DEEP LEVEL GOLD MINING IN SOUTH AFRICA

Where we are, where we’re going

South Africa’s deep level gold mining industry is under the spotlight – a position it has occupied for quite some time. With every passing year the sector’s challenges and operational difficulties continue to escalate, which has seen the world questioning its future. LAURA CORNISH and CHANTELL KOTZE talk to some of the country’s leading mining experts on the subject and present an in-depth look at their views on the industry and what is needed to secure a sustainable future.

THE CHALLENGES OF DEEP LEVEL GOLD MINING

The technical point of view

According to: Dr Declan Vogt, Director: Centre for Mechanised Mining Systems (CMMS) at the Wits School of Mining Engineering

Deep gold mines face three major technical challenges:
- High rock stress – this leads to rock bursts, and can be controlled by careful mine design.
- Heat – this leads to a need for a lot of cooling which is very expensive, typically 20% or more of the total running cost of a mine.
- Distance to the workplace. Our deep mines are also old, so workplaces are far from the shaft, or involve a combination of several shafts, so it takes a long time to get people and materials to the work place. For example, three hours out of an eight hour shift can go to travelling underground.

Against this background, the following challenges also arise:

Pricing

The gold price is set internationally. While it is a balance between supply and demand, there is a lot of gold in storage on surface, so the price is typically more influenced by sentiment and markets. Miners do not control it.

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Given that the price is fixed externally, miners compete on cost. The most cost effective mines are more profitable (or make smaller losses) than those higher up the cost curve. At the moment, roughly 75% of all mining companies have a sustaining cost greater than the current gold price.

Labour

Labour is a major cost, typically about 50% of a typical deep gold mine. At a time when unions are seeking above inflation increases, mines are increasingly aware of the challenge of labour costs.

There is another issue: it is getting hard to attract unskilled labour into mining. Rockfill operators have a critical role in mining as they drill the holes necessary to blast the rock. Their jobs are highly physical, in a hot, uncomfortable environment, so it is becoming harder to attract operators and their average age is rising steadily.

Logistics

The key issue around logistics is the distance from surface to the workplace. In older mines, this may involve the descent of three shafts, then a walk in excess of an hour. There are two immediate consequences: people spend a lot of their shift time in transport instead of productively working; and it is difficult to remedy breakdowns or lack of supplies quickly. Even if needs can be communicated by telephone, it may still be the next day before necessary supplies arrive at the work place.

Power

The price of electricity has soared in the last few years. In a deep level gold mine, electricity is used for ventilation and cooling, and pumping water out of the mine. It is also used for ancillaries such as lighting, and for hoisting rock.

The rock around the tunnels gets hotter with depth so, as mines deepen, they require more cooling; at the same time that the cost of using electricity to do this is getting more expensive. This double whammy is of great concern for mines at present.
And mining challenges associated with this?
In addition to the above mentioned challenges, the reality is that as tunnels become deeper, the weight of the rock above increases, so stresses on the rock increase. As mining goes below current levels, mine designs will have to be reviewed to make sure that there is sufficient support for the weight of the rock above.

The advisory point of view
According to: Andries Rossouw, PWC assurance partner
In the 1980s, gold was South Africa’s most important export commodity, whereas today it is only the fourth most exported commodity after coal, iron ore and platinum.

The long-term decline in gold production is indicative of the ever increasing depths of existing mines, technical difficulties experienced by start-up operations and a continually growing cost base.

Employee costs, including contractors, normally make up more than 50% of total cash cost with utility costs contributing in excess of 10% further. The recent above inflation cost increases for labour and electricity have significantly added to the cost basis and a further weakening in margins.

The weaker rand has resulted in only a 4% average rand/oz gold price increase over the last 12 months. This increase is clearly not sufficient to curb the impact of costs on margins achieved. The low dollar gold price puts further pressure on production as marginal mines are mothballed.

The investment point of view
According to: Daniel Hooijer, KPMG gold commodity expert for South Africa
What do we look for when investing in gold companies? After you have discounted commodity price risk you would probably look at infrastructure, the local economics, regulatory certainty, political stability, all combining to give you an acceptable rate of return.

Let us look at infrastructure in South Africa. On the macro side we have airports, roads and ports. Unfortunately, where we fall short is on stable power supply and water management in the deeper level mines.

The technical consulting point of view
According to: William Joughin, partner and principal mining geotechnical engineer at SRK Consulting (SA)
In deep mines, rock falls and rock bursts remain a significant challenge. While
accident rates have reduced significantly, they remain a concern in high stress environments. Narrow, tabular, flat dipping stopes are very difficult to mechanise and therefore people have to work under hazardous conditions in order to extract the gold ore.

The support systems necessary to ensure their safety have developed incrementally over the years and have significantly reduced the risk, but have to be installed manually, while crawling in the narrow stopes. Miners have to remain disciplined to keep installing the support to the required standard to prevent rock burst damage.

In addition to this, mining induced seismicity is not well understood, despite major technological advances in seismic monitoring and deep level rock mechanics. It requires ongoing investigation, numerical modelling and monitoring of seismicity, in order to optimise mining layouts to minimise the occurrence of large seismic events.

Further research and development is required to better understand and mitigate rock fall and rock burst hazards.

THE WAY FORWARD

According to: Dr Declan Vogt

It is worth stating that there is a very large resource of gold left in South Africa. Estimates vary, depending on the mining method and cost of mining, but the figure may be as high as 30,000 t, or about a fifth of all the gold ever mined on earth, and nearly as much as the Witwatersrand in its entire history. This is a prize worth fighting for.

Digital mining

What is required is modernisation. The industry needs to implement tools and systems that will improve productivity. For example, good communication between stope and surface will enable spares and artisans to be dispatched timeously. Good sensing, coupled with effective IT systems will enable mine managers to have a real-time view of what is going on underground, which can greatly improve their management decision making.

At Wits, we call this ‘Digital Mining.’ There are other improvements that can be made to the efficiency of current operations, for example implementing ventilation-on-demand, where only the areas of the mine that contain people are ventilated. There are opportunities for energy recovery, for example three-chambered pump systems that recover energy from water going underground to assist in pumping it back out again.

But if we really want to access the deep reserves into the future, we have to
remove people from the faces: as mines go deeper the seismic risk increases, and the virgin rock temperature increases. The first puts people at risk; the second makes the environment unpleasant to work in.

If mines can be mechanised, machines can do the dangerous work at the face. If only a small number of people go underground, it becomes cost effective to provide them with personal cool suits, rather than cooling the whole mine.

AngloGold Ashanti is developing reef boring as a technique on its deep gold mines, and the future for Sibanye and Gold Fields is also likely to see a move to fewer people directly involved in underground mining. Instead, operators will sit on the surface working remotely, and artisans will maintain machines in safe, cool workshops underground.

According to: Daniel Hooijer
In order for South Africa to attract the gold investment, we would need to develop better relationships with our stakeholders, local and national government, labour, communities and investors.

We need to demonstrate sustainable free cash flow generation and the ability to generate an acceptable rate of return for investors. Finally we would need to harness first world technology better and include innovation in our mine plans which will allow flexibility in this low margin environment we operate in.

According to: William Joughin
During the last ten years or so, Japanese and South African researchers have collaborated to analyse mining induced seismicity. For the Japanese, deep South African gold mines offer the opportunity to install instrumentation close to the source of small earthquakes and to monitor the ground response in great detail. Japan brings funding, seismological expertise and new technology. However, the most recent research programme has been completed and it is not certain whether a new research programme will continue in its place.

This fundamental research is very important, but it is also essential to carry out more practical applied research that can be readily implemented. The Mine Health and Safety Council (MHSC), through
the Safety in Mines Research Advisory Committee (SIMRAC) has initiated a new research project on permanent areal support systems in mines, which will be carried out by SRK Consulting.

Permanent areal support systems could address rock falls and rock burst damage that occurs in between rock bolts or timber props. These support systems are very difficult to implement in narrow stopes with the current mining methods, but innovative support systems are being successfully installed in a few mining areas, where it is considered essential.

Of course, the installation of these support systems must be efficient and cost effective to ensure that deep gold mining remains competitive. The objective of this research is to identify appropriate permanent areal support systems for different mining environments and to develop training programmes for implementation.

While these projects are encouraging, more research and development is required. Historically, South Africa had world-leading dynamic support testing facilities, which are essential for the design and quality assurance of rock burst resistant support.

Unfortunately, South Africa no longer has a single working test facility. Support manufacturers have to send their new products to Canada or Australia to be tested, which has stifled development of new support products.

Another area of research and development that requires funding is numerical modelling. Rock engineers on deep mines should carry out routine numerical modelling of mining layouts to investigate their influence on potential stress damage and seismicity. It is important that the software is continually developed to include new tools and to incorporate new methods of analysis. Rock engineers also need to be trained to use these tools.

These are just two additional research focus areas which are important for continued mining at depth in South Africa. In the longer term, innovative mining methods have to be developed to limit the exposure of people to the hazards, which will ensure the profitable future of the deep gold mining industry.

**MINING HOUSES ARE TAKING ACTION**

**Sibanye’s Safe Technology initiative**

Sibanye has always considered the development of technology as a fundamental strategy. To this end, after a 2014 executive strategy session, Safe Technology was identified as a strategic imperative and in the third quarter was established as an executive portfolio with a new operating structure.

The Safe Technology department is intent on enabling Sibanye’s employees to meet their targets by providing them with a safer and more productive working environment by developing and implementing safer technologies and processes.

Safe Technology is being positioned to focus on, and create value in, three fundamental areas:

- Developing future safe mining methods;
- Safety enhancing current mining practices; and
- Capitalising on legacy mining.

The Safe Technology strategy is positioned against the background of life-of-mine (LoM) projections, ore body complexity, productivity profiles and cost pressures, as well as its growing portfolio of capital expansion projects.

“A paradigm shift in hard-rock mining is required for us to remain competitive locally and globally.” As such, one of the Safe Technology projects that has emerged is stope mechanisation. A stope mechanisation programme has
A paradigm shift in hard-rock mining is required for us to remain competitive locally and globally

subsequently been launched to enable Sibanye to reduce costs and pay limits with non-explosive, continuous production. Sibanye is pursuing 25 registered micro projects and 10 macro projects in total under the Safe Technology umbrella.

Micro projects are in alignment with its current mining process improvement strategy. They are either initiated by the Safe Technology department or put forward by the operations, and include smaller safety enhancing and production optimisation projects.

Examples include roof bolting optimisation and standardisation, localised hydro power mining, winch signalling, automated cleaning methods, continuous dust monitoring and suppression, structural inspection and maintenance management system optimisation, diesel particulate matter reduction and control (interim measures), among many others.

Registered macro projects are aligned with Safe Technology’s old gold recovery and future safe mining methods. Macro projects are initiated and driven by the Safe Technology department with operational assistance from selected mining units. All macro projects represent a significant departure from conventional mining methods and aim to incorporate industry and often world-leading technologies.

Examples of ground-breaking developments include the Sibanye Gold locomotive. The locomotive incorporates a power unit, moving away from conventional and inefficient direct current drives to highly efficient, regenerative, permanent magnet alternating current (PMAC) drives. Phase 2 of the locomotive will also make use of solid state lithium-ion yttrium-phosphate batteries, which substantially increase in operating life and charging capacity compared to the lead-acid equivalent.

Coupled to the solid state batteries will be a Tier 4 generator set to charge the battery in terms of a predefined and optimised discharge cycle. Other macro projects include an adaptable, ultra-low-profile, mechanised platform capable of supporting various attachments. Various functionalities are being developed, including systems to facilitate rapid drilling cycles in areas where conventional mining practices restrict accessibility and face time or a completely revolutionary, non-explosive, 24-hour mechanised mining machine. Macro projects vary in scale and complexity but all share a common characteristic: a radically innovative paradigm shift in mining method and process.

Sibanye believes it has the potential to extend its LOM operating profile at approximately 1.6 Moz on a sustainable basis – for a period exceeding 10 years, if all its pipeline projects are developed.

AngloGold Ashanti’s reef boring approach

AngloGold Ashanti’s Technology Innovation Consortium (ATIC) believes that reef boring holds the key to its future deep level underground success and started testing the methodology extensively in 2014. It focuses on mining the gold reef, and only the gold reef.

Reef boring technologies have now progressed beyond initial trials and have produced gold from certain sites. Reef boring machines in three different sizes are in operation to address the variable reef channel widths that reside in the deep underground mining environment of AngloGold Ashanti’s assets.

The biggest challenges were found in areas with softer footwall conditions, typically associated with the C-reef ground. Work teams will continue to focus on improving technical and work management aspects of machine performance toward design expectations.

The successful development of the ultra-high-strength backfill (UHSB) product, necessary to replace the extracted reef area, together with the reef-boring technology for use in mining applications as a support medium, creates the potential for the earlier-than-planned mining of shaft pillars, the pre-extraction of planned stabilising pillars and post-extraction of existing stabilising pillars.

Harmony Gold works to reduce energy consumption

Energy

Deep level mining is inherently energy intensive. The impact of climate change on energy pricing has seen energy pricing rise steadily in South Africa since 2010 and given rise to tariff increases exceeding 8%. Having had an impact on the sustainability of several of Harmony’s operations, the mining company’s strategy to mitigate the energy price is to rebalance its portfolio towards shallower/open-cut mining operations.

Harmony’s business strategy has also been influenced by the company’s drive to reduce energy consumption and greenhouse gas emissions, as well as by the need to adapt to climate change and diversify its energy mix.

Its responsible stewardship of the environment encompasses:

- Promotion of energy efficiency at all deep-level operations in South Africa;
- Design and development of renewable-energy driven operations in Papua New Guinea;
- Optimisation and rebalancing of the asset portfolio through the decommissioning of operations where the marginal returns of mining payable reserves are outweighed by the rising cost of the energy to mine those reserves;
- Promotion of an alternative energy mix; and
- Alignment of its rehabilitation programme with the green energy agenda.

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Dedicated staff have been appointed to manage Harmony Gold’s energy efficiency programme, to which the company has allocated R12 million. Harmony has also been working with Eskom to manage electricity usage, which includes the use of demand-side management strategies to reduce electricity consumption during peak periods. Most of the demand-side management projects have a 50:50 match funding arrangement.

Energy optimisation initiatives result in savings of 61 158 MWh – total savings of 201 000 MWh from all electrical energy initiatives implemented. Harmony is also the only gold mining company in the top 8 Carbon Disclosure Project’s Leadership Performance Index on the JSE in the ‘A’ performance band on the Johannesburg Stock Exchange 100 Climate Performance Leadership Index.

Harnessing technology to provide a sustainable future

New technology provides us with an opportunity to increase our competitive advantage and make our business model more resilient as we move into the future. For example, we can use new technology to respond to cost pressures such as electricity tariff increases and labour, which will allow us to make our production and costs more efficient. This, in turn, can help us increase revenue and share more benefits. Ways in which we are working on capitalising from new technology include safety improvements, energy efficiency, alternative energy mix, water conservation technology, nuclear radiation rehabilitation and we also continue to evaluate new mining methods. Every one of our strategic objectives can be enhanced by embracing innovation through new technology which will increase efficiencies, productivity and safety.

Safety

Deep level mining brings with it inherent safety risks. We prioritise safety primarily to protect our people. Apart from the effect safety has on our employees’ mindsets and productivity, it also has the potential to impact our reputation, stop production, lead to litigation and decrease the overall value of Harmony. We view safety as an opportunity to engage with many key stakeholders, particularly our employees, and to entrench our values.

Gold Fields addressing lack of mechanised mining skills

Many of the challenges at Gold Fields’ deep level South Deep are related to the shortage of mechanised mining skills in South Africa. Gold Fields has started to address this by putting in a strong senior management team with underground mechanised mining experience gained in the platinum industry (recruited from the successful Two Rivers mechanised underground platinum mine). The Australian team is starting to collaborate with the South African platinum industry in setting training baselines for mechanised mining.

At South Deep, Gold Fields is pioneering mechanised gold mining on a scale and depth not previously seen in South Africa, and the success of the operation is largely dependent on its people.

Its strategy is to grow its own skills base through focused internal training efforts and to recruit the best local mechanised mining skills to supplement the existing talent pool.

During 2014, Gold Fields spent over US$13 million globally on training and developing its employees. A significant effort has been made to introduce international best practice standards at South Deep.

In addition to the focus on operational cost containment, Gold Fields took the decision to scale down its involvement in activities which are typically the domain of larger, industry-leading companies.