Surface drainage around the Venetia pit

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Synopsis

Venetia is an open pit, truck and shovel operation owned by De Beers South Africa and situated in the northern part of South Africa in the Limpopo province. The kimberlite body was discovered in 1980 and full production started in 1992. The mine is currently mining the fourth cut of the open pit and plans are in place to take the mine underground by 2014 employing a block cave mining method.

This project was initiated because of a lack of a drainage system that prevents stormwater from reporting into the open pit during the rainy seasons. The project had been attempted before without much success and the problem in question is escalated by an ever expanding pit.

Project background

The rainfall pattern in Venetia mine ranges from the beginning of October until the end of March with a mean annual rainfall of 366 mm/y. This is not a wet area but when it rains one can expect quantities of 30 mm/h. Figure 1 gives a clear indication of this rainfall pattern.

The uncontrolled accumulation of stormwater into the open pit results resulted in operational challenges that can be summarized as follows.

Challenge 1: Impact on the geotechnical stability of the mine.

Venetia mine has two haul roads that lead into the open pit, north haul road and south haul road. The latter has been observed to experience a considerable number of instabilities, hence management decided to install survey prisms that monitor displacement along the haul road. These prisms are connected to an alarm system, which notifies the control room and management should abnormal displacement be detected. This set-up ensures that management can implement the necessary pit evacuation procedures before major disasters can occur.

Figure 2 shows readings that were obtained from the survey prisms that measure displacements along the ramps. Before the rainfall, there was no movement on the cracks, but after 65 mm of rain in five days, a 12 cm wide crack on the haul road opened to a width of 1.4 m, resulting in impossible hauling conditions on the south haul road.

Challenge 2: Inability to mine according to plan

During this project the Venetia pit was at a depth of 275 m, with bench 21 being the bottom bench from which kimberlite (the diamond bearing rock) was being loaded. At that time there were 25 000 t of blasted kimberlite rock which was schedule to be loaded in a space of two to three days. During the first day of loading operations 120 mm of rain came down with most of the run-off reporting to the pit bottom. After the rainfall, bench 21 had over 62.1 million litres of stormwater at depths exceeding four metres, this making it very difficult for mining machinery to access that area due to the unfavourable working conditions.

The pit bottom at that stage had a pumping system of two centrifugal pumps, which at a utilization of 85% could deliver a flow rate of 12 million litres out of the open pit, in 24 h. With those parameters we dried the bench was dried after five days, three days deviation from the initial plan of three-days. Note that this is also a three day delay on the metallurgical plant. Stormwater control had to be enforced as this was an unacceptable situation.

Challenge 3: Flooding

The other observed challenge was that of the possibility of endangering or exposing men working at the pit bottom to floods. This was the case on 29 of March 2007. There were two Boart Long Year exploration rigs at bench 20, and after 60 mm of rain over two hours, the rigs were half submerged in stormwater. Fortunately no one was injured but the exploration company had to spend a

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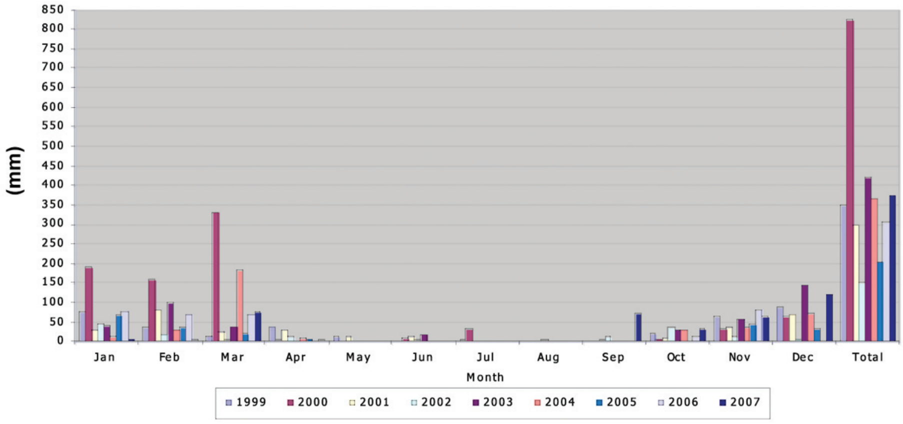

Figure 1—Rainfall patterns for Venetia mine

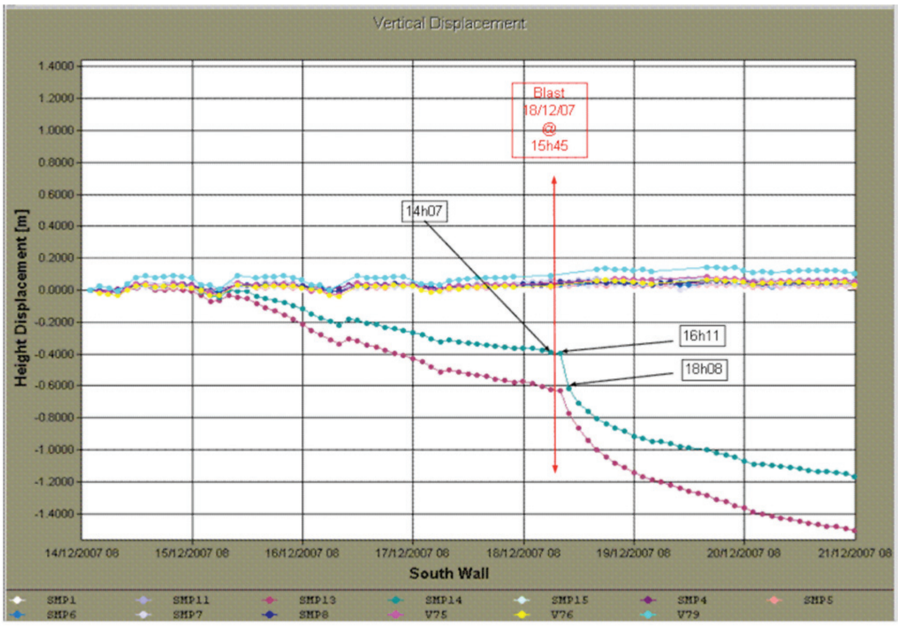

Figure 2—Displacement measured on the south ramp

substantial amount of money (1 million rands) in order to get their programme running again.

As a control measure during the phase of the project I implemented rain meters and ensured that procedures pertaining to floods are enforced at the control room and all the pit foremen are aware of such procedures.

Project objectives

At the end of this project I had to put forward a plan to prevent stormwater from entering into the Venetia pit during rainy seasons. Most importantly, critical areas such as the ramps had to be addressed and stormwater flow via the ramps had to be minimized. This is the infrastructure from which the pit collects a substantial amount of stormwater.

Methodology

Figure 4 shows the sequence of how this was executed up until a stage whereby we could present a stormwater plan for the mine. It was a process of going through plans of the pit, carrying out inspections, taking photos of the pit during rainy days, and consulting experts that had done work on this subject before at Venetia mine.

This also included a team on the mine made up of pit leads, a section engineer from pit services, mining engineers, and safety and environmental personnel, so as to manage the problem in question during the rainy season.

Analysis and findings

The first step in the problem-solving stage was to determine how much water accumulates in the catchment area, over a year and what path it follows until it finds its way to the bottom of the open pit.

This required visual examination of the open pit during rainy days to determine the route of the current problem.

Figure 5 shows a plan view of the pit with the ring road around it. There are three dumping sites, which are not visible, namely Krone, Venetia and Rugen dumps. The blue lines on the plan show the path along which stormwater flows until it reaches the pit bottom. It very clear from the plan that the areas that need to be addressed are the dumps

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Figure 3—Ramp condition before and after rainfall

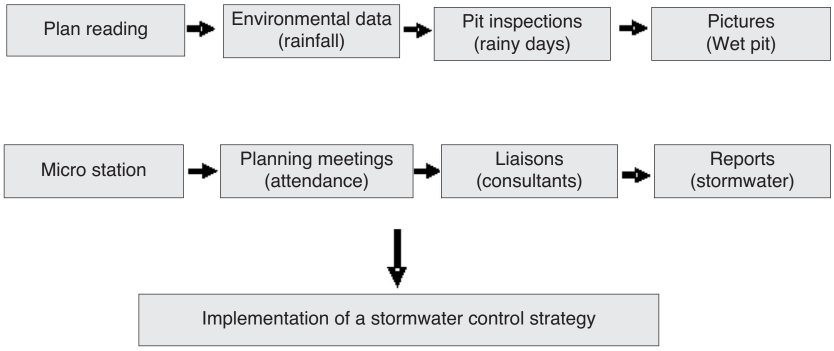

Figure 4—Methodology layout

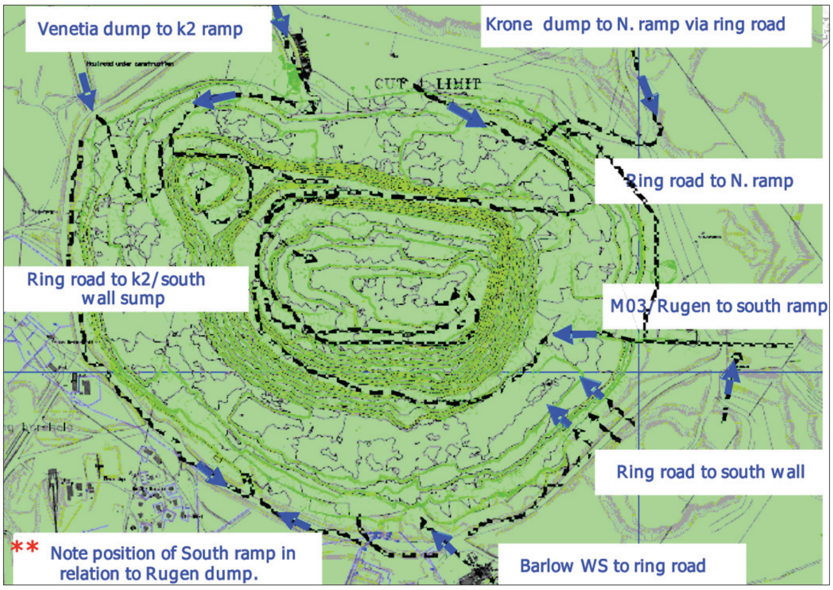

Figure 5—Stormwater entry points

and pit ring road as this is from where stormwater is collected.

The amount of water that accumulates on the identified catchments over a year, are shown in (Table I.)

Pumping strategy

There are two centrifugal pumps, 255 mm ∅ impellers which can deliver a flow rate of 170 ℓ/s to the surface stormwater storage dam. If this system had to pump out all the stormwater that collects in the pit over a year, it would take about 112 days. This is not continuous pumping over 112 days as it does not rain continuously for 112 days over a rainy season; it is few days each month of the entire rainy season. (Figure 6.)

The 112 days also represent a delay in accessing high grade ore as well as a major delay in the metallurgical plant. During the project it was projected that if there were no surface stockpile delays on the plant would have been in the region of over 2 000 hrs/y.

Possibilities

The data obtained clearly show that something has to be done in order to minimize the inflow of stormwater. The obvious thing to do was to control water at the entrances into

Table I

Stormwater accumulation

Catchment	Accumulation M ℓ/y
Venetia dump	143
Krone and Rugen dump	312
Ring road	505
Direct on pit	685

Note: that rain directly on the pit does not form part of this study as this is impractical to avoid unless if the pit is covered with an umbrella during rainy seasons. The figure 685 ML/yr is shown in order to create a picture of the required pumping capacity.

the pit. (Figure 7.)

There are six entrances that lead into the pit ring road, and from there this water finds its way into the open pit. A drainage system had to the adopted for these entrances. The system selected should also suit the operation of machinery that needed to enter the pit without causing any operational constraints.

After much brainstorming with the project team, the following options were considered:

- Option 1: drainage trench with grizzly (Figure 8.)
- Option 2: drainage basins (Figure 9.)
- Option 3: humps (Figure 10.)
- Option 4: sandbags.

The sandbags would have to be aligned on both shoulders of the road in such a manner that a bunt wall is constructed; the road has to be cambered in such a manner that stormwater is encouraged to flow towards the sandbags and diverted away from the pit road entrance.

The structures considered are aimed at reducing the inflow of stormwater through the ramps; their main mode of operation is to collect stormwater from external pit road networks and divert it away from the ramp and ring road networks.

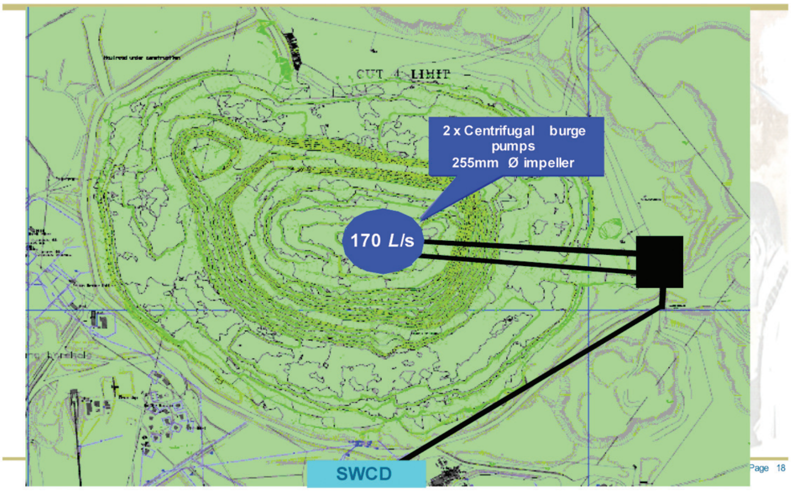

Figure 6—Venetia pit pumping strategy

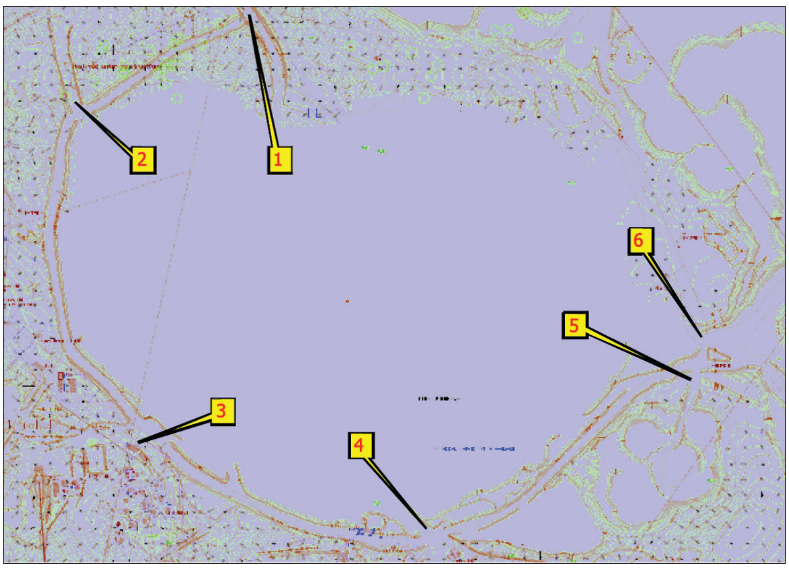

Figure 7—Pit entrances

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Conclusion

After looking at the various possibilities that can be implemented, one can conclude that these structures must be put in place in order to keep the bottom bench as dry as possible and as soon as possible, mainly due to the potential loss that can be experienced if the plant has no ground to process.

Venetia mine is currently undergoing feasibility studies in order to establish an underground block cave mine so as to mine the rest of the ore reserve. It is very important to monitor water inflow to the pit as this can accumulate and cause major geotechnical challenges for the underground operations.

A good drainage strategy must be implemented at pit entrances and the ring road as this is where the ramps collect a considerable amount of the runoff.

Recommendations

The first recommendation would be to camber the ring road away from the pit, as it is currently cambered towards the open pit and this has a potential accumulation of 505 million litres per annum.

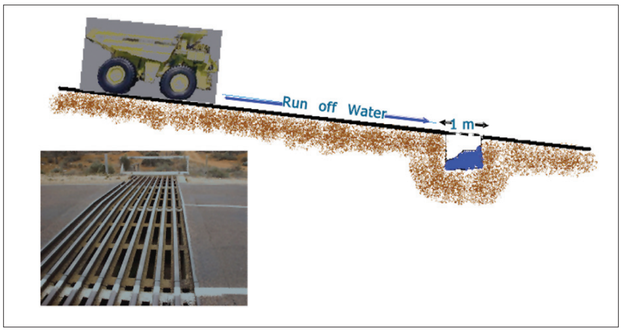

Figure 8—Drainage trench with grizzly

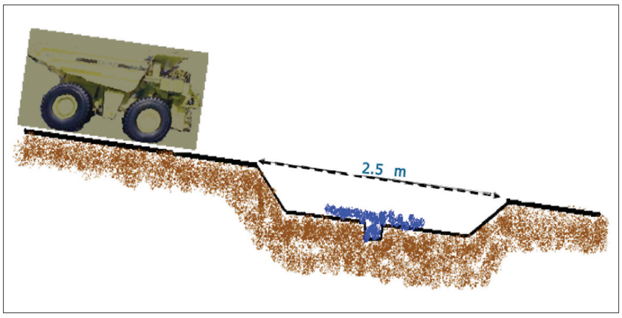

Figure 9—Drainage basins

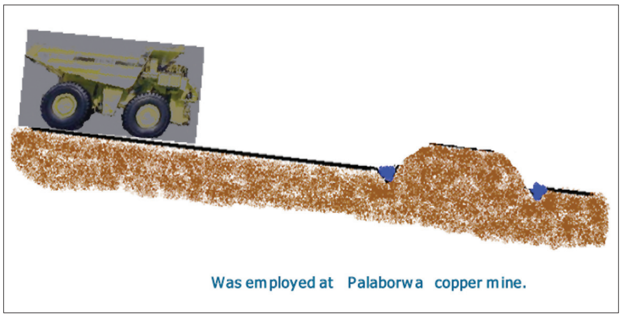

Figure 10—Humps

Table II

Comparison of the various possibilities

Parameters	Grid	Trench	Hump	sandbags
Cost				
Potential				
Maintenance				
Health and safety				
Spillage				
Construction time				
Rehabilitation				
Impact on machinery				

Table III

Simplified cost analysis

Action	By whom	Cost
Ring road cambering @ R320/h	Dust A side	R337 290
Sandbags	Construction	R2 000
Add. sumps	Construction	R15 000
Improved pumping	Engineering	R800 000
Cost @ 15% escalation		R2.5 M

The drainage systems that where considered for the ring entrances were put head to head, based on the parameters listed on the right-hand side of the table. Red—negative impact, yellow—moderate impact, green—positive impact. After this study it is recommended that sandbags be implemented at ring road entrances. (Table II.)

The recommendations will have to work hand in hand with the pumping strategy. Replace the 255 mm impellers with 260 mm impellers that can give a flow rate of 200 ℓ/s vs. 170 ℓ/s at the same head. Working with ring cambering and entrance controls, the total pumping duration can be reduced by up to 40 days/y. This will reduce bottom bench kimberllite inaccessibility by 65% /y.

Cost study

A basic, simple cost analysis was done in order to determine how much it would cost to implement a drainage strategy for Venetia mine, taking into account the recommendations that were made. The total figure of R2.5 million that was quoted can be approved only if the whole organization understands the opportunity that exists in saving the mine from floods and major production delays. (Table III.)

Suggestions for further work

It is recommended that a study on pit seepage needs to be undertaken to asses the magnitude of water that has seeped into the country rock, which has been said to be the major contributor to pit slope failures that have been experienced in the mine throughout the years. Impact must be quantified and action plans must be put in place.

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