

# The implementation of Nos. 16 and 20 shaft projects

L.A. JAGGER  
*Impala Platinum*

The world's second largest producer of platinum, Impala Platinum Ltd, approved two new twin shaft projects at the end of September 2004, Nos. 16 and 20 Shafts. Both shaft projects are stand-alone entities and are being sunk from surface.

Previously Impala had embarked on a strategy of extending the life of its third generation shafts by means declines. No. 16 Shaft is the first of a new fourth generation shaft complex, while No. 20 Shaft is the last of the third generation type shafts in the so-called shallow to intermediate mining zone.

This paper details the basic designs of each project and covers the initial implementation. Although both projects are twin shaft systems, the access methods from the shafts to the reef horizon differ. Initiatives implemented to speed up the projects are also briefly covered.

## Introduction

Impala Platinum Ltd approved two new shaft projects at the end of September 2004, Nos. 16 and 20 Shafts. Both shaft projects are stand-alone entities and are being sunk from surface. No 16 Shaft is located in the south-east of the Impala lease area, while No 20 Shaft is located in the north-west.

Previously Impala had embarked on a strategy of extending the life of its third generation shafts by means of declines. No. 16 Shaft is the first of a new fourth generation shaft complex, while No. 20 Shaft is the last of the third generation type shafts in the so-called shallow to intermediate mining zone.

This paper details the basic designs of each project and then covers the implementation of each project, from approval of the projects and up to the end of May 2006—a period of about 20 months.

## No. 16 Shaft project

### Location

No. 16 Shaft is located in the south-east corner of the Impala mining lease down-dip of No 1 Shaft. The project incorporates an area approximately 4.5 km on strike and 2.4 km on dip and represents ground which will be officially classed as being 'intermediate' i.e. > 1 000 metres below surface.

The up-dip boundary is determined by the future mining activities at No 1 Shaft and for part of the Merensky block by a seismically interpreted fault with a down-throw displacement to the west. The down-dip boundary is defined by the current mine design, i.e. the reef contours for 27 level (-2 269 meters below datum). Part of the southern boundary borders the Anglo Platinum operations on the farm Paardekraal 279 JQ and the northern boundary is currently limited to 18 km on strike from the proposed No. 16 Shaft position.

### Geology and reserves estimates

The 16 Shaft mining block is underlain by the pyramid gabbro-norite (main zone) and the mathlagame norite-anorthosite (critical zone), of the Rustenburg layered suite of the Bushveld Complex. The Merensky Reef and the UG2 chromitite layer located in the upper critical zone are the two economic horizons exploited within the Impala lease area.

Geological interpretations and the projection of structures across the area of interest have been primarily derived from geophysical and three-dimensional seismic interpretations and confirmed by superimposing exploration boreholes onto the seismic volumes.

Both the Merensky Reef and UG2 chromitite layers strike in a NW-SE direction and dip angles to the east vary between 8° and 12°. Except for isolated areas between faults the strike is relatively uniform. The vertical separation between the reef planes averages 111 metres and ranges from 127 to 93 metres due to faulting, potholing and thickness variations on strike and dip.

### Seismic reinterpretations

Advanced geoprocessing software, applied by Leeds University, enabled Impala to retrieve additional value from its original data, without the need to resort to costly root-and-branch seismic reprocessing. The techniques were used in conjunction with underground geological mine plans to interpret and three-dimensionally map faults with < 10-metre fault displacements.

### Faults and fault zones

No major faults (displacement >10 metres) were intersected during drilling. This is not surprising as three-dimensional seismic interpretations were used to guide the selection of borehole sites in the field. The majority of these structures strike in a NNW-SSE, NW-SE and N-S direction, with the NW-SE orientation being the most prominent. The faults

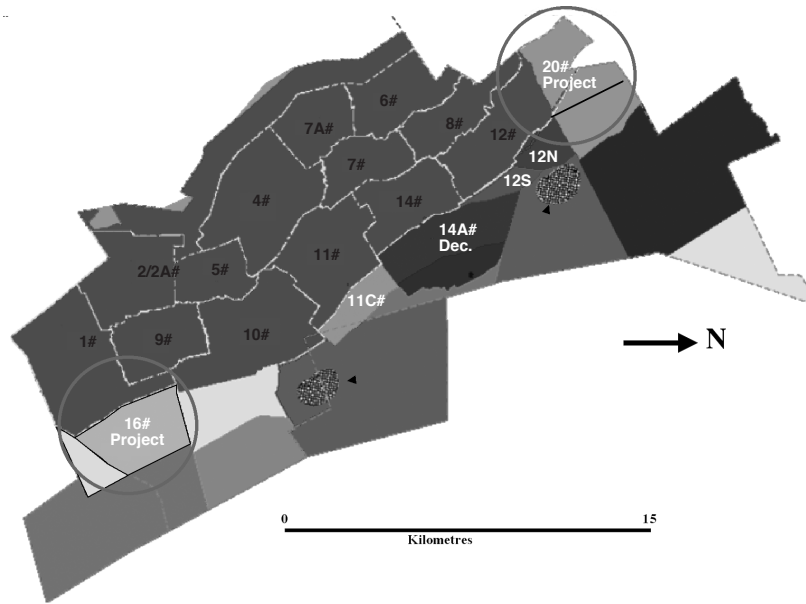


Figure 1. Location of No. 16 and No. 20 Shaft within the Impala lease area

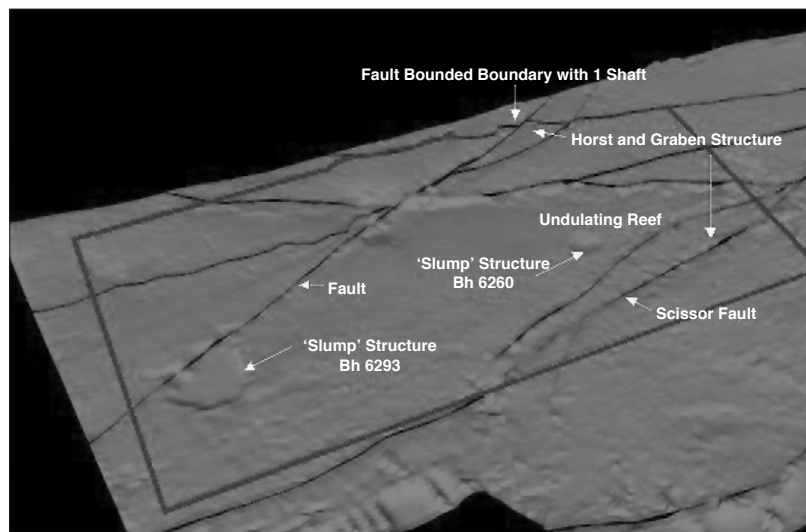


Figure 2. Three-dimensional seismic survey

have a near vertical inclination and there appears to be no preferential dip direction. The 3-D seismic model depicted in figure 2 indicates major features.

**Dykes**

Three prominent dolerite dykes traverse the No. 16 Shaft block. The estimated/recorded thickness range from 30 to 50 metres and the dips of the structures are predominantly near vertical. The intrusions do not appear to displace the economic horizons.

Some boreholes intersected lamprophyre dykes at various stratigraphic levels. The borehole thickness of these ranged from a few centimetres to approximately 35 metres, but commonly averaged less than 1 metre. Lamprophyre dykes are common features across the Impala lease area and are characterized as being friable intrusions, which intruded zones of weakness such as faults and joints.

**Table I**  
Resources and reserve estimates No. 16 Shaft

Economic horizon	Resource tons (t)	Reserve tons (t)	Reserve grade (g/t)	Reserve metal content (kg)
Merensky	17 625 882	23 904 119	4.22	100 849
UG2	15 924 895	23 654 274	4.02	95 033
<b>Total</b>	<b>33 550 777</b>	<b>47 558 393</b>	<b>4.13</b>	<b>195 882</b>

**Mining**

No. 16 Shaft is planned to produce 226.5 ktpm per month of reef from seven operational levels, as shown in Figure 3. The levels will access both the Merensky and UG2 reef horizons, with the emphasis being on mining the Merensky Reef. Waste production is planned at 13% of reef production. The mining calendar is based on 23 days per month for development and stoping.

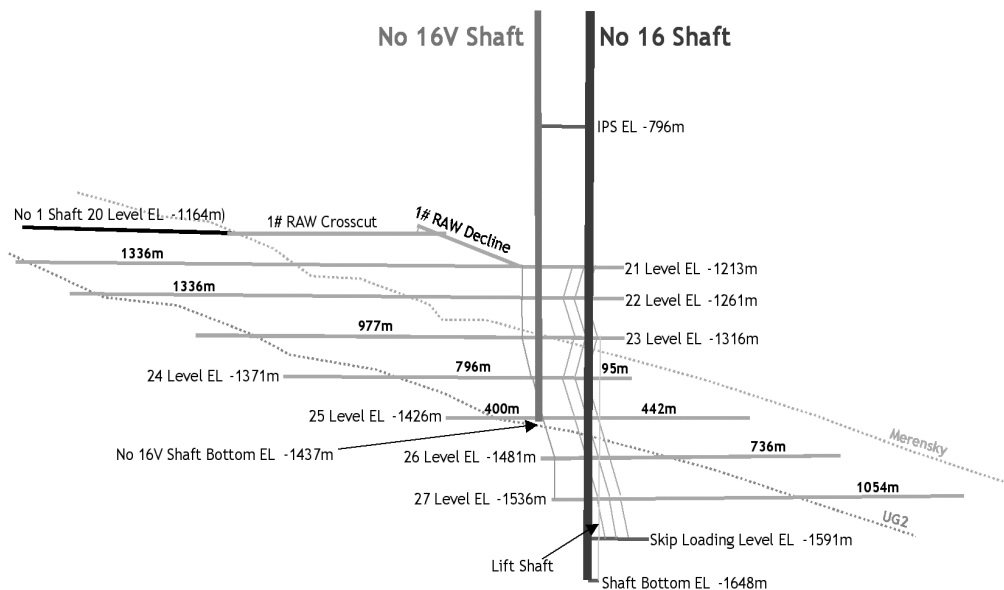


Figure 3. No. 16 Shaft project cross-section

The man/material and rock hoisting shaft, No 16 Shaft, will be a 10.0 m diameter (inside concrete lining) shaft sunk to 1 648 metres below surface. The shaft will also be the main down-cast ventilation shaft, with some additional down-cast ventilation being supplied from the existing No 1B Shaft. The shaft support system will be confirmed from actual ground conditions encountered during sinking, but the CBE is based on support pattern 5, the most conservative of the support patterns. Ventilation air will be up-cast through No. 16 V shaft and via No. 1A Shaft. No. 16V shaft will be a 6.8 m diameter (inside concrete lining) shaft, sunk to 1 437 m below surface.

No. 16 Shaft will have seven double 'D' stations, an intermediate pump station, main pump station and skip loading facility. Service water will be clarified in two vertical high rate settlers.

Separate ore passes will be raise-bored for each reef type and waste. The ore passes from the lowest level, 27 level, to the loading level will be lined. Above 27 level the ore passes will be lined only if ground conditions so dictate

Cross-cuts to reef will be developed and from there strike drives developed below the plane of each reef. Travelling ways and box holes will be developed to reef and two winze and raise connections, on reef, per half level per reef type included in the capital battery limits of the project.

Stoping equipment and rolling stock will be provided. No allowance has been made for spares, which must be provided from existing operations.

### Mining method

Stoping will be by conventional double-sided breast mining in accordance with Impala best practice. Face panel length will be 28 m and 24 m for Merensky and UG2 respectively, with panels being separated by 6 x 3 m grid pillars with 2 m ventilation holings. Stopping width will be 1.0 m and 0.86 m for Merensky and UG2 respectively.

Stope face drilling will be by hand-held pneumatic rock drills and air legs. Stopping will be based on achieving 18 blasts per month, with a single timed blast per day. Stopping advance is based on achieving 0.86 m per blast, utilizing 1.2 m drill steel.

Stope cleaning will be by electrical scraper winches (37 kW face units, 55 kW strike units and 75 kW central dip gully units).

Development will be by conventional means (hand-held drilling, rocker shovel loading, etc.).

### Mine layout

The Merensky and UG2 layouts are designed to produce 124.5 ktpm and 102 ktpm of reef respectively. Access to both reef planes will be via main cross-cuts and strike footwall drives. Rock will be transported to No. 16 Shaft via a conventional tracked system, in the cross-cuts and strike footwall drives.

Development of 21 to 24 levels will be done from No 16 V Shaft, prior to commissioning of No. 16 Shaft. This will ensure rapid tonnage build-up soon after the completion of No. 16 Shaft. With the early development of the first four levels from No. 16 V Shaft, an opportunity also exists for early production from No. 16 V Shaft. The No. 16 V Shaft headgear will be designed to allow future conversion to a rock hoisting system

A lift shaft will be installed between 23 level and shaft bottom, allowing man/material access to the lower levels and shaft bottom during equipping of No. 16 Shaft. This innovation results in a significant saving on the overall schedule.

### Rock engineering

No. 16 Shaft is the first of the fourth generation shafts and represents a change from the well-understood shallow environment (<1 000 m depth) to the intermediate environment (>1 000 m depth). Typical characteristics of the intermediate environment include variable induced stress concentrations, associated stress-driven fracturing and excavation failure. Experience in this environment is limited within the Bushveld Complex.

Rock engineering design parameters have been reviewed on an ongoing basis, both internally and by outside consultants. The process culminated in a mine design that takes cognisance of the relevant geoscientific issue and is premised on conservative rock engineering design parameters.

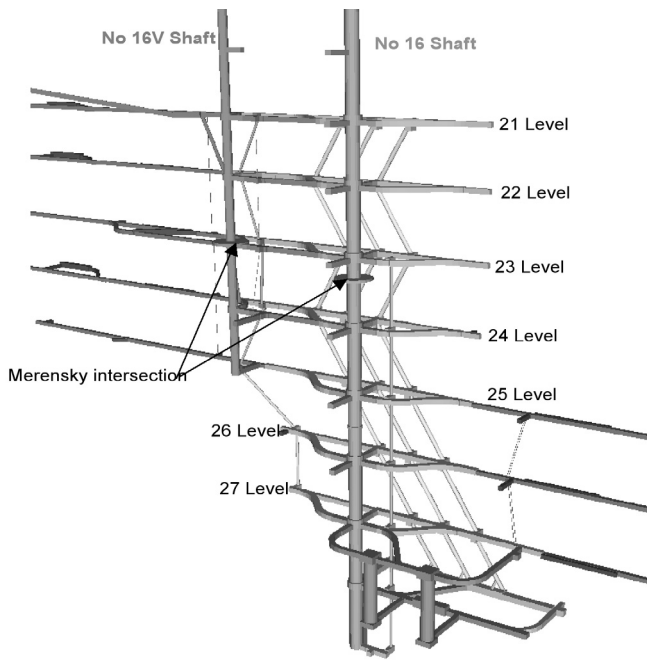


Figure 4. Isometric view of mine layout and shaft infrastructure

## Ventilation and refrigeration

### Ventilation and refrigeration system

Global vent/cooling balances have been evaluated, utilising the proprietary VUMA software. For the design year of 2028, when strike distances are about 1 800 m out (north and south), the global mine energy balance is satisfied if the total primary ventilation of 900 kg/s is cooled to 4°Cwb on surface. This relates to an overall flow factor of 3.6 kg/s per ktpm of rock (reef and waste).

Carrying capacity of No. 16 Shaft is limited by maximum design air speeds of 10.5 m/s for conveyance stability. Furthermore, the ventilation design is premised on synergies with neighbouring No 1 Shaft. The up-cast air

flow requirement of 900 kg/s will be achieved by up-casting 650 kg/s via No 16 V Shaft and 250 kg/s via No 1A Shaft.

Virgin rock temperatures (VRT) will vary from 49°C (21 level) to 57°C (27 level) resulting in a total refrigeration requirement of 40 MW. 30 MW of the total 40 MW refrigeration requirement will be provided from the No. 16 Shaft refrigeration plant, while the remaining 10 MW will be supplied from No. 1B Shaft.

The ventilation and cooling system design will incorporate high degrees of flexibility; modular systems will be applied, which can be phased in with maximum delay in capital expenditure. In addition, the refrigeration system will allow cooling carrying capacity of the down-cast shaft to be maximized. Recent studies at Impala have highlighted the benefits of using systems with ultra-cold air for deep workings. This led to the first system being installed and successfully operated at No. 1B Shaft. The system is based on making very cold water, which will comprise base-load equipment prechilling water prior to delivery to an ice/thermal storage dam containing tube banks. Ice forms on the outside of the tubes during the cold part of the day and then melts during the critical warm part of the day. This principle allows design of the system for average rather than peak loads, leading to significant capital cost savings. The refrigeration plant at No. 16 Shaft will have an installed capacity of 24 MW, utilizing an ice making plant, similar to that used at No. 1B Shaft. The plant will comprise four refrigeration modules, identical to standard Impala refrigeration modules. Cold water will leave the system at temperatures close to 0°C.

The chilled cold air will be distributed to the stopes via an on-reef airway on the Merensky Reef horizon and cross-cuts on levels 24 to 27, as shown schematically in Figure 5. Ventilation air will be returned to No. 16 V Shaft via the stopes to strike reef drives, cross-cuts and dedicated on reef return airway (RAW). As ventilation requirements increase at No. 16 Shaft and decrease at No. 1 Shaft, down-cast air will be increased from 700 kg/s to 900 kg/s, utilizing No. 1B Shaft. Up-cast capacity will be increased utilizing No. 1A Shaft.

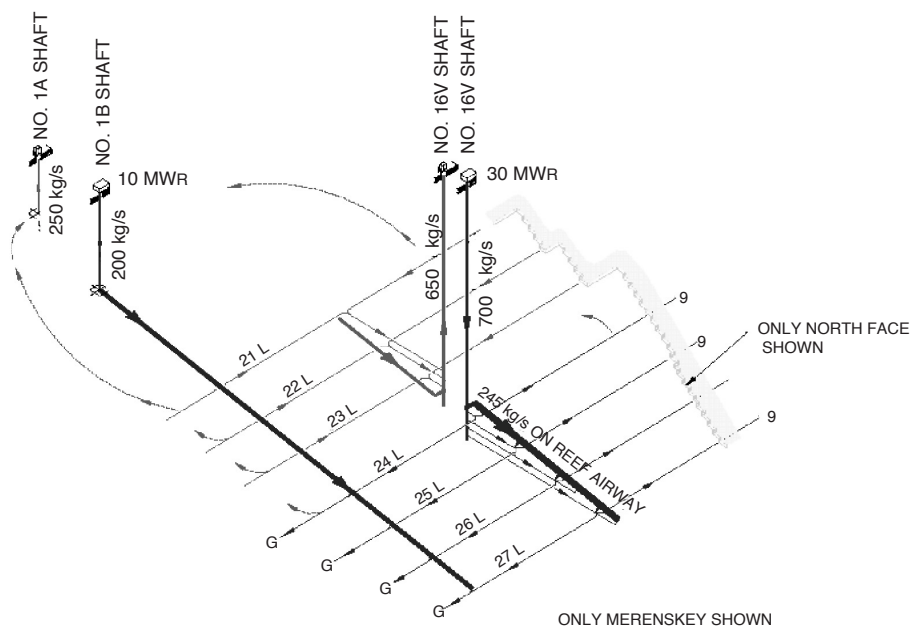


Figure 5. Schematic representation of ventilation distribution system

## Mine engineering and systems

A concrete headgear, 106 metres high, will house two Koepe winders that have been designed to be identical mechanically, including rope specifications. The one winder will hoist personnel and material and the other winder rock. A ground mounted double drum winder will be provided as a service winder. The permanent operating shaft configuration is shown in Figure 6.

The rock hoist tipping arrangement will be located inside the concrete headgear to minimize noise pollution. A conveyor will transfer reef and waste from the headgear bins to a transfer tower, from where reef will be transferred into two concrete silos (one for Merensky and one for UG2). Waste will be transferred from the transfer tower to the waste rock dump and deposited by a spreader conveyor system. The reef transfer and storage system has been modelled in conjunction with the ore transport network on surface to confirm storage capacities.

Two of Koepe winders utilizing integrated motor technology with DC link converters will be installed in the concrete headgear for permanent rock and man winder duty. Each system will feature four head ropes, 54 mm diameter 1 470 MPa full lock coil rope type.

Rock winder duty is specified as:

- 25 ton payload
- 1 632 m length of wind
- 16 m/s rope speed
- 6.5 m drum diameter
- A motor duty cycle RMS rating of 4 815 kW.

Man winder duty is specified as

- 22.5 ton payload (300 persons)
- 1 591 m length of wind
- 16m/s rope speed
- 6.5 m drum diameter
- A motor duty cycle RMS rating of 2 536 kW.

Trains, comprising 10-ton locomotives and 6-ton hoppers will haul rock from the stope ore passes to the tip/ore passes, located in the main cross-cuts on each level. Merensky, UG2 and waste ore passes are provided to allow unencumbered transport of reef and waste through independent systems.

Ore passes will feed onto a transfer conveyor, located on the skip loading level. The transfer conveyor will discharge onto a loading conveyor, which feeds either of the two rock hoisting skips. The loading conveyor will be controlled to discharge rock into the empty skip at a slow rate initially, accelerating to full speed achieving a 15 s loading pause. This control philosophy will ultimately improve rope life and reduce overall maintenance costs.

## Surface infrastructure

Permanent power requirements will be met from a new ESKOM 88/33 kV 2 x 40 MVA substation at No. 16 Shaft fed by two 88 kV overhead lines from existing ESKOM 88 kV yard at No. 15 shaft. The permanent Koepe rock and man/material winders will be fed directly from the main intake 33 kV switchboard. Other load centres will be fed at 6.6 kV. Maximum demand at 33 kV is estimated to be some 35 MW.

Potable water will be supplied from the storage reservoir at the UG2 koppie.

Compressed air will be generated on the bank area, with an overland pipeline connection to the Impala main reticulation system.

An automatic telephone exchange will be installed at No. 16 Shaft, with tie-lines to the main Impala exchange

All sewage will be collected and pumped to the sewage plant at No. 2 Shaft.

A tarred access road will be built, while roads at the shaft complex and on the terrace will be gravel.

Surface electric locomotives and 50-ton hoppers will transport ore from the storage silos adjacent to the shaft to the receiving bins at either the main processing plant or the UG2 plant.

Security fencing will be provided around the shaft complex with an additional security fence around the cable yard.

A single gatehouse will be provided and laid out with entry and exit roadways to facilitate the flow of vehicles. The entire traffic system is designed to eliminate the requirement for pedestrians to cross roads.

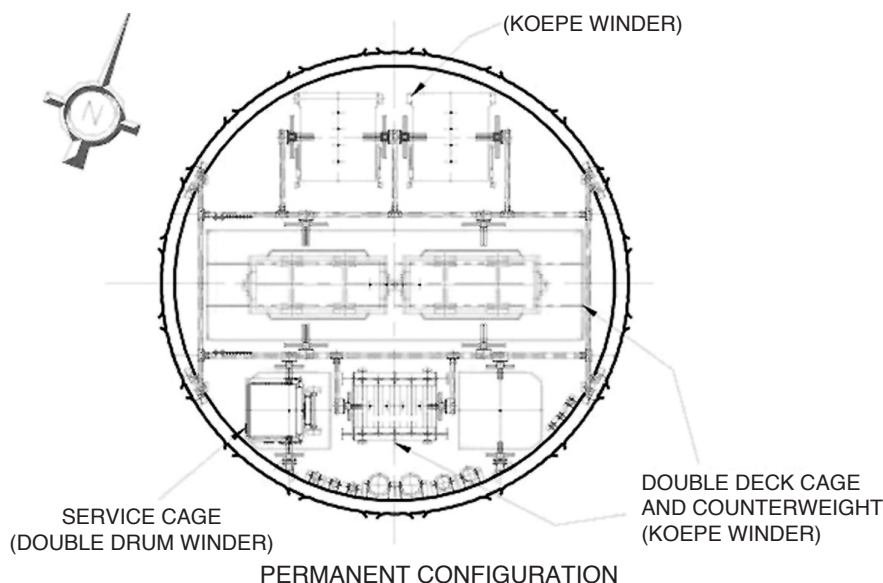


Figure 6. No. 16 Shaft permanent configuration

The bank area has been laid out to allow for easy rope changing, using a mobile heavy duty friction winch.

### Capital cost

Capital cost for the project is estimated at R2 561 115 at base date of June 2004, escalated to R3 650 000 at completion of the project.

### Project programme

The project master programme was derived from first principles, based on the experience of the project teams. Input was also obtained from contractors as and where required and reviewed both internally and externally. Key dates from the programme are summarized in Table II. The programme was extensively reviewed internally and through a third party audit.

### Project implementation

Project execution is by a conventional engineering, procurement and construction management (EPCM) contractor, overseen by a relatively small Impala owner's team.

The project is currently ahead of schedule and under budget.

Subsequent to the project approval, the following initiatives assisted to speed up the programme:

- An early start was made on the ventilation shaft sinking by employing the shaft sinking contractor's winders for sinking in preference to purchasing new winders as had been planned and budgeted
- By doing the initial presink to the collar position of the main shaft by means of a box-cut and six wheeler vehicles in preference to conventional sinking an earlier start could be made on the presinking operation
- Employing a putzmeister concrete pump to pump concrete vertically up the headgear during construction in preference to the conventional crane and 'shoe' arrangement resulted in an earlier start on the main shaft sinking operations.

## No. 20 Shaft project

### Location

The No. 20 Shaft project is located north of No.12 Shaft on the north-west corner of the Impala mining lease area on the farms Boschkoppies 104JQ and Goedgedacht 110JQ. The project incorporates an area approximately 3.0 km on strike and 3.5 km on dip and represents the last remaining reserve within the current mining lease area that can still be classified as being shallow i.e. less than 1 000 m below surface.

**Table II**  
Key dates No. 16 Shaft

Activity	Start	Complete
Approval to first production	01/10/2004	17/08/2011
Ramp-up to full production	17/08/2011	31/10/2014
<b>No 16 Shaft</b>		
No 16 Shaft Main Sink	03/05/2006	25/06/2010
No 16 Shaft Equipping	28/06/2010	06/03/2011
<b>No 16 V Shaft</b>		
No 16 V Shaft Headgear	20/09/2006	31/03/2006
No 16 V Shaft Main Sink	03/04/2006	14/10/2008

### Geology

The No. 20 Shaft mining area is underlain by the pyramid gabbro-norite (main zone) and the mathlagame norite-anorthosite (critical zone), Rustenburg layered suites of the Bushveld Complex. The Merensky Reef and the UG2 chromitite layer located in the upper critical zone are the two exploitable economic horizons within the lease area.

Geological interpretations and the projection of the complex structures across the mining area have been primarily derived from geophysical and 3D seismic interpretations and confirmed by superimposing exploration boreholes onto the seismic lines, directly affecting the calculation of reserves.

Analysis of this information has revealed a complex structural regime for the No. 20 Shaft area.

Both the Merensky Reef and UG2 chromitite layer strike in a NW-SE direction and dip to the east (between 2° and 12° ) to an elevation of 1 177 mbc (metres below collar) and 1 237 mbc respectively. These variable dips and the rolling nature of the reef horizons are primarily responsible for the irregular reef contours. The vertical separation averages 65 m and ranges from 27 m to 92 m due to faulting, potholing and thickness variations on strike and dip.

### Mining access

The shaft system will comprise an 8.5 m diameter (depth 1 051 m) downcast, man, material and rock shaft together with one upcast ventilation shaft of 6.5 m diameter (depth 977 m). These shafts are strategically positioned, relative to the orebody, to access each of two reef planes by establishing a triple decline system.

The main shaft will provide capacity to hoist up to 241 000 tons per month of ore and waste. The ventilation shaft will transfer 650 kg/s of refrigerated air to the workings.

A multiple decline access system parallel to the plane of the reef has been proposed to provide men and materials access, rock handling and logistical services to production. This access system was chosen to accelerate the time to full production.

The conventional rail bound rock transport system, positioned in the footwall below the reef on each mining level will provide reliable, cost-effective production performance. This system provides some flexibility to negotiate the frequent reef displacements caused by faulting. Operational and maintenance skills are available at existing Impala operations for rail haulage.

A footwall decline situated close to the central axis of the reserves, equipped with a high capacity conveyor will transfer rock from the haulage ore passes to the rock loading facilities at the hoisting shaft. Surface silos will store the rock for loading to the surface rail system for delivery to the concentrator.

**Table III**  
Resources and reserve estimates No. 20 Shaft

Economic horizon	Resource tons (t)	Reserve tons (t)	Reserve grade (g/t)	Reserve metal content (kg)
Merensky	20 880 011	23 002 047	3.77	86 748
UG2	9 457 619	15 117 785	3.15	53 023
<b>Total</b>	<b>30 337 630</b>	<b>38 119 832</b>	<b>3.67</b>	<b>139 771</b>

## Mining method

The proposed mining method is essentially a system combining conventional mining and support methods in the stopes and footwall drives as on existing shafts, and mechanized mining methods in the decline development. This system makes use of conventional hand-held rockdrills for the drilling and blasting cycle with scraper winch cleaning on stoping, and conventional tracked locomotive and loader cleaning and tramming to ore passes on strike footwall drives.

The envisaged mining method has been selected for No. 20 Shaft for the following reasons:

- rapid access, improved logistics and ramp-up to full production
- provision of an early exploration platform for more detailed orebody definition within the ramp-up phase
- rapid reestablishment ability on strike beyond geological discontinuities
- lower technical and financial risk with proven equipment and good cost information availability from current operations at shallow depths.

## Mine layout

The Merensky and UG2 mining layouts are each designed to produce 185 ktpm of ore. Access to the two reef planes will be via two material declines positioned between the Merensky and UG2 reef planes. Rock will be transported to the shaft via a conveyor system in a third decline located below the UG2 plane.

The two material declines are initially developed 5 m wide by 4 m high to provide adequate ventilation for establishment of the capital footprint. Subsequently they will be reduced to 4.5 m wide by 4.0 m high. The declines will be 15 m apart with connecting splits. One decline will have a chairlift and overhead monorail installed.

The conveyor decline will be developed 6.3 m wide by 3.3 m high, allowing for trackless vehicle access alongside the conveyor (for conveyor decline development and maintenance purposes).

Footwall drives will be developed on strike at 1:200 gradient and 18 m below the reef plane, using conventional tracked locomotive and loader techniques.

The reef true dip is 8° and the declines will be developed at an apparent dip averaging 6.5°.

The strike footwall drive dimensions will be 3.5 m wide and 3.3 m high.

Within the capital footprint, the initial on reef development will enable a quicker ramp-up to full production. When the full capital footprint is established, this development will convey ventilating air in sufficient quantities to the workings in block B and return the contaminated air to the ventilation shaft from block A. The future reef access raises are developed parallel to the dip fault bracket pillars. The ASGs are developed from these reef raises and kept within 2.5 m to 3 m ahead of the breast panels.

Each stope connection on the Merensky plane will serve on average seven stope panels of 30 m open span including the ASG.

In-stope drilling will be by pneumatic rock drills and air-legs using 1.5 m drill steel followed by conventional scraper winches cleaning. The raises are expected on average to have true dip back lengths approaching 200 m between strike footwall drives with a dip gully scrape of around 165 m.

## Rock engineering

The regional support system is a combination of fault bracket pillars, potholes and replacement pegmatoid bodies designed to compartmentalize the mine and eliminate plug failure. These regional support pillars in conjunction with yielding in-panel grid pillars stabilize the stope hanging-wall up to the bastard Merensky parting plane or UG2 leaders.

The No. 20 Shaft regional support pillars are strike and dip orientated, incorporated into the fault bracket pillars at various intervals not exceeding 400 m on strike. The pillars have been designed using numerical modelling.

The off-reef material and conveyor declines (dip orientated) and footwall drives (strike orientated) are located deep enough in the footwall to cater for fluctuations and undulations of the reef plane during development and to be unaffected by increased stresses due to stoping.

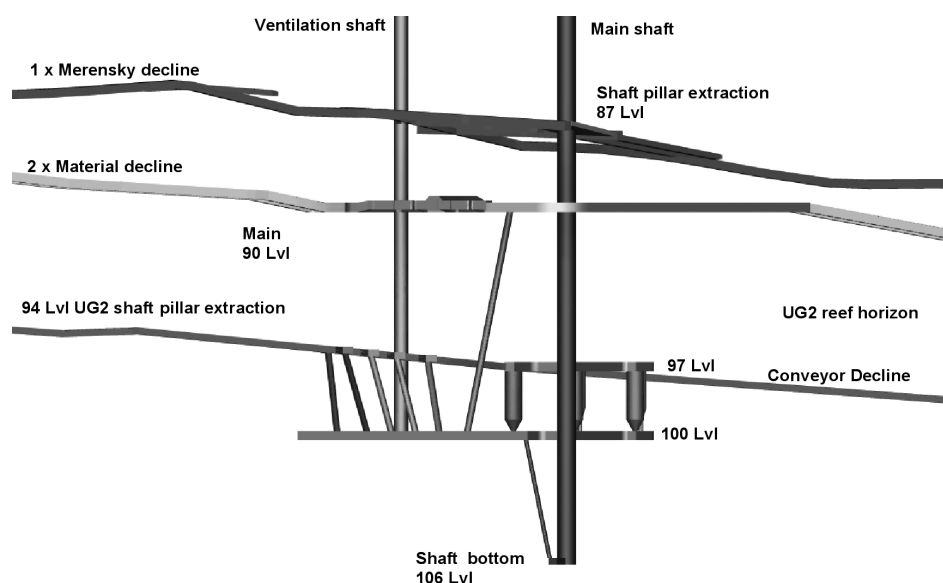


Figure 7. Cross-section of shafts and declines

The main material declines are planned at 30 m below the Merensky reef plane; the Merensky and UG2 conveyor decline is planned at 30 m below the UG2 reef plane. The Merensky and UG2 strike footwall drives are positioned at 18 m below the reef plane.

The need for a shaft protection pillar has been assessed following the conclusion of a numerical modelling evaluation conducted by a specialist external rock engineering consultancy. It has been decided to pre-extract the shaft pillar on the Merensky reef horizon on the main shaft and the UG2 shaft pillar on the ventilation shaft. The Merensky shaft pillar on the ventilation shaft will not be pre-extracted to ensure a sealed return airway and to prevent short-circuiting of intake ventilation. The UG2 shaft pillar will not be extracted as the geotechnical borehole has indicated the reef as being replaced. Further modelling work has been completed to assess the stability of major off-reef excavations such as workshops, pump chambers and airways located near the shaft.

### Ventilation and refrigeration

Bulk cooled air is generated on surface and supplied into the downcast main shaft via sub-bank ducting. The chilled air is distributed to the stopes underground via the main material declines and the strike footwall drives.

A downcast air quantity of 650 kg/s is adequate for the dilution of all air pollutants and contaminants and heat removal during mining. The required quantity of air is most sensitive to the mine reject wet-bulb and dry-bulb temperatures and the virgin rock temperature (VRT) at which mining is taking place.

The principal ventilation infrastructure (shafts and airways), will be fully utilized when full production is attained. Little or no residual ventilation capacity will be available to increase production beyond 185 ktpm of ore.

The requirement to downcast 650 kg/s of fresh air results in a full production air factor of 3.2 kg/s per ktpm of rock broken.

The workings are ventilated by a semi flooding type ventilation system and the return air is exhausted up the ventilation shaft, from the stopes, via a combination of strike footwall drives from block B and the on-reef Merensky access decline from block A. This on-reef decline is used to accelerate the early tonnage build-up.

Mining is divided into four geographical ventilation districts. Air will intake on the footwall located material declines in both a western (up-dip) and eastern (down-dip) direction to the furthest two or three strike footwall drives from where it will flow to the working faces north and south. The aim is to introduce, on the production levels in block B, furthest from the shaft complex, as much fresh air as possible. The in-stope dip ventilation controls will be the blast barricades, and single and double ventilation curtains. Velocities in excess of 1.0 m/s are envisaged at about 3 m from the stope faces. The air will flow up dip along all the stope faces and return down dip in the worked out areas and the on-reef access decline to the upcast ventilation shaft.

Air velocities in the downcast and upcast shafts, at collar elevation, are calculated at 11.5 m/s and 19.9 m/s respectively.

The collar and sub-bank shaft air intake is capable of handling 650 kg/s. Of this amount up to 600 kg/s will pass through the bulk air cooler and the balance of 50 kg/s through the collar from the bank area.

Cooling infrastructure for the mine will be created in two phases, with first cooling required in about 2010. Full

production will be reached by 2011, at which time 550 kg/s of chilled air will be required. The need for cooling gradually increases as production progresses further away from the shaft complex and to greater depths. In the period 2020 to 2025 the refrigeration machine capacity requirement will be about 22 MW(R). Merensky mining will be to a depth of 1 177 mbc at a VRT of 49.8°C. UG2 mining will be to a depth of 1 237 mbc where the VRT is 51.2°C

### Shaft infrastructure

The permanent headgear will be a 50 m high steel A-frame type structure (450 tons) serving three winders (rock, man/material, service) using five compartments in the main shaft (twin skips, cage and counterweight, and single service cage).

The rock hoist tipping arrangement in the headgear will have a transfer bin with a storage capacity of approximately eleven skip loads. Conveyors will remove hoisted rock on a continuous basis to either of two concrete storage silos or beyond to the waste rock dump.

Rock hoisting skips will be of the bottom discharge type with a payload of 15 tons.

The man/material compartments will be serviced by one large single deck conveyance capable of handling 150 persons per trip or a low profile LHD with a mass of up to 15 tons. The single service conveyance will comprise two decks with a capacity of 11 persons per deck.

### Winders

The rock winder will be of the double drum type with a winding speed of 15 m/s and a hoisting capacity of 450 tons per hour (tph). Hoisting will take place six days per week with an availability of 75% and utilization of 95%. The winder will operate automatically but facility for manual operation will be provided.

The man/material winder will also be of the double drum type with a winding speed of 12 m/s and a single deck cage with capacity of 150 persons or 15 tons payload. The winder will be operated manually.

The service winder will be of the single drum type with a winding speed of 7 m/s and a double deck cage (22 persons). The winder will be operated manually.

### Underground rock handling

Trains, comprising of 10 ton locomotives and 6 ton hoppers will haul the rock from the stope ore passes to the station tips above the conveyor decline. The rock is conveyed to the shaft rock handling system consisting of surge ore and waste passes and skip loading transfer conveyor. Reef and waste will be handled separately by campaign.

The Merensky and UG2 conveyor decline, located in the footwall of the UG2 reef horizon, will convey ore to the shaft. Shuttle conveyors at the discharge of the conveyor decline will transfer ore or waste to their respective passes. These conveyors will be 1 200 mm wide, and designed to handle 600 tph.

The loading station conveyor (126 m long) will be 1 200 mm wide, designed to run at a speed to match the winding cycle, and loading 15 ton measuring flasks for transfer of rock to the skips for hoisting to surface.

Ore feeding onto the conveyors from the ore passes will be controlled by chutes and gates operated by compressed air cylinders. Vibrating feeders will control the flow rate.

LHDs and drill rigs will be used for infrastructure and decline development. Air loaders will be used for development in the strike footwall drives.

### Materials handling

Shaft service vehicles include forklifts, small cranes, shunters, material cars and delivery vehicles. Transport from the surface to underground will be undertaken using material transport cars.

Material handling on the main level is facilitated by a material loop to access shaft conveyance from both sides.

The material transport cars will be marshalled on the main access station for distribution to production levels via the monorail system. Forklifts will be used to load and unload pallets with material. It is expected that further work will be done on materials handling to optimize the final design during the detailed design phase.

A number of LHDs, drill rigs and rock bolters will be used to develop the declines, supported by a fleet of utility vehicles.

Mono winches will be used for transporting supplies into the stopes.

Personnel transporters will be available at shift times and for use by maintenance personnel.

A chairlift will be installed to transport men to the extremities on dip, while travelling on strike will be by foot.

### Underground workshop and store

A centralized workshop will provide for all services and repairs to all vehicles underground. The workshop will be situated close to the main shaft and underground main store.

The satellite service and battery bays will be established on each level to limit the number of production vehicles travelling long distances for servicing.

Drill rigs and roofbolters for decline development will be serviced in a bay close to the respective workplaces. Major repairs and overhauls will be done in the main workshop on the main level.

Maintenance stock levels will be kept underground instead of on surface. Availability to the user should be quick without having to lose a shift waiting for components from the surface store.

Bulk items for production will remain on the normal order and delivery from surface, as is the usual practice.

### Services piping

Service and potable water are supplied from surface to the respective production sections in blocks A and B via a cascade system utilizing separate pipelines. Water will be supplied from each cascade dam directly to the respective production sections below the dam.

Compressed air generated on surface is supplied to the production section via a column in the main shaft and by pipe through airways/declines up to general services and stoping sections. A connection from the shaft will form a limited ring feed, which will improve air pressures in the production sections.

Mine return water is pumped to surface after being settled underground, for recirculation. Settler underflow is pumped to surface for settling and evaporation in dedicated storage dams. Some water will be returned to the underground working areas.

### Surface infrastructure

The main electrical power supply will be taken from the ESKOM substation at 33 kV. The supply will be by overhead lines in a ring formation. Two 33/6.6 kV, 20 MVA transformers will be installed at the No. 20 Shaft consumer substation.

Potable water to No. 20 Shaft will be supplied via a pipeline.

Compressed air will be generated from three centrifugal compressors. An overland pipeline connection to the Impala main reticulation system will be constructed in accordance with Impala's overall compressed air strategy.

An automatic telephone exchange will be installed at the shaft, with tie-lines to the main Impala exchange.

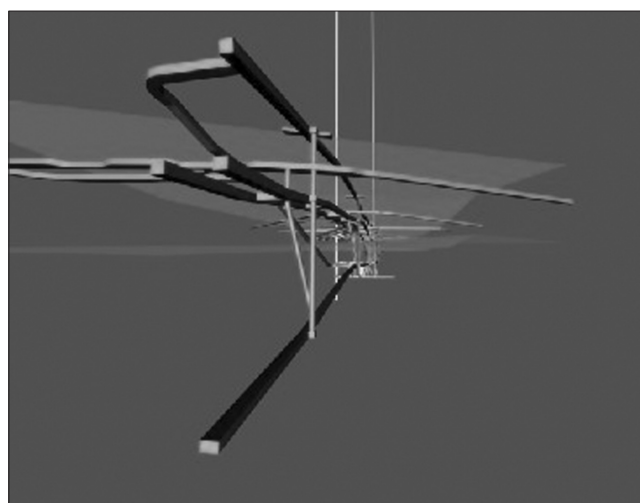
All sewage will be routed to a collection point from where it will be pumped to existing Impala facilities.

A 2.3 km tarred access road will be built, whilst all roads around the shafts and on the terrace will be gravel.

A single gatehouse will be provided and laid out with entry and exit roadways so as to facilitate the flow of vehicles with a minimum of delay and interference with pedestrians. Pedestrian access will be via turnstiles with security badge readers.

**Table IV**  
**Keydates No. 20 Shaft**

Activity description	Start	Finish
Project 'Go Ahead'	01-Oct-04	N/A
Surface terrace construction	13-Oct-04	19-Apr-05
Main shaft collar construction and presink	12-Nov-04	05-Oct-05
Main shaft equipping and commissioning	7-Apr-08	14-Jan-09
Vent shaft collar construction, presink	24-Nov-04	12-Aug-05
Vent shaft headgear installation	09-May-05	07-Oct-05
Vent shaft sinking	08-Oct-05	25-Sep-07
Vent shaft material and conveyor declines and ramps develop	26-Sep-07	24-Nov-08
Vent shaft changeover	25-Nov-08	9-Jan-09
Production start	15-Jan-09	
Full production		15-May-11



**Figure 8. A 3-D depiction of underground infrastructure**

## **Project programme**

### ***Capital estimates***

Capital cost for the project is estimated at R2 088 611 at base date of April 2004, escalated to R3 000 000 at completion of the project.

### **Project implementation**

Project implementation is by a conventional engineering, procurement and construction management (EPCM) contractor overseen by a relatively small Impala owner's team.

The project is currently ahead of schedule and under budget.

Subsequent to the project approval, the following initiatives assisted to speed up the programme:

- By utilizing the synergy from combining the civil and mining contractors, both of whom came from the same parent company, the surface infrastructure preparation could be completed ahead of schedule and the sinking operation commenced ahead of schedule
- An early start was made on the ventilation shaft sinking by employing the shaft sinking contractor's winders for

sinking in preference to purchasing new winders as had been planned and budgeted

- An early start was made on the main shaft sinking by purchasing a secondhand rock winder from a gold mine and employing this as a kibble winder initially, in preference to purchasing a new winder as had been planned and budgeted
- Use was made of the permanent headgear and winder for sinking purposes.

## **Conclusion**

Both projects are progressing ahead of schedule and under budget. At the time of writing (May 2006), the respective shafts had reached the following depths:

20 Ventilation shaft = 843 m

20 Main Shaft = 765 m

16 Ventilation Shaft = 515 m

16 Main Shaft = 225 m

While No. 20 Shaft project has been free of any water, some intrusions have been experienced on both the shafts at No. 16 Shaft project. Normal cementation procedures have been used to seal these as they have been encountered.