Cut Project update - July 2017
CDM current production sections

View Nth – BP 2018

645L - Retreats
717L - Retreats
732L - Retreats
747L - Retreats
UC-824L
Prod - 839L
NTH Crusher
GH & RAW - 895L

Petra Diamonds Limited: CDM C-Cut Project update - July 2017
C-Cut view

C-CUT PHASE 1

was 89% complete as at 31 May 2017
C-Cut geology

Grade distribution across the footprint in cpht

- Waterberg Quartzites
- Ferrile
- Gabbrro S/T
- Norite
- Transvaal Supergroup and Metasediments
- Grey Kimb.
- Brown Kimb.
- BAV
- BAW
- AUC
- BB1E
- CCUT P1
- CCUT P2

- Black HK
- Piebald HK
- Grey TKB
- Brown TKB

32H
40Ha
22Ha
12Ha

Grade range: 12E - 23E

Internal waste: >30%
Geotechnical
Geotechnical environment

HR 20-25m for MRMR 35
Geotechnical Salient features

Modelling Inputs

• All drilling is dry within kimberlite orebody
• Low MRMR in especially contact waste/grey kimberlite and internal contacts < 35
• UC sequence from weak to strong and then finishing in weak area

Outcomes / Recommendations

• Drawpoint spacings adjusted to ensure stability (from 16m to 18m with some at 21m)
• Adapted sequence is globally stable but local conditions should be monitored continuously and design and schedule adapted

Secondary Tunnel Support

• Contact Arch Sets and Stiff Brow across footprint thus a about 50% increase on secondary support
• Support area on contacts shear zone was increased due to poor ground conditions
• On Undercut, major apex pillar, additional anchors installed
• Additional secondary support required more wetcrete an hence upgrade of batching facilities
Geotechnical Modelling (Rockmass behaviour)

Source: D. Beck
Geotechnical Modelling (cont.)

[Diagram of a geotechnical model with labels and annotations]

Source: D. Beck
• Tunnel Sizes and Spacing confirmed and adjusted where required
• Drawpoint spacing increased from 16 to 18m to 21m in NE corner
• Sequence globally stable: however, local ground conditions to be reinterpreted continuously and design & sequence adapted accordingly
Geotechnical Modelling (interaction with upper cave)

Dec 2016 – Limited potential of contact shearing and column chimneying

April 2017 – Contact movement and possible chimneying

Nov 2017

Jan 2018
Development – UC and Extraction Levels

824mL

Tip 1
Tip 2
Tip 3
Tip 4
Tip 5
Slot Tunnel 1
Slot Tunnel 2
Blindbore Holes
for UC Slots

839mL

North

Crusher 1 Tip
Crusher 2 Tip
Crusher 3 Tip
Crusher 4 Tip
North Rim
North Ramp

South

Development ahead of UC Face
Undercutting Slotting Sequence
C-CUT UC and Extraction Level Sequence (Oct 2016)
C-CUT UC and Extraction Level Sequence (Jan 2017)
C-CUT UC and Extraction Level Sequence (Apr 2017)
C-CUT UC and Extraction Level Sequence (July 2019)
C-CUT Kimberlite Tunnel Support

UC tunnel support in kimberlite – Sealant, Bolts, Mesh and 100mm Wetcrete

Kimberlite/waste contact steel set support
C-Cut Ground support

Drawpoint ground support – Stiff-brow, concrete fill, FW concrete, anchors wetcrete etc.

Kimberlite/waste contact steel set support
Groundhandling and Other UG infrastructure
Crusher North 1 (NC1) & production Tip 1 July 2017
Conveyor NPC2 and bulk heads 1 & 2 June 2017
Production Tip 2 North June 2017
Dam – Dewatering System 2018/19
Crusher South 2 (SC2) & production Tip 2 South
Ground Handling and RAW Level (895mL)
Ground Handling

Production double Tip 1 (South - 100-120ktpm at the moment)

Production loading from Drawpoint

Jaw Crusher 1

Conveyor planning – feeder below crusher on main conveyor
C-Cut Milestones and Performance
# C-Cut milestones

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<td>H2</td>
<td>H1</td>
<td>H2</td>
<td>H1</td>
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<tr>
<td>Development of Declines &amp; Access Tunnels</td>
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<td>Blasting of Under Cut at 824L</td>
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<td>New Production level at 839L</td>
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<td>Development of Shaft #1 to 943L</td>
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<td>Production from C-Cut Phase 1</td>
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<tr>
<td>Development of ore-handling system at 895L</td>
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<tr>
<td>Steady state ROM production of 4 Mtpa</td>
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<tr>
<td>New Cullinan Plant to be operational</td>
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</table>

- No. 1 # (Rock) Shaft sinking completed and winder No1 operational from 905mL.
- No. 3 # (M&M) commissioned down to 839mL
- Ground handling system south hot commissioned.
- Development of waste and blue tunnels in progress and over 24 230 metres developed to date
- First undercut rings drilled and blasted during June 2015
- The first draw bell drilled and blasted during January 2016
C-Cut performance to date

Scope given to selected Contractors

<table>
<thead>
<tr>
<th>Year</th>
<th>Plan</th>
<th>Actual</th>
<th>Prog Plan</th>
<th>Prog Actual</th>
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<tr>
<td>FY10</td>
<td>48,1</td>
<td>537</td>
<td>357</td>
<td>1370</td>
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<td>4894</td>
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<td>FY12</td>
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Petra Diamonds Limited: CDM C-Cut Project update - July 2017
### C-Cut scorecard

### C-Cut Phase 1: Status

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<tr>
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<th>Total Project</th>
<th>CTC May 2017</th>
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<tr>
<td></td>
<td>Base Plan</td>
<td>Actual</td>
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<tr>
<td>Horizontal Development</td>
<td></td>
<td></td>
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<tr>
<td>Waste Development</td>
<td>16 416</td>
<td>16 713</td>
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<tr>
<td>Blue Development</td>
<td>10 365</td>
<td>7 517</td>
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<tr>
<td>Total Horizontal development</td>
<td>26 781</td>
<td>24 231</td>
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<tr>
<td>Scheduled (All - Incl Engineering)</td>
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<tr>
<td>Capital Spent - Total Estimate</td>
<td>R 4 615 000 223</td>
<td>R 3 767 202 998</td>
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</tbody>
</table>

![C-Cut Phase 1 - Project to Date - Status](chart.png)

- **90%**, Actual Development
- **89%**, Scheduled Progress
- **82%**, Financial Spent

*Petra Diamonds Limited: CDM C-Cut Project update - July 2017*
Shafts
Shaft Scope

Note
All project activities had to be carried out concurrently with current mine production

Men and Material Shaft (3#)
• Shaft 6m dia.
• Deepen and equip 3# from 805mbs to 885mbs (+80m)
• No winder upgrades were required

Rock Shaft (1#)
• Shaft dimensions 12m~9m by 2.8m
• Deepen current shaft from 580mbs to 934mbs (+354m)
• Shaft steelwork
• Upgrade headgear, winders, MCC and cages
• New Loading level, silos and shaftbottom
### Shaft change over sequence

<table>
<thead>
<tr>
<th>DEC 2013</th>
<th>DEC 2014</th>
<th>DEC 2015</th>
<th>Dec 2016 &amp; April 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Change No 2 Winder motor.</td>
<td>• Upgrade No 1 winder Completely. Mech. &amp; Elect.</td>
<td>• Up grade No 2 Winder completely. Mech. &amp; Elect.</td>
<td>• Change the No 3 Shaft Winder ropes.</td>
</tr>
<tr>
<td>• Install new 40 mm Short ropes</td>
<td>• Lift the Sheave wheels in headgear and replace No 1 sheave wheels.</td>
<td>• Change both winder ropes to permanent 40 mm ropes. For full length of wind.</td>
<td>• Commission the two winders to full depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Complete the headgear upgrade.</td>
<td>• Commission the Loading arrangement underground.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Change Winder Attachments and install New Catch plates in headgear.</td>
<td>• Commission the headgear tipping arrangement with the new skips</td>
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</table>
No 1# (Rock Shaft) upgrades

- Headgear sheave wheels and structure upgrades
- Aluminium “light-weight” skips
- Winder upgrades
- Winder MCC upgrades
No 1# and 3# Deepening

No. 1# Landing for Sky-jack

1# Deepening

1# Deepening

2# Raisebore hole below shaftbottom

3# Deepening

3# Lined
Silos, Loading Level and conveyors

Silo Loading box

Silo No.2

North Conveyor No.2

North conveyor head-section
Concrete Supply
Surface Batching Plant refurbishment

Old batching plant on surface – never fully commissioned

- Batchplant on surface
- Slicklines to 732mbs
- Re-mix
- Agicas to C-Cut
- 60-80m³ per day

Refurbishment of old batching plant

Completed Batching Plant
Undercutting and Block Cave Progress
UC slot rings – Mushroom (12m)
C-Cut Undercut and Extraction Level progress

BP 2014 at end of FY2017

BP 2018 at end of FY2017
3months ahead of schedule

Monthly (together with MO 3-month rolling plan) and quarterly reconciliations are done in Mine2-4D
C-Cut Phase 1
BELLS opened.
32% completed by end FY 2017
Steady-state in FY2019 (requires 70% of footprint)
Production Level - Bell Design El teniente
Production Level - Bell LHDB

- LH drillrig with on-board hole measurement
- Dry-drilling with onboard Ilmeg dust collection system
- Blindboring to establish free-breaking face
- Charge holes in bell slot
- Logging of electronic detonators
- Muck after blast
C-Cut info and maturity rules used in Mine2-4D

**Column/Cave Tonnes per Draw Point** 130000t or 451t/m²

**UC Ring** Blasted tonnes @ 2m Burden 800t
Loaded on UC @ 80% Extraction 640t

Bell Blasted Ring Tonnes 6400t / Through

Total Footprint t/m² = 487t/m²
Draw Point = 16m x 18m = 288m²
Draw Bell = 32m x 18m = 576m²

### Column/Cave Tonnes Maturity Rules per Draw Point

<table>
<thead>
<tr>
<th>Draw Point Age (months)</th>
<th>Max. capacity tonnes/day</th>
<th>Max. Draw mm/d</th>
<th>Draw point tonnes/month</th>
<th>Bell tonnes/month</th>
<th>DPs required at Draw rate to achieve 1mpa</th>
<th>DPs required at Draw rate to achieve 2mpa</th>
<th>DPs required at Draw rate to achieve 4mpa</th>
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<tr>
<td>0</td>
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<td>1050</td>
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<td>6510</td>
<td>26</td>
<td>52</td>
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Challenges
Challenges experience

- Brown fields: congestion and production interaction and hand-overs
- Logistics down declines and water management
- Waste/Ore handling separation system - Meta-sediment influence plant recovery process
- Ventilation access and RAW requirements underestimated
- LHDB:
  - 20m slot rings on UC accelerated caving that resulting in oversize reporting on UC
  - Initial caving oversize on UC and production level (allowance for sec. breaking fleet)
  - Temporary sizing and Rockhandling systems before commissioning of GH system
  - Electronic detonators on slot blasts (dead-pressing)
- Workshops and equipment maintenance
- Twin access to major infrastructure excavations to ensure that its not shared with production
- General skills amongst the workforce / contractors
# Factors that Influenced Progress

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<td>Establishment of contractors - late approval of M&amp;R contract</td>
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<td>Metasediment</td>
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<td>Low grade - reduce waste</td>
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<td>Industrial action</td>
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<td>Silo deepening methodology</td>
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<td>Shaft capacity from 4-6 m/t pa</td>
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<td>Working cost hand over delay</td>
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1. Establishment of contractors
2. Metasediment
3. Low grade - reduce waste
4. Industrial action
5. Silo deepening methodology
6. Shaft Capacity
7. Working cost hand over delay

- Delay in approval of M&amp;R contract
- Double handling
- Low waste development rate
- Delayed waste development
- Sliping more time consuming than raise bore
- Additional engineering required
- Constraint on ground handling capacity
Contract Management and lessons learnt
**C-Cut Project Structure**

**CDM Owners Team**
- Lab. (9) excl survey
- Engineering Management
- Procurement
- Project Eng. Planners

**CDM Mine Manager**
- Production (excluded)

**C-Cut PM**

**Design**
- Mine Design & Schedule – Consultant
- Shaft, Silos and LL – Sinking Contractor
- Conveyors – Consultant
- Tips and Crushers – Consultant
- Orepasses and Feeders design -Consultant

**Contractor**
- Shaft(s) deepening, Winders, slos, LL and shaftbottom
  - Max. Lab. 394
- Major Excavations and Waste Development
  - Lab. 130
  - Dev : 86
  - Constr : 44
  - 220m/month

**Contractor**
- Blue/Ore Development
  - Lab. 79
  - 220-280m/mo

**Contractor**
- Tunnel support and Batchplant
  - Lab 129
  - Sec Support : 111
  - Batchplant : 18
  - 4 Bells/mo (8xSBrows)
  - 4 contact sets
  - 271 m/mo sec sup.
  - 216 anchors
  - 363 m³ wetcrete
  - 372 m³ RW & Sets

**Contractor**
- LHDB
  - Lab. 93
  - SIB : 45
  - CCUT : 48
  - 120-140rings/mo

**Contractor**
- Engineering : Fleet Maint. & Infra. Equipping
  - Lab.:103
  - TMM Maint. : 51
  - Constr. : 37
  - E&I : 15

**Contractor**
- Fabrication
  - Lab 18 (adhoc)

**Contractor**
- Raiseboring
  - Lab 12 (adhoc)

---

project Labour : 750-1000

(Sinking Contractor work completed end of July)
Lessons Learnt

- Appropriate project FEL / Understanding
- One GM, clear organisational reporting structure and legal accountability
- Strong owner’s team (PM, QS, Accountant, Eng, Min, Survey, Planners etc)
- Contractors & personal approved by PM.
- Clear lines as to area of responsibility and hand-over mechanisms in place
- Every 6 months CDM have interaction session with DMR where:
  - Provide SHE roadmap for next 6 months
  - Exchange ideas to best manage SHE aspects
- QA/QC personnel appointed by Contractors but report into owner’s team
- Fleet Maintenance outsourced but managed by owner’s team
- Contracts must have pain/gain mechanisms build into contract
- Contractors part of mining team and treated as such, retention strategies included
- All steel structures to be pre-assembled and inspected before going underground to enable Mecano type assembly
- Strong Contracts and QS services critical
- Regular assurance reviews
Questions ?