

PLATINUM AND PALLADIUM SURVEY 2019

Platinum and Palladium Survey 2019



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GFMS PLATINUM GROUP METALS SURVEY 2019

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MAJOR 2019 RELEASES

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| • GFMS Gold Survey 2019 | 7th May 2019 |
| • World Silver Survey 2019 | 11th (New York) April 2019 |
| | 11th (Dubai) April 2019 |
| | 12th (Mexico City) April 2019 |
| • GFMS Gold Survey 2019: H1 Update and Outlook | 25th July 2019 |
| • GFMS Gold Survey 2019: H2 Update and Outlook | 29th January 2020 |

ACKNOWLEDGEMENTS

The estimates shown in GFMS, Refinitiv Platinum Group Metals Survey for the main components of mine production, scrap, fabrication, investment and stock movements are calculated on the basis of a detailed supply/demand analysis for each of the markets listed in the main tables. In the vast majority of cases, the information used in these analyses has been derived from visits to the countries concerned and discussions with local traders, producers, refiners, fabricators and central bankers. Although we also make use of public domain data where this is relevant, it is the information provided by our contacts that ultimately make GFMS, Refinitiv Surveys unique. We are grateful to all of them.

NOTES

UNITS USED:

troy ounce (oz) =	31.1035 grammes
tonne =	1 metric tonne, 32,151 troy ounces

- Unless otherwise stated, all statistics on supply and demand are expressed in terms of fine metal content.
- All references in this publication to “ounces” refer to troy ounces.
- Unless otherwise stated, US dollar prices and their equivalents are for the p.m. fixes of the London Platinum and Palladium Fixing Company Limited for prices prior to 1st December 2014 and the p.m. LBMA Platinum Price and LBMA Palladium Price from 1st December onwards and the Johnson Matthey London a.m. Rhodium Price.
- Throughout the tables, totals may not add due to independent rounding.

TERMINOLOGY:

”_”	Not available or not applicable.
”0.0”	Zero or less than 0.05.
”dollar”, “\$”	U.S. dollar unless otherwise stated.
”3PGM”	Platinum, palladium & rhodium
”4E”	Four elements: platinum, palladium, rhodium and gold (3PGM+Au).
”6E”	Six elements: 4E plus iridium and ruthenium (5PGM+Au).

Estimates of **supply** include mine production and the recycling both of scrapped autocatalysts and old jewellery, but exclude contributions from above-ground stocks, such as supplies from stocks controlled by state institutions in Russia. **Demand** estimates are net of recycling with the exception of autocatalyst and jewellery, where gross demand is shown - i.e. the total amount of metal absorbed to these two sectors. Estimates of recycling from scrapped autocatalysts and jewellery are shown separately as part of supply given their scale and potential for change. Estimates of demand exclude the movements of any above-ground stocks held within the specified industries, for example any changes in stocks held by the automotive industry.

By simple arithmetic, this leaves either a **“Physical Surplus or Deficit”** (in previous publications “Gross Surplus or Deficit”) before any movements in above-ground stocks are considered. This is a critical measure of the underlying fundamentals of platinum and palladium and indicates the extent to which fabrication demand may have depended on the release of above-ground stocks, or otherwise. At the same time, this also indicates the change in global above-ground stocks.

Unless otherwise stated, all references to **“above-ground stocks”** of platinum and palladium refer to stocks of refined metal, of a form and quality accepted as good delivery in the London and Zurich market and the world’s principal commodity exchanges. Our supply/demand tables also show **“Estimated Movements in Stocks”**. These specific movements relate only to above-ground stock holdings for which reasonable estimates of movement can be made and attributed. A listing and breakdown of these appears in the more detailed tables in the Appendices section of this Survey.

Having allowed for the Estimated Movements in Stocks as defined above, the **“Net Balance”** (previously “Residual Surplus or Deficit”) is arrived at by deduction. A negative Net Balance implies the extent to which other **above-ground stocks**, including those held by financial institutions and/or investors, were released to meet fabrication demand. Conversely, positive Net Balance implies the extent to which these other **above-ground stock** holdings were augmented. However, this should not be construed as indicating the change in global above-ground stocks. For this, please refer to the reported Physical Surplus or Deficit.

1. SUMMARY AND OUTLOOK

After a relatively unspectacular performance in 2017, last year proved to be quite turbulent and distressing for platinum. With an increase in supply, primarily on the back of growth in autocatalyst scrap, and weaker demand, mainly in autocatalyst applications and the jewellery sector, the platinum market remained in a physical surplus for the second consecutive year. Meanwhile, a remarkable rally in global equity markets, along with the risk-on mode among investors, the latter being supported by growing optimism towards the U.S. economy and continuing commitment from the U.S. Federal Reserve towards monetary policy tightening, added pressure on the precious metals complex. This, along with platinum's weak fundamentals, saw investors becoming increasingly bearish towards the white metal, sending the price to ten-year lows by the third quarter.

Palladium, on the other hand, recorded another year of stunning performance, although quite volatile, breaking new price records towards the end of 2018.

On the fundamentals side, the picture once again appeared brighter compared to its sister metal, as the palladium market remained remarkably tight, recording another large physical deficit last year. Strong demand in autocatalyst applications and the chemicals industry far outweighed metal supply, despite higher volumes of autocatalyst recycling. Nevertheless, hefty liquidation from palladium ETP holdings helped to somewhat reduce the tightness.

Rhodium was undoubtedly deemed as the bright star out of the three platinum group metals in 2018, rising to eight-year highs by the end of the year and posting an intra-year gain of 43%. Being a niche market and with limited above-ground stocks, there is a potential for significant price spikes in case of a mismatch in its fundamentals. Last year's price rally was largely driven by growing concerns over a supply crunch, after the announcement of production cuts by South Africa's Impala Platinum, and solid demand from the auto sector, the primary source of demand for rhodium.

WORLD PLATINUM SUPPLY AND DEMAND

(000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f	Chg (18/17)
Supply											
Mine Production											
South Africa	4,750	4,740	4,182	4,368	3,220	4,522	4,273	4,289	4,318	4,201	1%
Russia	785	818	803	741	687	721	678	708	695	683	-2%
North America	238	389	338	337	397	365	396	363	345	369	-5%
Others	411	457	472	565	541	529	619	606	601	569	-1%
Total Mine Production	6,183	6,404	5,796	6,011	4,844	6,137	5,967	5,966	5,959	5,822	0%
Autocatalyst Scrap	926	1,020	952	1,090	1,134	1,107	1,203	1,262	1,328	1,432	5%
Old Jewellery Scrap	681	778	864	752	731	679	695	661	746	785	13%
Total Supply	7,790	8,201	7,612	7,854	6,710	7,924	7,865	7,889	8,033	8,039	2%
Demand											
Autocatalysts	3,029	3,114	2,976	2,972	3,122	3,175	3,166	3,187	3,158	3,208	-1%
Jewellery	2,291	2,424	2,601	2,753	2,675	2,612	2,339	2,235	2,125	2,080	-5%
Chemical	482	487	398	435	586	439	587	536	625	723	17%
Electronics	283	256	227	202	195	183	178	197	232	239	18%
Glass	505	338	361	22	-71	189	280	351	479	254	37%
Petroleum	168	144	126	107	122	96	135	172	173	204	0%
Other Industrial	494	559	621	649	700	665	727	748	774	804	4%
Retail Investment	95	312	282	136	141	582	550	296	311	287	5%
Total Demand	7,347	7,634	7,592	7,276	7,470	7,942	7,963	7,722	7,877	7,800	2%
Physical Surplus/(Deficit)	443	567	19	578	(761)	(18)	(98)	167	156	239	
Stock Movements	(579)	(256)	(538)	(1,891)	1,079	142	35	15	(137)	150	
of which ETP Release/(Build)	(579)	(156)	(238)	(891)	(221)	192	(15)	15	(137)	150	
Net Balance	(136)	311	(519)	(1,314)	318	123	(63)	182	19	389	
LBMA PM Price (US\$/oz)	1,609	1,722	1,551	1,487	1,388	1,053	989	948	880	845	-7%

Source: GFMS, Refinitiv; LBMA

PLATINUM IN 2018

The platinum market remained in a **physical surplus** in 2018, for the second year in succession, with a rise in autocatalyst and jewellery scrap offsetting a modest contraction in mine production, to deliver a 2% increase in total supply. Meanwhile, demand was also stronger last year, edging 2% higher, as strong growth in industrial applications offset a decline in jewellery fabrication.

Platinum **mine production** decreased 0.1 Moz (2 t) to 6.0 Moz (185 t) in 2018, representing a mere contraction from 2017. South African output rose by 1% to 4.3 Moz (134 t), and production in the United States increased by 2% to 0.1 Moz (4 t), while losses were posted in Canada and Russia. Total Cash Costs + Capex basis rose by 1%, reaching \$938/oz, excluding Russia. South Africa, which produces 72% of the world's platinum, is experiencing several power supply and labour difficulties, which led to a cost rise of 1%, to \$985/oz. Even though the last few years miners all over the globe have been improving costs efficiency, mainly by closing high-cost shafts, we estimate a total of 38% of all platinum mines are loss-making at current

platinum prices. Elsewhere, TCC+Capex rose by 9% in Zimbabwe and 6% in the North American region. On the other hand, Russia managed to reduce its cost structure by 9%, favoured by a depreciation of the rouble and by improving its operating productivity.

Global platinum jewellery **scrap** rose 13% in 2018 to 0.7 Moz (23 t), a five-year high. This outcome may appear somewhat counterintuitive given the average platinum price retreated 7% last year, however, the increase was almost exclusively driven by a 20% jump in Chinese recycling due to weak consumer demand for platinum jewellery, which encouraged a wave of recycling across the supply chain. Elsewhere, scrap supply was tempered by the weaker price, with Japan and Europe edging 4% and 2% lower, respectively.

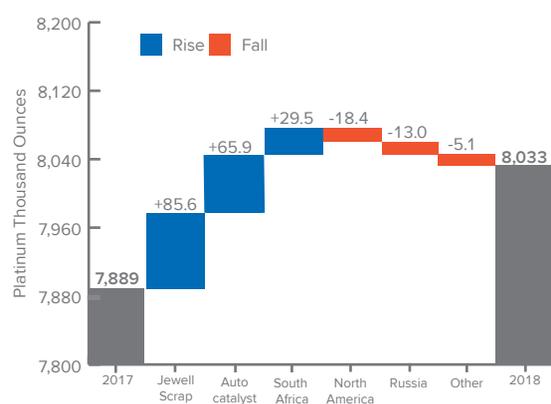
Autocatalyst scrap recorded a 5% year-on-year rise in 2018, the third in succession, to an estimated 1.3 Moz (41 t). Increases were seen across the board, with a rise in recycling volumes in all key markets. China led the way, with a 10% increase in recycling volumes, while our other regions category rose 9% on a year-on-year basis. The more mature markets were also stronger, with scrap volumes in Europe,

WORLD PALLADIUM SUPPLY AND DEMAND

(000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f	Chg (18/17)
Supply											
Mine Production											
Russia	2,722	2,704	2,624	2,527	2,582	2,575	2,526	2,728	2,671	2,636	-2%
South Africa	2,646	2,686	2,391	2,432	2,008	2,653	2,467	2,568	2,555	2,492	0%
North America	726	959	953	934	978	925	932	896	947	1,030	6%
Others	518	512	528	575	568	561	615	602	601	559	0%
Total Mine Production	6,612	6,861	6,497	6,468	6,136	6,713	6,540	6,794	6,774	6,717	0%
Autocatalyst Scrap	1,307	1,514	1,472	1,587	1,826	1,763	1,956	2,097	2,240	2,369	7%
Old Jewellery Scrap	215	194	203	182	118	82	65	47	49	51	4%
Total Supply	8,134	8,569	8,172	8,238	8,080	8,558	8,561	8,938	9,063	9,137	1%
Demand											
Autocatalysts	5,324	5,617	6,264	6,648	7,040	7,362	7,949	8,373	8,621	8,879	3%
Electronics	1,260	1,250	1,242	1,134	1,109	991	938	892	822	791	-8%
Chemical	369	385	379	409	385	374	459	470	504	520	7%
Dental	590	567	546	511	475	449	426	408	389	366	-5%
Jewellery	798	675	597	527	481	329	294	287	268	261	-6%
Other industrial	101	103	110	110	117	116	113	117	124	132	6%
Retail Investment	80	61	37	38	45	45	45	53	33	29	-39%
Total Demand	8,522	8,658	9,175	9,377	9,652	9,664	10,225	10,599	10,762	10,978	2%
Physical Surplus/(Deficit)	(389)	(89)	(1,003)	(1,139)	(1,571)	(1,106)	(1,664)	(1,661)	(1,698)	(1,841)	
Stock Movements	(290)	1,282	(148)	(300)	(299)	577	877	293	367	300	
of which ETP Release/(Build) (1,090)		532	(448)	0	(899)	727	637	383	527	300	
Net Balance	(678)	1,193	(1,151)	(1,439)	(1,870)	(529)	(786)	(1,369)	(1,332)	(1,541)	
LBMA PM Price (US\$/oz)	525	734	643	725	803	692	614	869	1,028	1,340	18%

Source: GFMS, Refinitiv; LBMA

WORLD PLATINUM SUPPLY



Source: GFMS, Refinitiv

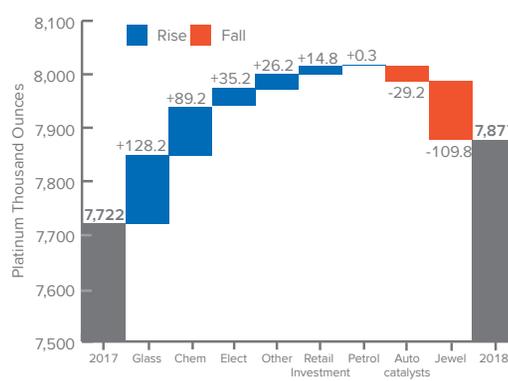
North America, and Japan rising 4%, 5%, and 3%, respectively.

Turning to demand, platinum consumption in **autocatalyst applications** fell 1% last year to 3.2 Moz (98 t). Unsurprisingly, the biggest drop was recorded in Europe, where platinum demand contracted by over 8%. This loss was somewhat offset by a minor rise in North America, increasing by 4%, whereas demand from Japan and China remained largely flat. Our other regions category saw a rise of 10% last year.

Platinum **jewellery** fabrication retreated 5% year-on-year to reach an estimated 2.1 Moz (66 t), the fifth consecutive annual decline and the lowest level since 2008. China accounted for the bulk of this loss, with this major market dropping 11% year-on-year as economic pressures limited consumer spending on discretionary items and competition from carat gold jewellery. Japanese fabrication returned to growth as lower platinum prices and a rise in tourists helped to boost consumption, while in the United States a firmer economic footing flowed through stronger consumer demand for luxury items.

Turning to **industrial demand**, growth was recorded in all industry segments in 2018, with a combined increase (excluding autocatalyst applications) of 14% year-on-year, to a cumulative total of 2.3 Moz (71 t). The most pronounced gains were seen in the **glass**, **chemical** and **electronics** sectors, which jumped 37%, 17%, and 18% respectively, with the former benefiting from a surge in demand from the fibre glass sector, while demand for platinum in the chemical sector was boosted by new paraxylene units in China and our other region category.

WORLD PLATINUM DEMAND



Source: GFMS, Refinitiv

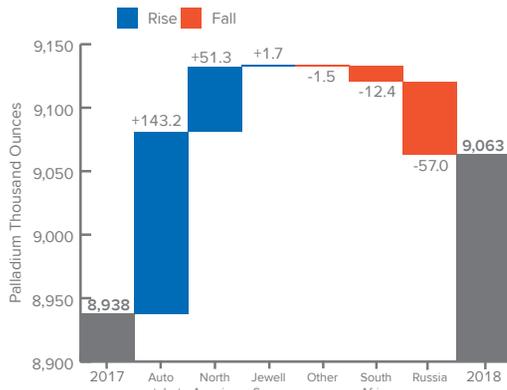
Retail investment returned to growth in 2018, rising 5% to an estimated 0.3 Moz (10 t). The modest rise, following two consecutive declines, was largely the result of an uptick in Japan, where demand rose by 27% year-on-year, however, retail demand was somewhat muted compared to previous years despite the yen platinum price falling to ten-year lows. Elsewhere, demand in North America was broadly stable, while European demand fell sharply as interest turned to other asset classes.

PALLADIUM IN 2018

Palladium's **physical deficit** inched higher in 2018 to an estimated 1.7 Moz (53 t). A 1% rise in total supply, as higher recycling volumes offset a slight contraction in mine supply, was partially offset by a 2% gain on the demand side. Adjusting for stock movements (from ETP redemptions and industry stocks) the **net balance** slipped to a deficit of 1.3 Moz (41 t).

Mine production of palladium dropped by less than 1%, achieving an output of 6.8 Moz (211 t) in 2018. Strong results in the North American region were offset by lower production in South Africa, Russia and Zimbabwe. At a company level, Sibanye-Stillwater consolidated its position as a strong PGM producer, after its palladium output rose by 24% to 0.8 Moz (26 t), while Glencore and Lonmin production fell by 13% and 6%, respectively. Russian Norilsk also posted a year-on-year rise, as maintenance at its Krasnoyarsk Precious Metals Refinery forced it to produce only from Russian sources, stopping all third parties feed. It is important to note that higher metal prices are driving several exploration projects forward, which we estimate will help counterbalance the maturing of current operations.

WORLD PALLADIUM SUPPLY



Source: GFMS, Refinitiv

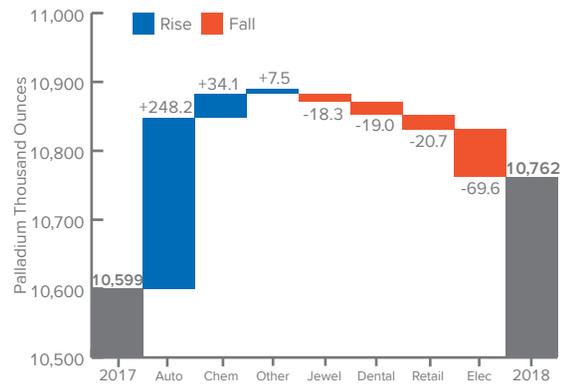
Autocatalyst scrap reached a record high in 2018, increasing 7% on year-on-year basis to an estimated 2.2 Moz (70 t). A rise in end-of-life vehicle (EVL) scrappage, buoyed by surging palladium prices, encouraged higher industry recycling volumes. The fastest growth in percentage terms was seen in our other regions category, which jumped by 13% last year, while volumes from China and Europe both increased by 8% on an annual basis.

The recycling of palladium **jewellery scrap** rose 4% last year to 0.05 Moz (2 t), with the 18% jump in the average palladium price encouraging both consumers and the supply chain to liquidate old items, with modest gains in Europe, Japan, and North America. Scrap supply in China fell to negligible levels as the domestic fabrication market has all but collapsed and access to recycling services remained limited.

Palladium demand in **autocatalyst applications** rose 3% to 8.6 Moz (268 t) last year, a new record high. The annual increase occurred despite a modest decline in global gasoline vehicle production in 2018 which contracted 1% to 74.5 M units. The main driver behind the drop in production was China, which fell 5% in 2018. The rise in demand for palladium instead was generally a reflection of rising loadings, in particular in parts of our Other Regions category and China. Palladium demand in North America also rose moderately on the back of a further roll out of Tier III federal emissions legislation, which had a positive effect on loadings. Demand from Europe as a bloc rose just 1%, while demand from Japan dipped 3% year-on-year.

Demand for palladium used in other **industrial applications** was marginally stronger in 2018, with total combined offtake rising 2% to an estimated 1.4 Moz (57 t). Ongoing thrifting and substitution

WORLD PALLADIUM DEMAND



Source: GFMS, Refinitiv

accounted for the annual declines in the **electronics** and **dental** markets, which retreated 8% and 5% respectively. Meanwhile, **chemical** and the **other industrial** segment both recorded healthy year-on-year gains, the former driven by strong investment in new capacity for purified terephthalic acid (PTA).

Palladium used in **jewellery fabrication** fell for the tenth consecutive year, by 6% to 0.3 Moz (8 t) last year. The high price was the chief culprit in both North America and Europe, with demand impacted by a shift away from palladium to more affordable alloying options for white gold. Demand in China, meanwhile, has all but evaporated, with no standalone fabricators left in the country and little hope of a renaissance in the current market.

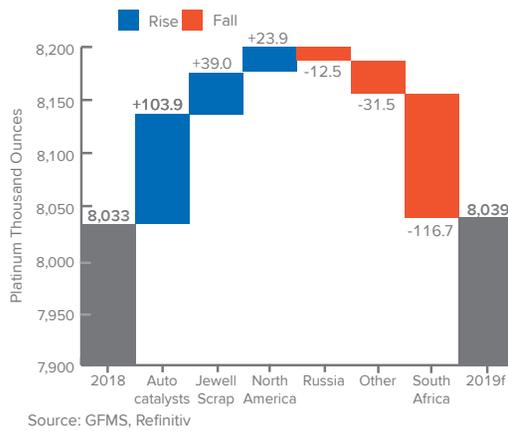
Retail investment for palladium fell 39% last year to an estimated 0.03 Moz (1 t), a level not seen since the start of the millennium as elevated palladium prices encouraged liquidation of investment products across all markets, with North America, which dominates this space, dipping 5% year-on-year.

PLATINUM, PALLADIUM AND RHODIUM, US\$/OZ

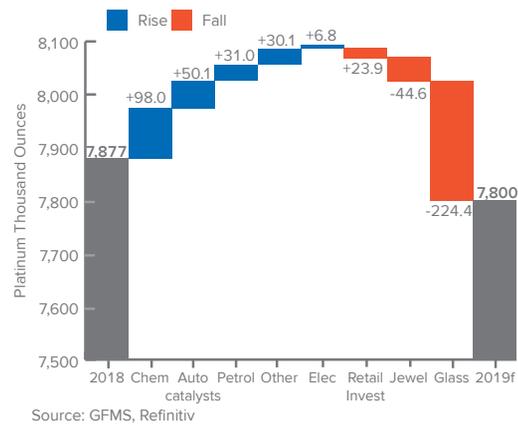


Source: GFMS, Refinitiv

WORLD PLATINUM SUPPLY FORECAST



WORLD PLATINUM DEMAND FORECAST



OUTLOOK FOR 2019

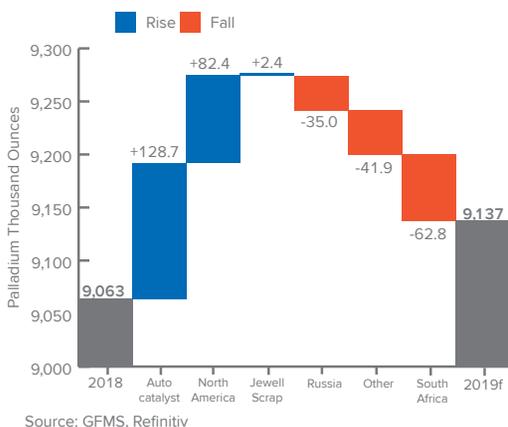
We expect **platinum** prices to stabilise and recover this year, although any recovery will likely be modest as supply will continue to outpace demand, with a physical surplus of 0.2 Moz (7 t). Global mine production is set to dwindle slightly, primarily on the back of lower primary supplies from South Africa. That said, an expected increase in autocatalyst recycling and, to a lesser extent, jewellery scrap will see total supply broadly flat to marginally higher. Demand for platinum in autocatalyst applications is set to improve on the back of stricter regulations on vehicle testing procedures and tightening vehicle emissions standards in countries such as China and India.

Meanwhile, jewellery demand is likely to remain under pressure, primarily due to ongoing weakness in China as a result of cautious consumer sentiment, continued misalignment between the price tags for platinum jewellery pieces and the international platinum price, as well as growing competition from other products such as gold and high-end silver jewellery. We expect investment demand to weaken this year. Given a

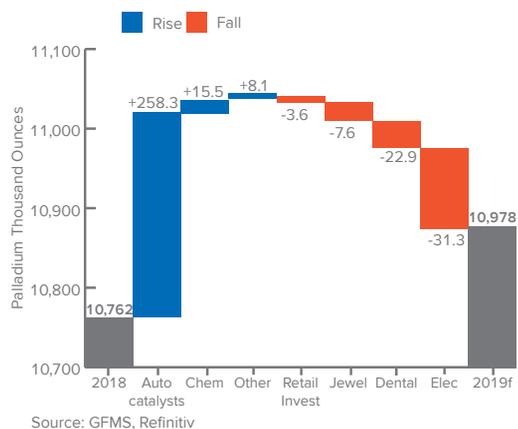
substantial price drop seen in 2018, there is likely to be limited scope for further downside potential, thus restricting fresh buying from retail investors in Japan. In addition, any material price recovery could prompt significant liquidation from ETP investors, given that total ETP holdings remained relatively flat over the past years, compared to palladium.

Palladium is forecast to continue to outperform its sister metal, with strengthening fundamentals and buoyant investor sentiment towards the metal expected to drive the annual average price higher this year. The physical deficit is set to widen further in 2019, underpinned by strong demand in autocatalyst applications due to tightening emissions regulation, particularly in Europe and China. While we expect lower mine production this year, on the back of shaft closures in South Africa and lower sales from Russia, higher palladium prices will continue to stimulate autocatalyst and jewellery scrap, with total supply edging higher as a result. We are likely to see another year of selling from ETP investors, given our price forecast, although this will still not be anywhere near to closing the gap between supply and demand.

WORLD PALLADIUM SUPPLY FORECAST



WORLD PALLADIUM DEMAND FORECAST



2. PGM PRICES

PLATINUM & PALLADIUM

Platinum suffered yet another disappointing year in 2018 with spot prices falling 15%. The annual average platinum price has now decreased for seven years in succession, and was down from an average of \$949/oz in 2017, to an average of \$880/oz last year. The trading range was from \$772/oz to \$1,020/oz. The average 20-day rolling price volatility fell to 15% last year, from 17% the year prior. The decline in the platinum price last year was mostly driven by concerns over lower platinum use in European diesel cars, and the physical market remaining in physical surplus.

On the other hand, **palladium** continued to outperform its precious metals peers by posting an 18% price return in 2018, after already advancing by 58% in 2017. Towards the end of 2018, the palladium price was even seen occasionally above the gold price on certain trading days (and that had been the case again in the first quarter of 2019). The annual average price increased by 18% to \$1,028/oz, up from \$868/oz in 2017. Palladium's trading range last year was from \$849/oz to \$1,271/oz. The average 20-day rolling price volatility fell marginally to 24% last year. Demand for the metal from China was strong last year, adding to an already tight physical market. While China's vehicle production fell by 4% in 2018 to 27.8 million units, their progressive shift from China V to China VI increased demand for palladium as the average loading of palladium per vehicle is much higher under the new regulations.

Platinum attempted to break above \$1,000/oz several times in the first quarter of 2018, but failed. Nevertheless, platinum still managed to increase

PGM PRICES: SOUTH AFRICAN RAND



by 0.4% in the quarter. Palladium was able to carry forward its strong momentum from 2017, breaking above \$1,100/oz in January. Indeed, according to the weekly CFTC reports, managed money positions were so bullish on palladium that net positions hit 85 tonnes equivalent on 9th January 2018, which was an all-time high. As expected, palladium lost steam later on as elevated prices gave rise to liquidation, with the price falling back below \$1,000/oz by March. Palladium lost over 10% in the first quarter.

In the second quarter, platinum began to lose momentum, and turned notably weaker starting in May, just as the price closed below \$900/oz, for the first time since May 2017. In contrast, palladium was strong in April, attempting to break through the \$1,000/oz level several times. Towards the end of June, global tensions intensified as rhetoric surrounding a trade war between the United States and China gathered momentum. Investors perceived the U.S. dollar as the ultimate safe haven and the currency surged, while metals took a beating. Platinum eventually lost 9%, while palladium remained steady in the three months ending June.

Platinum was heading lower in the third quarter, and was dragged along with gold and silver, breaking below the \$800/oz level by mid-August, losing another 4% in the third quarter. However, despite a strong dollar and uncertainties surrounding the trade dispute, the palladium price rose 13% in the three months ending September, as demand from China surged suddenly which led to a metal shortage.

Platinum's price performance continued to disappoint in the final quarter of the year, as it slipped through below \$800/oz level once again in December. Adding salt to the wound, December recorded another meltdown in both the U.S. equities market and the dollar index. While this was bullish for most commodities, unlike other precious metals, platinum failed to take advantage of this environment, losing another 3% in the last three months of the year. On the other hand, palladium remained strong throughout the quarter, breaking above \$1,100/oz in a convincing fashion in early November. The strong momentum continued, and the price of palladium even surpassed gold on several occasions in December. Palladium gained another 18% in the last quarter of the year.

PRECIOUS METALS PRICE PERFORMANCE (ANNUAL AVERAGE)

	Au	Ag	Pt	Pd	Rh
2017	1,257	17.05	949	868	1,101
2018	1,268	15.71	880	1,028	2,218
Change (yoy)	1%	-8%	-7%	18%	101%

Source: GFMS, Refinitiv; LBMA; Johnson Matthey

2018 was another disappointing year chalked up for platinum, especially considering that it failed to perform in concert with its other precious metals peers in December 2018. Investment sentiment towards platinum was pessimistic, considering that NYMEX platinum was in net short positions for 30 consecutive weeks under managed money positions, the longest streak since the CFTC amended its disclosure to the current format since 2007. On the other hand, funds' participation at the NYMEX palladium was not very active, considering that the annual average of managed money net positions was just 34 tonnes equivalent (compared to the peak of 85 tonnes equivalent on 9th January 2018), therefore it is fair to conclude that the surge in the palladium price had little to do with speculative funds in the futures market.

The platinum/palladium ratio averaged 0.86 in 2018, compared to 1.61 in 2016 and 1.09 in 2017. In the first four months of 2019, the average ratio fell further to 0.66.

RHODIUM

Rhodium continued to outperform palladium, with the metal price rising by 101% in 2018. The trading range was between \$1,690/oz and \$2,600/oz. After a brief consolidation in January 2018, rhodium busted through the \$2,000/oz territory by late March last year, and the price gained even more momentum in the second half of the year. Market demand was strong, not just from the automobile industry (as China VI needs more rhodium), but also from the chemicals sector. Investors also bought physical rhodium for price speculation, and were not tempted to sell it back to the market. On the other hand, mine supply of rhodium is expected to continue to fall at least in the next two years, as Impala Platinum and Anglo American Platinum's planned production cut will have a negative impact on rhodium production.

Rhodium finally saw a more significant price correction in late March 2019, losing \$235/oz, after surging by over \$800/oz in the previous six weeks to exceed \$3,300/oz, the highest level since 2008. The big selloff in palladium, which saw the price fall by \$175/oz or 11% in March, also caused panic, promoting investors to sell off their rhodium, increasing supplies in the market. Rhodium was consolidating just a tad lower than \$3,000/oz in May 2019.

RUTHENIUM & IRIIDIUM PRICES

The **Ruthenium** price also recorded an impressive performance in percentage terms in 2018, up by 42% year-on-year, with the annual average price increasing by more than two fold, to \$241/oz. As a very tight market, ruthenium continued to benefit from increasing demand from the magnetic data storage sector. A large player in the memory computing industry plans to introduce a new technology in magnetic-assisted magnetic recording (MAMR) to facilitate larger capacity of hard disk drives for enterprise customers. This technology relies on ruthenium layers in its construction. Meanwhile, a demonstration plant which uses ruthenium as a catalyst was built to convert sugars into glycolaldehyde, a precursor for MEG, which is a key component of PET plastic used for food packaging, bottles and polyester fabrics.

Iridium was the best performer of all, with the price appreciating by 53% over the course of 2018, while the annual average increased by 43% to \$1,282/oz. Iridium is mainly used in electronics, as well as spark plugs, electrodes and chemical catalysts. Last year the iridium market continued to suffer from a supply deficit, which helped to drive prices higher.

RUTHENIUM & IRIIDIUM PRICES



Source: GFMS, Refinitiv

PLATINUM AND PALLADIUM PRICE CORRELATIONS

Platinum and palladium belong to the same group in the periodic table and share many similar properties. First and foremost, they tend to occur together in mineral deposits. In terms of demand, both metals are used in automotive catalytic converters, electronics, jewellery and act as catalysts during chemical processes. However, despite the similarities of the two metals, their price correlations are not very high, though the trend is moving upwards. One of the reasons for this is because sometimes platinum and palladium are competing against each other in terms of demand. Platinum had become the victim of the Volkswagen emissions incident in 2015, and the diesel engines (that use primarily platinum in catalytic converters) were losing market share to gasoline (that use palladium in catalytic converters). Europe, which is traditionally the largest market for diesel engines, also began embracing palladium made catalytic converters in 2018. There was no bright spot in terms of platinum demand last year, and another year of supply surplus saw investors losing interest in platinum, as evidenced by the 30-consecutive weeks of managed money net short positions in NYMEX platinum in 2018.

On the other hand, palladium was heavily favoured by the market, despite uncertainties led by the trade war. Strong demand from the automobile industry, particularly from China, saw an already tight market become even tighter. The long-time backwardation of palladium suggested the market did not have sufficient supplies, and buyers had to buy physical metal from ETPs, resulting in a consistent outflow from palladium ETPs throughout the year. As a result, the platinum-to-palladium ratio, after breaking below 1.0 since the end of September 2017, continued heading downwards, averaging 0.86 throughout 2018.

Similar to previous years, platinum remained at a relatively high correlation with gold for most of last year, even though the strength of the relationship was decreasing towards the end of the year. A lack of a compelling story on platinum in recent years left the market with no choice but to value platinum in terms of gold. The annual average gold-to-platinum ratio increased from 1.33 in 2017 to 1.45 throughout 2018, with the ratio skewing towards the higher range as platinum underperformed gold in the second half of 2018, particularly in December when the ratio broke above 1.6. In the first quarter of 2019, the ratio retreated below 1.5 as market participants felt platinum was oversold, along with concerns over supply disruption following labour disputes at a South African PGM mine. To put the ratio in context, the historical average for 1985-2017 was 0.82.

In the first quarter of 2019, strong momentum was carried through into 2019 for palladium, as the price of the metal surpassed the gold price in a convincing fashion. The palladium price hit an historical high of near \$1,615/oz on 21st March, before facing some sharp corrections, closing below \$1,400/oz by the end of the first quarter. Meanwhile, platinum was also resilient in the first four months of 2019. While the price appreciated by 7% in the first quarter, funds continued to build their long positions in platinum, with the platinum price briefly breaking through \$900/oz in April. Net long positions in platinum reached 36 tonnes equivalent by mid-April, the highest level since February 2018.

QUARTERLY CORRELATION COEFFICIENTS

(daily log returns)

	2017	2018	2018	2018	2018	2019
	Q4	Q1	Q2	Q3	Q4	Q1
Platinum-Palladium	0.26	0.47	0.45	0.65	0.32	0.47
Platinum						
Gold	0.65	0.66	0.59	0.81	0.51	0.48
US\$/Euro Rate	-0.33	-0.51	-0.35	-0.47	-0.47	-0.53
CRB Index	0.15	0.16	0.15	0.48	0.42	0.42
Oil (WTI)	0.29	0.40	0.20	0.29	0.22	0.28
Palladium						
Gold	0.20	0.36	0.43	0.48	0.33	0.44
US\$/Euro Rate	0.02	-0.2	-0.36	-0.20	-0.46	-0.38
CRB Index	0.21	0.10	0.31	0.52	0.26	0.20
Oil (WTI)	0.27	0.38	0.33	0.30	0.17	0.14

Source: GFMS, Refinitiv

PLATINUM, PALLADIUM AND OTHER COMMODITIES



Source: GFMS, Refinitiv

3. INVESTMENT

- **Total Identifiable investment in platinum, which includes retail investment and ETP inventory build, rose by 59% in 2018 to 0.4 Moz (14 t). This was due to a shift in ETP investment to net inflows and a modest uptick in retail investment.**
- **Palladium recorded a net disinvestment for a fourth consecutive year in 2018, at a total of 0.5 Moz (15 t), largely on the back of hefty liquidation from ETP holdings as well as lower retail investment.**

COMMODITY EXCHANGES

Platinum futures on **TOCOM** saw a strong increase in net-long positions in the January to May period, jumping by a remarkable 365%, to hit 249,000 ounces (8 t). The move was partly driven by short-covering initially triggered by a rally in the platinum price in Japanese yen terms at the start of the year (which mirrored the dollar platinum price), sending the local price to a 10-month high in the third week of January. By the end of May, speculative short positions dropped to just 42,000 ounces (1 t), the lowest level in six months, recording a 58% fall since the start of the year. With the price of platinum retreating far into bear territory in the following months, as well as the metal's increasing price discount to gold, there had been some spur in opportunistic buying, resulting in a fresh build-up in long speculative positions, which rebounded by 88% by end-May to 291,000 ounces (9 t), the level last revisited in November 2017.

The price of platinum experienced further sharp downward corrections in both U.S. dollar and Japanese yen terms over the summer months, which resulted in the metal trading near ten-year lows at the beginning of September. However, significantly lower prices failed to continuously support investors' interest as platinum's weakening fundamentals in the form of a growing net surplus, as well as market expectations

for further tightening of monetary policy from the U.S. Fed, dampened sentiment. Net investor positions experienced steady declines since June, dropping to just 86,000 ounces (3 t) by the end of October, the lowest since January. The move was driven by a 94% increase in short speculative positions over the five-month period and a drop of 42% in speculative longs. Net positions recovered slightly towards the end of the year, standing at 163,000 ounces (5 t) by end-December, roughly in line with the year's average.

Looking at palladium futures on TOCOM, after sinking into net shorts and staying in this territory for most of 2017, last year saw a reverse in this trend, shifting back into net longs between February and August. By the end of March, net positions reached 5,026 ounces (0.2 t), the highest level since May 2016. The rise was on the back of short-covering, as well as some new long positions were established. The following months saw net longs retreat and go back up again, before switching back into a net short market in September as speculators added to their gross short positions, while cutting gross longs.

Turning to investor activity on **NYMEX** and starting with platinum, weekly CFTC reports on managed money positions indicated some interesting shifts in investors' stance towards the metal over the course of last year. Net investor positions rose to 2.5 Moz (77 t) by the end of January, the highest since September 2016, sending the price of palladium to a new record high of \$1,129/oz by mid-January.

The rise was mostly on the back of short-covering, with speculative shorts dropping by 40% since end-December 2017, while gross longs jumped by 16% over the same period to a record level of 3.7 Moz (115 t). The interest started to wane thereafter; net investor positions recorded a steady fall, before switching into net shorts at the beginning of July for the first time since July 2004. The market

IDENTIFIABLE INVESTMENT*

(000 ounces)	Platinum					Palladium				
	2015	2016	2017	2018	Change	2015	2016	2017	2018	Change
Retail Investment	582	550	296	311	5%	45	45	53	33	-39%
Exchange Traded Funds	(192)	15	(15)	137	n/a	(727)	(637)	(383)	(527)	n/a
Total Identifiable Investment	391	565	282	449	59%	(682)	(593)	(330)	(494)	n/a
Indicative Value \$M**	411	559	267	440	65%	(472)	(364)	(286)	(495)	n/a

*Excludes investment activity in the futures and OTC markets.

**Indicative value calculated using annual average volume and prices.

Source: GFMS, Refinitiv

NET INVESTOR POSITIONS ON TOCOM AND NYMEX

(end-period; positive represents net longs)	Platinum				Palladium			
	Q1.18	Q2.18	Q3.18	Q4.18	Q1.18	Q2.18	Q3.18	Q4.18
TOCOM Futures Contracts	13,495	13,835	8,869	10,144	313	246	(83)	(52)
- equivalent in ounces (000)	217	222	143	163	5.0	4.0	(1.3)	(0.8)
NYMEX Futures Contracts	32,979	656	8,222	17,831	12,783	8,709	9,700	14,380
- equivalent in ounces (000)	1,649	33	411	892	1,278	871	970	1,438

Source: TOCOM, CFTC

recorded 11 consecutive weeks of net shorts, its longest run since 2001, with a weekly average of 125,000 ounces (4 t), compared to 23 consecutive weeks and an average of 44,000 ounces (1 t) in 2001. This saw the platinum price plummet to a ten-year low of \$772/oz by early September. Net investor positions returned into positive territory in the second half of September and slightly recovered towards year-end, although were still some 64% down on January’s level.

After a strong start to the year, speculative investors had been trimming their palladium net long positions for most of 2018, to hit 21,000 ounces (1 t) by the third week of August, the lowest level since April 2003. A fresh build-up in gross longs and short-covering saw net positions recover for the rest of the year, helping to fuel the price of palladium to fresh highs by year-end.

RETAIL INVESTMENT

Platinum retail investment demand rose by 5% in 2018 to 311,000 ounces (10 t), following two consecutive years of declines. The increase was mostly driven by a rebound in Japanese demand, which was partly offset by lower investment in other regions, predominantly Europe. Investment demand in Japan rebounded by 27% to 222,000 ounces (7 t), taking the country’s share of global retail investment up to 71% from 59% a year ago. This was largely attributed to a dramatic fall in the yen platinum price, which hit ten-year lows in August, and a further increase in platinum’s discount to gold, which boosted opportunistic purchases.

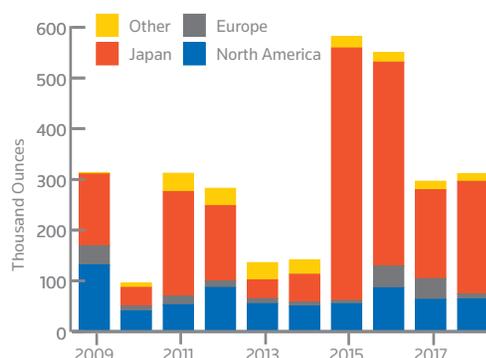
Investment demand in North America remained broadly flat last year, standing at 64,000 ounces (2 t). Growing optimism revolving around the U.S. economy, supported by positive economic data and a series of interest rate hikes from the Fed, saw investors giving preference towards riskier assets such as equities. Indeed, last year saw U.S. stocks rally to all-time highs, before a sharp correction in the final months of the year. Having said that, a marked drop in the dollar platinum price to its lowest level since 2008 helped to ignite some buying among bargain

hunters. Meanwhile, an impressive rally in the price of palladium gave rise to some liquidation, resulting in a 5% year-on-year decline in physical investment.

Meanwhile, retail investment in Europe recorded a sharp drop of 76%. It is worth adding that in absolute terms this market had continued to represent only a small fraction of the global retail investment figure. Similar to the North American region, the risk-on mode among investors and an impressive rally in stock markets were among the key drivers behind last year’s lacklustre demand. In addition, increasingly negative investor sentiment towards the metal, driven by its weak fundamentals and plunging prices, contributed towards poor demand.

Demand for platinum in the coin sector jumped by 28% in 2018 to 110,498 ounces (3 t), following a sharp drop in the previous year. Demand from North America, with its share standing at 70% of the global coins market last year, rebounded by 54%, with much of demand taking place in the first quarter, following the initial drop in the platinum price. Europe was another region to register strong offtake, while demand in Japan dropped for the second consecutive year, as no sales were recorded in the first and final quarters. Sales of American Eagles hit 30,000 ounces (0.9 t), up by 50% from a year ago. Maple Leaf recorded a 2% increase, while Austrian Philharmonic coins registered a drop of 11%.

PLATINUM RETAIL INVESTMENT



Source: GFMS, Refinitiv

PLATINUM, PALLADIUM AND RHODIUM EXCHANGE TRADED PRODUCTS

Platinum ETPs recorded net inflows of 137,000 ounces (4 t) in 2018, closing the year at 2.7 Moz (84 t). Despite positive net inflows for the full year, H1 2018 recorded some hefty liquidation. The bulk of outflows took place in Q2 as the price of platinum slid through the \$900/oz level, hitting a two-and-a-half year low by the end of the quarter. This prompted some investors to liquidate their positions, with total holdings down by 132,000 ounces (4 t), the largest quarterly net outflows since Q3 2016. The selling was concentrated in South Africa, with investors reducing their holdings by 47,000 ounces (2 t), representing 36% of total selling on a global scale for this quarter. Funds in North America saw some dramatic liquidation, with ETF Securities recording the largest decline of 43,864 ounces (1 t), which accounted for 73% of total outflows from this region and a third of total selling on a global scale. European funds also recorded a somewhat smaller attrition, totalling 22,772 ounces (1 t).

The second half of the year saw a pick-up in investor interest, particularly in months when the price of palladium was in steady decline, while periods of a price recovery witnessed ETP investors closing some of their positions. The biggest increase in holdings on a net basis took place in Q4, which saw total inflows of 259,365 ounces (8 t), outweighing selling in the first six months. Most of the buying was in South Africa and to a lesser extent North America, while there was some selling by European ETP investors.

Palladium ETP holdings recorded another year of hefty net outflows, falling by 526,803 ounces (16 t) or 40% from the end-2017 level, to a total

NET MOVEMENTS IN PLATINUM, PALLADIUM & RHODIUM ETPS

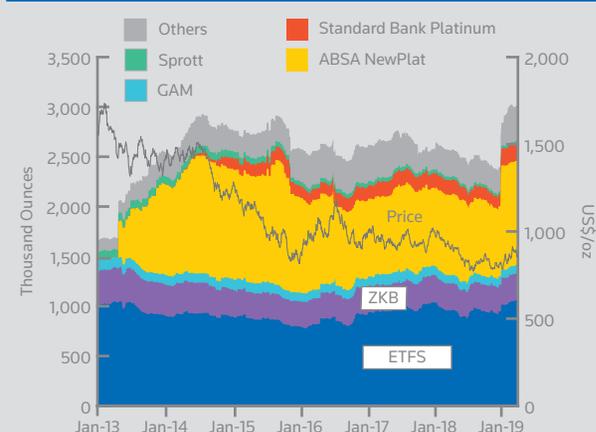
	2017	2018	YoY%	Jan-Mar 2019
(000 ounces)				
Platinum	(15)	137	n/a	298
Palladium	(383)	(527)	38%	45
Rhodium	(18)	(45)	153%	(3)

Source: Respective ETF issuers

of 0.8 Moz (25 t), the level last seen back in 2009. While selling prevailed for most of the year, the biggest declines in holdings occurred in the first two quarters and the final quarter. Holdings fell by 195,791 ounces (6 t) in Q1, as the price of palladium hit a fresh high of \$1,129/oz in mid-January, prompting investors to liquidate some of their positions. The drop in ETF Securities accounted for the bulk of selling that quarter, with holdings falling by 161,330 ounces (5 t) or 26%. After the price broke through the \$1,000/oz level again in mid-April, this prompted further selling, with total ETP holdings reducing by another 150,306 ounces (5 t) in Q2. ETF Securities recorded the biggest decline of 27% over that period, followed by a drop of 12% in holdings of South African Standard Bank ETF. Another 153,415 ounces (5 t) were slashed from total ETP holdings in the final quarter as the price of palladium embarked on a renewed rally, hitting fresh highs towards the end of the year.

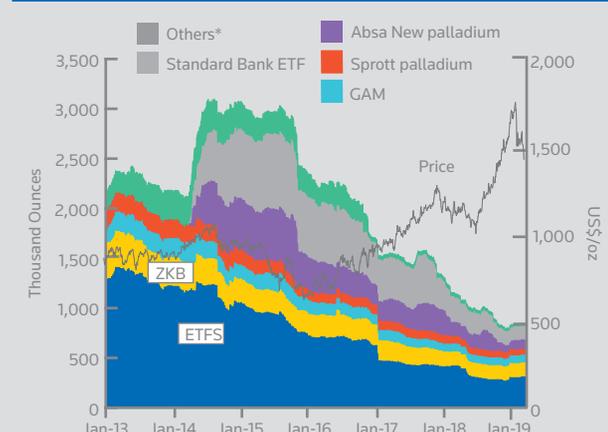
Rhodium ETPs recorded another year of net outflows, with total holdings dropping by 45,496 ounces (1 t) or 53% in 2018. The bulk of liquidation happened in the first half of the year, with ETP investors reducing their positions by 37,312 ounces (1 t) or 43%. Africa Rhodium ETF recorded the largest decline over the six month period, with its holdings down by 63% or 23,675 ounces (1 t), followed by a 28% reduction in holdings of the DB Physical Rhodium ETC fund.

PLATINUM ETP HOLDINGS



Source: GFMS, Refinitiv; collated from respective ETP issuers' data
*Others: Mitsubishi, DB ETC, I Shares, Souce Physical, and Granite Share

PALLADIUM ETP HOLDINGS



Source: GFMS, Refinitiv; collated from respective ETP issuers' data
* Mitsubishi, DB Physical Palladium, Source Physical and IShares Physical Palladium ETC



4. SUPPLY

- Global platinum mine production decreased by less than 1% to total 5.9 Moz (192 t) in 2018, led by losses in Russia and Canada, partially offset by an output increase of 1% in South Africa.
- Palladium mine production in 2018 edged slightly lower year-on-year, following drops in South Africa and Russia. As a counterbalance, strong results were posted in the North American region, especially in Canada.
- Rhodium output decreased by 3% compared to 2017, after losses were reported in South Africa and the United States. World production totalled 0.7 Moz (24 t), the lowest level since 2015.

- Global Total Cash Costs (expressed in U.S. dollars) increased by 2% in 2018 to \$812/PtEqoz, when Russia is not considered. Several labor disruptions and power cuts in South Africa are the main driver of this cost increase.
- Total Cash Costs + Capex (sustaining and expansionary) increased by 1% to an average of \$938/PtEqoz, after higher Capital Expenditures were posted, as companies are investing in improving the technologies used in the mines, as well as in the development of several highly-prospective projects.

WORLD PLATINUM MINE PRODUCTION

(000 ounces)	2017	2018	2019fChg(18/17)	
South Africa	4,289	4,318	4,201	1%
Russia	708	695	683	-2%
Zimbabwe	479	480	460	0%
Canada	232	211	221	-9%
United States	131	134	148	2%
Others	127	121	109	-5%
World Total	5,966	5,959	5,822	0%

Source: GFMS, Refinitiv

WORLD PALLADIUM MINE PRODUCTION

(000 ounces)	2017	2018	2019fChg (18/17)	
Russia	2,728	2,671	2,636	-2%
South Africa	2,568	2,555	2,492	0%
Canada	468	489	588	4%
United States	428	459	441	7%
Zimbabwe	396	395	362	0%
Others	206	206	197	0%
World Total	6,794	6,774	6,717	0%

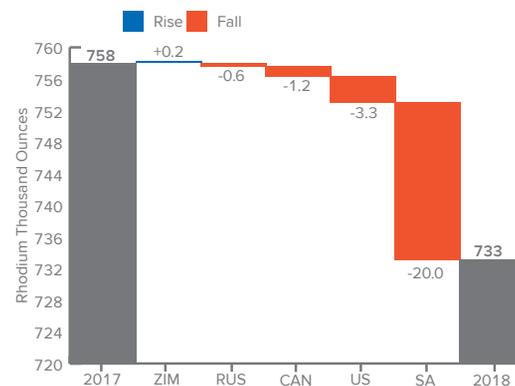
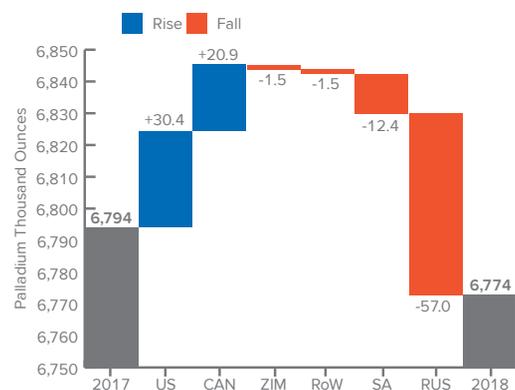
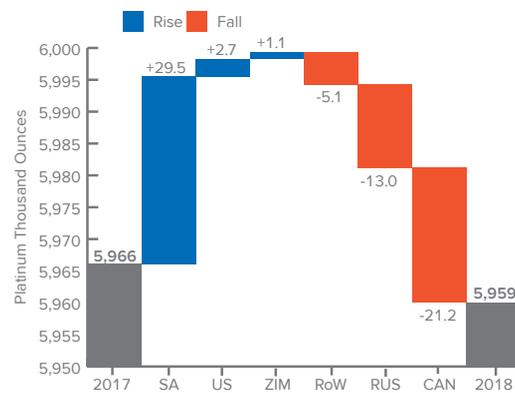
Source: GFMS, Refinitiv

WORLD RHODIUM MINE PRODUCTION

(000 ounces)	2017	2018	2019fChg (18/17)	
South Africa	625	605	614	-3%
Russia	65	64	67	-1%
Zimbabwe	43	44	29	0%
Canada	22	21	23	-6%
United States	3	0	3	-86%
Others	-	-	-	0%
World Total	758	733	736	-3%

Source: GFMS, Refinitiv

PGM PRODUCTION VARIANCE



Source: GFMS, Refinitiv

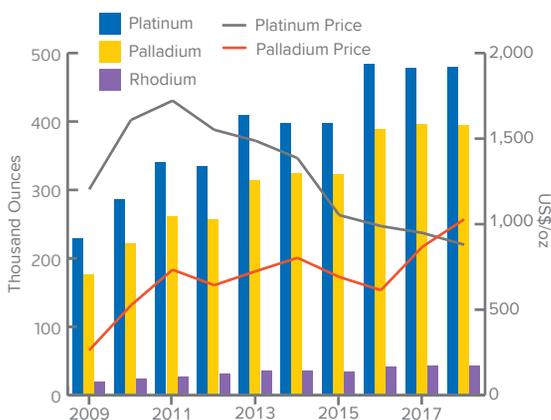
MINE PRODUCTION

ZIMBABWE

Zimbabwe posted 3E PGM production of 0.9 Moz (29 t), similar to the previous year. Output at Zimplats' Ngezi mine, which accounts for over half of the country's total production, dropped by 4% to 0.5 Moz (17 t), due to lower throughput. Zimplat's focus remains on bringing the Bimha mine to its former production level, after a collapse in the shaft in 2014. After spending over \$66 M in its redevelopment, the mine returned to normal operation on April 2018 and is expected to reach the orebody by Q2 2019. Following a 25-year plan to maintain current PGM output, the company is also investing over \$264 M on developing the Mupani Mine, which will replace the Rukodzi and Ngwarati mines. On the other hand, Amplats' Unki mine produced a record 0.2 Moz (6 t) PGM's, representing a 16% increase from 2017, due to higher tonnes milled and higher grades. The company is expecting to lower costs while improving efficiency from 2019, after the commissioning of the Unki smelter in Q3 2018.

At a country level, several business-oriented policy changes from the government are boosting investors interests. As a result, important projects are being materialised including the development of the \$4 bn Darwendale platinum deposit project, a Russian-Zimbabwean JV with estimated resources of 45.0 M PGM ounces. The privately owned Karo Platinum project, which includes mining, concentration, smelting and refining of PGMs is also under development, and is expected to produce 2.0 Moz (64 t) of refined PGMs per annum on completion, including 0.6 Moz (19 t) of purchased concentrates from other companies.

ZIMBABWEAN MINE PRODUCTION



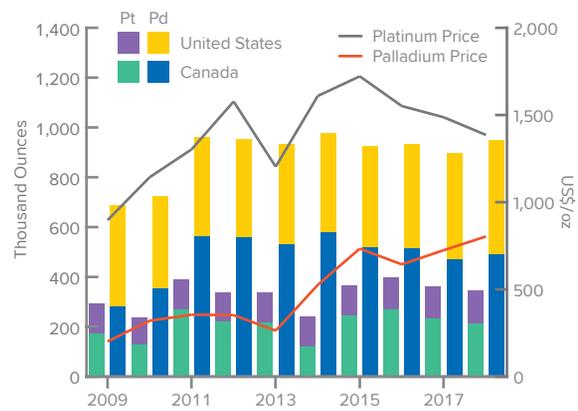
Source: GFMS, Refinitiv

CANADA

Canada's PGM's production had a somewhat mixed performance during 2018, as platinum output dropped by 9% to 0.2 Moz (7 t), while palladium increased by 4% to 0.5 Moz (16 t). The country's only primary palladium mine, Lac des Iles, increased its throughput by 52% and produced 45% more concentrates than the previous year. Total platinum and palladium amounted to 0.02 Moz (1 t) and 0.2 Moz (7 t), an increase by 33% and 18%, respectively, representing around half of Canada's total PGM production. The company doubled capital expenditures from the previous year, in order to improve the geological understanding of the deposit. And during Q1 2018 it announced the discovery of new mineralization targets at Sunday Lake, while the NI 43-101 technical report, released in Q4 2018, reflects an extension of the mine life to 2027, including the ramp-up of the average underground production.

Vale's platinum production, including custom feeds, dropped by 6% to 0.1 Moz (4 t), while palladium output increased by 2% to 0.2 Moz (7 t). The company is undertaking a strategic change in its nickel business, resulting in the reduction of the metals production profile, thus affecting PGM's output. Glencore's nickel operations posted losses for the third consecutive year, after PGM production dropped by 17% to 0.2 Moz (6 t). KGHM International's Sudbury Basin mines achieved production of 0.3 Moz (8 t). The company is currently developing the Victoria Project in the area, which consists of a copper/nickel underground mine with PGM content, with a life of mine over 13 years. Other interesting projects in the country include Sibayne-Stillwater's Marathon Project, in which the company plans to invest \$1.1 M annually in drilling the PGM-bearing dykes. The project has an estimated 3.9 Moz (128 t) in platinum and

NORTH AMERICAN MINE PRODUCTION



Source: GFMS, Refinitiv

TOP 10 PLATINUM PRODUCING COMPANIES

Rank	2017 2018		Company	Output (000 ounces)	
	2017	2018		2017	2018
1	1		Anglo American Platinum Ltd. ¹	1,420	1,292
2	2		Impala Platinum Holdings Ltd. ²	1,048	1,016
3	3		Sibanye-Stillwater ³	780	819
4	4		Lonmin plc. ⁴	718	679
5	5		OJSC MMC Norilsk Nickel	670	653
6	6		Northam Platinum Ltd. ¹	298	307
7	7		Royal Bafokeng Platinum Ltd. ⁵	212	239
8	8		ARM Platinum	178	173
9	9		Vale S.A. ⁶	144	135
10	10		Glencore plc.	116	119

¹ Refined production from mining operations

³ Company registered as Sibanye Gold Ltd.

Source: GFMS, Refinitiv

TOP 10 PALLADIUM PRODUCING COMPANIES

Rank	2017 2018		Company	Output (000 ounces)	
	2017	2018		2017	2018
1	1		OJSC MMC Norilsk Nickel	2,780	2,729
2	2		Anglo American Platinum Ltd ¹	1,035	951
3	3		Sibanye-Stillwater ³	663	823
4	4		Impala Platinum Holdings Ltd ²	657	654
5	5		Lonmin plc. ⁴	332	313
7	6		North American Palladium Ltd.	202	237
6	7		Vale S.A. ⁶	214	218
9	8		Northam Platinum Ltd. ¹	142	171
8	9		ARM Platinum	160	159
10	10		Glencore plc.	136	119

² Attributable mine production including Zimplats

⁴ Calendar year refined sales; ⁵ Estimated metal in concentrate;

⁶ Including custom feeds. Source: GFMS, Refinitiv

palladium resources, but low grades (0.8 g/t) make it currently financially unviable.

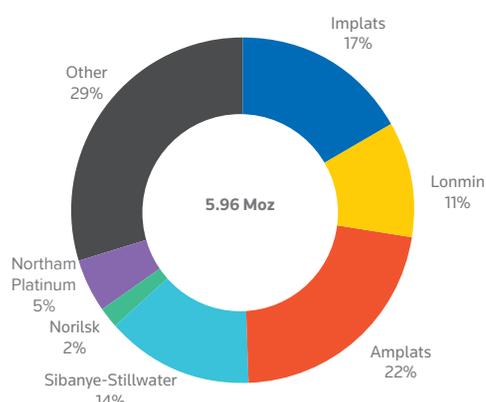
UNITED STATES

The **United States** solidified its position as the world's fifth largest PGMs producer, following an increase in mine production for the fourth consecutive year. Specifically, platinum production rose by 2% to 0.1 Moz (4 t) and palladium output grew by 7% to 0.5 Moz (15 t). The country's solid performance was supported mainly by a ramp-up at Sibanye-Stillwater's Montana operations, which includes the East Boulder, Stillwater and Blitz mines. Stillwater is the world's highest grade PGM deposit, averaging 19.2 g/t and holds over 14.8 Moz (476 t) in PGM's reserves, 76% of which is palladium, and the rest platinum. The adjacent Blitz mine started production in October 2018 after the commissioning of three stope blocks and is expected to continue its ramp-up during the next few years, reaching design capacity by late 2021, totalling a production of 0.3 Moz (10 t) annually from 2022. The East Boulder mine is also expected to add a further

5% to annual production for all U.S. PGM operations by 2022, as high returns are anticipated from the ongoing Fill the Mill project. Around half of Sibanye-Stillwater's capital expenditures forecast of \$240 M for 2019 is destined for the development of the above mentioned projects.

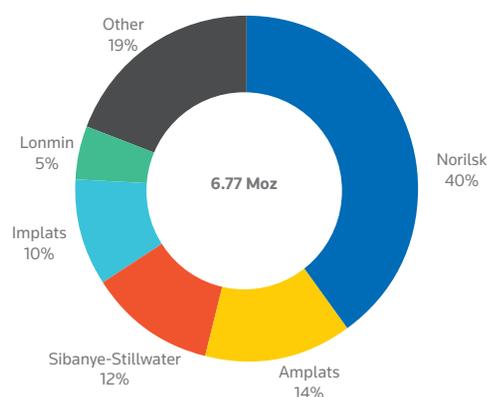
In 2018, Sibanye-Stillwater entered into a streaming transaction, in which 5% of refined mine palladium will be delivered to Wheaton Precious Metals for a cumulative total of 0.4 Moz (12 t). Thereafter the percentage will drop to 2% of total production for a further 0.2 Moz (6 t), and finally to 1% over the life of mine of the U.S. PGM operations. In exchange, the company received \$500 M on July 2018, and will be paid an equivalent between 18% and 22% of the spot price of palladium deliveries during each term. The East Boulder and Stillwater mines also have streaming agreements with Franco-Nevada for 5% of their PGM production. The other producer in the country, Lunding Mining, posted a decrease in its PGM production to near zero values. The company's Eagle mine changed its operational sequencing, resulting in low grades.

2018 PLATINUM MINE PRODUCTION BY COMPANY



Source: GFMS, Refinitiv

2018 PALLADIUM MINE PRODUCTION BY COMPANY



Source: GFMS, Refinitiv

RUSSIA

Russian palladium production decreased by 2% to 2.7 Moz (86 t) in 2018, representing 40% of the world's total mine supply. The drop follows Norilsk Nickel, the main producer, decision to cease all third-party palladium feeds. During the last few years, the company has been improving the efficiency and reducing pollutant emissions in its operations, mainly at the Polar and Kola divisions, positioning Norilsk as the lowest-cost PGM producer. During 2018, palladium was the largest contributor to the company's revenue, accounting for 34% of its total. Robust metal prices, averaging 19% higher than 2017, led to the sale of owned metal stocks which were accumulated during 2017, increasing physical volume sales by 24% to 2.9 Moz (93 t).

Platinum production in the country decreased by 2%, totalling 0.7 Moz (22 t). Output at Norilsk's Russian operations dropped to 0.6 Moz (21 t), including the material processed at the Harjavalta Plant in Finland. The company signed in February 2018 an agreement with Russian Platinum, forming a strategic partnership to develop disseminated ore deposits in the Norilsk Industrial District. The JV aims to produce 2.2 Moz (71 t) to 3.1 Moz (100 t) annually, becoming one of the largest PGM producers. While the feasibility study is due to start at the end of 2019, it is estimated that the project, which includes the Kondyor, Norilsk-1 and Chernogorskoye deposits, holds over 168.0 Moz (5,401 t) in PGMs resources, and over 3.9 Moz (125 t) of gold resources.

Rhodium production dropped for the third consecutive year, falling to the lowest level since 2005, mainly due to lower concentrate purchases

from Rostec. According to our estimations, Russian total output was 0.1 Moz (2 t), a 9% share of total rhodium output, maintaining the position as the second largest producer.

SOUTH AFRICA

South African platinum production increased by 1% in 2018, totalling 4.3 Moz (138 t). The biggest gains were posted at Impala's Marula, Northam's Booyendal and Amplats' Mogalakwena and Mototolo mines, increasing output by a combined 0.1 Moz (5 t). Record production of 0.6 Moz (20 t) was reported at the Kroondal mine, owned by Sibanye-Stillwater and Amplats on a 50%-50% basis, representing a 7% increase from 2017. On the other hand, losses were realised at Impala's Rustenburg operations, where a plan to close five shafts and sacrifice over 0.2 Moz (7 t) of annual platinum production during the next three years, in order to fight increasing costs, is undergoing. Further losses were posted by Atlasa Resources' for the Bokoni mine, as it was put on care and maintenance in October 2017.

On February 2018, Heraeus Precious Metals and Northam Platinum announced the opening of a new smelter at the Zondereinde mine. Both companies entered a 20-year partnership agreement in 2015, in which Heraeus refines Northam's PGM concentrates and purchases up to 40% of its refined precious metals, in exchange for Heraeus investment in the smelter expansion.

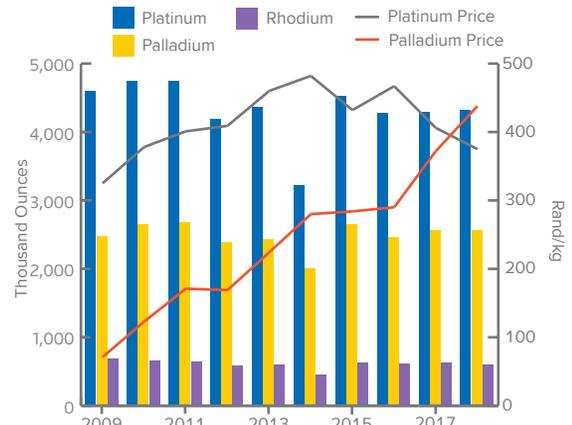
At the end of 2017, Sibanye-Stillwater announced its intention of taking over Lonmin, in an all-share deal valued at \$382 M. During 2018 the deal

RUSSIAN MINE PRODUCTION



Source: GFMS, Refinitiv

SOUTH AFRICAN MINE PRODUCTION



Source: GFMS, Refinitiv

was approved by both Lonmin's and Sibanye's shareholders, but the South African Competition Tribunal imposed several labour and financial conditions that Sibanye-Stillwater appealed. The transaction is expected to see the final green light in H1 2019, after which the company's position in South Africa will strengthen considerably. Sibanye's 3PGE+Gold reserves will grow by 32.2 Moz (1,035 t) to total 52.7 Moz (1,694 t). The company is expected to become the third largest platinum producer and second largest palladium miner, with a share of 35% and 22%, respectively, of the world's total.

PRODUCTION COSTS

After the closure of several loss-making shafts in 2017, especially in South Africa, and a robust performance in Russian operations, Total Cash Costs (TCC) plus Capex fell by 3% to \$740/PtEqoz. The biggest year-on-year cost increase was posted in Zimbabwe, mainly fuelled by the Real Time Gross Settlement (RTGS) forex loss, which led to higher import costs from South Africa, the main manufactures and services supplier. Amplats' Unki mine costs rose marginally by 1%, but after the commissioning of a new smelter in Q3 2018, the company expects to lower costs in the near future. Lower throughput at Zimplats' operations, Zimbabwean PGM's main producer, pushed costs up by 5%. Further cost rises were posted in the North American region, mainly following higher mining expenses and lower head grades at North American Palladium's Lac des Iles mine, in Canada, and considerable higher capital expenditures in Sibanye-Stillwater U.S. operations.

TOTAL CASH COSTS PLUS CAPEX PER EQUIVALENT OUNCE

	2017	2018	Chg (18/17)
North America	752	800	6%
South Africa	979	985	1%
Zimbabwe	725	787	9%
Russia	567	512	-10%
World*	766	740	-3%
World**	925	938	1%
Unprofitable ounces*	32%	38%	
Unprofitable ounces**	18%	20%	

*Excluding Russia; **Including Russia.

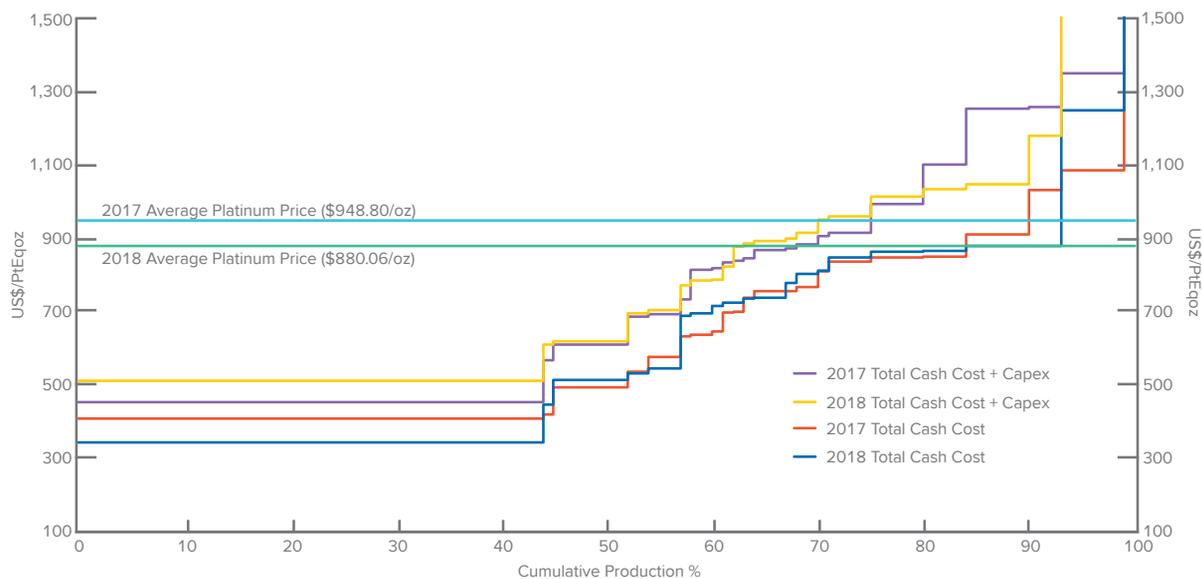
Note: Figures include sustaining and expansionary capex

Source: GFMS, Refinitiv

Additional cost increases were posted in South Africa, the highest-cost country, as TCC+Capex rose by 1% to \$985/PtEqoz. The main two reasons behind this hike were labour disruptions in most operations and costs associated with the ongoing crisis at State-run power producer, Eskom, with costs negatively impacted by the combination of load shedding and tariff hikes. For the 2019/2020 period, a further increase of 9% is scheduled, and the company is lobbying for further hikes to partially solve its financial problems. This could inflict further punishment on the platinum sector which is already stressed by unfavourable market conditions, despite the closure of several high-cost shafts during the last few years.

Offsetting the costs rise, Russian costs performance was stellar during 2018, where the depreciation of the rouble against the U.S. dollar and the optimisation of material processing pushed costs down by 10%, to \$512/PtEqoz. At a global level, we estimate around 20% of the PGM operations are loss-making, an increase of 2% from last year.

2018 COST CURVES



Source: GFMS, Refinitiv



AUTOCATALYST RECYCLING

- Global platinum recycling rose 5% to 1.3 Moz, while palladium scrap recovered from autocatalysts also increased by 7% to 2.2 Moz last year.
- Refinery outages have affected the supply chain and capacity remains tight.
- Impurities such as silicon carbide or carbon have become increasingly present in autocatalysts, increasing smelting complexities.

Last year, autocatalyst recycling volumes returning from the market were good. Platinum supply recovered from autocatalysts grew 5% to 1.3 Moz (40 t), while palladium witnessed an increase of 7% reaching 2.2 Moz (68 t). At that rate, platinum autocatalyst scrap contributed to 17% of total supply of platinum last year whereas palladium’s share is slightly higher at a quarter. Particularly in the case of palladium, scrap supply at the moment is very needed. The market has been squeezed repeatedly with supply of new palladium ounces almost exclusively finding their way back into the automotive space, driving prices up in the process.

Since the emergence of the VW emission scandal, major automakers have overhauled their strategy in regards to their future powertrains by embracing more electrification. This means more hybrid vehicles which are driven by gasoline with palladium rich aftertreatments installed. As such, demand for palladium has skyrocketed resulting in high capacity utilisation rates at PGM refiners and longer lead times than normal. The outage of two pgm refiners created a bit of a bottleneck in the market last year too, which, despite volumes rising, could have spillover effects into this year.

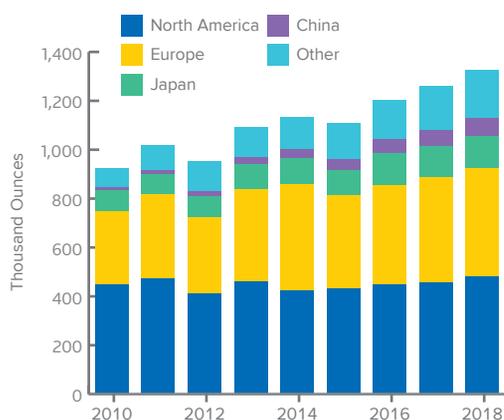
Although its a global phenomenon, platinum, particularly in Europe, had to deal with increasing challenges regarding silicon carbide containing scrap from particulate filters returning from the market. Smelters have indicated for years the increasing challenge of dealing with material containing aluminium titanate, vanadium pentoxide or silicon carbide. Particularly silicon carbide creates issues in the furnace, which supposedly is three times as heavy as cordierite material. Most furnaces are not designed for dealing with high impurities in their feed.

In the case of the presence of aluminium titanate, the material needs special treatment which is better placed for a base metals smelter to take care off. Base metals smelters, however, are not that good in recovering rhodium. Other major challenges that have emerged in recent years are the presence of the insulating bearing mats which contain refractory ceramic fibres and are considered similar to asbestos. As such, dealing with them requires special treatment.

For these reasons, autocatalysts are considered hazardous material by the European authorities, at least as long as they are not installed on a vehicle. At the same time, regulation surrounding the treatment of this material differs in the various European countries which makes dealing with the material challenging.

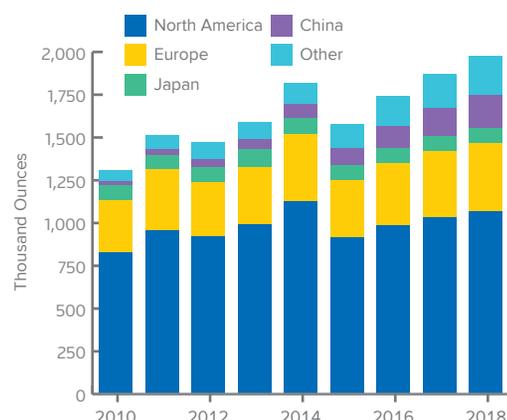
The increasing presence of impurities in autocatalyst smelter feeds has had an effect on how prices for the material are calculated based on not only the presence of precious metals, such as platinum, palladium and rhodium, but also, for example, the carbon content. If impurities are higher, smelters will charge a premium to compensate for the increase in effort to win back the metal, such as blending it with higher grades.

GLOBAL PLATINUM AUTOCATALYST RECYCLING



Source: GFMS, Refinitiv

GLOBAL PALLADIUM AUTOCATALYST RECYCLING



Source: GFMS, Refinitiv

Due to the backwardation in the palladium market, smelters indicated that they need to allocate more capital to cover the possible rise in lease rates. At the same time, credit facilities seem to have dried up, similar to what seems prevalent in the overall mining industry. In North America, volumes for platinum, palladium and rhodium all rose last year on higher volumes of catalysts coming back from the market. Industry consolidation remained a factor, particularly in European operations, which however, also stretch their collection arms into foreign territories. As such, some individual gains also point towards increases in market share, but in general, we have the view that volumes were good last year. The reduction in recycling rates in previous years due to low steel prices has turned the other way, particularly with prices for two out of the three precious metals, palladium and rhodium, used in autocatalyst recycling having increased by 23% and 70% respectively since the beginning of 2018.

Not all the same material comes back from the market. In fact, last year we saw a larger amount of diesel truck autocats returning in North America, mainly containing DPF and DOC filters. Platinum rich catalysts are still concentrated in Europe but palladium catalysts are also increasingly returning from the market. This is a result of Europeans buying smaller cars with smaller engines which increasingly are more gasoline driven with palladium and rhodium rich aftertreatment options installed. With the usual lag in lockstep, autocatalysts coming back from the market in Europe largely consist of vehicles with filters that adhere to Euro 2, 3 and 4 emission legislation.

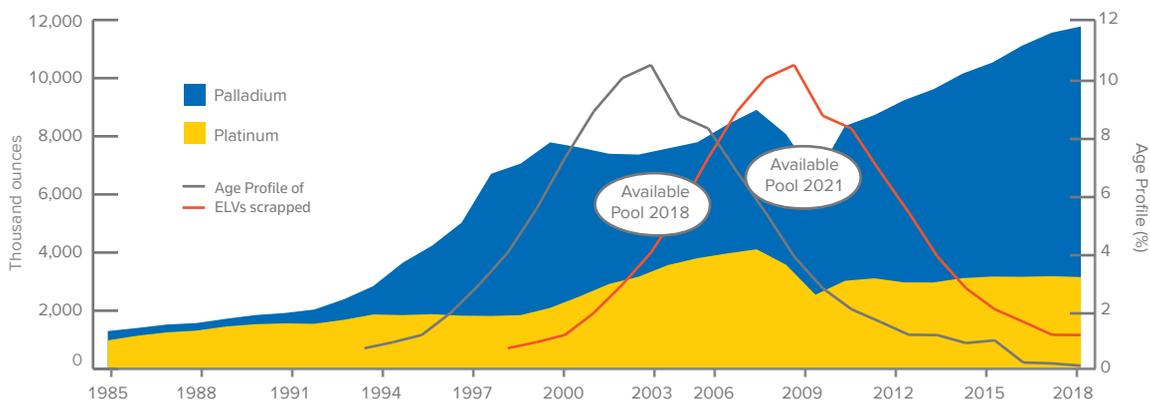
In terms of the composition of material returning from the market, some indicate that levels of rhodium in specific vehicles can be particularly high. Rhodium is used for NOx conversion and is the only precious

metal that can deal with that well. NOx limits are increasing across the board and as such loadings are on the rise in newly manufactured cars as well as scrapped ones. Particularly in the case of hybrids, the presence of rhodium can be very high. This is a reflection of the technology which allows for more frequent stop starts, and with that, a cooling of the engine and resultant catalyst. As such, higher loadings are required to deal with that in addition to the cold start of the vehicle when the engine temperature is running low.

Looking forward, we expect autocatalyst recyclers to continue to have plenty of business in the coming five-to-ten years. Some consolidation in the supply chain, particularly on the collecting lower end of the market, seems to be easy to deal with. Where it becomes more challenging is at the refiner front, where there are only approximately two handful of players. If some go offline for whatever reason, this can quickly develop bottlenecks in the market. At the same time, as is the case with electronic scrap, throughput seems to be increasing and impurities and loadings falling, which forces smelters to increase their efforts for the same amount of revenue. The current higher prices are certainly helping in maintaining a solid stream of metal.

Beyond autocatalysts, however, once BEVs and even fuel cell vehicles start to become the norm, recycling will change dramatically. Fuel cells and batteries might be green in their use, however, recycling the metals from batteries or fuel cells is a different, complicated and a challenging business. The amount of precious metals present will be far less in the case of BEVs and with fuel cells proper dismantling will be required. Recyclers will have to educate themselves properly before engaging in this new endeavour.

AUTOCATALYST DEMAND AND AGE PROFILE



Source: GFMS, Refinitiv (Johnson Matthey demand data for pre-1999)



JEWELLERY SCRAP SUPPLY

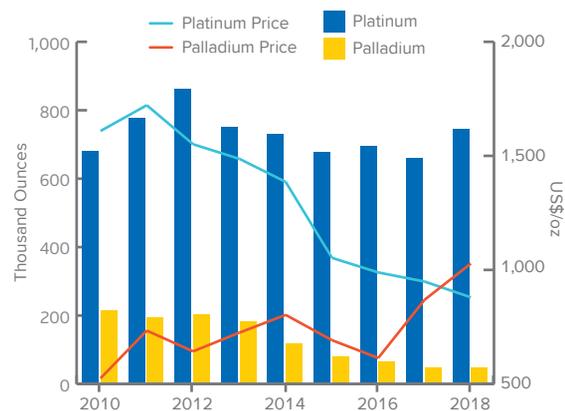
- Global platinum jewellery scrap increased by 13% year-on-year to 0.8 Moz (23 t), largely driven by higher recycling volumes from China. Supply elsewhere was tempered by weaker prices.
- Platinum jewellery scrap from China jumped by 20% in 2018, to 0.6 Moz (17 t).
- Palladium jewellery scrap in 2018 increased by 4% year-on-year to 48,698 ounces (2 t) aided largely by acutely higher prices.

Global platinum jewellery scrap stood at 0.8 Moz (23 t) in 2018, 13% higher on a year-on-year basis. Platinum jewellery scrap from **China**, jumped by 20% last year, to 0.6 Moz (17 t) and accounted for 74% of the global market. Domestic jewellery fabricators have increased the proportion of scrap used in the manufacturing process in recent years, rising from an estimated 27% in 2015 to 48% in 2018, and is poised to jump to over 50% in 2019. With the lackluster performance of the industry, fabricators had to lower their production costs, and using scrap over fresh metal is one way to achieve this. While there is no Value Added Tax (VAT) when buyers purchase physical platinum from the Shanghai Gold Exchange, the selling price usually comes with a 5%-6% market premium, which can be viewed as another form of taxation. As a result, fabricators increased their efforts in collecting jewellery scrap to limit overheads. Moreover, consumers are also returning their old platinum pieces in exchange for new gold items.

Elsewhere, **North American** platinum jewellery scrap increased by just 2% year-on-year to 6,100 ounces (0.2 t). Accounting for less than 1% of the total global scrap that was collected last year, supply was tempered by the weaker price activity. Meanwhile in **Europe**, the volume of platinum jewellery scrap dipped by 2% year-on-year to 6,500 ounces (0.2 t). Recycling volumes in **Japan** were also weaker in 2018, falling by 4% over 2017 volumes, with the 9% fall in the yen platinum price discouraging consumers from liquidating old items.

Globally, palladium jewellery scrap supply rose 4% last year to 0.05 Moz (2 t), with the 18% jump in the average dollar palladium price encouraging higher rates of recycling. In Europe, higher prices motivated both consumers and the supply chain to sell back old stock to the market last year, pushing supply higher by 5% to 10,776 ounces (0.3 t). Japan also received

PLATINUM & PALLADIUM JEWELLERY SCRAP



Source: GFMS, Refinitiv

higher jewellery scrap last year, by 11% to 26,823 ounces (0.8 t), with the 17% rise in the yen palladium price accounting for the material increase. While scrap supply increased in all other locations, in China it fell to negligible levels as the domestic fabrication market has all but collapsed.

ABOVE-GROUND BULLION STOCKS

- The platinum market remained in a small surplus last year, resulting in above-ground stocks of 7.6 Moz (236 t) at the end of 2018.
- Above-ground stocks of palladium declined for a ninth year, resulting in the market recording its deepest deficit this century.

METHODOLOGY

Our supply/demand balances for platinum and palladium are designed to separate any distorting effect of flows from pre-existing above-ground stocks. Where we are able to identify such flows, these are shown separately as “below the line” items. Consequently, the arithmetical difference between our estimates of new supply (from mining and recycling) and fabrication demand, i.e. the physical surplus or deficit, represents our view of the underlying fundamentals of these metals. When a physical surplus is reported, this shows an excess of new supply over fabrication demand, implying an increase in above-ground stocks. Conversely, a physical deficit, which developed to vastly contrasting degrees for platinum and palladium in 2018, indicates a shortfall of new supply relative to fabrication demand. This implies a similar decline in above-ground stocks as this metal is required to redress that shortfall and satisfy fabrication needs. Meanwhile, we also quantify the scale of above-ground platinum and palladium bullion stocks. This includes inventories in the terminal markets,

allocations to physically-backed ETPs and declared stock holdings on futures exchanges. In addition, we include an estimate for Russian government stocks of palladium and stocks of refined metal that may be held by industrial consumers and producers over and above normal levels.

PLATINUM

In 2018 the platinum market remained in a small surplus, although this had contracted somewhat from 2017 levels, falling by 6% or 11,000 ounces to 156,000 ounces (5 t). Total supply rose by 2% or 144,000 ounces to 8.0 Moz (248 t), its highest level since 2011, with falling mine production (which modestly declined by 0.1% or 7,000 ounces to 6.0 Moz (187 t), its lowest since 2014, on the back of falling production in North America and Russia), not being able to offset a sharp increase scrap levels. Indeed, both jewellery and automotive scrap inflows increased by 5% and 2% respectively, with the latter recording its highest level of scrap returns this century at 1.3 Moz (40 t). Meanwhile, total demand also rose last year by 2% or 155,000 ounces to 7.9 Moz (246 t), driven by a surge in demand for chemical and glass applications. We estimate that above ground stocks at the end of 2018 were in the region of 7.6 Moz (236 t), an increase of 2% or 156,000 ounces, equivalent to 11.5 months of demand. While, ETPs recorded inflows last year of 137,000 ounces, the absorption of metal was not enough to offset the surplus in above-ground stocks, with our net balance still recording a modest surplus of 19,000 ounces (0.6 t), although this was 90% lower than in 2017. Please note, like in 2017, there was no marked change in industry stocks last year.

ESTIMATED MOVEMENTS IN STOCKS

PLATINUM (000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Physical Surplus/(Deficit)	443	567	19	578	(761)	(18)	(98)	167	156	239
Industry Stocks	0	(100)	(300)	(1,000)	1,300	(50)	50	0	0	0
Exchange Traded Funds	(579)	(156)	(238)	(891)	(221)	192	(15)	15	(137)	150
Sub total - stock movements	(579)	(256)	(538)	(1,891)	1,079	142	35	15	(137)	150
Net Balance	(136)	311	(519)	(1,314)	318	123	(63)	182	19	389

PALLADIUM (000 ounces)

Physical Surplus/(Deficit)	(389)	(89)	(1,003)	(1,139)	(1,571)	(1,106)	(1,664)	(1,661)	(1,698)	(1,841)
Russia	800	800	400	200	0	0	100	200	0	0
Industry Stocks	0	(50)	(100)	(500)	600	(150)	140	(290)	(160)	0
Exchange Traded Funds	(1,090)	532	(448)	0	(899)	727	637	383	527	300
Sub total - stock movements	(290)	1,282	(148)	(300)	(299)	577	877	293	367	300
Net Balance	(678)	1,193	(1,151)	(1,439)	(1,870)	(529)	(786)	(1,369)	(1,332)	(1,541)

Source: GFMS, Refinitiv

PALLADIUM

The palladium market recorded its ninth year being in deficit in 2018, with the deficit level deepening from 2017 by 2% or 37,000 ounces to 1.7 Moz (53 t), the largest deficit recorded in the market since 2000. Despite total supply levels increasing by 1% or 125,000 ounces to 9.1 Moz (283 t) (on the back on increased scrap levels in jewellery and in particular automotive scrap, which rose to its highest level this century). It was not enough to offset the rise in total demand levels, which jumped by 2% or 162,000 ounces to 10.8 Moz (336 t), the highest level since the turn of the century. This impressive rise in demand was driven largely by the automotive market, which recorded a rise in demand of 3% or 248,000 ounces to 8.6 Moz (268 t), while rising demand from both the chemical and other applications sector aided the jump, offsetting losses in electronics, dental, jewellery and retail investment, which fell to its lowest level since 2002. We estimate that total above-ground stocks by end-2018 were at 6.2 Moz (193 t), a decrease of 22% or 1.7 Moz (53 t), equivalent to 6.9 months of demand cover.

Looking to our net balance, the palladium deficit slightly eased last year, contracting by 3% or 37,000 ounces to 1.3 Moz (41 t). This result was largely influenced by the significant outflows in ETPs, which recorded 527,000 ounces of metal being released into the market, the largest level of outflows since 2016, with industry stocks unable to absorb the excess metal.



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5. DEMAND

FABRICATION BY REGION, 2010-2019

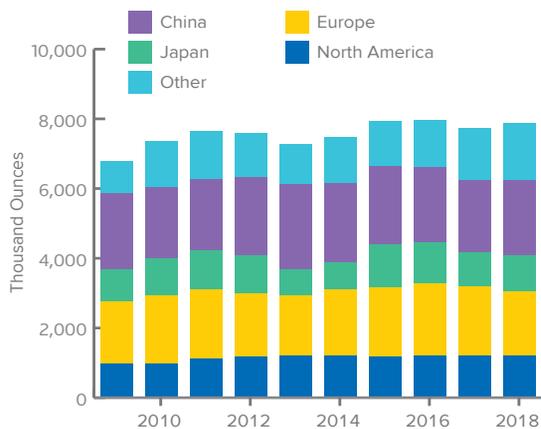
PLATINUM (000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
North America	982	1,125	1,178	1,206	1,225	1,193	1,218	1,228	1,217	1,268
Europe	1,965	2,002	1,810	1,748	1,883	1,985	2,082	1,973	1,849	1,799
Japan	1,036	1,097	1,082	734	756	1,224	1,172	961	1,010	986
China	2,067	2,049	2,261	2,416	2,274	2,228	2,138	2,079	2,181	1,975
Other Regions	1,297	1,362	1,261	1,173	1,333	1,311	1,353	1,480	1,619	1,771
Total	7,347	7,634	7,592	7,276	7,470	7,942	7,963	7,722	7,877	7,800

PALLADIUM (000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
North America	2,026	2,046	2,367	2,572	2,565	2,651	2,827	2,912	2,951	2,985
Europe	2,010	2,222	2,166	2,112	2,190	2,301	2,350	2,415	2,423	2,342
Japan	1,537	1,442	1,608	1,536	1,538	1,422	1,382	1,393	1,336	1,300
China	1,678	1,694	1,787	1,938	2,012	1,951	2,242	2,364	2,421	2,601
Other regions	1,272	1,253	1,247	1,220	1,346	1,339	1,424	1,516	1,630	1,750
Total	8,522	8,658	9,175	9,377	9,652	9,664	10,225	10,599	10,762	10,978

Source: GFMS, Refinitiv

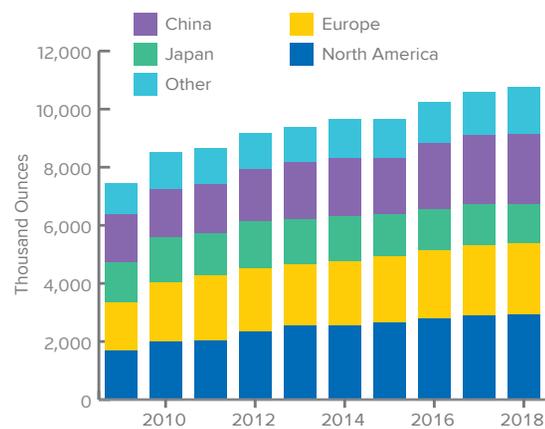
- Global platinum demand edged 2% higher last year to 7.9 Moz (245 t) as stronger industrial demand was offset by falls in jewellery and autocatalyst demand.
- Demand for platinum in autocatalyst applications retreated 1% in 2018, led lower by weakness in Europe and a modest decline in Japan, with all other major markets stronger year-on-year.
- Platinum usage in glass, electronics, and chemical applications all enjoyed impressive gains in 2018 but all key sectors were stronger on a year-on-year basis.
- Platinum jewellery fabrication fell 5% in 2018, to a ten-year low, dragged lower by a double-digit fall in China, with annual gains recorded in North America, Europe, Japan, and our Other Regions category.
- Total palladium demand rose 2% last year to an estimated 10.8 Moz (335 t) as growth in autocatalyst, chemical, and other industrial demand was tempered by falls in electronics, jewellery, and dental fabrication.
- Palladium used in autocatalyst fabrication jumped 3% in 2018 to a new record high. Growth was recorded in all markets with the exception of Japan, which declined marginally, as higher loadings and tighter emission control pushed demand higher.
- Palladium jewellery fabrication declined 6% in 2018 to a record low, with falls in all major markets.
- Retail investment for palladium slumped 39% last year with liquidation of bars in Europe and North America having the greatest impact.

PLATINUM DEMAND BY REGION



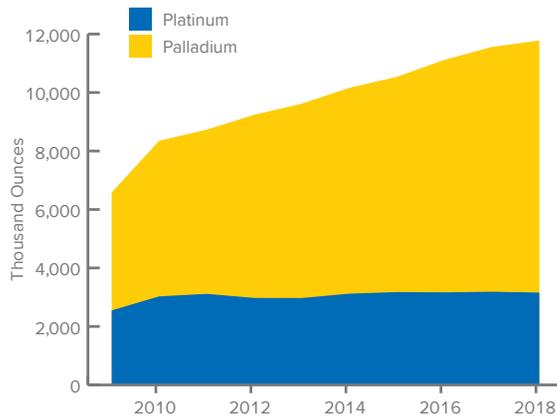
Source: GFMS, Refinitiv

PALLADIUM DEMAND BY REGION



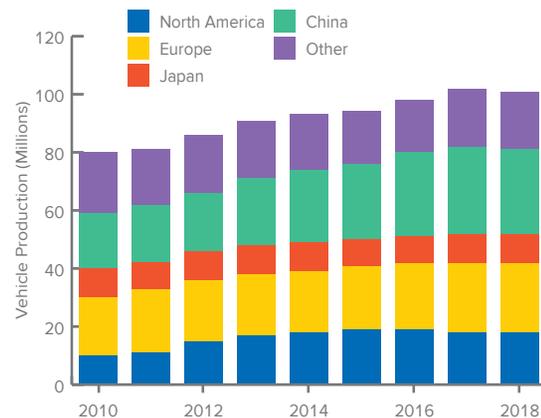
Source: GFMS, Refinitiv

PGM AUTOCATALYST DEMAND



Source: GFMS, Refinitiv

GLOBAL VEHICLE PRODUCTION



Source: GFMS, Refinitiv; LMC Automotive

AUTOCATALYST DEMAND

PLATINUM OVERVIEW

Platinum finds a wide usage in LDV and HDV diesels as an oxidizer of CO and hydrocarbons. In diesel vehicles it also finds wide usage in diesel particulate filters (DPF) in combination with palladium. Generally, palladium and/or rhodium are used to combat the NOx. Modern diesel aftertreatment solutions frequently consist of an oxidations catalyst (DOC) combined with a selective catalytic reduction (SCR) and a particulate filter (DPF). Often an SCR is assisted by an ammonia slip catalyst that captures some of the urea used in an SCR to reduce the NOx. This technology is increasingly utilised in mid and large vehicles. SCR's don't have PGMs loaded on them but the DOC in many cases needs to be higher loaded to compensate for that. Generally though, this route opts for decreasing use of PGMs compared to, for example a lean NOx trap (LNT), however, due to increasingly tighter emission legislation and stronger emission test procedures, particularly in Europe, forces that counter this trend are also at play.

Globally, platinum demand in autocatalyst applications fell 1% last year reaching 3.2 Moz (99 t). Unsurprisingly, the biggest drop was recorded in Europe, where platinum demand contracted by 8% to 1.3 Moz (40 t). The 116 koz loss was somewhat offset by a minor rise in North America, increasing by 4%, whereas demand from Japan and China remained largely flat. Our other Regions category saw a rise of 10% last year.

As a result of the VW emission scandal breaking in 2015, it was clear diesel vehicles were at the forefront of the emission rigging procedures. In order

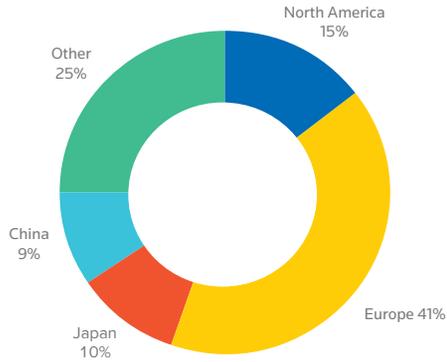
to get a foothold in the North American market, VW installed software that would detect lab vehicle testing conditions and switch the mode of the car to one that would be compliant with the emission standards. The discrepancies detected during a road testing procedure by an independent party eventually brought the whole practice to light. VW eventually turned out not to be the only one rigging the game; there were many more European and Japanese OEMs involved in similar practices. Indeed, the European Union regulators recently found that German automakers colluded to withhold the most effective emissions control systems from European consumers. However, after three years of ongoing legal battles, the final fines from a batch of court procedures are dripping in at VW (and FCA). Porsche was recently fined \$600 ml for its role in diesel engine emission rigging and Audi, also under the VW umbrella, was fined by almost \$1 bn as well.

AUTOCATALYST DEMAND

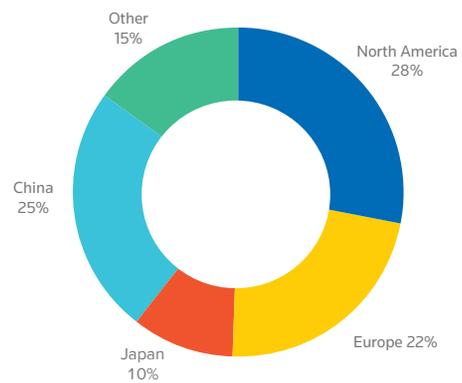
PLATINUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	443	461	500	4%
Europe	1,408	1,292	1,236	-8%
Japan	324	322	314	-1%
China	293	294	307	0%
Other regions	720	790	851	10%
Total	3,187	3,158	3,208	-1%
PALLADIUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	2,368	2,430	2,472	3%
Europe	1,912	1,939	1,872	1%
Japan	878	852	837	-3%
China	2,050	2,113	2,281	3%
Other regions	1,165	1,287	1,417	11%
Total	8,373	8,621	8,879	3%

Source: GFMS, Refinitiv

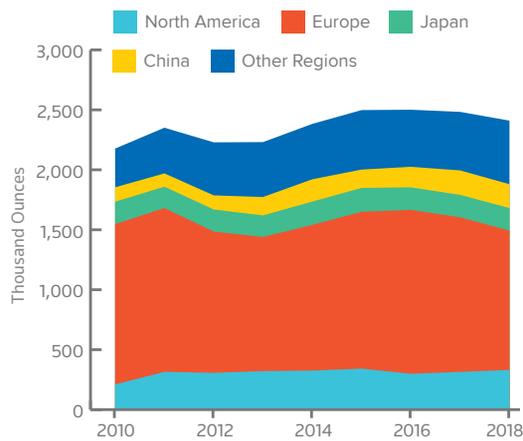
PLATINUM DEMAND IN AUTOCATALYSTS, 2018



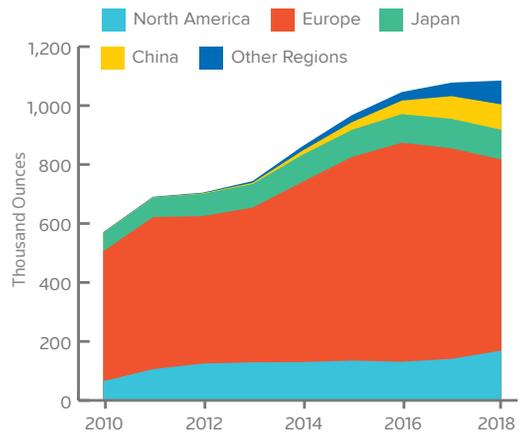
PALLADIUM DEMAND IN AUTOCATALYSTS, 2018



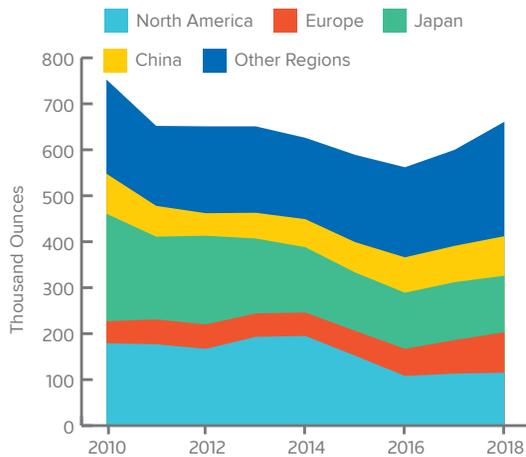
DIESEL PLATINUM DEMAND



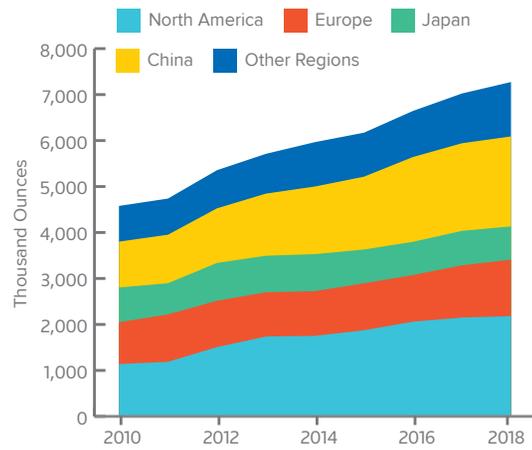
DIESEL PALLADIUM DEMAND



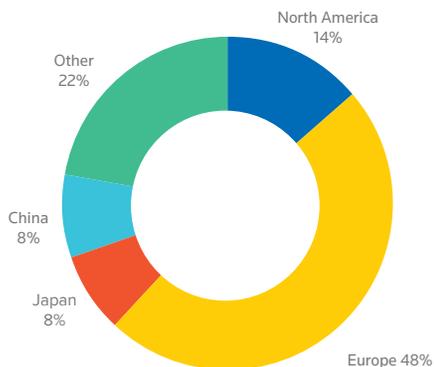
GASOLINE PLATINUM DEMAND



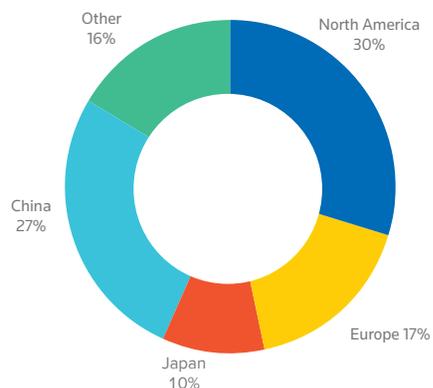
GASOLINE PALLADIUM DEMAND



PLATINUM IN DIESEL, 2018; REGIONAL DEMAND



PALLADIUM IN GASOLINE, 2018; REGIONAL DEMAND



Source: All charts; GFMS, Refinitiv

DEMAND

What became clear was that the lab based testing procedure was dated and needed to be revamped. Since then, many governments have started to tighten the testing procedure. As such, from September 2018, car makers were made subject to a far more rigorous emission testing procedure, also known as Real World Driving (RDE) which involved extensive road driving with different cycles in terms of speed, load, surroundings and other variables. A conformity factor still allows for a wider variation in the real results and some argue that it actually sets compliance back to levels of Euro 5, but over time these will also be tightened. The result, however, is that the level of complexity in terms of aftertreatment options is increasing considerably too.

The traditional DOC+SCR+DPF are making way for a whole host of combinations. DPF and SCR are increasingly more integrated into a SCRf technology with or without a slip catalyst, depending on the dosing and other factors. Pure LNT and DPF options are likely going to decrease as well, making way for a LNT and SCRf technology combined with an SCR brick that contains an ammonia slip catalyst. Depending on where the catalysts will be fitted, under body or close to the engine (to increase speed of reaching the right operating temperatures), some options are going to be assisted with electric heating to combat the cold start emissions. We estimate loadings of diesel vehicles remained flat last year, and coupled with significantly lower vehicle production volumes in the region, responsible for the decline in platinum demand.

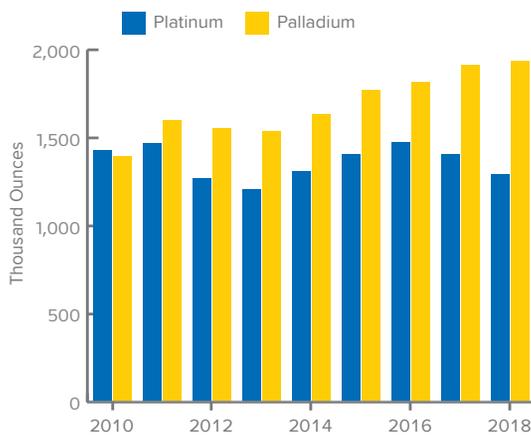
Following the diesel scandal in North America, production of diesels actually increased last year by 2% to 1.1 M units. On the face of it this might sound surprising, but VW was targeting the passenger car

market, hoping to raise production levels significantly there. As a result of this, diesel penetration has not fallen, as most of the growth was in the truck SUV, car SUV and pick-up segment and not in the traditional sedans segment. In the aftermath of the diesel scandal, those remain almost exclusively focused on gasoline, hybrid gasoline, BEV and increasingly fuel cell vehicles too.

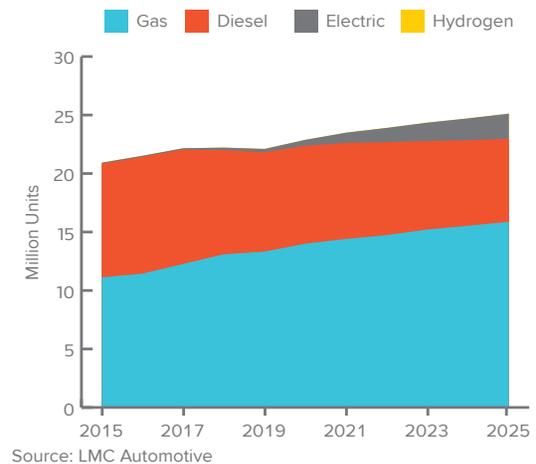
The automotive industry has made strong progress towards lower tailpipe CO2 emissions and higher fuel economy in recent years. In model year 2018, the industry achieved record low new vehicle CO2 emissions and record high fuel economy; 348g/mi of CO2 and 25.4 miles per gallon, which is almost half and double the amount respectively compared to 1975. In spite of engine technology progress and autocatalyst improvements, this is an impressive development given that North America has seen a considerable rise of SUV vehicles entering the market in recent years; they now account for 40% of all vehicles produced. SUV's tend to be larger in size and weight and as such pollute more emissions and consume more fuel. With the rise of the size of engine, so did autocatalyst, although this is not a given anymore in current modern vehicles. Nevertheless, loadings are still expected to continue to rise with the latest SULEV 30 limits based on California's Air Resource Board (CARB) with a phase in started in 2015 and the nationwide standards from EPA's Tier III rolled out in 2017. As such, we estimate that platinum consumed in North America in the light duty vehicle space reached 152 koz (5 t) last year, which was an annual rise of 2% compared to 2017.

Platinum demand in other regions is following similar developments as those recorded in Europe and North America. Japan has long been a big advocate for

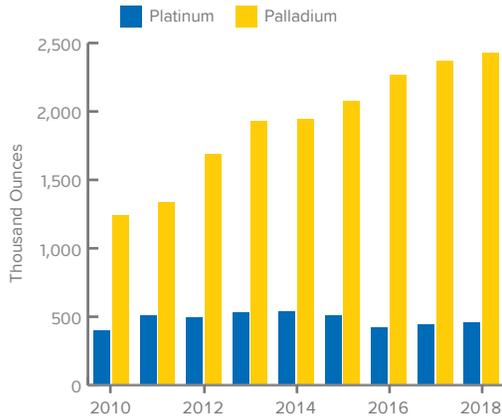
AUTOCATALYST DEMAND: EUROPE



EUROPEAN LIGHT DUTY VEHICLE PRODUCTION



AUTOCATALYST DEMAND: NORTH AMERICA



Source: GFMS, Refinitiv

hybrid vehicles, and as such, demand for those are considerable in the country (this will be addressed in the palladium section). The next big bet seems to be on hydrogen fuel cells, which we will also address in the next section, but clean diesels have not been completely off the minds of the Japanese OEMs. Clean diesels, when having proper aftertreatment options installed, are actually really clean and will be able to meet the increasingly more stringent emissions legislation. But their image in the LD space, beyond pick-up trucks and some SUV models, has faded following the emission scandal.

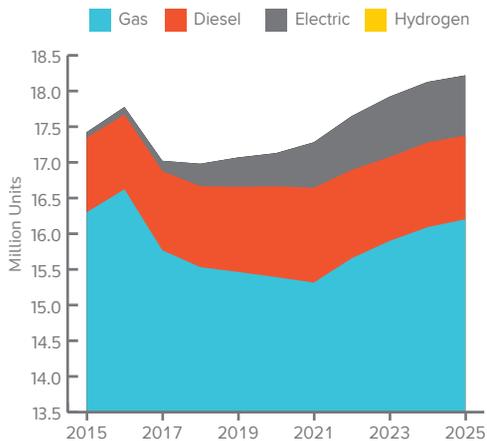
Platinum consumed in the gasoline sector we believe is even larger than platinum used in diesels. That has everything to do with the fact that gasoline vehicles are far more abundant in Japan than diesel vehicles and platinum is used in much smaller quantities per vehicle in gasoline compared to diesels. Platinum can be easily interchanged with palladium in some diesel aftertreatment options purely based on characteristics and driven by of course the price, which is hugely in platinum's favour these days. But the regulatory and costs burden so far have not motivated a lot of OEMs

to do so yet. We might see more of that in the coming years and definitely in the aftermarket.

In line with Europe, Japan has started to implement the new test cycle, harmonized world light vehicle test producer (WLTC) which forces OEM's to use more real life testing methods, such as not relying on the kerb weight of a vehicle, but adding another 75 kg minimum to account for a driver. All combined, we forecast platinum demand to have reached 229 koz (7 t) in 2018, which is 2% lower annually, mainly due to a drop in vehicle production.

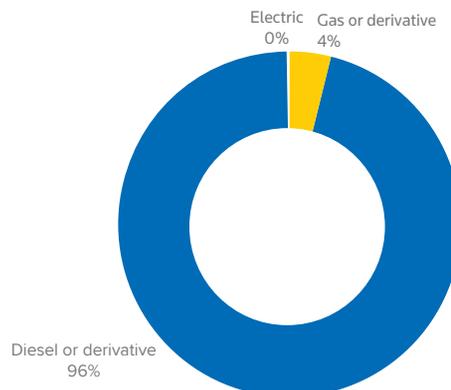
Similar to Japan, China also recorded a drop in LDV production last year falling by 4% to 26.6 M units. Diesels only make up 6% of that and also contracted to 1.7 M units. The general saturation in the Chinese market has had its effect on global sales; China accounted for 28% of global vehicle production last year. In spite of this, China is still lagging its emissions legislation compared to North America, Japan and Europe, but plans are there to make it, in the near future, the country with the strictest environmental standards, once China 6a for diesels gets rolled out in 2020. As is always the case, the first roll out will occur in the major cities before it gets implemented nationwide a couple years after. China, and other developing countries for that matter, however, have had issues with fuel quality in recent years, which usually included elevated sulphur levels that poison the catalyst and significantly reduce its functionality. This issue has been addressed by the Chinese refiners and the fuel quality has improved in recent years, which should allow for better air quality once the tighter emission regulation gets implemented and enforced. Until then, however, China 5 – equivalent to Euro 5 – is the prevalent emission legislation car makers have to adhere to. Considering no step

NORTH AMERICA LIGHT DUTY VEHICLE PRODUCTION



Source: LMC Automotive

NORTH AMERICA HEAVY DUTY VEHICLE PRODUCTION



Source: LMC Automotive

change has taken place in 2018 for diesel vehicles we estimate that PGM loadings have remained flat, but due to the drop in vehicle production, total platinum used in LDV contracted 2% to 173 koz (5 t).

Contrary to the developments recorded in the more mature markets, platinum demand from our Other Region category continued to rise last year by a whopping 12% reaching 242 koz (8 t) in 2018. Drivers for platinum demand are a function of more stringent emissions legislation and vehicle production too, but due to the wide range of countries in this group the differences vary widely. Big markets in our Other Region category are India, South Korea and Thailand, which jointly account for 79% of the regions total. South Korea, for example, runs legislation equivalent to Europe's 6d temp, which mean higher loadings per vehicle and relatively higher platinum demand as well, whereas India, on the other hand, still has Bharat Stage 4 in place which is considerably less stringent and therefore tends to consume less platinum per vehicle.

PALLADIUM OVERVIEW

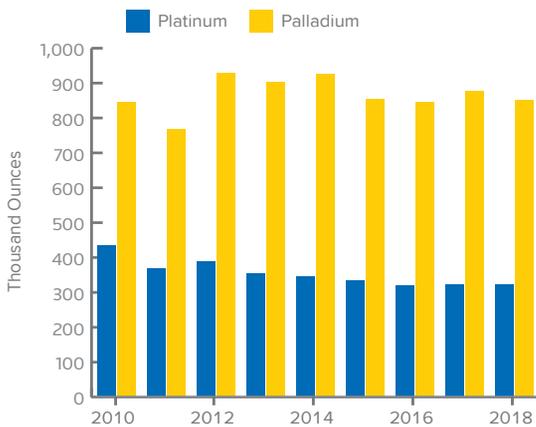
Global gasoline vehicle production contracted less than 1% to 74.5 M units last year. The main driver behind the drop was China, which fell 5% in 2018 and is responsible for one third of global production. With a market share of 13%, vehicle production in the United States also contracted by 2% to 9.9 M units, while Japan shaved 0.4% of its output to 8.3 M units in 2018. Those three markets account for 53% of total vehicle production. Contrary to the sentiment in diesels, gasoline powered vehicle production in Europe recorded healthy increases of 8% and 6% for the East and West part of the continent respectively, which is generally divided in a 40-60 split.

As is always the case, developments per individual country within Europe vary widely. Germany, the largest European market, good for a quarter of total output, witnessed a rise of 3% last year. But production from the second and third largest markets, Spain and Russia, who each had their struggles in recent years, particularly in the case of the latter, recorded double-digit growth.

On the emission legislation front, Europe is more harmonised, with the current Euro 6d temp legislation being supportive for palladium demand. This is particularly the case in gasoline vehicles, where we estimate a rise of 8% last year, countering the decline of palladium from diesels. The latest regulation requires compliance of particulate in number (PN) and NOx levels to be tested on RDE procedures. This legislation was introduced at the end of 2017 and will be applicable for all new models next year. Last year also saw the introduction of the WLTP replacing the outdated NEDC cycle. Both have increased the testing burden for automakers and resulted in an increase of PGM loadings on the three way catalyst. In addition, in order to reduce the PM in mass and number, many gasoline direct injection engines are fitted with a gasoline particulate filter (GPF). The difference to a DPF is that they generally are smaller in size and are not always PGM coated; loadings vary widely from non-existent to similar to what is on a three-way catalyst. As a result, palladium demand rose in Europe last year to 1.9 Moz (60 t) and we forecast this upward trend to continue in the coming years.

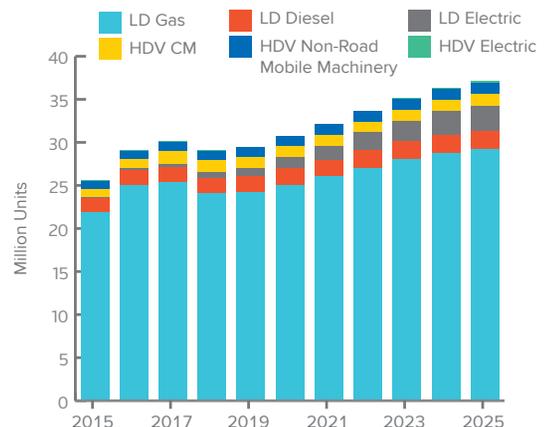
Despite a drop in gasoline vehicle production, palladium demand in North America rose moderately too mainly on the back of a further roll out of Tier III federal emissions legislation, which had a positive effect on loadings, rising 3% to 2.4 Moz (76 t). We

AUTOCATALYST DEMAND: JAPAN



Source: GFMS, Refinitiv

CHINESE VEHICLE PRODUCTION



Source: LMC Automotive

expect further upward pressure on catalyst loadings in the coming years on the back of tighter emission legislation.

A similar sentiment is present in the largest global vehicle market. Through the introduction of its Blue Sky Protection Plan, China consumed 3% more palladium in aftertreatment formulations last year reaching 2.1 Moz (65 t). If it wasn't for the drop in vehicle production numbers, demand would have risen even more substantially. As can be seen from the overview on page 35, China will be introducing China 6a emission regulation next year. This is expected to have significant upward pressure on loadings, which could be further exacerbated once China 6b gets introduced in 2023, forcing testing to be done on RDE requirements. Due to the slowdown in Chinese vehicle production, we feel that most of the rise in palladium demand in the coming years will come from the sales, or replacement, of vehicles adhering to the higher emission standards and using higher PGM loadings.

A certain saturation seems to have set in China, which is plagued with massive traffic jams in major cities and a government keen to restrict vehicle growth as well as a slowing economy. An inventory overhang is not helping either. China will probably have to adjust in the coming years but the further push to shore up its polluted skies will continue to keep PGMs in demand.

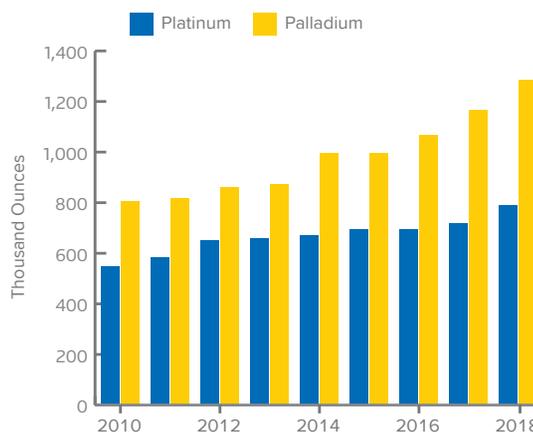
Those are also reasons why we continue to be optimistic about our Other Region category, which expanded vehicle production by 2%, or 221K units, to 13.4 M gasoline powered units last year. Considering the vast amount of different countries representing this category, the rate of progress in terms of vehicle production and implementation and enforcement of stricter emission standards differ considerably too. But one thing they all have in common is that all countries are moving in the same direction, which is towards the next stage of stricter standards. Each at their own pace. India, for example, will jump from Bharat stage 4 to Bharat stage 6 in the main cities as well as nationwide, which is a huge step change. Not far behind, Brazil will probably switch to the next stage in 2022-2023 called PROCONVE, whereas South Korea will continue to phase in their variant of K-LEV III, which is based on the U.S. version. All in all, the vehicle production trajectory points upwards, particularly for gasoline vehicles in the coming years, which coupled with more stringent emissions legislation across the board will drive PGM demand up too.

HEAVY DUTY VEHICLES

Heavy duty vehicles can be divided into on-road commercial vehicles, consisting of buses, medium and heavy duty trucks and non-road mobile machinery (NRMM) which entails all off road equipment. Emission legislation on road going heavy duty transport was in fact the first sector in transport to tackle emissions and as such, legislation tends to lead even the LDV space. In the case of the matured markets, most of the legislation focuses on reducing greenhouse gasses, such as CO₂, and increasing fuel economy and fuel consumption. In order to be compliant all new trucks are expected to deal with NO_x and PM on top of all the other pollutants. Through the extensive use of DOC+SCR+DPF, in various forms, with or without exhaust gas recirculation (EGR), the traditional emissions are reduced to levels compliant with the respective legislation.

Loadings in general are under pressure due to thrifting and the SCR technology, which more often uses a copper or vanadium based filter and no or very little, in the case of the presence of a slip catalyst, PGMs. Total platinum demand rose 4% to 579 koz (18 t). Unsurprisingly, North America and Europe take up the largest share of demand, 27% and 28% respectively, followed by China in third. In the matured market loadings are on the decline so the majority of demand will have to come from actual vehicle production and sales. North America, Japan, and Other Regions saw an increase in vehicle production whereas Europe and China witnessed a decline last year. In contrast to the matured markets, China and the Other Regions category still witnessed a rise in demand for PGMs through the increased use of advanced filter systems, countering the drop in production in China. North America was the region that stood out due

AUTOCATALYST DEMAND: REST OF WORLD



Source: GFMS, Refinitiv

to continued good production volumes on a strong economy whereas our Other Region had both, rising vehicle sales and tightening legislation.

NRMM has a wider range of different applications and as such, even in the mature markets aftertreatment options are not always installed. In fact, particularly in the developing countries this sector has plenty of scope to catch up. But even in the matured markets, harmonisation of legislation and therefore aftertreatment options remains a challenge which forces OEMs to look at the individual application and in which market it will be utilised. Demand for both platinum and palladium rose on balance 14% to 143 koz (14 t), of which platinum makes up the bulk, 96%, of the market in 2018.

FUEL CELLS

Fuel cells have long been the promising application in the industry that is supposed to offset the drop in PGM demand from autocatalyst. Fuel cells can be roughly divided into stationary – backup power and the like, transport – forklifts, buses, trucks cars etc – and portable, which includes a wide range of military as well as consumer applications. Fuel cell usage in transport applications looks the most promising in terms of PGM consumption, and in particular platinum, most definitely if you include future shipping and rail freight.

Proponents of fuel cells often compare it to BEV, which they claim have superiority over fuel cells in cars. BEV are cheaper, the infrastructure is actively being rolled out, energy conversion is higher, hydrogen is explosive etc. Some arguments hold more merit than others but in general we think it helps not to see fuel cell vehicles as a competitor to BEVs but more as a complimentary option. In the end, fuel cells also have a battery in their powertrain set up that becomes available during times a vehicle is expected to accelerate faster than the energy it can convert from hydrogen fuel, think, for example about an uphill drive. As such, we think of fuel cell vehicles as more a hybrid with BEVs.

That said, fuel cells do require a totally different set up as BEVs, something that supports a hydrogen infrastructure within and outside of the vehicle. Generating hydrogen can be done out of mainly two processes: natural gas and water. Extracting hydrogen out of natural gas is the most widely used option at the moment, which requires a lot of energy to do so and

is not really clean due to the presence of a fossil fuel, natural gas. Going down the electrolysis route would eliminate the need for fossil fuels, although getting hydrogen out of water remains an energy intense process as well. In order to make this powertrain option truly green, the same actually applies for a BEV, is asking the question as to how the energy is generated required for the hydrogen cracking or powering of the battery in case of a BEV?

To tackle that issue one could opt for the generation of electricity through solar power and store the hydrogen. This would deal with the energy storage challenge. It could contribute towards evening out peak and through energy demand by using flexible solar capacity, in sun abundant areas, throughout the day to convert their energy generation to hydrogen. In some areas, California for example, solar capacity gets switched off during the slow part of the duck curve, as the other base load energy generation capacities are enough to deal with the low demand of the day.

In that sense, fuel cell vehicles could extend the conversation towards energy storage and offer a solution to that area, which makes them a more compelling proposition. Some truck manufacturers, such as Nikola, already propose to go down that route to make it a truly energy intense, but green powertrain option.

As of today, we estimate demand for platinum in fuel cells to be around 50-60 Moz (1,555 t) which is likely to be evenly split between the transport and stationary sectors. Portable applications dwarf both transport and stationary in numbers, but their actual volume of platinum is very small. In a 50-50 division between transport and stationary, transport will be the driver of future demand. Various OEMs, particularly in Japan, Toyota, Mitsubishi and Hyundai, have rolled out commercial vehicles a few years back and growth is expected to be in the double, if not triple, digits, coming from an extremely low base.

The most prevalent fuel cell use is the PEMFC, which uses platinum in its membrane. That is likely to continue, although the SOFC technology is likely to complement it.

Although the LDV segment will probably see the largest growth in fuel cell vehicle production in the coming years, fuel cells also make a particularly good proposition in the HDV segment, where range and torque are important. As such we expect

developments to accelerate from here onwards, despite the fact the industry has been waiting for this moment for maybe over 30 years.

The slight caveat to this development is that once China, for example, puts their weight behind this alternative powertrain source in order to clean up its polluted cities, BEVs are not without drawbacks either, demand for platinum ounces could significantly accelerate. At current platinum consumption of 25gr/fuel cell of 100 kWh, a 1% penetration rate, or give or take 1ml units in the near future, we could see demand just short of 1 Moz (31 t), which, at a

8.5 Moz (264 t) market, is 12% of current supply. At a 2% penetration rate, with thrifting taken into consideration to 20gr/fuel cell, fuel cell demand would quickly rise to approximately 16% of supply. Despite being in surplus today, that would create a numerable shock to the platinum market. The question in our view, therefore, should not be “when will fuel cells be the next big thing for platinum?”, but “when fuel cell demand properly takes off in the coming years, will the platinum industry be ready to serve this rapid rising source of consumption?”

HIGHLIGHTS OF EMISSION STANDARD TIMETABLES

Light duty Vehicles Legislative Overview

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Europe	Euro 6b		Euro 6c / Euro 6d TEMP			Euro 6d / 95 g/km CO2						
North America Epa	Tier 2		Tier 3 Introduction									
North America CARB	LEV III Phase in					LEV III Tightning						
Japan	Japan 09 (JC08)			Japan 18 (WLTC)								
South Korea (diesel)	Euro 6b		Euro 6d TEMP			Euro 6d						
China (Nationwide)	China 4			China 5		China 6a				China 6b		
India	Bharat Stage 4					Bharat Stage 6						
Brazil	PROCONVE L6								PROCONVE L7			
Thailand	Euro 4									Euro 5		

Heavy Duty Vehicles On-Road Legislation Overview

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Europe	Euro VI								Possible Euro VII			
North America	Greenhouse Gas Phase 1						Greenhouse Gas Phase 2					
Japan	Japan 09		Japan 16 (WHTC)									
South Korea	Euro VI								Euro VII			
Brazil	PROCONVE P7							PROCONVE P8				
Russia	Euro IV			Euro V								
India (major cities)	Bharat IV				Bharat VI							
India (nationwide)	Bharat III		Bharat IV			Bharat VI						
China (major cities)	China IV		China IV									
China (nationwide)	China IV		China V				China VI					

Heavy Duty Vehicles Non-Road Mobile Machinery Legislation Overview

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Europe	Tier 4b				Stage V							
North America	Tier 4b							Carb/Epa				
Japan	Tier 4b											
South Korea	Tier 4b				Possible Stage V							
Brazil	Tier 3					Tier 4a			Tier 4b			
China (major cities)	Tier 3			Tier 4a				Tier 4b				
China (nationwide)	Tier 3					Tier 4a			Tier 4b			

Source: Various Government Departments; GFMS, Refinitiv

JEWELLERY

- **Platinum jewellery fabrication declined by 5% to an estimated 2.1 Moz (66 t) in 2018, dragged lower by a sizeable fall in demand from China, with gains recorded elsewhere.**
- **Palladium jewellery demand fell 6% last year to 0.3 Moz (8 t), with the largest falls in volume terms seen in Europe and North America.**

Last year, **platinum** jewellery fabrication retreated 5% year-on-year to reach an estimated 2.1 Moz (66 t), the fifth consecutive annual decline and the lowest level since 2008. China accounted for the bulk of this loss, with this market dropping 11% year-on-year as economic pressures limited consumer spending on discretionary items, in addition to competition from carat gold jewellery. The performance in the other main markets was much stronger with annual gains recorded across the board. Japanese fabrication returned to growth as lower platinum prices and a rise in tourists helped to boost consumption, while in the United States a firmer economic footing flowed through stronger consumer demand for luxury items. In addition, our other regions saw further expansion with another year of gains from India.

Palladium used in jewellery fabrication declined for the tenth consecutive year, by 6% to 0.3 Moz (8 t). The high price was the chief culprit in both North America and Europe, with demand impacted by a shift away from palladium to more affordable alloying options for white gold. Demand in China had all but evaporated, with no standalone fabricators left in the market.

JEWELLERY DEMAND

PLATINUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	244	246	247	1%
Europe	198	203	206	3%
Japan	315	321	318	2%
China	1,293	1,152	1,086	-11%
Other regions	185	203	222	10%
Total	2,235	2,125	2,080	-5%

PALLADIUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	50	45	44	-10%
Europe	145	142	138	-2%
Japan	46	43	42	-7%
China	3	0	0	-100%
Other Regions	42	38	37	9%
Total	287	268	261	-6%

Source: GFMS, Refinitiv

CHINA

Chinese **platinum** jewellery fabrication declined for the fifth consecutive year, falling 11% to 1.2 Moz (36 t) in 2018, and there is still no sign of bottoming. To put the industry into context, the country's demand for platinum reached peak levels in early 2000s, when annual demand from the jewellery sector was north of 60 tonnes. However, platinum's glory days in the domestic industry are long gone, although ironically, China still remains the globe's largest platinum consumer in the jewellery sector, contributing 54% of the world's market share.

Contributions to the lacklustre performance of the Chinese platinum jewellery industry in recent years appear to be very complex, with a fair amount of blames pointing towards the whole supply chain.

First of all, the poor performance of China's platinum jewellery industry in recent years had been attributable to the lack of support from the retailers. Understandably, retailers tend to always chase quick profits, and they only promote products that can turn into cash in a short period of time ideally (along with decent margins). Despite higher margins, platinum jewellery has not been a very popular segment among consumers, and thus retailers only want to carry a minimum amount of platinum jewellery pieces just to satisfy the very small portion of the market. As a result, with a lack of adequate choices and availability of platinum pieces in the retailer's showcase and a drop in promotional campaigns, consumers' awareness of platinum jewellery had remained at low levels in China.

Secondly, while retailers do offer price discounts from time to time, the price tags for platinum jewellery has not reflected the performance of the dollar platinum price in recent years. Unlike platinum, the gold price in China offers a much higher transparency, and hence when the international gold price broke below the \$1,500/oz level in 2013, many Chinese thought it was a bargain and rushed to stores to buy all the gold items they could get, since prices of gold products in the local market had always been in sync with international price movements. However retailers still refused to lower price tags for platinum products to be more in line with the metal price, because some of these inventories were built at times when platinum prices were at much higher levels. If retailers were to adjust the retail price to much lower levels, then they would have had to take some write-offs based on accounting principles and realised the losses. This

is especially true when the product mix of platinum represents only a very small portion, and thus retailers do not even bother or care whether a small amount of platinum inventories could be liquidated.

When order books from the retailers are low, it makes the business of fabricators even more challenging. Last year, there were a total of four platinum fabricators, which either went bankrupt or got out of the platinum business, leaving the total number of platinum jewellery fabricators in China closer to ten (compared to 20 just a few years ago). It is interesting to note that a big corporation that is in a different industry saw an opportunity in the platinum jewellery industry towards the end of last year. They started a marketing campaign in the fourth quarter, making their products available for sale through online platforms. While they initially had ambitious plans for 2019, sales, unfortunately, proved to be underwhelming, and their jewellery business has been running on a limited scale since then.

As a result of the lacklustre market, fabricators have had few incentives to invest into research and development, and to develop new product lines that could possibly become the next market darling. Fabricators have been willing to invest and make new gold products, from 22 carat, 18 carat, 3D Hard Gold to the latest 5 G Gold. Fabricators have tried to invent a new market through new products so that it would be lucrative for early entrants before copy cats start duplicating their products which would inevitably lead to market saturation. On the other hand, the development of the platinum jewellery has been rather slow. China's platinum jewellery market is still made up of purities in Pt999, Pt990 and Pt950, which has been largely unchanged over the last five years. The only notable change was that in the past, Pt999 and Pt990

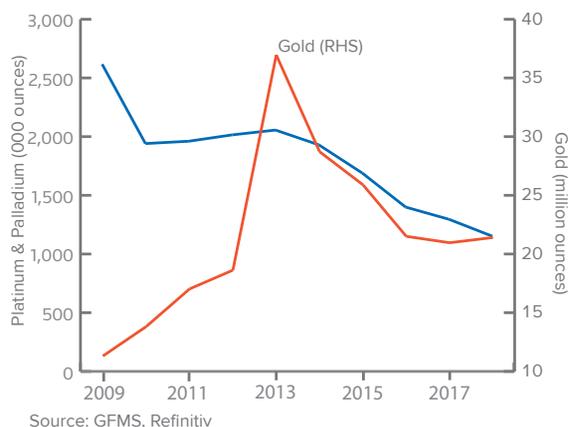
were commanding the lion's share of the market, while Pt950 had recently become the most popular, commanding over 70% market share in 2018.

Another problem that platinum faces is the rise of competition from other products. The nature of platinum has also limited the variety of designs, as the strength of 18-carat gold, for example tends to be more suitable for sophisticated designs, thus offering consumers more choices.

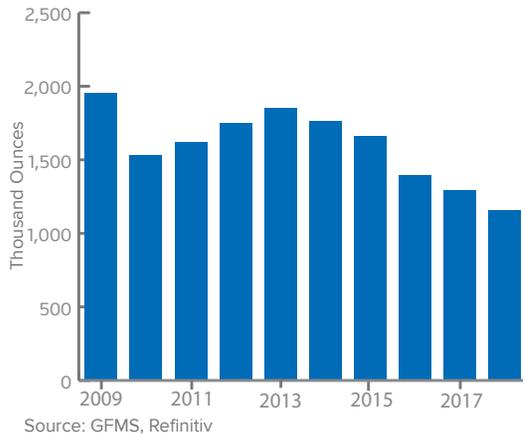
Not only is platinum facing direct competition from jewellery of different colours, but even within the white colour segment, platinum has had to fend off other white metals including 18 carat white gold. The emergence of 18 carat gold in recent years has eroded the market share of platinum within the jewellery segment, but even white gold is rapidly falling behind its 18 carat coloured gold peers. However the lacklustre performance of the international platinum price last year made the fabrication cost of 18 carat (white gold) even more expensive, and thus fabricators began shifting back to platinum for gem sets. Another direct competitor for platinum had been high end jewellery pieces made of silver but adding a tad of rhodium to fight against the oxidation. The prices of the latter has been far more affordable compared to platinum pieces and is considered more suitable for budget conscious consumers.

Last but not least, the liquidity of platinum jewellery is far lower compared to gold. In China it is far easier and more convenient to convert old gold jewellery into cash, compared to platinum. On top of a somewhat limited access to scrap collection, the bid ask spread for platinum could be as high as 15%, compared to just 3-4% for gold. The large gap in the spread of platinum compared to gold is partly attributed to the higher cost of refining and working with platinum, although scrap collectors also try to take advantage of the lower transparency on platinum pricing in the country. As a result, consumers think buying gold jewellery offers a bigger bang for their buck, an asset that can maintain higher value in the future if they want to trade in or cash out. There were also more consumers bringing back their old platinum jewellery to trade in for new gold pieces last year, and hence the proportion of scrap supply to total jewellery demand continued to increase, which saw jewellery scrap contributing approximately half of the raw demand from the jewellery sector.

CHINESE JEWELLERY FABRICATION



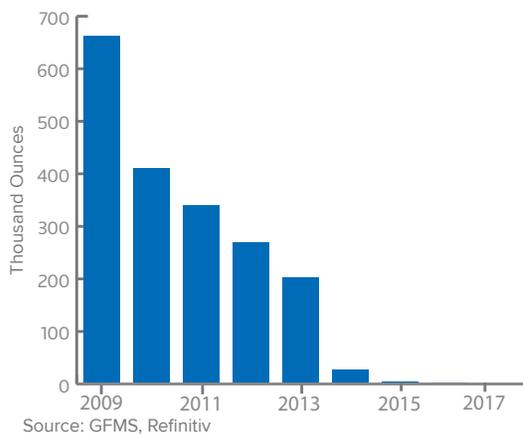
CHINESE PLATINUM JEWELLERY FABRICATION



Looking forward, we expect the downward trend for platinum in the Chinese jewellery market to continue in 2019, with sales data in the first quarter of 2019 declining year-on-year. Fabricators are introducing smaller pieces which carry less platinum or blending platinum with other metals (such as gold) in new designs that will inevitably use less platinum. China’s consumption market is also struggling at the moment, with this cautious consumer sentiment dragging down the jewellery market. The market focus, whether from the perspective of retailers or from consumers, remains on gold, diamonds and other high-end items.

Palladium jewellery fabrication in China is now close to non-existent, due to its high price, as well as a lack of consumer awareness and appreciation. On the other hand, due to the high metal price, scrap collectors have been offering more incentives for consumers to return their old palladium jewellery scrap, but volumes to this point have been negligible.

CHINESE PALLADIUM JEWELLERY FABRICATION



JAPAN

Japanese platinum jewellery fabrication returned to growth in 2018, recording a 2% rise to an estimated 0.3 Moz (10 t) on a gross basis. The modest rise followed two consecutive falls in both 2016 and 2017, and lifted the annual total to a three-year high. It was not all plain sailing for the local platinum market, with periods of stagnation and weakness across the retail sector, as consumers battled with economic uncertainty and in the case of the third quarter, a series of natural disasters across the country that dragged down consumer spending. Japanese economic growth was particularly volatile in 2018. All in all, it decreased sharply for the full-year to 0.7%, from 1.9% in 2017. As mentioned, the country was hit by a typhoon in the third quarter of 2018 that weakened most of the components of demand, and thus growth. In the fourth quarter, activity picked up moderately returning the country to growth, which encouraged an increase in retail activity and boosted fabrication demand. The final quarter resurgence in demand, aided by a significant drop in the platinum price, helped to offset earlier losses.

The modest recovery towards year-end was helped by lower platinum prices, which boosted fabrication as the supply chain restocked ahead of the busy Christmas period. The average platinum price in yen terms fell 9% last year to ¥3,126/g, the lowest level since 2004, trading below ¥3,000/g for several months in the second half of the year.

In contrast to the previous year, when a strong finish on investment markets saw the local bourse hit multi-year highs, Japan’s Nikkei booked a 12% decline in 2018, its first annual loss since 2011 and breaking the longest winning streak since the late 1980s. The broader Topix recorded a 18% decline over the year, its biggest annual loss since 2011. Japan is a country with an aging population and a high proportion of retirees, but it is this market demographic that fuels retail sales as they often have a greater disposable income. The weaker performance on the local bourse last year is likely to have arrested consumer spending and limited demand for luxury items by domestic consumers.

One area that fuelled greater consumption of luxury products was tourism, with this segment again a stand out and enjoying solid gains. The estimated number of overseas visitors to Japan reached a record high 31.2 million in 2018, up 9% from the previous year,

marking the country's seventh consecutive year of increases. A relaxation of tourist visa requirements, which had aided Asian countries such as China in particular, and an expansion in destinations covered by both regular airlines and low-cost carriers had been strong contributors to the surge in foreign visitors, with the additional retail demand helping to offset a weaker domestic appetite. This was most notable at the higher end of the market, with international brands such as Tiffany benefitting from the rise in visitors, while sales demand in the discount stores also ticked up.

The strength of the branded high-end and mainly foreign brands came at the expense of locally produced mid-tier items, which were reportedly weaker than in previous years. High-end brands lowered sticker prices (especially for bridal jewellery) in response to the drop in the platinum price, but locally branded item prices were rarely discounted so the two products lines were often competing against each other. Indeed, with younger generations and many tourists preferring foreign brands, if similarly priced, it may not have been a terribly smart sales strategy by the local retail stores.

While dominating the market in terms of market share, the platinum bridal market continued to edge lower in 2018 as the number of weddings in the country continued to decline due to a falling and aging population. In a bid to offset this decline the industry has been promoting a greater range of non-bridal jewellery that has been doing well across all age demographics. This fashion jewellery is the future for the domestic market, with the bridal segment expected to see further declines in the coming years. The lower platinum price in 2018 saw sticker prices adjusted lower in some cases, encouraging consumers to purchase larger items such as pendants

or necklaces and look at higher purity designs. Jewellery aimed at the male demographic also picked up sharply (from a low base), while demand for heavier items, and in particular kihei chain, also boosted demand in this segment. The non-bridal segment has traditionally been dominated by Pt850 purity items, but in the last two years there had been a notable uplift with Pt900 and Pt950 increasingly being used in this sector, with the high cost of palladium (used as an alloy in the lower purity items) accounting for that.

Turning to Japanese palladium jewellery, we estimate that offtake declined 7% last year to 43,000 ounces (1 t), the fifth consecutive fall. Palladium is principally used in jewellery fabrication as an alloying ingredient, used in both white gold and platinum. Last year, demand for platinum jewellery was relatively stable, however, a drop in demand and overall market share loss for white gold drove demand lower, while sharply higher palladium prices also curbed demand.

NORTH AMERICA

Platinum jewellery fabrication in North America edged 1% higher in 2018 to an estimated 0.3 Moz (8 t), the first annual increase in three years. Platinum jewellery is widely used in the bridal segment, particularly in the form of engagement rings, but in recent years, has also been making inroads into the fashion jewellery market however, competition from other jewellery segments (gold and silver) remains fierce at the retail level. Platinum has a solid reputation for its strength and reliability, and is often promoted as such to prospective customers, with its ability to protect the setting (mainly diamond) a key selling point.

The robust economic performance of the United States last year helped boost retail sales, with rising wages, low unemployment, and tax cuts feeding through to higher disposable incomes. However, encouraging consumers to part with their cash is always a challenge for retailers, especially on discretionary items like jewellery. A number of campaigns by the Platinum Guild International (PGI) and by high-end retailer Tiffany & Co, helped promote new lines of jewellery products, which over time, should help boost consumption in this key market.

Palladium used in jewellery fabrication fell 10% to 45,000 ounces (1 t) last year. This marked the ninth consecutive annual decline and the lowest level of fabrication since 2004. While there is niche market for

JAPANESE PLATINUM JEWELLERY FABRICATION



Source: GFMS, Refinitiv

palladium jewellery, a lack of marketing has hindered its penetration into the wider market. Palladium is principally used in jewellery fabrication as an alloying agent, in both white gold and platinum. Last year, demand was impacted by the surge in the palladium price, as fabricators shifted to cheaper alternatives.

EUROPE

After four consecutive years of lacklustre demand, platinum jewellery fabrication in Europe finally recovered in 2018, although at a modest rate of 3%, as most countries in the region recorded positive growth, largely helped by an acute fall in the platinum price. The largest year-on-year increase in percentage terms was registered by **Switzerland**, where demand for platinum is dominated by the watch industry. Following four years of successive declines, demand in this sector rebounded by 41% last year to the highest level in the past three years. To put this in context, last year's offtake accounted for 49% of the 2013 peak, up from just over 40% in 2017. Stronger demand last year was largely helped by markedly lower platinum prices, while improving demand from Russian and Chinese tourists seemed to have also aided the recovery.

The second largest percentage increase in platinum jewellery demand in the region was recorded by the **United Kingdom**, where an 11% drop in the annual average sterling price boosted the offtake, and was also helped by the robust wedding ring market. That said, cautious consumer sentiment in light of the uncertain political and economic outlook limited last year's growth to a single percentage rate. Similarly, while fabrication levels started to recover in **Germany, Italy and France**, economic uncertainty put pressure on consumer spending, restricting growth to just a little over 1% last year.

In contrast, **palladium** jewellery demand continued to decline for the third year in a row, dropping by 2% in 2018. It is not particularly surprising given that the price of palladium continued to advance to fresh highs last year, curbing demand for carat palladium jewellery in all the major markets in the region. Nevertheless, greater sales of white gold and platinum jewellery pieces helped to offset some of these losses, resulting in just a small year-on-year decline for the region.

Switzerland was the most obvious example of this, where a rebound in gold and platinum watch sales saw palladium jewellery offtake post the largest growth in the whole region, although still limited to a single percentage rate. On the other hand, slightly higher sales of white gold and platinum pieces in the **United Kingdom** were not enough to outweigh a sharp drop in carat palladium jewellery, resulting in one of the worst year-on-year falls in the region.

INDIA

Indian platinum jewellery fabrication rose by 14% in 2018 at an estimated 78,000 ounces (3 t). While the recent growth has been impressive it is important to note this sector of the market is coming from a low base and commands a very small market share. Nevertheless, although this segment is still at its nascent stage, it is encouraging to see Indian consumers are showing interest in white metal jewellery, which looks elegant and is less expensive compared to traditional gold jewellery. Our field survey reveals that younger generations are attracted to light weight and less expensive fashion jewellery, and platinum jewellery is perfectly suited to this criteria. At the same time, silver jewellery plated with platinum is also becoming popular amongst the youth demographic.

NORTH AMERICAN PLATINUM JEWELLERY FABRICATION



EUROPEAN PLATINUM JEWELLERY FABRICATION



DENTAL

— Demand for palladium in dental applications retreated 5% last year to 0.4 Moz (12 t).

Palladium used in dental applications last year declined 5% year-on-year to 0.4 Moz (12 t), extending the long term trend of declines and pushing demand from this sector to a record low. In the past decade or more, the proportion of palladium used in this segment, especially in industrialised economies, has been eroded by alternatives, such as resin composites, ceramics and porcelain-fused metal due to both price and cosmetic reasons.

The global dental market, in terms of palladium consumption, is dominated by **Japan**, which contributes just over 55% of the global total. Indeed, palladium is still commonly used in the fabrication of a dental alloy known as Kinpala, which consists of gold, palladium and silver and is still widely used in the majority of dental treatments. Japanese demand last year largely mirrored that of 2017 with offtake on track for annual growth part way through the year, but fell away sharply as the price of palladium surged in the final quarter. This left the supply chain reluctant to replenish inventory levels as the price of the white metal was much higher than available via the government rebate, with annual demand slipping 4% to an estimated 218,000 ounces (7 t), a new record low. Demand has been trending lower in recent years with this trend likely to continue as younger generations turn to more cosmetically pleasing applications favoured in other developed markets.

North American palladium dental offtake contributes close to 30% of global demand, with this market retreating 5% last year to 114,000 ounces (4 t). Substitution, higher palladium prices, and the introduction of new product alternatives has been a major force in the decline of palladium demand in this sector, with the movement away from noble

DENTAL DEMAND

PALLADIUM

(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	119	114	109	-5%
Europe	53	50	45	-7%
Japan	227	218	205	-4%
China	1	1	1	-15%
Other regions	8	7	6	-10%
Total	408	389	366	-5%

Source: GFMS, Refinitiv

metal based alloys to more cosmetically pleasing applications such as zirconia and lithium disilicate glass ceramics are now common in place. Dental fabrication demand in **Europe** fell by 7% in 2018 to a nine-year low of 50,000 ounces (2 t). Substitution losses accounted for the bulk of the fall, but this was aided by the 38% rise in the average euro palladium price last year and a fragile economy, which saw consumers delay non essential dental work.

ELECTRONICS

- **Platinum demand from the electronics sector surged by 18% last year to 0.2 Moz (7 t) as an increase of capacity in hard disk drives required more platinum.**
- **Palladium demand, meanwhile, fell another 8% in 2018, to 0.8 Moz (26 t).**

Being used as part of a magnetic storage media to provide thermal stability and enhance data storage capabilities in hard disk drives (HDD), platinum is an important metal often used in the data storage component within the computing industry. Global HDD shipments had been falling for four consecutive years, as the consumption pattern had changed, with the popularity of smartphones replacing some of demand for personal computers (PC). As a result, the life cycles for PCs has been stretched. Having said this, while global HDD shipments fell by 7% in 2018, we actually recorded an improvement in shipments compared to previous years, with growth recorded in both the second and the third quarters of the year. HDDs is a centralised industry, with very few players globally (indeed the market share of the two largest HDD

ELECTRONICS DEMAND

PLATINUM

(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	6	5	5	-17%
Europe	2	2	1	0%
Japan	18	20	23	11%
China	27	27	28	0%
Other regions	142	174	181	23%
Total	197	232	239	18%

PALLADIUM

(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	187	173	166	-8%
Europe	116	107	103	-8%
Japan	214	197	190	-8%
China	178	156	150	-12%
Other regions	196	189	182	-4%
Total	892	822	791	-8%

Source: GFMS, Refinitiv

manufacturers last year accounted for approximately 77% of the global market). However, it is important to note that the level of shipments of HDDs is just part of the formula to determine platinum demand from this industry, as an increase of disks and storage per drive (memory capacity), requiring additional platinum per drive, more than offset the decline in shipments in recent years. Despite the increasing use of platinum in HDDs, the threat of substitution from solid-state drives (SSDs) had remained real and continuous. SSDs do not adopt magnetic memory, but instead use interconnected flash memory chips and therefore do not require platinum. The advantages of SSDs over HDDs include a lower power draw, as well as faster opening and writing speed, although they remain more expensive than HDDs (approximately six times more expensive per gigabyte compared to HDDs). As a result, consumers may prefer computers using SSDs for the main operating system, while using HDDs for storing documents, pictures, music and other files.

Indeed, the adaptation rate of SSDs in computers has already reached approximately 50% in 2018, splitting the market share with HDDs in the global computers market. According to one of the major players in the storage media industry, they predict that the market share of SSDs may surge to 90% within three to four years' time.

Due to cost differences, HDDs are likely to evolve from storage media on computers to enterprise storage and data centres, with primary concerns for data centre storage being reliability, storage density and cost. Not only is the cost of an HDD only a fraction of SSD, higher density drives will provide greater storage density, and hence require more platinum. Besides, while more and more computers are adapting

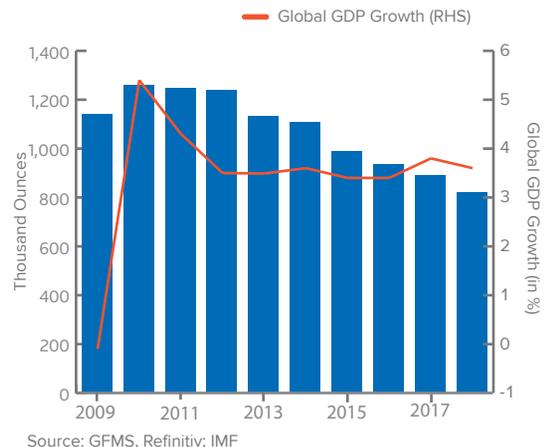
SSD over HDD, consumers would still prefer to have an additional secondary storage in HDD, for cost reasons. In fact, players in the storage media industry are already developing new technologies in HDDs, for example, there is speculation that the first Heat-Assisted Magnetic Recording (HAMR) technology for HD will be introduced in 2020 (known as a 20TB+ drive), with prospects for doubling areal density to occur every 30 months, meaning a possible 100TB disk drive could be in use by 2025/2026.

Demand for palladium from the electronics industry fell 8% to 0.8 Moz (26 t), its lowest level in the last decade. This is in comparison to 1.3 Moz (39 t) recorded in 2010, when consumption of palladium in this sector peaked. The main source of demand in the electronics sector stems from multi-layered ceramic capacitors (MLCCs), which manipulate electrical characteristics and are widely utilised in consumer electronics including computers, digital televisions, automotive vehicles and smartphones. Meanwhile global production of certain electronics, namely automobiles, mobile phones and computers all experienced a modest retreat in 2018, due to uncertainties in the global economy. The MLCC industry fell into a global supply shortage since 2018, with industry players suggesting that they expect shortages to continue until 2020 (largely on the back of growth in the automobile industry). In addition, due to a surge in the palladium price, thrifting had been taking place in recent years in some of the production of MLCCs, as manufacturers are using base metals (base metals electrode) technology, which negatively impacted the use of palladium in this field. However, MLCCs used in high end electronics remained heavily palladium based.

GLOBAL HARD DISK DRIVE SHIPMENTS



GLOBAL PALLADIUM ELECTRONICS DEMAND



GLASS

- Glass demand for platinum surged in 2018, rising 37% to a total 0.5 Moz (15 t), boosted mainly by expansion in fibre glass capacity.
- Rhodium demand dipped 13% to an estimated 95,000 ounces (3 t).

Last year saw a significant rise in demand for platinum in the glass industry with our analysis pointing to a 37% year-on-year increase to an estimated 479,000 ounces (15 t), an eight year high. Inventory replenishment in the fibre sector was at record levels, with Chinese producers investing significantly in new plants and capacity to meet the increase in demand.

Platinum is widely used in the production of display glass and glass fibre, primarily due to its high temperature tolerance and inert nature. Rhodium, on the other hand, is mainly used as a strengthening agent in the process and in combination with platinum form an alloy that are used in melting tanks to produce display glass and equipment known as ‘bushings’.

As outlined above, the impressive growth last year was largely a function of a surge in demand for fresh metal to satisfy expanding production capacity and mainly within the glass fibre sector. China was the standout with annual demand for platinum more than doubling to 346,000 ounces (11 t) and accounting for more than 70% of global demand. Part of the recent growth can be attributed to the rise in the use of glass fibre reinforced polymers (GFRP) in the construction industry as well as in the automotive industry, not only due to its lightweight but also to enhance performance. Additionally, there has been a rise in demand for renewable energy owing to the growing environmental concerns, with increasing application of fibre glass in wind as well as other power generation activities. While the Chinese domestic market accounts for the largest share of new investment, Chinese companies have also been adding to capacity outside their home country, in order to avoid anti-dumping duties in their overseas markets, and in order to qualify for local incentives and tax reduction programmes.

The other main area of glass demand for both platinum and rhodium is for display glass used predominately for portable electronic devices, including mobile phones, portable media players, portable computer displays, and television screens. The industry segment also enjoyed solid gains in

GLASS DEMAND

PLATINUM

(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	47	18	23	-62%
Europe	15	15	15	1%
Japan	22	12	9	-47%
China	147	346	131	135%
Other regions	120	89	76	-26%
Total	351	479	254	37%

RHODIUM

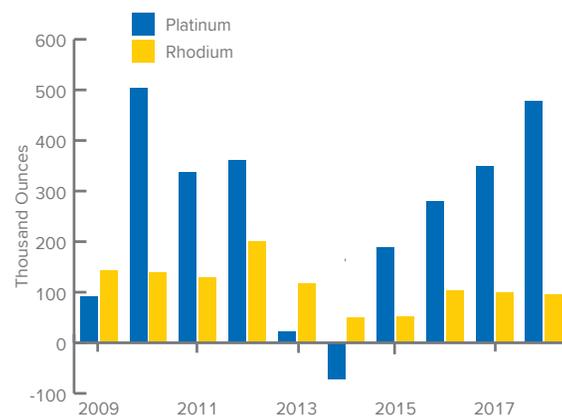
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	4	7	5	75%
Europe	7	6	6	-14%
Japan	2	2	2	0%
China	79	64	62	-19%
Other regions	17	16	16	-6%
Total	109	95	91	-13%

Source: GFMS, Refinitiv

2018 with China again leading the way with demand buoyed by the opening of new display glass facilities. Indeed, U.S. giant Corning Incorporated opened a new Generation 10.5 liquid crystal display (LCD) glass substrate manufacturing facility in the Anhui Province, China. Generation 8.5 still represents the largest volume of shipments globally, more than 50% of shipments in 2018 were this size, but Gen 8.6 and Gen 10.5 are growing more rapidly as consumers look at larger televisions as the norm.

While platinum demand surged to an eight-year high last year, demand for rhodium used in the glass industry dipped 13% to an estimated 95,000 ounces (3 t). Price was the main culprit as some manufacturers thrifted the metal (using more platinum) to reduce production costs.

GLOBAL PLATINUM & RHODIUM GLASS DEMAND



Source: GFMS, Refinitiv

CHEMICAL

- **Platinum demand in the chemical sector rose to its highest level this century.**
- **Palladium demand also recorded a boost, rising by 7% to 0.5 Moz (16 t).**

Demand for platinum and palladium from the chemical sector (in which we include demand from the petrochemical industry), arises from their use as catalysts. In the case of platinum, this is historically for the production of paraxylene (PX), nitric acid and Active Pharmaceutical Ingredients (APIs), while it is also used in the curing of silicones. More recent technologies have also recorded the use of platinum catalysts for use in the production of on-purpose propylene and isobutylene derivatives via propane and butane dehydrogenation reactions (PDH & BDH). We estimate that platinum use in the chemical sector rebounded last year, jumping 17% year-on-year to its highest level this century at 0.6 Moz (19 t).

In terms of areas of usage, each sector recorded a rise in demand last year, with the nitric acid industry making the largest impact, with demand rising by 43%, on the back of growing production and modestly increasing consumption. Elsewhere, demand from platinum's largest area of demand, silicones (with market share standing at 40%), rose for a fifth consecutive year, with growth concentrated in China. Platinum as a catalyst in PX production recorded a third consecutive rise in demand in 2018, jumping by 8%, with continued demand for polyester products (of which PX is the key feedstock to PTA, which is used to create polyester), resulting in an expansion of already present capacity. In conjunction, new capacity additions in our 'other regions' category occurred as several projects (integrating petroleum refining with petrochemical refining) were set in motion. Meanwhile, demand from PDH units, particularly in China, were supported by the coming online of delayed projects in our 'other regions' category, while rising demand in APIs resulted in platinum use in this industry ticking up by 4% in 2018.

Palladium's usage in the chemical sector primarily derives from demand for catalysts in the production of vinyl acetate monomer (VAM), purified terephthalic acid (PTA), hydrogen peroxide, catchment gauzes in nitric acid synthesis and for use in the removal of acetylene during the production of methyl ethylene glycol (MEG) from coal, palladium salts are used for

CHEMICAL DEMAND

PLATINUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	67	77	80	15%
Europe	77	93	95	21%
Japan	41	38	44	-7%
China	180	215	253	19%
Other regions	170	201	250	18%
Total	536	625	723	17%
PALLADIUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	64	66	67	4%
Europe	166	171	171	3%
Japan	22	22	22	3%
China	126	145	161	15%
Other regions	93	99	98	7%
Total	470	504	520	7%

Source: GFMS, Refinitiv

electroplating purposes. We estimate that palladium use in the chemical sector rose by 7% in 2018, to 0.5 Moz (16 t), its third consecutive annual rise and third year of elevated demand (above 0.4 Moz).

Despite PX demand rising impressively last year (as mentioned above), PTA demand (while remaining positive), was unable to live up to 2017's demand levels, which benefited from investment in new capacity and biennial plant turnarounds. Elsewhere however, more positive results came from nitric acid demand, with global consumption rising steadily. A further significant area of demand growth in 2018 came from palladium's use in the production of MEG from coal. China is the leader in the field for this technology and has heavily invested in new capacity, making the most of their large coal supplies. Meanwhile, steady demand persisted from palladium's use in electroplating. Starting from a smaller demand base, other palladium utilising technologies recorded a marked growth, with hydrogen peroxide and VAM both recording gains.

PLATINUM & PALLADIUM CHEMICAL DEMAND



Source: GFMS, Refinitiv

PETROLEUM

- Global demand for platinum in the petroleum sector rose for a third consecutive year in 2018, albeit modestly, to 170,000 ounces (5 t).
- Palladium strongly benefited from increased demand for higher purity fuels, boosting demand to their highest level this century at 24,000 ounces (1 t).

Demand for platinum and palladium from the petroleum sector arises from their use as catalysts. In the case of platinum, developments in oil refining capacity, specifically new catalytic reforming and isomerisation capacity, remain the largest elements of platinum demand, while it is also utilised in alternative fuel producing technologies, such as GTL plants. Palladium usage in the petroleum sector primarily arises from its use as a bifunctional catalyst, in a two stage hydrocracking (HC) unit, associated with a large proportion of downstream crude refiners globally.

If we focus on platinum, we estimate that demand last year rose by 0.2% or 1,000 ounces (0.03 t) to 173,000 ounces (5 t), its highest level since 2008. While this result indeed marks the third consecutive year of increases from this sector, supported in general from a rising crude oil price (with Brent crude oil averaging \$72 bbl last year), demand was wildly varied from region-to-region. Indeed, while China and our ‘other regions’ category recorded growth in demand of 7% (2,000 ounces or 0.06 t) and 18% (11,000 ounces or 0.2 t) last year respectively, demand was partly offset by weakness in both the North American and European markets, which fell by 19% (13,000 ounces or 0.4 t) and 23% (6,000 ounces or 0.2 t) respectively. While the Japanese market (after the conclusion of the delayed merger deal between Idemitsu and Showa Shell Sekiya late last year), recorded metal coming back to the market in light of refinery consolidations.

Weakness from Europe, which recorded its third year of declines in 2018, comes as the long suffering region continued to be unable to compete with more modern refineries in the East, while higher oil prices tightened margins. Meanwhile in North America, record high run rates were not enough to compete with catalyst replacement requirements last year. On the other hand, positive growth demand in China and our ‘Other Regions’ categories were driven by the growing trend towards integrating petroleum and petrochemical refineries, to create mega-refineries, in

PETROLEUM DEMAND

PLATINUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
North America	68	55	55	-19%
Europe	24	19	18	-23%
Japan	-7	-1	0	n/a
China	27	29	36	7%
Other regions	60	71	95	18%
Total	172	173	204	0%
PALLADIUM				
(000 ounces)	2017	2018	2019f	Chg(18/17)
Total	18	24	30	35%

Source: GFMS, Refinitiv

the hope of further diversifying these regions product portfolios and becoming less reliant on imports (in light of increasing protectionism ideology). While China (in particular), focused on new plant designs enabling them to produce higher quality fuel products (to meet higher legislation fuel standards such as China 6) and reduce pollution levels.

Turning to palladium, demand soared last year, jumping by 35% or 6,000 ounces (0.2 t) on the back of increased demand to produce higher quality fuels for the incoming tighter emission legislations, which will affect not only the automobile industry but the marine industries as well. The latest legislation from the International Maritime Organisation (IMO), will implement the reduction of sulphur in fuel oil down to 0.5% mass by January 2020. Palladium is heavily utilised in the upgrading of heavier and sourer fractions of crude oil and will therefore become a necessity to refineries maintaining to these new standards as well as refiners in the Middle East or Asia, which typically process heavier fractions of crude oil from their domestic sources.

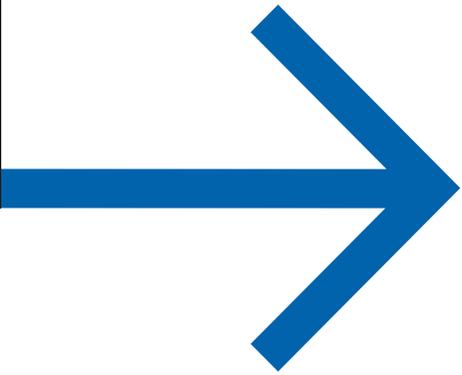
PLATINUM AND PALLADIUM DEMAND





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APPENDIX 1 - PLATINUM SUPPLY AND DEMAND 2010-2019

(000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Mine production										
South Africa	4,750	4,740	4,182	4,368	3,220	4,522	4,273	4,289	4,318	4,201
Russia	785	818	803	741	687	721	678	708	695	683
Canada	127	270	220	217	278	242	268	232	211	221
United States	111	119	118	120	119	122	129	131	134	148
Zimbabwe	286	341	335	409	398	398	484	479	480	460
Others	124	116	137	156	142	131	136	127	121	109
Total Mine Production	6,183	6,404	5,796	6,011	4,844	6,137	5,967	5,966	5,959	5,822
Autocatalyst scrap										
North America	450	475	413	464	425	433	452	459	481	489
Europe	299	347	313	375	434	381	407	429	446	506
Japan	83	78	83	100	106	102	128	126	130	137
China	13	17	23	30	36	43	54	66	72	82
Other regions	80	102	120	122	133	148	162	182	199	218
Total Autocatalyst Scrap	926	1,020	952	1,090	1,134	1,107	1,203	1,262	1,328	1,432
Old jewellery scrap										
North America	12	10	9	10	9	6	6	6	6	7
Europe	10	8	8	7	7	7	7	6	6	7
Japan	281	344	257	235	245	216	198	184	177	184
China	376	412	587	497	467	447	482	461	554	584
Other regions	2	3	3	3	3	3	3	3	3	4
Total Old Jewellery Scrap	681	778	864	752	731	679	695	661	746	785
SUPPLY	7,790	8,201	7,612	7,854	6,710	7,924	7,865	7,889	8,033	8,039
Autocatalyst demand										
North America	402	509	491	531	539	511	421	443	461	500
Europe	1,431	1,468	1,273	1,209	1,309	1,407	1,474	1,408	1,292	1,236
Japan	435	370	390	354	347	336	320	324	322	314
China	214	184	173	217	255	227	257	293	294	307
Other Regions	547	583	650	661	672	694	694	720	790	851
Total Autocatalyst Demand	3,029	3,114	2,976	2,972	3,122	3,175	3,166	3,187	3,158	3,208
Jewellery demand										
North America	212	218	224	235	243	248	246	244	246	247
Europe	219	214	212	221	217	215	213	198	203	206
Japan	262	283	320	327	318	324	317	315	321	318
China	1,529	1,620	1,746	1,852	1,759	1,662	1,396	1,293	1,152	1,086
Other Regions	69	89	99	118	138	163	166	185	203	222
Total Jewellery Demand	2,291	2,424	2,601	2,753	2,675	2,612	2,339	2,235	2,125	2,080
Chemical demand										
North America	95	78	65	74	77	60	80	67	77	80
Europe	81	91	79	80	98	72	108	77	93	95
Japan	50	31	22	24	45	36	40	41	38	44
China	80	95	102	120	154	143	173	180	215	253
Other regions	176	191	131	136	213	128	185	170	201	250
Total Chemical Demand	482	487	398	435	586	439	587	536	625	723

APPENDIX 1 - PLATINUM SUPPLY AND DEMAND 2010-2019

(000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Electronics demand										
North America	34	27	15	11	7	7	6	6	5	5
Europe	9	4	4	4	3	3	3	2	2	1
Japan	35	30	25	22	21	19	18	20	23	23
China	37	36	34	31	30	27	26	30	27	28
Other Regions	167	160	149	134	134	127	124	139	174	181
Total Electronics Demand	283	256	227	202	195	183	178	197	232	239
Glass demand										
North America	(7)	12	18	(1)	4	7	23	47	18	23
Europe	15	9	13	11	3	34	15	15	15	15
Japan	142	108	98	(92)	(116)	(34)	2	22	12	9
China	157	56	143	121	1	85	177	147	346	131
Other Regions	198	154	89	(16)	37	98	63	120	89	76
Total Glass Demand	505	338	361	22	(71)	189	280	351	479	254
Petroleum demand										
North America	30	28	41	52	33	37	57	68	55	55
Europe	35	16	15	4	23	55	27	24	19	18
Japan	21	8	8	(12)	7	(21)	4	(7)	(1)	0
China	7	7	11	15	7	3	7	27	29	36
Other Regions	75	84	51	47	52	23	41	60	71	95
Total Petroleum Demand	168	144	126	107	122	96	135	172	173	204
Retail investment										
North America	40	53	87	55	50	55	86	63	64	67
Europe	10	17	13	10	8	7	43	41	10	8
Japan	37	206	148	37	55	498	402	175	222	200
Other Regions	8	36	34	34	28	23	19	17	15	12
Total Retail Investment	95	312	282	136	141	582	550	296	311	287
Other industrial demand										
North America	175	200	237	248	272	269	298	291	291	290
Europe	165	183	202	208	222	192	198	208	216	220
Japan	56	60	71	73	79	66	69	70	74	78
China	43	50	52	60	68	82	102	110	118	134
Other Regions	56	65	59	59	59	57	60	69	76	84
Total Other Industrial Demand	494	559	621	649	700	665	727	748	774	804
DEMAND	7,347	7,634	7,592	7,276	7,470	7,942	7,963	7,722	7,877	7,800
Physical Surplus/(Deficit)	443	567	19	578	(761)	(18)	(98)	167	156	239
Identifiable stock movements										
Industry Stocks	0	(100)	(300)	(1000)	1300	(50)	50	0	0	0
Exchange Traded Funds	(579)	(156)	(238)	(891)	(221)	192	(15)	15	(137)	150
Sub Total - Stock Movements	(579)	(256)	(538)	(1891)	1079	142	35	15	(137)	150
Net Balance	(136)	311	(519)	(1314)	318	123	(63)	182	19	389

APPENDIX 2 - PALLADIUM SUPPLY AND DEMAND 2010-2019

(000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Mine production										
South Africa	2,646	2,686	2,391	2,432	2,008	2,653	2,467	2,568	2,555	2,492
Russia	2,722	2,704	2,624	2,527	2,582	2,575	2,526	2,728	2,671	2,636
Canada	352	560	557	530	578	519	512	468	489	588
United States	374	399	396	404	401	406	420	428	459	441
Zimbabwe	222	261	256	314	325	323	388	396	395	362
Others	296	251	272	261	243	238	227	206	206	197
Total Mine Production	6,612	6,861	6,497	6,468	6,136	6,713	6,540	6,794	6,774	6,717
Autocatalyst scrap										
North America	831	961	922	992	1,126	1,054	1,109	1,150	1,216	1,249
Europe	306	358	317	334	393	363	409	467	503	529
Japan	83	78	83	100	106	102	128	126	130	137
China	23	33	47	62	79	98	134	164	176	209
Other Regions	64	84	104	99	122	147	176	191	215	245
Total Autocatalyst Scrap	1,307	1,514	1,472	1,587	1,826	1,763	1,956	2,097	2,240	2,369
Old jewellery scrap										
North America	1	2	3	4	4	3	3	3	4	4
Europe	10	12	12	11	9	9	10	10	11	12
Japan	32	39	29	28	30	27	23	24	27	27
China	165	136	153	133	67	36	23	3	0	0
Other Regions	7	7	7	7	8	7	6	6	8	8
Total Old Jewellery Scrap	215	194	203	182	118	82	65	47	49	51
SUPPLY	8,134	8,569	8,172	8,238	8,080	8,558	8,561	8,938	9,063	9,137
Autocatalyst demand										
North America	1,244	1,336	1,686	1,930	1,945	2,076	2,266	2,368	2,430	2,472
Europe	1,395	1,599	1,558	1,537	1,637	1,771	1,816	1,912	1,939	1,872
Japan	845	769	929	904	927	854	847	878	852	837
China	1,032	1,093	1,229	1,401	1,535	1,665	1,955	2,050	2,113	2,281
Other Regions	808	820	861	875	996	995	1,066	1,165	1,287	1,417
Total Autocatalyst Demand	5,324	5,617	6,264	6,648	7,040	7,362	7,949	8,373	8,621	8,879
Jewellery demand										
North America	115	85	78	75	65	55	52	50	45	44
Europe	138	146	148	149	150	151	150	145	142	138
Japan	49	48	54	56	55	54	48	46	43	42
China	412	341	269	204	172	28	4	3	0	0
Other Regions	85	55	48	42	40	41	40	42	38	37
Total Jewellery Demand	798	675	597	527	481	329	294	287	268	261
Dental demand										
North America	188	178	170	163	148	135	127	119	114	109
Europe	97	91	83	72	63	59	56	53	50	45
Japan	289	283	278	263	253	244	234	227	218	205
China	2	2	2	2	2	2	1	1	1	1
Other Regions	14	13	13	11	10	9	8	8	7	6
Total Dental Demand	590	567	546	511	475	449	426	408	389	366

APPENDIX 2 - PALLADIUM SUPPLY AND DEMAND 2010-2019

(000 ounces)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Chemical demand										
North America	53	54	54	55	55	55	68	64	66	67
Europe	161	165	161	158	152	157	183	166	171	171
Japan	21	21	21	22	21	20	22	22	22	22
China	44	66	78	101	76	54	90	126	145	161
Other Regions	90	80	64	74	82	87	96	93	99	98
Total Chemical Demand	369	385	379	409	385	374	459	470	504	520
Electronics demand										
North America	290	275	273	238	233	208	197	187	173	166
Europe	189	187	186	170	166	139	122	116	107	103
Japan	324	315	318	284	277	248	225	214	197	190
China	185	189	206	227	222	198	197	178	156	150
ROW	272	284	259	215	211	198	197	196	189	182
Total Electronics Demand	1,260	1,250	1,242	1,134	1,109	991	938	892	822	791
Retail investment										
North America	68	47	27	30	35	34	33	39	37	38
Europe	12	14	10	8	6	5	6	6	(3)	(5)
Other Regions	0	0	0	0	5	6	6	8	0	(2)
Total Retail Investment	80	61	37	38	45	45	45	53	33	29
Other industrial demand including petroleum										
North America	65	71	74	78	77	77	73	73	74	77
Europe	17	17	15	14	15	15	16	16	16	16
Japan	8	7	7	7	6	6	6	6	5	5
China	2	2	1	3	3	3	3	3	3	4
Other Regions	0	0	0	1	1	1	1	1	1	1
Total Other Industrial Demand	91	99	98	101	102	102	99	99	100	102
DEMAND	8,522	8,658	9,175	9,377	9,652	9,664	10,225	10,599	10,762	10,978
Physical Surplus/(Deficit)	(389)	(89)	(1,003)	(1,139)	(1,571)	(1,106)	(1,664)	(1,661)	(1,698)	(1,841)
Identifiable stock movements										
Russia	800	800	400	200	0	0	100	200	0	0
Stillwater	0	0	0	0	0	0	0	0	0	0
Industry Stocks	0	(50)	(100)	(500)	600	(150)	140	(290)	(160)	0
Exchange Traded Funds	(1,090)	532	(448)	0	(899)	727	637	383	527	300
Sub Total - Stock Movements	(290)	1282	(148)	(300)	(299)	577	877	293	367	300
Net Balance	(678)	1,193	(1,151)	(1,439)	(1,870)	(529)	(786)	(1,369)	(1,322)	(1,541)

APPENDIX 3 - PLATINUM SUPPLY AND DEMAND 2010-2019

(tonnes)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Mine production										
South Africa	147.7	147.4	130.1	135.9	100.2	140.7	132.9	133.4	134.3	130.7
Russia	24.4	25.4	25.0	23.0	21.4	22.4	21.1	22.0	21.6	21.2
Canada	4.0	8.4	6.9	6.8	8.7	7.5	8.3	7.2	6.6	6.9
United States	3.5	3.7	3.7	3.7	3.7	3.8	4.0	4.1	4.2	4.6
Zimbabwe	8.9	10.6	10.4	12.7	12.4	12.4	15.0	14.9	14.9	14.3
Others	3.9	3.6	4.3	4.9	4.4	4.1	4.2	4.0	3.8	3.4
Total Mine Production	192.3	199.2	180.3	187.0	150.7	190.9	185.6	185.6	185.3	181.1
Autocatalyst scrap										
North America	14.0	14.8	12.9	14.4	13.2	13.5	14.0	14.3	15.0	15.2
Europe	9.3	10.8	9.7	11.7	13.5	11.9	12.7	13.4	13.9	15.7
Japan	2.6	2.4	2.6	3.1	3.3	3.2	4.0	3.9	4.0	4.3
China	0.4	0.5	0.7	0.9	1.1	1.3	1.7	2.0	2.3	2.6
Other regions	2.5	3.2	3.7	3.8	4.1	4.6	5.0	5.7	6.2	6.8
Total Autocatalyst Scrap	28.8	31.7	29.6	33.9	35.3	34.4	37.4	39.3	41.3	44.5
Old jewellery scrap										
North America	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Europe	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Japan	8.7	10.7	8.0	7.3	7.6	6.7	6.2	5.7	5.5	5.7
China	11.7	12.8	18.3	15.5	14.5	13.9	15.0	14.3	17.2	18.2
Other regions	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Old Jewellery Scrap	21.2	24.2	26.9	23.4	22.8	21.1	21.6	20.5	23.2	24.4
SUPPLY	242.3	255.1	236.7	244.3	208.7	246.5	244.6	245.4	249.9	250.0
Autocatalyst demand										
North America	12.5	15.8	15.3	16.5	16.8	15.9	13.1	13.8	14.3	15.6
Europe	44.5	45.7	39.6	37.6	40.7	43.8	45.9	43.8	40.2	38.4
Japan	13.5	11.5	12.1	11.0	10.8	10.5	9.9	10.1	10.0	9.8
China	6.7	5.7	5.4	6.7	7.9	7.1	8.0	9.1	9.2	9.6
Other Regions	17.0	18.1	20.2	20.6	20.9	21.6	21.6	22.4	24.6	26.5
Total Autocatalyst Demand	94.2	96.9	92.6	92.4	97.1	98.8	98.5	99.1	98.2	99.8
Jewellery demand										
North America	6.6	6.8	7.0	7.3	7.6	7.7	7.7	7.6	7.6	7.7
Europe	6.8	6.7	6.6	6.9	6.7	6.7	6.6	6.2	6.3	6.4
Japan	8.1	8.8	10.0	10.2	9.9	10.1	9.9	9.8	10.0	9.9
China	47.6	50.4	54.3	57.6	54.7	51.7	43.4	40.2	35.8	33.8
Other Regions	2.1	2.8	3.1	3.7	4.3	5.1	5.2	5.8	6.3	6.9
Total Jewellery Demand	71.2	75.4	80.9	85.6	83.2	81.2	72.7	69.5	66.1	64.7
Chemical demand										
North America	3.0	2.4	2.0	2.3	2.4	1.9	2.5	2.1	2.4	2.5
Europe	2.5	2.8	2.4	2.5	3.1	2.2	3.4	2.4	2.9	3.0
Japan	1.5	1.0	0.7	0.8	1.4	1.1	1.3	1.3	1.2	1.4
China	2.5	3.0	3.2	3.7	4.8	4.4	5.4	5.6	6.7	7.9
Other regions	5.5	6.0	4.1	4.2	6.6	4.0	5.8	5.3	6.2	7.8
Total Chemical Demand	15.0	15.1	12.4	13.5	18.2	13.6	18.3	16.7	19.4	22.5

APPENDIX 3 - PLATINUM SUPPLY AND DEMAND 2010-2019

(tonnes)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Electronics demand										
North America	1.1	0.8	0.5	0.4	0.2	0.2	0.2	0.2	0.2	0.2
Europe	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Japan	1.1	0.9	0.8	0.7	0.6	0.6	0.6	0.6	0.7	0.7
China	1.2	1.1	1.1	1.0	0.9	0.8	0.8	0.9	0.9	0.9
Other Regions	5.2	5.0	4.6	4.2	4.2	3.9	3.9	4.3	5.4	5.6
Total Electronics Demand	8.8	8.0	7.1	6.3	6.1	5.7	5.5	6.1	7.2	7.4
Glass demand										
North America	(0.2)	0.4	0.5	0.0	0.1	0.2	0.7	1.5	0.6	0.7
Europe	0.5	0.3	0.4	0.3	0.1	1.0	0.5	0.5	0.5	0.5
Japan	4.4	3.4	3.1	(2.9)	(3.6)	(1.1)	0.1	0.7	0.4	0.3
China	4.9	1.7	4.5	3.7	0.0	2.6	5.5	4.6	10.8	4.1
Other Regions	6.2	4.8	2.8	(0.5)	1.2	3.0	1.9	3.7	2.8	2.4
Total Glass Demand	15.7	10.5	11.2	0.7	(2.2)	5.9	8.7	10.9	14.9	7.9
Petroleum demand										
North America	0.9	0.9	1.3	1.6	1.0	1.1	1.8	2.1	1.7	1.7
Europe	1.1	0.5	0.5	0.1	0.7	1.7	0.8	0.8	0.6	0.6
Japan	0.6	0.3	0.3	(0.4)	0.2	(0.6)	0.1	(0.2)	0.0	0.0
China	0.2	0.2	0.3	0.5	0.2	0.1	0.2	0.8	0.9	1.1
Other Regions	2.3	2.6	1.6	1.5	1.6	0.7	1.3	1.9	2.2	3.0
Total Petroleum Demand	5.2	4.5	3.9	3.3	3.8	3.0	4.2	5.4	5.4	6.3
Retail investment										
North America	1.3	1.6	2.7	1.7	1.6	1.7	2.7	2.0	2.0	2.1
Europe	0.3	0.5	0.4	0.3	0.2	0.2	1.3	1.3	0.3	0.2
Japan	1.1	6.4	4.6	1.2	1.7	15.5	12.5	5.4	6.9	6.2
Other Regions	0.2	1.1	1.1	1.1	0.9	0.7	0.6	0.5	0.5	0.4
Total Retail Investment	3.0	9.7	8.8	4.2	4.4	18.1	17.1	9.2	9.7	8.9
Other industrial demand										
North America	5.4	6.2	7.4	7.7	8.5	8.4	9.3	9.1	9.0	9.0
Europe	5.1	5.7	6.3	6.5	6.9	6.0	6.2	6.5	6.7	6.8
Japan	1.7	1.9	2.2	2.3	2.5	2.0	2.1	2.2	2.3	2.4
China	1.3	1.6	1.6	1.9	2.1	2.5	3.2	3.4	3.7	4.2
Other Regions	1.7	2.0	1.8	1.8	1.8	1.8	1.9	2.2	2.4	2.6
Total Other Industrial Demand	15.4	17.4	19.3	20.2	21.8	20.7	22.6	23.3	24.1	25.0
DEMAND	228.5	237.5	236.1	226.3	232.4	247.0	247.7	240.2	245.0	242.6
Physical Surplus/(Deficit)	13.8	17.6	0.6	18.0	(23.7)	(0.6)	(3.0)	5.2	4.9	7.4
Identifiable stock movements										
Industry Stocks	0.0	(3.1)	(9.3)	(31.1)	40.4	(1.6)	1.6	0.0	0.0	0.0
Exchange Traded Funds	(18.0)	(4.8)	(7.4)	(27.7)	(6.9)	6.0	(0.5)	0.5	(4.3)	4.7
Sub Total - Stock Movements	(18.0)	(8.0)	(16.7)	(58.8)	33.6	4.4	1.1	0.5	(4.3)	4.7
Net Balance	(4.2)	9.7	(16.1)	(40.9)	9.9	3.8	(2.0)	5.6	0.6	12.1

APPENDIX 4 - PALLADIUM SUPPLY AND DEMAND 2010-2019

(tonnes)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Mine production										
South Africa	82.3	83.5	74.4	75.6	62.5	82.5	76.7	79.9	79.5	77.5
Russia	84.7	84.1	81.6	78.6	80.3	80.1	78.6	84.9	83.1	82.0
Canada	11.0	17.4	17.3	16.5	18.0	16.1	15.9	14.5	15.2	18.3
United States	11.6	12.4	12.3	12.6	12.5	12.6	13.1	13.3	14.3	13.7
Zimbabwe	6.9	8.1	8.0	9.8	10.1	10.0	12.1	12.3	12.3	11.3
Others	9.2	7.8	8.4	8.1	7.6	7.4	7.1	6.4	6.4	6.1
Total Mine Production	205.6	213.4	202.1	201.2	190.9	208.8	203.4	211.3	210.7	208.9
Autocatalyst scrap										
North America	25.9	29.9	28.7	30.9	35.0	32.8	34.5	35.8	37.8	38.8
Europe	9.5	11.1	9.8	10.4	12.2	11.3	12.7	14.5	15.7	16.5
Japan	2.6	2.4	2.6	3.1	3.3	3.2	4.0	3.9	4.0	4.3
China	0.7	1.0	1.5	1.9	2.5	3.0	4.2	5.1	5.5	6.5
Other Regions	2.0	2.6	3.2	3.1	3.8	4.6	5.5	5.9	6.7	7.6
Total Autocatalyst Scrap	40.7	47.1	45.8	49.4	56.8	54.8	60.8	65.2	69.7	73.7
Old jewellery scrap										
North America	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Europe	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Japan	1.0	1.2	0.9	0.9	0.9	0.9	0.7	0.8	0.8	0.8
China	5.1	4.2	4.7	4.1	2.1	1.1	0.7	0.1	0.0	0.0
Other Regions	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total Old Jewellery Scrap	6.7	6.0	6.3	5.7	3.7	2.5	2.0	1.5	1.5	1.6
SUPPLY	253.0	266.5	254.2	256.2	251.3	266.2	266.3	278.0	281.9	284.2
Autocatalyst demand										
North America	38.7	41.6	52.4	60.0	60.5	64.6	70.5	73.6	75.6	76.9
Europe	43.4	49.7	48.5	47.8	50.9	55.1	56.5	59.5	60.3	58.2
Japan	26.3	23.9	28.9	28.1	28.8	26.6	26.3	27.3	26.5	26.0
China	32.1	34.0	38.2	43.6	47.8	51.8	60.8	63.8	65.7	70.9
Other Regions	25.1	25.5	26.8	27.2	31.0	31.0	33.2	36.2	40.0	44.1
Total Autocatalyst Demand	165.6	174.7	194.8	206.8	219.0	229.0	247.3	260.4	268.1	276.2
Jewellery demand										
North America	3.6	2.6	2.4	2.3	2.0	1.7	1.6	1.6	1.4	1.4
Europe	4.3	4.5	4.6	4.6	4.7	4.7	4.7	4.5	4.4	4.3
Japan	1.5	1.5	1.7	1.7	1.7	1.7	1.5	1.4	1.3	1.3
China	12.8	10.6	8.4	6.4	5.3	0.9	0.1	0.1	0.0	0.0
Other Regions	2.6	1.7	1.5	1.3	1.2	1.3	1.3	1.3	1.2	1.2
Total Jewellery Demand	24.8	21.0	18.6	16.4	15.0	10.2	9.2	8.9	8.3	8.1
Dental demand										
North America	5.9	5.5	5.3	5.1	4.6	4.2	3.9	3.7	3.5	3.4
Europe	3.0	2.8	2.6	2.2	2.0	1.8	1.7	1.6	1.5	1.4
Japan	9.0	8.8	8.6	8.2	7.9	7.6	7.3	7.1	6.8	6.4
China	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Other Regions	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2
Total Dental Demand	18.4	17.6	17.0	15.9	14.8	14.0	13.3	12.7	12.1	11.4

APPENDIX 4 - PALLADIUM SUPPLY AND DEMAND 2010-2019

(tonnes)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019f
Chemical demand										
North America	1.6	1.7	1.7	1.7	1.7	1.7	2.1	2.0	2.1	2.1
Europe	5.0	5.1	5.0	4.9	4.7	4.9	5.7	5.2	5.3	5.3
Japan	0.7	0.6	0.7	0.7	0.6	0.6	0.7	0.7	0.7	0.7
China	1.4	2.1	2.4	3.1	2.4	1.7	2.8	3.9	4.5	5.0
Other Regions	2.8	2.5	2.0	2.3	2.5	2.7	3.0	2.9	3.1	3.1
Total Chemical Demand	11.5	12.0	11.8	12.7	12.0	11.6	14.3	14.6	15.7	16.2
Electronics demand										
North America	9.0	8.6	8.5	7.4	7.2	6.5	6.1	5.8	5.4	5.2
Europe	5.9	5.8	5.8	5.3	5.2	4.3	3.8	3.6	3.3	3.2
Japan	10.1	9.8	9.9	8.8	8.6	7.7	7.0	6.7	6.1	5.9
China	5.8	5.9	6.4	7.1	6.9	6.2	6.1	5.8	5.4	5.2
Other Regions	8.5	8.8	8.1	6.7	6.6	6.2	6.1	5.8	5.4	5.2
Total Electronics Demand	39.2	38.9	38.6	35.3	34.5	30.8	29.2	27.7	25.6	24.6
Retail investment										
North America	2.1	1.5	0.8	0.9	1.1	1.1	1.0	1.2	1.2	1.2
Europe	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	(0.1)	(0.2)
Other Regions	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	(0.1)
Total Retail Investment	2.5	1.9	1.2	1.2	1.4	1.4	1.4	1.7	1.0	0.9
Other industrial demand (including petroleum)										
North America	2.0	2.2	2.3	2.4	2.4	2.4	2.3	2.3	2.3	2.4
Europe	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Japan	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
China	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other Regions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Industrial Demand	2.8	3.1	3.1	3.1	3.2	3.2	3.1	3.1	3.1	3.2
DEMAND	265.1	269.3	285.4	291.7	300.2	300.6	318.0	329.7	334.7	341.5
Physical Surplus/(Deficit)	(12.1)	(2.8)	(31.2)	(35.4)	(48.9)	(34.4)	(51.7)	(51.7)	(52.8)	(57.3)
Identifiable stock movements										
Russia	24.9	24.9	12.4	6.2	0.0	0.0	3.1	6.2	0.0	0.0
Stillwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industry Stocks	0.0	(1.6)	(3.1)	(15.6)	18.7	(4.7)	4.4	(9.0)	(5.0)	0.0
Exchange Traded Funds	(33.9)	16.5	(13.9)	0.0	(28.0)	22.6	19.8	11.9	16.4	9.3
Sub Total - Stock Movements	(9.0)	39.9	(4.6)	(9.3)	(9.3)	17.9	27.3	9.1	11.4	9.3
Net Balance	(21.1)	37.1	(35.8)	(44.7)	(58.2)	(16.5)	(24.5)	(42.6)	(41.4)	(47.9)

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