



## Causes of Mine Decline in South Africa

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*South Africa's mineral resource base is internationally well-known with commodity resources ranging from several decades to several hundred years of supply still remaining. Technological breakthroughs lead to extension of mine life and allow for previous, marginal deposits to be revisited and exploited anew. There are numerous examples of deposits, previously unwanted or discarded that are today being re-opened, as technological solutions arise and commodity prices remain high enough to justify development. With this strong base from which to work, there abound cases of mine decline and ultimate closure. South Africa has a modern formalised mining history that encompasses 160 years and it is common to find mines ranging from 50 years to as much as 110 years operational history. In this time period South Africa has encountered numerous types of mine decline, across individual mines, entire commodities and on the largest scale, the entire mining sector. It is customary to associate the decline of mining with the exhaustion of mineral reserves. The causes for mine decline are considered and described with examples from South Africa's 160-year mining history. The entire South African mining sector decline in 2000-2008 is not widely reported or described, this while the commodity boom was commencing. Observations and analysis is made of selected minerals such as gold, nickel, diamonds and iron ore decline over this period. The decline of the complete tungsten, asbestos and primary copper sector is reviewed and several cases of individual mine decline and closure and the causes are analysed. The reasons for decline include mines closure for social, economic, safety and environmental reasons. Government policies that trigger declines are also investigated.*

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### South Africa's Mineral Assets

South Africa's mineral wealth is due to its unique and interesting geological phenomenon. The Witwatersrand Basin and the Bushveld Igneous Complex, two unique structures to South Africa, host the majority of the country's mineral wealth.

Research on industry reporting standards during 2011 (Baartjes & Gounden, 2011) indicated that the mineral endowment in South Africa is \$4.71 trillion. The top five contribution minerals by value were reported to be Platinum-28%, Palladium-21%, Gold-15%, Iron-13% and Coal-12%

Collectively the PGM suite contributed 49% of the value. Taken along with other minerals unique to the Bushveld formations, the Bushveld Complex hosts 55% of South Africa's mineral wealth. The Witwatersrand Basin, the dominant host of gold and uranium contains only 16% of South Africa's mineral wealth, which is equivalent to 42% of recorded global gold reserves.



South Africa still has years of mining to look forward to for a variety of commodities and the emergence of a move towards increased beneficiation will surely be influenced by knowing the value of minerals in-situ.

### **Mine Decline – Internal and External Causes**

Mine decline and closure was narrowly described as the end-stage when the ore was depleted or mined out with no possibility of returning (Limpitlaw, 2004). This traditional and limited definition meant that all instances of mine decline and ultimate closure were considered to be due to similar reasons. Conventional mining in South Africa commenced in the 1850's with the opening of the first copper mines but in many commodities we find examples of mines continuously producing for in excess of 50 years. Examples include the numerous diamond mines in Kimberley and along the west Coast of South Africa and some gold mines of the Witwatersrand. These long lived mines typically display the traditional stages of mine life cycle from exploration, development, production, gradual decline and ultimate closure.

The finality of mine closure was often considered to simply be the end of all extraction activities at the mine and over South Africa's long mining history many mines have been started and then ultimately closed. The number of mines that have closed, not been rehabilitated and have become the liability of the state now exceeds 6 000 mines. The financial liability of these derelict and ownerless mines, to the state, is estimated to be R1.6 billion over 10 years but ultimately requiring a conservative estimate of R30-billion. The social and health impacts of these closures on the state remain to be determined. The Department of Mineral Resources in South Africa has a strategy to deal with these mines that have closed (DMR, 2009) but this strategy does not consider in any great detail the exact causes of decline and ultimate closure. Even though there are 6 000 derelict mines in South Africa, this is small when compared to the almost 600 000 found in the United States (US Bureau of Mines, 1994).

Mine decline can occur over an extended period. This is usually predictable and the various decline phases are systematically scheduled and described as the mining companies can use the reserve levels of the mine to plan for closure. There are some instances where mine decline is not yet taking place but at the height of production catastrophic closure can occur. This catastrophic closure is sometimes a consequence of high-impact events such as accidents and structural collapse of mine infrastructure.

Work completed by EcoPartners (Baartjes and Gounden, *in prep*; Baartjes, 2009) reduced the myriad of reasons for mine decline and closure to five overarching reasons. The critical ones are: declining grade; decreasing tonnage and depth of mining leading to high extraction costs. These three causes of decline are specific to the ore body and as such are classified as geological factors.

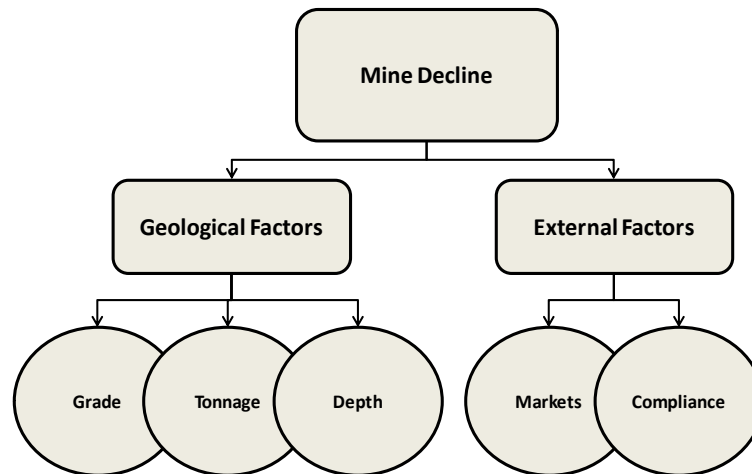


Figure 1: Factors of Mine Decline

### Geological Factors

The metal or valuable mineral content of an ore body are fixed and so the mining method used will determine the ultimate grade. Once this method is selected it is very difficult to change mining methods dramatically so the average grade of a deposit is relatively fixed for much of the mines duration. These can drift downwards over time (for example with increased dilution). Tonnage, like grade is largely determined by the mining method employed. Some small modifications can increase tonnage yields but this, like grade, are in decline over the life of a mine. Depth is an immutable feature of a deposit so companies are rarely able to change this. What many companies have been able to achieve though is to mine at deeper levels and thereby extend their ore body and so doing the life of an operation.

### Mine Decline and Closure in South Africa due to Grade and Tonnage

#### Tungsten

Tungsten mineralisation occurs as veins in the granite and gneiss structures. Even though some deposits are high grade, their size is too small and distribution erratic. Tungsten has the highest



melting point and tensile strength than all other metals and is therefore used as a hardener in metal compounds, but in recent times other metals such as molybdenum, titanium or the use of diamond tools have substituted for tungsten alloys. South Africa does not have significant concentrations of the mineral. The Northern Cape did have some deposits of economic concentration but have since been mined out. Tungsten mining has ceased in South Africa since the 1970's, due to the depletion of known reserves.

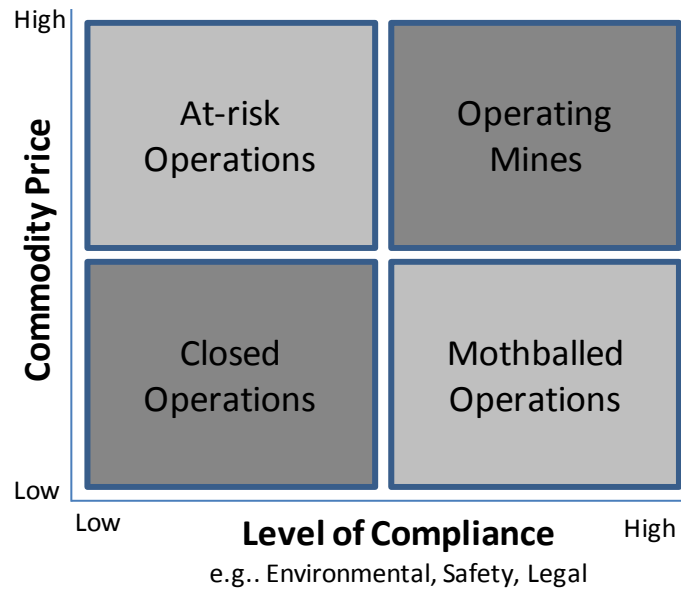
### **External Factors**

Target generation conducted during 2010 and 2011 indicated that there are two additional external causes of decline (and sometimes closure). These are commodity prices and margin; and compliance costs - Figure 2. These reasons are not directly affected by the factors unchangeable to the ore body and are not set at the commencement of mining.

Commodity prices are a proxy for market demand and as commodity prices increase then revenues are expected to increase. This may often be the case but it was found during the 2000-2008 commodity price rally that some companies experienced an increase in costs so margins remained under pressure. When commodity prices decrease over a period of time, mines can sometimes close down completely if they do not readjust their cost structure or mining method (the former is easiest to change and the latter is very difficult to alter). This aspect of the external factors is sometimes also referred to as the 'commodity supercycle'

An often overlooked feature of economic distress is issues of work stoppages due to labour withholding their productive efforts or reducing this. In 2011 and early 2012 platinum mines permanently reduced staff compliments when work stoppages (for wage increases) affected the ongoing safety of certain parts of mines. It was then better to completely close these parts of mines than to continue mining it.

Compliance requirements refer to Environmental, Legal and Safety requirements. In South Africa mines have been shut down for various non-compliance reasons, this factor however, is not terminal, as mines can work towards creating a compliant environment. This is the only factor that mining companies can have a firm handle on.



**Figure 2: External causes of mine decline**

In the recent history of mining in South Africa there have been numerous instances of compliance closures. These are, in this study, classified as ‘At-risk Operation’s where profitability is reasonably assured but the mine is stopped by the regulatory authorities due to non-compliance- Figure 2. For example in the following commodity classes in South Africa have experienced the temporary closures which could lead to total closure; coal, gold, uranium, sand, diamonds and chrome. Some ‘At-risk Operations’ are the sites of numerous illegal mining operations as well.

Mines can similarly have high levels of compliance but when market forces combine to restrict profits then these operations are typically mothballed.

The only genuinely closed operation should be a mine that has low level of regulatory compliance as well as a low commodity price which cannot sustain it.

#### **Mine Decline and Closure in South Africa due to Legislation**

South Africa has experienced the complete closure of an entire mining industry, asbestos, due to decisive legislation barring its trade. This remains as the only example of a commodity legislated into closure.



## **Asbestos**

Asbestos was a large contributor towards South Africa's mining income, accounting for almost 5% of foreign revenue. The mining continued for several decades since the first asbestos mine opened in South Africa in 1893. South Africa held a dominant position in the supply of amosite and crocidilite (both in excess of 95% of world supply) in the world was well documented. In global rankings, South Africa was ranked the 8<sup>th</sup> largest global producer (DME, 1997). At that time there were only four asbestos mines operating, one in the current Limpopo province, two in the current Barberton region of Mpumalanga province and a fourth mine near Kuruman in the Northern Cape province.

The health effects of asbestos are now widely documented and it is these effects on people that lead to a global movement emerging whereby asbestos was gradually being phased out. As this gained momentum South Africa joined many other countries to ban the mining and manufacturing of asbestos products. By 2003 asbestos mining, trade and manufacturing had ceased in South Africa and by 2008 the ban was easily implemented. In terms of the Environmental Conservation Act (1989) asbestos can also no longer be recycled. The result is that an entire commodity and all the attendant industries were phased out.

Asbestos as a commodity is rarely mined today (though in countries like Canada and Brazil, mining is still ongoing). The combination of finding alternative compounds and products, as well as the health impacts, has meant that in South Africa, which does have significant asbestos resources still unmined, the entire sector has been shut down.

### **Mine Decline in South Africa during the Commodity Boom of 2000 - 2008**

There are many proposed drivers of the 2001-2008 commodity boom. A case can be made for the flowing together of several of the following that lead to commodity price rises. These can be summarised as (Baartjes, 2009):

- Speculators and Traders: who entered the markets and kept bidding up commodity prices in the anticipation that demand would increase;
- Security premium: Some countries were concerned that China's anticipated growth and demand for commodities would preclude them from access to raw materials to support their own industries. The result was that a premium was often paid to ensure the continued supply of goods;

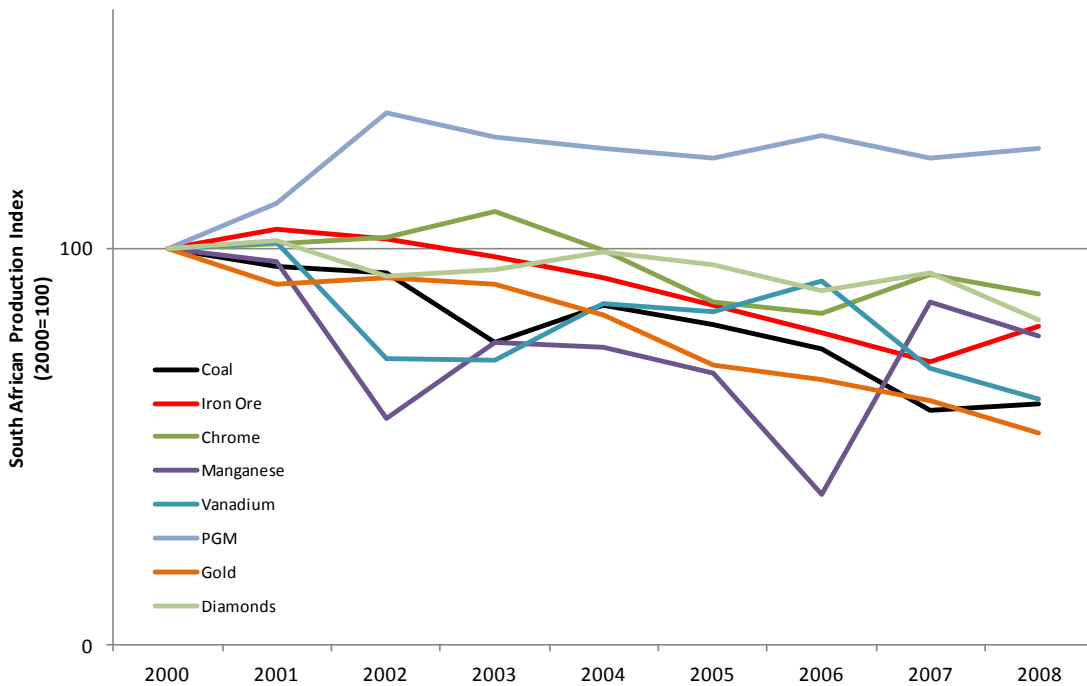


- Transfer of energy costs: During the 2000-2008 commodities rally there was an earlier increase in energy prices and these were simply transferred from the ore producers to the commodity price;
- Decline in new discoveries: For several years before the commodity rally one of the concerns raised was that the number of new discoveries were in decline and for some commodities (such as diamonds) the ability to supply future demand would cause a price rally;
- Chinese demand: Urbanisation in China was leading to increased demand for products as that country embarked on a massive infrastructure programme to deal with an influx of its rural population into the cities.

All of these combined to drive the commodity rally in various forms.

In South Africa the commodity boom was not as significant and widely spread. The levels of employment increased by 24% in the period 2000 to 2008 from close to 417 600 to 518 500. Over this same period the JSE resource index increased from approximately 20 200 to 76 100 (JSE, 2011). This resource market value increase was, at greater than 250%, actually growing faster than employment creation was. The growth in employment for that period was widely eliminated when the market crashed in 2009.

At a commodity level the period 2000 to 2008 saw South Africa's market share in PGM increase but in at least seven other key international commodities it had declined.



**Figure 3: Index of South African commodity output for eight key commodities in the period 2000-2008**

Source: SAMI (various years)

A discussion of a select few of these is provided to illustrate the varying reasons.

### Gold

In 2000 gold production in South Africa stood at 428 tons (t). By 2004, while the commodity boom had commenced gold production declined to 341t and by 2008, the year when the commodity collapse occurred, gold production had fallen to 213t. This dramatic decline, though not the biggest loss of market share in SA over this period, was largely driven by a decline in grade and issues around technology limitations around mining at depth. The concomitant drop in South Africa's international market share was from 17% in 2000, to 14% in 2004 and 9% in 2008.

### Diamonds

South Africa has historically been a globally significant diamond producer. De Beers was, for many decades, the dominant producer internationally as well as in South Africa. In the last few years De Beers has generally scaled back in South Africa and today South African diamond production is dominated by the De Beers' Venetia mine in Limpopo province. No significant diamond mines have been developed in the last few decades. In 2000 South African diamond production was at 10.8





million carats (Mcts) and by 2004 increased significantly to 15.8Mcts. By 2008 though this had dropped back to 12.9Mcts. Over this same period the SA market share had gone from 10% in 2000 and 2004 declining to 8% in 2008. The lack of new discoveries, the changing demand profile of diamonds and lower grade mines all contributed to this general decrease.

### **Iron Ore**

In 2000 iron ore production in South Africa was at 34 million tons (Mt). By 2004, this had reached 39Mt and eventually by 2008 it reached 49Mt. This period represented a rapid increase in iron ore production from the current producers. The market share of international iron ore production though had started in 2000 at 3.5%, decreased to 3.3% in 2004 and reached 2.8% in 2008. The declining market share could be attributed to the common constraint of all iron ore producers, the logistics bottleneck along the Orex rail line from Sishen to Saldanha Bay.

### **Vanadium**

South Africa is a dominant producer of vanadium and hosts the largest unmined resources in the world. In 2000 South Africa produced 18kt vanadium which represented 57% of the international market share. By 2004 this had increased to 23kt but this was only 49% of global market share. By 2008 this had shrunk to 20kt which was merely 35% of global market share. Vanadium is not necessarily mined as a co-product and even with international prices rising during the period 2000 to 2008, South African producers had to restrict output to balance price. This behaviour is because in certain areas, such as vanadium (but also with manganese), South African market dominance means that as a swing producer, small decisions in setting output levels can influence global prices dramatically. Oligopolistic producers concentrated in a specific area can act in a way that allows maximum profits without increasing production capacity. Swing producers then tend to keep production levels steady or even decrease them to keep prices high.

### **Nickel**

Nickel is a by product of PGM mining with the only primary nickel mine in SA, Nkomati Nickel, producing low amounts of primary nickel. The South African production levels in 2000 were 37 kilotons (kt) and represented 3% of international nickel supply. By 2004 it had just breached through 40kt and was still only 3% of international market share. This pattern illustrates that in certain areas South Africa was able to maintain market share but it was the PGM sector that was able to support this.



### **Mine Decline or Decline in Mining Interest – the impact of Administrative Malfeasance**

There has been a distinguishable tendency in South Africa of poor administration of rights applications and processes, which can be described as administrative malfeasance by government officials tasked with the administration of the rights applications. The recent examples of Kumba v ICT (in 2011) has been most prominent and similarly the case of London-listed Lonmin v HolGoun (in 2010) with overlapping rights applications for the same or similar orebodies. In 2008 the US-based Doe Run Exploration Company took to court issues with fraudulent issuance of rights over properties which Doe Run had explored. This has led to a dramatic increase in scepticism of South Africa as a mining destination. The judge in the Doe Run case, delivered in 2008 stated: *A lamentable trend has developed in cases of this nature, i.e. concerning the issuing of rights under the Act, that very lengthy delays are experienced by applicants to have their applications finalised by the Department. The present case is no exception. These lengthy delays cannot be in the interests of the economy, where much needed investment is delayed and sometimes even lost. In the present matter a US company has already invested millions of Rands and stands ready to invest more, provided it can have finality on its applications. The extraordinary delays, alluded to in this judgment, are adverse to such foreign investment. Of further concern in this matter is that the Respondents had failed to discover the records of the various decisions, as they were called upon to do in terms of Rule 53(1). It took a contempt of court application to have same discovered. I would hope that this Court has seen the last of this disturbing trend in the present matter.* (Doe Run, 2008)

Malfeasance does not directly lead to the decline of a mine but has the ability to lead to decline in confidence of an entire economic sector; mining, in South Africa.

### **Revisiting Derelict and Ownerless Mines**

South Africa has in excess of 6 000 derelict and ownerless mines. These mines are so termed because they have no legally identifiable owner and their legacy effects have been assumed by the state. In South Africa these represent in excess of 40 minerals and commodities including PGM, gold, diamond and coal mines. In assuming the liability for these mines it is at present not considered that these mines will be re-evaluated and re-opened in the foreseeable future.

A derelict and ownerless mine has been closed for one of the five reasons classified above. The overwhelming assumption appears to be that these were all closed due to geological factors. This



incorrect assumption or blanket approach has meant that many small, near surface deposits that were partly mined remain inaccessible to the rural populations that close to it. This is an example of resource sterilisation.

In 2011 EcoPartners commenced a low level research programme to revisit the economic potential of only the diamond derelict and ownerless mines (there are approximately 900 diamond derelict and ownerless diamond operations, of which most are alluvial and less than 100 kimberlitic). From this several mines were identified and during 2011-2012 a project has been launched which will attempt to re-open some of these diamond mines identified and previously classified as uneconomic due to grade problems.

### **Recommendations for Derelict and Ownerless Mines**

South Africa needs to develop a new paradigm around the decline and final closure of mines. The current system of short temporary stoppages for safety and longer short-term stoppages for environmental and legal non-compliance could have the undesired effect that it leads to permanent closure of some mines. Similarly, for companies exposed to stoppages there is a benefit in ensuring compliance is correctly addressed.

The 6 000 derelict and ownerless mines in South Africa represent an economic opportunity. They are typically near surface occurrences which are easier to mine and can be rejuvenated. The recommendation for this suite of mines is as follows:

- Re-visit derelict and ownerless mines from a techno-economic and compliance perspective;
- Reduce compliance requirements for those individuals, communities and small companies that want to re-open these mines; and
- Re-open the mines with state support and allow these to become centres of rural development.

South Africa has seen the full life cycle of mining, since the opening of the first mines in 1850. It has been a centre of mining development and technological breakthroughs which were rapidly adopted by other producer countries around the world. As the mines in South Africa became older and the ore body mined out there has been a lack of active management of these properties. Decline then quickly translated into closure.



The nature of mining is that all deposits are non-renewable and will drift into decline over the period in which mining is taking place. This is expected, is largely anticipated and well understood. The propensity to hasten the decline of mines due to external drivers needs to be carefully managed within a national strategy. Compliance linked closures must be aggressively managed and dealt with because these are not necessarily the permanent closure.

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