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Upcoming economic hurdles for new South African platinum supply

B. CLARKE*, S. FORREST*, and A. RYAN*

*SFA (Oxford) Ltd, UK

This conference paper provides an appreciation of the cost of producing virgin metal by taking into account the cost and profit dynamics of production on a regional basis (Western Bushveld, Eastern Bushveld, Northern Bushveld, Zimbabwe, USA, Canada and Russia) and on a producer level. An examination of the PGM value chain for the major orebodies is also presented. The ratios of primary metals and by-products for each orebody are assessed relative to market requirements, and benchmarked in terms of net margin after by-product credits (per 4E PGM ounce).

Similarly, the paper offers a concise overview of the junior PGM sector, drawing from operational and financial models covering more than 20 projects across the South African Bushveld Complex. Consideration is also given to geology, resources, location, depth, grades, forecast production, lead times and start-up timescales. In covering 30 established and approved mining operations and understanding the costs and profit dynamics of each, consideration is given to the realistic costs of new supply and the characteristics that could make or break new projects.

An evaluation of current PGM supply, resource depletion rates and growth projections out to 2025 is presented. Using SFA's independent supply demand projections, estimates of the potential contribution and timing of new supply are provided and conclusions drawn on the optimal start-up timing for new mine development and whether the industry can meet new market requirements.

Introduction: deriving economic comparisons of the PGM industry

Economic extrapolations of PGM basket prices, costs and profitability are derived from weighted individual producer statistics that evaluate the total cash costs per refined 4E¹ PGM ounce of the main PGM producers in South Africa, USA, Canada, Zimbabwe and Russia, covering more than 90% of global primary production.

Taking account of co-product² and by-product³ revenues, all mines are profiled as stand alone and not in terms of attributable ounces. This paper covers producer costs and focuses primarily on performances in 2005, 2006 and 2007.

SFA presents costs on a calendar year basis. A number of producers have differing financial year-end dates, on 30 June and 30 September (Impala Group, Lonmin Plc and Aquarius Platinum Ltd), so the average metal prices realized and the exchange rates in each FY reporting period can vary meaningfully and, consequently, our historical cost and margin extrapolations can be misunderstood and misrepresented. Therefore, to avoid confusion and to provide an 'apples-to-apples' comparison, our cost database converts to calendar years those producers that do not report on a December year end. A full methodology statement is included at the back of this paper.

¹4E troy ounces are equivalent to the sum of platinum, palladium, rhodium and gold.

²Co-product revenue from ruthenium and iridium.

³By-product revenue from copper and nickel.

Economic profiles by region

The widening platinum and rhodium market deficits seen in 2007 were driven by strong automotive sector PGM demand for use in emissions reduction technologies, as well as constrained supply owing to a combination of safety concerns, industrial action and metal recovery issues. The market deficits led to record prices for the metals, with rhodium trading, on average, 36% higher at \$6 183/oz in 2007 relative to 2006, compared to platinum (+13.8% at \$1 309/oz), palladium (+9.6% at \$357/oz) and gold (+23% at \$696/oz). In addition, base metals, which can also be an important contributor to platinum producer profitability, sustained significant increases over 2006 prices, with nickel trading 56% higher at \$36 213/t and copper +6% at \$7 093/t. The varying nature of PGM deposits in terms of the ratios of metals produced, even from the same economic horizons, is therefore important in distinguishing the comparative performance of mining operations.

Fifty-nine per cent of the world's PGMs and 77% of its platinum are derived from South Africa. The metal ratios vary between the Limbs of the Bushveld Complex. The ratio of platinum to palladium is more than 2:1 from the UG2 and Merensky Reefs on the Western Limb, while from the Platreef on the Northern Limb and the UG2 Reef on some parts of the Eastern Limb the distributions of platinum to palladium are almost equal. Outside of South Africa, primary production tends to be palladium dominant.

Our 2007 estimates of regional industry profitability and costs using reported metal prices and exchange rates highlighted, particularly on a 4E PGM oz basis, the

significant margin being achieved in all regions. The 2007 regime of high metal prices was a key influence. While total average cash costs increased some 14% in 2007 (reaching \$494/4E oz from \$433/4E oz in 2006), net cash margins leapt some 44% (from \$710/4E oz to \$1 022/4E oz) on the back of the strong metal price increases outlined above.

Comparatively, our regional extrapolations for 2006 and 2007 show a 32% rise in 4E PGM prices to \$1 448/4E oz on the Western Limb, with total cash costs (before credits) increasing by almost 20% to \$686/4E oz. However, rises in by-product credits (up 32% or \$207/4E oz), coupled with the significant basket price increase, led to a 47% leap in net cash margins to \$970/4E oz compared to the net-margin achievement of \$661/4E oz in 2006. The orebody chemistry and combination of mining both the Merensky and UG2 Reefs on the Western Bushveld are such that the region benefits considerably from current high platinum and by-product credit prices, whilst also receiving reasonable revenues from rhodium. This gives the Western Limb producers an added advantage over their Eastern Limb counterparts, which achieve fewer nickel and copper credits.

The Eastern Limb producers continued their 2006 improvement trend into 2007 due to new, shallow mine start-ups, which have lower operating costs. Coupled with an average basket price increase of some 33% and weighted to rhodium, this allowed them to close the gap (net cash margins increased some 59%) on their Western Limb counterparts, as illustrated in the 2007 regional total cash cost and margin profile in Figure 1.

The Northern Limb and Zimbabwean producers remain competitive, with net cash margins of over \$700/4E oz. Both regions enjoy significant nickel and copper credits to offset cash costs. Nevertheless, with a platinum to palladium ratio of around 1:1 on the Northern Limb, prices received on a 4E basis lag behind those of the Western and Eastern Limbs where the platinum to palladium ratios are closer to 2:1. In addition, the Northern Limb and Zimbabwean producers are not benefiting as much as the other regional producers from the high rhodium prices.

Basket price increases have so far more than offset cost inflation in the industry. The major South African producers reported working cost increases of between 15% and 20% (ZAR terms) for 2007, primarily as a result of above-inflation wage settlements combined with significant rises in the prices of most consumables. The weaker South African rand (4% lower than in 2006), however, served to soften the impact of the ZAR-based cost increases, thus limiting the overall cost increase (in US\$ terms) for the South African peer group to around 18.6%, to \$684/4E oz (weighted average). The total cash costs for Western Limb producers (typically at steady state) have risen by 19.7%, while the Northern Limb operations have seen the steepest rises of almost 30%. For Eastern Limb producers, however, total cash costs increased by only 6.4% on 2006, primarily as a result of new, shallow and lower-cost mines beginning production.

Economic analysis of South African PGM reefs

The current regime of high platinum and rhodium prices is skewing the profitability of the UG2 Reef artificially in the short term, with the highest prices received compared to other reefs at \$1 654/4E oz for 2007 (see Figure 2). However, Merensky and Platreef producers are more geared to nickel and copper by-product credits and, with base metal prices at significant highs, these reefs have the added benefit of offsetting cash costs. On this basis, despite UG2 ore receiving the highest price, a lack of by-product credits means that the reef occupies last place behind the Merensky Reef and Platreef for profitability (see Figure 2).

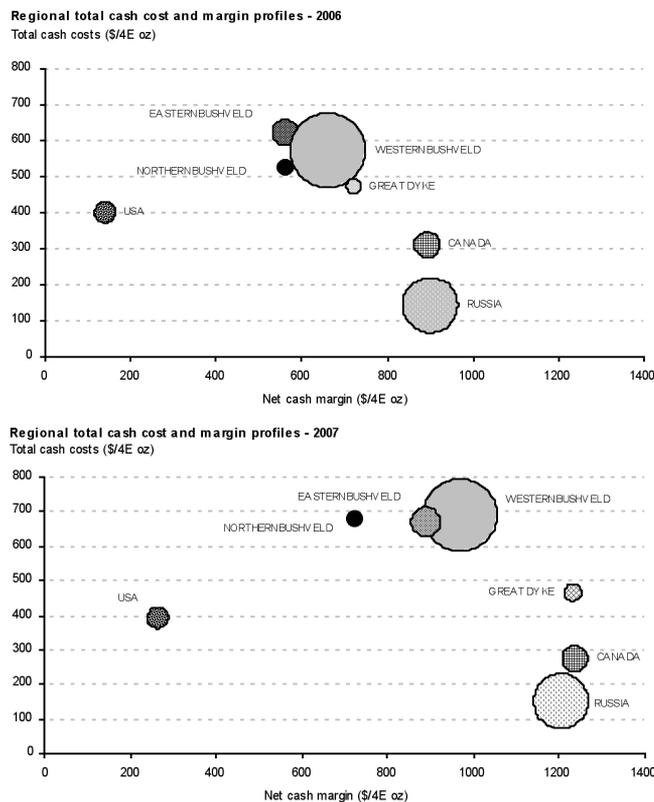
The Merensky and Platreef economic horizons have a diversity of metals in their splits that will allow producers to maintain some basic levels of earnings regardless of whether PGMs or base metals are experiencing downturns in their price cycles.

The UG2 Reef, however, has an over reliance on rhodium (33% of revenues), see Figure 3, which means that producers exploiting the reef to the exclusion of others are taking more risk as the reef revenue split is more vulnerable to downturns in the PGM price cycle, and especially to the historically volatile rhodium price.

In addition, SFA's analysis of future sources of supply in South Africa highlights a growing trend away from exploitation of the Merensky Reef to mining the UG2 Reef, with the UG2 to Merensky split rising from 65% in 2006 to 75% by 2010.

Producer economics

After restating costs and margins to calendar years, our official 'winners' for 2007 are the by-product producers, i.e. those companies that produce PGMs as a by-product of nickel output. These companies, including Norilsk,



Source: SFA estimates. NB. Bubble size represents PGM (4E) production in ounces.

Figure 1. Regional cost and margin profiles (US\$/4E oz) — 2006/7

producer margins as, despite their attractive basket price weighting to rhodium, they receive fewer by-product credits of nickel and copper to offset cash costs. So, should the rhodium price drop, margins could be more at risk. Kroondal is normally ranked close to the top of the peer group owing to its successful implementation of low-cost, mechanized mining methods, but some other UG2 producers have not been particularly attractive until recently when the rhodium price surged by 36% last year to an average of \$6 183/oz.

Whilst other producers may not benefit as much from the recent escalation in the rhodium price, nearly all the remaining producers are comfortably receiving margins of above \$500/4E oz. Western Limb producers, in particular, typically received 4E basket prices of above \$1 000/oz whilst also benefiting from healthy by-product credits of copper and nickel which, on average, resulted in net cash margins in excess of \$700/4E oz.

South African junior PGM sector economics

The disruptions caused by the power rationing by South Africa's energy supplier, Eskom, are likely to affect platinum supply for at least four years. The loss, calculated at 6% of annual output, is likely to translate into a much slower annual growth rate of 3% for the period out to 2013. Prior to the Eskom capacity shortage, growth projections were around 6% annually. The platinum market is therefore forecast to remain in deficit or very closely balanced until 2012, encouraging the need for new supply. Furthermore, a likely scenario beyond 2010, whereby the tightening and roll-out of global emissions legislation continue beyond current announcements, would place the market in permanent deficit.

Many junior companies have already included an Eskom capital contingency in their project planning. Shallow projects include capital provisions for diesel generators,

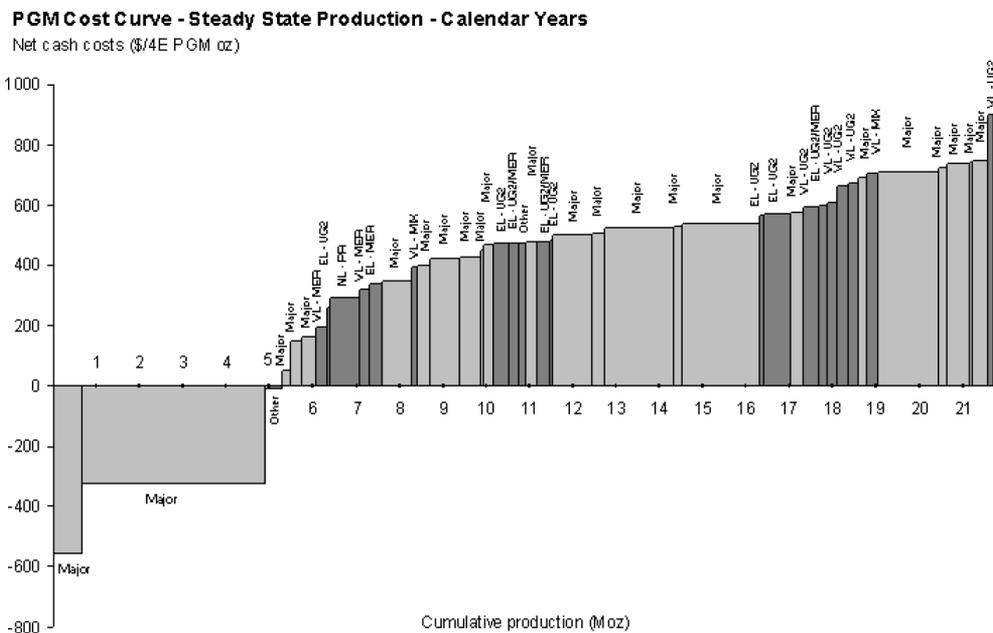
whilst deeper operations have made changes to mine design to reduce electricity requirements, with some switching to deeper decline mining from planned vertical shaft designs. Deeper (>1 000 mbs) or very large-scale projects could be delayed beyond current start-up timing. Some juniors have employed consultants to solve the electricity supply difficulties.

The current industry weighted average mine depth is 887 mbs; seven of the South African 21 junior projects modelled by SFA will be deeper, with many requiring costly refrigeration and increased power requirements. Most juniors expect projects to be developed and commissioned by 2015, which we consider to be optimistic.

SFA's global peer-group benchmarking, which includes modelling of established mines based on historical average prices and exchange rates⁴, shows that many juniors are probably underestimating operating costs. Close scrutiny of Figure 5 shows the stark contrast between planned junior PGM project operating costs and those of the global peer group of major producers and newly commissioned projects, highlighting an apparent competitive advantage to established operations.

Projects that are planned to mine solely the Merensky Reef should rank favourably among the global peer group (see Figure 5). The benefits of mining only the Merensky Reef are the yields of significant by-product credits and a 4E PGM basket geared to long-term average prices, as well as relatively high mill head-grades. This has led to high peer group rankings for juniors mining only the Merensky Reef, which are placed in the second quartile for net cash costs. However, the successful mining of the Merensky Reef on certain parts of the Eastern Bushveld is yet to be proved.

⁴Average prices for the assessments of future supply were \$1,135/oz Pt, \$299/oz Pd, \$4,420/oz Rh, \$582/oz Au, \$3,240/t Cu and \$15,805/t Ni, while the rand-dollar exchange rate of 6.76 was used.



Source: SFA estimates. Using three-year average PGM prices and exchange rate parameters as well as long-term nickel and copper prices. EL = Eastern Limb, WL = Western Limb, NL = Northern Limb.

Figure 5. Industry PGM net cash cost curve including selected junior PGM projects (dark grey)

Considering the compromised position of the current crop of junior projects in structurally challenging or isolated locations, as well as ambitious production scaling, SFA would expect new projects to rank in the third quartile for operating costs. The more mature and structurally challenged operations are likely to rank in the fourth quartile of the cost curve.

Internal rate of return (IRR) valuations, using historical prices, highlight that many junior projects still require significant technical considerations to convert them into viable long-term propositions. SFA considers that returns of between 10% and 15% may lead to only project break-even and suggests that an IRR of greater than 17.5%, and even 20% for higher risk projects, would be required to secure project approval or become attractive investment prospects (see Figure 6).

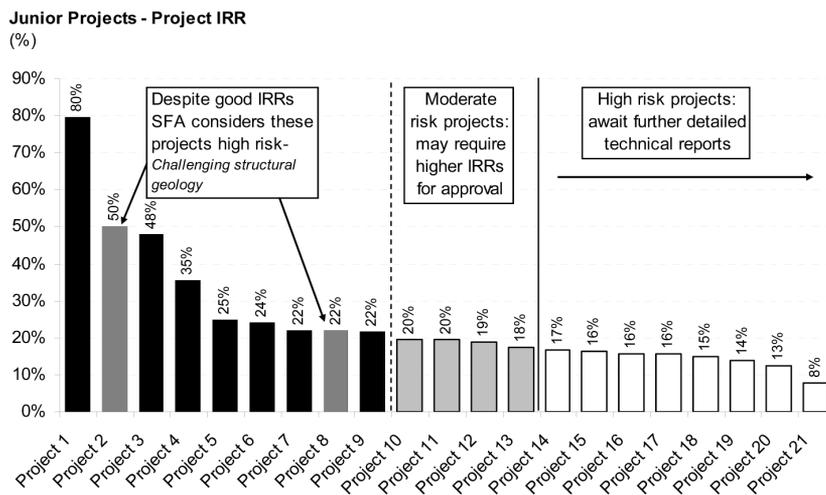
Project valuations suggest that eight projects do not meet investment hurdle rates at present. Together, these projects add up to 1 moz of potential annual platinum production. This leaves projects with a combined annual production of 2 moz.

Furthermore, two other projects with structurally complex geology carry considerable risk despite high rankings. Combined, these two projects add up to a potential 320 koz of annual platinum production. Therefore, this leaves around 1.7 moz of output from junior projects likely to go ahead in the future.

New supply and market requirements

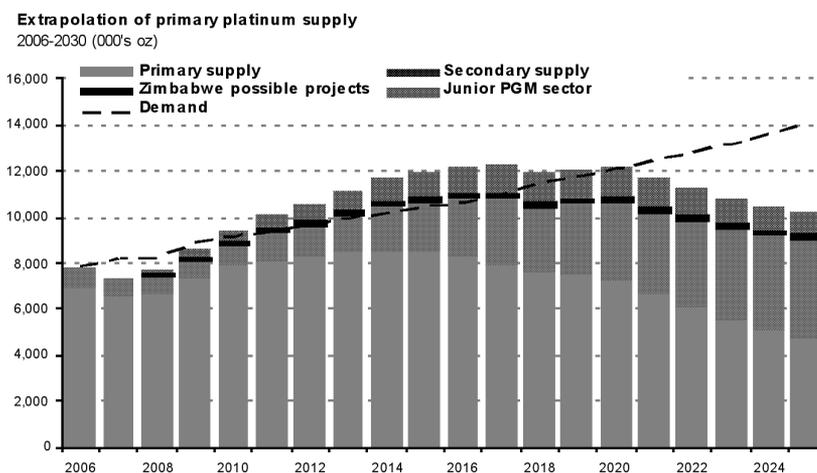
Strong supply growth is forecast in the period 2009 to 2010, with output increases averaging 8% p.a., even with Eskom shortages. By 2011, primary supply is projected to breach 8 moz, and slower but continued growth should lead to a peak in production of 8.6 moz by 2014 (see Figure 7). SFA has also overlaid its forecast outlook for demand to highlight market requirements for junior project supply.

A number of new mine start-ups are expected in the period 2008 to 2010, including Unki (60 koz), Blue Ridge (75 koz), Smokey Hills (45 koz), Pilanesberg (~140 koz), and later in 2015 the start-up of Impala Platinum's recently approved No. 17 Shaft (170 koz).



Source: SFA Oxford

Figure 6. Ranking of project IRRs using long-term historical prices



Source: SFA Oxford

Figure 7. Platinum market extrapolations and the need for PGM juniors beyond 2017

A loss of 1.3 moz of platinum is estimated between 2014 and 2020 from mine closures and mature mine shaft depletion. Six PGM mines are forecast to close by 2020, adding up to 700 koz of lost supply. These mine closures are Lac des Iles, Smokey Hills, Crocodile River, Kroondal P&SA, LP Limpopo (P1) and Everest South, plus a 700 koz loss from industrywide shaft depletion. The junior projects considered most promising are included in our extrapolations but could keep the market well supplied for only an additional three years between 2017 and 2020. This would alleviate market tightness as other mines close and deplete but, despite favourable prices, external influences, rising start-up costs and the difficult geology of the remaining projects suggest that this new supply is likely to be delayed and downscaled, and there is also the possibility that some junior projects may stall.

Conclusions

This paper has highlighted the phenomenal financial operating performances of current PGM mines on the basis of the significant metal price appreciation of rhodium, platinum and nickel. This has served to ensure that all operations are currently profitable and, in particular, has assisted the expansion of the UG2-dominant Eastern Limb operations, largely on the back of high rhodium prices.

SFA's economic analysis of South African PGM reefs, however, highlights the vulnerability of the UG2 projects to a downturn in future PGM prices received, with heavy weighting to rhodium revenues (33% on 2007) and a lack of meaningful by-product contributions from copper and nickel relative to other reefs.

Using historical metal price and exchange rate averages to evaluate junior projects further compounds this argument, with Western Limb (UG2 and Merensky mix) and Northern Limb (Platreef) juniors benefiting from ore-body diversity and higher base metal contributions to costs.

Challenges to bringing on new supply are mounting, including the difficult structural geology of the remaining mineral leases, shortages of skills and materials, cost inflation and rising capital expenditure requirements, which now include independent electric power facilities. Some junior projects are better placed than others to survive future price disruptions. SFA's current evaluation of 21 juniors indicates that at least ten projects carry the risk of failing to meet investment hurdles.

Nonetheless, SFA's forward extrapolations of platinum supply and demand to 2025 and beyond highlight the need for new supply, particularly from 2016 when established

resource depletion rates accelerate. SFA suggests this period as an economic window to expansion or new project development to benefit from higher prices and accelerated capital payback.

Even with the inclusion of supply from those junior projects that SFA calculates could be approved, beyond 2020 it will be difficult to meet the market demands of green technologies requiring platinum.

Costs and margins methodology

Our regional PGM industry benchmarking and cost modelling evaluate the total cash costs per refined 4E PGM oz (i.e. Pt, Pd, Rh and Au) of the main PGM-producing regions in South Africa, North America, Zimbabwe and Russia, covering more than 90% of global primary production. Our cost and margin profiles present a regional view of the PGM industry as a whole, and give an insight into the cost characteristics and profit dynamics of its various regions.

Cost profiles are consistently based on cash costs and exclude capital, financing and depreciation/amortization charges in order to provide a coherent, like-for-like framework for comparison. The basic cost measures reflect, primarily, physical production costs and include other cash costs incurred, which are mostly corporate overheads, marketing and royalties. Finally, costs are also calculated net of the credits arising from the sale of co-products and by-products (Net TCC/4E oz). The volumes of platinum, palladium and rhodium, the most significant of the platinum-group metals, and gold are aggregated as the principal components of output, and cost assessments are therefore expressed in US dollars as total cash costs per 4E oz (US\$ TCC/4E oz).

Mines that do not have PGMs as their primary output but are substantial PGM producers have also been included in our analysis. These include two main producers listed as 'Norilsk', the nickel producer, and 'Canadian Other' which includes the operations of Inco (now Vale) and Falconbridge (now Xstrata). The costs of these producers have been adjusted to reflect the proportion of their revenues due to 4E as a share of total producer revenues. This ratio is also applied to the base metal credit calculations, which compute net total cash costs and margins per 4E oz.

Average prices for the assessments of future supply were \$1 135/oz Pt, \$299/oz Pd, \$4 420/oz Rh, \$582/oz Au, \$3 240/t Cu and \$15 805/t Ni, while the rand-dollar exchange rate of 6.76 was used.



Beresford Clarke

Head of Research, Senior Consultant, SFA Oxford

Beresford has been dedicated to platinum-group metals' market analysis since 2003. His work involves addressing all aspects of PGM supply, demand and price forecasting for strategic business planning purposes. Beresford has led a number of bespoke consultancy assignments for major industry stakeholders, new market entrants and financial institutions and provides immediate solutions for regular clients who require PGM market intelligence for decision making purposes. He specializes in analysis related to present and future PGM supply, which includes the financial and operational evaluation of PGM mines and future potential projects worldwide. Beresford also spent time producing commodity market briefings and price forecasts for hedge funds. After postgraduate studies in mineral economics at Imperial College and spending two years working for an exploration company in Africa, Beresford worked for as a Precious Metals Analyst in London, specializing in the global supply, exploration and mining of PGMs and gold.