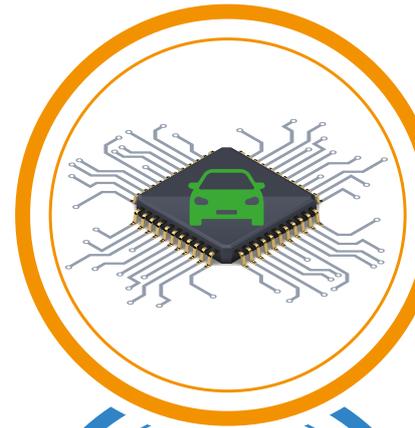


The Palladium Standard 2021
Setting the PGM agenda for the year ahead



Produced in collaboration with





THE PALLADIUM STANDARD

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TPS COLLECTION: AGENDA-SETTING COMMENTARY



The Palladium Standard was first published in September 2016, following the successful launch of The Platinum Standard in May 2014



One-half review, one-half preview, The Palladium Standard comprises analytical commentary on those issues we believe will set the PGM agenda for the year ahead



If you are interested in reading the collection, you can now download the editions via our [new website](#)



FOREWORD



Foreword

“We are on the point of moving up again, and the adventure appears more desperate than ever.”

George Mallory, dispatch from 28,000 ft up Everest on 28 May 1924, one week before a fatal attempt on the summit.

Where next for palladium?

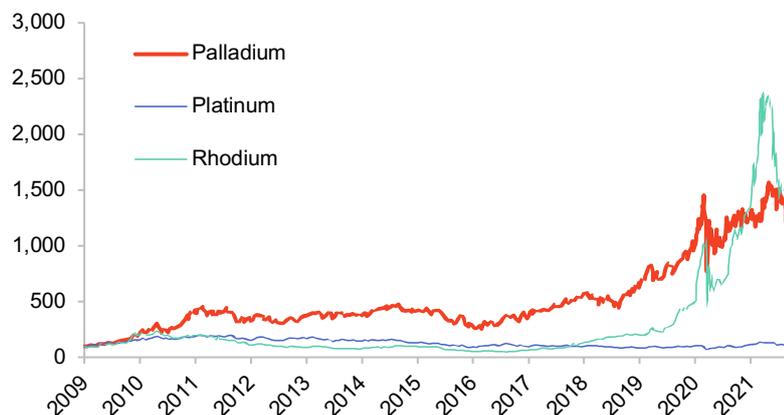
Peaks come in many a range, and with a multitude of ways to reach the top and to navigate safely down. In this issue of *The Palladium Standard*, we look at ‘Peak Palladium’: the dangers of high altitude and the safe ways onward. Our guidebook is illustrated with historical PGM price charts not unlike the profiles of some of the world’s great mountain ranges. Think of supply and demand trends as the geology determining the shape of the next mountain, valley or plateau.

Welcome then to the Stillwater Complex, deep in Big Sky Country in the US, with our guides, Ryan McKinley and Kevin Butak of Sibanye-Stillwater’s US PGM operations. Geology has been more than generous here, above forming the stunning Absaroka-Beartooth Mountains, below crafting the highest-grade platinum and palladium ore body in the world. The J-M Reef (Johns-Manville) in the Stillwater Complex boasts almost three-quarters of an ounce of Pt+Pd per tonne.

The Stillwater Complex is distinguished from other well-known PGM deposits, such as those in the Bushveld Igneous Complex and Norilsk, not only by its very high grade, but also by its high palladium-to-platinum ratio, 3.5oz of palladium for every 1 oz of platinum. It is concentrated in a narrow mineralisation zone that averages over 0.7oz/ton Pt+Pd (21.8g/tonne).

PGM prices: peak palladium?

Indexed to 100, 1 Jan 2009



Source: SFA (Oxford), Bloomberg

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Grades such as this mean that the Stillwater mines have palladium as their primary product. In Southern Africa and Russia, palladium is a by-product from, respectively, platinum and nickel mining. Mining palladium from Stillwater is thus always going to be blown by the prevailing and forecast palladium price winds, rather than the platinum or nickel prices. And as it is not far from the renowned Yellowstone National Park, the 'adventure' naturally requires adherence to peak environmental, social and governance (ESG) standards.

Attempts by the auto industry to climb back to pre-Covid production peaks have been severely hampered by the semiconductor chip shortage. Pete Kelly from LMC Automotive shows how the crisis began, and the path automakers must take to get back on track.

The recovery in automotive demand as the pandemic eased late in 2020 caught many in the supply chain by surprise. But consumer and business electronics manufacturers had quickly requisitioned much of the chip manufacturing capacity, leaving auto companies dangling.

Korea, Taiwan and Japan, with strong domestic semiconductor industries, have weathered the shortages much better than much of Europe and North America. Over-reliance on huge quantities of these cheap components, plus under-appreciation of the lead time needed to build new chip production capacity, is forcing a recalibration of sourcing, purchasing and supply relationships by the automotive sector. More respect for the terrain, in fact.

Risks on the palladium commodity mountain are mapped out very clearly for us by Nicky Shiels from MKS PAMP Group. Palladium has drawn in many investors over the past two decades, from institutional investors to fast-money day traders. Heady price volatility might take the breath away, but for some it's irresistible, so long as there is sufficient liquidity. Or, as in the case of retail investors (tourist climbers?) since the mid-2000s, so long as interest rates are low enough and the 'story' – technicals and macro sentiment, not the fundamentals – is tempting enough.

That climbing Mount Palladium is not a more popular sport is easily explained. The confluence of unpredictable liquidity, wild price swings, lack of sell-side market coverage ('story' tellers) and limited access to derivatives has deterred generalist participation. Which leaves 'palladium-eering' mainly to the pros. A shift "back to basics" (OTC-dominated) with smaller forays. Which usually means a descent in price. But Nicky warns that prices could hold on while rising inflation gives real assets a leg up, and hybridisation expands rapidly before the full ascent of electric vehicles.

The way up (and down)

“Mountaineering would lose its zest if there were no dangers for the daring and skilful.”

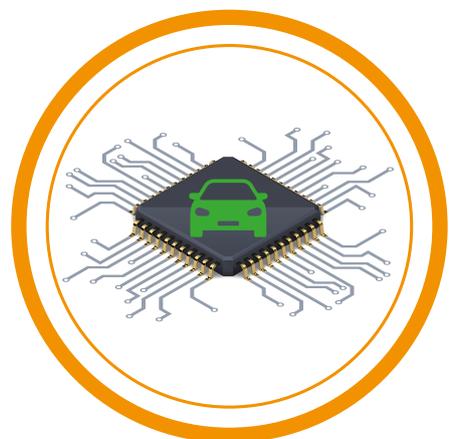
George Mallory, 1923

The palladium market is simultaneously contending with a supply interruption from Russia and demand disruption from the automotive industry. As detailed by Pete, the chip shortage has grown progressively worse, while Russian supply has begun to recover, South African output is back to pre-pandemic levels and, as Ryan and Kevin note, Stillwater is ramping up the Blitz project.

With some 7 million fewer light vehicles being produced this year than initially forecast, palladium and rhodium demand has been reduced substantially, and palladium and rhodium prices have retreated from their record highs. SFA thinks they are on a slippery slope to lower prices as the chip shortage looks set to continue well into 2022.

Platinum has escaped the worst of the semiconductor storm but it's poised precariously, with a large surplus and little investor interest this year. The platinum price has also pulled back from its high earlier in the year. However, it may be nearer the valley floor than either the palladium or the rhodium price, as platinum could be the metal that receives some support from inflation-hedging real asset purchases.

**THE GLOBAL AUTOMOTIVE
SEMICONDUCTOR SHORTAGE –
A CRISIS THAT WAS A LONG
TIME IN THE MAKING**



The global automotive semiconductor shortage – a crisis that was a long time in the making

Pete Kelly, Managing Director, LMC Automotive

How the chip shortage developed

The pandemic has led to large and dynamic displacements across many economic sectors – automotive is no exception. China was among the first countries to bring in a hard nationwide lockdown in response to the coronavirus outbreak and was, therefore, also one of the first to recover. The vehicle market in China collapsed in February 2020 but was already bouncing back by late March. With lockdowns hitting in other locations from March onwards, many large automotive markets were also hit hard. Global light-vehicle sales were down by 30%, year-on-year, in the second quarter of 2020.

Lockdowns hit automakers hard last year...

But the rebound in sales, post-lockdown, was rapid. The seasonally adjusted annualised selling rate went from a modern era low of 49 million units/year in April 2020 to 90 million units/year by August. This rate of sales was very close to the 2019 pre-Covid level and so, for a while at least, the market had largely recovered.

...but the sales rebound was rapid

The bounce in automotive demand has been underpinned by two primary factors. Firstly, the huge economic impact of the pandemic has been far from even across the income spectrum. With the tourism, leisure and hospitality sectors devastated by deep and repeated periods of lockdown or other crippling social distancing controls, employment income from those sectors has fallen sharply (though mitigating grants, income replacement and other schemes have helped a great deal). This has been a tragedy for those working in the impacted sectors, but the resulting financial difficulties have not had a dramatic effect on new car sales, since, to simplify somewhat, this worker cohort has never really been the primary source of new car buyers. That role has more traditionally been provided by the middle classes, many of whom found themselves working from home with their incomes relatively unimpacted, during a period of enforced saving as holiday and leisure spending was dramatically curtailed.

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Secondly, during the summer of 2020, surveys across the world started to show a marked shift in consumer preferences towards vehicle ownership. In a world in which travelling on public transport creates a higher risk of Covid infection, consumers are indicating a strong preference towards personal, not shared, mobility, particularly car ownership.

In response to the pandemic, consumer preferences shifted to car ownership

These factors, taken together, produced a strong demand rebound and, were it not for the current new vehicle supply constraints, would likely be responsible for surging vehicle sales now.

However, in October 2020, the first reports of the emergence of a shortage of semiconductors started to appear, mainly in China. Having been ahead of the curve in both lockdown and recovery, China's automotive sector started to experience problems with semiconductor chip scarcity. This then began to spread to other regions and by January was causing difficulties in most major vehicle-producing nations. (Note, some nations with strong domestic semiconductor industries, such as Korea, Taiwan and Japan, have been far more insulated from the impact of shortages and continue to look relatively better off as the situation continues.)

The semiconductor shortage started in China and was soon felt elsewhere

The initial issue related to the response from the automotive sector when in Q2 of 2020 it cancelled component orders, including semiconductors, *en masse*, in order to avoid tying up capital in the supply chain when the risk of a profound demand shock was looming in the immediate future. The demand shock never came, of course, for the reasons outlined above, but nobody was gambling on a sharp recovery at the time – industrial caution prevailed. The difference between semiconductors and other components was that the foundries used to build chips were quickly repurposed to meet exploding lockdown demand for consumer and business electronics, something that lingers to this day.

The auto industry cancelled orders in Q2'20..

The lead time for genuine new capacity for these foundries is significant, at six to nine months, meaning that only in summer 2021 was an initial flow of new capacity coming on stream. However, the competitive non-automotive demand continues to be an issue and the automotive sector seems unable to secure enough capacity to meet its needs.

...but now can't secure enough capacity to meet its needs

It has been possible, of course, to pull some levers to mitigate the situation in terms of overall revenue impact. The main one of these has been relying on new vehicle inventories to satisfy demand. However, inventories have been sharply depleted during the course of 2021 and, as an example, are now at record lows in the US. This one-off palliative has been used up and it relies on new car buyers being willing to accept vehicles that would not be their first choice, for example with different models, colour and specifications delivered instead. Meanwhile, buyers have switched to used cars in order to achieve their desired increase in personal mobility – and record used-car pricing has been a result.

What is the automotive industry situation now?

The semiconductor shortage continues to impose a speed limit on the pace of the global light-vehicle production and demand recovery. While Q2 was expected to represent the peak of chip-related auto manufacturing disruption in 2021, the prospects for improvement in the second half of the year have been sharply downgraded in just the last month.

Prospects for recovery in H2'21 have deteriorated

The continuing tight supply of semiconductors has prompted a widespread extension to new downtime and build-rate cuts during Q3. In addition, earlier OEM plans to begin catch-up production activity by working through normal summer shutdowns have largely been curtailed or abandoned. However, China shows some early signs that the crisis may be abating locally with semiconductor stocks improving, but this is principally only amongst domestic Chinese brands.

The way out of this is likely to be quite uneven across different vehicle manufacturers and different geographies. Disparity of impact has been a feature in any case – as a smaller impact for Japanese and Korean OEMs shows – reflecting not just privileged access to semiconductors but also more risk-averse supply chain management created in response to previous major supply chain disruptions (strikes, earthquakes and tsunamis).

However, the recent rising Covid-19 cases in parts of Asia where vaccination rates are low have prompted the reimposition of new local lockdowns and constraints which have further interrupted key parts of the regional automotive supply chain, including semiconductors. Indeed, this disruption is already set to help scupper hopes of any global catch-up activity in vehicle production during H2'2021.

Rising Covid-19 cases in Asia have interrupted the automotive supply chain

We now – as of August – expect the 2021 global light-vehicle production to be approaching 7 million units lower than our view at the end of 2020 when the semiconductor crisis was in its infancy.

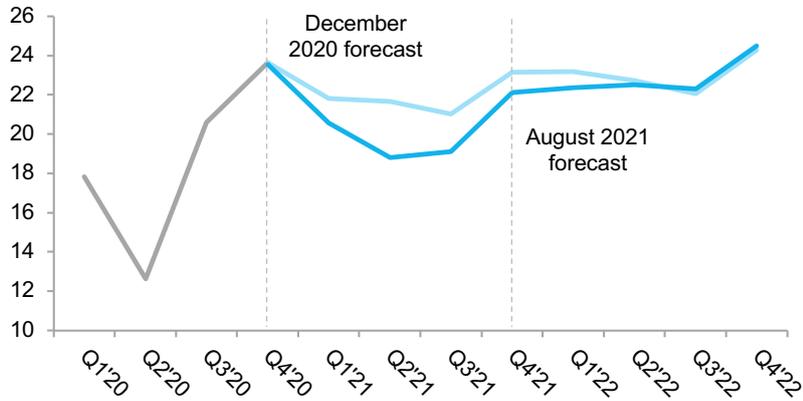
Global light-vehicle production lost in 2021 could be ~7 million units

Given the elongation and depth of the semiconductor crisis and its impact upon output, the cumulative depletion in inventory has finally fed through into previously resilient markets. Selling rates in both the US and more recently Europe, for example, have plunged as inventories dwindle, triggering a richer model mix and average prices to rise. With continuing supply-side shortages providing little scope to replenish inventories to more normal levels in the near term, vehicle market recoveries are expected to be markedly hindered and further demand recovery pushed out into 2022.

The chart below shows a comparison between our December 2020 forecast and our latest view. The different forecast profiles essentially highlight the dominant effects of the chip shortage through 2021 and, indeed, into 2022.

Global light-vehicle production forecast comparison

Units (m)



Source: LMC Automotive

What are the lessons from the chip shortage for the automotive sector?

It is likely that this specific automotive supply problem was going to emerge sooner or later in any case, given the now-entrenched global shortage of electronics of many kinds. But the situation was made considerably worse when the automotive sector, in effect, chose to front-load the supply shortage by cancelling orders in early to mid-2020. This led to earlier depletion of inventories and deeper cuts in production this year.

Clearly, the automotive industry – particularly at the OEM and Tier 1 supplier level – did not understand its heavy reliance on huge quantities of these relatively cheap components, nor was the lead time for the creation of new capacity factored into plans. In almost all other historical supply shortages, the financial muscle of the sector has been effectively deployed, resulting in relatively rapid resolution of the main blockages. But with inter-industry demand competing effectively for semiconductor capacity, the auto sector found itself in an unusually weak position.

*Other industries
out-competed the
auto industry*

What next?

Moving into 2022, we expect the semiconductor impact to ease. A pivot towards the global consumption of services as economies open up is set to reduce the auto sector's inter-industry competition for semiconductor capacity – consumers may have sated their desire for electronics to a significant degree and are already spending more again on leisure activities, hospitality and holidays. Nevertheless, supply-side disruptions are expected to take time to fade and thus catch-up vehicle industry activity is anticipated to remain somewhat disrupted and be increasingly skewed towards the second half of 2022. Once again, risks of more entrenched semiconductor shortages may jeopardise catch-up timing and scale, with further disruption pushing the recovery in vehicle output further into 2022 and even 2023. It appears unlikely there will be a rapid resolution.

*Auto production
catch-up is skewed
to H2'22*

**STILLWATER IS OF
'PRECIOUS' IMPORTANCE
IN PGMS TODAY**



Stillwater is of ‘precious’ importance in PGMs today

Ryan McKinley and Kevin Butak, Sibanye-Stillwater US PGM operations

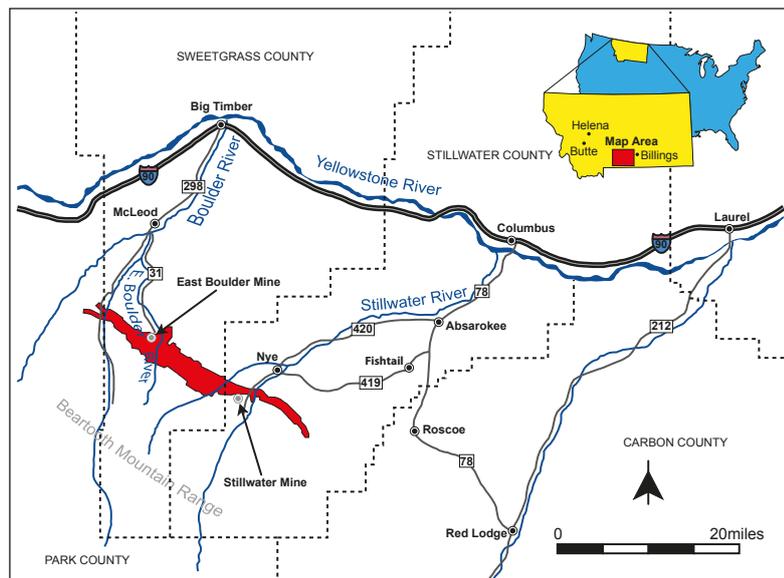
Deep in the heart of Big Sky Country, nestled up against the Absaroka-Beartooth Mountains, lies the highest-grade platinum and palladium ore body in the world (almost three-quarters of an ounce per tonne)...the J-M Reef (Johns-Manville) in the Stillwater Complex.

The J-M Reef is the highest-grade platinum and palladium ore body in the world

Since mining started in 1986, the J-M Reef in the Stillwater Complex has been the only platinum-group metal (PGM) producer in the United States. It has produced over 14 million ounces of platinum and palladium, millions of tons of copper and nickel, as well as a bevy of other platinum-group elements including rhodium, iridium and gold.

Sibanye-Stillwater has two underground mines on the deposit, both with their own surface mill sites. The Stillwater Mine lies south-west of Nye, Montana, along the Stillwater River and the East Boulder Mine lies approximately 48 miles (77 km) south-west of Big Timber, Montana. These two sites make up the first and second highest grade platinum-palladium mines in the world. They are separated by 12 miles (19 km) of pristine wilderness, under which lies the least explored section of the accessible J-M Reef, potentially worth tens of billions of dollars in today’s market.

Map showing relative location of the two Stillwater mines



Source: Company reports

A busy history book

Since the discovery of the J-M Reef by the Johns Manville Corporation in 1973, the deposit has been managed and owned by numerous parties, most recently Sibanye Gold (now Sibanye-Stillwater). In 1979, Manville partnered with Chevron USA Inc. to further develop and explore the J-M Reef, starting underground mining in 1986. Between 1979 and 1986, part ownership of the Stillwater Mining Company (SMC), formed in 1983, was exchanged between the Manville Corporation, Chevron, and later Anaconda Minerals and LAC Minerals.

The J-M Reef was first discovered in 1973, with the first ounces produced 14 years later

The first ounces of platinum and palladium were produced in 1987, along with the plans to develop the East Boulder Project. Manville and Chevron bought out the remaining shares from LAC Minerals in 1988. Pittsburg and Midway Coal Mining Co. took over management of SMC from Chevron Resources in 1990. In 1992, the Manville Sales Corporation changed its name to Schuller International Inc., and on 23 February 1992 the millionth ounce of combined platinum and palladium was produced by SMC. In 2003, SMC entered an agreement to sell a 55% majority of the company stock to MMC Norilsk Nickel for \$248.2 million. Norilsk sold its majority share in 2010. In 2017, SMC stockholders agreed to Sibanye Gold acquiring the company, leading to the formation of Sibanye-Stillwater.

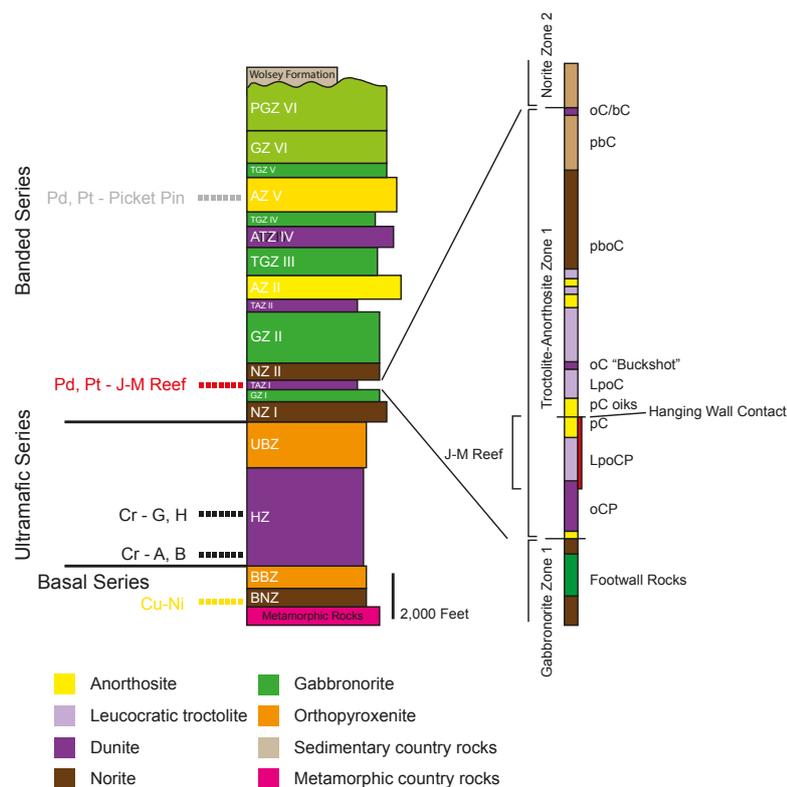
Magmatically different from the rest

The Stillwater Complex is a 2.7-billion-year-old layered mafic intrusion in south-central Montana, covering an area of approximately 1,890 square miles (4,900 km²) between Big Timber and Columbus. Thick sedimentary rocks overlie most of the intrusion, but a 30 mile-long (49 km) sliver of the deposit is accessible on its southern border in the Beartooth Mountains, due to the uplift of the Rocky Mountains 60-80 million years ago. This uplift tilted the deposit an average of 45-65° to the north, and up to 65° overturned to the south, requiring a range of underground mining methods to extract the valuable ore body.

Owing to complex geology, a range of underground mining methods are required

The PGM-rich J-M Reef lies within the stratigraphic unit called Troctolite-Anorthosite Zone I, or TAZ I, in a stratigraphic region called the Lower Banded Series. The Lower Banded Series consists primarily of norites and gabbro-norites as well as the highly variable olivine and anorthosite-bearing TAZ I. An unconformity between TAZ I and GZI formed as a result of thermal erosion within the magma chamber of the complex. This unconformity is present across the entire strike length of the uplifted J-M Reef and varies greatly in its vertical extent, ranging from the complete removal of GZI in the Stillwater River Valley to nearly 1,000 ft (300 m) of additional undisturbed stratigraphy at the East Boulder River.

Stratigraphic column showing the relative location of the J-M Reef within the Stillwater Complex



Source: Company reports

The J-M Reef formed at the top of this unconformity, varying its stratigraphic location between the top of NZ I to the top of GZI. Immediately after, or during, the formation of the reef and deposition of the PGM-bearing sulphides, a stark textural contact formed within TAZ I. This contact separates the PGM-rich, coarse crystalline reef package from the PGM-poor, fine crystalline rock above. This textural change can also be traced throughout the deposit, forming what we call the Hanging Wall Contact, which the grade control geologists use to follow the ore body underground. Approximately 40% of the total J-M Reef is economic, averaging 70-75% ore within the planned production areas. The average horizontal width of the ore body is about 4 ft (1.2m), but can pinch and swell from a few inches to over 100 ft (30 m).

40% of the J-M Reef is economic

Wider regions of the ore body, known as ballrooms, can provide a bonanza in reef tonnes

A wide variety of PGM-bearing sulphides makes up about 0.25-1% of the mineralised zone. These sulphides include pyrrhotite, pentlandite, chalcopyrite and braggite, among others.

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The two most significant characteristics of the J-M Reef that set it apart from other deposits such as Merensky, Bushveld and Norilsk are its very high grade and its high palladium-to-platinum ratio. Unlike other deposits, which require bulk-tonnage at very low grade, the J-M Reef is concentrated in a narrow mineralised zone that averages over 0.7 oz/ton Pt+Pd (21.8 g/tonne) with a ratio of 3.5 oz of palladium for every 1 oz of platinum. This concentration of the ore, along with the relatively steep dip of the ore body, requires narrow vein mining techniques to be economic. These methods require constant monitoring and direction by our grade control geologists to keep us on the reef and at the correct width to mine the ore most effectively.

A high palladium to platinum ratio sets the J-M Reef apart from other ore bodies

Typical ore sample



Source: Company reports

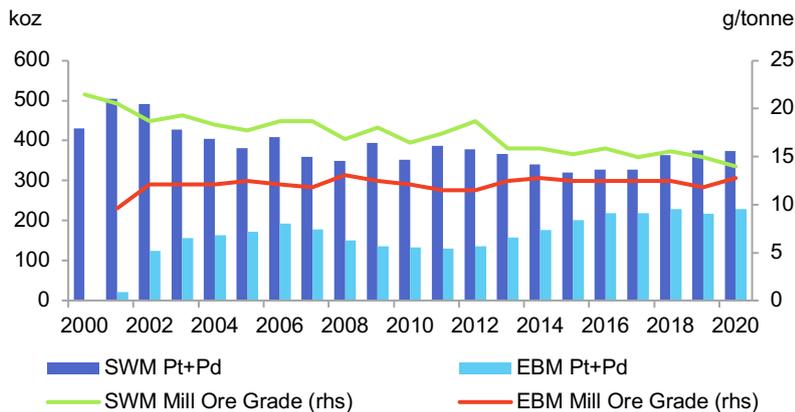
Mining practice makes perfect

The J-M Reef is a primary source of palladium and platinum, with by-products of copper, nickel, gold, rhodium and other PGMs. The PGMs are primarily used in vehicle catalytic converters, converting toxic emissions of nitrogen oxide, carbon monoxide and hydrocarbons to the relatively less harmful nitrogen gas, carbon dioxide and water vapour.

In its first full year in 1988, the Stillwater Mine produced 186,444 combined ounces of platinum and palladium at a grade of 0.75 oz/ton Pt+Pd (23.3 g/tonne), confirming it as the highest-grade PGM mine on the planet. Since then, further development at the Stillwater Mine, as well as the East Boulder Mine in 2000, has allowed production to increase but at a lower overall grade, mostly due to changes in mining practices.

Grade has decreased over time but remains high relative to other mines

Production ounces and grade



Source: Company reports. Note: SWM = Stillwater Mine, EBM = East Boulder Mine.

Throughout their history, the Stillwater and East Boulder mines have undergone many changes, affecting how we conduct business and extract our resources. Owing to the variability of the J-M Reef, many mining practices are utilised to maintain productivity without compromising the quality of the product and safety of our employees.

Early implementation of captive mining (equipment is held within the mining area and is only accessed by raises either by ladder or by air-driven climber. Rounds are drilled out with jack-legs and mucked out with narrow slusher buckets) allowed the narrow J-M Reef to be mined with very little dilution from the surrounding waste rocks, keeping the realised grade as high as possible.

Owing to changing safety standards and mining practices, this method is only utilised in rare cases today. Overhand (mining over previous cut which is filled with waste sand from the mill) and underhand (mining under the previous cut which is filled with cemented backfill, paste ore cemented rock fill) mechanised cut and fill mining is by far the most common practice at both mine sites.

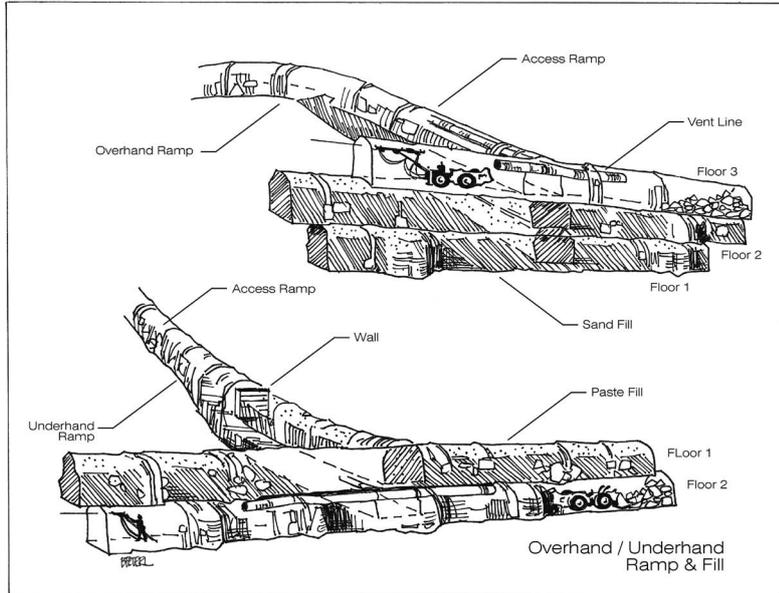
Modern mining methods dilute the grade of ore

Unfortunately, mechanised mining requires a wider minimum width than captive stope mining, which dilutes the relatively narrow J-M Reef, lowering the overall grade substantially.

- **Backstopping and sub-level extraction** are used in areas where the reef is more consistent in width and direction, maximising the efficiency of tons produced, while minimising the amount of dilution.
- **Transverse extraction** requires the use of cemented rock fill and is utilised in areas where the mineralised reef is wider than usual, but located in an area with poorer ground conditions.

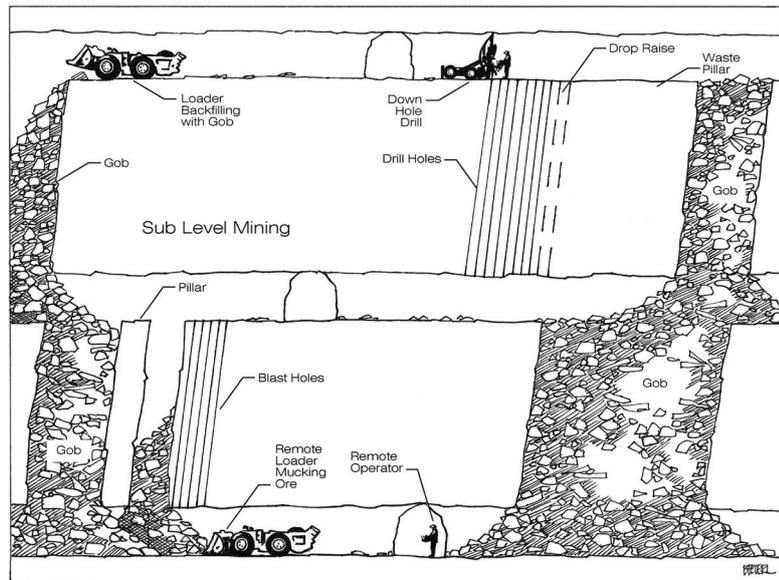
Sibanye-Stillwater's commitment to safety means we are constantly trying to innovate and keep our miners out of harm's way. An example of this is the transition from the use of jack-legs in our production headings to the CMAC-Thyssen's DHS, or Drill Handling System. This gets the jack-leg out of the miners' hands, decreasing fatigue and risk of injury.

Example of overhead and underhand mechanised mining



Source: Company reports

Example of sub-level mining



Source: Company reports

Proving green credentials

As the United States' only domestic PGM producer, the Stillwater Complex is of utmost global importance because of its relative geopolitical stability. Additionally, the local economy and community benefit even more by the provision of good paying jobs, an influx of taxes for local school systems and community programmes, as well as the generous donations made throughout the mines' history to various causes. All of this allows local businesses to thrive and enables people to live and work in a beautiful area. Sibanye-Stillwater creates superior value for all its stakeholders.

In a world focused on humanity's effect on the global environment, it is more important than ever to seek out solutions that limit the impact on our surroundings, especially during extraction of natural resources. Sibanye-Stillwater is a shining example of the right way to conduct business in a heavily regulated and often demonised industry. Owing to its location near the Absaroka-Beartooth Wilderness and Yellowstone National Park, the environmental impact of the two mines is of highest concern to the company, as well as the surrounding community. In an effort to mitigate potential environmental impacts, in May 2000 SMC entered into a "Good Neighbor Agreement" with the Cottonwood Resource Council, the Northern Plains Resource Council, and the Stillwater Protective Association. These groups place considerable importance on the quality of the Stillwater and East Boulder Rivers, which run through both mine sites respectively. The company has put in place world-class water treatment facilities to remove and dispose of nitrate-laden mine water. These facilities include two anaerobic bio-denitrification plants (bug-plants), lined waste piles to collect and treat meteoric water, land application over nitrogen-loving plants, and percolation ponds for water that does not interact with the mining process. Other environmental considerations include dust mitigation, decreasing light pollution by use of diffused outdoor lighting, and traffic reduction by provision of buses and vans to transport employees as well as enforcing strict carpooling standards.

In addition to our current environmental standards, Sibanye-Stillwater is working towards Environmental, Social and Governance (ESG) compliance, and is currently being audited for ISO 14001 certification. As a recently inducted member of the International Council on Mining and Metals, the company is dedicated to continuously improving its practices concerning the environment, social and self-governance.

There is increasing pressure on the mining industry to align with global climate goals

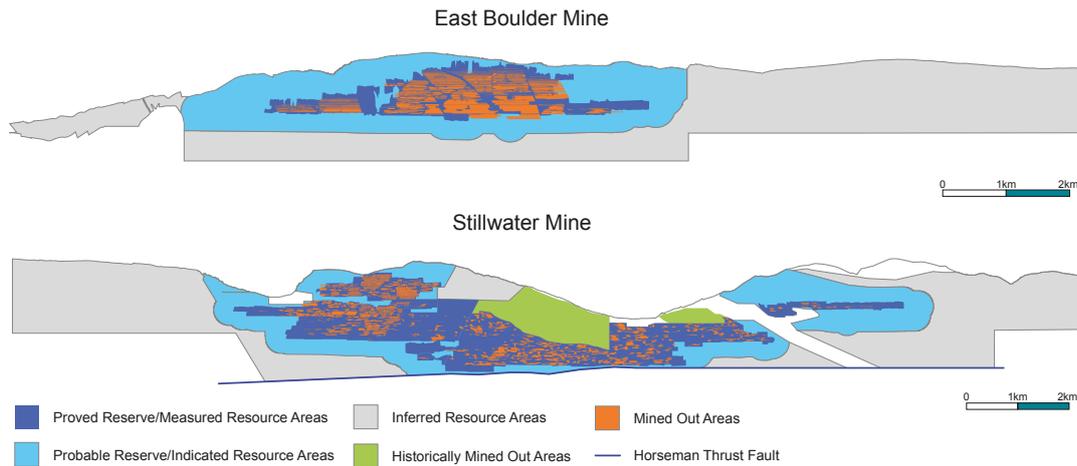
Sibanye-Stillwater is working towards ESG compliance

Shaping the future

The Stillwater and East Boulder mines continue to develop rapidly, with plans to significantly increase underground core drilling and primary development in 2022. The ramping up of development and production is in an effort to increase proven reserves, making it possible to fill Stillwater’s expanded mill capacity. This mill expansion is currently underway as part of the Stillwater East (Blitz) project.

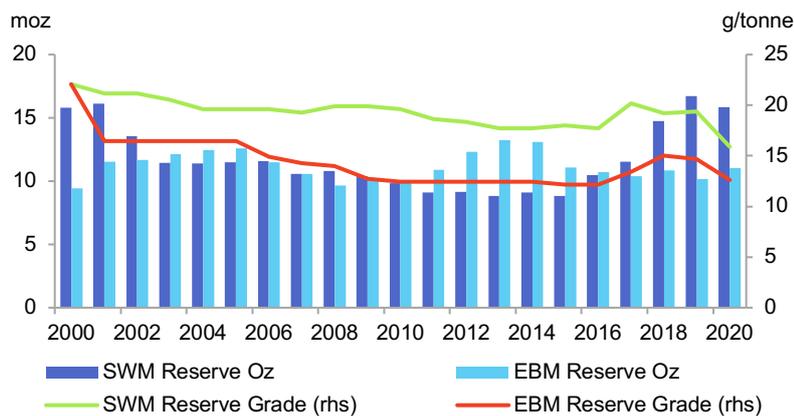
Once complete, the mill expansion will double the production of platinum and palladium

Mine reserves and resources



Source: Company reports

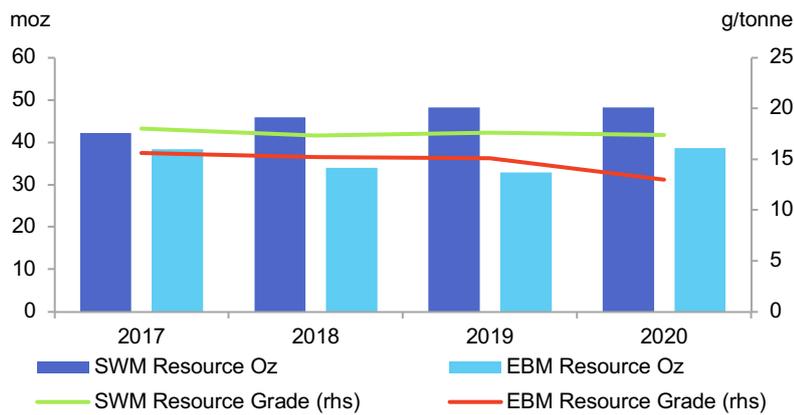
Reserve ounces and grade



Source: Company reports. Note: SWM = Stillwater Mine, EBM = East Boulder Mine.

Higher metal prices allows for the inclusion of lower grade material previously classified as uneconomical reserves

Resource ounces and grade

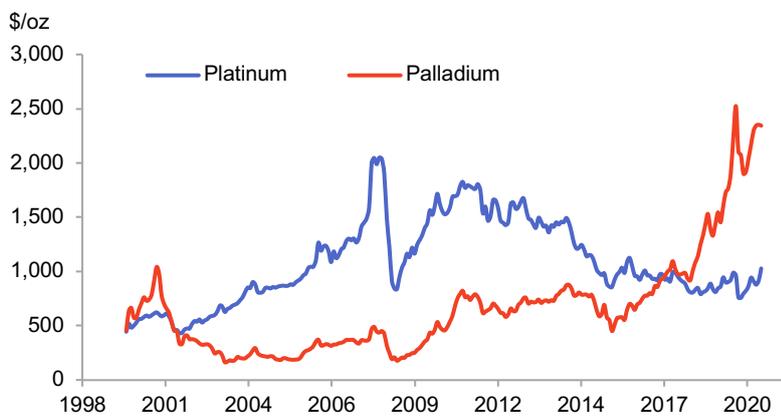


Source: Company reports. Note: SWM = Stillwater Mine, EBM = East Boulder Mine.

Being the highest-grade platinum and palladium deposit in the world, and given our unique palladium to platinum ratio of 3.5:1, the Stillwater mines (Stillwater Mine and East Boulder Mine) are set up for a bright future given current economic conditions. As palladium prices rise, the combined metals price allows the Stillwater mines to increase profitability while continuing to expand their proven reserves. This, along with the commitment to the community and the environment, makes the Stillwater and East Boulder mines very competitive with the larger mines around the globe. Sibanye-Stillwater’s mining truly improves lives!

A high ore grade and strong ESG credentials make the Stillwater and East Boulder mines very competitive

Platinum and palladium market prices 2000-2020



Source: Public data sources

For more information, please visit sibanyestillwater.com

**PEAK PALLADIUM:
*VENI, VIDI, VICI...***



Peak palladium: *Veni, Vidi, Vici...*

Nicky Shiels, Head of Metals Strategy, MKS PAMP Group

The MKS PAMP Group is an industrial and trading services group specializing in all aspects of the precious metals business. This family company was established over 60 years ago and is now an innovative global business serving precious metals producers, users and traders worldwide.

As we approach this year's New York Platinum Week, there are a few key anniversaries pertinent to the commodities space. It has been 20 years since 9/11 and two decades of the war against terror in which geopolitical risk was bid to varying degrees. It is also 10 years since the US debt was downgraded in August 2011 which jump-started gold to all-time highs. Finally, it has been 50 years since the Nixon shock on 15 August 1971 (when President Nixon ended the convertibility of the US dollar to gold), effectively 'thrusting' the precious metals sector into the investment limelight as a viable hedge against the fiat system.

Palladium, a relatively niche commodity, is currently an 11 moz market and at ~\$26 bn, it is roughly one-tenth the size of the current gold market, and has been the best performing commodity on an annual basis for five of the past 20 years (2010, 2014, 2017, 2018 and 2019). It is a better-known weapon in fighting global pollution than platinum. It has caused major market disruptions and freezes on two dominant market exchanges (in 2001 on TOCOM and more recently on NYMEX). Palladium was the cause of a \$1bn write-off in a major automaker's earnings in 2001/2, while it also generated extraordinary returns for most South African and Russian producers during the boom years, despite being a by-product.

While commodities are inherently extremely cyclical in nature – it is either 'feast-or-famine' – the headlines that palladium has achieved in light of its relative size over the past two decades indicate that it "came", it "saw" and it "conquered" (*veni, vidi, vici*).

It is 50 years since President Nixon closed the gold window, 10 years on since the US's credit rating was downgraded and 20 years on since 9/11

Palladium has been the best performing commodity in five of the last 20 years - it "came", it "saw" and it "conquered" (veni, vidi, vici)

Heat map of annual commodities returns, 2001-2020: Palladium is the star performer for 5 out of 20 years

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021 YTD	KEY
Palladium	7.9%	96.7%	133.1%	67.6%	82.6%	154.5%	93.0%	5.6%	153.1%	96.6%	10.1%	19.2%	26.2%	11.4%	-3.5%	103.7%	55.3%	18.6%	54.2%	47.5%	118.7%	Palladium
Gold	3.4%	57.3%	75.4%	42.8%	50.8%	126.2%	76.7%	-10.7%	152.4%	83.2%	8.2%	15.2%	7.2%	6.9%	-9.6%	60.6%	32.4%	17.9%	34.5%	26.0%	69.7%	Gold
Silver	2.5%	25.6%	51.1%	41.3%	40.5%	80.9%	57.2%	23.0%	129.4%	51.5%	5.8%	12.2%	1.7%	3.9%	-10.4%	59.4%	31.2%	6.9%	31.6%	25.9%	45.2%	Silver
Platinum	2.4%	24.6%	35.6%	33.6%	39.8%	61.4%	42.7%	-24.7%	118.1%	46.7%	2.8%	0.2%	0.2%	3.8%	-10.7%	45.0%	30.5%	-0.4%	21.5%	25.1%	35.9%	Platinum
Nat Gas	0.4%	21.5%	34.6%	26.0%	36.5%	47.7%	34.3%	-24.9%	77.8%	31.5%	-9.3%	9.9%	-1.0%	-1.7%	-11.8%	21.0%	30.5%	-1.6%	18.3%	24.8%	20.8%	Nat Gas
Oil/WTI	-3.8%	12.5%	34.5%	23.5%	29.2%	46.4%	31.0%	-31.0%	58.9%	31.4%	-17.8%	9.0%	-3.4%	-2.2%	-17.8%	17.4%	27.5%	-8.5%	15.2%	19.7%	22.0%	Oil/WTI
Coal	-14.6%	12.5%	29.2%	14.9%	17.9%	37.2%	18.8%	-36.1%	56.8%	30.0%	-18.3%	8.0%	-6.7%	-5.5%	-19.1%	14.9%	24.3%	-14.5%	11.0%	18.7%	12.6%	Coal
Copper	-17.6%	5.1%	24.3%	5.9%	16.2%	31.2%	16.7%	-38.8%	48.2%	29.5%	-19.0%	7.9%	-41.0%	-11.8%	-20.3%	13.6%	13.1%	-16.5%	3.4%	16.0%	14.0%	Copper
Aluminum	-19.2%	3.5%	19.4%	5.4%	12.7%	24.2%	14.6%	-49.3%	45.7%	20.8%	-20.9%	7.1%	-14.0%	-14.0%	-26.1%	13.5%	12.5%	-17.4%	3.4%	14.6%	16.4%	Aluminum
Zinc	22.0%	0.5%	18.0%	-0.6%	10.3%	23.2%	10.4%	-51.1%	24.4%	15.2%	-21.4%	4.2%	-18.6%	-15.6%	-26.1%	11.3%	6.9%	-17.5%	4.4%	10.9%	8.4%	Zinc
Nickel	-24.8%	-2.4%	16.0%	-3.6%	5.4%	17.1%	6.1%	-53.5%	1.8%	11.3%	-21.6%	2.3%	-22.2%	-16.0%	-26.6%	8.6%	4.7%	-19.2%	-4.7%	10.8%	-1.8%	Nickel
Lead	-26.0%	-12.7%	4.4%	-10.3%	4.2%	0.0%	-16.7%	-55.4%	-0.9%	5.2%	-24.2%	-7.1%	-38.0%	-19.3%	-29.4%	1.2%	3.0%	-22.2%	-9.5%	3.3%	-4.7%	Lead
Com	-54.1%	-16.4%	4.2%	-17.0%	-7.3%	-25.2%	-23.6%	-56.5%	-11.4%	-5.2%	-25.2%	-9.2%	-35.8%	-31.2%	-30.5%	-1.9%	-0.4%	-24.5%	-18.0%	-1.3%	-6.6%	Com
Wheat	-73.1%	-45.9%	-18.7%	-18.4%	-10.1%	-43.8%	-47.1%	-52.5%	-13.4%	-21.2%	-32.2%	-16.8%	-39.6%	-45.6%	-41.9%	-13.2%	-20.7%	-24.8%	-25.9%	-20.5%	-9.5%	Wheat
AVERAGE	-17.5%	12.3%	32.9%	15.1%	23.5%	41.5%	22.4%	-36.6%	60.1%	30.5%	-13.1%	5.3%	-10.5%	-9.8%	-20.2%	25.3%	17.9%	-8.8%	9.4%	15.8%	24.3%	

Source: MKS PAMP Group, Bloomberg, U.S. Global Investors research. Note: The heat map of analysis does not encompass all commodities, but merely provides an overview of some key – large, liquid and/or economically integral – agricultural, energy and metals commodities. Note: Returns are based on historical spot prices or most active futures prices (LME or CME). 2021 YTD returns as of September 2021.

Supply-side dynamic No. 1: Supply “leftovers”

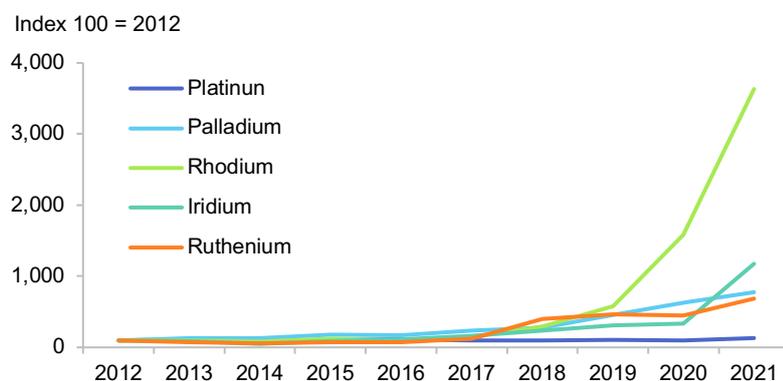
A key driver of palladium’s performance and growing popularity for investors is that 90% of mined palladium is a by-product of other metals and hence supply is relatively very inelastic to demand and technological trends; it is a by-product of nickel production in Russia and of platinum production in South Africa. By-product metals such as silver and palladium typically either boom for longer (than their primary sister metals) or bust for longer given this in-bred inelasticity. There is no ‘quick switch’ to turn on PGM supply as it usually takes several years for mining capacity to respond to demand trends. Scrap recycling usually has a quicker response time but current melting/refining capacity for autocatalyst scrap is approaching its physical limits. Supply cannot respond quickly unless *all* by-product prices (e.g. palladium, rhodium, iridium etc.) collectively turn parabolic and drive producers’ headline earnings, which has been the case recently. The tail (by-products) is wagging the dog, which complicates expectations around future supply dynamics for other metals. The rand PGM basket now drives supply decisions, not the primary metal (XPTUSD), for South African producers, highlighting the inherent difficulties in balancing six PGM markets with vastly varying degrees of deficits and surpluses.

Palladium’s supply is relatively inelastic to demand trends...

...which leads to longer booms and busts...

... and complicates expectations around future supply dynamics, highlighting the inherent difficulties in balancing six PGM markets with vastly varying degrees of deficits and surpluses

South African 5E revenues



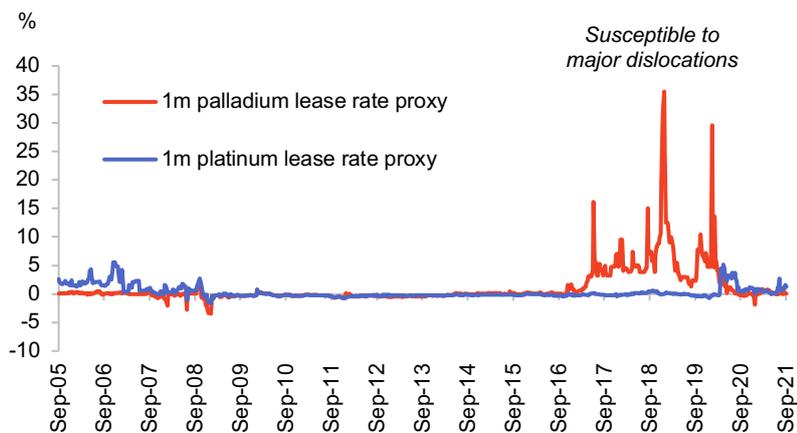
Source: SFA (Oxford). Note: ZAR real 2021 revenues presented.

Supply-side dynamic No. 2: Historical black holes make for limited visibility around stockpiles

In addition to the complications arising from palladium being a by-product, for current production there is extremely limited visibility around accumulated above-ground stockpiles. There is an underappreciation that for decades before 2000, the primary production of palladium hailed from the historically 'closed' socioeconomic/political regimes of the Soviet Union and Apartheid South Africa. That made visibility into supply and associated data opaque to say the least. The market attempted to put (wide-ranging) estimates on Russian stockpiles and dissected historical import/export data for clues on stockpiles and supplies, but ultimately the best proxy for 'known unknowns' (such as OTC stockpiles) is price action. The recent secular bull market in palladium, combined with outlandish physical dislocations (lease spiking to over 30% in 2018-2020; ETF metal being *drawn* to quench Asian demand), simply indicates limited above-ground availability. By the same token, historically compressed platinum prices vs. those of its peers, and the inability to *sustainably* rise on any supply-side flare-ups post-2007 (Eskom crises, political riots, mining strikes) indicate a very saturated market.

Price action indicates limited palladium stock availability

Platinum and palladium short-term (one-month) lease rates



Source: Bloomberg, MKS PAMP Group

Demand: emission technology changes faster than supply responses

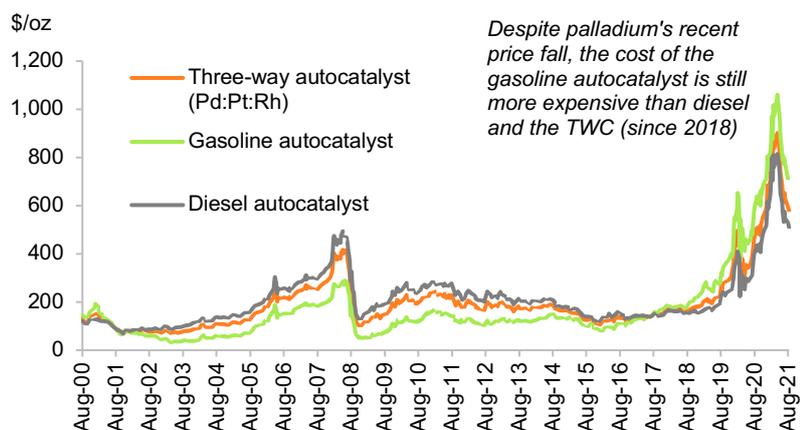
Opaque and/or limited stocks cannot alone drive price spikes; it is the combination with demand trends that was (*still is?*) out of sync with the inherent production prill splits (ratios) that has caused unusual volatility across PGMs. During the bear market years of 2009-2017, OEMs and consumers mostly benefited from exceptionally low prices and availability risk across all PGMs. This was at the expense of the producer community which had to contend with increasing labour and other unit costs, and a complex regulatory, operating and political environment that fostered a lack of capital investment. That is now, arguably, coming home to roost given recent blow-off tops in palladium and rhodium. In 2018, markets were convinced US auto sales would plateau or fall and in 2019 it was the Chinese “car crash” – both major auto economies for palladium, yet prices remained in tireless price uptrends.

Demand trends are out of sync with production ratios

The complexity of catalyst technologies and emission regulations are real, where changes (higher loadings) are occurring faster than supply responses. However, price spikes are one (faster) way to resolve limited availability, as consumers respond by thrifting. With platinum near its cheapest ever vs. palladium (\$1,500 discount vs. 20-year average of a \$370 premium), it is already prompting some auto re-engagement and substitution. This is especially evident in the heavy-duty sector and in China (very strong import numbers year-to-date) and North America, driven by rising loadings for China 6 and US LEV III legislation, respectively. Even with the recent ~\$600 palladium repricing lower from its May 2021 peak, the palladium-heavy gasoline autocatalyst remains pricier than diesel and three-way autocatalysts, allowing for further substitution by platinum and away from rhodium and palladium in the coming years.

Prices still support substitution by platinum away from palladium and rhodium

Costs of various autocatalysts



Source: Bloomberg, MKS PAMP Group. Note: Costs calculated are a very rough proxy.

Supply chain risks: chipless cars show growing risks that are here to stay

Cars in “Tuxedo black” or “Royal red” were suddenly unavailable a decade ago due to the closure of the only factory making the vital pigment (after the 2011 tsunami in Japan). A shortage of a much more vital component – semiconductors – has hit the industry and left automakers unable to install the necessary electronics that control driving, safety features and entertainment in an ever-growing electronic world. And two decades ago, a major automaker misjudged the availability of palladium at a time when tailpipe emission regulations were taking off in China and Europe. All of these events highlight the inherent supply chain risks facing automakers. Today, those risks are increasing due to governments’ Covid policies (especially Covid-zero policies in APAC regions), stickier trade policies, and relatively higher national interests with scarcer resources/higher commodity prices. This is exacerbated by the reliance on outsourcing (technology) components to ‘tier one’ suppliers; in effect, keeping suppliers (such as chipmakers) at arm’s length to automakers.

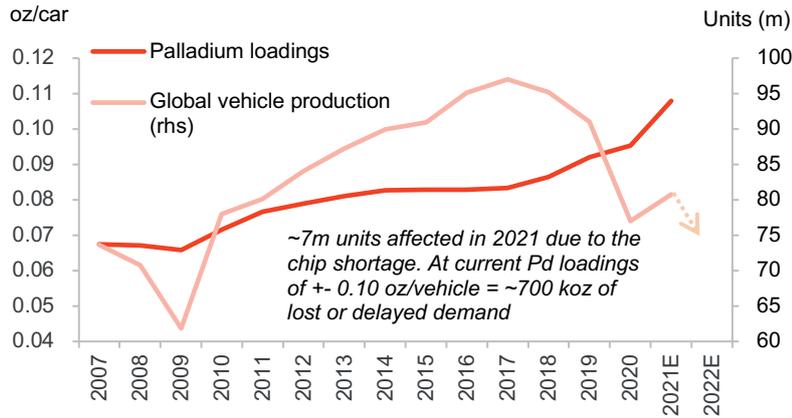
*Supply chain risks
abound for automakers*

Until recently the market largely expected the semiconductor shortage to be resolved by Q4’21 at the latest, when the reallocation of capacity from semiconductor foundries and potentially some cooling-off of consumer electronics demand (which redirects chip demand away from autos) could provide better supply security. However, the recent announcement of cuts by many auto producers, with Toyota slashing auto production forecasts by 40%, has shifted expectations of any ‘resolution’ out to mid-2022. IHS Markit Automotive has revised down its global vehicle demand growth for 2021 to -80 million units (only an 8.3% increase over 2020 levels), with downside risk still possible. This puts the FY’21 risk associated with semiconductor shortages between 6.3 and 7.1 million units globally. A ‘back-of-the-envelope’ calculation puts the current palladium loading rate for ALL vehicles at 0.10 oz/car, and thus implies maximum² auto demand losses of -700koz. Overall, there continues to be very little visibility up and down the supply chain; any shortages or bottlenecks negatively impact PGM demand, but could also slow the shift to the electric future over the very short term as electric vehicles (EVs) contain twice as many chips by value than internal combustion engine (ICE) vehicles.

*A resolution of the chip
shortage could take
until mid-2022*

² The chip shortage largely affects light-duty vehicles which have much lower loadings than heavy-duty vehicles.

Chipless cars? Global vehicle production falling while palladium loadings have been rising persistently since 2009



Source: Bloomberg, MKS PAMP Group, IHS Markit, SFA (Oxford). Note: Palladium loadings calculated by dividing annual autocatalyst palladium demand by annual vehicle production.

Investor changes from market access to participation rates: it's "back to basics" (OTC)

While consumers shun volatility, it is this high-beta characteristic that draws in much investor interest, providing there is sufficient liquidity. Palladium has charmed many investors – from institutional investors to CTAs and fast-money day traders – over the past two decades. The shift in exchange dominance, from TOCOM in the 1990s (indicative of the auto technological shifts developed in the East), to the explosion of CME from the mid-2000s (indicative of new-found generalist interest with the launch of global ETFs in the West), highlights the global nature and allure of investor interest in palladium. The arrival of that retail investor in the mid-2000s (accelerated by lower interest rates, quantitative easing (QE) and expanded market access), whose flows are driven more by the “story”, technicals and macro sentiment (as opposed to deep market fundamentals), frustrated market specialists. But it was a double-edged sword as major market disruptions occurred on these two exchanges.

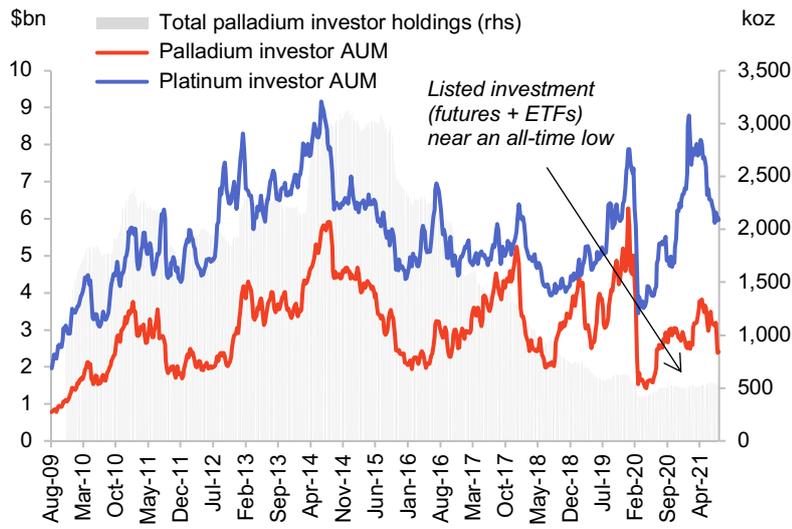
In 2001, TOCOM froze prices and trading for several days amidst “widespread disorder in palladium trading”. More recently, NYMEX instituted a series of trading and delivery limits due to the lack of metal availability. Total known investor holdings (COT + ETF) swelled to a peak of over 3.2 moz in 2014 but the palladium derivative markets (either ETF or futures) are now both shadows of their former self, with CME Aggregate Open Interest one-fifth of peak positioning and ETFs one-sixth of peak holdings. Overall, that indicates that investor interest and participation have either dissipated or shifted underground/OTC. The confluence of unpredictable liquidity, wild price swings (palladium printed multiple \$150+ *intraday* ranges), the lack of sell-side market coverage and the subsequent limited access to derivatives, just as quickly shunned generalist participation. The market is now shifting “back to basics” (OTC-dominated), governed by specialists instead of generalists and with smaller participation rates and limited liquidity, and that is usually a net deflationary force for prices.

Investor interest in palladium has been global

Investors have reduced their exposure to palladium

The market is now shifting OTC, governed by specialists instead of generalists with smaller participation rates and limited liquidity, which is usually a net deflationary force for prices

Investor positioning and AUM in PGMs



Source: Bloomberg, MKS PAMP Group, CFTC. Note: AUM is measured by multiplying total investor holdings (ETF + gross long COT) by price.

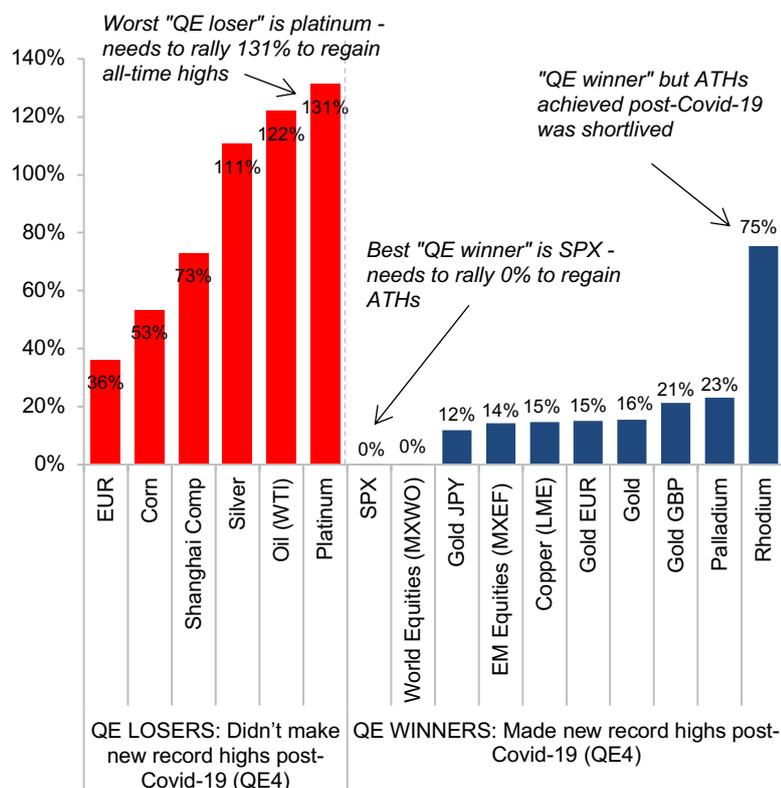
Macro liquidity: great for niche deficit markets

Given the larger exodus of retail investors (visible in exchange products' positioning), it should not be a surprise that a smaller market tends to hit 'speed bumps' during seasonal (roll periods, month or year-ends), event-driven or macro inflection points. The largest macro shock has been Covid-19 but also the subsequent warlike and extraordinary monetary and fiscal stimulus post-Covid globally, and its influence on reflation assets (largely growth-on commodities from oil and copper to lumber). It is interesting that both palladium and rhodium are the clear "QE winners" in 2021; both correspondingly hit all-time highs in May 2021, arguably the peak of the six-month+ long "inflation fear" trade, beginning with the twin copper and oil rallies from September 2020. Perhaps it is purely coincidental (deficit markets with tighter 2021 emissions into massive macro stimulus), but clearly niche deficit markets reflate just like typical reflation/QE-sensitive assets such as US equities. Palladium has enjoyed a stronger correlation with SPX (weekly correlation of +0.44) since the Federal Reserve initiated QE in 2008, than gold (+0.4) or the rand (-0.36), highlighting its attraction for risk-on investors. Therefore, any delay in the Fed's tapering (and thus extension of global liquidity) is likely to ensure recent "QE winners" extend gains, vs. the hopeful thinking that the market rotates into past "QE losers" (such as platinum, oil or the euro). Past records do matter, and the playbook won't change much during a potentially messy Fed transition period.

Palladium has been a "QE winner"

A delay to Fed tapering could see "QE winners" extend their gains

Post-Covid-19 QE winners (blue) vs. losers (red) and the % required to regain past record highs



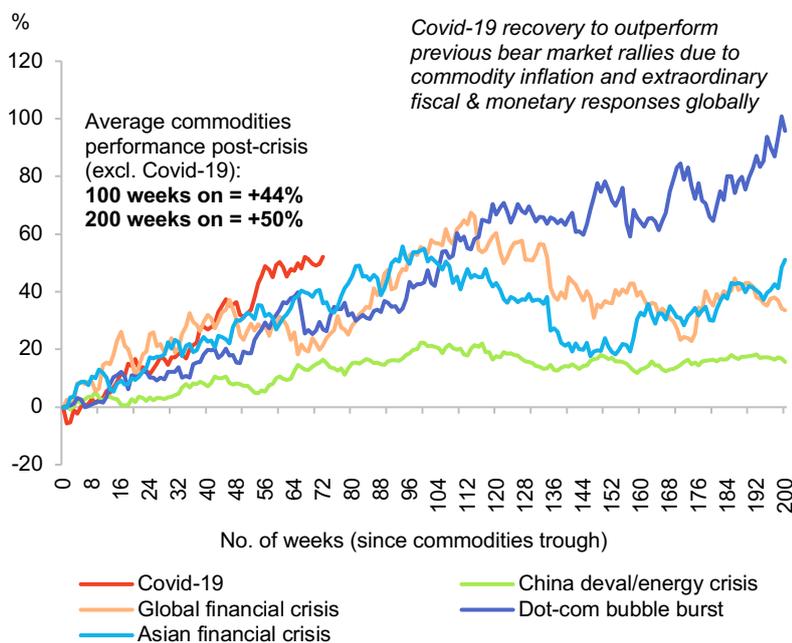
Source: Bloomberg, MKS PAMP Group. Note: ATH refers to all-time high [price].

Macro outlook: the (inflation) case for real metals exposure

While QE winners/losers are sensitive to short-term taper talk, longer-term inflation risks are rising and underappreciated given the Fed's stubborn stance hinging on it being "transitory". Real rates have aggressively shifted more negative, providing a cornerstone for any precious metals exposure. The Fed will likely wrongfoot the exit, and will need to do a lot more than taper at year-end, given 3x CPI prints of over 5%, to derail a bulled-up inflation trade. Wage growth, bottlenecks that are not alleviating, and commodity inflation with businesses passing on costs, all indicate stickier long-term inflation. Additional structural inflation tailwinds also stem from: 1) expansionary global fiscal policies, 2) potential social unrest especially in middle-income countries given vaccination disparities and a mishandling of Covid, 3) unsustainable US debt/fiscal path with swelling twin deficits, 4) the cost push from ESG, and 5) continued protectionist trade policies and increasing supply-chain risk. There is a growing risk that markets could shift more quickly from financial/equity inflation into real asset inflation as a hedge. That ensures higher PGM floors and increasingly outsized tactical rallies, given the disconnect between strong investor inflows (due to continued availability of macro liquidity and lower rates) and market size/liquidity.

There is a growing risk that markets could shift more quickly from financial/equity inflation into real asset inflation as a hedge. That ensures higher PGM floors and increasingly outsized tactical rallies

Commodity bear market rallies, post-crisis and 200 weeks on



Source: MKS PAMP Group, Bloomberg. Note: Performance of commodities is the BCOM Index rally from its price trough in April 2020 (Covid-19 crisis), January 2016 (energy/China currency devaluation crisis), February 2009 (global financial crisis), December 2000 (dot-com bubble burst) and February 1999 (Asian financial crisis). Commodity bear markets are defined as a -20% drop within a rolling 3-month period.

Where to next? Well, the energy transition – trajectories are never linear and consensus is usually dangerous

While the macro backdrop promotes exposure to real (precious) assets, the growing consensus now is around “peak palladium” (being behind us), as per this article’s title. That hinges on the threat of EVs and few new industrial demand applications, and is exacerbated by an expected surge in secondary supplies (much greater volumes of palladium vs. platinum as it has been the dominant metal in light-duty vehicle emissions control for the last two decades). Palladium auto demand is expected to peak in the mid-2020s, despite palladium being successfully marketed as the ‘go-to’ input in hybrids (which contain PGMs but are palladium-rich), before the EV market share really takes off beyond 2025. By contrast, platinum is more “auto-cat proof” (only 30% of demand is for autos), and is supported by the promise of the hydrogen economy. Key market players are also showing their hand: a major global producer is ramping up its portfolio of battery materials given investors’ focus on green production, awareness around ESG and simply as a hedge against the powertrain market/PGMs (*in which they see palladium prices falling to \$1,000/oz after 2025*). This overtly popular need to shun “old energy” such as fossil fuels and embrace “new energy”, especially if executed at any cost and/or subsidised substantially by governments, will create major dislocations in commodities for decades.

The overtly popular need to shun 'old energy' and embrace 'new energy', especially if executed at any cost and/or subsidised substantially by governments, will create major dislocations in commodities for decades

Already the energy market, which is a leader of commodities, exploded higher in H1'21 (driven primarily by oil rallying >50%, gasoline ~60% and natural gas 35%) in the face of Joe Biden’s clean energy revolution. It was driven by a ‘V’-shaped recovery in demand but was less cited, and also constrained supply (CAPEX is expected to hit a six-year low in 2021 as investment in new production is being “crimped by environmental concerns”!). Most auto companies and Biden’s expectations are that 50% of all vehicles by 2025 will be BEVs but this is an optimistic objective, especially considering constraints around supply. EVs are not necessarily that “clean” (electricity usage), while both higher prices and concerns over supply (from politically higher-risk regions) around nickel, cobalt, lithium, copper and manganese are the largest threats to EV battery costs. The growing consensus around a gasoline “carpocalypse” after 2025 is too early (*markets usually are*) and too optimistic. Financial markets tend to trade to pain levels first, and as the world transitions to a cleaner energy future, that ironically is a world of \$100+ oil, and much higher palladium prices (*a ‘Λ’ -shaped repricing into the 2025 EV inflection year?*). Palladium spent two decades conquering any dangerous consensual view and its sister metal rhodium catapulted by 30x in just five years (2016-2021). Therefore, while, fundamentally, peak palladium may soon be behind us, betting on cratering palladium prices in the face of rising inflation while hybridisation remains a cornerstone of the energy transition, is ill-fated.

Don't bet against palladium while hybrids proliferate and inflation is rising

THE PGM MARKETS IN 2021



The PGM markets in 2021

Dr. Ralph Grimble, SFA (Oxford)

The palladium market

Summary

Palladium has been hit by supply and demand shocks for the second consecutive year. In February, two of Nornickel's mines suffered from flooding and there was an accident at a concentrator which is currently estimated to cut 365koz from supply. Alongside that, automotive demand has been repeatedly revised down as the post-pandemic recovery in light-vehicle production has been hampered by a shortage of semiconductor chips that now looks set to drag on into 2022. In August, the lost light-vehicle production caused by the lack of chips was put at 3.7 million units (-517koz), but it is going to be worse than that by the end of the year.

Supply and demand shocks hit palladium again in 2021

Global demand is predicted to be 10.0moz this year, a 9.4% improvement on 2020, assuming 3.7 million units fewer light vehicles are produced than planned. That number is likely to rise, and demand will therefore be lower, but even that worse outcome still leaves the palladium market in deficit this year.

A shortage of chips has constrained automotive production and palladium demand

Palladium is on track to average its highest price ever this year. The price hit a new record in May, briefly trading at over \$3,000/oz as the price rallied following Nornickel's announcement of the mine flooding incident. However, with the on-going chip shortage shaving off ever more demand in 2021, the price has retreated from its record high.

Palladium market remains in deficit this year

Primary supply

Refined palladium production is forecast to increase by 6% to 6.77 moz in 2021. This is despite Nornickel's difficulties as most other regions' output returns to more normal levels after Covid-induced stoppages last year. Nornickel's production was planned to be 2.7-2.8moz this year, but the flooding at Oktyabrsky and Taimyrsky mines and the concentrator accident have resulted in a loss of 365koz of palladium output, and Russian supply is now expected to be 2.35 moz.

Global palladium output rises 6% despite Russian supply falling 16%

South African refined output suffered the largest drop last year owing to Covid restrictions and processing plant outages, which resulted in a build-up of smelter matte. This year, refined production is predicted to jump by 45% to 2.67 moz, which includes some of the stockpiled material being processed.

The Palladium Standard

Zimbabwean supply is projected to edge up 2% to 415 koz this year as Zimplats' Mupani and Bimha mines continue to ramp up. Last year, the PGM mines were permitted to continue operations during the nationwide lockdown, hence the relatively modest increase. After some Covid-related production losses last year, North American output is forecast to grow by 5% to 1.00 moz in 2021.

Recycling

Palladium recycling is predicted to rebound by 15% to 2.76 moz in 2021. The autocatalyst recycling industry has had to deal with several challenges over the last year, including difficulties related to Covid lockdowns, high costs and delays for international shipping, greater working capital requirements, refinery capacity constraints and the amount of silicon carbide diesel particulate filters in the mix. However, the number of vehicles reaching the end of their lives is rising and as these are predominantly gasoline-powered, secondary palladium supply is also increasing.

Demand

Total palladium demand is forecast to grow by 9% to 10.03 moz this year. Automotive demand is recovering from last year's pandemic low but, with the lack of semiconductors hampering auto production, the rebound could be less than currently anticipated. Industrial demand is predicted to be flat year-on-year as growth in chemical and other end-uses is matched by declines in dental and electrical usage.

Total palladium demand is above 10 moz

Automotive demand

Global automotive demand is projected to grow by 11% to 8.23 moz this year. The disruption to semiconductor supplies for the automotive industry is estimated to have reduced global light-vehicle production by 3.7 million units which equates to a loss of 517 koz of palladium demand. That still leaves light-vehicle production up 11% from the pandemic low of 2020. However, the chip shortage is on-going and automakers seem to have reached the limits of what they can do to mitigate the impact on their output. Dealers' vehicle inventories have fallen to low levels in the US and China. The loss of light-vehicle production and palladium demand could prove to be significantly worse by the end of the year.

Chip shortage reduces demand by over 500 koz

Industrial demand

Palladium requirements in industrial end-uses are expected to drop marginally to 1.62 moz this year. Declines in electrical and dental usage are being mostly offset by gains in chemical and other end-uses. Electrical demand continues to fall with on-going thrifting in microelectronics and substitution by gold in plating. Dental demand remains in decline owing to the high palladium price and use of cosmetically more appealing materials. Chemical demand is expanding owing to the use of palladium to substitute for rhodium in nitric acid catalysts and the expansion of caprolactam capacity in China.

Industrial usage drops slightly

Investment

Palladium ETF holdings rose by 47 koz to 549 koz in the first eight months of 2021 and could be on track to increase for the first time in seven years. The driver of this growth has been US investors who have added 52 koz to their ETF holdings. The UK, Swiss and other regions' ETF holdings were little changed and South African ETFs have shed 6 koz.

The speculative futures' position on NYMEX became net short at the end of August for the first time in more than 10 years. The non-commercial traders' short position (0.33 moz) is currently marginally larger than the long position (0.32 moz). The long position collapsed along with the price in February and March last year and has not recovered since then.

The platinum market

The platinum market is forecast have a surplus this year (excluding investment) of close to 1.0 moz. Investment demand in 2020 absorbed the surplus, but so far this year investment demand has been weak. ETF holdings have fluctuated this year, coming close to 4.0 moz in July before falling back. At the end of August, global holdings were down 37 koz from the start of the year as a result of net sales from South African and Japanese ETFs outweighing gains in other regions. Investors in Japan were also net sellers of platinum bars in the first half of the year, taking profits when the price exceeded ¥4,000/g.

Another large surplus but weak investment demand

Automotive platinum demand is predicted to rise by 26% to 2.93 moz this year. This reflects not only the recovery from the pandemic-induced slump in demand last year but also gains from substitution and tighter emissions legislation. This year, the impact of substitution of platinum for some palladium in three-way catalysts is modest, but it does help the overall improvement in demand.

Despite diesel passenger car sales in Western Europe continuing to slide, the introduction of tighter emissions legislation in China and India has helped to lift platinum demand from heavy-duty diesel vehicles. China VI legislation came into force in July and requires heavy-duty diesel vehicles to be fitted with PGM-containing catalysts for the first time. Chinese automotive platinum demand is projected to climb by over 50% to 720 koz this year. In addition, 2021 is the first full-year of Bharat VI legislation in India following its introduction in April 2020.

Tighter emissions legislation in China and India is lifting HDV platinum demand

Global platinum jewellery demand is forecast to recover some, but not all, of the losses suffered last year, rising by 14% to 1.78 moz. North American demand has recovered strongly, aided by platinum's price discount to gold. China has also performed better than expected so far this year, but with usage estimated at 875 koz, the largest market for platinum jewellery remains far below its peak. The rise in Covid cases in other regions and lockdowns in India, in particular, have restricted the recovery.

Industrial platinum demand is expected to see strong growth of 16% to 2.21 moz this year, not only recovering from the Covid-related drop of 2020 but also comfortably exceeding 2019 demand levels. While all industrial demand segments are likely to have higher demand this year, gains from the petroleum industry are particularly strong, accounting for just over half the increase. This is driven by new oil refining and gas-to-liquids capacity, some of which has been delayed from last year. Chemical demand is also recovering well with growth in silicone production and new paraxylene capacity in China. Platinum used in hydrogen applications is still a relatively modest part of industrial demand but is growing rapidly from a low base.

Industrial demand jumps 16%

Primary supply is projected to increase by 24% to 6.13 moz this year. South African refined production is estimated to jump by 39% to 4.52 moz, recovering to pre-pandemic levels. With the Anglo Converter Plant (ACP) now back in full operation, some of the stockpiled smelter matte is being processed which is boosting the rebound in refined output. North American supply is recovering after some pandemic-related stoppages last year and Zimbabwean output is set to expand modestly. However, Nornickel's problems have resulted in Russian production falling by 17% this year.

South African output is back to pre-Covid levels

Secondary platinum supply is predicted to grow by 7% to 1.85 moz this year. Jewellery recycling is expected to recover somewhat to 440 koz. Autocatalyst recycling is projected to rebound this year to 1.40 moz despite refineries operating close to capacity and the difficulty of processing silicon carbide diesel particulate filters.

The rhodium market

The rhodium price began the year by continuing its strong rally from the 2020 Covid low, hitting a record price of \$29,800/oz in March, as the market was exceptionally tight. However, the price is now trading close to where it started the year. The semiconductor chip shortage is taking much longer to overcome than initially anticipated and this has resulted in significant downward revisions to light-vehicle production and rhodium demand. This, combined with a recovery in refined rhodium output from South Africa, along with some stockpiled material being processed, has resulted in the market balance being revised to show a surplus of 30 koz for the year.

Lack of refined output saw the price near \$30,000/oz in March

Automotive demand for rhodium is forecast to increase by 14% in 2021, taking it up to 1.00 moz for the first time as light-vehicle production recovers from the pandemic lows and emissions legislation tightens. The impact of the chip shortage on light-vehicle production is estimated to have cut global production by 3.7 million units, reducing automotive demand by 75 koz. However, it appears that the automotive industry's problems in sourcing enough chips are not likely to be overcome this year and that could further reduce rhodium demand.

Disruption to auto production could result in a surplus market this year

Primary rhodium supply is expected to jump by 24% to 780 koz this year. After being impacted by lockdowns and processing problems last year, South African refined rhodium production is set to return to 2019 levels this year at 640 koz. Anglo Platinum's ACP ramped up during Q1'21 and has been processing some of the smelter matte that was stockpiled last year, boosting refined output. The incidents suffered by Nor Nickel are estimated to reduce Russian rhodium supply by 15 koz to 65 koz this year, while production in other regions holds steady.

Industrial requirements for rhodium are predicted to fall by 15 koz to 115 koz in 2021 as the exceptionally high price continues to drive substitution in the glass and chemical industries.

The price outlook for the next six months

Palladium: \$1,950/oz

After having hit a record level earlier this year following the news of Nor Nickel's mine flooding incident, the palladium price has retreated as market conditions have eased. The semiconductor chip shortage, which was initially claimed to be a relatively minor problem that would be resolved by the second half of 2021, has become increasingly serious. A conservative estimate is that the shortage of chips means automotive production will be 3.7 million units lower than expected this year. This has reduced palladium demand by over 500 koz.

The automotive industry has on-going problems with sourcing semiconductors and this looks set to continue well into 2022. Even as overall light-vehicle production increases, output is limited by chip availability and this could prevent the production of several million more vehicles over the next six months, restricting the upside for palladium demand. This is occurring at a time when Nor Nickel's refined palladium output is recovering and could even result in the market being in surplus next year. The price is therefore forecast to average \$1,950/oz over the next six months.

Platinum: \$990/oz

Once again the platinum market is forecast to be in significant surplus (ex. investment). Both supply and demand have recovered from last year's pandemic-induced declines and the market surplus is expected to be close to 1.0 moz.

Tighter emissions legislation for heavy-duty vehicles in China and India has helped automotive demand to rebound strongly this year. Industrial uses have also shown robust growth, but jewellery's recovery has lagged those. Meanwhile, global primary production has recovered to near pre-pandemic levels and secondary supply has also rebounded.

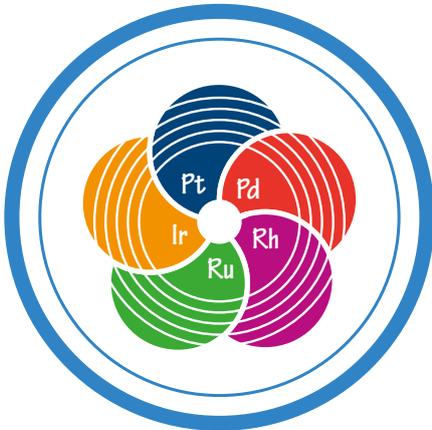
Investment demand has been weak this year and the platinum price has retreated from its high near \$1,300/oz. Platinum is now in its seasonally weak period but that changes later in the year. The platinum price could be lifted along with gold if higher inflation proves to be less temporary than central banks are claiming, so an average price of \$990/oz is predicted for the next six months.

Rhodium: \$13,000/oz

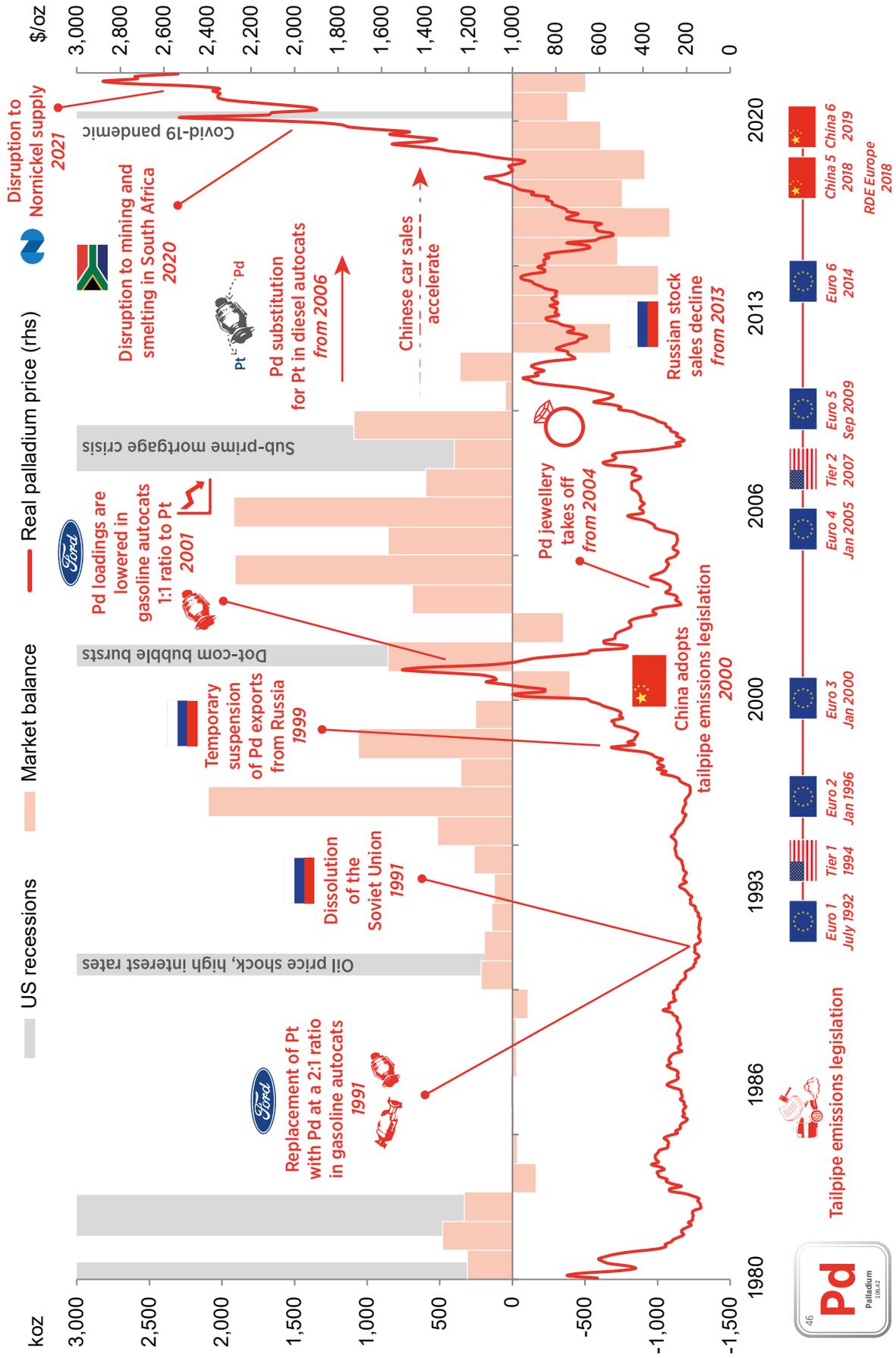
The rhodium market has recovered from the extreme tightness that saw the price hit a record level in March. South African supply has revived to pre-Covid levels and Anglo Platinum is also processing stockpiled material. Russia produces little rhodium so Nor Nickel's problems have had only a minor impact on rhodium supply.

Meanwhile, the automotive industry's chip problem is preventing light-vehicle production from recovering as fully as expected this year. This has restrained growth in automotive demand with the result that the market is now estimated to have a small surplus this year. The chip shortage looks likely to continue into 2022 and that will cut demand further, possibly keeping the market in surplus next year. This would reduce support for the price, so over the next six months rhodium is forecast to average \$13,000/oz.

PGM PRICE HISTORY

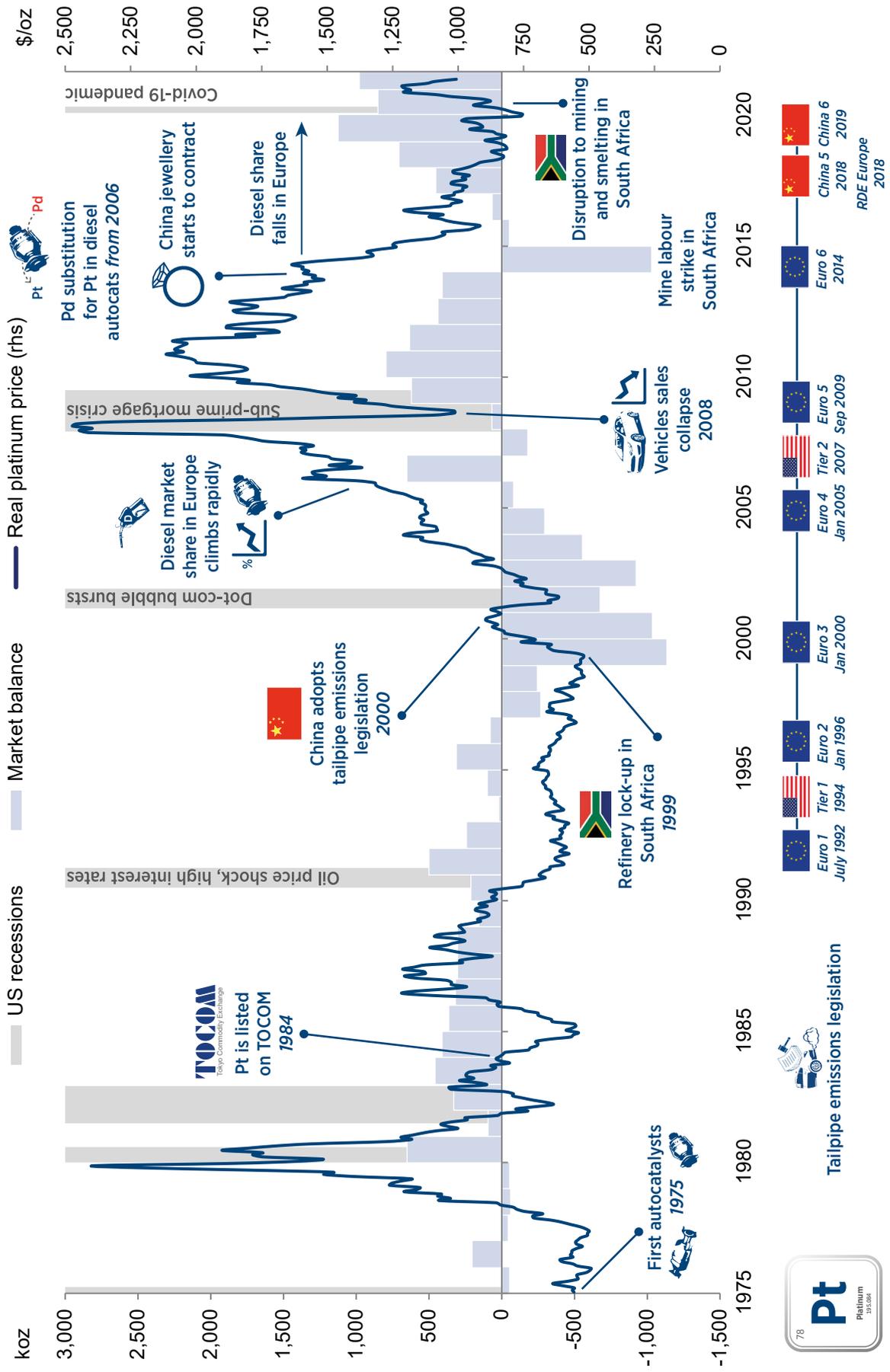


Palladium



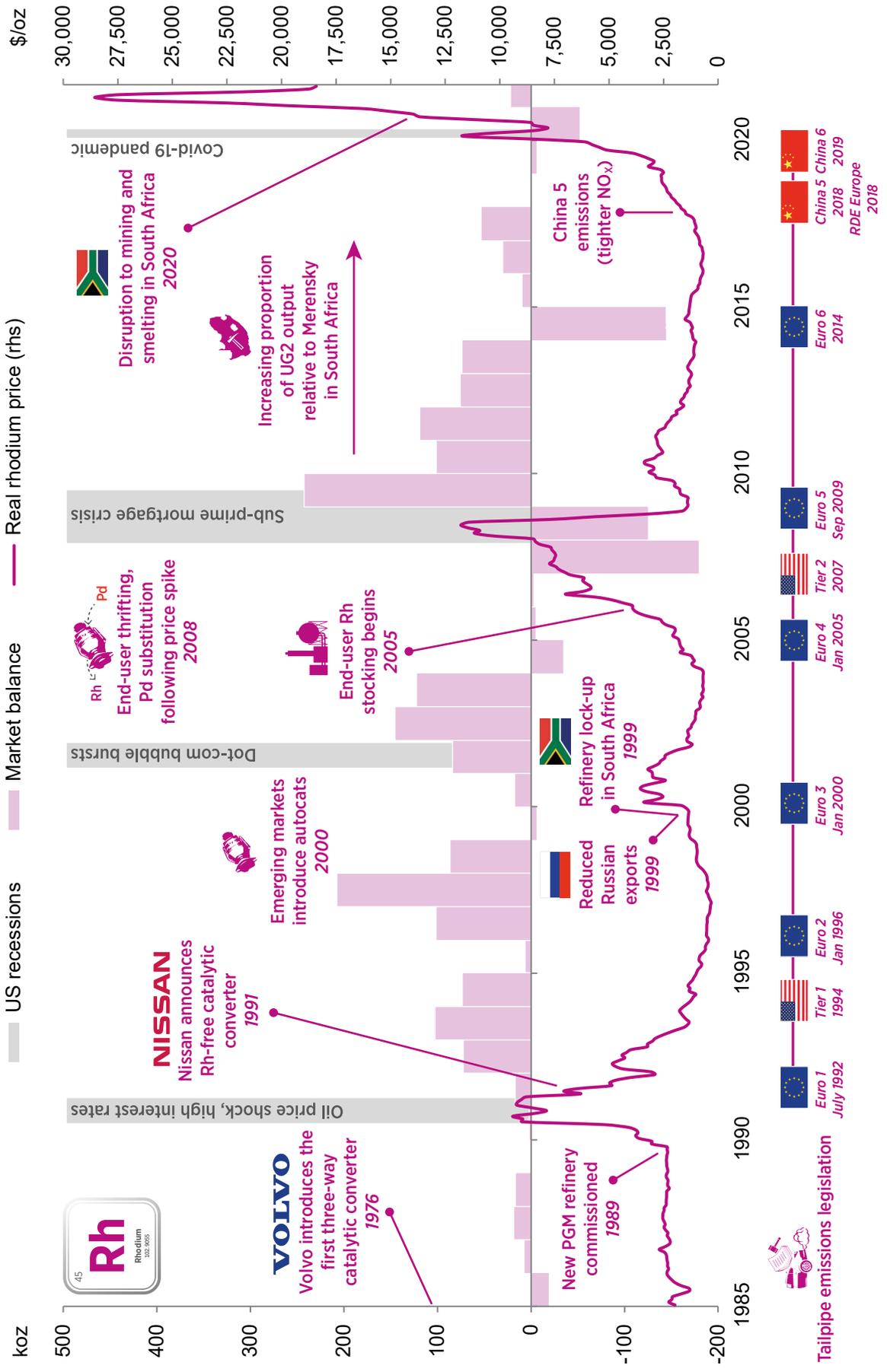
Source: SFA (Oxford), Bloomberg

Platinum



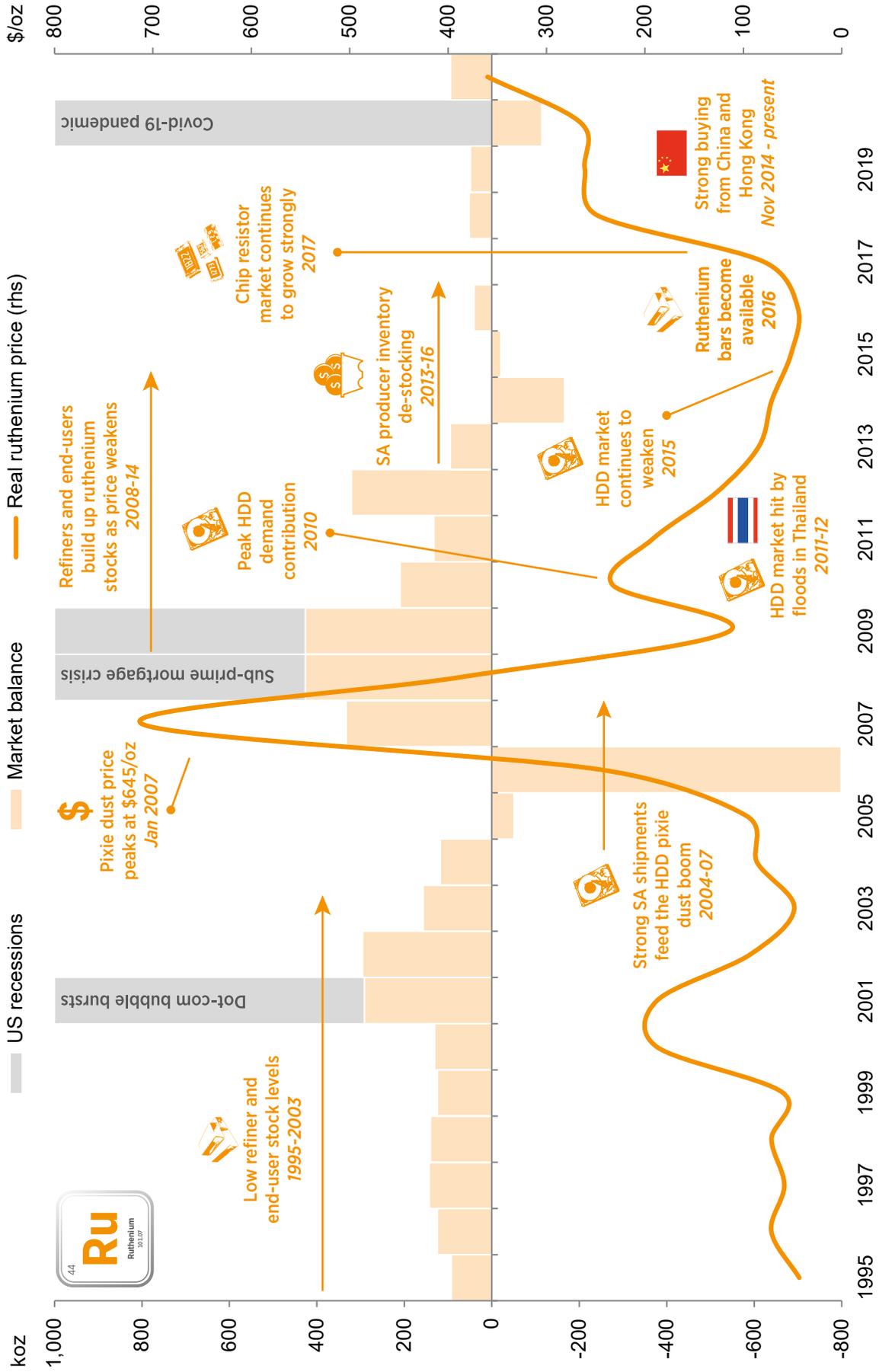
Source: SFA (Oxford), Bloomberg

Rhodium



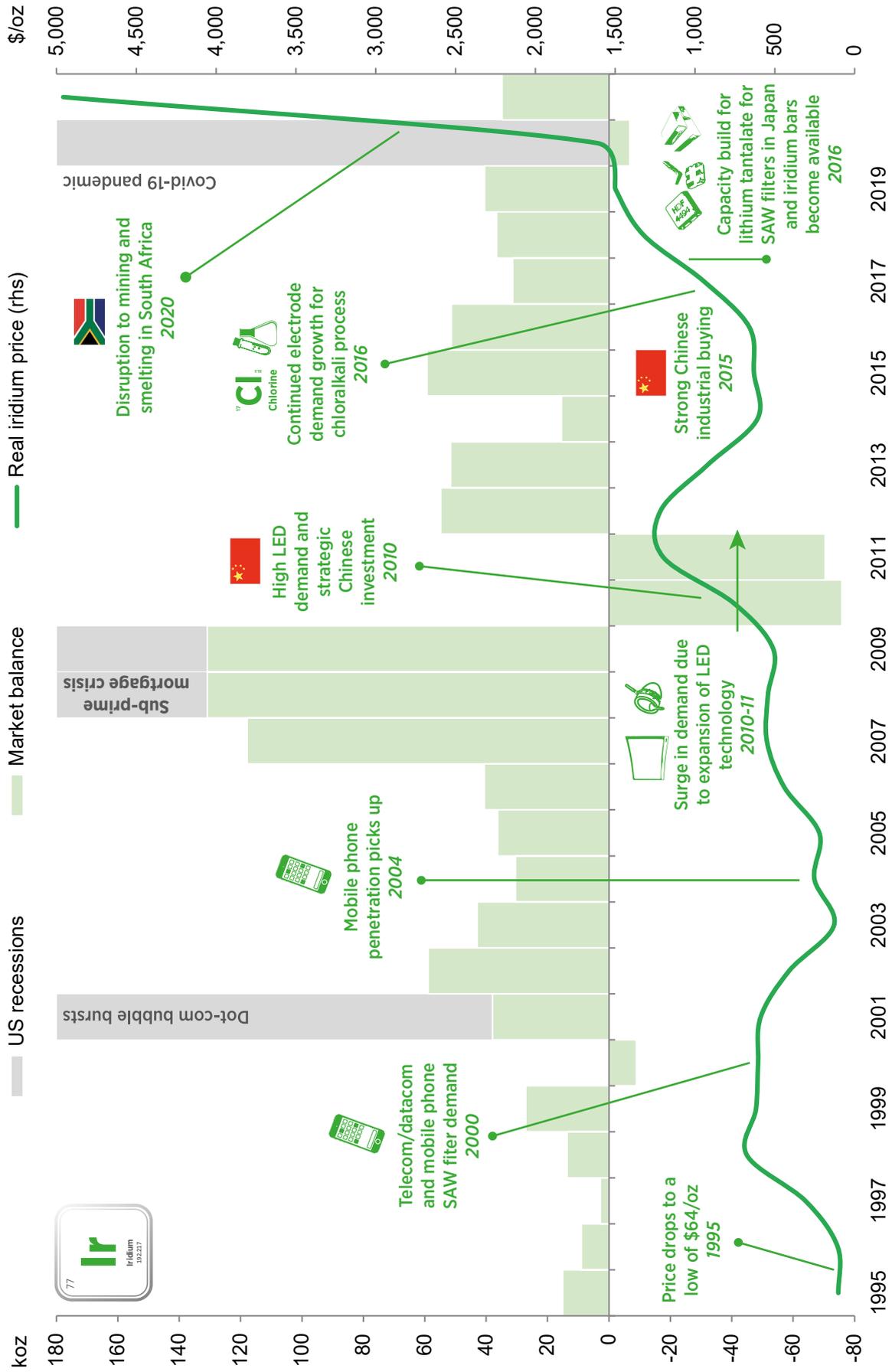
Source: SFA (Oxford), Bloomberg

Ruthenium



Source: SFA (Oxford), Bloomberg

Iridium



Source: SFA (Oxford), Bloomberg

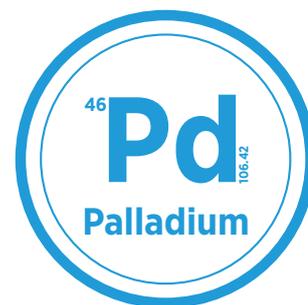
APPENDIX



Palladium supply-demand balance

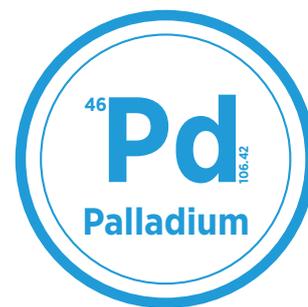
koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Primary supply									
Regional									
South Africa	2,360	1,870	2,560	2,375	2,530	2,500	2,555	1,845	2,670
Russia	2,580	2,690	2,605	2,555	2,740	2,670	2,870	2,810	2,350
Zimbabwe	315	330	325	395	395	380	385	405	415
North America	975	1,055	995	1,065	985	1,035	975	950	1,000
Other	450	460	455	420	415	395	395	385	335
Total	6,680	6,405	6,940	6,810	7,065	6,980	7,180	6,395	6,770
Demand & recycling									
Autocatalyst									
Gross demand	7,110	7,475	7,585	7,925	8,145	8,290	8,445	7,400	8,230
Recycling	1,645	1,720	1,610	1,710	1,920	2,040	2,180	2,005	2,310
Net demand	5,465	5,755	5,975	6,215	6,225	6,250	6,265	5,395	5,920
Jewellery									
Gross demand	350	295	240	240	225	220	215	155	180
Recycling	145	120	80	80	70	60	55	50	55
Net demand	205	175	160	160	155	160	160	105	125
Industrial demand	1,990	1,935	1,945	1,905	1,860	1,845	1,730	1,625	1,620
Other recycling	410	430	435	385	380	375	375	345	400
Gross demand	9,450	9,705	9,770	10,070	10,230	10,355	10,390	9,180	10,030
Recycling	2,200	2,270	2,125	2,175	2,370	2,475	2,610	2,400	2,765
Net demand	7,250	7,435	7,645	7,895	7,860	7,880	7,780	6,780	7,265
Market balance									
Balance (before ETFs)	-570	-1,030	-705	-1,085	-795	-900	-600	-385	-495
ETFs (stock allocation)	-5	930	-665	-640	-375	-560	-90	-115	
Balance after ETFs	-565	-1,960	-40	-445	-420	-340	-510	-270	

Source: SFA (Oxford)



Palladium demand and recycling summary

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Autocatalyst									
North America	1,820	1,930	1,855	1,935	1,850	1,860	1,815	1,460	1,650
Western Europe	1,545	1,665	1,785	1,685	1,700	1,710	1,670	1,245	1,355
Japan	750	740	745	775	805	840	875	765	825
China	1,525	1,705	1,725	1,985	2,055	2,035	2,255	2,420	2,625
India	170	170	185	225	245	265	240	205	290
RoW	1,300	1,265	1,290	1,320	1,490	1,580	1,590	1,305	1,485
Total	7,110	7,475	7,585	7,925	8,145	8,290	8,445	7,400	8,230
Jewellery									
North America	40	35	35	35	35	35	35	30	35
Western Europe	75	60	55	55	55	55	55	25	30
Japan	65	55	50	50	50	50	50	40	45
China	145	120	75	75	60	55	50	40	45
RoW	25	25	25	25	25	25	25	20	25
Total	350	295	240	240	225	220	215	155	180
Industrial									
North America	410	385	380	370	340	300	295	240	240
Western Europe	290	290	315	325	310	290	285	255	260
Japan	415	425	420	395	360	335	300	250	240
China	420	395	395	385	440	500	435	515	510
RoW	455	440	435	430	410	420	415	365	370
Total	1,990	1,935	1,945	1,905	1,860	1,845	1,730	1,625	1,620
Total gross demand									
North America	2,270	2,350	2,270	2,340	2,225	2,195	2,145	1,730	1,925
Western Europe	1,910	2,015	2,155	2,065	2,065	2,055	2,010	1,525	1,645
Japan	1,230	1,220	1,215	1,220	1,215	1,225	1,225	1,055	1,110
China	2,090	2,220	2,195	2,445	2,555	2,590	2,740	2,975	3,180
RoW	1,950	1,900	1,935	2,000	2,170	2,290	2,270	1,895	2,170
Total	9,450	9,705	9,770	10,070	10,230	10,355	10,390	9,180	10,030
Recycling									
Autocatalyst									
North America	1,005	975	895	960	1,060	1,135	1,190	1,130	1,245
Western Europe	345	365	270	260	305	330	335	300	370
Japan	125	135	125	125	145	180	200	185	200
China	50	60	115	160	165	155	165	150	180
RoW	120	185	205	205	245	240	290	240	315
Total	1,645	1,720	1,610	1,710	1,920	2,040	2,180	2,005	2,310
Jewellery									
Japan	20	20	20	20	20	15	15	15	15
China	125	100	60	60	50	45	40	35	40
Total	145	120	80	80	70	60	55	50	55
WEEE									
North America	75	70	85	70	65	65	65	55	60
Western Europe	90	95	80	70	75	70	70	60	70
Japan	135	145	165	135	120	115	110	100	110
China	40	30	25	35	40	40	45	50	65
RoW	70	90	80	75	80	85	85	80	95
Total	410	430	435	385	380	375	375	345	400
Total recycling									
North America	1,080	1,045	980	1,030	1,125	1,200	1,255	1,185	1,305
Western Europe	435	460	350	330	380	400	405	360	440
Japan	280	300	310	280	285	310	325	300	325
China	215	190	200	255	255	240	250	235	285
RoW	190	275	285	280	325	325	375	320	410
Total	2,200	2,270	2,125	2,175	2,370	2,475	2,610	2,400	2,765



Platinum supply-demand balance

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Primary supply									
Regional									
South Africa	4,355	3,135	4,480	4,265	4,385	4,470	4,405	3,260	4,520
Russia	740	740	710	715	720	665	710	705	590
Zimbabwe	405	405	405	490	480	465	460	480	490
North America	355	395	365	390	360	345	350	330	365
Other	215	200	200	185	185	180	185	175	160
Total	6,070	4,875	6,160	6,045	6,130	6,125	6,110	4,950	6,125
Demand & recycling									
Autocatalyst									
Gross demand	3,135	3,240	3,250	3,360	3,300	3,105	2,835	2,320	2,930
Recycling	1,120	1,250	1,180	1,220	1,325	1,420	1,490	1,300	1,395
Net demand	2,015	1,990	2,070	2,140	1,975	1,685	1,345	1,020	1,535
Jewellery									
Gross demand	2,945	3,000	2,840	2,505	2,460	2,245	2,095	1,560	1,775
Recycling	855	775	510	625	560	500	500	415	440
Net demand	2,090	2,225	2,330	1,880	1,900	1,745	1,595	1,145	1,335
Industrial demand	1,565	1,665	1,805	1,905	1,760	1,940	2,025	1,900	2,210
Hydrogen	5	25	25	45	45	70	40	40	75
Other recycling	5	5	5	5	10	10	10	10	10
Gross demand	7,650	7,930	7,920	7,815	7,565	7,360	6,995	5,820	6,990
Recycling	1,980	2,030	1,695	1,850	1,895	1,930	2,000	1,725	1,845
Net demand	5,670	5,900	6,225	5,965	5,670	5,430	4,995	4,095	5,145
Market balance									
Balance (before ETFs)	400	-1,025	-65	80	460	695	1,115	855	980
ETFs (stock allocation)	905	210	-240	-10	100	-240	995	505	
Balance after ETFs	-505	-1,235	175	90	360	935	120	350	

Source: SFA (Oxford)



Platinum demand and recycling summary

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Autocatalyst									
North America	425	465	480	410	390	390	380	285	410
Western Europe	1,350	1,395	1,450	1,640	1,550	1,330	1,140	790	840
Japan	585	585	510	450	435	430	400	310	320
China	130	125	145	195	230	220	245	425	725
India	165	170	180	170	175	195	155	110	160
RoW	480	500	485	495	520	540	515	400	475
Total	3,135	3,240	3,250	3,360	3,300	3,105	2,835	2,320	2,930

Platinum demand and recycling summary (continued)

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Jewellery									
North America	200	230	250	265	280	280	275	210	255
Western Europe	220	220	235	240	250	255	260	175	190
Japan	335	335	340	335	340	345	330	245	260
China	1,990	1,975	1,765	1,450	1,340	1,095	945	755	875
India	140	175	180	145	175	195	210	120	135
RoW	60	65	70	70	75	75	75	55	60
Total	2,945	3,000	2,840	2,505	2,460	2,245	2,095	1,560	1,775
Industrial									
North America	335	330	260	400	345	350	300	235	325
Western Europe	200	245	310	285	280	315	300	280	270
Japan	95	30	90	80	40	100	105	85	100
China	535	500	585	650	590	510	620	725	825
RoW	400	560	560	490	505	665	700	575	690
Total	1,565	1,665	1,805	1,905	1,760	1,940	2,025	1,900	2,210
Hydrogen									
North America	5	10	5	10	10	15	10	10	15
Western Europe	0	0	0	5	0	0	0	0	5
Japan	0	5	15	25	30	35	15	20	40
China	0	0	0	0	0	0	0	0	0
RoW	0	10	5	5	5	20	15	10	15
Total	5	25	25	45	45	70	40	40	75
Total gross demand									
North America	965	1,035	995	1,085	1,025	1,035	965	740	1,005
Western Europe	1,770	1,860	1,995	2,170	2,080	1,900	1,700	1,245	1,305
Japan	1,015	955	955	890	845	910	850	660	720
China	2,655	2,600	2,495	2,295	2,160	1,825	1,810	1,905	2,425
RoW	1,245	1,480	1,480	1,375	1,455	1,690	1,670	1,270	1,535
Total	7,650	7,930	7,920	7,815	7,565	7,360	6,995	5,820	6,990
Recycling									
Autocatalyst									
North America	560	560	505	535	585	640	645	575	565
Western Europe	365	465	370	400	440	465	505	425	495
Japan	95	105	95	95	100	110	110	100	115
China	20	30	55	40	40	35	40	30	35
RoW	80	90	155	150	160	170	190	170	185
Total	1,120	1,250	1,180	1,220	1,325	1,420	1,490	1,300	1,395
Jewellery									
North America	0	0	5	5	5	5	5	5	5
Western Europe	0	5	5	5	5	5	5	5	5
Japan	250	235	160	150	160	145	140	110	115
China	600	530	335	460	385	340	340	285	305
RoW	5	5	5	5	5	5	10	10	10
Total	855	775	510	625	560	500	500	415	440
WEEE	5	5	5	5	10	10	10	10	10
Total recycling									
North America	560	560	510	540	590	645	650	580	570
Western Europe	365	470	375	405	445	470	510	430	500
Japan	345	340	255	245	260	255	250	210	230
China	620	560	390	500	430	380	385	320	345
RoW	90	100	165	160	170	180	205	185	200
Total	1,980	2,030	1,695	1,850	1,895	1,930	2,000	1,725	1,845



Rhodium supply-demand balance

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Primary supply									
Regional									
South Africa	590	425	620	615	620	625	640	475	640
Russia	70	75	70	70	75	75	80	80	65
Zimbabwe	35	35	35	45	45	40	40	45	45
North America	35	30	30	25	25	20	20	20	20
Other	10	10	10	10	10	10	10	10	10
Total	740	575	765	765	775	770	790	630	780
Demand & recycling									
Autocatalyst									
Gross demand	785	845	860	835	865	900	985	880	1,000
Recycling	260	275	260	280	295	335	355	330	360
Net demand	525	570	600	555	570	565	630	550	640
Industrial demand	150	165	150	180	165	210	165	130	115
Other recycling	1	2	3						
Gross demand	935	1,010	1,010	1,015	1,030	1,110	1,150	1,010	1,115
Recycling	260	275	260	280	295	335	355	330	365
Net demand	675	735	750	735	735	775	795	680	750
Market balance									
Balance (before ETFs)	65	-160	15	30	40	-5	-5	-50	30
ETFs (stock allocation)	50	5	-5	5	-20	-50	-15	-10	
Balance after ETFs	15	-165	20	25	60	45	10	-40	

Source: SFA (Oxford)



Rhodium demand and recycling summary

koz	2013	2014	2015	2016	2017	2018	2019	2020	2021f
Gross demand									
Autocatalyst									
North America	220	240	240	235	230	225	220	175	190
Western Europe	200	225	250	210	210	225	285	220	245
Japan	140	140	125	125	125	130	130	110	115
China	95	110	110	130	150	155	180	235	290
India	15	15	15	20	20	20	20	15	25
RoW	115	115	120	115	130	145	150	125	135
Total	785	845	860	835	865	900	985	880	1,000
Industrial									
North America	20	20	15	20	20	20	20	15	15
Western Europe	10	15	10	15	15	25	15	10	5
Japan	15	5	10	10	10	10	10	10	10
China	65	75	70	85	70	80	70	65	60
RoW	40	50	45	50	50	75	50	30	25
Total	150	165	150	180	165	210	165	130	115
Total gross demand									
North America	240	260	255	255	250	245	240	190	205
Western Europe	210	240	260	225	225	250	300	230	250
Japan	155	145	135	135	135	140	140	120	125
China	160	185	180	215	220	235	250	300	350
RoW	170	180	180	185	200	240	220	170	185
Total	935	1,010	1,010	1,015	1,030	1,110	1,150	1,010	1,115
Recycling									
Autocatalyst									
North America	165	160	150	160	165	180	190	180	195
Western Europe	55	60	45	50	55	60	65	60	65
Japan	25	30	30	35	35	45	45	40	45
China	5	5	10	5	5	5	5	5	10
RoW	10	20	25	30	35	45	50	45	45
Total	260	275	260	280	295	335	355	330	365

Source: SFA (Oxford)



GLOSSARY OF TERMS

APAC

Asia-Pacific.

AUM

Assets under management.

Basket price

Collective revenue of metals divided by 4E oz.

BEV

Battery electric vehicle.

CAPEX

Capital expenditure.

CME

Chicago Mercantile Exchange.

CoT

Commitment of Traders.

Covid-19

An infectious disease caused by a newly discovered coronavirus.

DRC

Democratic Republic of Congo.

ESG

Environmental, social and governance.

ETF

Exchange-traded fund.

Fed

U.S. Federal Reserve.

FCEV

Fuel cell electric vehicle.

GDP

Gross domestic product.

Gross demand

A measure of intensity of use.

HDD

Hard disk drive.

ICE

Internal combustion engine.

J-M Reef

Johns-Manville Reef.

koz

A thousand troy ounces.

LED

Light-emitting diode.

LEV III

The third Low Emission Vehicle Standard.

LME

London Metal Exchange.

M&A

Mergers and acquisitions.

Merensky Reef

A PGM-bearing horizon within the Bushveld Igneous Complex, South Africa. Also contains nickel and copper sulphides that are mined as by-products.

moz

A million troy 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.

NO_x

Nitrous oxides.

NPI

Nickel pig iron.

NYMEX

New York Mercantile Exchange

OEM

Original equipment manufacturer.

OTC

Over-the-counter.

oz

Troy ounce.

PGM

Platinum-group metals.

Primary supply

Mine production.

QE

Quantitative easing.

R&D

Research and development.

RDE

Real driving emissions.

Secondary supply

Recycling output.

Thrifting

Using less metal in order to reduce costs.

TOCOM

Tokyo Commodity Exchange.

TWC

Three-way catalyst.

UG2 Reef

A PGM-bearing horizon within the Bushveld Igneous Complex, located stratigraphically below the Merensky Reef. One of the main chromite-bearing reefs of the Bushveld Igneous Complex. Typically comprises lower base metals contents than the Merensky Reef.

WEEE

Waste electrical and electronic equipment.

4E

Platinum, palladium, rhodium and gold.

Currency symbols

XPTUSD Spot platinum \$US price.

\$ US dollar.

¥ Japanese yen.

ZAR South African rand.

METHODOLOGY

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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