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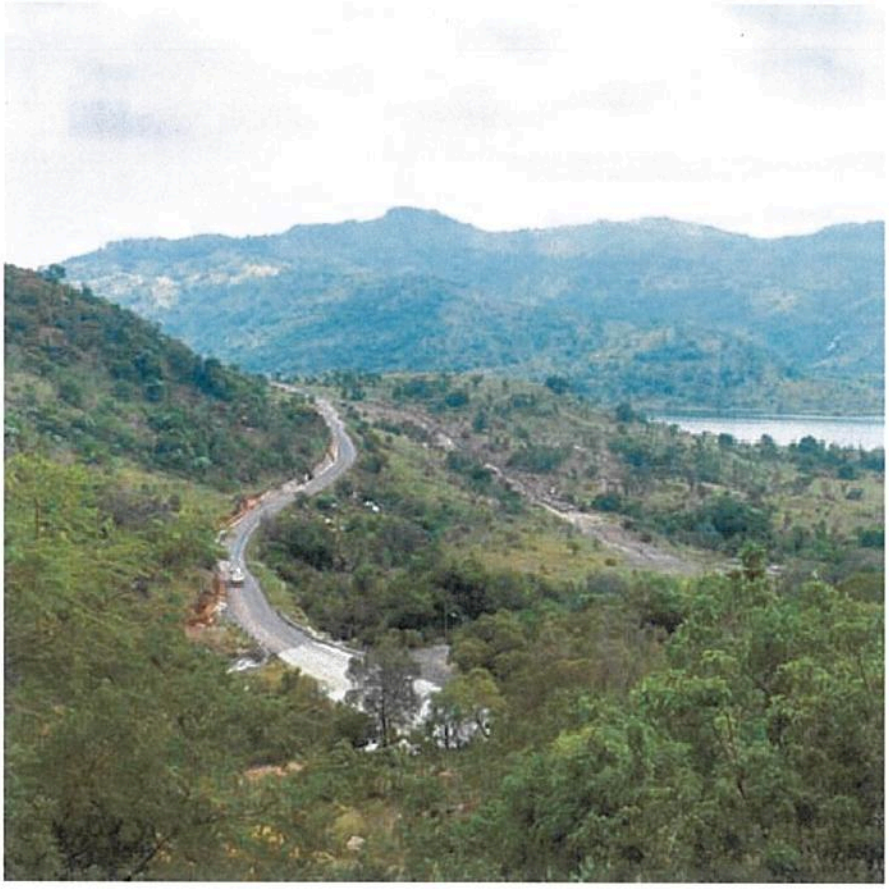
STRUCTURAL CHANGES IN SOUTH AFRICA'S PGMs INDUSTRY

DIRECTORATE: MINERAL ECONOMICS



mineral resources

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Cover Picture: Location of Der Brochen, Amplats's Greenfield project on the eastern limb of the Bushveld Complex.
Source: Amplats' 2012 Annual Report

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ABSTRACT

In South Africa, platinum-group metals (PGMs) occur in economic concentrations in three separate, extensive layered reefs; the Merensky Reef, the Upper Group II (UG2) Chromitite Layer, and the Platreef. After decades of mining, the Merensky reef is now being depleted and costs are escalating as producers are forced to exploit the deeper-lying UG2 reef. The increase in costs was partly augmented by the need to upgrade ore processing infrastructure in order to accommodate UG2 ore, and further compounded by relatively depressed PGMs prices and labour unrests. This has resulted in producers mothballing operations and suspending projects, which impacted negatively on employment in the sector. As a result, speculation is now rife that mechanization may be the future of the country's PGMs production, particularly in the northern limb of the Bushveld Igneous Complex (BIC).

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ABBREVIATIONS AND SYMBOLS

4E	platinum, palladium, rhodium and gold.
BIC	Bushveld Igneous Complex
COC	cash operating costs
DMR	Department of Mineral Resources
et al	and others
g	grams
g/t	grams per metric tonne
km	kilometeres
koz	kilo-ounces
m	metres
MPRDA	Minerals and Petroleum Resources Development Act
Mt	million tonnes
oz	ounces
Pd	palladium
PGMs	Platinum Group Metals
Pt	platinum
Rh	rhodium
RLS	Rustenburg Layered Suite
SA	South Africa
t	metric tonne
UG2	Upper Group 2 Chromitite Layer

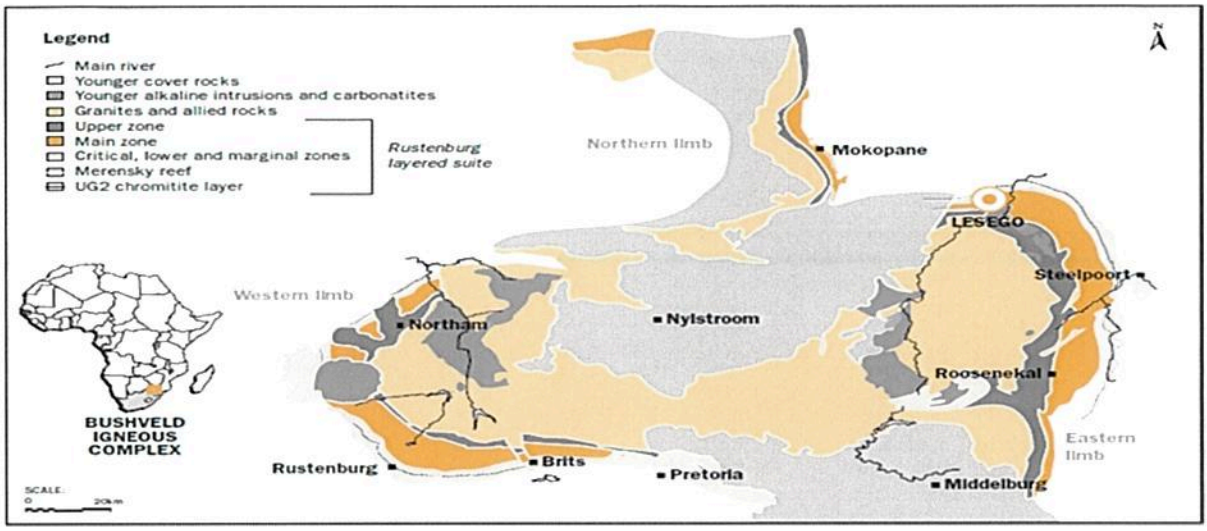
1. INTRODUCTION

The PGMs constitute a family of six chemically similar elements. They are divided according to their densities into a heavier category, comprising platinum, iridium and osmium, and a lighter group, consisting of palladium, rhodium and ruthenium. Their excellent catalytic qualities, resistance to corrosion, chemical inertness and high melting points render them most suitable for a number of specialist applications. In South Africa, PGMs, together with the by-products gold, silver, nickel, copper, cobalt and chromite, occur in economic concentrations in three separate, extensive layered reefs associated with the mafic rocks of the Rustenburg Layered Suite (RLS) of the BIC. They are the Merensky Reef, the UG2 Chromitite Layer, and the Platreef. Mining of PGMs in the Bushveld has been primarily centred on the Merensky reef for many years. However, the Merensky reef is now being depleted and costs are escalating as producers exploit the deeper-lying UG2 reef. The objective of this report is, therefore, to provide an overview of PGMs mining in the country, focusing on structural changes and their effects on production, employment, mechanization and costs, which ultimately could determine the sustainability of the industry.

2. GEOLOGICAL SETTING: THE BUSHVELD IGNEOUS COMPLEX

The BIC is the world's largest layered igneous intrusion that hosts PGMs and the associated elements. The 2 billion year old complex accounts for more than 90 percent of known global PGMs reserves. It contains the intrusive, mafic-ultramafic RLS, which outcrops as three main needle-shaped limbs and ranges in thickness from 7 km to 12 km. The limbs occupy parts of the North West, Mpumalanga and Limpopo provinces, and are known in that order as the western, eastern and northern limbs (Figure 1). The RLS stratigraphy is subdivided into, from lowest to highest, the marginal zone, lower zone, critical zone (with the latter further subdivided into lower and upper units), main zone and the upper zone. The upper critical zone hosts the largest concentration of PGMs in two significant ore bodies, the Upper Group Chromitite No. 2 (UG2) and Merensky reefs. The vertical separation between the two is variable across the BIC, ranging from 20 m to 140 m on the western limb, and from 170 m to 400 m on the eastern limb. The northern limb also hosts the Platreef mineralization, which may be as thick as 250 m, in the upper critical zone.

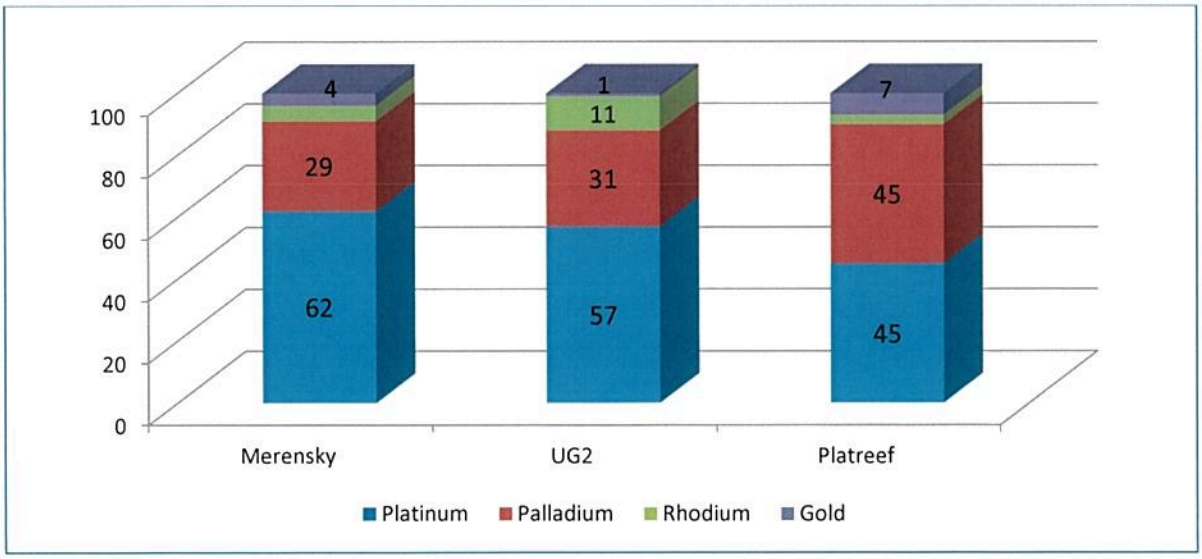
FIGURE 1: THE THREE LIMBS OF THE BIC.



Source: Village Main Reef Intergrated Annual Report, 2012.

The Merensky reef is generally regarded as a uniform reef type, but large variations occur in reef thickness and composition, as well as the position of mineralization. It has been traced for 300 km along the entire outcrop of the eastern and western limbs, up to depths of 5 km. The reefs are quite different from each other in terms of composition (Figure 2), and therefore require different approaches of metallurgical processing. For example, UG2 ore has a much lower content of nickel and copper sulphides, contains much more chromite than Merensky ore and contains a lower Pt:Pd ratio. The Merensky ore has higher PGMs grades and Pt:Pd ratio. The Platreef can be considered as metallurgically similar to Merensky ore, although somewhat enriched in palladium.

FIGURE 2: THE RELATIVE 4E PERCENTAGE COMPOSITION OF THE REEFS OF THE BIC.



Source: Amplats Technical Task Team Presentation, 2013.

3. PGMs MINING IN SA

3.1 Role Players

In 2013, PGMs in SA were recovered from 29 mining operations, employing more than 190 000 workers including contractors. Anglo Platinum (Amplats) is the world's leading primary PGMs producer, accounting for roughly 40 percent of the world's newly mined platinum, followed by Impala Platinum (Implats) at 17 percent and Lonmin at 15 percent. Amplats's operations were restructured in 2013, with Khomanani mine and Khuseleka 2 shaft being placed on long-term care and maintenance, while Union North and Union South mines were intergrated into Union mine and the uneconomical Union North decline closed. Bathopele, Thembelani, Khuseleka, Siphumelele, Tumela, Dishaba, Union, Mogalakwena and Twickenham mines remain managed operations of the group, in addition to a number of joint ventures.

Implats has operations situated on the Impala lease area on the western limb of the BIC near Rustenburg, and in Springs east of Johannesburg. The company has a 73 percent stake in Marula Platinum Limited, one of the first operations to have been developed on the relatively under-exploited eastern limb of the BIC. The Two Rivers Platinum Mine is a joint venture between African Rainbow Minerals (55%) and Implats (45%). The operation is situated on the southern part of the eastern limb of the BIC in Mpumalanga. Lonmin's Marikana operations on the western limb of the BIC currently contribute around 92 percent of the company's annual production.

Other notable producers include Aquarius Platinum, whose primary operation is the Kroondal mine, and Northam Platinum, which wholly owns and operates Zondereinde mine and the recently commissioned Booysendal mine. Atlatsa Resources and Royal Bafokeng Platinum are black economic empowerment PGMs producers, controlling and operating Bokoni and Bafokeng-Rasimone mines, respectively. Platinum Australia, Platmin, Village Main Reef and Wesizwe Platinum are involved in various exploration and new mine development projects, with production from some of these expected as early as 2015.

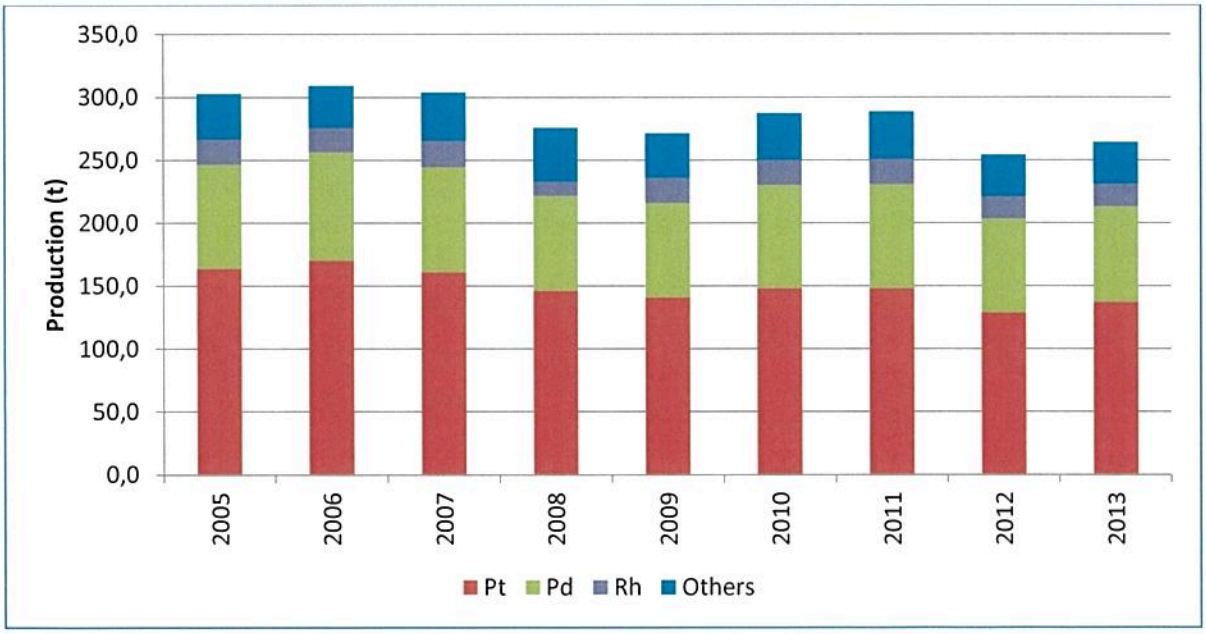
The ore extracted from the mines is processed by concentrators onsite, before being further processed by smelters and refineries. Only Amplats, Implats, Lonmin and Northam Platinum own smelting and refining operations situated in SA. Northam, however, does not own PGMs refining facilities due to insufficient volumes of production. Instead, the company's PGMs concentrate is toll processed by a German-based company, Heraeus, with platinum and palladium refined in SA and

other PGMs in Germany. Smelting and refining operations treat concentrates not only from companies' wholly owned operations, but also from joint ventures and third parties in the form of toll treatment contracts.

3.2 Production

Since 2005, the decreasing Merensky to UG2 production ratio has had a marginal effect on the proportions of PGMs produced. According to statistics from the Directorate Mineral Economics, platinum production decreased from 54 percent of all PGMs produced in 2005 to 51.9 percent in 2013 (Figure 3). Palladium production remained around 27 percent from 2005 to 2009, before increasing slightly to around 28 percent in 2010, where it remained until 2013. Rhodium accounted for 6.7 percent of all PGMs produced in 2005, but inexplicably fell to 4.1 percent in 2008. For the past five years, however, the metal's production remained around 7 percent.

FIGURE 3: PRODUCTION OF PGMs IN SA, 2005 - 2013.



Source: Directorate Mineral Economics

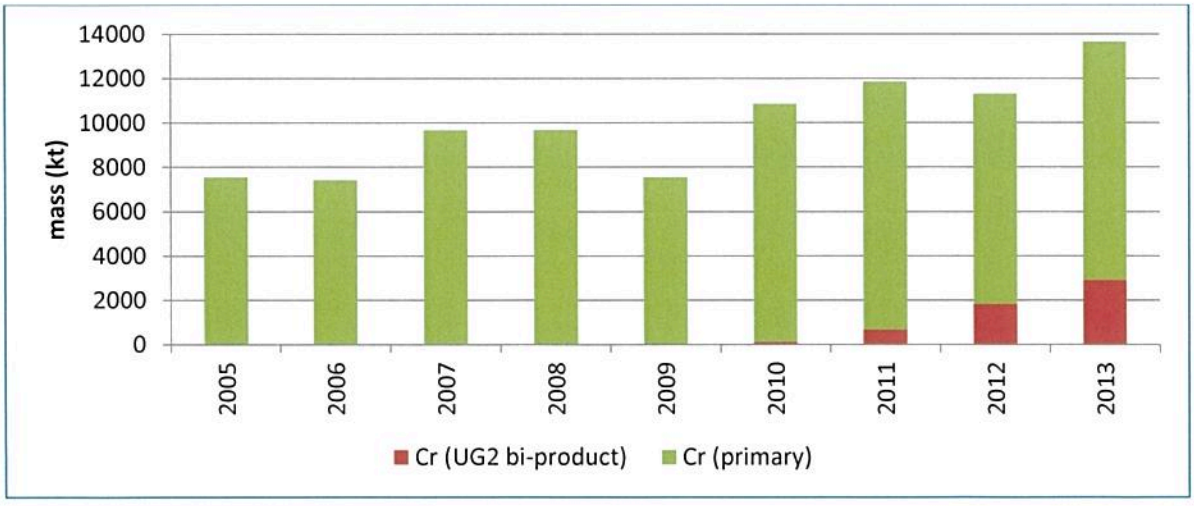
The marginal differences observed are consistent with the fact that the Merensky reef is still being exploited concurrently with the UG2 in certain areas of the BIC. Furthermore, the PGMs content of the UG2 reef is comparable with, and sometimes higher than that of the Meresnky reef. The latter ranges between 4 and 10 g/t, whereas the UG2 contains between 4.4 and 10.6 g/t. However, no matter how marginal the changes are, they give a clear indication of SA's future production profile,

which augurs well for the expected supply-demand dynamics. The country remains the largest supplier of platinum, the demand for which continued to increase in 2013, particularly on the back of investment demand, while automotive demand for palladium reached record levels.

Higher grades and Pt:Pd ratio of the Merensky reef were able to provide producers with maximum benefits possible, particularly at a time the platinum price was at its highest, in 2008, just before the onset of the global economic crisis in the same year. With autocatalyst demand for platinum decreasing, largely due to substitution of the metal by palladium, the mining change from Merensky to UG2 reef is in sync with supply-demand dynamics as it signifies relatively more palladium production. The high demand for palladium, particularly in the autocatalysts sector, makes the processing of UG2 concentrates very attractive, while its higher chromite content presents major opportunities for significant profits and may offset losses brought about by lower nickel content.

The most significant effect of increased UG2 production is evident in increased chrome ore production, or the reporting thereof. Data from the Mineral Economics Directorate clearly indicates that many UG2 chrome ore producers did not start reporting data until 2011. The drive by the DMR to ensure reporting compliance from producers saw UG2 production increase by 340 percent between 2011 and 2013 (Figure 4). As DMR intensified the compliance campaign in 2013, reported UG2 production grew by approximately 60 percent, thereby increasing the country's total chrome ore output by 21.4 percent to a record 13 731 kt. Increased output has led to increased exports of chrome ore in the past few years, resulting in an oversupplied chrome market and impacting negatively on prices and competency of SA's chrome and ferrochrome industry.

FIGURE 4: SOUTH AFRICA'S CHROME ORE PRODUCTION, 2005 – 2013.

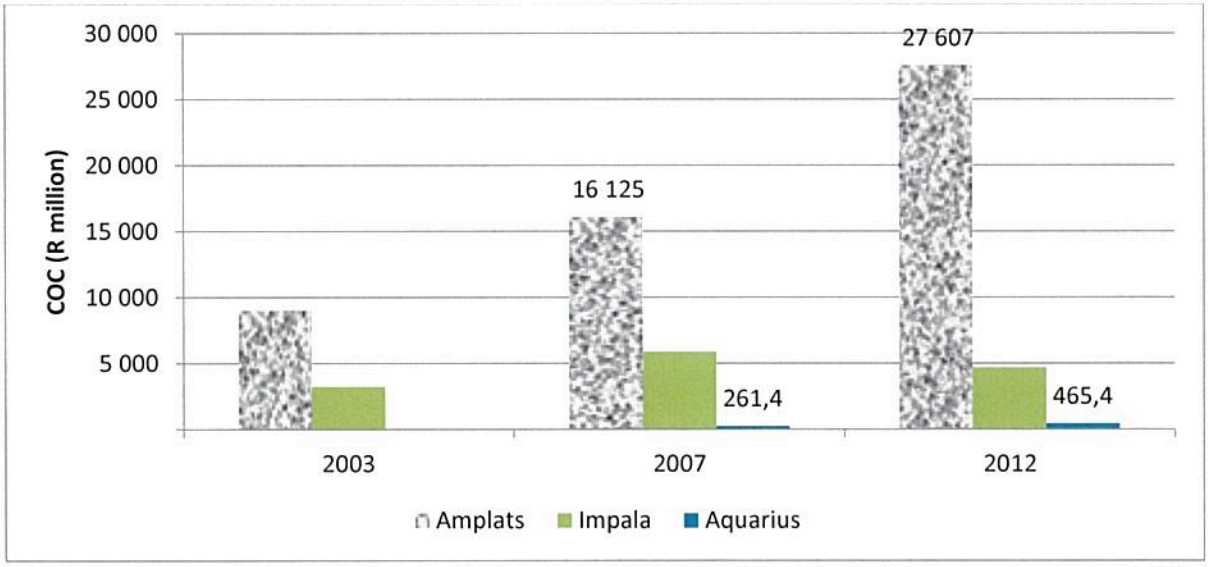


Source: Directorate Mineral Economics

4. PRODUCTION COSTS AND PRICES

SA's PGMs industry is facing challenges relating to rising costs and relatively depressed dollar prices. The deepening of the mines to reach the deeper and more technically difficult UG2 deposits has led to increased costs and less productivity as more personnel is needed to mine the same amount of ore. On-mine cash operating costs (COC) for three producers; Amplats, Impala and Aquarius, are depicted in Figure 5. Amplats's COC tripled from around R9 billion in 2003 to about R27 billion in 2012. Implats's COC increased from R3.2 billion in 2003 to R4.7 billion in 2012, even though the latter represents a 20.5 percent decline when compared with 2007. COC for Aquarius Platinum, increased by 78 percent, from R261 million in 2007 to R465 million in 2012. Several factors may be responsible for the observed differences, but the most notable one could be the fact that Amplats has traditionally operated more shafts than its competitors.

FIGURE 5: ON-MINE CASH OPEARTING COSTS OF SOME SA PGMs PRODUCERS.

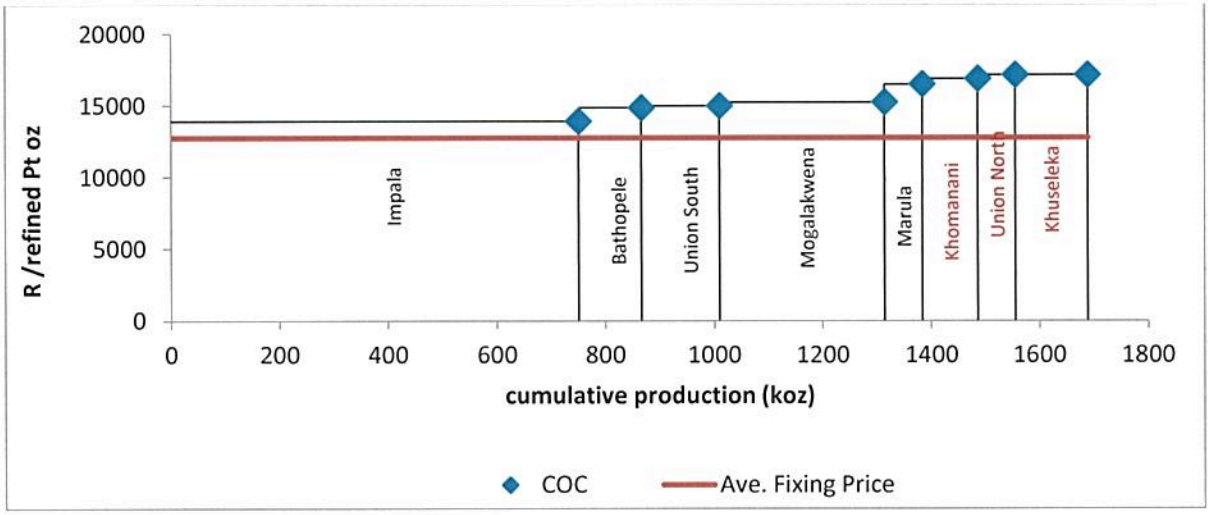


Source: Companies' Annual Reports

Figure 6 depicts some platinum mines' COC curves for 2012. The mines with low production capacities occupy the upper quartile of the cost curve, while the opposite is true for the mine with the largest production capacity. This is consistent with the analysis done by Tholana *et al* for PGMs mines from 2007 to 2011, as part of an MSc research study at the University of Witwatersrand. The companies with mines under analysis were African Rainbow Minerals (ARM), Aquarius, Amplats, Impala, Lonmin, Northam and Royal Bafokeng Platinum. Mogalakwena, Mototolo, (both Amplats) Two Rivers (ARM), and Kroondal (Aquarius) were some of the low cost unit operations, while

Zondereinde (Northam), Bokoni (Atlatsa), Khomanani, Dishaba, Thembelani, and Siphumelele (all Amplats) were among high unit cost operations.

FIGURE 6: INDUSTRY COC CURVE FOR SELECTED PGMs MINES, 2012.



Source: Companies' Annual Reports

Mogalakwena is an open pit mine, which is less labour intensive than conventional underground mining and the biggest power cost is diesel, not electricity. Mogalakwena's on-mine cost in 2012 was R315/t, compared with an average of R692/t for all Amplats's other managed mines. Reasons for such a spread along the cost curve are summarized in Table 1. In addition to production, depth of operation, mining method and level of mechanization also affect the cash cost performance and competitive position of platinum mines. At least 50 percent of Amplats' mines were found to be in the upper quartiles of the industry cost curve.

The increase in costs was augmented by the need to upgrade ore processing infrastructure in order to accommodate UG2 ore. Flotation circuits that existed in the early 1980s were designed to recover PGMs minerals associated with base metal sulphides in the Merensky ore. Even electric furnaces that existed then were ideal for smelting of Merensky concentrate. The challenge, therefore, was to embark on a costly process of designing flotation circuits and electric furnaces for the physically and metallurgically different UG2 ore.

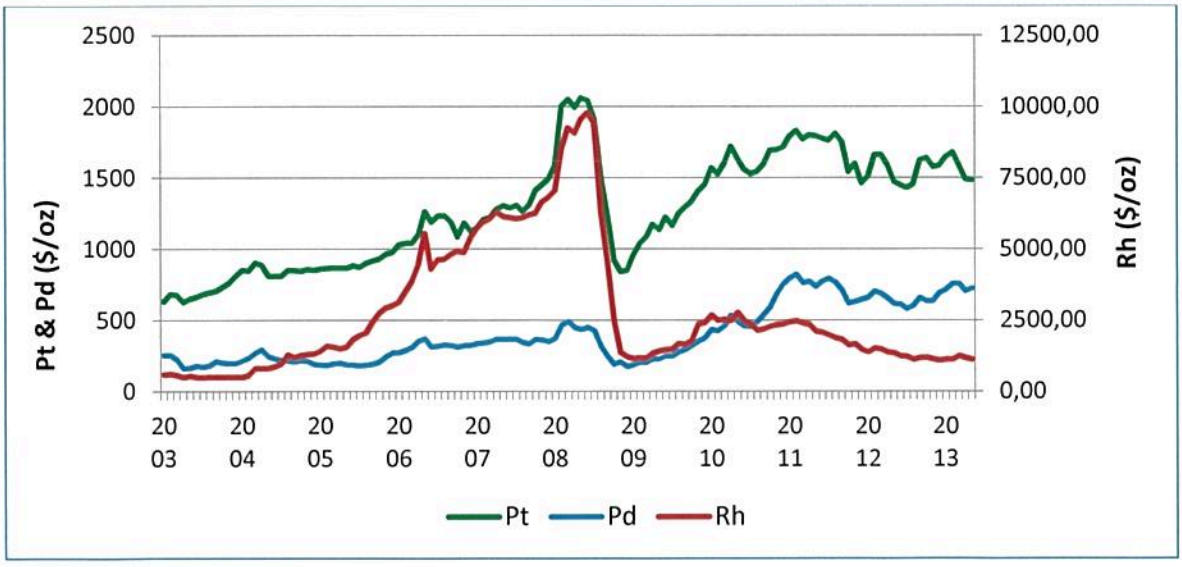
TABLE 1: A SUMMARY ANALYSIS OF LOW AND HIGH UNIT COST PLATINUM MINES

	Mine	Max. Depth (m)	Mining Method	Mechanization Level
Low Unit Cost Operations				
	Mogalakwena	240	Open pit	Mechanized open pit
	Kroondal	450	Room and Pillar	Mechanized
	Mototolo	450	Room and Pillar	Fully mechanized
	Two Rivers	250	Room and Pillar	Fully mechanized
High Unit Cost Operations				
	Siphumelele	1 350	Breast stoping	Conventional
	Thembelani	900	Scattered breast	Conventional
	Dishaba	1 250	Scattered breast	Conventional and mechanized
	Khomanani	1 245	scattered breast	Conventional and mechanized
	Zondereinde	2 200	Breast mining	Conventional

Source: MSc Thesis, T Tholana, Wits University, 2012.

The situation has been compounded by relatively depressed PGMs prices. From 2003 onwards prices rose steadily and peaked in 2008 just before the onset of the global economic crisis. Rhodium fell from just under $10 000/oz in 2008 to just over $1 000/oz in 2009 (Figure 7). As markets recovered, prices rose again, with Rh peaking in 2010, whereas Pt and Pd peaked in 2011. However, neither Pt nor Rh was able to reach pre-economic crisis levels. Since 2011, price movements were affected by several factors such as the dollar's fluctuating fortune, political tensions in the Middle East and North Africa, the severe earthquake and tsunami in Japan in March 2011, industrial actions, safety stoppages as well as concerns over sovereign debt problems in the eurozone.

FIGURE 7: AVERAGE PRICES OF SELECTED PGMs, JAN 2003 - DEC 2013.



Source: Johnson Matthey

Whereas Rh has been on an outright downward spiral since 2010, Pt and Pd prices have somewhat fluctuated while decreasing at the same time. Fortunately, for SA mines, this has largely been partly offset by the weakening of the rand against the dollar, particularly in 2013. At just under 900 koz per year, rhodium production is tiny, compared with approximately 7 Moz each for platinum and palladium, but for years it provided producers with super-profits from the mining of Merensky reef. While it is generally accepted that the drop in the Pt price squezzed profit margins of most producers, the impact of the plunge in Rh price exacerbated the situation.

A combination of rising costs and depressed prices took its toll in the industry in the last few years, resulting in restructuring, which ultimately led to several mine closures. Consequently, the country's platinum output fell to its lowest level in 11 years in 2012, although it must be mentioned that labour unrests and safety stoppages were partly responsible as well. But these have heightened the cost pressures as well and if costs continue to rise, more operations will be under severe financial pressure, which threatens not only the production of platinum but the sustainability of the industry as a whole.

5. IS MECHANIZATION THE FUTURE?

Rising costs and labour unrests have revived the argument in favour of mechanizing South Africa's loss-making platinum mines, at a time when the rest of the mining industry, from copper to coal, has been transformed by automation, unmanned trucks and remotely controlled equipment. However, mechanizing existing platinum mines is considered a distant prospect due to the associated high cost and risk, brought about by relatively weaker prices for platinum and tough conditions underground. Recent labour unrests have, however, rendered mechanization almost inevitable for future mining As a way of avoiding high labour costs and high-risk industrial relations, some producers are considering mechanization, with attention poised to shift from the labour intensive Rustenburg operations on the western limb to the northern limb of the Bushveld Complex. The latter is considered well-suited to mechanized mining operations because of its relatively thicker platinum-bearing reefs and as such is the focal point of future new mines development.

In the past 20 years, mechanization across the mining industry as a whole has resulted in an increase in productivity and around 16 percent drop in the workforce, from 610 000 in 1994 to 510 000 in 2013. On the contrary, platinum mines added just under 100 000 jobs over the same period to reach around 191 000, with reduced productivity. Increased productivity as a result of mechanization

could in turn result in larger manufacturing and beneficiation sectors, which, to a large extent, would rely on the success of the Beneficiation Strategy of the government. In this way, production volumes would be stabilized, while the loss of unsafe low-paying jobs would be offset by skills improvement and the creation of safer, higher-paying jobs.

6. KEY STRUCTURAL DEVELOPMENTS

Relatively shallow platinum deposits were recently discovered by a Canadian company in Waterberg, beyond the mapped northern limb of the Bushveld Complex. The orebody is at a relatively shallow 100 m and because of its unique nature, the mineralisation of this deposit is being referred to as having T-reef and F-reef. It is totally different to the Platreef in that it is 20 percent gold in its metal balance. Another discovery was made on the Platreef itself; a flat-lying orebody which can be mined by room–and–pillar method. According to the company, it will be highly mechanized and the labour component per unit of platinum produced will be very low compared with traditional underground mining. These discoveries indicate ample potential for the country to produce PGMs at relatively lower costs, and encourage further prospecting in areas yet to be exhaustively explored.

In the wake of a sharp drop in interim profit after a five-month strike in the first half of 2014, Amplats announced plans to sell its Union and Rustenburg mines, as well as exit Pandora and Bokoni joint ventures. The focus of the company is likely to shift to Mogalakwena mine, signaling the intention to focus on mechanization rather than the deep-level, labour-intensive and technically complex mines in the Rustenburg area. The production of Mogalakwena can be doubled to replace the output that Amplats would lose from selling Rustenburg mines. Job losses at the Rustenburg and Union mines are unlikely as Amplats seeks to exit operations through sale or public market exit. This presents opportunities for transformation and black ownership, as advocated by the Minerals and Petroleum Resources Development Act No. 28 of 2004 (MPRDA).

7. CONCLUSIONS

South Africa's PGMs mining industry has continued to evolve over the years, with the ongoing shift from Merensky to UG2 reef exploitation driving significant changes across the industry. One of the most significant changes is increased chrome ore production, which led to increased chrome ore exports to China for ferrochrome production, sadly at the expense of the local ferrochrome industry.

The need to exploit the deeper-lying and more technically difficult UG2 has resulted in increased costs, with the situation exacerbated by relatively depressed prices and, to some extent, labour unrests. This has resulted in producers mothballing operations and suspending projects, which impacted negatively on employment in the sector.

Recent developments point to mechanization as the possible future of the country's PGMs production, particularly in the northern limb of the BIC. Existing mines would be difficult to mechanize due to high costs and tough geological conditions, as such their sustainability remains in doubt due to the associated high labour costs and high risk industrial relations.

8. RECOMMENDATIONS

Increased chrome ore output offers opportunities to further raise production levels of ferrochrome in the country, in line with the government's policy of increasing the value of the country's exports. This could be achieved by urging producers, through amendment of the MPRDA, to make a certain percentage of their chrome ore production available at mine gate prices. Export taxes could be used to introduce price advantages for the domestic market.

Mothballed operations and suspended exploration projects could be better utilized, as they provide fresh opportunities for investment and transformation, including increased black ownership. The MPRDA should thus include a provision for a review of licenses for such operations, allowing for new ownership that satisfies the government's empowerment targets.

Mechanization should be supported and appreciated as largely a skills provider, not as unskilled labour provider, as is the case with conventional mining. For most currently operating mines, however, high labour intensity appears to be the only way to extract ore. As a result, mining companies, the government and organized labour need to jointly address poor socio-economic conditions that have fuelled instability in the sector.

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