The Rehabilitation of Eland Shaft after an Earthquake

SPH KRUGER
Section Manager, Matjhabeng Mine

SYNOPSIS

An earthquake measuring 4.6 on the Richter scale struck Eland Shaft on April 23, 1999. The event caused severe damage to the shaft steelwork and services, resulting in the whole nightshift crew being trapped underground. Unfortunately, two workers lost their lives during the event. Major damage to both surface and underground structures put the shaft out of production for 5 months and 13 days. Eland shaft is of strategic importance for Matjhabeng Mine and Anglogold, because it produces an average of 530kg of gold per month.

This paper will deal with the event itself and the subsequent rescue and rehabilitation of the shaft after the earthquake.

BACKGROUND

Description of Shaft

Eland shaft is Anglogold’s second oldest operating shaft in South Africa. Sinking of the shaft began in 1948 and the first gold was produced in June 1956. It is Matjhabeng Mine’s deepest shaft and consists of both a vertical and a sub-vertical shaft system. The Dagbreek fault intersects the main shaft at 1715.5 meters below collar and the Sub-shaft at 1515 meters below collar. The shaft provides access to the Eastern portion of the Matjhabeng lease area.

The main shaft has a depth of 1795 meters below collar and the sub–shaft’s bottom lies 2031 meters below collar. Eland and its sister shaft Kudu are the only two remaining unlined shafts in Anglogold, having buntons supported on concrete sills.

Production profile

Eland shaft produces 38% of Matjhabeng Mine’s gold and 50% of its tonnage. Approximately 2700 people are employed, in size it is comparable to Deelkraal Mine.

Eland shaft was one of the five shafts that were incorporated into Anglogold, during the formation of Freegold. The shaft pillar is a particularly significant resource for Anglogold, being one of the few areas of high-grade ore still unmined and containing in excess of 13 tons of gold. It has a projected life in excess of three years. In addition to unmined areas, Eland shaft contains significant volumes of broken ore (old unswept areas), which can and are being turned to account.
GEOLOGICAL AND ROCK ENGINEERING DETAILS

Geological detail

Eland Shaft lies in the vicinity of a number of major faults. On the South side are the Toc H Gekregen and Lotgevalle faults. The Dagbreek fault lies on the East side of the shaft and comprises a series of sympathetic faults known as the Dagbreek Fault Zone (Dfz). It intersects the main shaft between 55 and 57 levels. The sub shaft is intersected by the Dfz below 49 level. The Rietpan and Utopia faults cross the North side of the shaft’s lease area.

Figure 1: Matjhabeng Mine and Location of Eland Shaft
Figure 2

Section through Main and Sub-shaft showing major geology

Main Shaft
Coal seam 200m below collar

Wingate Dyke
Gold estates
Upper Shale marker
Reef Intersection
Dagbreek Fault Zone

Sub-Shaft
Dagbreek Fault Zone

45 level
47 level
49 level
51 level
53 level
55 level
57 level
49 level
51 level
53 level
55 level
57 level
59 level
61 level
63 level
64 level
Fire

Fire that was to become a complication to the rescue

A fire broke out in 55W23 stope, 22 days before the earthquake. During the fire-fighting process 56 Proto teams were used to bring it under control. Thereafter and before work recommenced, a risk assessment was performed to determine potential sites for noxious gas accumulations. Employees in these areas were trained and issued with self-rescuers. In order to ensure no change in ventilation flow in the case of a power failure, the main surface fan at the old Freddies 3 Shaft was repaired to serve as a back up. In this way, it was thought that adequate due diligence had been satisfied. Unfortunately the earthquake resulted in a total power failure at all shafts of Matjhabeng Mine causing the entire night shift to be trapped underground with the fire still burning.

Earthquake Event Information

(PROVIDED BY ISSI, DR G. VASWEGEN)

An earthquake of local magnitude 4.6 occurred on Friday 23 April 1999, at 00:19, due to slip along one (or more) components of the Dagbreek fault zone (Dfz) adjacent to the Eland Shaft pillar, resulting in severe local damage. Due to the immediate power failure, vital seismic data was lost and no quick location could be provided by the seismic monitoring system. It was later determined that the epicentre of the earthquake was 1 000m south-east of the main shaft and 200m from the working place where two persons were fatally injured in a fall of ground.

The aftershock distribution suggests that the area south of the Lotgevalle dyke, along the fault zone, had experienced an increase in shear stress.

Routine seismic monitoring failed to detect the imminence of the earthquake. A seismic alert was issued based on the seismic behaviour of the shaft pillar. It appears that the increased seismic strain rate in the pillar reflected a larger scale instability.

The distribution of all events greater than magnitude 4.5 in the history of the Welkom gold field shows that, in all cases, major faults being mined out on both sides, were involved. The Matjhabeng earthquake is the third for the Dfz. An extensive back analysis of the Dfz seismic history shows that, prior to the event, a seismic gap (area of low seismic strain) existed along the fault zone in the area of Eland Shaft. This gap was filled by the earthquake.

The back analysis revealed that some clusters of seismicity could have served as warning about the fault zone being unstable. The one cluster was evident in the fault loss close to the stope where mining took place and where the fatal accident occurred. Despite the spatial association with mining, the time-of-day distribution of seismic events in this cluster differs from that normally associated with the daily seismic response to production blasting. The time-of-day activity appears random, suggesting that some force other than the daily mining-induced stress changes controlled the seismic events in the cluster, i.e. the deforming fault caused local deviation from a regular temporal pattern in seismicity. Another small cluster of seismic events occurred 6 days before the earthquake in the fault loss area near the suite of haulages going East. A total of 11 events were recorded within 2 minutes and no evidence could be obtained of any sort of blasting in the area at the time. As no mining related cause could be found, such unexpected seismic activity might in future be considered as an indication of a potential seismic gap.
The underground fire North of the shaft pillar caused an increased seismic strain rate for this area. Although quantitatively it is not possible and therefore seems unlikely, for the seismic deformation associated with the fire to have caused the earthquake, a special analysis would need to be done to ascertain its potential to have triggered the main event.

Based on seismic data alone, one can conclude that the likelihood of another tremor of similar magnitude and in the same source region as the Matjhabeng earthquake is very small. Smaller events could, however, damage excavations close to the structure all along its strike length. Such areas are being analysed through appropriate back analysis and numerical modelling methods, which take into account the seismic history of the fault zone. This however cannot be done effectively in the absence of a reliable geological model of the internal structure of the DfZ in the areas of concern.

<table>
<thead>
<tr>
<th>Year</th>
<th>Magnitude</th>
<th>Fault</th>
<th>Minimum fault slip (mm)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>4.5°</td>
<td>Erfdeel</td>
<td>?</td>
<td>Damage to Kudu shaft steelwork and concrete lining</td>
</tr>
<tr>
<td>1976</td>
<td>5.2°</td>
<td>Dagbreek</td>
<td>150</td>
<td>Extensive underground and surface damage: the original “Welkom earthquake”</td>
</tr>
<tr>
<td>1982</td>
<td>4.8°</td>
<td>Wesselia</td>
<td>410**</td>
<td>Extensive underground and surface damage. Kudu and Sable shafts out of action for several days.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Erfdeel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>4.8°</td>
<td>Dagbreek</td>
<td>200</td>
<td>Extensive underground damage along fault zone at St Helena Mine</td>
</tr>
<tr>
<td>1989</td>
<td>4.8</td>
<td>Brand</td>
<td>370</td>
<td>Widespread damage, but ‘burst’ type damage confined to few highly stressed pillars and dykes</td>
</tr>
<tr>
<td>1990</td>
<td>4.8</td>
<td>Stuurmanspan</td>
<td>?</td>
<td>High stress drop event, intense local underground damage, noticeable pre-cursory seismicity</td>
</tr>
<tr>
<td>1992</td>
<td>4.7</td>
<td>Saaiplaas</td>
<td>150</td>
<td>Extensive damage to main haulage transecting fault.</td>
</tr>
<tr>
<td>1999</td>
<td>4.6</td>
<td>Dagbreek</td>
<td>200</td>
<td>Extensive damage spatially associated with fault zone, Eland Shaft and Sub-shaft damaged</td>
</tr>
</tbody>
</table>

Table 1
A list of tremors > magnitude 4.5 in the Welkom gold fields since 1972

* Magnitude from national network

** The measurements of fault slip were made three years after the event. Some post-seismic creep could be included.
Figure 3
Estimates of the locations and source areas of tremors > magnitude 4.5 in the Welkom Gold Fields

EFFECT OF THE EARTHQUAKE

The earthquake caused severe damage to surface structures, machinery, the main and sub shaft and underground excavations. An extended power failure occurred due to damage to Alma Power Station, which supplies the entire Matjhabeng Mine. The immediate results were the loss of compressed air supply and of all other electrically powered services such as: shaft conveyances, fans, surface telephones, fire detection system and pumps. Extensive flooding of the sub-vertical shaft ensued. Some offices, change houses, and hostel areas had to be evacuated due to the severity of damage to the structures. The sub-shaft was shortened by 150mm and there was horizontal displacement of 380mm which resulted in damage and buckling of 5 bunton sets and guides at the Dagbreek fault intersection. On the main-shaft there was damage to the shaft barrel, stations and steelwork between 49 to 58 levels. The shaft was shortened by 150mm and a horizontal displacement of 400mm was measured. Below are photographs taken after the earthquake. A detailed summary of the damages appears in the sketches below.
Figure 4
Damage to office buildings – This entire wall had to be broken down and re-built

Figure 5
Due to the movement of the earthquake the main rock winder bearing casing broke
Figure 6
Bent buntons and guides in the main-shaft

Figure 7
49 level station hanging wall
Figure 8

- Brattice walls
- Crushed
- 49 level station
- Steelwork replacement
- Ground movement and barrel displacement
- Concrete and sills to be removed
- Footwall lifted and bent rails
- Stuck skip
- Station King post bent
- Loading station ok
- Loading Box
- Very Extensive damage to shaft steelwork
- Very Extensive damage to shaft steelwork
- Moderately damaged Buntons x14
- Heavily damaged shaft steelwork
- Shaft in good condition
- Large rocks & steelwork debris
- Guides missing
- Very Extensive damage to shaft steelwork
- Dam, Settler and Pumps Ok
- Moderate damage to steelwork
Figure 9
Major falls of ground can be seen in these haulages.

Figure 10
Sub-Vertical Shaft – damaged buntons
A total of 425 night shift people were underground at the time the earthquake struck. The control centre being used to monitor the underground fire was still in operation and emergency procedures were initiated. The full extent of the damage was not immediately recognized, but with an underground fire still burning, no power, no compressed air to make underground refuge bays life sustaining and no conveyance to get people out from underground an “explosive” situation existed.

Underground employees evacuated their working places and assembled at the stations. Employees started to report in from underground to the control centre.

The Mine Overseers managed to account for all their employees, except for one working place. The night shift cleaner of 43 W15 stope and three of his crew members dug themselves open and crawled through various falls of ground, until they reached the station. The cleaner phoned and reported that two of his workers were trapped by falls of ground.

With all surface and underground fans standing, the fire gases were no longer controlled through the chimney, and moved to the upper levels through mined-out areas. Employees on 47 level station area reported that their tox alarms (detection device for Carbon Monoxide) had started flashing. The manager in control instructed a night shift cleaner to test for carbon monoxide on the other side of the station and report back to control. The report back was negative and an instruction was given to move all people to the other side of the station. At that stage, thick white smoke was reported approaching the station. The water sprays were opened in the shaft to try and counteract the reversal of ventilation flow and to maintain down cast of air in the shaft. At 5:30 one surface fan was restarted on emergency power which restored the ventilation.

Surface winders were severely damaged and the roof of the Mary Ann building had caved in. Only one man winder serving compartments 1&2 was available, and it could only go down to 49 level. The cage serving compartments 1&2 was between 43 and 45 levels. It was brought to surface by close monitoring the load cell; this was the only way to get a conveyance to surface. The Engineer assessed damage to the rope and had to cut front ends before the first cage descended at 8:30 to assess damage and try to rescue the people on 49 level.

In the meantime Proto teams descended at Tshepong Mine and Nyala shaft, which are respectively 12km and 8km away from Eland shaft, and connected by a tunnel on 55 level. With telephone communication from various places underground people were guided from control through various routes from the lowest level, which is 63 level up to 55 level where they could travel to Tshepong and Nyala shafts. Traveling was difficult and it was very hot due to fans standing and some people had to be treated by Proto members for dehydration along the route. Except for the two persons trapped in 43 W15 stope, all persons were brought safely to surface, some having been underground for more than 20 hours and having traveled in excess of 16km.

The rescue operation to get the two people trapped in 43 W15 stope was immediately started. Various smaller seismic events took place whilst opening major falls of ground. Rescue operations continued under difficult circumstances around the clock for a two week period. Sadly neither of the trapped workmen survived; the body of the first trapped employee was discovered on May 5, 1999, and that of the second one was found the next day.
ASSESSMENT OF DAMAGE IN THE SHAFT

Before any shaft rehabilitation program or schedules could be drawn up it was necessary to perform a proper assessment of damage in the shaft. A multi-disciplinary team representing mining, engineering, rock engineering and survey, identified the following repair work:

49 level station

- Removal of the concrete station brow and footwall sills and making safe of the shaft barrel in that vicinity. Support of the shaft barrel perimeter by GML support and 10m longhole tendons. A concrete wedge was protruding into the numbers 5 and 6 compartments, and had to be removed, and the exposed rock face supported. In the station area two crushed pillars had to be consolidated by strapping them with longhole tendons. This work could be performed concurrently with the shaft barrel rehabilitation, as the locations are not in the immediate vicinity of the shaft (see diagram).

49 to 51 level

- Installation of thirty 10m length longhole tendons required in the shaft perimeter area for 8m below 49 level station footwall;
- Sliping of the shaft barrel to provide a minimum clearance between conveyances and sidewall of 250mm;
- Repairs to previously installed GML support and estimated at 50% of that area. GML support of the area sliped to provide the prerequisite conveyance clearances;
- Shotcreting of the entire shaft barrel perimeter from 49 to 51 levels;
- Replacement of steelwork.

51 level station

Rock Engineering recommended similar remedial work to that specified for on 49 level station, as damage was very similar in nature. The work included the following:

- Removal of the concrete station brow and footwall sills and making safe of the shaft barrel in that vicinity;
- Replacing existing support with GML support and a limited number of longhole tendons;
- Replacement of station steelwork.

51 to 53 level

- GML support of 10% of the barrel area to allow for repair to previously sound sidewall areas as well as to areas sliped to provide conveyance clearances;
- Replacement of damaged steelwork.
53 to 55 level ( shaft pillar removal area )

Rock Engineering recommended that an area from 30m above to 20m below the reef intersection be GML supported in preparation for the shaft pillar removal. If neglected from the schedule, it would consume numerous weekends of work after recommissioning. In order to enable the pillar extraction to be brought forward and to “break the back” of the work, the following had to be done.

- Stripping out the old steelwork and installation of the tower, GML holes to be drilled and grout rods installed;
- The meshing and lacing of an area of only 10m above and 10m below the reef intersection.
- Rock Engineering was satisfied that this would be adequate to commence shaft pillar mining.
- The balance of meshing and lacing could be installed outside of the schedule over weekends;
- Replacement of damaged steelwork.
53 to 57 level

- GL support of 20% of the shaft barrel area. This took cognisance of the poor ground conditions observed in the Dagbreek fault area;
- Shotcrete 20% of the East sidewall area to prevent further weathering and provide a skin support was required;
- Replace damaged steelwork.

REHABILITATION OPTIONS

After extensive deliberation with both the Anglogold corporate Mining and Engineering Consultancies, a base case was derived. Its salient features were:

49 to 53 level

Accommodate possible future sidewall movement, and provide adequate clearance for conveyances by sliping the barrel sidewall to a depth of 250mm, as recommended by Rock Engineering, between 49 and 51 levels and between 51 and 53 levels, and installing buntons on adjustable chairplates.

53 to 57 level

Simultaneously repair the catastrophically damaged shaft steelwork and install the suspended towers between 53 and 55 level and between 55 and 57 level which were already planned for shaft pillar extraction, thereby providing:

- a potentially earlier start date for the shaft pillar extraction;
- removal of the constraint on shaft time imposed by the original weekend work schedule for installation of the suspended steelwork;
  - expediting the repair work through the award to Shaft Sinkers of a Management Contract incorporating Matjhabeng Mine labour thereby;
- acquiring combined labour resources to man 8-hour shifts;
- acquiring Shaft Sinkers’ expertise and specialization, which, taking cognisance of the catastrophic extent of the damage, would decrease risk and increase confidence in timely completion of the rehabilitation work;
- achieving “ownership” on completion through the participation of the mine’s employees.

Further exploration of the base case revealed two potential options.

Option 1 (completion 19 December 1999)

This option involved the systematic rehabilitation of the shaft from 49 level to 57 level, as described in the base case.
Option 2 (completion 5 October 1999)

The reduction in duration was achieved by separation of the shaft into two working areas by the installation of a plug above 53 level. Concurrent activities, as described in the base case, could then take place above and below the plug. It would be more costly in terms of equipment and manpower than Option 1.

Other options that were considered are briefly described below:

- Abandonment of the shaft below 49 level and reestablishment of the shaft bottom skip loading facilities on 51 level. It was rejected because:
  - The cost and duration would be prohibitive
  - Ground conditions on 51 level were unacceptably poor

- Utilisation of Rockprops instead of buntons and adjustable chairplates. It was rejected because:
  - Expert engineering concern was expressed in that it was not prudent to use a Rockprop in the dual function of resisting slamming forces from winding as well as a support medium to restrain forces arising from rock movement
  - The opportunity to use existing undamaged buntons and chairplates, particularly between 49 and 51 levels, would be lost.

The deadline to make the rehabilitation of Eland shaft viable was October 5, 1999. Option 2 was therefore selected.

REHABILITATION PROCESS

Due to the complexity and difficulty of the project a decision was made to award Shaft Sinkers a contract, incorporating Matjhabeng Mine labour. Excellent support was provided by Corporate Office. This resulted in good combined expertise. Initially there was a “them and us” syndrome, but teamwork and mutual respect developed as time went by.

All surface winders were repaired successfully by May 8, 1999. The ropes of the skip and cage in compartments 3 & 6 were successfully retrieved by means of single drum hoisting and the use of a special crosshead.

Due to rock falls, a catastrophically damaged, skip and cage were jammed in badly buckled steelwork below 55 level in compartments 3 and 6 respectively, and were impossible to retrieve intact. The cage was raised to the station using chainblocks. Due to its construction of aluminum it had to be cut out of the shaft using specialized cutting equipment. The skip was lowered and cut up conventionally in the shaft bottom.

In order to establish a separate access way down the shaft, the damaged brattice wall between compartments 2 & 3 was repaired with screens. Compartments 1 & 2 were completely sealed off and plugged below 49 level.

Separate access ways would permit access for men and material, and a transport route for rehabilitation steelwork, so that repairs in compartments 3, 4, 5, 6 and 7 could proceed uninterrupted, that is 24 hours per day, 7 days per week.
The shaft was separated into two work areas by means of a plug installed on 53 level. Buntons on adjustable chairplates were installed in the upper section (49 – 53 level) and suspended towers were installed at the lower section (53-57 levels).

The plug on 53 level was designed to be strong enough to prevent a guide from passing through it, should one should fall down the shaft. The rock generated from sliping operations between 49 and 53 levels fell into the plug through the chute. All broken rock accumulated through the chute was pulled with a scraper and loaded with a mechanical loader on 53 level.

The separation of the shaft into two working areas allowed concurrent activities to take place above and below the plug. Conveyances of compartments 3, 4, 5, 6 and the services compartment were used to do repair work in the upper section.

A double deck equipping stage was installed in order to strip the old steel and to install the suspended tower between 53 and 55 levels and between 55 and 57 levels.
Four 7.5kw crab winches were installed on 53 level in order to raise and lower the equipping stage.
Two equipping 22kw winches were installed on 53 level in order to lower and raise two equipping skeletons.
Two equipping skeletons to transport men and material to the equipping stage were used.

The rock generated from the lower section was collected on a platform installed on 55 level. The platform was relocated to 57 level after completion of repair work between 53 and 55 levels. Blasted rock was pulled with a winch and loaded with a mechanical loader.

The equipping stage was stripped on reaching the platform on 57 level. Once the stage was demolished, the plug above 53 level was removed and all steelwork in the vicinity of the plug was repaired.

Large rock and steelwork debris in the shaft bottom was removed concurrently with repair work in the shaft, using the platform installation on 57 level.

A special tunnel was developed for the purpose.

Station brows requiring precision blasting made blasting operations extremely difficult. EDD’s were used to blast station brows. Magnum and cordtex were used for blasting operations in the shaft.
Figure 18

Section of shaft showing repair

47 lev
- Boiler shop established

49 lev
- Repair using platform of baskets under conveyances
- RSJ bunton on Adjustable chairplates

51 lev
- 2 Single drum winches For equipping Skeletons

53 lev
- Storage area for Tower steelwork
- 2 Equipping skeletons transport men and material to the equipping stage

55 lev
- Diverter chute relocated on completion of 53 to 55 level

57 lev
- Spillage Handling

MODUS OPERANDI

- Material to Sub-Shaft
- Concurrent
- No. 1 & 2 comps Screened and plugged
- Double skin plug To permit concurrent Repairs and chute to divert Rock onto station
- 4 Crab winches to Lower equipping stage
- Double deck equipping stage Strip old steel and install Tower steel and drill for GLM.
- Slipe and install RSJ buntons on chairplates
- To tips
- To loading belt
- Suspended tower installation
- To tips
- Diverter chutes to collect Rock sliping operations

SHAFT BOTTOM
Once agreement had been reached, a detailed dynamic schedule was drawn up to encompass the whole project, a summary is shown below.

In order to maintain tracking of the project, daily progress meetings were held which were to also include problem solving, since, conditions of the shaft barrel and station areas were changing as work progressed. Any deviation from the scheduled plan would be discussed and the schedule revised so as to eliminate any delays. Quality control measures were then conducted on a shift for shift basis to control and eliminate deviations from the standard required. Once the plug on 53 level was installed and the shaft was split into upper and lower working areas, the scheduling took on a different appearance. The tasks were broken down into smaller units. This proved valuable in that the quantity of work delivered was easier to measure resulting in greater control of the progress. Daily progress reports were e-mailed through to Corporate Office and to the Mine Manager.
### ELAND SHAFT REHABILITATION - PROJECT FINANCIALS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>ORIGINAL ESTIMATE</th>
<th>FINAL COST</th>
<th>VARIANCE ORIGINAL vs. FINAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURFACE WINDERS</td>
<td>R 500,000.00</td>
<td>R 487,013.29</td>
<td>-R 12,986.71</td>
</tr>
<tr>
<td>CONTRACTORS</td>
<td>R 5,856,000.00</td>
<td>R 4,071,222.60</td>
<td>-R 1,784,777.40</td>
</tr>
<tr>
<td>WORKSHOP ORDERS</td>
<td>R 2,070,840.00</td>
<td>R 5,197,578.68</td>
<td>R 3,126,738.68</td>
</tr>
<tr>
<td>SURFACE BUILDINGS</td>
<td>R 792,251.00</td>
<td>R 1,094,172.25</td>
<td>R 301,921.25</td>
</tr>
<tr>
<td>MAIN SHAFT (EXCL. STORES &amp; W/S ORDERS; INCL. PSO'S)</td>
<td>R 740,160.00</td>
<td>R 1,019,912.35</td>
<td>R 279,752.35</td>
</tr>
<tr>
<td>PROTO</td>
<td>R 600,000.00</td>
<td>R 255,936.06</td>
<td>-R 344,063.94</td>
</tr>
<tr>
<td>CONSULTANTS PROVISION</td>
<td>R 200,000.00</td>
<td>R 282,229.03</td>
<td>R 82,229.03</td>
</tr>
<tr>
<td>OVERTIME</td>
<td>R 1,138,997.00</td>
<td>R 1,636,320.49</td>
<td>R 497,323.49</td>
</tr>
<tr>
<td>SUB SHAFT (EXCL. STORES &amp; W/S ORDERS)</td>
<td>R 654,500.00</td>
<td>R 492,129.00</td>
<td>-R 162,371.00</td>
</tr>
<tr>
<td>INFRASTRUCTURE (EXCL. STORES &amp; W/S ORDERS)</td>
<td>R 110,000.00</td>
<td>R 24,641.98</td>
<td>-R 85,358.02</td>
</tr>
<tr>
<td>CONSUMABLES (EXCL. PSO'S)</td>
<td>R 1,900,000.00</td>
<td>R 3,572,673.51</td>
<td>R 1,672,673.51</td>
</tr>
<tr>
<td>SPECIAL BONUS</td>
<td>R 710,000.00</td>
<td>R 710,000.00</td>
<td>R 0.00</td>
</tr>
<tr>
<td>CATERING &amp; TRANSPORT COSTS</td>
<td>R 0.00</td>
<td>R 72,246.86</td>
<td>R 72,246.86</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>R 15,272,748.00</strong></td>
<td><strong>R 18,916,076.10</strong></td>
<td><strong>R 3,643,328.10</strong></td>
</tr>
</tbody>
</table>

### COMMENTS

- Steelwork for plug and divertors underestimated from original conceptual sketches: R 3,127,000.00
- Savings on Contractors, Proto and Sub-shaft: -R 2,106,789.00
- Further serious deterioration of the Escom supply and consumer sub-stations: R 300,000.00
- Underestimated on Design costs due to extra fabrication: R 81,000.00
- No original estimate for catering & transport costs: R 72,000.00
- Original workload underestimated thus overtime exceeded provision: R 497,117.00
- Stores items previously not included in final estimate: R 1,673,000.00

**TOTAL** R 3,643,328.00

Table 2
Financial overview
CONCLUSION

The success of this project can only be attributed to extremely hard work and very intensive planning. The contribution of Corporate Office was extremely valuable. Another important factor was the team spirit between Shaft Sinkers and the Engineering department on Eland Shaft. The Engineering department must be congratulated on their excellent achievement in bringing the shaft in operation 1 week ahead of schedule.

ACKNOWLEDGEMENTS

Thanks and appreciation are extended to AngloGold for permission to publish this paper, and for their contributions and assistance in its preparation to

- Harold Storbeck (Shaft Engineer)
- Dr Gerrie van Aswegen (ISS)
- Pieter Verster (MTE) and my colleagues at Matjhabeng