SFA Oxford

# THE PLATINUM STANDARD

MAY 2014

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MAY 2014

First edition

# Contents

# SFA (Oxford) Ltd

SFA (Oxford) is an independent, global authority on the platinum-group metals (PGM) market, whilst providing tailored intelligence on numerous other strategic commodities. The company is wholly independent and its in-depth market research and integrity is underpinned by extensive consulting from mine to market to recycler, as well as an unrivalled global industry network.

Stephen Forrest, Chairman, one of the PGM industry's foremost authorities, set up SFA (Oxford) in 2001 having worked as a Commodities Strategist, Fund Manager, top-rated Mining Analyst covering PGMs, and Operations Manager of platinum mines. Through this multi-faceted history, he has built up an exclusive network of contacts that transcends individual industrial sectors and value chain linkages, placing him in a unique position to provide cross-commodity expertise to a trusting client base.

With our team of nine dedicated PGM analysts, who have wide and varied industry expertise and knowledge, each one specialising in a core area of the value chain, as well as many internationally-based associate experts, we are able to provide our clients with answers to the most difficult questions affecting the future of the industry.

We work with producers, refiners, recyclers, end-users, investors and governments, many of whom have remained loyal clients throughout more than a decade in the business.

Apart from our regular market intelligence on the PGMs and other commodities, the backbone of SFA's business is bespoke consulting. The team works confidentially, often augmenting business planning efforts and assisting with company strategy. Whether it is an end-user wanting to know the impact of a new end-use on the market and metal prices, a mining company scheduling shafts or reviewing its labour requirements, investors and miners evaluating projects, providing price forecasts for underwriting and capital-raising purposes, recyclers and refineries wanting to extract more value from their business, or investors wanting to quantify price risk, SFA has the know-how to offer confident and independent direction for your strategic decision-making.

# Foreword

## Setting the standard, setting the agenda

**The PGM industry is at a turning point**
To simply use words such as 'unstable' and 'fluid' to describe the state of our markets is no longer sufficient, serving only to downplay the significant shift in the spheres of PGM influence relating to supply and demand that has occurred over the last 10 years.

South Africa, the world's primary PGM producer, continues to lose ground as its long-held influence over metal prices continues to slip. Unsatisfied by on-going supply downgrades and increased price volatility, end-users sought alternative sources of supply, namely more freely 'available' palladium at the expense of platinum and rhodium, which are both primarily supplied by South Africa. Key to supply growth is the rhodium price.

We have also seen the birth of the 'proxy supplier' – Japan, North America – as excess stockpiles and increased recycling of PGMs caused a return to the market of metal surplus to regional requirements.

However, demand has not been immune to its own identity crisis as the traditional hub of industrial consumption, Europe, bowed out to the new heartland of China as its successor in the wake of the continent's continued economic and political struggles. China, a country with a growing penchant for platinum jewellery, had been gradually gaining on Europe for some time, and is now the world's largest consumer of platinum.

A fundamental change to the PGM markets is real and is happening now. The likelihood is that the sector we know today will be different tomorrow.

With that in mind, SFA (Oxford), spurred on by public demand, felt a certain responsibility as a trusted source of PGM analysis to create a publication that brings to light those issues – industrial, economic and political – that will affect the industry over the next 12 months.

*The Platinum Standard* is one-half review, one-half preview. For the former, we, alongside our expert associates, have collated all the key industry data and indicators for the past 12 months, taking account of the major factors that have impacted PGM supply, demand, and pricing over that period.

Looking ahead at 2014 and beyond, we then put together a number of feature articles about those issues we believe will set the PGM agenda going forward, including one on the current Ukraine-Russia crisis, authored by Dr Paul Chaisty, a pre-eminent expert in the field of Russian political affairs. In this, the first edition of *The Platinum Standard*, we felt the following topics were the most relevant under this heading:

**Platinum's global spheres of influence**
*A look at the changing PGM landscape*

**Rhodium: Key to PGM supply growth**
*The impact of rhodium on South Africa's PGM basket*

**The Ukrainian crisis and its impact on Russian PGMs** *by Dr Paul Chaisty, Professor of Russian Government at Oxford University*
*PGMs and Cold War politics*

*The Platinum Standard* will be an event-driven report, released twice-annually in May (London Platinum Week) and September (New York Platinum Week) each year.

*The Platinum Standard is one-half review, one-half preview.*

As always, thank you for your continued support of SFA (Oxford) and its work. Our success as a company is due primarily to our clients who, despite the challenges facing the PGM markets, have remained with us throughout.

**Beresford Clarke**
Managing Director, Head of Research
SFA (Oxford) Ltd

# Platinum's global spheres of influence

# Platinum's global spheres of influence

## A changing market landscape

The platinum landscape is changing, both fundamentally and irreversibly. Decades-old dynamics are falling victim to a market that is less tolerant of price volatility. Users want certainty and security instead. Meanwhile, producers need ever higher prices for their basket of metals as mines mature.

The balance of power shared amongst many more players

This article focuses on the regional shifts that are taking place, mainly away from presiding PGM powers and towards newly developing spheres of supply and demand. These shifts are essential to securing platinum's future.

There was a time when South Africa dominated platinum output to market, providing over 75% of world supply. Likewise, Europe remained unequalled in the need for platinum to fit into its catalysts, accounting for 35% of global demand before the financial crisis.

Nowadays, platinum is no longer flowing quite so freely out of South Africa, nor is it being sought quite so readily by Europe; a combination of cost inflation and price volatility has seen to that.

The platinum sector today is far more fragmented, with the balance of power shared amongst many more players.

There are four main spheres of influence affecting tomorrow's platinum market.

First, how great an influence will South Africa have on PGM markets going forward – will end-users pay for cost inflation in South Africa and on-going mine disruptions? Can the void be filled by lower-cost output from Zimbabwe and the Northern Limb of the Bushveld Igneous Complex?

Second is the emergence of "new suppliers" or recyclers, namely the USA, with surplus platinum from end-of-life automotive catalysts yielding more platinum than the country needs, and Japan, from scrapped jewellery. How significant is this? Can recycling offset declining output from South Africa or replace the need for new projects?

Third, market commentators focus on Europe when discussing platinum demand, but China has overtaken Europe as the largest platinum consumer. Consequently, China has been coined the "new heartland" as its market is dominated by jewellery demand and the emotions that drive that demand.

Finally, there are what might be called "new frontiers" – a collective of regions, including Southeast Asia, other Asia and South America. The question is whether this collective could replace large but stagnant demand in Europe, and if so, when?

These four spheres are essentially good news for platinum. The market's biggest contributors are struggling to maintain market share, but there are new contributors waiting in the wings to play their part.

# SPHERES OF INFLUENCE CHANGING

## SUPPLY SINKING

SA supply down
1.2 moz since peak
2006 levels

### SOUTH AFRICA

-21%

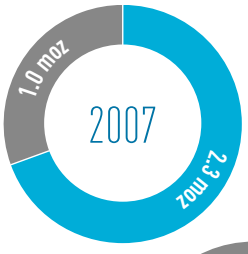
Platinum Supply
2006 ›› 2013

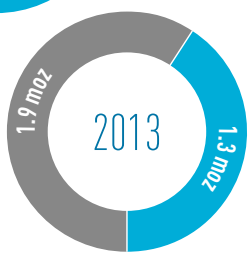


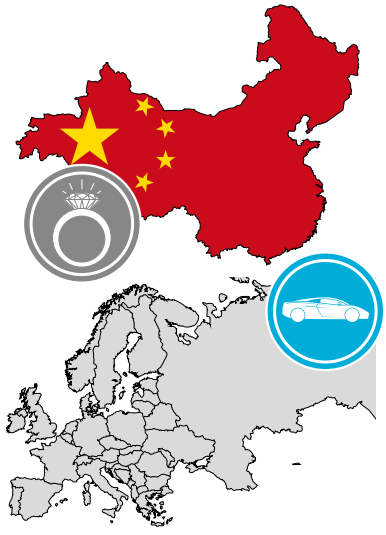

### ZIMBABWE

+1 moz Platinum Supply POTENTIAL?


## DEMAND HEARTLAND



EUROPE 2007 ›› 2013

-1 moz

### CHINA JEWELLERY

+900 koz

2007 ›› 2013

NON-ROAD AUTOCATALYST

ON-ROAD AUTOCATALYST

HDV AUTOCATALYST

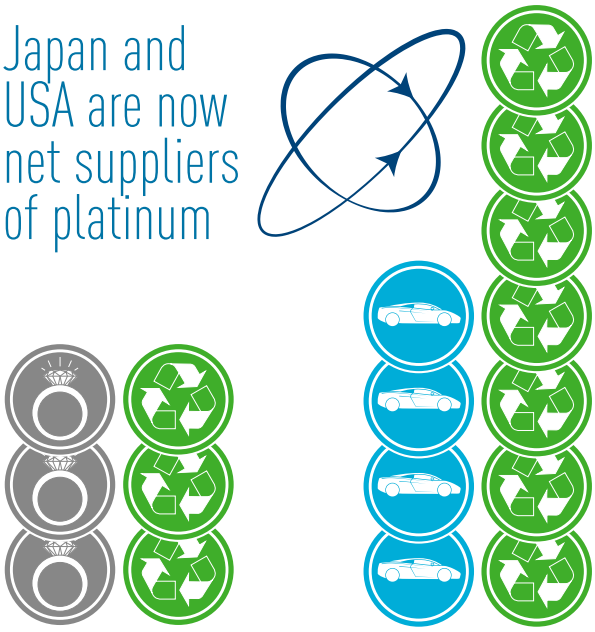
PLATINUM RECYCLING

PLATINUM JEWELLERY

PLATINUM MINE SUPPLY

# NEW SUPPLIERS

Japan and USA are now net suppliers of platinum



## RECYCLING

Growth of 1.5 moz since 2000

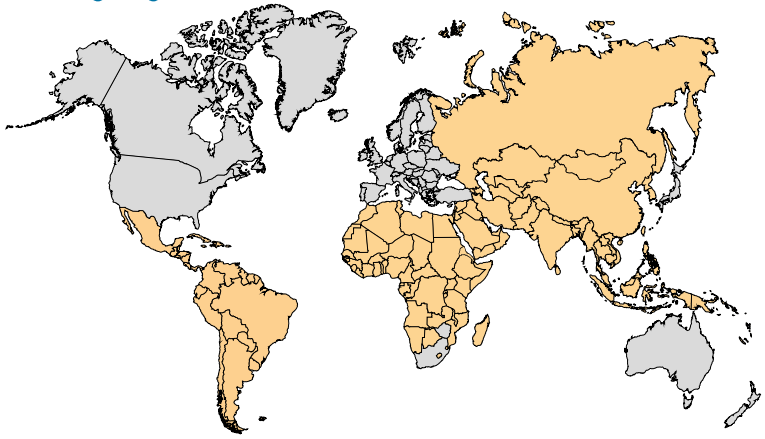
Now 26% of supply

JAPAN 2013

USA 2013

# NEW FRONTIERS

Tighter tailpipe emissions legislation in emerging markets



# UPSIDE

## +2.1 moz

Total Platinum Demand

0.9 moz

0.9 moz

0.3 moz

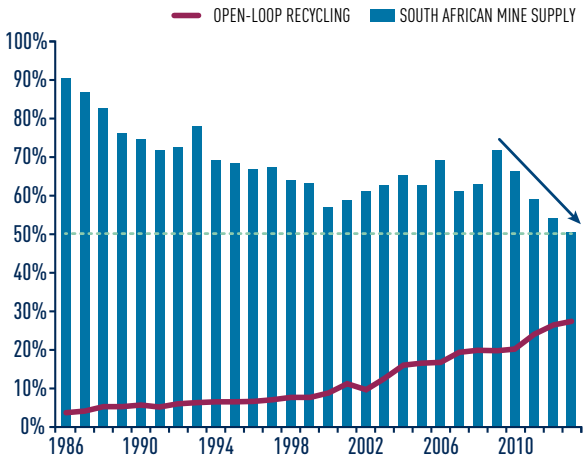
## South Africa's influence is waning

South Africa still provides over 70% of the world's primary platinum supply and 76% of rhodium, though only 35% of palladium.

It would seem that such concentrated supply would be enough to have a significant influence on price, but the launch of Absa's NewPlat ETF, absorbing over 1 moz of stock with no impact on prices, suggests otherwise. Why is this?

Looking at South Africa's platinum supply as a percentage of demand shows that the country is past its heyday in the 1980s when it provided most end-user requirements.

### South African platinum supply as a % of demand




*Source: SFA (Oxford)*

South African platinum supply has fallen from over 70% of demand in 2009 to just 50% in 2013. It peaked at over 5.3 moz in 2006, but was down by 1.2 moz to 4.1 moz in 2013.

During that time, supply has grown from another source – recycling.

Platinum supply from scrapped autocatalysts and jewellery is four times higher than in 2000, from just over half-a-million ounces to more than 2 moz p.a. today.

To put this in perspective, recycling supply has equalled output from a company the size of Lonmin incrementally every five years.

South Africa's influence on price, whether it be from supply disruptions or higher costs, is diminishing.

## South African supply is expensive

The cost of production in South Africa has risen exponentially in recent years, with dollar converted total cash costs increasing by 123% (or 12% p.a.) since 2003, from an already high base relative to other PGM-producing regions.

Average shaft depth in South Africa is over 1,000 metres below surface (mbs), whereas in Zimbabwe it is around 300 mbs.

Miners in Zimbabwe, Russia and North America, who produce more palladium than platinum, have lower cash costs on a PGM ounce basis and receive substantially higher by-product credits than South African producers.

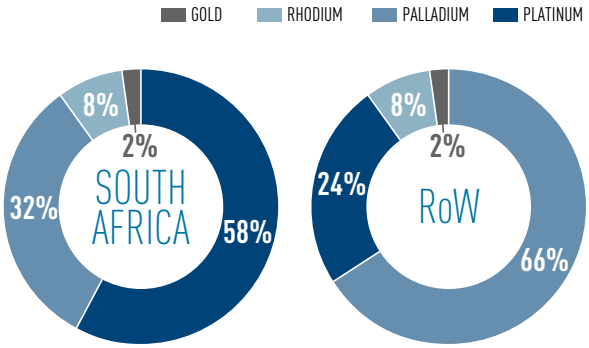
On a weighted global basis, palladium is therefore cheaper to produce than platinum.

South African producer total cash costs decreased in dollar terms in 2013 by around 16% as a result of a weaker rand. At the time of writing, the AMCU-led strike has extended to 15 weeks. Shaft closures, sale of assets and restructuring are the potential long-term ramifications of protracted strike action. Operations that restart are likely to be more cost-efficient, partly through attrition of labour.

Looking ahead, the country's cash costs are forecast to continue to rise, as its mine shafts become deeper and pressure mounts from the unions to meet unaffordable wage demands at current staffing levels.

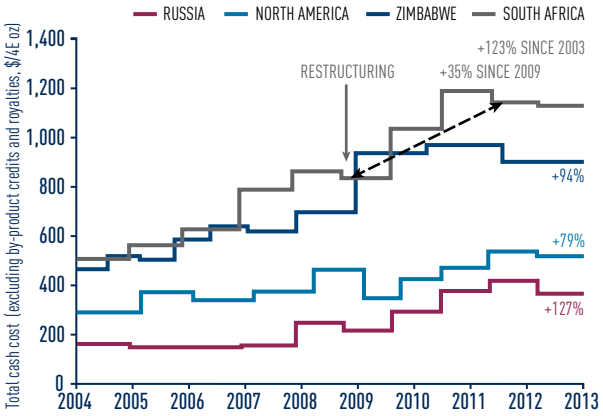
Future outperformance by producers will be from those that are able to tightly control their cost base.

### PGM production split by region




*Source: SFA (Oxford)*

### Producer cost curve by region, 2004-2013

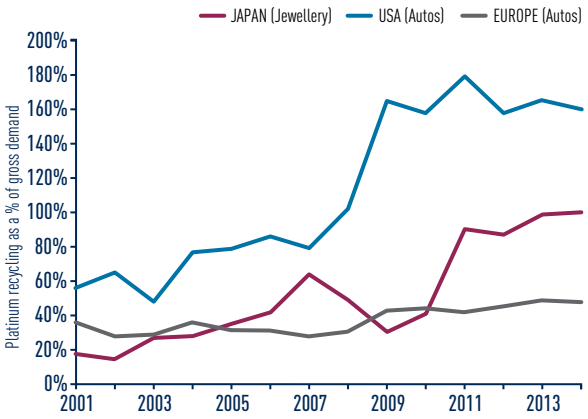



*Source: SFA (Oxford)*

## The new suppliers: Recycling

Offsetting the incremental loss of South African output is recycling.

### Platinum recycling as a percentage of demand




*Source: SFA (Oxford)*

Since the financial crisis, the USA has become a net supplier of platinum, producing up to 200 koz p.a. Palladium now fully dominates the US catalyst cocktail but platinum has increasingly come back to market through recycling of old platinum-loaded catalysts.

Similarly, Japan has a long history of its citizens buying platinum jewellery and some of this is now making a return journey. The volume of platinum being recycled is now exceeding consumer demand, so the country is also becoming a net supplier of platinum.

Since 2000, autocatalyst recycling in Europe has grown tenfold to over 400 koz in 2013, and this will continue to serve to partially offset new metal requirements as automotive demand on the continent recovers.

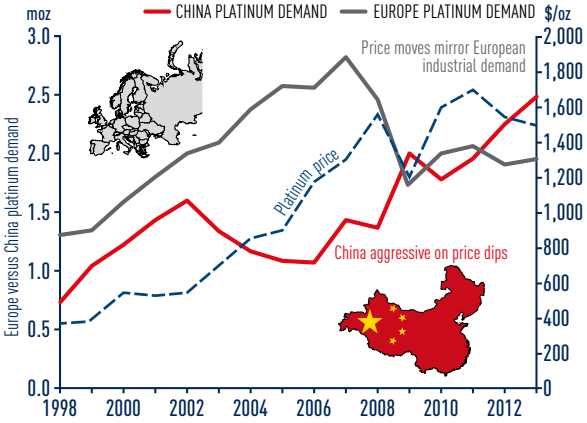
## New heartland: China tops consumption

Europe's industrial consumption bubble for platinum burst in 2008. Prior to this, demand peaked at 2.8 moz.

Notwithstanding the long march of recovery for automotive production, European platinum requirements are unlikely to reach these levels again owing to the compounding effect of substitution by palladium since 2006, which now makes up just over a third of diesel light vehicle catalyst loadings.

However, a weak Europe appears to be balanced by positive news elsewhere. In China, the growth of jewellery stores offering platinum, combined with a higher number of wedding registrations, has led to a strong upswing in platinum jewellery sales.

### Europe versus China platinum demand




*Source: SFA (Oxford), Bloomberg*

Total Chinese platinum demand reached an estimated 2.3 moz in 2013, which is 430 koz greater than in Europe.

Strong jewellery demand is supported by trade statistics indicating imports to China and Hong Kong of 2.48 moz of platinum in 2013, up 27% on 2012 and 320 koz higher than peak stock-building in 2009.

In 2013, Shanghai Gold Exchange trade was at record levels for platinum at 1.47 moz, which is over 400 koz higher than in 2012,

stimulated by lower local platinum prices relative to the last few years.

Looking ahead, store expansions are expected to continue at a strong rate for at least the next year or two. In the longer term, support can be expected as the demographic peak for weddings has yet to be reached.

*Source: Platinum Guild International*

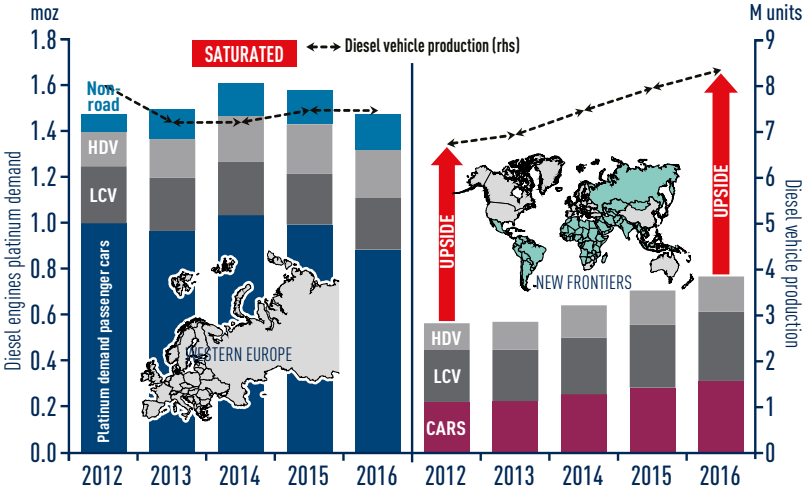
## New frontiers: Emerging market upside

There is limited upside in Europe, apart from the implementation of Euro 6 legislation this year affecting cars and heavy-duty vehicles with higher PGM loadings, as well as the steady increase in non-road PGM demand as legislation forces the fitment of catalysts to agricultural, construction and mining equipment. Vehicle manufacture remains lacklustre.

Looking to new frontiers (excluding China, but including India), there is enormous potential for platinum in diesel vehicles. The chart below shows the considerable gap between diesel vehicle production and platinum demand, whereas in Europe the two are almost parallel.

New frontiers could add 700 koz p.a. through tighter tailpipe emissions legislation

### Diesel engines platinum demand and diesel vehicle production




*Source: SFA (Oxford), LMC Automotive*

Therefore, if the so-called "new frontiers" were at the same stage of legislation as Europe, demand could be around the same level or even higher. This suggests an increase of at least 700 koz p.a. without taking into account non-road equipment or China's potential. Including China and non-road equipment indicates 2.1 moz of demand upside.

Add China and non-road engines and the upside rises to 2.1 moz

One of the key countries to watch in the medium term is South Korea which is introducing Euro 6 legislation for diesel cars and trucks in 2015 and where around 22% of cars are diesel-powered. Meanwhile, the roll-out of Euro 5 will possibly affect diesel cars this decade in India, where around 50% of cars are diesels. These cars will mostly be required to fit platinum-rich diesel particulate filters, which, along with higher vehicle production, will be enough to double platinum demand in India before 2020.

Cost-cutting and higher yield per worker are required

Elsewhere, Russia and Brazil are set to introduce Euro 6 equivalent standards for trucks before the decade is out.

## Summary: South Africa needs to adapt

In summary, the world needs platinum. Substitution and thrifting in automotive catalysts has taken place, but only to another PGM.

The outlook for the platinum sector is therefore positive and SFA believes that prices will rise over the medium to long term, particularly as the "new frontiers" catch up with European, US and Japanese tailpipe emissions legislation. Collectively, there is 2.1 moz p.a. of additional platinum usage in China and the Rest of the World waiting to be regulated.

However, there are more sources of supply than before, so end-users can carefully manage metal accounts to sell high and buy cheap, safe in the knowledge that supply is plentiful and will meet current demand. This excess market liquidity is evidenced by Absa's NewPlat ETF absorbing over 1 moz of platinum since its launch with limited impact on lease rates.

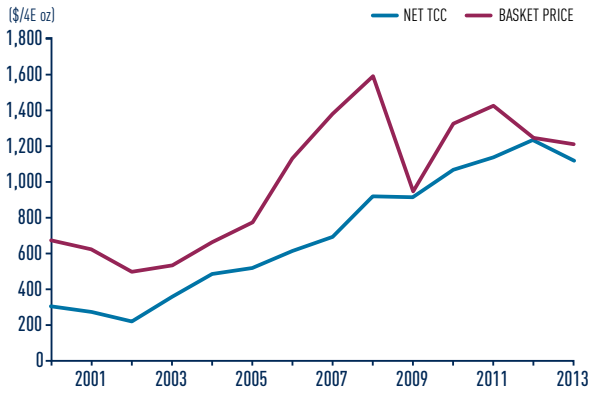
South Africa's influence on the market has waned demonstrably. Supply disruptions and producer management of output can no longer be guaranteed to lead to an increase in price. Furthermore, end-users are not willing to pay for continued rampant cost inflation, and the closure of numerous UG2-rich operations is proof.

A battle of the cost curve is taking place in South Africa. High-cost, inefficient operations will not survive in their current state so severe cost-cutting and higher yield per worker are required. See chart below which highlights the squeeze on margins at the 80th centile of the cost curve between price received and net total cash costs (net TCC). For this reason, Zimbabwe must become a real option as a replacement for mature South African supply.

The largest consumer of platinum is now China, but the region is far more flexible and patient regarding inventory management, with buying taking place only on price dips.

Taking all this into consideration, SFA is bullish about the long-term fundamentals of the platinum market. Prices will rise, but not at the rate of cost inflation in South Africa that has been the norm.

**South Africa: 80th centile net TCC vs. basket price**




*Source: SFA (Oxford)*

The market is becoming more globally diverse and therefore more sustainable, and within it there is a strong future for low-cost, efficient mines and equities. Arguably, less concentration on supply and demand might be thought of as bad for price - a move from a monopoly-style to a more perfectly-competitive market, such as gold. However, broader sources of demand and supply should help reduce price volatility, and this alone will likely bolster most end-use demand.

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# Rhodium: Key to PGM supply growth

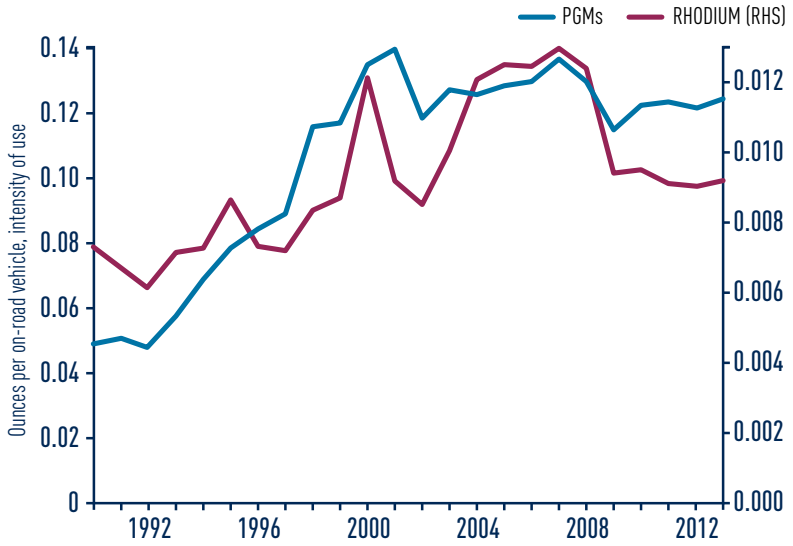
# Rhodium: Key to PGM supply growth

## Rhodium prices are historically low

The intensity of use of rhodium in autocatalysts has collapsed to 2002 levels since the price spike in 2008 to over $10,000/oz, as catalyst makers cut loadings in three-way catalysts and reduced the need for rhodium-rich lean $NO_x$ traps (LNT) to meet Euro 6 (2014) emission standards.

Rhodium's intensity of use is back to 2002 levels

### Ounces per on-road vehicle, intensity of use

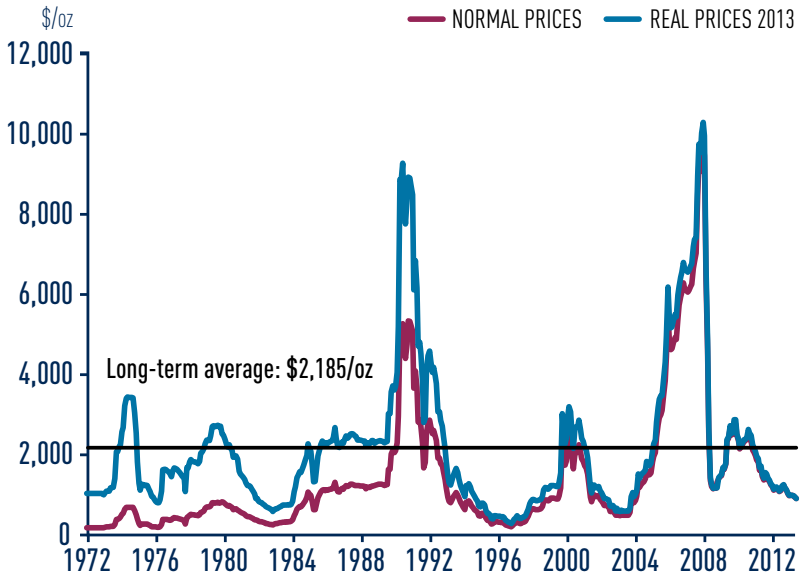



*Source: SFA (Oxford)*

Currently, the platinum and palladium prices are respectively 52% and 111% higher than their historical averages of $954/oz and $353/oz back to 1972. However, the rhodium price is down by 52% from an average of $2,185/oz over the same period.

The rhodium price is 52% below its historical average

### The long-term average rhodium price




*Source: SFA (Oxford)*

A 65% retreat in the rhodium price since early 2011 has rendered many UG2-dominant mines and sections marginal in South Africa.

Both platinum and rhodium have been heavily substituted and thrifted in recent years, mainly for palladium. Platinum and rhodium intensities of use peaked in 2007 and have been in decline since then. The rhodium market has been in fundamental surplus since 2009 and significant industry stocks are available in the hands of active sellers.

Despite heavy substitution to palladium, platinum intensity of use in vehicles should stabilise going forward as heavy-duty vehicles use platinum-loaded catalysts.

## Mines have become rhodium-dependent

Primary rhodium supply is almost entirely derived from South Africa, with the country accounting for 76% of mine production and 60% of total supply, including recycling. South African miners have increasingly focused on extraction of ore from the UG2 Reef since the mid-2000s, as older Merensky Reef operations deplete and newer generation shafts become deeper (higher cost). Six UG2 mines commenced operation between 2006 and 2009, adding some 70 koz p.a. of rhodium production capacity during this time. So the Merensky Reef now makes up just 23% of South Africa's output mix, from 49% in 2000. The UG2 Reef meanwhile accounts for 65% of platinum mined in South Africa, up from just 42% over the same period.

The UG2 Reef accounts for 65% of platinum mined in South Africa

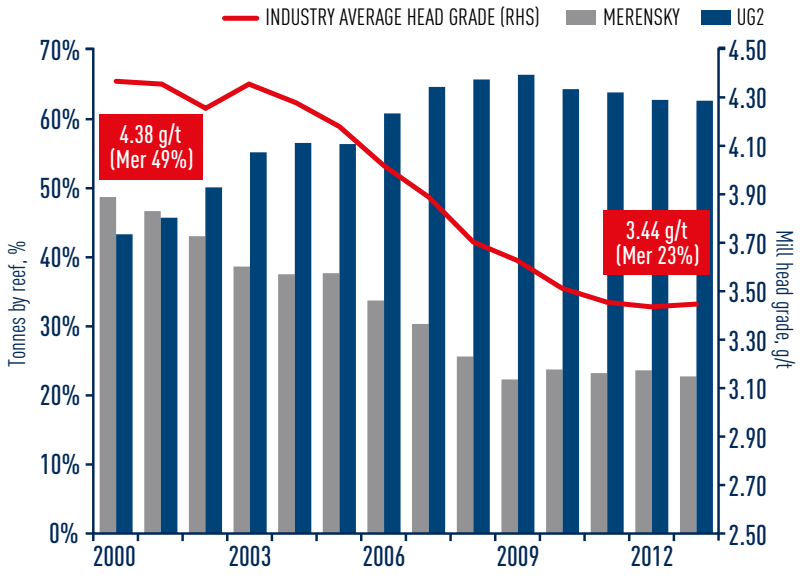
The UG2 Reef contains the highest proportion of rhodium at 10% of a 4E PGM split (platinum, palladium, rhodium, gold), versus 5% for the Merensky Reef and 3% for the Platreef. Since the rhodium price collapsed from a peak of more than $10,000/oz in June 2008 to <$2,000/oz in 2011, and subsequently to $1,070/oz in 2013, some 315 koz p.a. of platinum production capacity has been closed out, while some replacement/expansion capacity, currently in construction/build-up phase, may be at risk without basket price appreciation.

Unlike the Merensky Reef and the wide Platreef, PGM grade distribution in the UG2 Reef is typically bottom-loaded, so narrow reef UG2 miners are forced to extract waste (overbreak), resulting in dilution of head grade. The weighted average South African head grade declined from 4.38 g/t 4E in 2000 to 3.44 g/t 4E in 2013 as UG2 output increased (see chart below). This is compounded by the relative lack of by-products in the UG2 Reef (nickel and copper accounted for only 2% of total revenues in 2013) compared with the Merensky Reef (9%) and the Platreef (24%). Therefore, UG2 miners require a higher PGM basket price to mine economically, but with rhodium trading at around $1,100/oz, numerous mines and UG2 sections within mine lease areas are loss-making or marginal.

South African head grades declined from 4.38 g/t 4E in 2000 to 3.44 g/t 4E in 2013 as UG2 output increased

The charts overleaf compare revenues per tonne milled for the Merensky and UG2 Reefs. These show not only the impact of a lower head grade on revenue per tonne, but also a lack of diversity and the heavy reliance on rhodium in the UG2 Reef compared to the Merensky Reef.

## South Africa PGM orebody quality



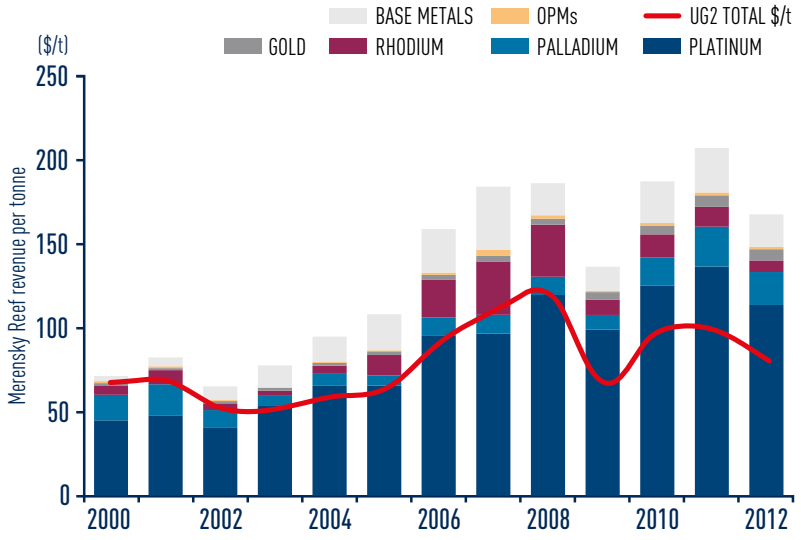

*Source: SFA (Oxford)*

At current prices, 54% of the industry is unprofitable

At current prices, 54% of the industry is unprofitable on a net total cash cost plus total CAPEX basis, and this is following five years of industry restructuring, high-cost shaft closures and capital project deferrals. Against significant levels of depletion, producers need higher prices in order to incentivise replacement projects, and to keep pace with cost inflation (averaging 12% p.a. total cash cost (ZAR/t) basis between 2008 and 2012), as well as recent wage trends (as high as 17% for basic salaries). Excluding the impact of any further wage settlements in 2014, the industry would require a rhodium price of close to $2,000/oz just to break even, and even higher to fund capital requirements.

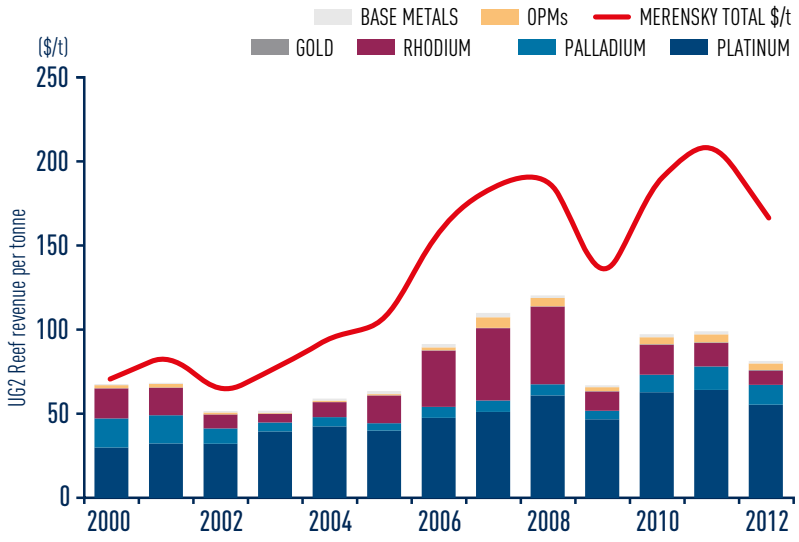
The industry would require a rhodium price of close to $2,000/oz just to break even

## Merensky Reef




*Source: SFA (Oxford)*

UG2 Reef




*Source: SFA (Oxford)*

Today's rand weakness is providing some respite, but further cost escalation is likely as wages increase.

Some mines in the fourth quartile of the cost curve are marginal at best with rhodium prices at around $1,100/oz. There is a very real possibility that if rhodium prices remain where they are, some operations may be forced to be mothballed. This could cut a further >260 koz of platinum and >100 koz of palladium output from the profile. These losses are on a best-case industrial relations scenario.

## Rhodium prices key to palladium supply

The palladium market has been in structural deficit since 2007 and is heavily reliant on stocks, which, while considerable, are drawing down at a rapid rate to meet growing end-user requirements.

It should be noted, therefore, that the UG2 Reef supplies 21% of global palladium mine production. Some 285 koz has already been lost from UG2 output since 2009 and >100 koz is at risk of imminent closure. However, most significantly, 340 koz p.a. has been deferred on lower rhodium prices and higher costs while a further 120 koz p.a. of replacement and expansion capacity is at risk. This represents 845 koz p.a. of potential lost palladium supply if rhodium prices continue to remain at current levels. This lost palladium adds up to 95% of the estimated deficit in 2013, although the deficit is set to widen in future.

The UG2 Reef supplies 21% of global palladium mine production

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# The Ukrainian crisis and its impact on Russian PGMs

# The Ukrainian crisis and its impact on Russian PGMs

by Dr Paul Chaisty, Professor of Russian Government at Oxford University

## The West and Russia

Russia's decision to annex Crimea has caused the most serious crisis in East-West relations since the Cold War. The decision of the Russian authorities to recognise the results of the Crimean referendum, in which residents of the Ukrainian autonomous republic voted overwhelmingly to join the Russian Federation, has led to reprisals against Moscow by the US and European governments. Concerns on financial markets about the possibility of economic sanctions against Moscow have led to price surges for commodities, especially in those sectors where Russia is an important player.

Current market uncertainty over events in Ukraine has had a particularly notable effect on prices for platinum-group metals (PGMs). This is for two main reasons. First, the crisis in East-West relations has compounded existing concerns about supplies of PGMs, which have deteriorated in the wake of labour unrest in South Africa. Second, stocks in the relatively safe PGM sector have become more desirable as investor confidence has been hit by events in Ukraine. The escalation of the conflict in eastern Ukraine over recent weeks has also introduced a third factor which could have a profound impact on PGMs: it has raised the possibility of Western sanctions against the mining sector, and likely retaliation by the Russian government in the form of an embargo on exports. However, the crisis would still have to escalate significantly for this to happen. Given Russia's comparative advantage in the PGM sector, and the lack of alternative sources of supply for Western industry, sanctions against this sector are only likely to be triggered by Russian military intervention in eastern Ukraine.

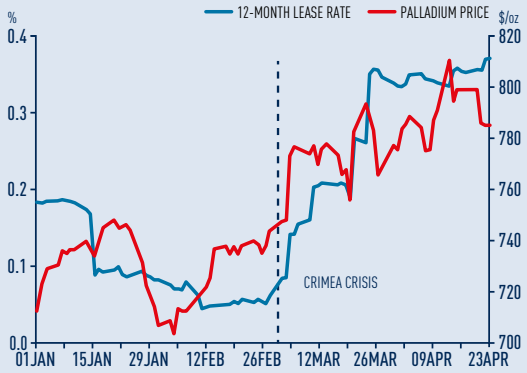
The Ukrainian crisis has nevertheless changed the nature of relations between Russia and the West. The issue of Crimea is likely to be a bone of contention in this relationship for many years to come, and will have profound economic and political consequences.

The likelihood of a new Cold War between Russia and the West is a distinct possibility, and Russia's isolation could have long-term effects on the country's commitment to market-oriented policies and its integration into world markets. In terms of

# IMPACT ON PRICES

## The Pd price and 12-month lease rates have picked up since February

### Palladium 12-month lease rates, (LIBOR-Swap Rate), 2014




*Source: SFA (Oxford), Bloomberg*

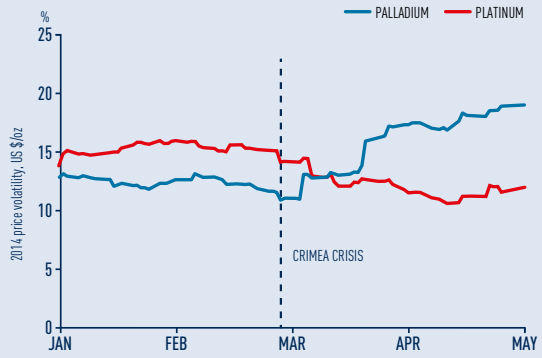
## The Pt-Pd price ratio has fallen from 1.96 to 1.76

### Platinum-palladium ratio, 2014


*Source: SFA (Oxford), Bloomberg*

## Pd price volatility outperforms Pt

### 2014 price volatility, annualised




*Source: SFA (Oxford), Bloomberg*

Russian PGMs, this would represent a reversal of successful government policies towards the sector in the post-Soviet period. This could significantly affect the investment that the sector needs to bring on future supply.

This review will identify the issue of sanctions and their likely effect in the short term. It will also discuss the longer-term economic and political consequences of the effects of Russia's isolation.

## The impact of sanctions

Investors in PGMs have kept a close eye on the West's response to the Ukrainian crisis. The crisis has interacted with existing supply problems in the sector – worsened in recent times by strike activity in South Africa – to drive palladium prices to their highest level in over a year. Of particular concern is the possibility of sanctions against Russia's precious metals sector. US President Barack Obama has said Washington would consider sanctions against key economic sectors, including metals and mining. Any movement in this direction would lead to further surges in PGM prices.

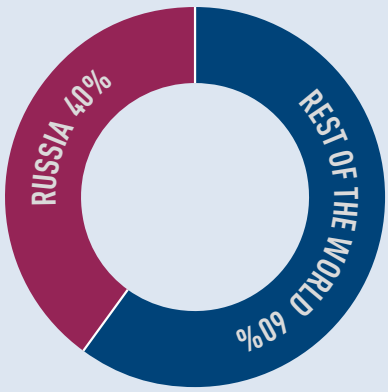
The situation in Ukraine remains volatile. Pro-Russian demonstrators in the eastern cities and regions of Ukraine are being watched carefully in Moscow and could be used as a pretext for intervention, especially if there is significant violence against the Russian population on this territory. This action would trigger tougher sanctions against specific economic sectors. Yet PGMs are likely to be one of the last sectors targeted. Russian supplies of PGMs are difficult to replace given their large share of global output; it has been estimated that global palladium supply could fall by 40% if the West were to impose sanctions.

The key question, therefore, is whether Russia would be willing to risk a more serious escalation of the conflict. Both President Putin and Russian Defence Minister Sergei Shoigu have stated that troops will not enter the eastern territories, and there is pressure from the Russian business community to de-escalate the crisis. The economic costs for Russia are high. Europe is Russia's main trading partner – almost half of Russia's exports are to the EU; Europe is a key supplier of machinery and consumer products, and European investors hold 75% of all foreign direct investment stocks in Russia. Nonetheless, Moscow appears determined to achieve its objective of gaining greater influence over the affairs of Ukraine, and there is significant

# PGM SUPPLIES

## Russia accounts for 40% of palladium supply

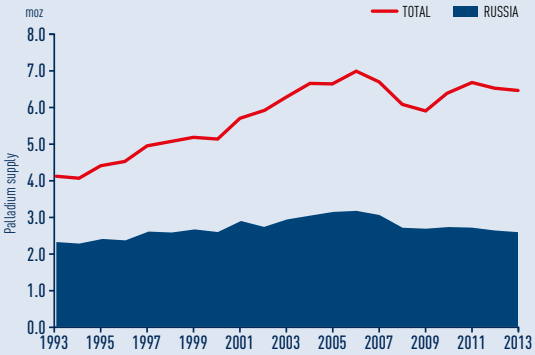
**Palladium supply, 2013**
**Total 6.45 moz**




*Source: SFA (Oxford)*

## Russian palladium supply peaked in 2006

**Palladium mine supply**




*Source: SFA (Oxford)*

**Norilsk Nickel's PGM production, 2013**

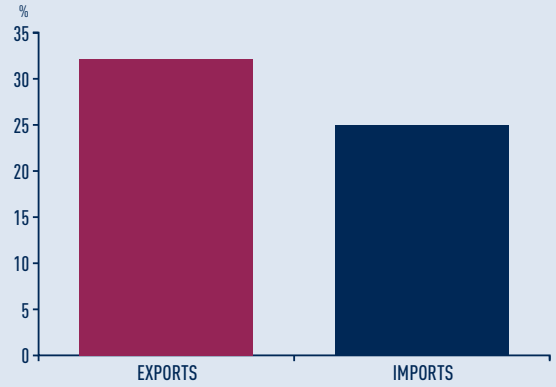

**2.7 moz**


**651 koz**

# BUSINESS RISKS

Russian exports are around a third of GDP, so sanctions would have a dramatic effect on the economy

**Russian imports and exports as a % of GDP in 2013**




*Source: SFA (Oxford), Oxford Economics*

Norilsk Nickel has so far been unaffected by the Crimean crisis and US sanctions – outperforms stock market

**Russian stock market index Base100**


*Source: SFA (Oxford), Bloomberg*

support for this action within the wider population. The Russian government has also stressed its desire to promote more autarchic economic policies if necessary, and might even consider the Soviet-era practice of embargos on exports as a form of retaliation against any sanctions. Moscow has already threatened a trade dispute with the US over the legality of sanctions under World Trade Organization (WTO) rules.

## The effects of Russian isolationism

Compared to other sectors in Russia – notably steel – the PGM industry has a greater capacity to withstand such punitive action. Norilsk Nickel is in a strong financial position. Its commanding share of worldwide nickel and palladium output has shielded its stock from the downturn in confidence in the Russian economy. While Russia's major steel corporations have suffered large falls on the Moscow Exchange (MICEX) during the current crisis, Norilsk Nickel has performed relatively well. For example, whereas Mechel steel stock was temporarily halted after a 27% decline in early March, Norilsk stock dropped by just 3%. Moreover, Norilsk's dominance means that it has the capacity to find alternative markets. Given the problems with market scarcity, any sanctions imposed on PGMs by the USA and EU would be offset by demand elsewhere, in particular from China. Recent increases in Chinese imports of PGMs suggest that domestic demand is growing (see page 33).

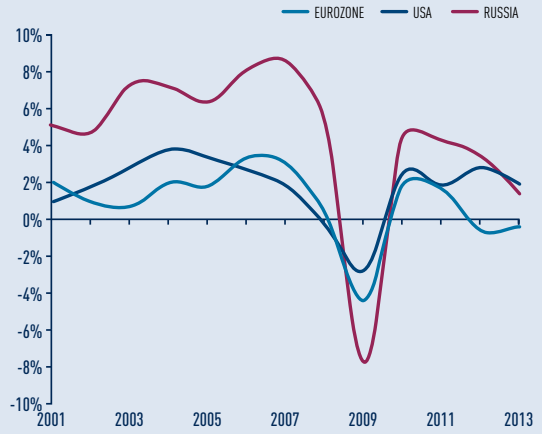
However, the significant deterioration in East-West relations could have more serious long-term consequences. The US government has reintroduced controls on various forms of economic co-operation that were used during the Cold War, and it is only a matter of time before Russia retaliates. This is rendered even more likely by the nationalist turn in Russian politics, which has been observed on the international stage by Putin's actions in Crimea. Since Putin's return to power in 2012, the official narrative of the regime has changed from one of economic modernisation, which defined Medvedev's presidency, to one of protecting Russia's traditional values.

This nationalist shift has, in part, been motivated by Russia's economic slowdown since the financial crisis of 2008-09. When the Russian economy was booming in the early 2000s, with growth averaging at 7% a year, policies oriented towards Russia's integration into the global economic system – membership of the WTO, good relations with

# MACROECONOMIC EXPOSURE

## The Crimean crisis could send Russia back into a recession

**Real GDP**
**Change year-on-year**




*Source: SFA (Oxford), Oxford Economics*

## Putin's approval rating has hit a new high

**Indices of assessment of situation in Russia**
**Positive minus negative evaluations**


*Source: Russian Public Opinion Research Center, wciom.com*

Western business circles, and so on – fitted with the narrative of modernity, which was juxtaposed with the economic failure of the 1990s. This narrative became the basis of Putin's unprecedented levels of popular support. However, the 2008-09 economic crisis undermined the credibility of this appeal, and in response the regime has engaged with a more traditional Russian agenda: suspicion of the West, its institutions and its values.

So far, Vladimir Putin has managed to combine Russian patriotism with support for global markets. Government policies towards PGMs have remained market-oriented, as evidenced by the cancellation of export quotas for precious metals in January 2007. However, the events in Crimea and Russia's decision to choose emotional nationalism (the re-unification of ethnic Russians) over economic considerations suggest that the regime is moving in a more isolationist direction.

To date, there is no indication that this will result in the renationalisation of Russia's monopolies, in particular Norilsk Nickel, but any disengagement from the global economic system will have consequences for growth in the Russian economy, and will ultimately affect Russian industry. This is of particular concern in the area of investment, both domestic and foreign.

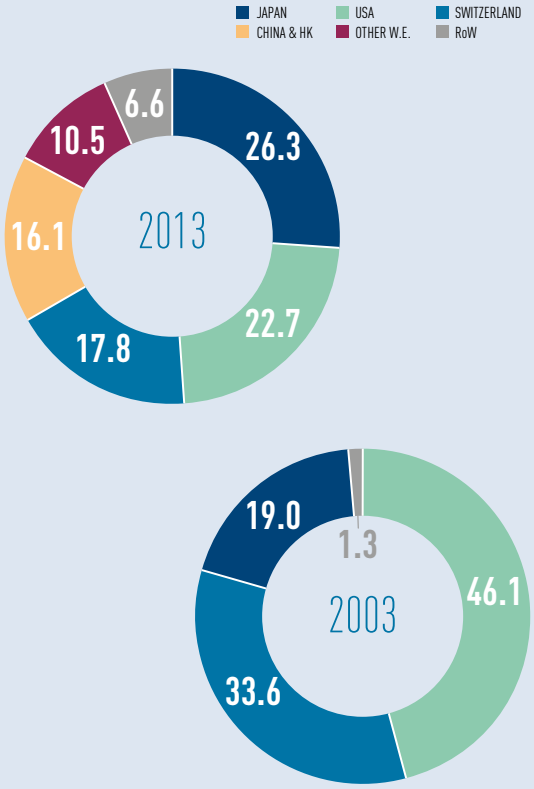
The official government explanation for the current slowdown in Russian economic growth is underinvestment in the economy. The events in Crimea are likely to exacerbate this problem. The ratings company S&P has estimated that $60bn (£36bn) left the country in the first three months of the year, and S&P has revised its outlook for Russia from stable to negative, based on rising geopolitical and economic risks. Russian business interests, in particular, are likely to be concerned about the impact of greater market volatility and the difficulty of obtaining Western credit, which could affect the future scheduling of Russian PGM projects.

Therefore, underlying structural problems are likely to grow with the freezing of East-West relations, and this will add to global supply-side problems. Moreover, while Norilsk will profit in the short term from the increase in prices for PGMs, it is likely to come under mounting fiscal pressure from the state, as the authorities seek to meet the budgetary shortfall caused by the slowdown in economic growth. Even before the crisis in Ukraine, the IMF reported that Russia's share of world GDP estimate would decline steadily over the next five years.

# TRADE FLOW & STOCKS

## Russian palladium exports have diversified

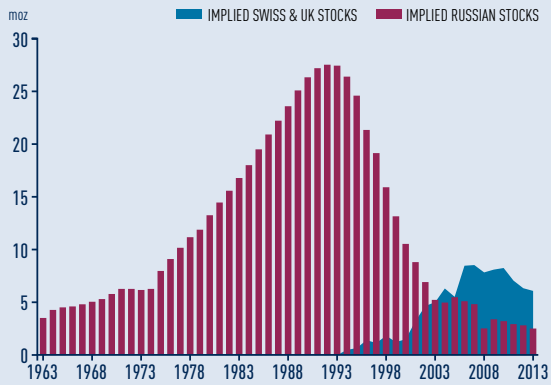
### Palladium exports from Russia




*Source: SFA (Oxford), GTIS*

## Russian stocks now reside elsewhere

### Est. above-ground stocks of palladium




*Source: SFA (Oxford), GTIS*

## Summary: Long-lasting consequences

The success of Russian PGM policy under Putin has been based on the commitment of the Russian government to market-oriented policies. The security concerns that dominated PGM policy during the Soviet period have been relaxed, and world markets have enjoyed more reliable supplies from Russia. This positive development has been undermined in recent weeks by the events in Ukraine. International condemnation of Russia's annexation of Crimea and the threat of economic sanctions pose a disruption risk to Russian supplies.

While the prospect of economic sanctions against precious metals is unlikely without a significant escalation of the crisis, the events in Ukraine have brought about a serious deterioration in East-West relations, which is likely to continue for many years to come. The crisis is also symptomatic of a nationalist turn in Russian politics which could threaten the regime's existing support for Russia's integration into the international economic system. While Putin's early presidential terms were defined by pragmatism in economic and foreign relations, his current term is more ideological. This ideology is based on a conservative view of Russia, which could result in policies which once again place national security considerations at the forefront of economic development.

SFA Oxford




# The PGM markets in 2013

# The PGM markets in 2013

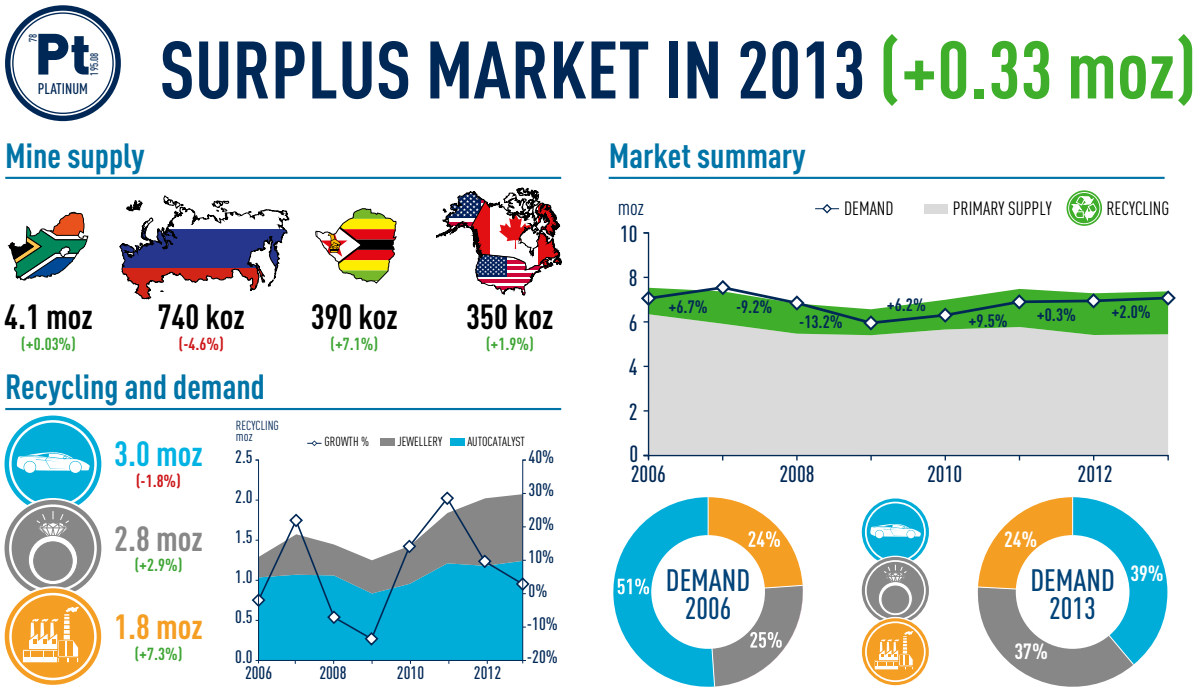
## The platinum market

Zimbabwe is the only country to have grown its platinum mine supply since 2006 (+220 koz). Primary platinum supply from South Africa decreased by almost 1.19 moz between 2006 and 2013, while from Russia it fell by more than 200 koz and from North America by 50 koz.

Global platinum production increased by only 0.5% to 5.88 moz in 2013. South African supply remained flat at 4.12 moz, with the start of the AMCU strike postponed until January 2014. Production in Zimbabwe rose by 7% to 391 koz and minor gains were achieved in North America (+2%), but these were offset by a 5% reduction from Russia. Platinum output from PGM tailings retreatment operations and non-primary PGM operations grew by 31 koz.

Primary platinum supply from South Africa has decreased by almost 1.19 moz since 2006

Mogalakwena, Lonmin and Kroondal mines posted the largest gains for South Africa in 2013 (+89 koz combined). Both mined volumes and head grade improved at Mogalakwena, and processing of ore through the Baobab concentrator lifted refined production to 342 koz for the year.




Lonmin mine's output was up by 3% in 2013, but its results are skewed by the six-week strike that occurred in 2012. Production at Kroondal stabilised at over 100 koz PGMs per quarter in 2013. Yield in the previous year was negatively impacted by the installation of new hanging-wall support systems, as well as safety-related stoppages.

Global primary supply remained flat at 5.9 moz in 2013

The closure of Crocodile River, Khomanani and Union North declines accounts for a drop in output of 105 koz y-o-y, plus strike-related losses of 48 koz PGMs (around 30 koz Pt) over 11 weeks at Zondereinde in the second half of the year.

There are some green shoots from new shafts, albeit on a small scale. In addition to the continued ramp-up of Impala's 20 shaft, Booysendal mine was commissioned in the first half of 2013 and produced 41 koz during the year (equivalent to 45% capacity). Tharisa produced ~29 koz in 2013 (+25 koz y-o-y) and is now operating at >40% of capacity.

Outside of South Africa, Zimplats' Phase 2 concentrator was commissioned in April 2013 and production continues to ramp up towards 290 koz p.a. The mine increased yield by 72 koz to 241 koz in 2013. Kevitsa, a Ni-Cu-PGM mine in Finland, doubled

output to 30 koz and is currently operating at 90% capacity. However, supply from the Lac des Iles Offset Zone fell short of target with commercial production from the Offset Zone pushed back to Q4.

Automotive platinum recycling increased 5% in 2013

Platinum recycling has grown strongly since 2009, from 1.26 moz to 2.08 moz in 2013. This is because of greater platinum jewellery recycling in China (1.8 times since 2009 to 500 koz) and Japan (2.5 times to 330 koz), but also from increasingly platinum-rich diesel catalysts which are being collected in Europe.

Platinum demand continued to recover in 2013, growing by 2% to 7.64 moz after slowing to +0.3% in 2012. Global demand has yet to recover to 2007 peak levels of 8.14 moz, with North America (420 koz below peak in 2013) and Western Europe (940 koz below peak) lagging. However, China has posted strong growth, with total consumption up by 880 koz since 2007.

Total demand still lagging 2007 levels, but China is leading the recovery

The rise in global demand was driven mainly by the jewellery and industrial sectors, growing by 3% and 5% respectively. Jewellery demand grew by 80 koz and industrial demand grew by 110 koz. The majority of growth (70 koz) came from China, followed by emerging economies and an improvement in Europe. The only contraction in demand was in Japan (-30 koz) mainly from the continual offshoring of automotive production. Jewellery recycling decreased slightly in 2013 (-1%), but this was offset by a 5% rise in autocatalyst recycling.

Chemical and glass applications accounted for a 110 koz increase in industrial demand in 2013, but this was partially offset by lower usage in the petroleum industry. Other demand remained stable.

In contrast, demand from the automotive sector, historically the biggest end-user and contributor to growth, dipped below 3 moz, with consumption in Western Europe and Japan declining by 2% (despite higher loadings ahead of Euro 6 emissions standards) and 6% respectively.

## The palladium market

Russia is the largest source of primary palladium, at 40% (2.58 moz) of mine supply in 2013, while South Africa accounted for 35% (2.28 moz). Peak output for both countries was in 2006, when together they accounted for 84% of primary supply at 3.16 moz and 2.72 moz respectively.

Primary supply from two key countries peaked in 2006

Output from Zimbabwe and North America increased in 2013. However, these countries still account for less than 20% of global supply, at 300 koz and 920 koz respectively, and therefore did not offset the drop in yield from Russia (-50 koz) and South Africa (-40 koz) in 2013.

Since 2000, recycling of palladium has accelerated at a much higher rate (9.5 times) than either platinum (3.6 times) or rhodium (2.6 times). This growth in palladium is the result of the cocktail and higher loadings of metals (emissions legislation tightened throughout the 1990s) in autocatalysts that are coming back to market via scrapped vehicles. Automotive recycling increased by 21% over the year to 1.79 moz in 2013 and, with minor gains in jewellery and Waste Electrical and Electronic Equipment (WEEE) recycling of 10 koz and 20 koz respectively, total recycling reached 2.29 moz in 2013.

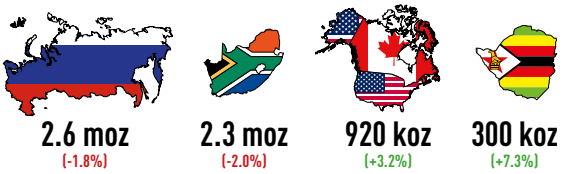
Palladium recycling rate is outstripping those of platinum and rhodium

Palladium demand climbed by 1.8%, from 9.45 moz in 2012 to 9.62 moz in 2013, with growth deriving mainly from the automotive sector.

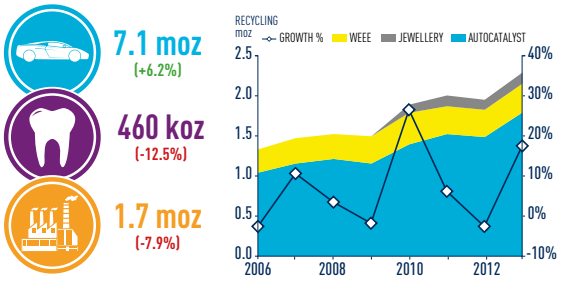
Automotive palladium demand rose strongly in North America, Western Europe and China. Although vehicle manufacture declined in Western Europe, gasoline engines continued to take more market share at the expense of diesel. Around 44.5% of all passenger cars sold in 2013 in Western

# MARKET DEFICIT IN 2013 (-0.89 moz)

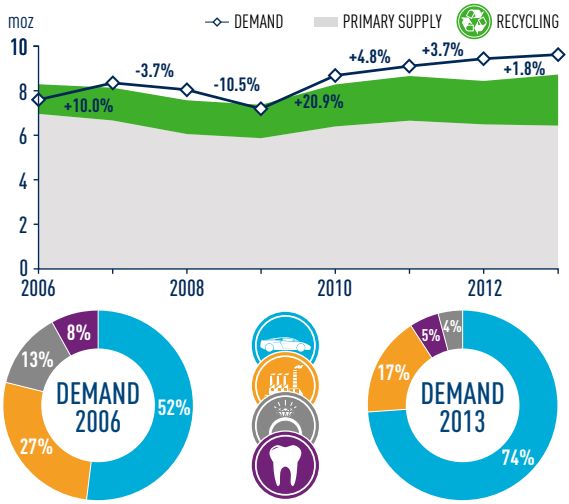
## Mine supply




## Recycling and demand




## Market summary




Europe were gasoline-powered, an increase of around 1.4% over 2012. This, combined with the substitution of platinum with palladium in passenger cars, resulted in palladium consumption growing by 100 koz in Western Europe. The largest gain in automotive demand was recorded in China (+180 koz), where palladium-rich gasoline cars dominate and where vehicle production rose by 12%.

Strong growth in automotive demand offset lower jewellery demand in 2013

Palladium jewellery demand continues to decline. Having peaked at 860 koz in 2008, consumption in 2013 totalled 390 koz, down 30 koz on 2012. While platinum jewellery sales in China have increased by 85% since 2008, demand for palladium jewellery has decreased by 69% over the same period to 190 koz in 2013. Marketing campaigns by Platinum Guild International and the expansion of jewellery stores to Tier 2 and 3 cities have driven platinum sales, but palladium has suffered without coordinated marketing effort as its price increased.

Consumption growth in the automotive sector means that palladium faces substitution by other materials in electronics and dental areas as prices climb. Demand in other industrial sectors is estimated to have fallen by 220 koz in 2013.

## The rhodium market

Primary rhodium supply derives predominantly from South Africa. The country accounted for more than 80% of rhodium production between 2005 and 2011, but this fell to 76% in 2013. For rhodium, South Africa's downward slide in PGM mine output has been exacerbated by UG2 mine closures in recent years.

UG2 mine closures have had a greater impact on rhodium supply

The UG2 Reef contains the highest proportion of rhodium at 10% of a 4E split, versus 5% for the Merensky Reef and 3% for the Platreef. Since the rhodium price retreated from a peak of more than $10,000/oz in June 2008 to less than $2,000/oz in 2011, and subsequently to $1,070/oz in 2013, some 90 koz p.a. of rhodium production capacity has been closed out. This is equivalent to 15% of South Africa's annual rhodium production.

Comparing the difference between 2012 and 2013 supply shows rhodium has lost 7% of output (to 720 koz) versus -2% for palladium and flat for platinum. South African

miners have increasingly focused on UG2 extraction since the mid-2000s, as older Merensky operations deplete and newer generation shafts increase in depth (higher cost). The volume of ore from the UG2 Reef, as a percentage of total PGM tonnes milled in South Africa, grew from 43% in 2000 to 63% in 2013, peaking at 66% in 2009 when several new UG2 projects were completed.

Recycling currently accounts for 27% (260 koz) of total rhodium supply. Secondary supply is almost entirely automotive-based, and growth occurred primarily in Western Europe (+10 koz) and North America (+6 koz) in 2013.

LNT: Rhodium is the most effective $NO_x$ removal catalyst

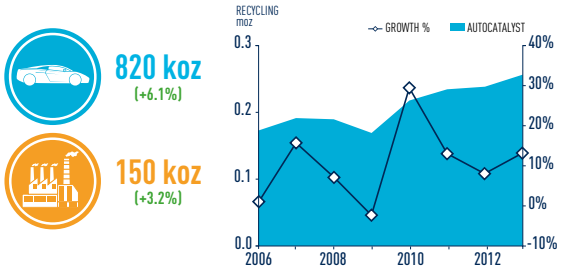
The rhodium price spike in 2008 resulted in heavy substitution out of three-way catalysts, and reduced the need for rhodium-rich lean $NO_x$ traps (LNT) to meet Euro 6 diesel regulations by adopting other technologies such as selective catalytic reduction (SCR). In an LNT, rhodium catalyses the chemical reduction of $NO_x$ to harmless nitrogen. In an SCR, a tank of urea solution is added to the system and the ammonia generated reacts with the $NO_x$, again

# BALANCED MARKET IN 2013 (0 koz)

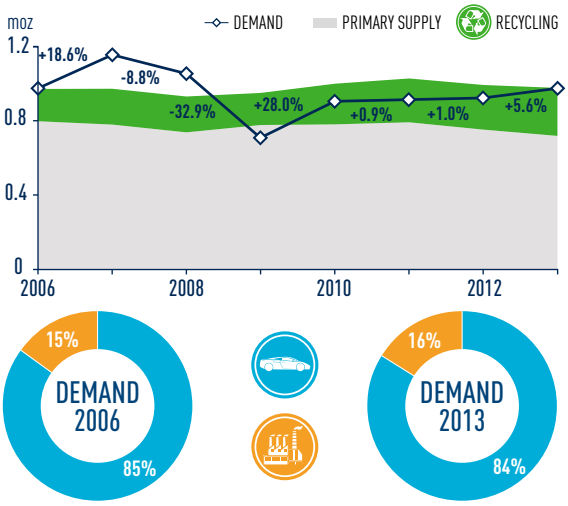
## Mine supply

550 koz (-6.1%) | 70 koz (-5.2%) | 30 koz (+4.4%) | 30 koz (+8.7%)

## Recycling and demand




## Market summary




to produce harmless nitrogen. Improvements in engine technology have also enabled engine-out $NO_x$ emissions to be cut, so that the rhodium can be thrifted, or in some cases excluded altogether, although this is increasingly difficult under Euro 6 emissions standards.

SCR: Originally for heavy trucks, now used in light vehicles too despite inconvenience of adding fluid

While modifying the combustion regime to avoid $NO_x$ production and adopting non-PGM catalyst solutions such as SCR is appropriate in some vehicles, for many vehicles the use of rhodium in PGM-based autocatalysts remains the most cost-effective, reliable and convenient solution to emissions legislation compliance. Therefore, rhodium is expected to retain an important role in automotive catalyst formulations.

Rhodium demand grew by 5.6% to 970 koz in 2013, more than the gains over the year seen in the platinum (+2.0%) and palladium (+1.8%) markets. Rhodium automotive consumption rose in all major markets except Japan and India, which saw vehicle production cuts in 2013. Other demand also edged up slightly, resulting in an overall increase of 51 koz on 2012.

# The price outlook for 2014

## Platinum $1,420/oz

The platinum market is forecast to be in deficit by more than 1 moz in 2014 as strikes in South Africa tighten the market. However, inventories have built up since the financial crisis as recycling has brought more than Lonmin-sized output to market, while automotive requirements for platinum collapsed owing to falling production and substitution to palladium. As of May, SFA (Oxford) estimates that excess inventories built up since the crisis, including metal allocated by ETFs, have been cut by a third owing to strikes. That leaves just over 2 moz of excess metal. Meanwhile, a lack of strong demand pull in the near-term indicates that price upside is limited for now. Accordingly, SFA (Oxford) forecasts a platinum price of $1,420/oz for 2014, with temporary risks to the downside once mineworkers return to work in South Africa. Significant restructuring and closures after the South African elections could accelerate the drawdown of inventories and lift prices later in H2, but a tailwind from demand is required to lead to a meaningful rally.

## Palladium $750/oz

The palladium market's structural deficits have been running at over 1 moz of inventory drawdowns per year as automakers overwhelmingly use palladium at the expense of platinum and rhodium. Perhaps the biggest impact of strikes in South Africa will actually be on palladium. Destocking could be as high as 1.8 moz in 2014. True, global inventories are significant, but they are being drawn down at a rapid rate and are increasingly being allocated by newly launched palladium ETFs in South Africa. Meanwhile, the on-going uncertainty surrounding the future of Russia's relationship with the West will keep palladium prices high and appreciating. For 2014, SFA (Oxford) expects prices to remain in the $730-$800 range while inventories remain ample and lease rates relatively low, for now. SFA (Oxford) expects a medium-term platinum:palladium price ratio of 1.5.

## Rhodium $1,050/oz

Rhodium has suffered most since the financial crisis with thrifting and substitution in automotive catalysts, its main application, where demand has yet to fully recover. For now, excess industry stocks of over 1 moz, in the unsafe hands of active sellers, will cap meaningful price appreciation. Yet restructuring and closures of marginal, narrow and rhodium-rich UG2 Reef sections in South Africa will help to accelerate the drawdown of global stocks. Arguably, rhodium prices should have the greatest upside since prices are trading at less than half their long-run average back to 1972. However, SFA (Oxford) remains cautious, so long as a liquid stock overhang remains, and forecasts $1,050/oz for the year.


78
Pt
195.08
PLATINUM


46
Pd
106.42
PALLADIUM


45
Rh
102.91
RHODIUM

# Appendix

## Platinum supply-demand balance, koz


| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Primary supply** | | | | | | | | |
| **Regional** | | | | | | | | |
| South Africa | 5,320 | 4,890 | 4,550 | 4,550 | 4,650 | 4,510 | 4,120 | 4,130 |
| Russia | 960 | 930 | 810 | 780 | 790 | 800 | 780 | 740 |
| Zimbabwe | 170 | 170 | 180 | 230 | 280 | 340 | 360 | 390 |
| Other | 400 | 390 | 370 | 270 | 390 | 580 | 580 | 620 |
| Total | 6,850 | 6,390 | 5,910 | 5,830 | 6,120 | 6,240 | 5,850 | 5,880 |
| **Demand & recycling** | | | | | | | | |
| **Autocatalyst** | | | | | | | | |
| Gross demand | 3,900 | 4,330 | 3,740 | 2,520 | 2,850 | 3,000 | 3,020 | 2,960 |
| Recycling | 1,030 | 1,070 | 1,060 | 830 | 950 | 1,210 | 1,180 | 1,240 |
| Net demand | 2,870 | 3,260 | 2,690 | 1,690 | 1,900 | 1,790 | 1,840 | 1,720 |
| **Jewellery** | | | | | | | | |
| Gross demand | 1,900 | 1,970 | 1,930 | 2,680 | 2,170 | 2,450 | 2,760 | 2,840 |
| Recycling | 260 | 510 | 390 | 410 | 470 | 630 | 840 | 830 |
| Net demand | 1,640 | 1,460 | 1,550 | 2,270 | 1,700 | 1,820 | 1,920 | 2,010 |
| **Industrial demand** | 1,830 | 1,850 | 1,720 | 1,210 | 1,790 | 2,000 | 1,710 | 1,830 |
| **Other recycling** | 0 | 0 | 20 | 10 | 10 | 10 | 10 | 10 |
| **Gross demand** | 7,630 | 8,140 | 7,390 | 6,410 | 6,810 | 7,460 | 7,480 | 7,640 |
| **Recycling** | 1,290 | 1,570 | 1,460 | 1,260 | 1,440 | 1,850 | 2,030 | 2,080 |
| **Net demand** | 6,340 | 6,570 | 5,930 | 5,150 | 5,380 | 5,610 | 5,460 | 5,550 |
| **Market balance** | | | | | | | | |
| Balance (before ETFs) | 520 | -180 | -20 | 680 | 740 | 630 | 390 | 330 |
| ETFs (stock allocation) | 0 | 220 | 100 | 390 | 540 | 180 | 210 | 900 |
| **Balance after ETFs** | 520 | -390 | -120 | 290 | 200 | 450 | 190 | -580 |

*Source: SFA (Oxford)*

## Platinum demand & recycling by region, koz

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Demand** | | | | | | | | |
| **Autocatalyst** | **3,900** | **4,330** | **3,750** | **2,520** | **2,850** | **3,010** | **3,030** | **2,970** |
| North America | 760 | 790 | 570 | 330 | 370 | 340 | 370 | 370 |
| Western Europe | 2,070 | 2,290 | 1,920 | 1,290 | 1,310 | 1,450 | 1,280 | 1,260 |
| Japan | 520 | 500 | 540 | 310 | 480 | 490 | 590 | 560 |
| China | 140 | 180 | 150 | 100 | 130 | 120 | 120 | 130 |
| India | 80 | 90 | 90 | 100 | 150 | 180 | 210 | 160 |
| RoW | 330 | 480 | 480 | 390 | 410 | 430 | 460 | 490 |
| **Jewellery** | **1,910** | **1,980** | **1,940** | **2,690** | **2,170** | **2,460** | **2,760** | **2,840** |
| North America | 250 | 230 | 200 | 140 | 160 | 160 | 190 | 200 |
| Western Europe | 200 | 200 | 200 | 190 | 180 | 180 | 170 | 220 |
| Japan | 620 | 490 | 450 | 430 | 370 | 320 | 330 | 330 |
| China | 760 | 980 | 1,020 | 1,860 | 1,370 | 1,670 | 1,910 | 1,890 |
| RoW | 80 | 80 | 70 | 70 | 90 | 130 | 160 | 200 |
| **Industrial** | **1,830** | **1,860** | **1,730** | **1,210** | **1,790** | **2,010** | **1,700** | **1,810** |
| North America | 450 | 420 | 380 | 280 | 370 | 400 | 440 | 440 |
| Western Europe | 330 | 350 | 350 | 270 | 370 | 430 | 420 | 430 |
| Japan | 250 | 230 | 200 | 140 | 240 | 260 | 150 | 150 |
| China | 180 | 300 | 200 | 90 | 280 | 200 | 230 | 310 |
| RoW | 620 | 560 | 600 | 430 | 530 | 720 | 460 | 480 |
| **Total** | **7,620** | **8,140** | **7,390** | **6,410** | **6,820** | **7,470** | **7,490** | **7,620** |
| North America | 1,450 | 1,440 | 1,140 | 750 | 900 | 900 | 1,000 | 1,010 |
| Western Europe | 2,590 | 2,840 | 2,470 | 1,740 | 1,860 | 2,060 | 1,870 | 1,900 |
| Japan | 1,390 | 1,220 | 1,180 | 880 | 1,090 | 1,070 | 1,070 | 1,040 |
| China | 1,080 | 1,450 | 1,370 | 2,050 | 1,790 | 1,980 | 2,260 | 2,330 |
| RoW | 1,110 | 1,190 | 1,230 | 990 | 1,180 | 1,460 | 1,290 | 1,340 |
| **Recycling** | | | | | | | | |
| **Autocatalyst** | **1,030** | **1,060** | **1,060** | **830** | **960** | **1,210** | **1,180** | **1,240** |
| North America | 650 | 630 | 580 | 550 | 580 | 600 | 580 | 600 |
| Western Europe | 230 | 270 | 310 | 130 | 200 | 420 | 410 | 430 |
| Japan | 100 | 110 | 120 | 110 | 140 | 110 | 110 | 90 |
| China | 0 | 0 | 0 | 0 | 0 | 10 | 10 | 20 |
| RoW | 50 | 50 | 50 | 40 | 40 | 70 | 70 | 100 |
| **Jewellery** | **260** | **510** | **390** | **410** | **470** | **630** | **840** | **830** |
| Japan | 260 | 310 | 220 | 130 | 150 | 280 | 280 | 330 |
| China | 0 | 200 | 170 | 280 | 320 | 350 | 560 | 500 |
| **WEEE** | **0** | **0** | **20** | **10** | **10** | **10** | **10** | **10** |
| **Total** | **1,290** | **1,570** | **1,470** | **1,250** | **1,440** | **1,850** | **2,030** | **2,080** |
| North America | 650 | 630 | 580 | 550 | 580 | 600 | 580 | 600 |
| Western Europe | 230 | 270 | 310 | 130 | 200 | 420 | 410 | 430 |
| Japan | 360 | 420 | 340 | 240 | 290 | 390 | 390 | 420 |
| China | 0 | 200 | 170 | 280 | 320 | 360 | 570 | 520 |
| RoW | 50 | 50 | 50 | 40 | 40 | 70 | 70 | 100 |

*Source: SFA (Oxford). Note: Rounding errors may occur between totals shown from the previous page.*


## Palladium supply-demand balance, koz

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Primary supply** | | | | | | | | |
| **Regional** | | | | | | | | |
| South Africa | 2,720 | 2,540 | 2,350 | 2,420 | 2,560 | 2,520 | 2,320 | 2,280 |
| Russia | 3,160 | 3,050 | 2,700 | 2,680 | 2,720 | 2,700 | 2,630 | 2,580 |
| Zimbabwe | 130 | 140 | 140 | 180 | 220 | 260 | 280 | 300 |
| Other | 960 | 960 | 880 | 610 | 900 | 1,190 | 1,270 | 1,290 |
| Total | 6,980 | 6,680 | 6,070 | 5,890 | 6,410 | 6,670 | 6,510 | 6,450 |
| **Demand & recycling** | | | | | | | | |
| **Autocatalyst** | | | | | | | | |
| Gross demand | 3,960 | 5,000 | 4,780 | 4,090 | 5,640 | 6,190 | 6,680 | 7,100 |
| Recycling | 1,040 | 1,160 | 1,210 | 1,160 | 1,400 | 1,520 | 1,490 | 1,790 |
| Net demand | 2,920 | 3,840 | 3,570 | 2,940 | 4,250 | 4,660 | 5,200 | 5,300 |
| **Jewellery** | | | | | | | | |
| Gross demand | 1,000 | 720 | 860 | 710 | 600 | 470 | 420 | 390 |
| Recycling | 0 | 0 | 0 | 0 | 100 | 130 | 130 | 140 |
| Net demand | 1,000 | 720 | 860 | 710 | 500 | 340 | 290 | 250 |
| **Industrial demand** | 2,640 | 2,640 | 2,410 | 2,400 | 2,470 | 2,470 | 2,360 | 2,150 |
| **Other recycling** | 290 | 320 | 310 | 340 | 390 | 350 | 340 | 360 |
| **Gross demand** | 7,590 | 8,360 | 8,040 | 7,200 | 8,700 | 9,120 | 9,460 | 9,630 |
| **Recycling** | 1,330 | 1,470 | 1,520 | 1,500 | 1,890 | 2,010 | 1,950 | 2,290 |
| **Net demand** | 6,260 | 6,880 | 6,520 | 5,700 | 6,810 | 7,120 | 7,510 | 7,340 |
| **Market balance** | | | | | | | | |
| Balance (before ETFs) | 720 | -200 | -450 | 190 | -400 | -440 | -1,000 | -890 |
| ETFs (stock allocation) | 0 | 280 | 380 | 510 | 1,090 | -530 | 290 | -20 |
| **Balance after ETFs** | 720 | 80 | -70 | 690 | 690 | 970 | -710 | -910 |

*Source: SFA (Oxford).*

## Palladium demand & recycling by region, koz

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Demand** | | | | | | | | |
| **Autocatalyst** | **3,960** | **5,000** | **4,800** | **4,090** | **5,650** | **6,180** | **6,680** | **7,090** |
| North America | 1,420 | 1,950 | 1,550 | 1,010 | 1,310 | 1,490 | 1,730 | 1,830 |
| Western Europe | 840 | 990 | 970 | 920 | 1,290 | 1,490 | 1,410 | 1,510 |
| Japan | 720 | 850 | 930 | 600 | 810 | 660 | 730 | 730 |
| China | 270 | 340 | 400 | 700 | 1,010 | 1,130 | 1,290 | 1,470 |
| India | 70 | 80 | 90 | 110 | 150 | 160 | 170 | 160 |
| RoW | 640 | 790 | 860 | 750 | 1,080 | 1,250 | 1,350 | 1,390 |
| **Jewellery** | **1,000** | **730** | **870** | **710** | **610** | **480** | **420** | **380** |
| North America | 40 | 60 | 60 | 60 | 70 | 50 | 50 | 40 |
| Western Europe | 40 | 40 | 50 | 50 | 70 | 70 | 80 | 70 |
| Japan | 130 | 80 | 90 | 70 | 70 | 70 | 70 | 50 |
| China | 760 | 520 | 640 | 500 | 370 | 260 | 190 | 190 |
| RoW | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| **Industrial** | **2,650** | **2,640** | **2,430** | **2,410** | **2,480** | **2,470** | **2,350** | **2,140** |
| North America | 610 | 560 | 520 | 500 | 500 | 500 | 480 | 480 |
| Western Europe | 490 | 460 | 380 | 360 | 410 | 380 | 380 | 350 |
| Japan | 640 | 640 | 610 | 590 | 580 | 550 | 550 | 390 |
| China | 410 | 440 | 330 | 430 | 440 | 420 | 400 | 430 |
| RoW | 500 | 540 | 590 | 530 | 550 | 620 | 540 | 490 |
| **Total** | **7,580** | **8,360** | **8,050** | **7,190** | **8,720** | **9,120** | **9,470** | **9,630** |
| North America | 2,070 | 2,570 | 2,120 | 1,560 | 1,870 | 2,030 | 2,260 | 2,350 |
| Western Europe | 1,360 | 1,500 | 1,390 | 1,330 | 1,760 | 1,930 | 1,870 | 1,940 |
| Japan | 1,480 | 1,560 | 1,620 | 1,260 | 1,460 | 1,280 | 1,360 | 1,170 |
| China | 1,440 | 1,290 | 1,360 | 1,630 | 1,820 | 1,820 | 1,880 | 2,100 |
| RoW | 1,230 | 1,440 | 1,560 | 1,410 | 1,810 | 2,060 | 2,100 | 2,070 |
| **Recycling** | | | | | | | | |
| **Autocatalyst** | **1,040** | **1,160** | **1,220** | **1,150** | **1,400** | **1,520** | **1,490** | **1,810** |
| North America | 700 | 770 | 850 | 890 | 970 | 980 | 930 | 1,110 |
| Western Europe | 190 | 240 | 250 | 130 | 210 | 330 | 330 | 380 |
| Japan | 100 | 110 | 100 | 100 | 180 | 130 | 130 | 120 |
| China | 0 | 0 | 0 | 0 | 0 | 10 | 20 | 30 |
| RoW | 50 | 40 | 20 | 30 | 40 | 70 | 80 | 170 |
| **Jewellery** | **0** | **0** | **0** | **0** | **100** | **140** | **130** | **140** |
| Japan | 0 | 0 | 0 | 0 | 10 | 20 | 20 | 20 |
| China | 0 | 0 | 0 | 0 | 90 | 120 | 110 | 120 |
| **WEEE** | **290** | **320** | **310** | **340** | **400** | **340** | **340** | **360** |
| North America | 80 | 90 | 90 | 80 | 80 | 70 | 70 | 70 |
| Western Europe | 60 | 70 | 70 | 70 | 110 | 80 | 80 | 80 |
| Japan | 110 | 120 | 110 | 120 | 130 | 120 | 110 | 130 |
| China | 10 | 10 | 10 | 20 | 20 | 10 | 20 | 20 |
| RoW | 30 | 30 | 30 | 50 | 60 | 60 | 60 | 60 |
| **Total** | **1,330** | **1,480** | **1,530** | **1,490** | **1,900** | **2,000** | **1,960** | **2,310** |
| North America | 780 | 860 | 940 | 970 | 1,050 | 1,050 | 1,000 | 1,180 |
| Western Europe | 250 | 310 | 320 | 200 | 320 | 410 | 410 | 460 |
| Japan | 210 | 230 | 210 | 220 | 320 | 270 | 260 | 270 |
| China | 10 | 10 | 10 | 20 | 110 | 140 | 150 | 170 |
| RoW | 80 | 70 | 50 | 80 | 100 | 130 | 140 | 230 |

*Source: SFA (Oxford). Note: Rounding errors may occur between totals shown from the previous page.*

## Rhodium supply-demand balance, koz


| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Primary supply** | | | | | | | | |
| **Regional** | | | | | | | | |
| South Africa | 650 | 640 | 610 | 660 | 640 | 630 | 590 | 550 |
| Russia | 100 | 90 | 80 | 80 | 80 | 80 | 80 | 70 |
| Zimbabwe | 10 | 10 | 10 | 20 | 20 | 30 | 30 | 30 |
| Other | 30 | 30 | 30 | 20 | 30 | 50 | 50 | 60 |
| Total | 790 | 780 | 730 | 770 | 780 | 790 | 750 | 720 |
| **Demand & recycling** | | | | | | | | |
| **Autocatalyst** | | | | | | | | |
| Gross demand | 820 | 1,000 | 910 | 600 | 730 | 740 | 770 | 820 |
| Recycling | 170 | 190 | 190 | 170 | 220 | 240 | 240 | 260 |
| Net demand | 650 | 810 | 720 | 430 | 510 | 500 | 530 | 560 |
| **Industrial demand** | 150 | 150 | 140 | 110 | 170 | 170 | 150 | 150 |
| **Other recycling** | 0 | 0 | 3 | 2 | 1 | 1 | 1 | 1 |
| **Gross demand** | 970 | 1,150 | 1,050 | 700 | 900 | 910 | 920 | 970 |
| **Recycling** | 170 | 190 | 190 | 170 | 220 | 240 | 240 | 260 |
| **Net demand** | 800 | 960 | 860 | 530 | 680 | 670 | 680 | 710 |
| **Market balance** | | | | | | | | |
| Balance (before ETFs) | 0 | -180 | -120 | 240 | 100 | 120 | 70 | 0 |
| ETFs (stock allocation) | | | | | | 20 | 40 | 50 |
| **Balance after ETFs** | | | | | | 100 | 40 | -50 |

*Source: SFA (Oxford).*

## Rhodium demand & recycling by region, koz

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Demand** | | | | | | | | |
| **Autocatalyst** | **820** | **1,000** | **910** | **600** | **730** | **740** | **770** | **810** |
| North America | 270 | 350 | 270 | 150 | 180 | 180 | 200 | 230 |
| Western Europe | 270 | 300 | 270 | 190 | 200 | 220 | 190 | 200 |
| Japan | 200 | 220 | 240 | 120 | 160 | 130 | 150 | 140 |
| China | 20 | 30 | 30 | 50 | 70 | 80 | 90 | 100 |
| India | 10 | 10 | 10 | 10 | 20 | 20 | 20 | 20 |
| RoW | 50 | 90 | 90 | 80 | 100 | 110 | 120 | 120 |
| **Industrial** | **150** | **140** | **120** | **110** | **180** | **180** | **150** | **150** |
| North America | 30 | 30 | 10 | 10 | 20 | 20 | 20 | 20 |
| Western Europe | 30 | 20 | 10 | 20 | 20 | 20 | 20 | 20 |
| Japan | 50 | 40 | 40 | 30 | 50 | 50 | 40 | 40 |
| China + RoW | 40 | 50 | 60 | 50 | 90 | 90 | 70 | 70 |
| **Total** | **970** | **1,160** | **1,050** | **700** | **900** | **910** | **920** | **970** |
| North America | 300 | 390 | 290 | 160 | 200 | 200 | 220 | 250 |
| Western Europe | 300 | 320 | 280 | 210 | 220 | 240 | 210 | 220 |
| Japan | 250 | 270 | 280 | 150 | 210 | 180 | 190 | 190 |
| China + RoW | 120 | 180 | 200 | 180 | 270 | 290 | 300 | 310 |
| **Recycling** | | | | | | | | |
| **Autocatalyst** | **170** | **190** | **190** | **170** | **220** | **240** | **240** | **250** |
| North America | 110 | 120 | 110 | 130 | 160 | 140 | 140 | 150 |
| Western Europe | 30 | 40 | 50 | 20 | 30 | 60 | 60 | 70 |
| Japan | 20 | 20 | 20 | 20 | 30 | 30 | 30 | 20 |
| China | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RoW | 10 | 10 | 10 | 0 | 0 | 10 | 10 | 10 |

*Source: SFA (Oxford) Note: Rounding errors may occur between totals shown from the previous page.*

# Glossary of terms

**Base metals**
Copper and nickel

**Basket price**
Collective revenue of metals divided by 4E oz

**By-products**
Copper, iridium, nickel and ruthenium

**CAPEX**
Capital expenditure

**Emissions legislation**
Tailpipe regulations affecting particulate matter, hydrocarbons and oxides of nitrogen

**ETF**
Exchange traded fund

**Euro 5/6 emission standards**
Euro 5 legislation introduced in 2009, Euro 6 in 2014, will be widely adopted later in other regions

**Gross demand**
A measure of intensity of use

**HDV**
Heavy-duty vehicle

**Head grade**
Grams of 4E PGMs per tonne of ore

**koz**
Thousand ounces

**LCV**
Light commercial vehicle

**Lean $NO_x$ traps (LNT)**
Rhodium-based, catalyses the chemical reduction of $NO_x$ in diesel engine exhaust to harmless nitrogen

**Lease rates**
Fees payable for the rental of an asset

**Merensky Reef**
A layer of igneous rock situated in South Africa that contains most of the world's PGMs

**Metal cocktail**
The make-up of polymetallic orebodies

**Mine lease areas**
Area defined by farm boundaries

**moz**
Million ounces

**Net demand**
A measure of the theoretical requirement for new metal, i.e. net of recycling

**Net supply**
Proxy supply of metal surplus to requirements

**Net total cash costs**
Total cash costs net of by-product credits (copper, iridium, nickel and ruthenium)

**Open-loop recycling**
Recycling in which products at end of useful life are used as a resource to manufacture other products

**OPMs**
Other platinum-group metals

**oz**
Ounce

**Particulate filter (DPF, GPF)**
Platinum-rich catalyst on ceramic filter, removes harmful fine particles from diesel exhaust, also now used in some gasoline vehicles

**PGMs**
Platinum-group metals

**Primary supply**
Mine production

**Secondary supply**
Recycling output

**Selective catalytic reduction (SCR)**
PGM-free, converts harmful $NO_x$ in diesel exhaust to harmless nitrogen, via tank of urea solution, used in heavy-duty diesel vehicles, increasingly competes with LNT in light-duty diesel vehicles

**Three-way catalyst**
Used in gasoline cars to remove hydrocarbons, carbon monoxide and $NO_x$, largely palladium-based now, with some rhodium

**Tonnes milled**
Concentrator throughput of ore

**UG2 Reef**
Also found in South Africa, this chromite-rich layer of rock contains fewer by-products than the Merensky Reef

**4E**
Gold, palladium, platinum and rhodium

**CURRENCY SYMBOLS**

| | |
|---|---|
| ZAR | South African Rand |
| $ | US Dollar |
| £ | UK Pound |

# Methodology notes

Primary supply is calculated from actual mine production and excludes the sale of stock in order to provide pure production data. Stock sales are treated separately in SFA's database as movement of stocks. Therefore, state stock sales from Russia are excluded in tabulations.

Gross demand is a measure of intensity of use.

Net demand is a measure of the theoretical requirement for new metal, i.e. net of recycling.

Automotive demand is based on vehicle production data not sales.

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