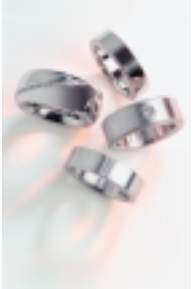
Platinum 2003

by Tom Kendall

Special Reports

Supply and Demand Tables

JM Johnson Matthey



Summary and Outlook

Platinum

- Demand for platinum grew by 5 per cent in 2002 to a new high of 6.54 million oz.
- Buoyant retail sales of platinum jewellery in China, despite higher prices, lifted total jewellery purchases by 9 per cent.
- Auto industry purchases of platinum were limited by the use of stockpiled metal by some companies, but consumption of the metal in autocatalysts grew strongly.
- Industrial demand for platinum increased by 2 per cent; the main contribution to the growth came from higher demand for catalysts from the chemical industry.
- Supplies of platinum increased by just 2 per cent as sharply higher output in South Africa was balanced by a drop in sales from Russia.
- The widening deficit between supply and demand was reflected in the platinum price, which rose by 24 per cent to finish the year at $598.

Demand for platinum grew by 5 per cent to 6.54 million oz in 2002, driven by another strong year of sales to the Chinese jewellery market and by greater use of platinum in autocatalysts. Supplies of platinum failed to keep pace with demand, rising by less than 2 per cent to 5.97 million oz. As a result, the deficit in the platinum market widened to 570,000 oz.

The consumption of platinum in **autocatalysts** grew by 17 per cent last year. Further growth in sales of diesel cars, rising light vehicle output, tighter emissions regulations, and greater use of platinum-based catalysts at the expense of palladium, all contributed to the higher use. Purchase of platinum by auto manufacturers, however, increased by less than 4 per cent to 2.61 million oz as some satisfied a significant proportion of their platinum needs from stocks.

Jewellery demand for platinum in 2002 expanded by 9 per cent to 2.83 million oz. Fabrication of platinum jewellery in China again climbed impressively, platinum demand rising by 14 per cent to 1.48 million oz. A recovery in Japanese purchases was due to less platinum being available from inventories following significant depletion of stocks in 2001, rather than a rise in retail sales. In the USA, a degree of restocking by jewellery retailers at the start of the year lifted demand for platinum, but purchases of metal by European manufacturers softened.

Industrial demand for platinum increased by 2 per cent to 1.59 million oz, led by demand for platinum-based catalysts from the chemical industry. Reduced investment in new manufacturing capacity caused a fall in purchases of platinum by the glass industry, while demand from electrical applications, such as computer hard disks, weakened slightly.

Net demand for platinum coins and bars from the **investment** sector edged lower in 2002 – higher prices in the second half of the year depressed sales of new products and led to greater disinvestment in Japan.

Supplies of platinum increased by 2 per cent in 2002, rising to 5.97 million oz. South African output expanded substantially but this was largely offset by a sharp fall in Russian sales. As a result, the deficit in the platinum market widened to 570,000 oz. Market stocks in Switzerland were heavily drawn down to help satisfy the shortfall, while the US Defense National Stockpile Center (DNSC) sold close to 90,000 oz of platinum during the year, exhausting its available inventory. Short-term lease rates responded to the increased market tightness, rising above 10 per cent several times and touching 20 per cent in October.

The platinum **price** rallied in response to the high lease rates and the widening supply deficit. Sporadic weakness due to long liquidation on TOCOM and NYMEX tended to be brief, and dips in the price swiftly attracted good bids for metal on the spot market. Market sentiment grew increasingly bullish on the back of the fundamental strength of demand, as well as a degree of concern about the potential for delays to planned mine expansions. In addition, a strong flow of speculative funds into hard commodities increased buying of platinum futures. As a result, the price rose from $481 in January to a peak of $607 in December.

Supply

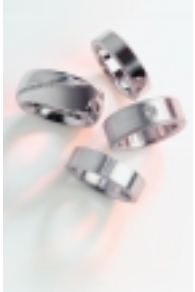
Supplies of platinum from **South Africa** reached a record high of 4.45 million oz in 2002, an increase of 8.5 per cent. Both the expansion of existing operations and growing production from developing mines contributed to the rise.

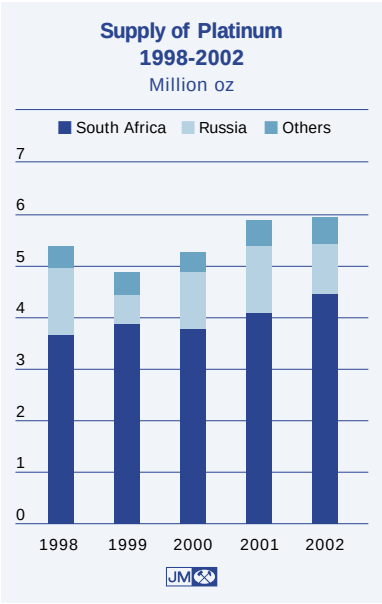
Anglo Platinum delivered a 6.7 per cent increase in platinum output in 2002, producing 2.25 million oz of refined metal. This, however, was 100,000 oz less than the group had initially forecast due to a slower than expected build up of output at the Bafokeng Rasimone Platinum Mine (BRPM) and a temporary decline in grades at PPRust.

These set backs, coupled with delays in granting new mining authorisations by the government, caused Anglo Platinum to revise its long-term expansion

Platinum Supply and Demand
'000 oz

	2001	2002
Supply		
South Africa	4,100	4,450
Russia	1,300	980
North America	360	395
Others	100	145
Total Supply	**5,860**	**5,970**
Demand		
Autocatalyst: gross	2,520	2,610
recovery	(530)	(570)
Jewellery	2,590	2,830
Industrial	1,560	1,590
Investment	90	80
Total Demand	**6,230**	**6,540**
Movements in Stocks	**(370)**	**(570)**





strategy. The group still plans to reach an annualised production rate of 3.5 million oz of refined platinum by the end of 2006 but a greater proportion of the increased metal output is now scheduled for 2005 and 2006. This will include contributions from a project to re-treat tailings dams around the Rustenburg area that was announced last year.

Platinum production from Impala's mining operations increased by 7 per cent, with output at its core lease area reaching a little over 1 million oz. At Crocodile River, however, geological difficulties caused a sharp fall in the volume of ore mined. Mine development began at the Marula project on the eastern Bushveld and Impala completed a first phase of expansion at its pgm refinery during the year. Throughput will rise as increased volumes of concentrate are delivered from smaller South African producers and from the Zimplats and ZCE Platinum mines in Zimbabwe. Output from the latter two companies rose as expansion gathered pace at the Mimosa and Ngezi mines.

The tonnage of ore milled at Lonmin rose in 2002, substantial expansions to concentrator capacity were brought on stream, and the Pandora joint venture with Anglo Platinum to mine reserves to the east of Lonmin's existing operations was approved by the South African government. Lonmin also commissioned its new smelter at Western Platinum during the year but this was damaged by an explosion in December. The repaired smelter is due to be recommissioned during the fourth quarter of 2003; in the meantime Lonmin has brought several of its older furnaces back into service, and a proportion of concentrate is being toll refined by Impala.

The volume of ore milled at Northam increased by 11 per cent in 2002, in part reflecting the loss of 32 days' production to a strike the previous year but also due to an improvement in face availability. Production at Aquarius Platinum's Kroondal mine continued to ramp up towards planned capacity and the company's Marikana operation began producing concentrate by the end of the year. Ore production at SouthernEra's Messina mine also began to build.

In 2002, **Russian** sales of platinum fell back from the previous year's high of 1.3 million oz, dropping to 980,000 oz. This level of shipments more closely reflected actual output of platinum at Norilsk Nickel and from the two alluvial operations in the Far East of Russia. Norilsk continued to invest in modernisation and efficiency programmes at its mining and processing facilities in Siberia and the Kola Peninsula but these had no impact on output in 2002.

Norilsk's sales in 2001 were boosted by the release of metal previously held as loan collateral by a Russian bank, and sales of metal were also made from central government stocks. During 2002, however, no further significant disposals from this source were evident.

Moves to declassify information on geological reserves and production of pgm in Russia gathered pace during 2002 but an act of parliament is required to rescind the existing legislation. This is not expected before the end of 2003. The level of government pgm stocks is almost certain to remain confidential.

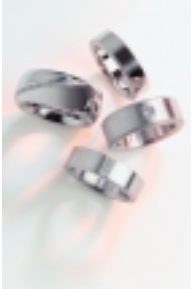
Supplies of platinum from **North America** increased substantially in 2002, rising by almost 10 per cent to 395,000 oz. Output at Inco climbed as the company exploited a small but pgm-rich ore body at one of its Sudbury mines in Canada. In the USA, production at Stillwater climbed in line with expanded palladium output at its East Boulder mine in Montana.

Demand

Despite substantial use of platinum inventories by some US auto manufacturers in 2002, purchases of the metal by the **autocatalyst** industry increased by 3.6 per cent to 2.61 million oz. Including stock draw downs, the underlying use of platinum in autocatalysts jumped by an impressive 17 per cent. In Europe, the growth in sales of diesel cars was instrumental in leading higher demand for platinum. In North America and Asia, firm growth in light vehicle production increased autocatalyst consumption of platinum. Demand was also stimulated by some auto manufacturers' programmes to minimise their palladium requirements through greater use of platinum-based autocatalysts, and the global trend towards tighter control of vehicle emissions.

Sales of diesel cars in Western Europe rose by 7 per cent in 2002 and the market share taken by them reached 40 per cent. With diesel vehicles utilising only platinum-based autocatalysts, this growth was responsible for a significant proportion of the sharp rise in demand for platinum to 1.24 million oz.

In both Europe and North America, some manufacturers made greater use of platinum-based catalysts on a number of their gasoline car models at



the expense of palladium-rich systems. This switching reflected programmes introduced in 2000 and 2001 by several auto companies to reduce their reliance on palladium, following the sharp rise in the metal's price. Given the long lead-time for the development and certification of new catalyst systems, the effect of these programmes was only fully felt in 2002.

A strong rise in light vehicle production in the USA also boosted consumption of platinum in autocatalysts. Although light vehicle sales fell, manufacturing rates were high throughout the first half of the year as auto companies sought to rebuild inventories at dealerships. As a result, light vehicle production increased by almost 7 per cent.

However, despite the greater use of platinum in autocatalysts in North America, purchases by auto companies dropped by 28 per cent to 570,000 oz. Several US auto makers had stockpiled significant volumes of platinum over the previous few years – these inventories were diminished during 2002, reducing demand for the metal.

The limits on automobile emissions continue to tighten worldwide and had an impact on platinum autocatalyst demand last year, particularly in Japan. Although tighter emissions standards are not due to enter legislation until 2005, a significant proportion of Japanese cars already meet proposed lower limits. This improvement in emissions control in advance of legislation had the effect of raising average platinum loadings in 2002. Coupled with a 6.2 per cent increase in car production, this boosted Japanese autocatalyst demand for platinum by 25 per cent to 425,000 oz.

China experienced a 35 per cent jump in light vehicle production in 2002 to 2.65 million vehicles and the regulation of car emissions in the country is tightening. These two factors drove a 15 per cent increase in autocatalyst demand for platinum in the Rest of the World.

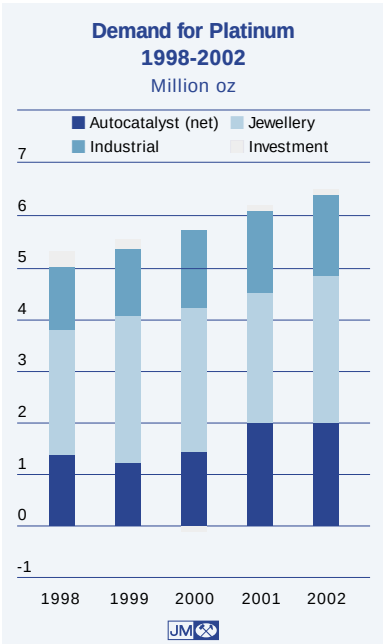
Demand for platinum in **jewellery** rebounded by 9 per cent in 2002, reaching 2.83 million oz. The Chinese jewellery sector again led the growth: purchases by Chinese fabricators jumped by 14 per cent to 1.48 million oz. In Japan, retail sales weakened further but purchases of metal increased as less jewellery stock was recycled. In North America, restocking by retailers early in the year boosted demand for platinum.

Chinese sales of platinum jewellery were strong throughout 2002. Platinum jewellery has established a firm position in both the fashion and bridal sectors of the market, and consumers identify with the metal's attributes such as purity and its distinctiveness from traditional Chinese jewellery. With the Chinese economy continuing to grow rapidly and disposable incomes rising, retail sales of platinum jewellery continued to increase.

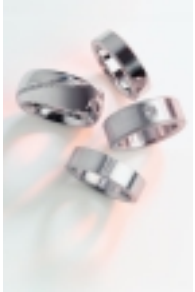
However, Chinese fabricators of platinum jewellery began to face difficulties in making sufficient profit margins during the second half of the year when the spot price of platinum climbed from under $550 per oz to $600 per oz. Chinese retailers of platinum jewellery have been reluctant to raise their prices, fearing a loss of market share, and so movements in retail prices lag well behind the price of platinum bullion. As the spot price increased, manufacturers were unable to pass on their higher raw material costs to retailers and their profit margins were eroded as a result.

The Japanese economy remained weak in 2002, GDP expanding by just 0.3 per cent year-on-year. Total sales of precious metal jewellery fell by 10 per cent on a piece basis and platinum jewellery sales slid by 15 per cent as retailers marketed white gold fashion jewellery to cost-conscious consumers. In the core bridal segment of the market, however, platinum retained its strong position.

Despite the fall in retail sales of platinum jewellery, purchases of metal by fabricators increased by 30,000 oz to 780,000 oz. The Japanese jewellery industry made strenuous efforts to reduce stock levels



Sales of diesel cars climbed again in Europe last year, spurring autocatalyst demand for platinum.



Demand for platinum in high-quality glass production fell in 2002 but remained firm by recent historical standards.

throughout 2001; consequently less metal was available to be recycled during 2002.

In North America, restocking by platinum retailers and fabricators during the first quarter of 2002 led to a rise in purchases of metal over the year of 30,000 oz to 310,000 oz. The uncertain economic outlook in the USA, however, meant that consumers were cautious in their spending on luxury goods and retail sales of platinum jewellery improved only marginally.

The European market for platinum jewellery was mixed – sales in the UK continued to rise but the German and Italian markets were depressed. Fabricators in these countries had some success in increasing export sales but this was not sufficient to prevent platinum demand in Europe as a whole from edging slightly lower in 2002.

Industrial demand for platinum increased moderately to 1.59 million oz. Demand for platinum-based catalysts from the chemical and petroleum refining industries increased, purchases of platinum for use in electrical applications were marginally down, while demand from the glass industry was affected by less investment in new manufacturing capacity.

Chemical industry demand for platinum in the form of process catalysts was boosted by 12 per cent, largely due to the construction of additional production facilities in the Middle East and Asia. Investment in new paraxylene plants and rising demand for silicones in China, in particular, supported higher demand for platinum-based catalysts.

In the electrical sector, purchases of platinum for use in computer hard disks softened slightly in 2002 – the growing use of hard disks in non-computing applications did not fully offset weak personal computer sales and the continued reduction in the average number of disks per hard drive. Demand for platinum in thermocouples also edged lower, reflecting overcapacity and a lack of investment in the steel, glass and semiconductor industries.

There was substantial expansion of LCD glass and fibreglass manufacturing capacity in Asia in 2001, which boosted demand for platinum equipment significantly. The rate of expansion slowed in 2002 and this, coupled with several glass furnace closures in North America and Europe, led to a fall in glass industry purchases of platinum. That said, at 255,000 oz demand was still firm by historical standards.

Demand for platinum from other market sectors was generally positive last year, and use of the metal in applications such as spark plugs, sensors and biomedical equipment increased. The use of platinum as a component of high-gold dental alloys, which increased in 2001 following the palladium price spike, flattened out in 2002 as palladium alloys began to regain market share.

Demand for platinum **investment** products remained relatively weak. Sales of platinum coins and investment bars are price-sensitive and demand dropped during the second half of the year as the price increased. The higher price also triggered greater sales of bars back to the market in Japan. In total, net investment demand for platinum softened to 80,000 oz.

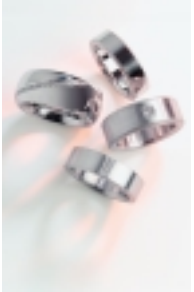
Outlook

The deficit between platinum supply and demand widened in 2002 as growth in the jewellery and autocatalyst markets outstripped increased supplies of metal from South Africa. The impact of tight physical availability was magnified during the first quarter of 2003 by strong fund buying of platinum futures on NYMEX and TOCOM, and the London fixing price surged to $705 on the 11th March – a 23-year high.

Purchasing from the Chinese jewellery sector fell away at this level as, with retail prices static, manufacturers' profit margins disappeared. Some fabricators switched a proportion of their output to white gold as a source of greater profits. The subsequently rapid fall in the platinum price back below $650 on concerted long liquidation of futures allowed platinum jewellery fabricators to regain a degree of profitability. However, unless retail prices increase significantly, margins are likely to remain tight.

In addition, the outbreak of the SARS virus has already had a noticeable impact on consumer spending in China. In late April the government announced that the week-long Labour Day holiday would be shortened to help to discourage widespread travel. This holiday has developed into one of the major shopping periods in the Chinese calendar in recent years. Its abbreviation, coupled with the wider effect of SARS on consumer behaviour, is expected to be detrimental to platinum jewellery sales.

The effect of poor manufacturer profit margins and weaker retail sales may well result in a fall in the level of platinum demand from the Chinese jewellery sector this year compared to the high level seen in 2002.



In Japan, inventories throughout the jewellery industry are now low. With little further opportunity to recycle stock, purchases of platinum by fabricators are likely to increase and will better reflect the level of consumption. The economy, however, remains weak and little growth is expected in retail sales.

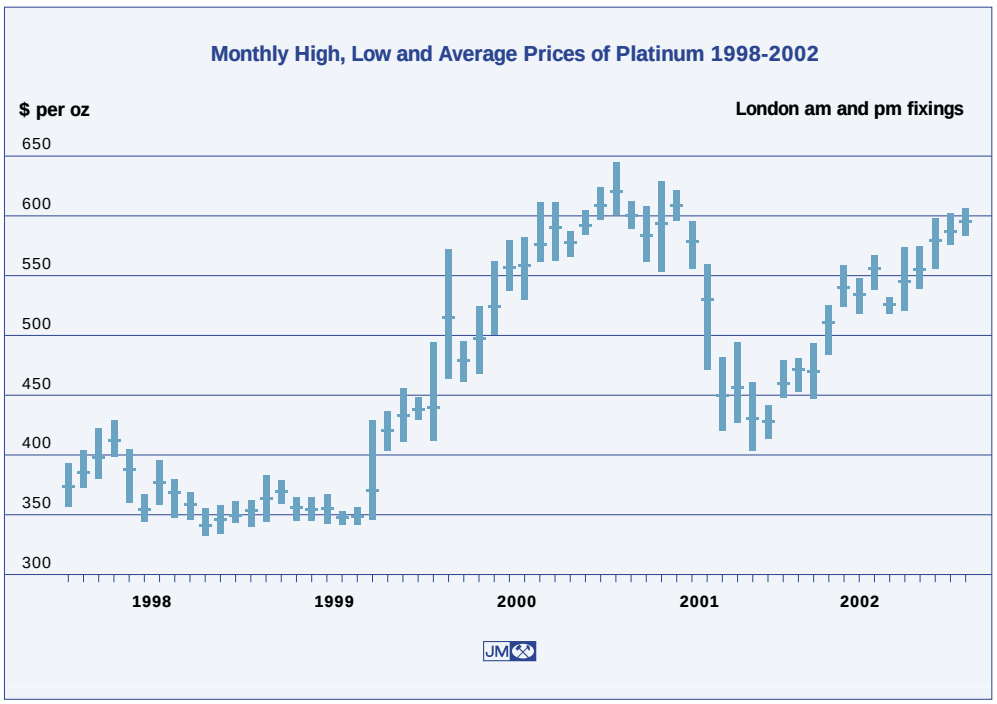
Purchases of platinum by the auto industry are likely to increase for the fourth successive year in 2003. Despite indications that car production in the USA may decline, the use of platinum inventories by US-based manufacturers will have less impact than in 2002 as stocks are run down. In Europe the penetration of diesel cars is expected to continue to grow and an increasing number of vehicles will meet the tighter Euro IV standards that will enter effect from 2005. All these factors will result in a further increase in autocatalyst demand for platinum.

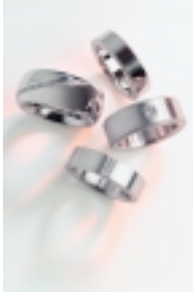
In all regions, auto manufacturers are re-examining the ratio in which they use pgm in light of the current large discount in the price of palladium to platinum. Although many manufacturers remain wary of the past price volatility, a degree of movement back in favour of palladium is expected. There will be little impact on platinum or palladium demand in 2003, however, as the process of emission systems development, calibration and certification takes many months.

We forecast another moderate increase in industrial purchases of platinum this year as demand for platinum in electrical applications such as computer hard disks and thermocouples is expected to improve. Demand in other sectors will largely depend on the rate of economic growth. The prognosis is mixed as both business investment and consumer confidence are still weak in Japan, the USA and much of Europe.

Platinum supplies from South Africa will increase further as the expansion of mining continues. Production should also rise again at the Zimbabwean mines but this will be offset by lower output in North America as Inco's production subsides from recent highs. Russian platinum shipments are forecast to continue at or close to the rate of production. In March 2003, Norilsk released an outline of its intended production plans through to 2015, noting that pgm production is expected to remain fairly constant, the emphasis of development being on increasing efficiencies and reducing costs.

In summary, we expect to see demand for platinum flatten out or soften moderately in 2003. Supplies from South Africa will continue to rise, while shipments from Russia are forecast to be stable. The overall increase in supply, however, is unlikely to close the gap with demand and physical availability of metal will remain tight. Consequently, we expect platinum to trade between $590 and $690 for the next six months.





Palladium

- Palladium demand slumped by almost 30 per cent in 2002 to 4.78 million oz, the lowest level for nine years.
- Heavy use of inventories and the effects of thrifting reduced palladium purchases by the auto industry by 39 per cent to 3.08 million oz.
- Purchases of palladium for electronics increased by 6 per cent but remained substantially below consumption due to a further reduction of inventories.
- Demand for palladium used in dental alloys recovered by 3 per cent – the metal's weaker price enabled palladium alloys to regain market share in the USA and Japan.
- Palladium demand in the remaining other applications grew by 12 per cent, led by higher jewellery alloy production in China and Japan.
- Supplies of palladium dropped steeply to 5.25 million oz as Russia continued to restrict sales. Despite this, the market remained in surplus and the price dropped by more than $200 to a low of $222.

Overview

In 2002, purchases of palladium by the auto industry dropped dramatically due to the very substantial use of stocks by some auto makers. Consumption of palladium on autocatalysts also declined as thrifting programmes and greater use of platinum-based autocatalysts took effect. In contrast, demand from the electronics sector improved somewhat as the use of inventories subsided but substitution of palladium by nickel in the capacitor industry continued. In total, palladium demand slumped by almost 30 per cent to 4.78 million oz.

Russian shipments of palladium fell sharply in response to the weak market but production of the metal in all other regions expanded. As a result, the market remained oversupplied and the price weakened from $440 at the start of the year to less than $230 in December.

Autocatalyst demand for palladium slumped to 3.08 million oz in 2002, a drop of almost 40 per cent. Leading US car companies built up substantial volumes of palladium in the late 1990s, anticipating continued strong growth in the metal's use in autocatalysts and further disruptions to russian. The sharp rise in the palladium price towards the end of that period, however, led auto makers to begin thrifting their use of the metal. With concerns about the security of palladium supply easing, palladium loadings successfully reduced, and profit margins in the US auto industry under pressure, auto companies made substantial inroads into their palladium inventories in 2002. In addition, some metal was sold back to the market by car manufacturers during the year.

In the **electronics** sector, the excess inventories of both palladium and manufactured components that accumulated towards the end of 2000 continued to be depleted last year. The use of stocks, however, was lower than in 2001 and purchases of palladium increased by 40,000 oz to 710,000 oz. Production of multi-layer ceramic capacitors (MLCC), the largest electronic application for palladium, increased year-on-year but nickel-based MLCC took further market share from palladium products.

The fall in the price of palladium during 2002 encouraged a moderate move back to greater use of palladium **dental** alloys in North America and Japan. In Europe, however, the substantial investment that has been made in base metal and porcelain-based dental materials, at the expense of palladium, precluded any significant revival of demand.

Demand for palladium in **other** applications advanced by 12 per cent to 610,000 oz. Production of jewellery alloys containing palladium increased, while demand for palladium-based chemical catalysts was broadly flat. Purchases of palladium for use in petroleum refining catalysts were positive following net sales of the metal back to the market the previous year.

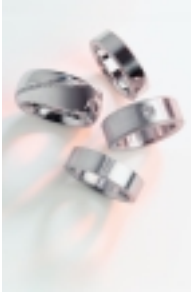
Supplies of palladium slid by 28 per cent in 2002 to 5.25 million oz as Russian shipments were cut back to levels not seen since 1990. In the face of weak demand, and in an effort to support the palladium price, Russian sales were restricted to just 1.93 million oz – less than half the previous year's total and some distance below the level of production. A significant proportion of Norilsk's palladium output was used to repay a long-standing government loan. Gokhran has stated that it made no sales from the state stockpile during the year.

Shipments of palladium from South Africa, however, climbed to 2.16 million oz, rising in line with growing platinum output. Palladium production in North America also increased substantially in 2002, nearing 1 million oz as expansions at Stillwater Mining and North American Palladium took effect.

Consequently, despite Russian efforts to bring supply more in line with weak demand, the palladium market

Palladium Supply and Demand
'000 oz

	2001	2002
Supply		
South Africa	2,010	2,160
Russia	4,340	1,930
North America	850	990
Others	120	170
Total Supply	**7,320**	**5,250**
Demand		
Autocatalyst: gross	5,090	3,080
recovery	(280)	(370)
Dental	725	750
Electronics	670	710
Other	545	610
Total Demand	**6,750**	**4,780**
Movements in Stocks	**570**	**470**



remained substantially in surplus in 2002. Liquidity was further increased as the US Defense National Stockpile Center (DNSC) sold more than 324,000 oz of palladium during the year. The combination of slack demand and oversupply resulted in the **price** falling for much of the year. Brief spikes caused by short-covering on the thinly-traded futures markets punctuated the decline, but over the course of 2002 the spot price dropped from $440 in January to under $230 in December.

Supply

Norilsk Nickel suspended spot sales of palladium in August 2001 and continued to sell metal only under contract throughout 2002. In addition, the **Russian** state treasury, Gokhran, has also said that no sales of palladium were made from government inventories during the year in support of Norilsk's position. The net result was a 56 per cent slump in sales of palladium from Russia to 1.93 million oz.

With Norilsk's sales running well below the level of production since August 2001, a substantial build up of palladium inventories would have occurred at the company but for two factors. Norilsk repaid a long-standing loan from the Ministry of Finance with a large volume of palladium – believed to be equivalent to as much as six months of production. In addition, the proposed deal under which Norilsk would acquire a majority stake in Stillwater Mining required the former to deposit 877,000 oz of palladium in a London vault by March 2003, the metal to be used as part payment of the share purchase. These two transactions will have accounted for much of Norilsk's production that would otherwise have accumulated.

Sales of palladium by **South African** pgm producers increased by 7.5 per cent to 2.16 million oz in 2002, reflecting the rise in platinum output from both established and developing mines. Anglo Platinum led the increase, with palladium output growing by 6 per cent to 1.11 million oz. Production in Zimbabwe also rose as mining rates increased at the Mimosa and Ngezi operations.

Output in **North America** jumped by 16 per cent to 990,000 oz – expansions of mining and processing capacity at both Stillwater Mining and North American Palladium delivered higher volumes of concentrate, while Inco's output reached a new high thanks to mining of small but pgm-rich ore zones.

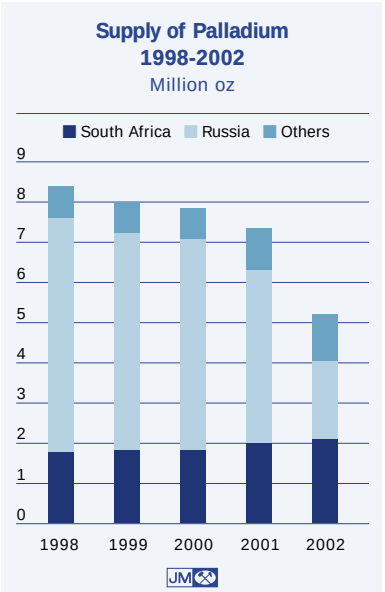
Demand

Purchases of palladium for use in **autocatalysts** plunged to just 3.08 million oz in 2002, a drop of a little over 2 million oz from the previous year. By far the largest component of this fall was the heavy use of inventories of metal by some US-based auto companies, which meant that purchases of metal were substantially lower than consumption.

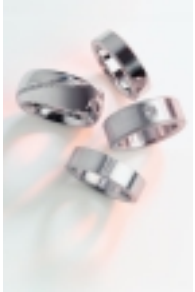
The US auto industry's view of the desirability of holding large stocks of palladium has changed over the last two years due to a combination of factors. A key aspect of this change has been the reduction in auto companies' own projections of their future metal requirements. Advances in both engine and emissions control technology, coupled with thrifting of palladium, have enabled many auto manufacturers to reduce their forecast palladium demand going forward.

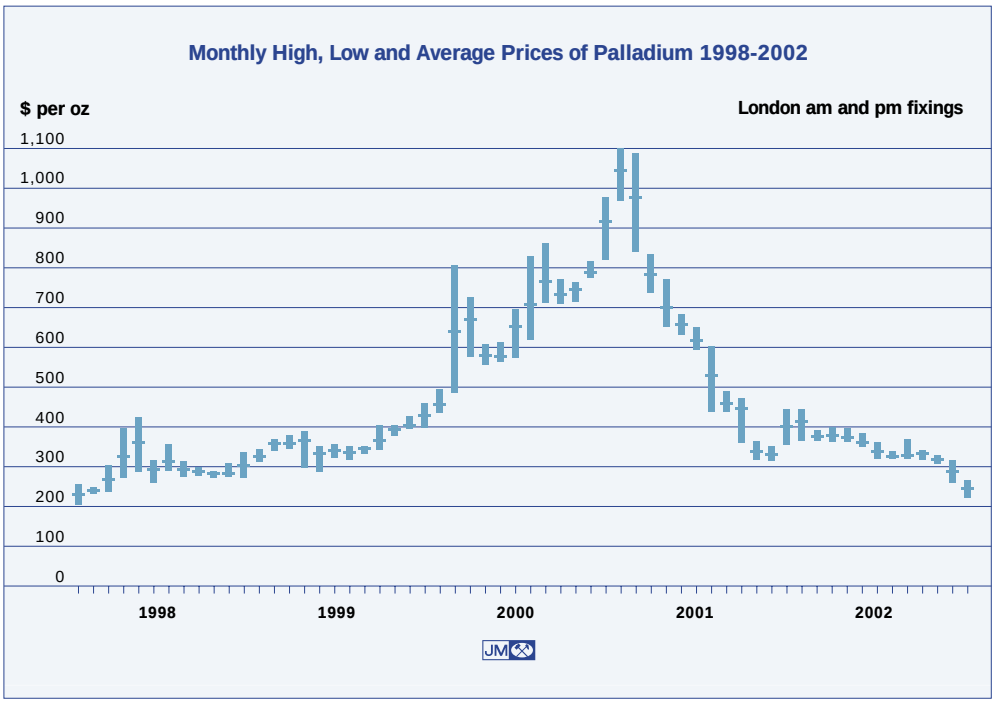
A second issue has been the balance sheet implications of holding large palladium inventories, which were reassessed following Ford's write-down of its pgm stocks last year, at a time when pressure to reduce costs within the industry was intensifying. In addition, confidence in the stability of supplies has risen, with output in South Africa and North America growing and Norilsk Nickel continuing to pursue long-term supply contracts.

Efforts to thrift palladium use on autocatalysts were spurred by the rise in the metal's price to over $1,000 in early 2001. Auto makers were successful in reducing their intensity of palladium use in a number of ways, including development of improved emission control



Banks of flotation cells at Norilsk Nickel's Talnakh operation on the Taimyr Peninsula in Siberia.





systems, increasing the proportion of rhodium used on some catalysts, and by moving towards greater use of platinum-based catalysts on certain vehicle models. These initiatives reduced the use of palladium on autocatalysts by 15 per cent last year, with the impact most noticeable in the USA. In Europe, a fall in gasoline vehicle production and a further loss of market share to diesels contributed to lower palladium demand.

Purchases of palladium by the **electronics** industry recovered somewhat in 2002, increasing by 6 per cent to 710,000 oz. Excess inventories of palladium and components within the industry as a whole were largely depleted during the year – the lower rate of stock utilisation compared with 2001 led to higher demand for palladium.

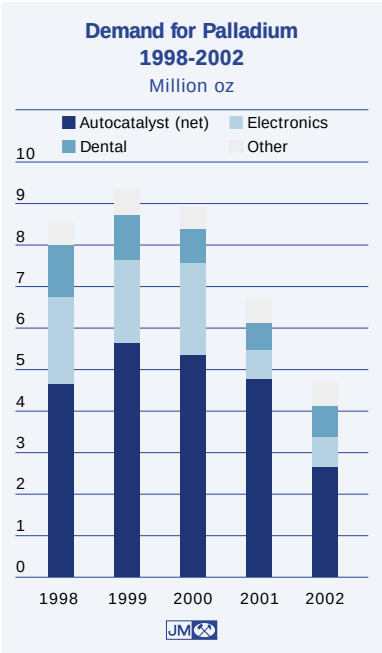
Shipments of MLCC rebounded by approximately 16 per cent in 2002, as sales of capacitor-intensive products such as mobile phones improved and demand from the automotive electronics sector grew. However, the substitution of palladium by nickel MLCC continued, the market share of palladium components falling to just 37 per cent.

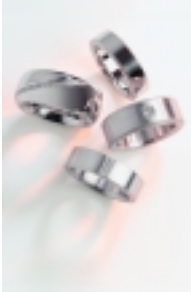
The fall in the price of palladium slowed efforts to substitute the metal in plating applications but demand remained static. With the exception of China, sales of personal computers and IT equipment were disappointing in 2002, and spending on telecoms infrastructure remained subdued. As a result, overall demand for palladium in applications such as hybrid integrated circuits (HIC) and resistors was flat.

Demand for palladium for use in **dental** alloys improved in 2002, the fall in the price of the metal enabling palladium-based alloys to regain a degree of market share in some markets. Total dental demand increased by 25,000 oz to 750,000 oz.

The Japanese dental market experienced moderate growth as the lower palladium price encouraged greater use of a 20 per cent palladium alloy. In North America, palladium-based alloys claimed some market share back from high-gold products, metal demand rising by 8 per cent. In most European markets, however, the substitution of palladium with cheaper base metal alloys or porcelain products appears to have become permanent. The exception was Italy, where precious metal products still dominate and where sales of palladium alloys increased. Across Europe as a whole, however, demand was flat.

Purchases of palladium for **industrial** and other markets grew in 2002, rising by 12 per cent to 610,000 oz. Most of the increased demand came from palladium used in jewellery alloys. In Japan in particular production of white gold climbed resulting in higher palladium demand (palladium is commonly





used as a whitening agent in white gold alloys in Japan). Demand for palladium-based catalysts from the chemical industry improved moderately, rising by 2 per cent, but soft economic growth in many regions restrained investment in new manufacturing capacity.

In 2001 the high price of palladium caused some petroleum companies to replace palladium-based refining catalysts with base metal products and sell palladium back to the market. The much lower price of the metal in 2002 reduced the financial benefits of substitution and demand for palladium used in hydrocracking catalysts was positive.

Tightening controls on vehicle emissions and rising car production in China are positive factors for palladium demand.

Outlook

Demand for palladium is expected to improve in 2003 as less use of inventories by both the auto and electronics industries will result in an increase in metal purchases. Although US auto companies will continue to consume stockpiled palladium this year, the rate of inventory use will be substantially lower compared with 2002. As a result, global purchases of metal will grow significantly but will remain a long way short of the 6.75 million oz bought in 2001.

Despite the increase in purchases, consumption of palladium in autocatalysts will fall further. The effect of continuing projects to thrift palladium by auto companies will be felt this year and average loadings are expected to decrease. Programmes to replace palladium-based autocatalysts with platinum-based alternatives on some vehicle models, however, have largely run their course and will have little further impact on palladium demand. Indeed, given the substantial discount in the price of palladium to platinum, some auto manufacturers are preparing to migrate a proportion of their autocatalyst systems back towards greater use of palladium.

North American car production in 2003 is set to fall from last year's high. Gasoline vehicle output in Western Europe is also likely to soften, with diesels taking further market share, and growth in auto manufacturing in Asia is expected to moderate. These factors will dampen consumption of palladium.

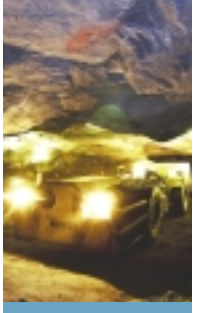
Inventories of palladium and components in the electronics sector have largely been run down to normal working levels and stock use is not expected to affect palladium purchasing in 2003. Demand for the metal will therefore increase and will be more closely aligned with consumption. However, nickel-based MLCC will take additional market share from palladium components and overall demand for palladium is likely to remain below 1 million oz.

Continuing price weakness should enable palladium-based dental alloys to make further small gains in market share in North America and Japan, but the combined increase in demand will be small in context of the overall palladium market.

Output of palladium from South Africa will grow substantially in 2003 as the expansion of platinum mining continues. Many of the developments at existing mines and the new projects on the eastern limb of the Bushveld Igneous Complex exploit reserves of UG2 ore, rather than the Merensky Reef. The UG2 typically contains a higher proportion of palladium than the Merensky Reef and this will provide an additional boost to palladium output going forward.

Sales of Russian metal are likely to exceed last year's low. Norilsk Nickel has reported some success in signing new supply contracts with consumers, while comments from the Ministry of Finance suggest that sales of metal from government stocks may resume this year. Disposals of palladium are also continuing from the US DNSC, although as of the end of April 2003 there were less than 160,000 oz left in the stockpile.

In summary, even though demand for palladium is forecast to improve in 2003, it is likely to be once again outstripped by supply and the market will remain in surplus. As a result, we expect the recent price weakness to persist, with palladium trading between $120 and $180 during the next six months.



Supplies

Supplies, Mining and Exploration

South Africa

South African platinum production increased to 4.45 million oz in 2002, an increase of 8.5 per cent (350,000 oz) compared with the previous year. All the major producers increased output, both through improvements at existing mines and the development of new operations. Shipments of palladium from South Africa rose by 7.5 per cent to 2.16 million oz, while sales of rhodium grew 7.3 per cent to 485,000 oz.

Anglo Platinum

Anglo Platinum's production of refined platinum increased by 6.7 per cent in 2002 to 2.25 million oz, 100,000 oz less than the group originally intended. Much of the increase came in the second half of the year as new projects began delivering increased volumes of concentrate. Output of refined palladium for the year rose 6 per cent to 1.11 million oz, and rhodium production increased to 211,700 oz.

At the group's Rustenburg section platinum output declined by 9 per cent to 655,500 oz but this was mainly a result of the incorporation of the Brakspruit, Bleskop and Paardekraal shafts into the Rustenburg UG2 Phase 1 project. At Amandelbult, head grades and concentrator recoveries improved and platinum output rose by 5 per cent to 711,000 oz.

In the first half of the year, a drop in mill head grade resulting from a low-grade intrusion in the south pit at Potgietersrust led to a 22 per cent fall in refined platinum output to 165,000 oz. An accelerated stripping programme, additional production from a new mini-pit, and completion of the Ga-Pila village relocation resulted in an increase in available ore reserves by year-end. Union Section maintained production levels and work focussed on upgrading infrastructure and increasing available ore reserves, while production, head grade and concentrator recovery all increased at Lebowa.

Refined platinum output at the Bafokeng Rasimone Platinum Mine climbed to 162,000 oz as stope development increased and mining efficiencies improved. Production commenced at the Rustenburg UG2 Phase 1 project and concentrator throughput built up rapidly through the year, yielding 145,000 oz of platinum. The concentrator at the Modikwa joint venture was also commissioned and the mine produced a total of 25,000 oz of platinum *(further details of this and other developing projects are given in the special feature on page 14)*. Downstream, Anglo Platinum completed construction of a new smelter at Polokwane. This will process concentrate from the group's new mines on the eastern limb of the Bushveld Igneous Complex, as well as taking concentrate from Lebowa and PPRust.

Impala Platinum

In 2002, the volume of ore milled at the Impala lease area increased by 5 per cent to 15.2 million tonnes, and refined platinum production rose 7 per cent to 1.063 million oz. In the longer term, to maintain output from the area at 1 million oz of platinum per annum, Impala is planning to construct a new R5 billion shaft. This will be capable of delivering over 0.5 million tonnes of ore per year from 2008 onwards to replace declining output from other areas of the Impala lease.

Impala Platinum intends to increase refined platinum output (including metal from bought-in concentrate and toll refining) to 2 million oz per annum by 2006. An expansion of refining capacity to 1.65 million oz platinum per annum has been completed and a study has been initiated to evaluate a further increase to 2.5 million oz per annum.

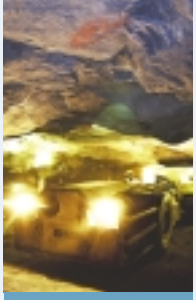
At the Crocodile River mine, in which Impala owns an 83 per cent interest, the volume of ore milled in 2002 fell by 23 per cent to 613,000 tonnes. Production of platinum in concentrate totalled a little over 33,600 oz. Extensive geological problems slowed development underground and had an adverse impact on face availability and output. In February 2003 Impala announced that an evaluation of the long-term viability of the mine had begun, and a decision on its future is expected by the end of June 2003.

At Impala's Marula project on the Eastern Bushveld, plant construction and mine development started in August and September 2002 respectively. Stockpiles of development ore from the UG2 reef are being built up in anticipation of the start of plant commissioning in September 2003.

During 2002, Impala increased its equity interests in Zimbabwean platinum producers. Impala now holds 50 per cent of ZCE Platinum (Aquarius Platinum holds the other 50 per cent) and has a 36 per cent direct interest in Zimplats. Impala already owned a 30 per cent direct interest in Makwiro Platinum, the Zimplats subsidiary that operates the Ngezi mine and Selous Metallurgical complex. Impala refines concentrate from both the ZCE and Zimplats operations.

PGM Supplies: South Africa
'000 oz

	2001	2002
Platinum	4,100	4,450
Palladium	2,010	2,160
Rhodium	452	485



The expansion of platinum mining in South Africa

A period of unprecedented growth

The South African platinum industry is currently expanding at an unprecedented rate in order to meet projected increases in demand. With the exception of Northam, all existing producers have ambitious expansion plans. They will be joined by several new entrants as the South African government's policy of black economic empowerment leads to the greater involvement of black-led companies in the platinum mining sector, mainly in the form of joint ventures with existing producers. Additional investment is also expected from non-South African companies, such as the UK's Cluff Mining and Canada's SouthernEra.

As a result of this expansion activity, platinum output is set to rise substantially over the next four years. If all new projects reach their targets, refined production from South African platinum mines could be as high as 6.3 million oz in 2006, with Anglo Platinum alone reaching an annual production rate of 3.5 million oz.

The changing focus of platinum mining

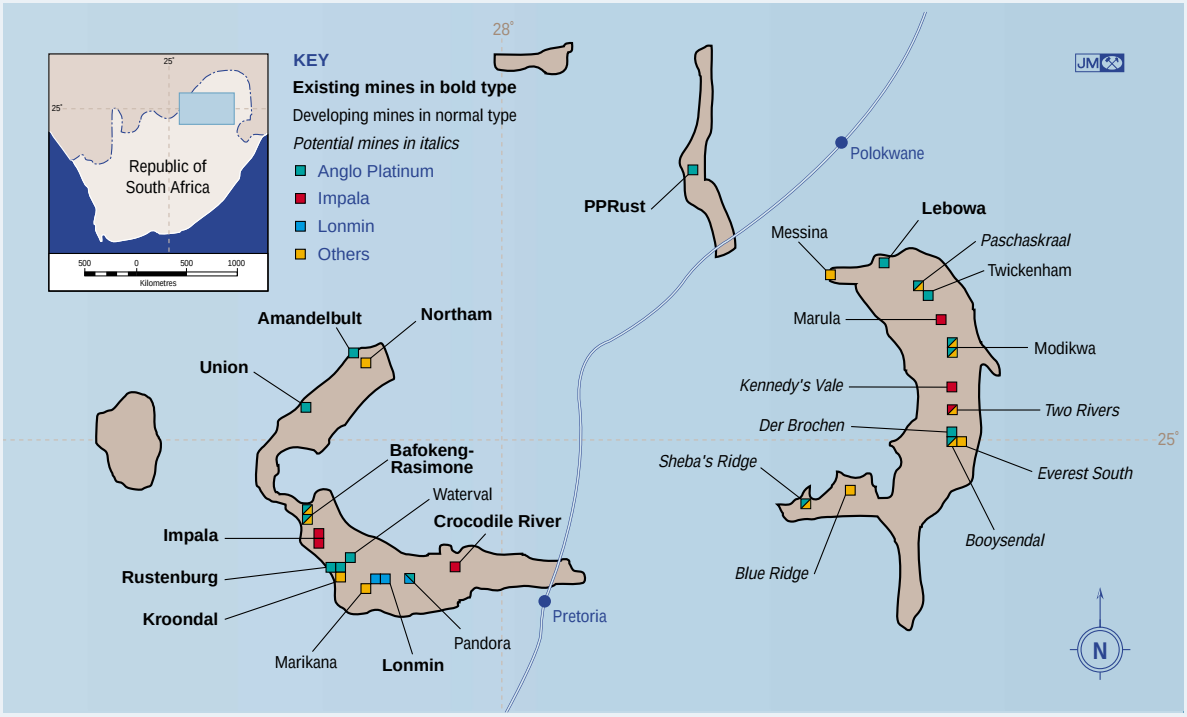
Traditionally, platinum mining in South Africa has been concentrated on Merensky Reef reserves hosted by the western limb of the Bushveld Igneous Complex. The Merensky Reef has been the main source of ore because it generally has a higher pgm content than the UG2 and, because of its lower chromite content, is also easier to process. However, as much of the shallow Merensky ore on the western Bushveld has now been extracted, most of the proposed new projects will mine UG2 reserves.

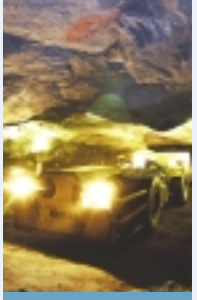
In 1998 – before the most recent phase of expansions – the UG2 reef accounted for around 38 per cent of the ore processed by South African platinum mines. By 2002, that proportion had risen above 50 per cent and in 2006 we expect UG2 to account for over 60 per cent of the total ore processed.

The Merensky Reef reserves on the western Bushveld were exploited in preference to those on the more remote eastern limb because grades in the west tend to be higher and access and infrastructure was easier to develop. However, higher platinum prices, the prospect of rising demand, and above all the depletion of the most attractive ore reserves on the western Bushveld have begun to offset these disadvantages. The eastern limb accounted for a mere 6 per cent of platinum production in 2002; by 2006, that proportion will be around 18 per cent and by the end of this decade, could be as high as 30 per cent.

These developments have important implications for the production of other pgm, especially palladium and rhodium. Assuming all the proposed expansions are successful, platinum output will rise by over 40 per cent between 2002 and 2006, but palladium and rhodium output will each increase by over 60 per cent. Ruthenium and iridium output will also increase significantly. Compared with the Merensky Reef, the UG2 contains a higher proportion of minor pgm, particularly rhodium and ruthenium, while the UG2 in some parts of the eastern Bushveld contains unusually high concentrations of palladium (in some places, exceeding the platinum grade) – see charts opposite.

Schematic map indicating the Bushveld Complex and showing the approximate locations of actual and potential platinum mines





The western Bushveld: near-term additions to production

Despite increased investment on the eastern limb, development is also continuing on the western Bushveld; in fact, in the short term, most additions to platinum production will come from projects in this area. The existing infrastructure means that expansions can often be brought on stream very quickly. For example, Phase 1 of Anglo Platinum's Rustenburg UG2 project was able to source ore through the redevelopment of existing Merensky Reef shafts. This enabled the project to reach production just 17 months after the decision to develop the mine had been announced. On the eastern limb, the construction of new mines and the build-up of production will generally be much slower.

Anglo Platinum is engaged in a number of other expansion projects on the western Bushveld, including a doubling of capacity at its Bafokeng Rasimone Platinum Mine. This project, which involves the Royal Bafokeng Nation as a 50 per cent joint venture partner, should add 230,000 oz of platinum to the mine's annual capacity.

In November 2002, Anglo Platinum announced a tailings retreatment project at Rustenburg, which will produce an average of 120,000 oz of platinum annually over its 15 year life, and a month later the group confirmed that it would proceed with Phase 2 of its Rustenburg UG2 project. This will involve a doubling of concentrator capacity to 800,000 tonnes of ore per month, and will generate an additional 306,000 oz of platinum annually (although this will be offset by declining output from the Merensky Reef at the Rustenburg Section).

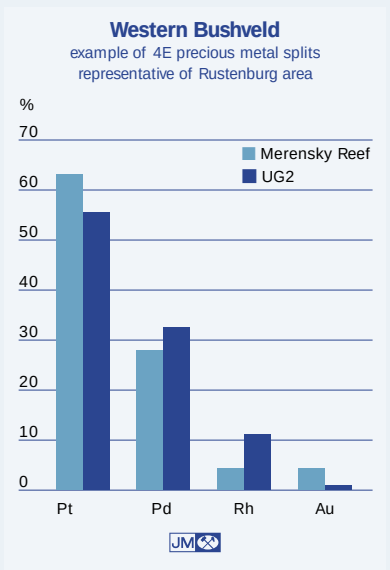
Lonmin is also expanding its existing mines on the western limb, with the aim of lifting platinum production to over 1 million oz per annum (this will include the company's share of output from the Pandora joint venture with Anglo Platinum). In October 2002 Lonmin commissioned two new 120,000 tonne per month concentrators; these will initially be used to process ore from newly developed open pits, and later to concentrate material from underground operations at the Karee mine and the Pandora joint venture. The latter is planned to mine some 320,000 tonnes of UG2 ore per month, yielding 230,000 oz of platinum per annum, when it reaches full production in 2007.

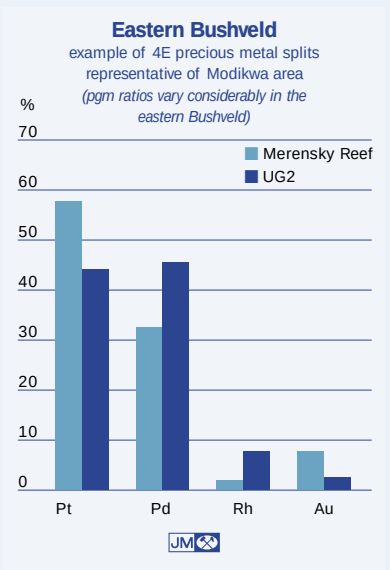
Impala's ability to grow output from its existing lease area is relatively limited. However, the company is considering investing in a new concentrator circuit to increase UG2 milling capacity and is also evaluating a tailings reprocessing project. These projects could help to lift annual platinum output from the Impala lease area to over 1.1 million oz per annum.

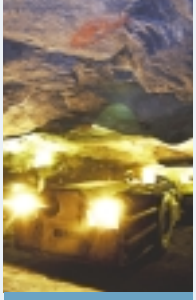
Towards the end of 2002, Aquarius Platinum brought the Marikana platinum mine into production following a very rapid construction and commissioning schedule. This is the company's second operation on the western limb, joining the Kroondal mine

The Marikana mine is one of several projects contributing to rising pgm production on the western Bushveld.

An aerial view of the Modikwa mine in the middle of the eastern Bushveld.







Supplies

Decline development at Impala's Marula mine, which is scheduled to produce 103,000 oz of platinum per year.

10 km to the west. The Marikana UG2 concentrator has a milling capacity of 128,000 tonnes per month, which will yield 95,000 oz of platinum in concentrate annually. The project will make its first significant contribution to platinum supplies this year.

New horizons: projects on the eastern Bushveld

Until 2001, Anglo Platinum's small Lebowa operation was the only active platinum mine on the eastern limb of the Bushveld (not counting PPRust on the northern extension). It was joined in 2001 by SouthernEra's redevelopment of the mothballed Messina mine, and in 2002 by the start of Anglo Platinum's Modikwa project, a joint venture with a black empowerment consortium led by African Rainbow Minerals.

The Messina project was partly developed in the early 1990s, but low pgm prices led to the operation being placed on care and maintenance in 1992. The Canadian company SouthernEra acquired the mine in March 2000 and limited pgm production began in 2001 from the Voorspoed section. Last year the company announced a decision to expand Phase 1 of the project by 50 per cent to 120,000 tonnes of ore per month; this is expected to yield around 95,000 oz of platinum per annum when full production is reached in 2005.

A second phase of development is currently in the advanced stages of planning; this will involve a further increase in production via the exploitation of resources on the farm Doornvlei, about 12 km east of the Voorspoed shaft. A third stage of expansion is also proposed that could encompass reserves on the Dwaalkop properties, which lie between Voorspoed and Doornvlei. Prospecting rights for this section were granted to a joint venture between SouthernEra and Mvelaphanda Resources in August 2002.

Sinking of the second shaft at Anglo Platinum's Twickenham project began with this blast in February 2003.

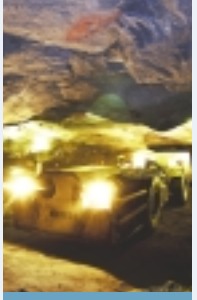
Modikwa is the most advanced of Anglo Platinum's suite of projects on the eastern Bushveld. The mine made its first contribution to platinum supplies last year, and output should increase rapidly in 2003. The concentrator reached its design throughput rate of 200,000 tonnes per month in September 2002, initially milling relatively low-grade ore from underground development and early stoping operations. The head grade should improve substantially this year and full production of 162,000 oz of platinum per annum is expected during 2004.

Anglo Platinum also began construction of the first decline at the new Twickenham mine in mid-2002. Sinking of a second shaft commenced in February 2003, and a 250,000 tonne per month concentrator plant is scheduled for commissioning in 2005. Full production of 160,000 oz of platinum and 176,000 oz of palladium should be achieved two years later.

The Der Brochen project is likely to be the next of the group's eastern limb projects to proceed. A feasibility study is due to be completed in 2003 and the mine is scheduled for commissioning in 2006. Anglo Platinum also has two proposed joint ventures adjacent to the Twickenham and Der Brochen project areas. These will be stand-alone operations, with ownership split 50:50 between Anglo Platinum and black empowerment groupings. The latter will contribute some mineral rights to the joint ventures, which were granted by the government in August 2002. The Booysendal project is located immediately south of Der Brochen, while Paschaskraal fills the gap between Lebowa and Twickenham (*see map*). No formal announcement of the scope of these projects has been made, but they are all likely to be substantial operations, similar in size to the Modikwa mine.

Impala is also undertaking a major project on the eastern Bushveld – the Marula platinum mine – in which it holds an 80 per cent interest. The remainder is split evenly between Mmakau Mining and a community-based empowerment consortium. Mine development began in September 2002 and stockpiles of development ore are being accumulated in anticipation of the start of concentrator commissioning in October 2003. Full mill throughput is planned for March 2004, with steady state production of 103,000 oz of platinum per annum from August of that year.

A second possible phase of development at Marula would involve an increase in the volume of UG2 ore mined and would lift platinum production to about 190,000 oz per annum. This could be undertaken about two years after Phase 1 is completed. A third phase would see Impala develop the Merensky Reef, which is



Legislation leads the changes

Two pieces of South African legislation enacted over the past year have been instrumental in opening up opportunities for new companies to enter the South African pgm industry.

The Mineral and Petroleum Resources Development Bill ('the Minerals Bill') was enacted in October 2002 and resulted in the control of mineral rights being transferred from the private sector to the state. A key aim of the bill was to broaden ownership of mineral rights and to expand opportunities for 'historically disadvantaged South Africans' (HDSAs) to participate in the mining industry. To this end, the legislation introduced the principle of 'use it or lose it' to prospecting and mining rights that had previously been granted. This resulted in significant packages of prospecting rights that had no record of recent or current exploration being relinquished by their previous owners to the government, many of them in advance of the legislation. Some of these were subsequently then put up for tender.

October 2002 also saw the publication of the Broad Based Socio-Economic Empowerment Charter for the Mining and Minerals Industry (the 'Mining Charter'). One of the key elements of this legislation is that mining companies have to provide for HDSA participation in the industry. Targets of 15 per cent HDSA ownership of equity or attributable production within 5 years and 26 per cent within 10 years have been set. This has encouraged the formation of joint ventures between established platinum producers and black economic empowerment groups to develop new pgm mines on the Bushveld Igneous Complex.

vertically separated from the UG2 by about 400 metres. This has the potential to more than double platinum output at Marula to around 400,000 oz per annum but is unlikely to go ahead before the end of this decade.

Another project that is likely to contribute to platinum production within the next two years is Aquarius Platinum's Everest South. This is immediately east of the Booysendal project area, in a location where a "bulge" in the UG2 has produced a small stand-alone deposit east of the normal path of the reef. During 2002, Aquarius undertook a feasibility study, including trial mining operations. The project is expected to be given the formal go-ahead during 2003 and to enter production about 12 months from the start of development. It will have a milling rate of 250,000 tonnes per month, generating around 135,000 oz of platinum annually.

Other projects on the eastern Bushveld are less advanced and are unlikely to add to platinum supplies before the second half of this decade. The Two Rivers project, immediately north of Anglo Platinum's Der Brochen project, is a joint venture between Anglovaal Mining, Impala, and a black empowerment consortium. It is currently at the feasibility study stage, and a formal decision to proceed is expected this year. At a milling rate of 175,000 tonnes of UG2 ore per month, annual output of platinum would be around 113,000 oz.

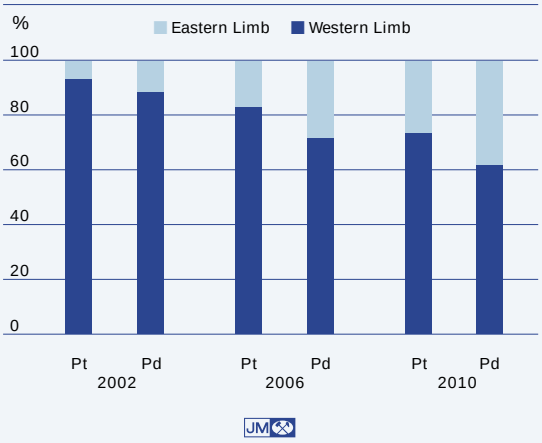
Other potential future producers include the mothballed Kennedy's Vale mine, in which Impala owns an 83 per cent stake via its holding in Barplats. The operation has an existing partly developed vertical shaft to a depth of 900 metres. Impala is currently evaluating the feasibility of redeveloping the mine to extract the UG2 reef using mechanised methods.

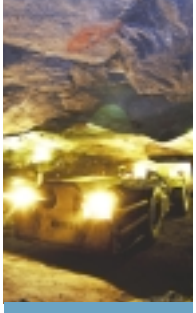
The UK company Cluff Mining has two active projects on the southern section of the eastern limb (in addition to other projects at a less advanced stage of exploration elsewhere on the Bushveld). Drilling at Blue Ridge West has enabled the company to outline a resource of 39 million tonnes of UG2 ore at a grade of 3.1 grams per tonne. A feasibility study is due to be completed in the second quarter of 2003, and this envisages a mine producing around 105,000 oz of platinum per annum.

Cluff is also currently undertaking a second phase of exploration at the Sheba's Ridge project, to the west of Blue Ridge, in a joint venture with Anglo Platinum. The area has a complex geology: previous drilling discovered five pgm-bearing reefs, including layers similar to the Merensky Reef, UG2 and Platreef.

A number of other companies are also exploring the pgm potential of properties on the Bushveld Complex, some through joint venture agreements with Anglo Platinum and Impala. Most of these projects, however, are at a very early stage of exploration.

The Changing Profile of PGM Production Across the Bushveld Complex





Supplies

Lonmin

Lonmin produced a total of 757,450 oz of refined platinum in the year to the end of September 2002, the increase of 6 per cent over the previous 12 months reflecting a rise in the tonnage of ore milled. The company intends to be producing 1 million oz per year of refined platinum by 2008. As part of this long-term development programme, two new 120,000 tonne per month concentrators were brought on stream in October 2002 (*see page 15 for details*).

In March 2002, Lonmin commissioned a large new smelter at its Western Platinum operations to replace the existing furnaces. However, in December the smelter's furnace suffered an explosion, resulting in significant damage. Subsequently, the older Merensky furnace and three Pyromet furnaces (which process UG2 ore) were re-commissioned and a proportion of concentrate is being sent to Impala for toll refining. The accident caused Lonmin to restate its planned platinum output for the 2003 financial year as being not less than 840,000 oz, compared to the previous target of 870,000 oz. Nevertheless, this would represent an 11 per cent increase on 2002. The smelter is due be brought back on line towards the end of 2003.

During 2002 the South African competition authorities gave permission for the Pandora joint venture between Anglo Platinum and Lonmin to proceed. Northam Platinum and the Bapo Ba Mogale Tribe will acquire minority interests in the venture to satisfy the Black Economic Empowerment requirements of the South African Mining Charter.

Flotation cells at the processing plant that serves Aquarius Platinum's Marikana mine. The plant was commissioned in November 2002.

In December 2002, Viking Platinum LLC signed a deal to supply Lonmin's Western Platinum operations with spent catalytic converter material. The deal allows for a build up in deliveries from March 2003 onwards, starting at a rate of 3,500 oz per month of contained pgm, rising to 8,500 oz per month.

In Western Australia, Lonmin decided not to advance its option to acquire a 50 per cent interest in the Munni Munni platinum project but continued to help fund development work on the Panton Sill project, owned by Platinum Australia Ltd. Testing of a cyanide leach process began in January 2003.

Northam

The volume of ore milled by Northam increased by 11 per cent to 2.2 million tonnes in 2002, yielding almost 315,000 oz of pgm in concentrate. The year-on-year increase was due in part to a 32-day strike in 2001. The proportion of UG2 milled (which generally has a lower grade than the Merensky Reef) increased to around 31 per cent, up from 26 per cent, but despite this there was an overall improvement in head grade.

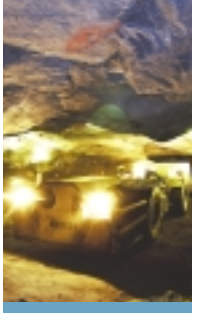
Northam initiated a programme of accelerated development of Merensky Reef reserves to improve face availability during 2002, which increased mining flexibility. This programme will continue throughout 2003 and should lead to a further small increase in pgm production this year. In March 2003, the company successfully re-commissioned its on-mine smelter after a planned furnace re-build.

Aquarius Platinum

Production of platinum in concentrate at Aquarius Platinum's Kroondal mine increased by 18 per cent to 134,000 oz and palladium output rose 13 per cent to 60,000 oz in 2002. The higher pgm output resulted from a plant expansion commissioned the previous year.

Production of pgm would have been higher still had Aquarius not encountered an area of increased potholing and faulting in the Kroondal mine during the second half of the year. This had a deleterious impact on mining performance, grade and recoveries. The company expects the problems to have been largely overcome by the end of the second quarter of 2003 through increased mine development.

At the Marikana mine, plant commissioning took place six weeks ahead of schedule in November 2002, and 2,243 oz of pgm in concentrate were produced by the end of the year. The full production rate of



155,000 oz of pgm per annum from the current open pit operations is expected during the third quarter of 2003.

A feasibility study into the Everest South project, including trial mining and bulk sample testing was completed in January this year. Subject to the results of the study, underground mining is expected to start in 2004 and at full production the project should yield around 220,000 oz of pgm per annum.

SouthernEra

At SouthernEra's majority owned Messina mine, 2002 saw completion of the main shaft to the 425 metre level, and construction and commissioning of the Voorspoed concentrator. This, together with a smaller existing concentrator, gives the operation a capacity of 120,000 tonnes per month. Ore production, which started to build during the final quarter of the year, is expected to reach 80,000 tonnes per month during the third quarter of 2003, and should achieve capacity during the second quarter of 2004. A programme to deepen the shaft to 730 metres has been initiated.

SouthernEra also concluded a 50:50 joint venture agreement with Mvelaphanda Resources covering the Dwaalkop properties, mineral rights to which were awarded to the partners in August 2002. These rights lie between the current Messina Phase 1 (Voorspoed) leases and the planned Phase 2 of development on ground held by SouthernEra to the east (Doornvlei section). A feasibility study on developing the Doornvlei resource was completed during 2002 and envisages a second 120,000 tonne per month mine reaching full production in 2005. The company is now considering how best to incorporate the Dwaalkop resource into its development plans.

Other Projects in South Africa

Details on other pgm development projects are given in the special feature that starts on page 14. The other existing source of pgm in South Africa is the Nkomati nickel mine in Mpumalanga province operated by Anglovaal Mining (Avmin). This produces in the region of 35,000 oz of pgm per annum. A feasibility study on an expansion programme that would result in nickel output increasing by three to four times the current rate of production was completed in 2002. This would also have the effect of substantially raising by-product pgm output. Mining authorisation and environmental applications have been submitted but Avmin is also examining alternative production scenarios.

Russia

Sales of palladium by Russia in 2002 are estimated to have fallen by 56 per cent to 1.93 million oz as Norilsk Nickel remained out of the spot market. Shipments of platinum and rhodium also fell, by around a quarter, to 980,000 oz and 90,000 oz respectively.

Norilsk Nickel suspended spot sales of palladium in August 2001 and therefore entered 2002 with a significant stockpile of unsold metal. The company maintained its absence from the spot market throughout most of 2002, although it continued to ship some metal under existing supply contracts. In May, Norimet, its marketing arm in London, gained the right to sell palladium independently of state pgm export agency Almaz (although Almaz remains the only organisation legally entitled to export pgm from Russia), and began to pursue long-term contracts for the supply of metal to various consumers. Norilsk has stated that it intends to market the majority of its palladium in future through long-term contracts, although it will continue to make spot sales of platinum and rhodium.

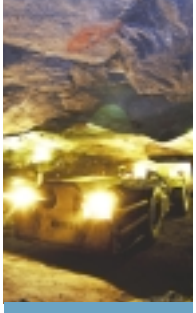
A significant portion of Norilsk's annual output of palladium, perhaps equivalent to about six months of production, was used last year to repay a long-standing loan from the Ministry of Finance. The loan, which dated from 1994, was repaid by a transfer of palladium to the state treasury Gokhran. This must have accounted for a large part of the stockpile of unsold metal dating from August 2001. In addition, Norilsk's proposed acquisition of a majority stake in Stillwater Mining involved the deposition of 877,000 oz of palladium in a London vault by early March 2003, against part payment of the share purchase. This, together with the repayment of the government loan, must have drawn Norilsk's residual stock of palladium down to a low level.

Gokhran itself has stated that it did not sell any palladium from state inventories in 2002, citing an agreement with Norilsk to restrict supplies to the market in the face of declining prices. The position of the other significant Russian holder of palladium, the Central Bank, is less clear. The Bank is believed to hold metal in Switzerland and may well have sold some of this stock in 2002.

During the year Norilsk continued to invest in its mining and processing facilities in northern Siberia and the Kola Peninsula. The largest expenditures were on

PGM Supplies: Russia
'000 oz

	2001	2002
Platinum	1,300	980
Palladium	4,340	1,930
Rhodium	125	90



Supplies

Part of the primary milling circuit at the Norilsk-Talnakh operations.

the Taimyrskiy and Skalistiy mines at Talnakh, and the development of the Pelyatka gas field which supplies the Norilsk-Talnakh operations.

In March 2003 the Board of Directors of Norilsk Nickel approved a 'Production Plan to 2015'. Although details of the plan have not been released, especially of the pgm aspects, it was made clear that the emphasis was on increasing production efficiencies and reducing costs, and not on expansion of mine output. In contrast with statements made in 2000 and 2001, when the palladium price was rising sharply, it was noted that pgm production would remain approximately constant. However, pgm output could be increased by processing stored pyrrhotite and other concentrates if justified by market fundamentals.

For the first time, the two major alluvial platinum producers in the Far East of Russia, Kondyor and Koryak, were allocated export quotas for their metal in 2002. Production at these operations has, however, declined in recent years as their deposits have become progressively depleted and both appear to be putting more emphasis on the exploitation of gold deposits in Khabarovsk and Kamchatka respectively.

North America

Supplies of platinum from North American mines climbed by 10 per cent in 2002 to 395,000 oz, and palladium shipments jumped by 16 per cent to 990,000 oz. Production of pgm at North American Palladium and Stillwater Mining increased as a result of recent expansion programmes, whilst Inco boosted its by-product platinum and palladium output by mining small but pgm-rich nickel ore bodies.

Canada

In 2002, North American Palladium's Lac des Iles mine processed 4.85 million tonnes of ore with a palladium head grade of 1.91 grams per tonne, yielding 219,325 oz of palladium in concentrate. This was an increase of 72 per cent compared to the previous year – a result of the major expansion of the mill and concentrator circuits completed in June 2001 and of improvements in head grade and recoveries. Platinum production in 2002 totalled 19,180 oz.

In September 2002 the operation's primary crusher had to be taken out of service for unexpected repairs. This affected both mill throughput and feed grade. The crusher was brought back into service in December but proved to be unreliable and a new primary crusher has been purchased. This is due to be operational by the middle of 2003; the company will continue to use contract crushing equipment until that time.

The nickel operations of Inco Limited produced a record 431,000 oz of by-product pgm in 2002, a rise of 6.4 per cent over the previous year (405,000 oz). Refined platinum output reached 189,000 oz, while palladium production climbed to 224,000 oz.

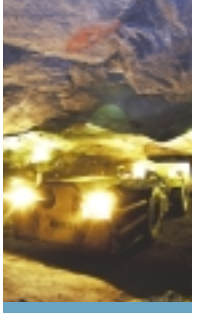
Inco's pgm output of more than 400,000 oz in both 2001 and 2002 was largely a result of the company's decision in the late 1990s to aggressively explore for and develop pgm-rich ore bodies around its existing mines, and to bring these rapidly into production to benefit from strong pgm prices. A small high-pgm grade ore body – the 138 zone – at its Copper Cliff North mine in Ontario was the source of substantial volumes of pgm-rich concentrate during the past two years.

In 2003, the company forecasts that overall pgm production will decline to 355,000 oz as the 138 zone nears depletion. Inco, however intends to bring pgm production back up to an annualised rate of 400,000 oz per annum by the end of the year. Exploration and definition drilling of other pgm-rich ore bodies have been accelerated, and nickel and copper separation in its matte processing plant will be improved, which will further reduce in-process inventories of pgm.

Output of by-product pgm from Falconbridge's Canadian nickel mines and from purchased feed eased back in 2002. Scheduled shutdowns and a shortage of mine and custom feed meant that its Nikkelverk refinery in Norway operated below capacity, and deliveries of pgm for the year as a whole declined. However, by the fourth quarter the supply of concentrates to the refinery had increased and it established a new quarterly pgm production record.

In common with Inco, Falconbridge has stepped up its exploration for new nickel deposits with a significant pgm content in the Sudbury Basin. During 2002 the total inferred resource at its Nickel Rim South prospect was increased to 6.3 million tonnes of ore averaging 1.7 per cent nickel, 3.4 per cent copper, 2.2 grams per tonne platinum and 2.5 grams per tonne palladium. A decision on whether to proceed with an underground exploration programme will be made in 2003.

During 2002, FNX Mining Company embarked on an extensive exploration programme of five Sudbury Basin properties, located around sites of former mines, which have been optioned from Inco. FNX has been



successful in delineating significant nickel-copper and copper-nickel-pgm resources at all of the sites, and plans to develop several ore bodies at the McCreedy West property during 2003. This is subject to approvals from Inco (which holds a 20 per cent interest in FNX and will process all concentrate from the company) and to receipt of government production permits.

First production is planned from a small, high-grade ore body, the 700 zone, which comprises a resource of 139,000 tonnes averaging 6.1 per cent copper, 0.81 per cent nickel and around 5.6 grams per tonne platinum, palladium plus gold. This will be mined at an initial rate of 200 tonnes per day.

USA

Stillwater Mining Company produced 476,000 oz of palladium and 141,000 oz of platinum in 2002, a 22 per cent increase from 2001. The Stillwater mine produced approximately 491,700 oz of pgm – less than the 504,000 oz produced the previous year due to a decline in head grades. The East Boulder mine produced approximately 125,600 oz of pgm in what was its first full year of production.

Stillwater's total pgm output of 617,000 oz was 3.5 per cent lower than forecast by the company in September 2002. In addition to the poorer ore grades in the upper west part of the Stillwater mine, industrial relations difficulties and disruptions caused by increased health and safety enforcement activity contributed to the shortfall. The company has forecast total pgm production of 615,000 oz in 2003, of which 450,000 oz will be produced by the Stillwater mine and 165,000 oz by East Boulder. Ore output at the Stillwater mine will be reduced but mining will focus on a higher grade ore zone during the year.

In November 2002, Stillwater Mining and Norilsk Nickel jointly announced that a deal had been agreed whereby Stillwater will issue 45.5 million new shares to Norilsk, giving the Russian company a 51 per cent equity stake. Norilsk will pay for the shareholding with $100 million in cash and 877,000 oz of palladium. Stillwater plans to sell the palladium under new long-term contracts; the metal is not intended be sold in lieu of production from the company's mines.

Should the deal be concluded, Norilsk Nickel will also offer to acquire up to 10 per cent of the remaining outstanding shares of Stillwater, which could increase its ownership to 56 per cent. The two companies will also negotiate an agreement under which Stillwater will purchase large volumes of palladium per year from Norilsk and market the metal to its customers.

The two companies received a request for further information from the US Federal Trade Commission in January 2003. Regulatory assessment was continuing at the time of writing and the deal was also still subject to approval by Stillwater's existing shareholders.

Zimbabwe

The expansion of the Zimbabwean pgm mining sector accelerated sharply in 2002. As development programmes at both the Mimosa and Ngezi mines progressed, platinum and palladium output increased almost five-fold to around 130,000 oz.

Expansion of the Mimosa joint venture between Impala and Aquarius Platinum accelerated during the second half of 2002. An expanded crushing circuit was brought on stream in the third quarter, followed by commissioning of a new concentrator. Production of pgm in the final quarter of the year reached 10,410 oz, an increase of 30 per cent on the same period in 2001. Expansion of the underground mine continued into 2003, with the full production rate of 4,760 tonnes per day expected in May. Once recoveries have been optimised, pgm output will total 135,000 oz per annum, of which around 65,000 oz will be platinum.

Opencast mining at Zimplats' 70 per cent owned Ngezi operation began in late 2001 and the ramp up of production continued in 2002. By the first quarter of 2003 the mill had achieved a processing rate of 6,000 tonnes per day of ore. The Selous metallurgical plant produced just less than 119,000 oz of pgm plus gold during 2002, containing around 55,000 oz platinum.

Trial underground mining at Ngezi started in September 2002 with the aim of proving the suitability of mechanised mining and assessing the geological conditions in detail. The increased level of geological knowledge has allowed Zimplats to upgrade an additional 34 million oz of pgm resources to reserves. Underground mining is expected to have a significantly lower cost per tonne compared to mining deeper portions of the planned open pit.

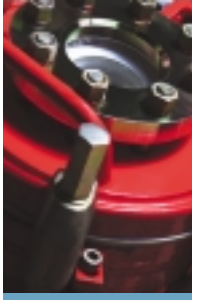
Output of pgm plus gold at Ngezi is expected to total 168,000 oz in the financial year ending June 2003, rising to 195,000 oz the following financial year. A feasibility study on the potential expansion of the mine to 400,000 oz pgm plus gold per annum is due to be completed by December 2003.

PGM Supplies: North America
'000 oz

	2001	2002
Platinum	360	395
Palladium	850	990
Rhodium	23	28

PGM Supplies: Zimbabwe & Others
'000 oz

	2001	2002
Platinum	100	145
Palladium	120	170
Rhodium	4	9



Platinum

Platinum

Autocatalyst

The use of platinum in autocatalysts grew by 17 per cent in 2002. Purchases of metal, however, increased by just 3.6 per cent to 2.61 million oz. The discrepancy was due to the use of significant volumes of stockpiled platinum by US auto manufacturers as they focussed on minimising costs. In Europe, where car companies tend not to hold stocks of pgm, sales of diesel cars climbed by 7 per cent and this led to strong growth in demand for platinum. Increased Japanese demand was primarily due to an export-driven rise in light vehicle production coupled with manufacturers working to meet lower emissions levels.

Europe

Sales of platinum to auto makers in Europe jumped by 17 per cent or 180,000 oz in 2002 to reach 1.24 million oz, the third consecutive year of double-digit growth. The strength of demand has been built on three key trends: growing sales of diesel powered cars (which only utilise platinum-based autocatalysts), tightening emissions standards, and the partial replacement of palladium-rich catalyst systems with those based on platinum on some gasoline models.

Sales of passenger cars in Western Europe were weak in 2002, dropping by 3.5 per cent overall to 14.3 million vehicles. Production was similarly sluggish, declining by around 2 per cent. The popularity of diesel powered cars, however, continued to soar and they took further market share from gasoline vehicles. The number of diesels sold rose by 7 per cent to reach 5.76 million cars – accounting for 40 per cent of total Western European sales.

European consumers have been very enthusiastic purchasers of the latest diesel models for a number of reasons: in many European countries diesel fuel is substantially cheaper than gasoline; diesel cars can be over 30 per cent more fuel efficient than the equivalent gasoline models; greater fuel efficiency means less carbon dioxide is emitted per kilometre (which is rewarded by lower taxation in some countries); and modern diesels offer good performance without the excessive noise or smoke that characterised many of their predecessors.

In contrast to diesels, both production and sales of gasoline powered cars declined by approximately 9 per cent in Western Europe in 2002. The sector lost out to diesels and sales suffered from the poor rate of economic growth in the major continental European economies. The impact on platinum demand, however, was mitigated by the move by some auto manufacturers to replace palladium-rich autocatalyst systems with platinum-based systems. These switching programmes were initiated in 2000 and 2001 when the palladium price soared to a substantial premium to platinum, but because lead times for the development of emissions control systems are lengthy *(see special feature on page 25)* the effect on platinum demand was not fully felt until 2002. The rapid and steep reversal in the palladium price and simultaneous rise in the price of platinum over the past 18 months, however, should preclude any further substitution and has encouraged auto manufacturers to re-examine their overall pgm mix.

Platinum demand also gained a boost in 2002 from tightening European emissions standards. Stringent new Euro IV standards for all light vehicles come into effect from 2005 and will cut permissible emission levels by around 50 per cent. Some manufacturers already offer Euro IV compliant vehicles and most new models currently under development will be certified to the new standards. Auto companies are likely to adopt a range of strategies to meet the new limits, and in some cases these will result in increased pgm use through higher loadings on catalysts or by increasing the number or volume of catalyst bricks.

Japan

Demand for platinum from Japanese auto makers surged by 25 per cent in 2002, reaching 425,000 oz. There were three primary reasons for the increase: rising car and light vehicle production, auto manufacturers working to tighter emissions standards and, in common with other regions, a degree of substitution of palladium with platinum.

Despite the continued weakness of the Japanese economy, domestic sales of cars climbed by 3.5 per cent to 4.44 million, supported by heavy promotion of new models. Production of cars grew even more strongly, rising by 6.2 per cent to 8.62 million units, as exports to North America and Europe remained robust.

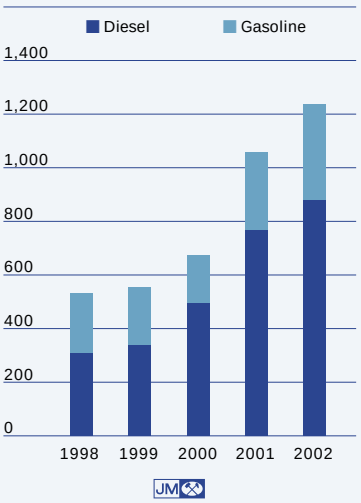
Japanese low emission vehicle (JLEV) and ultra low emission vehicle (J-ULEV) guidelines have been proposed that would require substantial reductions in NOx, HC and CO emissions from the current legal limits. Whilst these guidelines are not yet enforced by

Platinum Demand: Autocatalyst
'000 oz

	2001	2002
Europe	1,060	1,240
Japan	340	425
North America	795	570
Rest of the World	325	375
Total	**2,520**	**2,610**

JM

European Demand for Platinum in Autocatalysts 1998-2002
'000 oz



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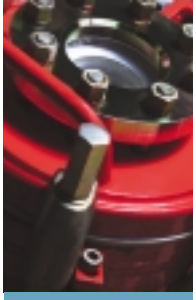


Lambda or oxygen sensors, which contain platinum electrodes, are essential components of auto emissions control systems. By continuously monitoring the engine exhaust composition they enable catalytic converter efficiency to be maximised.

legislation, the majority of Japanese manufacturers now produce cars that meet the proposed JLEV standards and many have already launched models that would qualify for J-ULEV status. This voluntary improvement in emissions control has involved a rise in pgm catalyst loadings and an increase in the number of catalyst bricks used in some instances.

Given its strong export focus, the Japanese car industry has also had to respond to tightening emissions controls in the USA and Europe. These too have had the effect of increasing average pgm loadings for a number of models.

In the late 1990s, Japanese auto makers were quick to respond to the rising price of palladium and growing concerns about possible supply disruptions. The increased use of platinum-based catalysts at the expense of palladium by Japanese manufacturers influenced their pgm demand as early as 2000, and boosted platinum purchases in 2001. By 2002, however, many of the switching programmes had already taken effect and so there was less impact on platinum demand.

North America

A substantial increase in light vehicle production, the impending introduction of tighter emissions standards, and the replacement of some palladium-based catalysts with platinum-based products led to a 14 per cent rise in the use of platinum in autocatalysts in North America in 2002. Purchases of the metal, however, fell by 28 per cent year-on-year to 570,000 oz as US-based car companies fulfilled a significant proportion of their requirements through the use of pgm inventories.

The US economy performed erratically in 2002 – strong GDP growth in both the first and third quarters led commentators to speculate that an enduring recovery might be underway. On each occasion, however, the optimism quickly evaporated and second and fourth quarter growth was poor. Against this background of economic uncertainty, a 1 per cent fall in light vehicle sales from the high levels of 2001 could be considered a good result. US-based manufacturers supported sales with a range of aggressive promotions and incentives, including interest-free financing packages and cash rebates.

On the production side, a need to rebuild car inventories at dealerships drove a strong increase in manufacturing rates in the first half of the year. This, together with the solid level of sales, resulted in light vehicle production rising by almost 6.9 per cent to over 12.3 million vehicles.

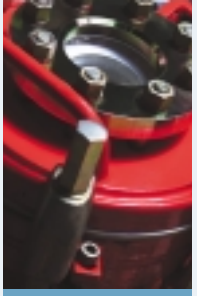
The swift fall in the palladium price plus the rise in the price of platinum during 2002 greatly reduced the justification for switching from heavy use of the former to greater use of the latter. Nevertheless, programmes to reduce dependence on palladium that were introduced in 2000 and 2001 by several auto makers continued to have a positive effect on platinum demand last year.

Counteracting these positive factors for platinum demand, however, was the depletion of the significant stocks of pgm held by US auto makers. The big US auto companies made large inroads into these inventories in 2002 as part of their intensive efforts to minimise costs and improve cash flows. Consequently, purchases of platinum fell even though the underlying use of the metal continued to rise.

Rest of the World

Autocatalyst demand for platinum in the Rest of the World expanded by 15 per cent (50,000 oz) to reach 375,000 oz. Rapidly rising light vehicle production in Asia – up by 17 per cent, excluding Japan – and the spread of tighter emissions limits were responsible for the growth.

Chinese light vehicle production grew phenomenally in 2002, surpassing all expectations by rising 35 per cent to 2.65 million vehicles. Production of cars, all of which are now fitted with catalytic converters, rose by a similar percentage, exceeding 1 million units for the first time. All Chinese



Autocatalyst development and the use of pgm

Significant changes in both the proportions of platinum, palladium and rhodium used in gasoline vehicle autocatalysts and in pgm loadings have occurred since the introduction of catalytic converters in the mid-1970s. This article dicusses the key influences on autocatalyst design and examines the process of catalyst development in the context of pgm use.

Emissions regulations and the pgm mix

The varying pattern of use of platinum, palladium and rhodium on autocatalysts over time has been intimately linked to the introduction and evolution of emissions regulations. Differences in these standards and how they are applied from country to country are instrumental in influencing pgm autocatalyst use.

Several other factors are also important, including:

- Fuel quality and the level of fuel impurities, which can reduce the effectiveness of autocatalysts.
- Wide variations in the types of vehicles and engine sizes produced (e.g. contrast the popularity of gasoline powered SUVs in the USA with diesel engined cars in Europe).
- Developments in engine design and electronic monitoring and control systems.
- Auto makers' strategies regarding pgm purchasing and use.

Catalytic converters were first fitted to cars in the USA and Japan in the mid-1970s in response to new emission standards, such as the US Clean Air Act Amendment of 1970. The first autocatalysts were oxidation catalysts, which convert carbon monoxide (CO) and hydrocarbons (HC) to carbon dioxide (CO_2) and water. These catalysts primarily used a mix of platinum and palladium.

The focus of regulation then turned to oxides of nitrogen (NOx) and new US regulations were phased in between 1981 and 1983. Because oxidation catalysts have little effect on NOx, the new standards resulted in the development and introduction of 'three-way catalysts' that simultaneously oxidise CO and HC while reducing NOx to nitrogen. The most common three-way catalysts fitted to cars in the 1980s contained platinum and rhodium in a 5:1 ratio, rhodium playing an important role in promoting the reduction of NOx.

Palladium came to the fore from 1989 onwards, as auto makers began using more durable palladium-based three-way catalysts to take advantage of the metal's price discount to platinum. In addition, the sudden spike in the price of rhodium to over $5,000 per oz in 1990 encouraged some manufacturers to utilise palladium-rich catalysts with lower rhodium loadings. Technological advances made by autocatalyst manufacturers enabled auto companies to be more responsive to the changing pgm price differentials.

The move to greater use of palladium gathered pace with the California Clean Air Act of 1990, the US Federal Tier 1 standards introduced in 1994, and the European Stage II regulations of 1996. These placed further limits on emissions levels, particularly for HC for which palladium is a highly-effective catalyst. The move into palladium was helped by reductions in the sulphur content of fuel in California, Europe and Japan.

Initially palladium loadings of two or three times that of platinum were required to maintain overall catalyst performance. However, as palladium was typically one-third to one-quarter of the price of platinum (averaging $88 versus $376 in 1991 for example) it was economical at much higher loadings.

The exceptionally rapid rise in auto company demand for palladium throughout the mid and late 1990s, coupled with disruptions to supplies from Russia, spurred the palladium price from around $200 at the start of 1998 to over $1,000 in January 2001. This triggered moves by some auto makers to shift a proportion of their autocatalyst pgm use back in favour of platinum. The subsequent reversal in platinum and palladium prices has created the financial incentive for the auto industry to re-examine greater use of palladium once again.

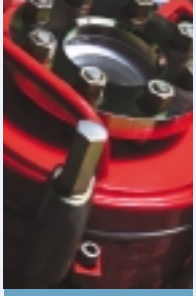
Influences on catalyst development

Car companies are already working with catalyst suppliers on vehicle models that will be launched in three to four years time and beyond, to meet the emissions regulations that will be in effect during these cars' lifetimes. The regulations stipulate what needs to be achieved in terms of emissions control and consequently influence many of the catalyst system parameters.

In addition to emissions legislation, other factors that will affect catalyst system designs include engine size, fuel type (gasoline or diesel), engine performance characteristics, and technical considerations such as the level of engine-out emissions, operating temperatures and exhaust system back pressure. Catalyst system design and layout (the number, size, shape and location of bricks, for example) will also be influenced by fundamental parameters such as the available space.

Although common components will be used as far as possible across a number of engine sizes, types, and even vehicle platforms, catalyst formulations and configurations and the calibration of engine control systems are tailored to individual models. Throughout the entire process the auto company, therefore, works very closely with the catalyst supplier in the design and formulation of an overall emissions control system that will meet the relevant emission standards at an acceptable cost.

Once a catalyst has been designed and the associated engine management controls have been calibrated, the system then has to be tested and approved by official certification bodies. After certification, changes to a catalyst system on a specific car model



cannot usually be made without it being re-certified.

In order to benefit from changes in pgm prices, auto manufacturers may re-examine the pgm loadings or ratios on an autocatalyst system after the vehicle model it is fitted to has entered production. However, catalyst design, testing and certification in association with calibration of the engine and on-board diagnostic systems typically takes many months and requires the input of highly qualified technical staff from both the auto manufacturer and catalyst supplier. It is complex, time consuming, and carries a significant cost to the car company.

Auto manufacturers, therefore, are reluctant to make major changes to pgm loadings once a specific model has entered production. By this stage the engine management and catalyst engineering teams will have long moved on to work on future models. Of course, knowledge gained and advances made in the development of a particular vehicle's catalyst system may be adapted and applied to subsequent models, and in this regard the process is evolutionary.

Advances in catalyst design

Substantial advances have been made in autocatalyst design and technology over the last 10 years and some have influenced pgm loadings. The most important trends can be summarised as:

Inspecting autocatalyst bricks on the production line at a plant in Shanghai.

- Improved thermal and chemical characteristics of the catalyst

  A number of advances in pgm salts and washcoat formulations have enabled substantial improvements to be obtained in the efficiency of pollution conversion and in the thermal durability of catalysts. A key enhancement was the addition of ceria (cerium oxide) to the washcoat. This helped to stabilise the surface area of the washcoat and greatly improved oxygen storage capacity. The latter is crucial in maximising the ability of three-way catalysts to both oxidise HC and CO and reduce NOx, and also enables on-board diagnostic systems to evaluate the 'health' of the catalyst. Subsequently, catalyst manufacturers developed sophisticated catalytic formulations that contain all the active components in a single washcoat.

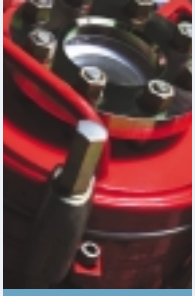
  The production of catalytic materials with greater thermal durability and stability at high temperatures has also been achieved. High thermal durability is particularly important as a more thermally durable catalyst can be fitted much closer to the engine, where exhaust temperatures are higher and where it will reach light off (the temperature at which it becomes active and starts converting pollutants) more rapidly. This is critical as the pollutants emitted before the catalyst reaches light off account for the great majority of total emissions. The previous generation of catalysts with lower thermal durability had to be loaded with more pgm to counteract the possibility of degradation in performance over time.

- Closely tailoring catalysts to individual vehicle models

  By optimising engine operating parameters (fuel combustion, the air:fuel ratio, exhaust temperature, etc.) in concert with close calibration of engine management systems and catalyst development, pgm loadings can be reduced compared to a one-catalyst-fits-all approach. Of course, improvements in engine design to reduce engine-out emissions will intrinsically lower the demands on the catalyst system and may also enable lower loadings of pgm to be utilised.

- Substrates with higher cell density and thinner walls

  Five years ago a standard ceramic catalyst substrate contained 400 cells per square inch (cpsi) and the cells walls would have been around 0.125 millimetres thick. Today, substrates with 600 cpsi are common and some of 900 cpsi with walls less than 0.06 millimetres thick are in use. Similar advances have also been made in increasing the cell density of metallic substrates. This has an indirect effect on pgm loadings as a larger catalyst surface area can be incorporated into a given converter volume and this allows better conversion efficiency and durability. Alternatively, smaller converters with the same performance can be produced, making the catalyst easier to fit close to the engine where space is usually limited. This close-



coupling allows light off to be achieved more rapidly, enabling emissions limits to be achieved with lower pgm loadings. Substrates with thinner walls also heat up more rapidly, again reducing the time to light off.

Changes in pgm loadings

Thrifting in the context of precious metals and autocatalysts is generally understood to refer to the reduction of pgm loadings on a vehicle's catalyst system without compromising its ability to meet the relevant emissions legislation.

The rationale for thrifting is primarily economic: the goal is the most cost-effective catalyst system possible. Given their relatively high cost, efforts to thrift precious metals are a consequence of this drive, although strategic considerations – the security and reliability of pgm supply – are also relevant. In addition, thrifting of pgm can only be taken so far without impairing catalyst performance. For all auto companies the need to maintain 100 per cent compliance with emissions regulations is paramount. The development of sophisticated new autocatalysts by catalyst manufacturers has enabled the use of lower pgm loadings while still comfortably meeting the relevant emissions legislation.

The fact that auto manufacturers place different emphasis on the importance of pgm thrifting also has to be taken into consideration. Those for whom environmental 'leadership' is a key element of their marketing strategy may attach greater weight to meeting new emissions legislation ahead of the required deadlines than they do to pgm thrifting.

It is also useful to draw a distinction between pgm loading levels on individual catalyst bricks and the loading of pgm across the whole catalyst system of any one vehicle. Two brick systems are common, and it is not unusual for larger, high-performance passenger cars to be fitted with four to six catalyst bricks. The loading, choice of precious metals, and ratio of pgm used can vary substantially from brick to brick. It is the use of pgm across the system as a whole that is important.

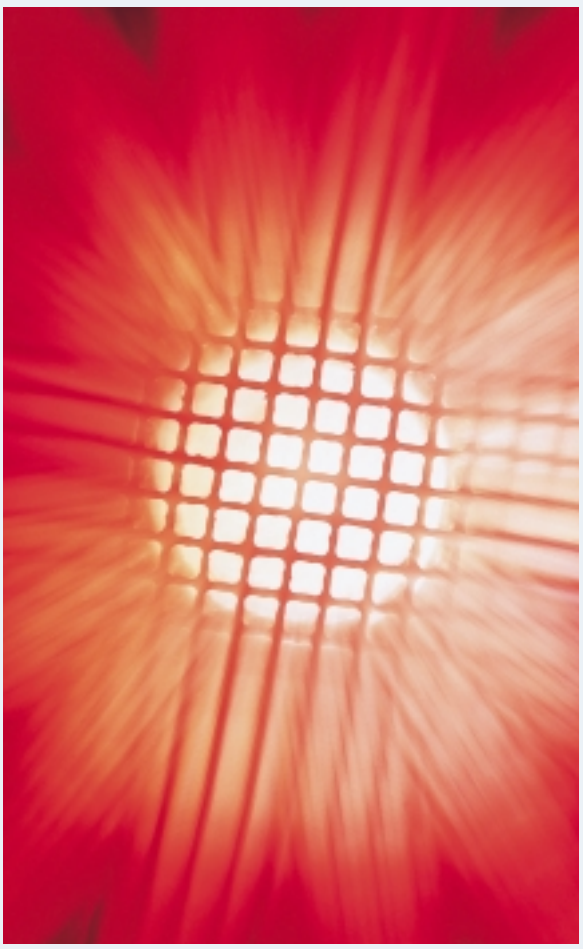
Dual certification – hard to justify

In light of the historical volatility in platinum and palladium prices, some auto companies have investigated the certification of both platinum and palladium-rich catalyst systems for the same vehicle model. Catalyst designers have responded by developing both palladium-rich and platinum-rich systems that meet existing emissions legislation, to enable car companies to adopt a more flexible approach towards pgm use. Dual certification would, in theory, allow a car manufacturer to have greater control over its pgm costs by switching from a platinum-rich catalyst system to a palladium-rich variant, or vice versa, when metal prices changed significantly (though this is only relevant to gasoline vehicles as diesels are dependent upon platinum-based catalysts).

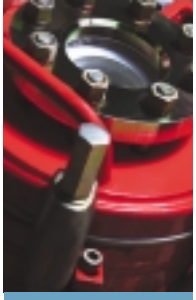
However, the characteristics of the two metals such as reactivity, pollutant conversion efficiency and durability are not identical and a recalibration of the engine management systems and on-board diagnostics will normally be required. This, in turn, usually means that the entire system has to be recertified.

Auto manufacturers, therefore, have to assess whether the cost of developing and certifying two separate catalyst systems for the same car model will be offset by the potential benefits that may be gained through being able to switch from one to the other. This cost-benefit analysis requires car companies to take a view on how pgm prices will move over the coming 3 to 4 years or more – a tough proposition given their recent unpredictability.

Dual certification also has to be seen in the context of the strong desire by most auto companies to minimise costs. In this environment it is hard to justify the capital expenditure and the redeployment of resources required for additional catalyst engineering, testing, calibration and certification when there is no guaranteed financial benefit. Although attempts are being made to speed up and simplify the cost of the catalyst certification process, it will still have an associated cost that the auto maker is not guaranteed to recoup.



Close-up through an autocatalyst substrate. The development of substrates with thinner walls and a greater number of cells per inch has had a number of benefits for catalyst performance.



Platinum

Platinum Demand: Autocatalyst Recovery
'000 oz

	2001	2002
Europe	(70)	(90)
Japan	(55)	(60)
North America	(370)	(380)
Rest of the World	(35)	(40)
Total	**(530)**	**(570)**

manufactured cars have to be certified to Euro I equivalent emissions limits and the introduction of Euro II standards has been accelerated. Vehicles sold in Beijing have had to meet Euro II limits from January 2003 and the regulations will be introduced nationwide in July 2003.

Elsewhere in Asia, South Korean light vehicle production exceeded 3 million vehicles, an increase of 4.5 per cent, with larger cars and SUVs gaining in popularity. Double-digit growth in production and sales were also seen in India, Thailand, Malaysia and across much of the rest of Asia. This growth far outweighed a worsening of the economic situation in South America, where Brazilian light vehicle production dropped by 9 per cent to around 1.43 million vehicles and Argentinean output slumped to less than 160,000 units.

Autocatalyst Recovery

Recovery and recycling of autocatalysts continues to provide a growing secondary source of pgm. An estimated 570,000 oz of platinum were recovered from recycled autocatalysts in 2002, an increase of 40,000 oz from 2001.

The increase was most marked in Western Europe, where greater collection and processing of spent autocatalysts resulted in a 20,000 oz rise in platinum recovery. The sector has for several years been attracting greater attention on the back of relatively high pgm prices and through the development of legislation to increase scrap vehicle recycling. The European End of Life Vehicle (ELV) recycling directive will apply from 2005 and aims to increase the rate of re-use and recovery of materials to 85 per cent by weight per vehicle by 2006.

Furthermore, as catalytic converters were only required on all new gasoline cars in Europe from 1993, the proportion of cars currently being scrapped that are fitted with catalysts is increasing as greater numbers of these vehicles reach the end of their lives.

Recovery has also increased in the USA, although to a lesser extent, as collection rates were already high relative to Europe. The strength of the platinum price in 2002, which averaged almost $540 over the year, helped to support the profitability of recovery and recycling businesses, despite the fall in the price of palladium. North American-based collection companies also sought to widen their sources of scrapped catalysts and imported increased volumes of material from Mexico and South America.

Platinum Demand: Jewellery
'000 oz

	2001	2002
Europe	170	165
Japan	750	780
North America	280	310
Rest of the World	1,390	1,575
Total	**2,590**	**2,830**

Jewellery

Demand for platinum from the global jewellery industry expanded by 240,000 oz (9 per cent) in 2002 to total 2.83 million oz. Strong sales of platinum to the Chinese jewellery industry again provided much of the growth, demand climbing 14 per cent to 1.48 million oz. Purchases of platinum by Japanese jewellery manufacturers also increased but here the growth was due to less metal being available from inventories, stock levels throughout the industry having been run down to low levels during 2001. Total European demand was marginally down, although the UK market again performed well. In North America purchases increased due to restocking by fabricators at the start of the year and to moderately improved retail sales.

Europe

European demand for platinum in jewellery declined marginally to 165,000 oz in 2002, reflecting soft conditions in most continental European markets. The UK and export markets, however, provided growth opportunities for some manufacturers.

The UK cemented its position as the largest European jewellery market for platinum in 2002 as the popularity of platinum bridal jewellery continued to grow robustly. Bridal jewellery accounts for approximately 90 per cent of the UK's total platinum jewellery market. The number of platinum items hallmarked by UK assay offices increased by almost one-third, and with the average weight per piece of jewellery rising, the total weight of platinum jewellery hallmarked jumped by 43 per cent to over 63,000 oz. The buoyant UK market provided a degree of relief for continental fabricators whose domestic markets were subdued, particularly those in Germany. Imports accounted for one-fifth of the total UK market, almost doubling year-on-year and exceeding 10,000 oz.

In contrast to the UK, the German jewellery market was depressed in 2002; the country's deepening economic problems dulled consumer spending on non-essential goods across the board. The fashion sector of the German platinum jewellery market suffered as non-precious white metals such as titanium and stainless steel made further inroads. German fabricators looked to export markets in the UK and North America to bolster sales but these did not wholly offset the weakness in the domestic market.

In Italy, sales of platinum jewellery to the bridal market were steady but in other sectors platinum came under price pressure from white gold as the year progressed. Italian platinum jewellery fabricators, however, have a large and well-established presence in international markets and gained a degree of success in increasing exports to North America and Japan. Sales of Italian jewellery also increased to stores in China, where modern European-style jewellery is distinctive and popular.

Demand for platinum from the Swiss jewellery industry softened somewhat in 2002 after performing particularly strongly in 2001. The weakness of demand for luxury goods in late 2001 resulted in lower numbers of platinum watches being manufactured in the first half of 2002 – a lead time of several months is common in this sector due to the complexity of the products and the labour intensive nature of the business.

Chinese stores reported strong sales of platinum jewellery during the New Year holiday period in 2002. Chinese demand for platinum in jewellery increased by 14 per cent to 1.48 million oz.

Japan

Demand for platinum from the Japanese jewellery industry increased by 30,000 oz to 780,000 oz in 2002. Although retail sales of platinum jewellery slipped lower, purchases of platinum by fabricators increased. Metal held throughout the manufacturing and retail pipeline had been run down to relatively low levels during the previous year and so there was less opportunity to recycle metal from stocks.

The stagnant Japanese economy and the rising price of platinum combined to produce a 15 per cent fall in platinum jewellery retail sales in 2002. However, this has to be put in the context of a 10 per cent fall in sales of all precious metal jewellery in Japan, and platinum still accounted for one-quarter of this market. Sales of platinum products to the core bridal segment of the market were broadly stable. Sales of platinum wedding bands in the over ¥50,000 price bracket actually increased by 4 per cent year-on-year, and platinum retained a very strong hold on the bridal jewellery market as a whole.

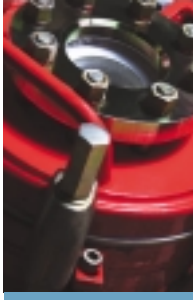
Sales of other platinum jewellery generally lost ground, with competition from white gold increasing in the lower-priced fashion sectors. Sales of platinum products such as women's rings, necklaces and earrings all lost ground. As the price of platinum rose from close to ¥2,000 per gram at the start of the year to over ¥2,300 per gram briefly in April, and then again in October, wholesalers and retailers were better able to market white gold jewellery to price-conscious consumers. The growth of white gold, in part at the expense of yellow gold, was evidence of the continued strong consumer preference for white precious metal jewellery in Japan.

North America

North American jewellery demand for platinum grew by 30,000 oz (close to 11 per cent) in 2002 to 310,000 oz. Retail sales held up reasonably well even though consumer confidence became more fragile as the widely predicted economic recovery failed to materialise. However, the growth in metal purchases by fabricators was primarily due to restocking of the manufacturing and retail pipeline during the first quarter of the year following a sustained run-down in inventories during 2001.

Reports from retailers about the level of sales of platinum jewellery were mixed in 2002, reflecting the increasingly unpredictable purchasing behaviour of consumers. The uncertainty about prospects for the market meant that retailers in turn were cautious in placing orders with fabricators.

Platinum has gained a substantial share of the bridal jewellery market in North America and white precious metal jewellery remains very popular, particularly amongst younger consumers. Although this sector remains more price resistant than the market for fashion jewellery, there was a degree of erosion of platinum's bridal market share by white gold in the lower-priced product ranges. That said, platinum still



Platinum Demand: Chemical
'000 oz

	2001	2002
Europe	105	115
Japan	25	30
North America	100	100
Rest of the World	60	80
Total	**290**	**325**

JM

Platinum Demand: Electrical
'000 oz

	2001	2002
Europe	65	65
Japan	80	80
North America	120	115
Rest of the World	120	120
Total	**385**	**380**

JM

accounted for more than one-third of total US sales of engagement rings and wedding bands in 2002.

The strength of platinum prices held back any growth in sales of fashion jewellery. In this sector, white gold offered higher margins and greater flexibility in terms of meeting key price points for both wholesalers and retailers.

Rest of the World

Demand for platinum from the Chinese jewellery market continued to grow rapidly in 2002, expanding by almost 14 per cent to reach 1.48 million oz (over 46 tonnes). This represented more than one-fifth of total global platinum demand.

Retail sales of platinum jewellery were strong throughout the year, but were particularly buoyant during the Chinese New Year and Labour Day holidays in February and May respectively. The Chinese New Year celebrations coincided with Valentine's Day, giving an extra promotional push to platinum jewellery sales.

In contrast to Japan, the Chinese platinum jewellery industry is not dominated by bridal rings, although they do account for a substantial proportion of sales. The largest sector of demand is for plain (not gem set) fashion rings, with diamond rings and other fashion items such as necklaces and pendants becoming increasingly popular.

The level of consumer enthusiasm for platinum jewellery appeared to be uninhibited by the metal's rising price in 2002. Platinum remained highly desirable, particularly among younger, affluent middle-class consumers for whom platinum jewellery is often regarded as a status symbol.

The successive rallies in the platinum price to around $560 in April, June and August also did little to discourage purchases by manufacturers, although the level of offers for metal tended to fall off at the peaks.

In October, however, buying by fabricators slowed noticeably as the price climbed quickly towards $600. A problem for manufacturers is that Chinese retail prices of platinum jewellery do not move in step with international bullion prices. The Chinese market is very competitive and is characterised by a high degree of price transparency as the majority of platinum jewellery is still sold by weight. In this environment retailers are very reluctant to increase their prices for fear of either driving consumers to competitors or away from platinum. Therefore, as the platinum spot price climbed fabricators were largely unable to pass on higher metal costs to retailers, and by the fourth quarter their profit margins had been heavily eroded.

Demand picked up again in November and December as it became evident that the platinum price was well supported around $580 and major retailers were persuaded of the need to push up their prices. However, the end-of-year increase in demand was not as great as might have been expected. Some stores, still unwilling to accept that firmer spot prices would persist, appeared to hold back from ordering stock for the Chinese New Year sales. There were also indications that some fabricators had accumulated inventories of metal and were able to satisfy orders without making further purchases. As 2002 drew to a close, many fabricators were awaiting either a further increase in retail prices or a significant softening in the platinum spot price.

Other Asian centres of platinum jewellery manufacturing primarily supply the export markets of North America, Japan and Europe. Demand for platinum from fabricators in South Korea and Thailand increased moderately in line with sales to the USA.

Chemical

Consumption of platinum in the chemical industry climbed to 325,000 oz in 2002, an increase of 35,000 oz from the year before. The construction of new paraxylene manufacturing plants and growth in demand for silicones, particularly in China, were the key components of higher demand for platinum-based catalysts.

New plants for the manufacture of paraxylene were constructed in the Middle East and Asia during 2002 and the installation of catalysts in these facilities boosted platinum demand. Paraxylene is an intermediate chemical in the manufacture of purified terephthalic acid (PTA), which in turn is the source of polyesters and polyethylene terephthalate (PET). Use of the latter continues to grow rapidly in plastic film and packaging applications and is expected to stimulate further investment in paraxylene capacity in Asia in the short to medium term.

Catalyst metal losses during the production of paraxylene are low and therefore replacement demand for platinum-based catalysts in this application is stable and relatively small.

The manufacture of silicone compounds is a major application for platinum catalysts. As the level of metal consumed during production is significant, the rate of

silicones output has a direct effect on catalyst demand. Silicone-based coatings, sealants and adhesives are used in a wide range of industrial and consumer applications but markets in North America and much of Europe were subdued in 2002 in line with weak levels of economic activity. Firm demand from Asia, however, provided a counterbalance with China leading the growth. Overall, sales volumes gained ground slightly and this was reflected in platinum catalyst demand.

Demand for platinum catalyst gauze for the production of nitric acid increased slightly in 2002. Activity in the global nitric acid industry depends largely on the level of nitrogen fertiliser output. Large fertiliser inventories carried over from 2001 depressed demand during the first quarter but as the year progressed the market improved, particularly in South America and Asia. Profitability throughout the industry, however, remained under pressure and investment in new capacity was restricted to a handful of plants in Eastern Europe and Asia.

Electrical

Demand for platinum used in electrical applications fell slightly in 2002 to 380,000 oz, 16 per cent below the peak of 455,000 oz purchased in 2000. Weak global economic conditions were responsible for a slight decrease in demand from both the hard disk and thermocouple sectors, but this was offset by an increase in the volume of platinum used in fuel cells and other applications.

Demand for platinum in computer hard disks grew rapidly throughout the late 1990s and 2000, as manufacturers rapidly adopted the use of platinum-cobalt alloys to improve data storage performance. Demand faltered in 2001, however, as sales of personal computers fell and softened further in 2002 as both consumer and business spending on new information technology equipment remained weak. The penetration of hard disks containing platinum now exceeds 90 per cent.

The average number of hard disks used per computer continued to trend lower in 2002 as growth in data storage density was maintained – the greater the data storage density, the fewer disks are required for a set level of performance. Balancing this, however, was the further spread of hard disks to non-computing applications such as video game consoles.

High temperature thermocouples utilising platinum wire are widely used in the steel, glass and semiconductor manufacturing industries and demand is related to both the level of production and investment in new capacity. Steel output was stable in Western Europe and increased by 2.5 per cent in North America; again, however, low profitability and excess capacity constrained capital spending. Although Chinese steel output surged by 20 per cent, most Chinese steelmaking plants do not generally utilise platinum wire thermocouples.

Semiconductor sales fell in Europe, North America and Japan in 2002 but increased in China and South East Asia. Overcapacity remained substantial and profit margins were under pressure from low product prices, holding back investment in new equipment. With production closely related to GDP, the global glass industry also faced tough conditions in many markets in 2002, particularly for float glass. The combined overall impact was a 10 per cent reduction in thermocouple demand for platinum.

There were numerous announcements of advances in fuel cell technology during 2002 (*see panel*). Of long-term significance was the increased commitment of some leading petroleum companies to the

Fuel Cell Developments

Several notable advances in fuel cell technology were made during 2002, not least within the automotive industry.

In late 2002, Honda and Toyota delivered the first 'commercial' fuel cell cars to government agencies and universities in Japan and in the USA. Although the cost of these test vehicles is still far higher than would be needed to make them a realistic alternative for consumers, the fact that they will be operated under normal driving conditions represents significant progress.

Other data from real-life operating environments will be obtained from the Japan Hydrogen and Fuel Cell Demonstration Project. Under this partnership Federal Express will operate a General Motors HydroGen3 fuel cell powered van on its regular delivery routes in Tokyo. Test programmes like these will allow car manufacturers to refine their present designs and reduce costs.

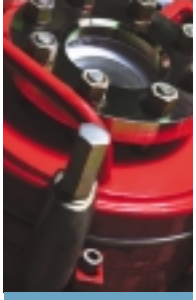
The attraction of fuel cells in powering cars was also evidenced by the increasing level of governmental involvement. In Japan, the government announced new initiatives to move the adoption of fuel cells forward, assisted by industry. The European Commission established a new high-level advisory group for hydrogen and fuel cell issues, and in January 2003, US President Bush proposed additional funding for fuel cell development.

Fuel cell cars are regarded as a long-term prospect, whereas other applications promise to come to the market sooner. Companies such as Smart Fuel Cell and Toshiba are working on fuel cell powered laptop computers. The primary advantage is extended operating times, and such products could be on sale in the first half of this decade.

Residential or small-scale fuel cells are also still on track to make their debut from 2005 onwards, and field trials of precious metal containing units (and some competing precious metal-free technology) continued. Again, the products first introduced into the sector are unlikely to have been optimised in terms of cost and performance but should find a market for low emission, low noise, electricity generation, for example in providing high quality back-up power.

For updates on fuel cell developments, visit ***www.fuelcelltoday.com***.

A General Motors HydroGen3 van (left) will be the first fuel cell vehicle fuelled with liquid hydrogen to be commercially tested in Japan. Federal Express will use one of these vehicles on its normal delivery schedules in Tokyo for one year from June 2003.



Platinum Demand: Glass
'000 oz

	2001	2002
Europe	10	10
Japan	85	80
North America	35	30
Rest of the World	160	135
Total	**290**	**255**

JM

Platinum Demand: Petroleum Refining
'000 oz

	2001	2002
Europe	15	15
Japan	5	5
North America	40	45
Rest of the World	70	75
Total	**130**	**140**

JM

development of hydrogen storage, transportation and refuelling systems that will be necessary to supply fuel cell powered vehicles. Demand for platinum used in catalysts for both proton exchange membrane (PEM) and phosphoric acid types of fuel cells grew but with commercialisation still some years away was still less than 20,000 oz.

Glass

The glass industry consumes substantial volumes of equipment either manufactured from or coated with platinum. Heavy investment in additional LCD glass and fibreglass manufacturing capacity in Asia in 2001 boosted platinum demand substantially but as the rate of new capacity construction slowed in 2002, metal consumption fell back to 255,000 oz.

Platinum purchases for glass production applications eased in 2002 from the high level of consumption seen in 2001. Nevertheless, total platinum demand of 255,000 oz was relatively firm by recent historical standards. Fewer new furnaces were brought on stream in China in 2002 than in the previous year but investment continued, particularly for LCD glass and fibreglass manufacturing capacity. The booming Chinese production of automobiles has boosted demand for textile (reinforcing) glass fibre, and growing consumer purchases of electronic goods such as televisions and computers are driving demand for TV and LCD glass.

In Western Europe and North America, weak domestic markets and competition from lower-priced imported glass products from Asia led to the closure of several glass furnaces between 2001 and the end of 2002. With demand from these markets relatively mature and fixed costs high compared to elsewhere, little investment in new capacity is expected in these regions. Eastern Europe and South East Asia offer greater potential for expansion going forward but these markets were largely stable in 2002.

Petroleum Refining

Demand for platinum in catalysts for the petroleum refining industry increased modestly to 140,000 oz in 2002. One significant addition to reforming capacity was made in North America and investment was also seen in the Middle East and Asia. This, however, was partly offset by the suspension or closure of other reforming and isomerisation units. In broad terms, the weak global economy in 2002 kept demand for petroleum products subdued and prices relatively low for much of the year. This, is turn, deterred capital investment.

The addition of a new petroleum reforming unit at a refinery in the south-eastern USA was partly responsible for an increase in demand for platinum-based petroleum catalysts in North America in 2002. This, however, was an exception in the region and demand for platinum was largely restricted to top-up catalyst orders for existing plants. The same was also true for the mature Western European market.

In Asia there was also some investment in new reforming and isomerisation capacity. However, this was offset to a certain degree by other plants being taken out of commission and there was little net change in platinum catalyst demand. Demand in the Middle East increased with the installation of new refinery capacity in Qatar.

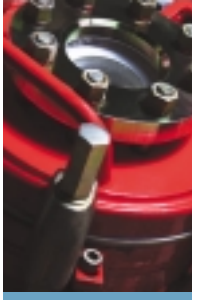
Other

Demand for platinum from other industrial end uses advanced in 2002, growing by 5 per cent to 490,000 oz. Use of the metal in dental alloys increased marginally as the effects of moves to substitute palladium following its price spike in 2001 drew to a close. Platinum demand for use in spark plugs, sensors and biomedical applications grew significantly but consumption in turbine blade manufacture decreased.

The consumption of platinum in dental alloys in Europe rose slightly in 2002 as programmes to replace palladium-based products with high-gold alloys (which typically contain 8 to 15 per cent platinum) were concluded in Germany. In the Italian market, however, palladium alloys began to regain market share as the price of the metal fell.

In North America, dental demand for platinum declined marginally in 2002. There were indications that a move back towards palladium-based alloys had started, although many users remained wary of a repeat of the previous price volatility. The impact on platinum demand, however, was limited as palladium took market share from a range of alloy types, not only from high-gold alloys containing platinum.

Platinum-tipped spark plugs continued to gain market share in 2002, leading to a noticeable rise in platinum demand. Spark plugs with platinum



electrodes have improved durability compared to conventional products, and this is important in maintaining engine performance and emissions control. The high durability and thermal stability of platinum also allows manufacturers to decrease the diameter of the electrode, which in turn means that a lower voltage is required. Platinum spark plugs are fitted as standard to most cars manufactured for the North American market and are increasingly specified in Europe, despite their higher cost.

Platinum electrodes are the key component of many gas sensors, including oxygen or lambda sensors that are essential to automobile engine management and emissions control systems. Demand for oxygen sensors in Europe increased substantially in 2000 and 2001 as auto companies increased the number used per car to enable engine control systems to meet tighter European emissions limits. In 2002, demand stabilised and more closely reflected the level of vehicle production. Demand from auto manufacturers in North America increased somewhat as light vehicle production rose but was largely flat in other regions.

Biomedical applications for platinum continued their recent strong growth in 2002, led by greater use of platinum equipment in surgery. Platinum electrodes are utilised in pacemakers, and platinum stents, coils, guide-wires and springs are becoming more widely used in a variety of surgical procedures.

Platinum is also used to manufacture radio-opaque marker bands fitted to plastic catheters for intravenous treatments. These marker bands allow surgeons to follow and control the progress of catheters using medical imaging techniques as they progress through the patient. The advantages of platinum include its chemical inertness, electrical conductivity, strength and radio-opacity.

Drugs used to combat cancer are a growing biomedical use for platinum. In August 2002 the US Food and Drug Administration (FDA) approved the drug Oxaliplatin, which was already in use in Europe and Asia, for the treatment of colon cancers. Oxaliplatin and related platinum-based anti-cancer pharmaceuticals consume a fairly limited volume of platinum per year but demand is growing.

The high melting point, corrosion resistance, and thermal durability of platinum lead to its use in the coating of turbine blades in jet engines. Demand for platinum from this industrial sector decreased in 2002 as a significant number of commercial aircraft orders were deferred or cancelled. In the longer term, growth in the international aerospace industry is expected to resume, and demand for higher performance aero-engines should rise. This would lead to renewed growth in demand for platinum-coated turbine blades in the most demanding applications.

Investment

Net demand for platinum investment products fell by an estimated 10,000 oz in 2002 to 80,000 oz. During the first half of the year sales of both Japanese bars and US platinum bullion coins continued at similar levels to 2001. However, as the price of platinum climbed above $550 the volume of metal sold back to the market by investors increased and sales of new products slowed.

Purchases of the US Mint's platinum American Eagle bullion coins during the first half of 2002 totalled just over 18,000 oz. The drop in the platinum spot price in January towards $450 stimulated buying, together with promotion of the new year's series of coins. Demand fell back through the following three months as the price climbed past $500 and then breached $550.

Greater purchasing was seen again in May and June but then dropped away during the second half of the year as the platinum price strengthened to average $565, and neared $600 on several occasions. Demand for US platinum American Eagle proof coins from specialist collectors declined by 7 per cent.

Japanese investors also took advantage of the relative price weakness of platinum during January and February by purchasing significant quantities of 500 g and 1 kg bars, both directly and through investment plans. As the platinum price then started to climb the volume of platinum sold back to the market increased, peaking in April as the price passed ¥2,300 per gram.

The level of disinvestment slowed as the price dropped back under ¥2,200, and as the yen strengthened versus the US dollar the level of new purchases rose again. The fall in the local price of platinum to under ¥2,000 spurred strong buying in July.

Conversely, August through to October saw sales of platinum bars back to dealers accelerate once more as the spot price of platinum climbed towards $600 and the price in yen again exceeded ¥2,300. Overall, Japanese investors purchased a net 35,000 oz of physical platinum during 2002.

Platinum Demand: Other
'000 oz

	2001	2002
Europe	155	170
Japan	35	40
North America	250	255
Rest of the World	25	25
Total	**465**	**490**

JM

Platinum Demand: Investment
'000 oz

	2001	2002
Coins and small bars		
Europe	0	0
Japan	5	5
North America	45	40
Rest of the World	0	0
	50	**45**
Large bars in Japan	**40**	**35**
Total	**90**	**80**

JM

Palladium

Autocatalyst

Purchases of palladium by auto manufacturers slumped to 3.08 million oz in 2002, a fall of almost 40 per cent from demand of 5.09 million oz in 2001. Actual use of palladium in autocatalysts, however, declined by a less dramatic 13 per cent. The difference was a result of the very considerable use of stocks of palladium by auto manufacturers in the USA and, to a much lesser extent, Japan. The fall in the underlying use of the metal was largely a reaction to the high and volatile palladium price of 2000 and early 2001. Auto companies were successful in reducing average palladium loading levels and some made greater use of platinum-based autocatalysts. A major contributory factor in Europe was the drop in gasoline car production as diesels gained further market share.

Europe

Demand for palladium in autocatalysts in Europe slid by 17 per cent to 1.43 million oz in 2002, a four-year low. The drop reflected a fall in sales of gasoline cars, programmes instigated by some auto manufacturers over the last two years to reduce their use of palladium-based catalysts, and the development of catalysts with lower palladium loadings.

Production and sales of diesel cars (which use platinum-based catalysts) continued to grow at the expense of gasoline vehicles. Production of the latter fell by 9.5 per cent, or around 900,000 cars, to 8.59 million cars as the penetration of diesels across Western Europe climbed to 40 per cent. With average loadings of between 3 and 4 grams of palladium per gasoline car, this had a significant impact on palladium demand. Diesel powered cars are expected to gain further market share in 2003.

Those auto manufacturers in Europe who had moved in favour of palladium-rich autocatalyst formulations during the 1990s instigated programmes to reduce their reliance on the metal in 2000 and 2001, when Russian supplies were interrupted and the price rose rapidly. As a result, a number of European car companies switched towards greater use of platinum-based catalysts on a proportion of their models. Because of the time taken to design, calibrate and certify new emissions control systems, the effect of these programmes to change pgm ratios reduced palladium demand in 2002.

The majority of catalyst systems used on European gasoline vehicles, however, still contain a substantial proportion of palladium. Auto manufacturers have been able to reduce average palladium loadings through the development of improved emissions systems and advances in engine design and control. This contributed to lower palladium demand in 2002.

Japan

Consumption of palladium by the Japanese auto industry increased by 8 per cent in 2002 as light vehicle output grew and tighter emissions standards resulted in higher average pgm loadings. However, purchases of palladium by Japanese auto companies improved by just 2 per cent or 10,000 oz as inventories of metal were drawn down. Certain Japanese manufacturers accumulated stocks of palladium in the late 1990s and reduced these during 2002. Japanese auto companies moved to thrift their use of palladium from 2000 onwards as the price started to rise, in part by moving to greater use of platinum-based catalysts. By 2002, most of these programmes had taken effect and there was little further impact on palladium demand.

A primary cause of the rise in the underlying use of palladium in autocatalysts was the 6.2 per cent increase in Japanese car production to 8.62 million vehicles. This was driven by both improved domestic sales and strong exports. Japanese exports of light vehicles climbed by 12.4 per cent to 4.65 million, with deliveries to the USA leading the rise.

Tighter vehicle emissions standards in Japan and abroad also contributed to the growth in palladium consumption. Japanese car companies are already producing vehicles that meet proposed stricter emissions standards, which are likely to be introduced before the end of 2005. This voluntary improvement in emissions levels by auto manufacturers is, to a certain extent, a reflection of the fact that environmental considerations can be significant in the purchasing decisions of Japanese consumers.

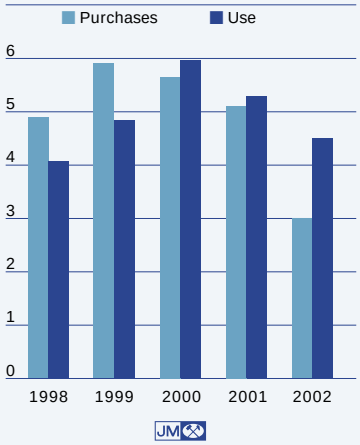
With exports accounting for around 46 per cent of Japanese car production, tightening emissions legislation in North America and Western Europe also had an impact on Japanese autocatalyst pgm demand in 2002. Reduced emissions levels of both domestic and export vehicles were achieved in some instances through increased average pgm loadings, boosting palladium usage.

Palladium Demand: Autocatalyst
'000 oz

	2001	2002
Europe	1,730	1,430
Japan	505	515
North America	2,375	635
Rest of the World	480	500
Total	**5,090**	**3,080**
Autocatalyst recovery	**(280)**	**(370)**

Palladium

Palladium Autocatalyst Demand 1998-2002
Million oz



North America

Consumption of palladium in autocatalysts in North America dropped by 21 per cent in 2002 as the switch towards greater use of platinum continued, and manufacturers successfully reduced palladium loadings. Despite this, consumption of palladium remained in excess of 2 million oz. Purchases of the metal, however, crashed to just 635,000 oz as large US-based auto companies drew very heavily on palladium inventories that they had accumulated in prior years.

This use of stocks in preference to purchasing palladium was a consequence of several factors, not least of which was the desire of auto makers to minimise raw material costs and expenditure, in part to support the large incentive packages offered to new car buyers. Several US auto makers had substantial palladium inventories at the start of the year – the imperative to reduce costs outweighed the strategic value of holding these stocks. The perceived necessity of holding large pgm inventories declined as higher volumes of metal were produced in North America and South Africa.

The net result of these elements was that the major US auto makers purchased very little palladium by recent historical standards during 2002; the majority of the 635,000 oz of demand came from the US subsidiaries of European and Japanese manufacturers.

The 21 per cent fall in the underlying palladium use in autocatalysts in 2002 can, to a large extent, be directly attributed to the jump in the palladium price from under $450 at the start of 2000 to over $1,000 in January 2001, plus previous disruptions in palladium supply from Russia. US car companies, some of whom had tended to use quite heavily loaded palladium-based catalysts, initiated programmes to reduce their reliance on the metal, adopting a twin strategy of switching to greater use of platinum-based catalysts and reducing average palladium loadings across certain model ranges. Many of these initiatives bore fruit in 2002, cutting palladium demand.

Rest of the World

Demand for palladium in autocatalysts in the Rest of the World grew by 4 per cent or 20,000 oz to reach 500,000 oz in 2002. Light-duty vehicle production across Asia expanded by 7.7 per cent, powering the increase in palladium purchases. The actual and imminent tightening of emissions regulations in countries such as China and South Korea also increased pgm use. However, palladium demand grew at a slower rate than platinum demand; the difference was primarily a result of greater use of platinum-based catalysts at the expense of palladium-rich systems.

Autocatalyst Recovery

The volume of palladium recovered from the recycling of scrapped autocatalysts increased by nearly one-third in 2002, rising by 90,000 oz to an estimated 370,000 oz. The high palladium price of 2000 and 2001 intensified interest in the collection of scrapped catalytic converters, while the average palladium content of catalysts recovered increased.

Much of the increase in the total volume of palladium recovered was due to a 30 per cent rise in metal recovery in North America, where there is a well-developed and extensive collection and recycling network. Recovery rates also increased in Europe, where impending legislation has increased the emphasis on automobile recycling. In Japan recovery was flat, while elsewhere the volumes of metal recovered increased but remained relatively small.

In the USA and Europe in particular, the average palladium content of recovered autocatalysts increased. Catalytic converters fitted to cars manufactured from the mid-1990s onwards contained significant loadings of palladium and the number of these vehicles now being scrapped is rising.

Chemical

Chemical industry demand for palladium was broadly stable in 2002, the total edging up by just 5,000 oz to 255,000 oz. This reflected the soft rate of economic growth in North America, Europe and Japan. Demand for both palladium-based process catalysts and for catchment gauze from the nitric acid industry showed little change from the previous year. Construction of new purified terephthalic acid capacity in China was the sole stimulus to demand.

Palladium catalysts are widely used in the production of the bulk intermediate chemical vinyl acetate monomer (VAM). Structural overcapacity in VAM manufacturing persisted in 2002 and there was little capital investment to boost palladium catalyst demand. The main uses of VAM are in the manufacture of polyvinyl acetate and polyvinyl alcohol – the former has numerous applications in paints, adhesives, fibres

Palladium Demand: Chemical
'000 oz

	2001	2002
Europe	65	70
Japan	20	20
North America	75	75
Rest of the World	90	90
Total	**250**	**255**

JM

and coatings, while the latter is used in packaging film and glass laminates. These are generally mature markets and demand was subdued.

The other major bulk chemical application of palladium catalysts is in the production of purified terephthalic acid (PTA). This is a precursor to polyesters and to polyethylene terephthalate (PET), a plastic resin used in packaging – demand for both is growing in Asia. Construction of new capacity provided a small boost to palladium PTA catalyst demand in China but there was little investment elsewhere as the market in general was oversupplied.

The fall in the price of palladium throughout 2002 and the rise in the price of platinum improved the cost-effectiveness of palladium catchment gauze used in the production of nitric acid. However, the great majority of nitric acid is used in the manufacture of nitrogen fertilisers and depressed fertiliser prices meant margins and cash flow in the industry were squeezed last year. Consequently there was little net change in demand for palladium gauze.

Dental

The fall in the price of palladium throughout much of 2002, combined with the rise in the gold price, made palladium-based alloys more attractive to dental practices. A moderate recovery in demand resulted and purchases of metal increased by 3.4 per cent (25,000 oz) to 750,000 oz. The improvement, however, was restricted to Japan and North America; in Europe the substitution of palladium seen over the last three years appears to be permanent.

In Japan, the cost of dental treatment using a 20 per cent palladium alloy ('kinpala') is partly underwritten by a state-backed health insurance scheme. When palladium peaked at almost $1,100 per oz in 2001, the rising cost of treatment to patients and the time lag between treatment and the reimbursement of dental practices' costs by the state deterred the use of the kinpala alloy. However, the fall in the price of palladium resulted in a resumption of growth in 2002. Demand grew by a modest 10,000 oz to 485,000 oz.

The North American market also experienced an increase in palladium demand, with purchases of metal rising by 8 per cent to 205,000 oz. The fall in the price of palladium compared with the rising and increasingly volatile price of gold during the year reversed the move from palladium-based alloys to high-gold alloys. To put this in context, however, demand for palladium in this sector in 2002 was approximately half of the level it was five years previously.

Most European dental practices moved away from the use of palladium alloys between 1999 and 2001 in reaction to the metal's rising and volatile price. Preferences for alternative dental compounds in Europe vary from country to country and so the effect of the reversal of palladium prices in 2002 was mixed.

In Germany, cheaper base-metal alloys have become widely accepted and continued to take market share from precious metal alloys. The Italian market, however, remains heavily biased in favour of precious metal alloys and here the drop in the palladium price stimulated an increase in demand for palladium-based products at the expense of high-gold alloys. Across Europe as a whole, dental demand for palladium flattened out at 50,000 oz.

Palladium Demand: Dental
'000 oz

	2001	2002
Europe	50	50
Japan	475	485
North America	190	205
Rest of the World	10	10
Total	**725**	**750**

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Electronics

Use of palladium in electronic applications continued to fall in 2002, dropping by 18 per cent compared to the previous year. Other than in China, spending on information technology was generally weak, and palladium-based capacitors lost further market share to nickel products. However, purchases of palladium staged a moderate recovery, climbing 6 per cent to 710,000 oz. Although manufacturers continued to run down excess metal and component inventories, the effect of this on palladium purchasing was lower than in 2001. In addition, the volume of palladium recovered from scrapped electronic circuitry declined.

Electronic component manufacturers were faced with substantial inventories of palladium pastes and finished components in 2001, when demand for electronic goods dropped much further and faster than expected. With electronics demand still fragile, the effect of this stock overhang continued to be felt during 2002. However, the impact on palladium demand was not as severe as the previous year. The lower proportion of inventory use meant that overall purchases of palladium increased by 40,000 oz.

Corporate IT spending and PC sales in Europe, Japan and North America were weak in 2002, reflecting sluggish economic growth and widespread reluctance to invest in new goods and technology.

Palladium Demand: Electronics
'000 oz

	2001	2002
Europe	35	80
Japan	260	155
North America	250	250
Rest of the World	125	225
Total	**670**	**710**

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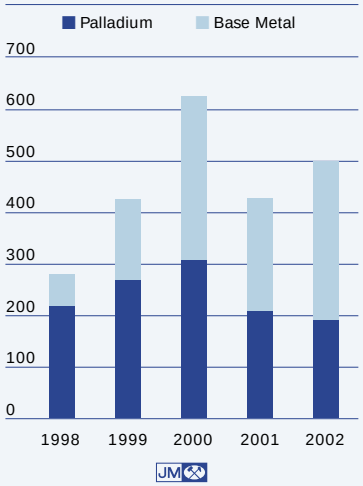
MLCC Production by Electrode Type 1998-2002

Billions



Global sales of mobile phones, however, grew by up to 5 per cent according to manufacturer estimates, helped by the introduction of new 3G products and by strong sales in China. Automobile demand for electronics also continued to expand as global light vehicle production recovered by around 3 per cent, and the electronics content of automobiles maintained its long-term growth trend.

These factors produced a rebound in multi-layer ceramic capacitor (MLCC) shipments, which rose by 16.5 per cent to 500 billion. Production of palladium-based MLCC, however, dropped as the market share of nickel products jumped from 52 per cent to 63 per cent. The switch in favour of nickel is a result of the substantial investment made by manufacturers in base metal capacitor fabrication plants between 1999 and 2001 in response to palladium's rising price.

After collapsing by 50 per cent in 2001, demand for palladium in plating applications stabilised in 2002. The price of palladium fell throughout the year, both in absolute terms and in relation to gold. After starting the year at a premium to gold of around $160, the palladium price fell to reach parity by the end of June. At this point palladium was significantly cheaper to use than gold in plating applications, as less metal is required to achieve the same performance of coating. The cost advantage of palladium widened during the final two months of the year as the metal's spot price dropped steeply and gold climbed. This helped to slow the substitution of palladium, although users remained wary of its price volatility. In addition, component manufacturers continued to make efforts to thrift their overall use of precious metals in the plating of lead frames and connectors.

Demand for palladium conductive pastes used in hybrid integrated circuits (HIC) was flat in 2002 – lower sales of HIC to the telecommunications market were offset by greater use in automobile electronic circuitry. In the resistor sector, demand for palladium pastes for chip and network components grew but that for surge resistors (used primarily in the telecommunications infrastructure) fell due to over-investment made in the late 1990s. Overall, net palladium demand for resistors was static.

Despite the increased attention being paid to recycling of old electronic scrap, the volume of palladium recovered in 2002 fell for the second year in succession to an estimated 240,000 oz. With spending on new IT equipment constrained, the number of obsolete products entering the recycling chain fell. The average precious metal content of scrapped components continued to decline, reflecting the previous success of manufacturers in thrifting pgm use.

Other

Palladium demand from the jewellery sector and other markets increased by 60,000 oz (20 per cent) to 355,000 oz in 2002. In Japan, higher production of white gold and a fall in the recycling of jewellery stock resulted in greater palladium demand. In North America, the drop in the price of palladium halted the trend to substitute some palladium-based petroleum cracking catalysts with base metal alternatives.

Demand for palladium in jewellery alloys increased by 13 per cent in 2002 to 260,000 oz, primarily due to increased purchases by the Japanese jewellery trade. Palladium is a constituent of many platinum jewellery alloys (typically from 5 to 10 per cent) and is commonly used as the whitening agent in white gold alloys (from less than 5 per cent to over 15 per cent palladium). Japanese sales of white gold articles jumped by 16 per cent in 2002, taking market share from both the lowest priced platinum jewellery and from yellow gold jewellery.

Demand for palladium was also assisted by the lower use of inventories of platinum jewellery in Japan compared to the year before. After cutting back stock levels heavily in 2001, there was much less slack in the fabrication and retail pipeline in 2002. As a result purchases of platinum jewellery alloys containing palladium rose, even though retail sales of platinum jewellery declined.

In China, the strength of the platinum jewellery market and rising white gold sales gave some impetus to demand for palladium as an alloying agent. However, only a minority of platinum and white gold alloys made in China contain palladium – a number of other metals such as nickel are also used – and so growth in palladium demand was not as strong as growth in the overall precious metal jewellery market.

In the industrial sector, the fall in the palladium price during 2002 reduced the economic incentive for petroleum companies to substitute palladium-based hydrocracking catalysts with base metal products. In 2001 this substitution caused net sales of palladium back to the market from refineries in North America but in 2002 demand across the industry was positive.

Palladium Demand: Jewellery & Other

'000 oz

	2001	2002
Europe	55	55
Japan	150	175
North America	15	45
Rest of the World	75	80
Total	**295**	**355**

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Other PGM

Other Platinum Group Metals

Rhodium

Total demand for rhodium rose by just under 3 per cent to 596,000 oz in 2002. Use of rhodium on autocatalysts grew strongly, driven by an increase in average rhodium loading levels, and higher light vehicle production in the USA and Asia. However, automakers in the USA satisfied a proportion of their rhodium requirements by further drawing down inventories. Demand for rhodium from the chemical catalyst and glass manufacturing industries weakened slightly.

Autocatalyst

In 2000, a number of US and Japanese auto companies built up substantial inventories of rhodium. At that time, the stability of supplies from Russia was uncertain and many auto manufacturers were anticipating having to use greater concentrations of rhodium on autocatalysts in order to meet increasingly stringent emissions legislation. In 2001, however, several auto makers utilised a proportion of their stockpiled metal to supplement purchases. This trend continued in 2002, when use of stocks by US auto companies increased sharply. Consequently, although the underlying use of rhodium on autocatalysts grew by 15 per cent, purchases of the metal by the global autocatalyst sector expanded by just 6 per cent to 600,000 oz.

Average rhodium loading levels increased in the USA in 2002 as a result of efforts to reduce reliance on palladium. Auto companies were able to reduce palladium loadings on some catalyst systems by raising the concentration of rhodium used. In addition, rhodium was added to some palladium-only catalysts, again to reduce the intensity of palladium use. The overall increase in average rhodium loading levels was small in terms of grams per individual catalyst, but the cumulative effect across the US light vehicle fleet was significant.

Also contributing to greater rhodium use in 2002 was the 7.6 per cent increase in US light vehicle production, representing a rise of around 850,000 vehicles. However, greater use of rhodium inventories by some US-based manufacturers more than offset these positive factors and demand for the metal dropped by 13 per cent in North America.

US Federal Tier 2 emissions standards will be phased in from the 2004 model year onwards and will require a further considerable reduction in fleet average NOx emissions. A number of manufacturers are likely to have to further increase rhodium loading levels on some of their catalyst systems in order to meet the Tier 2 requirements.

Japanese demand for rhodium in autocatalysts climbed noticeably in 2002. This was due in part to rising light vehicle production and exports – Japanese output of light vehicles increased by 4.7 per cent year-on-year. However, of greater significance for rhodium demand in Japan last year was an increase in average rhodium loading levels. This was primarily a result of the effect of tighter emissions regulations; both proposed in Japan and legislated in the European and North American export markets. A steadily increasing proportion of Japanese cars manufactured for the domestic market meet the published low emission vehicle guidelines, even though tighter standards are not likely to be enforced until 2005. To achieve the reduced level of NOx emissions that will be permissible in future, Japanese automakers increased average rhodium loading levels on autocatalyst systems on some of their models.

Autocatalyst demand for rhodium in Europe rose moderately in 2002, despite the almost 2 per cent fall in light vehicle production across Western Europe and a further increase in the market share taken by diesel cars (diesel autocatalysts do not contain rhodium). As in North America, the growth in rhodium consumption was due to a rise in the average rhodium loading per vehicle as some auto manufacturers thrifted palladium through more intensive use of rhodium.

In the Rest of the World, rhodium demand in 2002 increased by almost 8 per cent, reaching 95,000 oz. Light vehicle production strengthened across Asia, with the Chinese market in particular developing rapidly. Total passenger car production across the continent (excluding Japan) grew by 13.8 per cent, outweighing a 7 per cent fall in South America. Rhodium demand also continued to benefit from the spread of tougher emissions standards in countries such as China and South Korea.

The volume of rhodium recovered from scrapped autocatalysts climbed by 12.5 per cent to just less than 100,000 oz in 2002. Recovery rates in Europe continued to improve, although remained well below those in the USA. The European End of Life Vehicle Directive will further stimulate the dismantling and recovery of autocatalysts from scrapped vehicles from 2005 onwards. In North America, later model year cars now being scrapped contain higher loadings of rhodium

Rhodium Supply and Demand
'000 oz

	2001	2002
Supply		
South Africa	452	485
Russia	125	90
North America	23	28
Others	4	9
Total Supply	**604**	**612**
Demand		
Autocatalyst: gross	566	600
recovery	(88)	(99)
Chemical	44	42
Electrical	6	6
Glass	41	37
Other	10	11
Total Demand	**579**	**596**
Movements in Stocks	**25**	**16**

Samples of rhodium nitrate, a key component of many gasoline autocatalysts.

than earlier models, reflecting the introduction of strict limits on NOx emissions from the mid-1990s onwards.

Other

Demand for rhodium in chemical, glass and other applications fell by 5 per cent in 2002 to 96,000 oz. Demand for chemical process catalysts containing rhodium slipped marginally to 42,000 oz, primarily a reflection of lower demand in Europe where economic growth was sluggish and most sectors of the chemical market were subdued. Rhodium-based catalysts are used in the production of chemicals such as acetic acid, silicones, oxo-alcohols and hydrogen cyanide. Rhodium is a constituent of platinum wire used to fabricate nitric acid catalysts – demand from this sector was flat in 2002.

Rhodium is also a component of platinum alloys used in glass manufacturing applications. Demand from this industry decreased slightly in 2002. Overcapacity and competition from imports resulted in low profitability in the TV glass and reinforcement fibre glass sectors in North America and Europe. This led to the closure of several glass furnaces in 2002. These closures were partly offset by continued construction of new plants in Asia, notably in China, but the rate of expansion was not as great as in 2001. Demand for rhodium in thermocouples and other industrial applications in 2002 was broadly in line with the previous year.

Ruthenium & Iridium

Ruthenium demand in 2002 recovered from the sharp fall of the previous year, as excess inventories were worked out of the electronics market and demand for ruthenium-based catalysts increased from the bulk chemicals industry. The result was an increase in ruthenium demand of nearly 18 per cent to 410,000 oz. In contrast, iridium demand fell further, slipping to 77,000 oz as the surplus of crystal manufacturing capacity persisted in the electronics sector.

Demand for ruthenium used in electronic components improved in 2002 to 145,000 oz – a rise of 11,000 oz from the weak level of demand the previous year when a substantial overhang of both finished electronic products and components reduced raw material purchases. Component inventories at manufacturers were still significant at the start of 2002 but as the year progressed stock levels were drawn down towards normal working levels. Demand for ruthenium pastes used in resistors and hybrid integrated circuits (HIC) consequently increased year-on-year.

Sales of ruthenium-based resistors were flat in 2002, reflecting the weak level of investment in telecommunications infrastructure and the softness of the global market for IT equipment. However, shipments of HIC containing ruthenium increased, propelled by continued growth in the automotive electronics sector.

Total electronics demand for ruthenium in 2002 included small volumes of metal used in computer hard disks and fuel cell catalysts. During the year, two of the leading hard disk manufacturers introduced products containing a very thin layer of ruthenium – this has the effect of substantially increasing data storage densities. Other manufacturers are expected to rapidly follow their lead. Ruthenium is also a constituent of some catalysts used in proton exchange membrane fuel cells. The addition of ruthenium to platinum-based catalysts can help to improve fuel cell performance.

Iridium's principal use in the electronics industry is in the form of crucibles used to grow high-purity crystals. Significant overcapacity has persisted in this

Other PGM

sector following very strong sales of crucibles in 2000. Crystal manufacturers had ample capacity in 2002 to accommodate demand, which did not meet previous forecasts following the downturn in the mobile telecommunications industry.

The effect of this on iridium demand, however, was lessened somewhat by growth in demand for high purity crystals from medical equipment manufacturers. Materials manufactured in iridium crucibles are used in lasers and sophisticated medical scanners and sales of these products increased. Overall, demand for iridium in electronics applications slipped by 5,000 oz to 22,000 oz.

Demand for ruthenium used in chemical process catalysts was sharply higher in 2002, rising to 102,000 oz. Construction of new bulk and speciality chemicals manufacturing capacity, in particular for the production of acetic acid, boosted demand for ruthenium-based catalysts. The Cativa® acetic acid manufacturing technology utilises an iridium-ruthenium catalyst that offers the advantages of high selectivity, high reaction rates and reduced by-products over a wide operating range. Several new plants using the Cativa process were under construction in Asia in 2002.

Ruthenium and iridium are used to coat electrodes used in the manufacture of chlorine and caustic soda. The chloralkali industry is mature and there was little investment in new capacity in 2002. Chlorine demand, which correlates closely with industrial output, was largely flat. North American demand for ruthenium increased year-on-year, as one major producer continued with a long-term anode re-coating programme and another increased the ruthenium loading on its electrodes. These factors were primarily responsible for an 8,000 oz rise in total ruthenium demand to 100,000 oz. Iridium demand from the chloralkali industry was marginally higher at 23,000 oz.

By the end of 2002 the use of iridium as a component of some autocatalyst formulations had been virtually eliminated. Stricter emissions legislation has resulted in the phasing out of technology utilising iridium in favour of platinum-based catalysts. Small volumes of iridium were used in high performance spark plugs but penetration of the market by these products remained low.

In other markets, the use of corrosion resistant ruthenium-titanium pipe in the oil and geothermal energy industries was stable in 2002. In North America, platinum jewellery alloys containing 3 to 5 per cent ruthenium are commonly used for the manufacture of wedding bands. Demand from this market increased in 2002 in line with improved retail sales of platinum jewellery. Both iridium and ruthenium are used to manufacture anodes to prevent corrosion of shipping vessels and underwater structures. This market consumes several thousand ounces of each metal annually and demand was stable last year.

Ruthenium Demand by Application
'000 oz

	2001	2002
Chemical	61	101
Electrochemical	92	100
Electronics	134	145
Other	61	64
Total Demand	**348**	**410**

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Other PGM Supplies

Total rhodium supplies in 2002 grew slightly, rising to 612,000 oz. Lower sales of metal from Russia were offset by increased output in South Africa and Zimbabwe as platinum production expanded. The rising proportion of UG2 ore mined in South Africa is leading to greater rhodium output as the UG2 reef contains substantially higher concentrations of rhodium (as well as ruthenium and iridium) than the Merensky Reef. South African shipments of rhodium rose by 7.3 per cent during the year to 485,000 oz.

Russian exports of rhodium continued to ease back from the exceptional total in 2000, when large volumes were sold from state inventories to western auto manufacturers. In 2002, Russian sales of rhodium totalled 90,000 oz, 35,000 oz less than the previous year. However, with several US automakers utilising greater volumes of rhodium from their inventories, total supply was sufficient to comfortably meet demand.

Output of ruthenium and iridium climbed significantly in 2002 and substantially exceeded demand. The price of both metals weakened throughout the year as a result and producer stocks of the metals are presumed to have increased. South African production of ruthenium and iridium is rising as expansions to platinum mining operations come on stream and the proportion of UG2 ore mined increases.

Iridium Demand by Application
'000 oz

	2001	2002
Automotive	8	5
Electrochemical	22	23
Electronics	28	22
Other	28	27
Total Demand	**86**	**77**

JM

Prices and Futures Markets

Platinum

Solid demand, a widening deficit in supply, and a lack of physical liquidity combined to drive the platinum price upwards in several successive rallies in 2002. After weakening from an opening fix of $481 to the year's low of $449 on the 1st of February, platinum then gained almost $150 over the remainder of the year. The price advanced in a series of successive rallies punctuated by sharp corrections downwards as investors took profits on long positions.

Strong growth in the Chinese jewellery market, supported by increased purchasing from the automobile and industrial sectors, resulted in rising demand for platinum. Growth in supplies, however, failed to keep pace with demand for the fourth year in succession and this shortfall drove the climb in the spot price. Market stocks of metal in Zurich, which were already low at the start of 2002, were further depleted – the net outflow of metal during the year reaching 558,000 oz. With the availability of metal tight, short-term lease rates jumped on several occasions, pushing the spot price upwards.

In addition to the good physical demand for platinum, increased investor and speculative interest in platinum futures was also noted, particularly during the second half of the year. With equity markets in the USA, Europe and Japan all performing poorly, the US dollar weakening, and interest rates generally low, there was greater fund interest in most hard commodities, most noticeably for gold but also for platinum.

Platinum opened 2002 steadily, fixing at $481 on the 2nd of **January**. Once the Japanese market re-opened on the 4th, investors on TOCOM who had benefited from the strong rally at the end of 2001 started taking profits. This, coupled with selling on the London fixings, took the price down to $472. Support in the form of good physical demand was found around this level and the metal largely traded between $470 and $480 through to the 24th. From then on, investor and fund liquidation of long positions, particularly on TOCOM, knocked the spot price backwards. The fall accelerated on the 29th when the TOCOM December 2002 contract fell below ¥1,800 per gram, and on the 31st platinum was fixed at $455.

After slipping to $449 on the first fixing of **February** (the low-point of the year), the platinum price then recovered to $474 by the 8th as US-based funds began opening new long positions and dealers covered short exposures. The rise was aided by gold moving above $300 and by strong purchasing of platinum by a Swiss bank. A period of consolidation between $470 and $480 was followed by further fund buying on NYMEX and the start of short-covering by investors who had accumulated around 225,000 oz of net short positions on TOCOM. With physical demand solid, the price climbed above $490 and ended the month at $493.

Platinum quickly passed the $500 mark in early **March** and continued to rally to reach $526 on the 11th. Prospects for the US economy were increasingly seen as encouraging and strong buying by US funds coupled with further short-covering by individual investors on TOCOM fuelled the rise. Throughout the second half of the month the price traded steadily between $510 and $520, with physical demand providing strong support at the lower end of the range. Little platinum was shipped from Russia during the first quarter of the year as official ratification of 2002 export quotas was awaited. This lack of Russian metal contributed to a tightening of short-term lease rates in February and March, which in turn supported the spot price.

Platinum jumped to $537 on **April** 2nd, driven by continued unwinding of short positions on TOCOM and solid physical demand. After softening to $525 on the 4th on profit-taking, concerns that industrial action at Anglo Platinum could disrupt supplies began to emerge. With spot sales of Russian material still largely absent and short-term lease rates on the increase, the platinum price climbed to $543 on the 15th. One-month lease rates reached 13 per cent and short-covering on TOCOM intensified as the spot price passed $550.

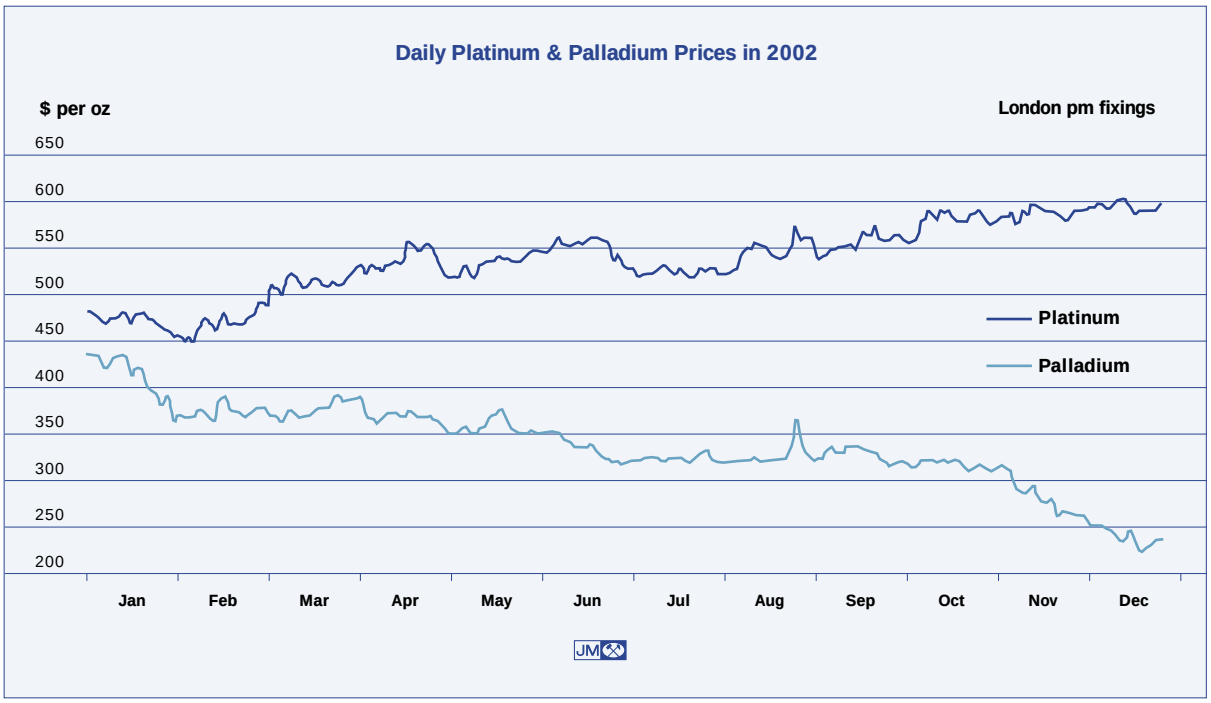
Higher volumes of metal, attributed to renewed Russian spot sales, came onto the market on the 19th and capped the rally before it reached $560. The price initially held firm in the face of the increased flow of metal, trading between $549 and $557 until the 29th. The offers of metal on the London fixings then weighed on the market, lease rates retreated, and as speculative selling came to the fore on TOCOM the price fell to $536 on the 30th.

The combination of physical sales and speculative selling by funds extended into early **May**, the platinum price falling to $519. Physical buying at this level halted

Average PGM Prices in $ per oz

	2001	2002	Change
Platinum	529.02	539.69	2%
Palladium	603.25	337.23	– 44%
Rhodium	1,603.89	838.05	– 48%
Iridium	413.01	293.57	– 29%
Ruthenium	132.11	66.41	– 50%

Platinum and palladium prices are averages of London am and pm fixings. Other pgm prices are averages of Johnson Matthey European base prices.



the slide and fund selling tailed off. Strong sales by the US auto industry, an indicator of underlying demand, and a spurt in the gold price to over $320, then drew the platinum price upwards again. By the 15th platinum had reached $537 and climbed to $546 on the 21st. A degree of dealer profit-taking was seen at this level and platinum consolidated between $537 and $548 for the remainder of the month.

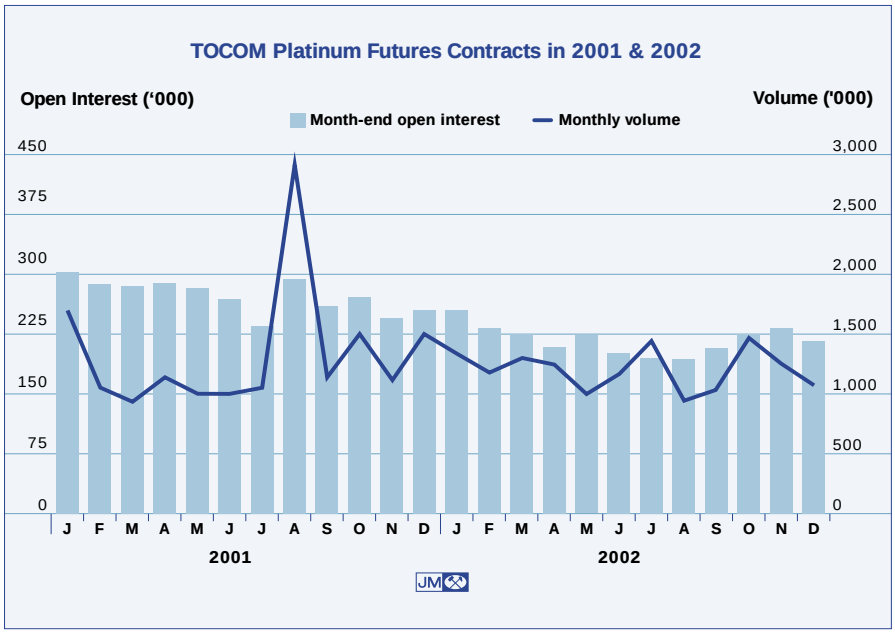
The platinum price passed $550 in early **June**, and then jumped to $564 on the 7th when investors on TOCOM increased their net long positions as gold also rose. After pausing around this level the price edged up again from the 14th as funds sought diversification from poor equity markets, platinum reaching $567 on the 21st. However, bids for physical metal then became lighter, offers on the fixings increased and the price slipped back to $560 on the 24th.

On the 26th the WorldCom accounting fraud broke and sentiment turned bearish. A sharp fall in the dollar against the yen triggered stops on TOCOM as longs moved to protect profits. Spot platinum slid to $539 on the 27th before consumer purchasing of metal enabled a recovery to $545 the following day.

The negative investor sentiment had depressed platinum to $520 by the 5th of **July**, the weakening dollar triggering stop-loss sell orders on TOCOM. The underlying robustness of demand then provided a platform for a moderate recovery, and by mid-month platinum had regained $530. Throughout the remainder of July the London market for physical metal was fairly quiet and the speculative selling on TOCOM abated. Platinum drifted back to $520 on the 24th as gold fell but again physical support proved to be solid, the metal floating between $520 and $530 through to the end of the month.

Platinum trade was thin in early **August** but from the 7th onwards investors, including hedge funds, opened new long positions on NYMEX and near-term borrowing interest increased. This pushed the platinum price to $540 on the 8th and past $550 on the 12th, which in turn precipitated short-covering by the general public on TOCOM. The rally climaxed at $558 on the 14th following Anglo Platinum's announcement that it would fall short of its 2002 production target. Bids for physical metal then waned and with steady volumes being offered the price settled back to fix at $541 on the 22nd.

Platinum was jerked higher in the final week of August by an intense bout of short-covering in the palladium market. When palladium contracts on TOCOM opened up at their daily limit on the 28th, the focus switched to platinum and with dealers struggling to cover short positions the price fixed at $574. The effects, however, were short-lived and by the end of the month the platinum price had slipped back to $564.



Platinum Prices in 2002
London am and pm fixings, $ per oz

	High	Low	Average
Jan	482.00	455.00	472.49
Feb	494.00	449.00	471.25
Mar	526.00	486.00	512.15
Apr	559.00	525.00	540.87
May	548.00	519.00	534.56
Jun	567.00	539.00	556.33
Jul	532.00	519.00	526.22
Aug	574.00	522.00	545.54
Sep	574.00	540.00	555.84
Oct	598.00	557.00	580.54
Nov	602.00	577.00	588.20
Dec	607.00	585.00	596.39

JM

At the start of **September**, poor US economic data sparked another futures-based sell-off, with US funds and Japanese dealers taking profits on their long positions. Sizeable offers of metal were also made on the London fixings and platinum dropped to $540 on the 5th. Physical demand and speculative buying halted the fall, and the price edged slowly up to $554 by the 16th.

Substantial short-term borrowing came into the European market on the 18th and 19th. With physical stock in Zurich low, one-month lease rates jumped towards 12 per cent and the platinum price hit $568. Japanese investors were caught short and as they covered their exposure the metal fixed at $570 on the 20th. Further short-term borrowing saw the price reach $574 on the 24th but once this demand was satisfied one-month lease rates dropped back rapidly towards 6 per cent and platinum settled between $560 and $565 for the rest of the month.

An improvement in physical availability took the platinum price down to $557 on the 4th of **October** but this lull proved to be fleeting. Further borrowing between the 8th and the 16th caused sharp rises in short-term lease rates, one-month offers nearing 20 per cent. As Japanese investors scrambled to cover large short positions (contracts equivalent to over 2.5 million oz were traded on the 10th) the spot price surged through the $570, $580 and $590 barriers. The rally peaked on the 16th when spot offers were made over $600 during tense trading in New York. Greater volumes of metal were attracted into the market and, as lease rates eased, platinum dropped back to trade between $580 and $590 for much of the remainder of the month.

This range was maintained throughout most of the first two weeks of **November**, before fund buying of futures initiated another rally. Borrowing swelled again on the 14th, moving lease rates upwards and the following day there was strong general public buying on TOCOM followed by dealer short-covering in London. The scramble to cover positions pushed the morning fixing to $602, the first time that $600 had been breached since May 2001. Buying of futures by investors continued on TOCOM on the 18th but physical demand fell back, particularly from the Chinese jewellery industry. In addition, dealers offered greater volumes of metal and the spot price softened a little to trade between $585 and $595, fixing at $592 on the 29th.

The bullish supply and demand outlook for platinum continued to underpin the market during **December**. US funds bought into the metal at around $590, while another slide in the US dollar against the yen prompted short-covering by Japanese investors. On the 6th the Zurich spot price moved over $600 and platinum fixed at $602 in London on the 9th. Buyers of physical metal were discouraged at this level, allowing a retreat back to $594. A steep year-end rally in gold gave fresh momentum to platinum from the 13th and the metal fixed at $607 on the 17th. Volumes of spot trade, however, were limited and investor profit-taking pushed the price back to $585 on the 24th. Platinum ended 2002 on a firm note at $598, its premium over palladium having grown from only $40 to $365 over the course of the year.

Palladium

Demand from most sectors of the palladium market was weak in 2002, with key customers in both the auto and electronics industries making substantial use of inventories. The resultant pressure on the palladium price was compounded by a growing surplus of metal as primary output in South Africa and North America increased, and production at Norilsk Nickel far outweighed sales. In addition, the US Defense National Stockpile Center sold almost 325,000 oz of palladium during the year.

These fundamentals alone were sufficient to

depress the price but as investors became increasingly aware of the scale of the market imbalance, short selling of palladium contributed to a fall of over $200 over the course of the year. Trading volumes were generally thin and the decline was interspersed with prolonged periods when the metal traded in tight ranges and by occasional spikes caused by fund activity on the illiquid futures markets.

Palladium fixed at $440 on the morning of the 2nd **January**, the high point of 2002, then spent much of the remainder of the year in decline. Good offers of metal weakened the price to $422 on the 7th but as the selling eased it crept back to $435 on the 10th. Support was then pulled from under the price by Ford Motor Company's decision to take a $1 billion charge against its inventories of pgm and related forward contracts. Palladium plunged to $413 on the 15th as traders speculated that the company would purchase little or no metal during the coming year, and might sell excess palladium back to the market. The price came under increasing pressure from fund selling in New York, crashing past $400 and ending the month $70 below the opening fix at $370.

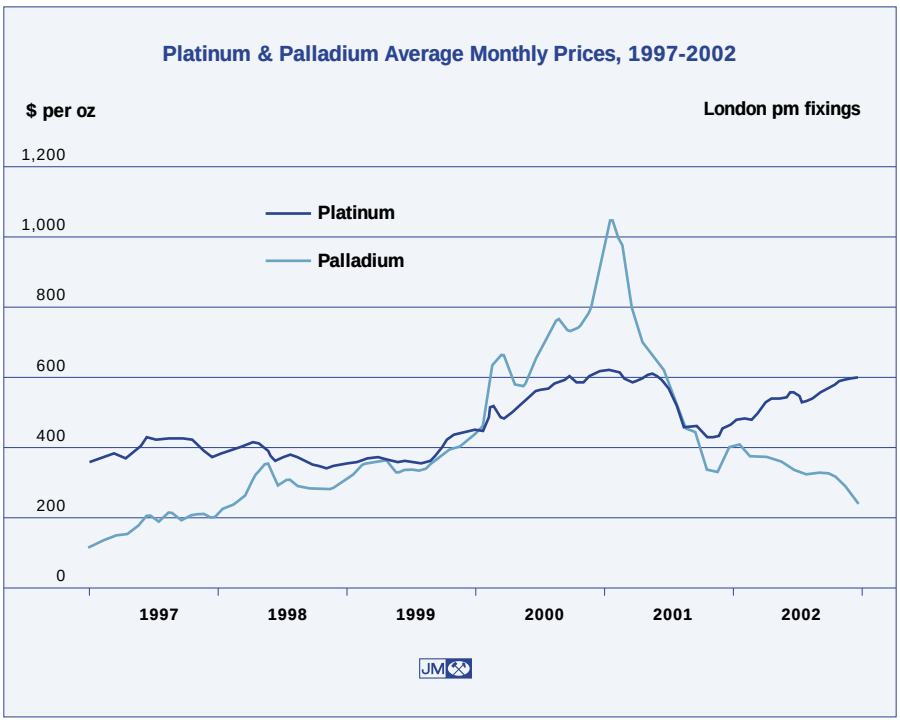
The fall was broken in early **February** as fund attention turned to gold and platinum. The palladium market was quiet for the first 11 days of the month, mainly trading between $365 and $375. On the 12th speculative buying by dealers in New York provided a spur to the spot price and this was followed on the 13th by a surge of borrowing in the USA. As short-term lease rates jumped, palladium fixed at $383. Contracts on TOCOM subsequently rose by the daily price limit on the 14th and the morning fixing in London was settled at $388. However, with physical liquidity good, and no fresh borrowing interest, the rally quickly subsided. The price slipped back to $380 on the 15th and for most of the rest of the month palladium traded thinly between $370 and $380.

Heavy selling on the fixings pushed palladium to a new low of $360 on the 6th of **March** but the price recovered to settle back into a narrow trading range around $370 until the 19th. An improved volume of bids for physical metal lifted the fixing to $380 on the 20th, aided by the continued absence of Norilsk Nickel from the palladium spot market. A small rally developed towards the end of the month when light speculative buying on NYMEX triggered a flurry of dealer short-covering that lifted the price to $393 on the 26th. The effect was transitory and palladium moved back to $386 at the month's final fixing on the 28th.

Confirmation from Ford that it was actively reducing its pgm inventories and would consider selling metal back to the market caused another slump in the palladium price in early **April**. Between the 2nd and 8th the price lost $30, dropping to $362. Although industrial demand remained weak, palladium managed a gentle recovery above $370, largely on the back of the strengthening platinum price. However, when the platinum rally ran out of steam, palladium drifted downwards, ending the month at $360.

The slow decline came to a halt in early **May**, moderate physical demand setting a floor around $350. The price fixed in a tight range of $349 to $357 for the first two weeks of the month with trading subdued. On the 16th, an increased level of bids on the London fixings, coupled with fund buying on NYMEX in a very thin market, pushed the metal to $368 in the afternoon. Persistent buying on the fixings over the next few days drove the rally to a peak of $378 on the 21st but then the weak fundamentals took over and a rapid decline followed. Higher physical sales attracted by the rise in the spot price served to erode the gains and by the end of the month palladium had eased back to $348.

The palladium market turned decidedly bearish in **June** and the price slipped by almost $30. There was



little activity during the first week, spot metal trading between $345 and $356. From the 10th onwards open interest increased on NYMEX as funds opened new short positions and the price scuttled back to $333 on the 14th. Increased interest in physical metal slowed the descent temporarily but once again offers were soon struggling to attract firm bids. Continuing sales of palladium from the US Defense National Stockpile Center and the disposal of excess inventories by some consumers contributed to the fundamental oversupply of metal. By the end of the month palladium was trading either side of $320, a discount of $220 to platinum.

The palladium market was extremely quiet for much of **July**, the absence of selling rather than any significant physical demand holding the price close to $320. Trading on TOCOM was almost at a standstill – only 535 contracts changed hands during the week ending the 12th (equivalent to a mere 25,800 oz of palladium). A small rally evolved from the 23rd to the 29th when purchasing on the London fixings and New York spot market lifted palladium to $332. By the end of the 31st, however, the price had returned to trade around $320.

The inertia continued into **August**, the price virtually static at $320 from the 1st through to the 23rd as traders struggled to generate any interest and volumes remained thin. On the 26th, a single fund decided to liquidate its short position on NYMEX and bought December 2002 contracts to close out its position. In such a thinly traded market this had a domino effect: other investors rapidly started covering their short positions and the December contract rose by $12 to move above $330.

The buying flowed over onto TOCOM on the 27th and further fund activity on NYMEX later in the day fuelled more frantic short-covering, the afternoon fixing in London climbing $12 to $342. On the 28th TOCOM contracts opened up by the daily limit and dealers in London were forced into further buying, squeezing the morning fixing up to $362. When the afternoon fix started at $375, however, over 25,000 oz of palladium were offered and the price quickly moved down to settle at $365.

The speculative rally evaporated over the final two days of August as good volumes of metal were offered, pushing the price down to $330 on the 30th.

The correction back to $320 was completed on the 3rd of **September**, then as the offers dried up, palladium edged up to $331 again on the 6th. For the next two weeks, the palladium market was very quiet, the metal mostly fixing between $330 and $335. Volumes of physical trade were thin, and activity on TOCOM was exceptionally light – a mere 39 contracts (just over 1,900 oz) changing hands on the 13th. By the final week of the month palladium was under renewed downward pressure as pessimism about the short-term US economic outlook resurfaced. With physical demand mediocre the price softened to $315 on the 30th.

Palladium continued to trade torpidly during **October**, with small volumes of physical business nudging the price between $310 and $320 for the most part. Light demand provided a degree of support but palladium was fixed towards the lower end of the range as the month drew to a close.

In **November** the support around $310 was broken and palladium fell steeply, the oversupply and weak demand fundamentals increasingly weighing on market sentiment. The price broke sharply lower between the 7th and 11th of November, dropping $20 to $288 on the London fixing. Persistent offers of relatively small volumes of metal found almost no buying interest and the fall was accelerated by stop-loss selling of futures contracts on NYMEX. By the 19th the metal had lost another $15, fixing at $273 as the selling pressure continued.

The proposed acquisition of a 51 per cent stake in Stillwater Mining by Norilsk Nickel for a combination of cash and 877,000 oz of palladium then further undermined sentiment. By the 25th selling in the Far East and Europe had depressed the spot price to $261 and palladium ended the month close to this level.

There was no respite for palladium during **December**, the price shedding almost another $30. Shipments of palladium from Russia increased dramatically, further adding to the already substantial volumes of metal held in Zurich. On the 4th offers totalling 17,000 oz were made and the price wilted to $255. Additional selling pressure the following day pushed the fixing price below $250 for the first time since March 1998.

The price continued to edge down the following week and when another substantial parcel of palladium was offered on the 16th it plunged to $233. The year's fixing low of $222 was reached on the 23rd and palladium ended December tiredly at $233, a discount of $365 to platinum.

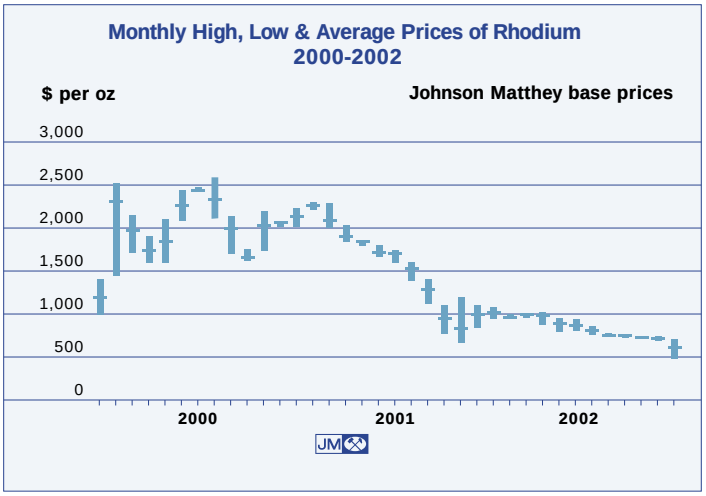
Palladium Prices in 2002
London am and pm fixings, $ per oz

	High	Low	Average
Jan	440.00	365.00	409.91
Feb	388.00	365.00	374.20
Mar	393.00	360.00	374.55
Apr	392.00	360.00	369.86
May	378.00	348.00	356.66
Jun	356.00	318.00	334.82
Jul	332.00	316.00	322.63
Aug	365.00	318.00	324.69
Sep	336.00	315.00	327.74
Oct	322.00	308.00	316.59
Nov	314.00	261.00	285.60
Dec	262.00	222.00	242.63

Other PGM

The price of rhodium was firm from January until almost the end of April, trading between $950 and $1,075 as the market awaited significant sales of metal from Russia. Physical availability then increased as Russian shipments accelerated. With South African production rising on the back of increasing platinum output, and some auto companies utilising inventories to supplement purchases, the price weakened. By the end of November rhodium had slipped below $700, then dropped sharply to $485 during December as offers of metal increased just when most purchasers had largely withdrawn from the market.

Prices for ruthenium and iridium also softened throughout 2002, the inevitable result of plentiful supply and weak demand for both metals.



The Johnson Matthey base price for rhodium edged higher during early January, reflecting steady consumer demand and a lack of Russian selling. However, after reaching a peak of $1,075 on the 11th, the price gradually drifted lower, settling to $960 during the first week of February. The market tightened in March with the continued absence of Russian sales, the JM base price moving up to $995 around mid-month and passing $1,000 in early April.

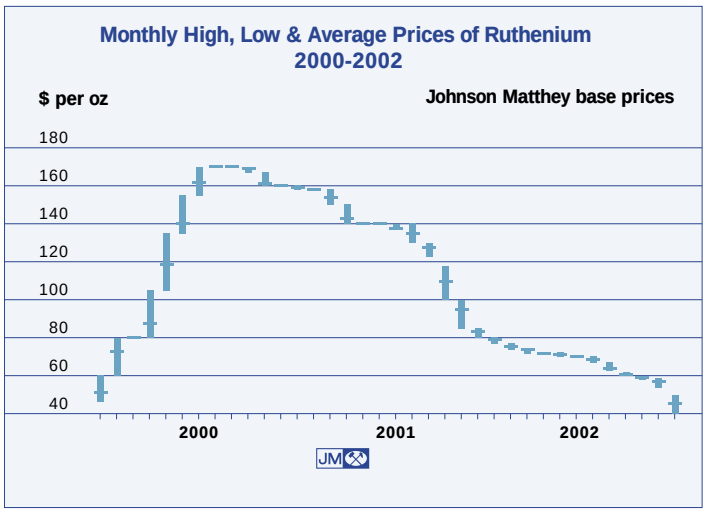
From the end of April physical availability increased noticeably as Russian selling reappeared. The JM base price slid down to $800 by the 8th May in response, then fluctuated between $800 and $950 through to the end of June as offers and bids of metal waxed and waned at either end of the range.

Rhodium broke below $800 during July as dealer selling found only weak buying interest, then slipped down to $740 in August in thin summer trade. From September through into November the market was very quiet, light trade being conducted either side of $750. From mid-November, however, the JM base price resumed its drift downwards as the volumes offered started to rise, dropping to $695 by month-end.

By early December significant volumes of rhodium were being offered to the market, with much of the metal reputed to be of Russian origin. As sellers competed aggressively for the very limited buying interest, the price fell below $600 on the 17th, hit $500 on the 24th and ended the year under pressure at $485.

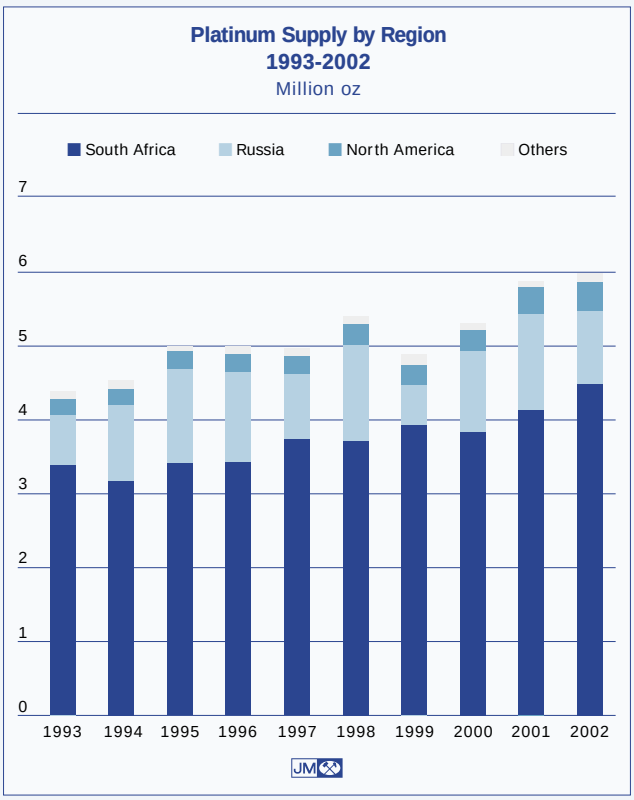
The JM base price for ruthenium opened the year at $80 and for the first six months of the year faded gradually to $70. Excess inventories of electronic components, which had depressed demand for ruthenium pastes used in resistors, had largely been worked off by the second half of the year but the price fell faster as demand remained subdued and supplies from South Africa increased. After hitting $54 by the end of November ruthenium then sank to $40 during December as dealers sought to maximise sales volumes and revenues before year-end. The decline continued the metal's correction back from the speculative driven surge of 2000.

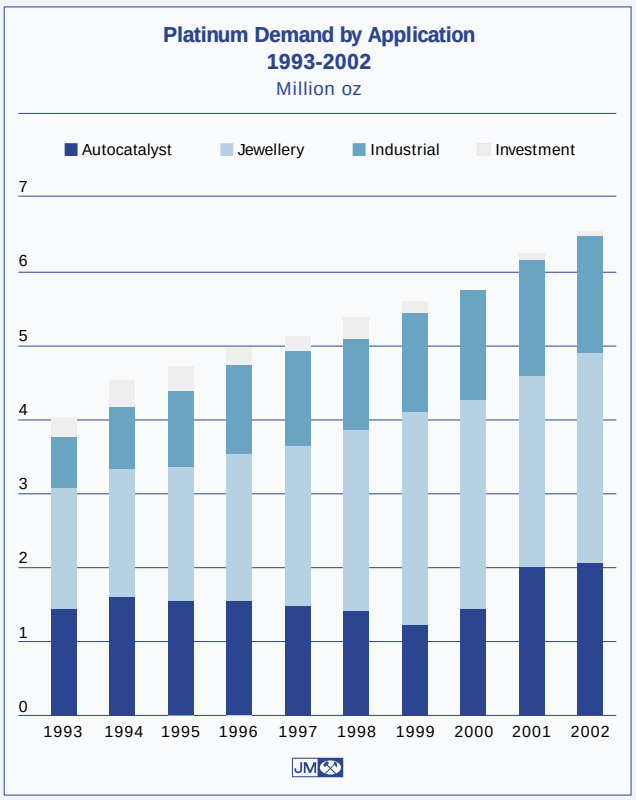
The iridium market suffered from an excess of crucible capacity for high-purity crystal manufacture during 2002 as the key electronics markets struggled to recover from the previous year's sharp downturn. With supply more than sufficient to meet generally poor demand, the JM base price dropped steeply from $395 at the start of the year to $125 by the end of December.



Platinum Supply and Demand

'000 oz	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Supply										
South Africa	3,360	3,160	3,370	3,390	3,700	3,680	3,900	3,800	4,100	**4,450**
Russia	680	1,010	1,280	1,220	900	1,300	540	1,100	1,300	**980**
North America	220	220	240	240	240	285	270	285	360	**395**
Others	130	140	100	130	120	135	160	105	100	**145**
Total Supply	**4,390**	**4,530**	**4,990**	**4,980**	**4,960**	**5,400**	**4,870**	**5,290**	**5,860**	**5,970**
Demand by Application										
Autocatalyst: gross	1,685	1,870	1,850	1,880	1,830	1,800	1,610	1,890	2,520	**2,610**
recovery	(255)	(290)	(320)	(350)	(370)	(405)	(420)	(470)	(530)	**(570)**
Chemical	180	195	225	230	235	280	320	295	290	**325**
Electrical	165	190	250	275	305	300	370	455	385	**380**
Glass	85	170	245	255	265	220	200	255	290	**255**
Investment: small	125	155	75	110	180	210	90	40	50	**45**
large	180	240	270	130	60	105	90	(100)	40	**35**
Jewellery	1,625	1,760	1,880	1,990	2,160	2,430	2,880	2,830	2,590	**2,830**
Petroleum	105	95	135	185	170	125	115	110	130	**140**
Other	170	195	230	255	295	305	335	375	465	**490**
Total Demand	**4,065**	**4,580**	**4,840**	**4,960**	**5,130**	**5,370**	**5,590**	**5,680**	**6,230**	**6,540**
Movements in Stocks	**325**	**(50)**	**150**	**20**	**(170)**	**30**	**(720)**	**(390)**	**(370)**	**(570)**



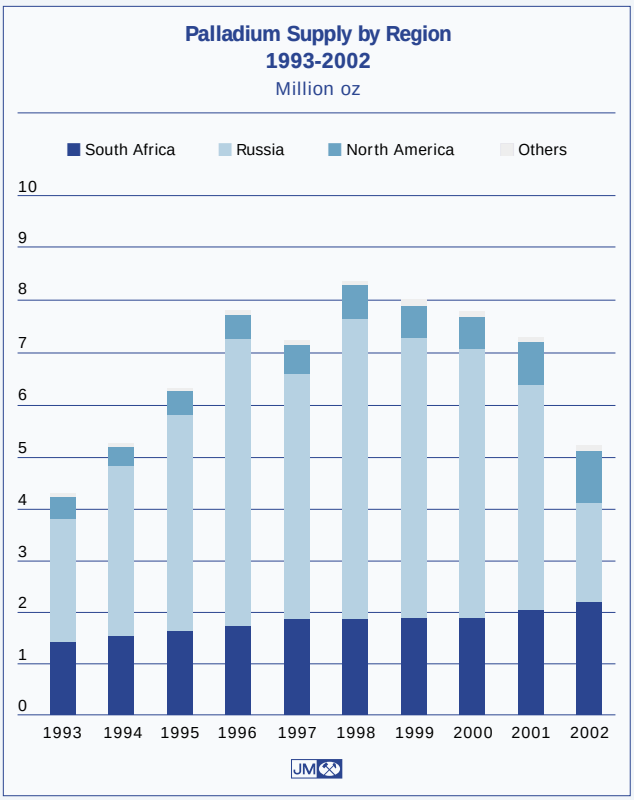


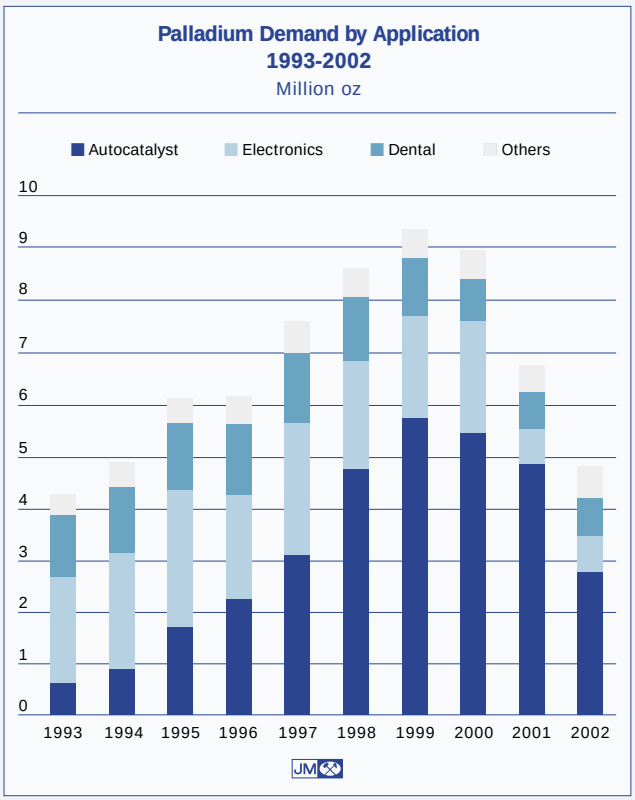
Platinum Demand by Application: Regions

'000 oz	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Europe										
Autocatalyst: gross	610	605	560	515	510	545	560	680	1,060	**1,240**
recovery	(5)	(10)	(15)	(20)	(25)	(30)	(30)	(40)	(70)	**(90)**
Chemical	40	50	55	60	70	60	80	100	105	**115**
Electrical	20	25	25	25	45	45	70	80	65	**65**
Glass	15	30	35	40	20	25	20	20	10	**10**
Investment: small	25	45	10	5	5	5	5	0	0	**0**
Jewellery	105	100	120	125	150	160	185	190	170	**165**
Petroleum	25	25	15	15	15	15	15	15	15	**15**
Other	60	65	75	75	85	85	90	105	155	**170**
Total	**895**	**935**	**880**	**840**	**875**	**910**	**995**	**1,150**	**1,510**	**1,690**
Japan										
Autocatalyst: gross	320	290	270	245	255	240	250	290	340	**425**
recovery	(50)	(45)	(40)	(50)	(50)	(55)	(60)	(60)	(55)	**(60)**
Chemical	15	15	20	20	20	20	20	20	25	**30**
Electrical	45	45	45	45	65	55	75	90	80	**80**
Glass	30	80	105	80	85	80	65	65	85	**80**
Investment: small	55	40	35	25	25	25	20	5	5	**5**
large	180	240	270	130	60	105	90	(100)	40	**35**
Jewellery	1,350	1,450	1,480	1,480	1,390	1,290	1,320	1,060	750	**780**
Petroleum	10	5	5	5	5	5	5	5	5	**5**
Other	20	25	25	25	30	30	35	35	35	**40**
Total	**1,975**	**2,145**	**2,215**	**2,005**	**1,885**	**1,795**	**1,820**	**1,410**	**1,310**	**1,420**
North America										
Autocatalyst: gross	600	790	820	850	800	775	535	620	795	**570**
recovery	(200)	(230)	(260)	(275)	(290)	(310)	(315)	(350)	(370)	**(380)**
Chemical	75	65	70	80	80	80	95	100	100	**100**
Electrical	65	75	115	130	100	105	120	145	120	**115**
Glass	15	20	25	30	45	20	25	50	35	**30**
Investment: small	40	65	25	75	145	175	60	35	45	**40**
Jewellery	45	55	65	90	160	270	330	380	280	**310**
Petroleum	40	5	40	60	50	40	40	35	40	**45**
Other	80	95	115	140	160	170	190	210	250	**255**
Total	**760**	**940**	**1,015**	**1,180**	**1,250**	**1,325**	**1,080**	**1,225**	**1,295**	**1,085**
Rest of the World										
Autocatalyst: gross	155	185	200	270	265	240	265	300	325	**375**
recovery	0	(5)	(5)	(5)	(5)	(10)	(15)	(20)	(35)	**(40)**
Chemical	50	65	80	70	65	120	125	75	60	**80**
Electrical	35	45	65	75	95	95	105	140	120	**120**
Glass	25	40	80	105	115	95	90	120	160	**135**
Investment: small	5	5	5	5	5	5	5	0	0	**0**
Jewellery	125	155	215	295	460	710	1,045	1,200	1,390	**1,575**
Petroleum	30	60	75	105	100	65	55	55	70	**75**
Other	10	10	15	15	20	20	20	25	25	**25**
Total	**435**	**560**	**730**	**935**	**1,120**	**1,340**	**1,695**	**1,895**	**2,115**	**2,345**

Palladium Supply and Demand

'000 oz	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Supply										
South Africa	1,395	1,500	1,600	1,690	1,810	1,820	1,870	1,860	2,010	**2,160**
Russia	2,400	3,300	4,200	5,600	4,800	5,800	5,400	5,200	4,340	**1,930**
North America	415	410	470	455	545	660	630	635	850	**990**
Others	70	70	70	95	95	120	160	105	120	**170**
Total Supply	**4,280**	**5,280**	**6,340**	**7,840**	**7,250**	**8,400**	**8,060**	**7,800**	**7,320**	**5,250**
Demand by Application										
Autocatalyst: gross	705	975	1,800	2,360	3,200	4,890	5,880	5,640	5,090	**3,080**
recovery	(100)	(105)	(110)	(145)	(160)	(175)	(195)	(230)	(280)	**(370)**
Chemical	190	185	210	240	240	230	240	255	250	**255**
Dental	1,210	1,265	1,290	1,320	1,350	1,230	1,110	820	725	**750**
Electronics	2,015	2,230	2,620	2,020	2,550	2,075	1,990	2,160	670	**710**
Jewellery	210	205	200	215	260	235	235	255	230	**260**
Other	35	115	110	140	140	115	110	60	65	**95**
Total Demand	**4,265**	**4,870**	**6,120**	**6,150**	**7,580**	**8,600**	**9,370**	**8,960**	**6,750**	**4,780**
Movements in Stocks	**15**	**410**	**220**	**1,690**	**(330)**	**(200)**	**(1,310)**	**(1,160)**	**570**	**470**





Palladium Demand by Application: Regions

'000 oz	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Europe										
Autocatalyst: gross	115	260	650	860	1,100	1,370	1,530	1,900	1,730	**1,430**
recovery	0	0	0	(5)	(5)	(5)	(10)	(15)	(30)	**(45)**
Chemical	65	60	65	65	70	65	65	95	65	**70**
Dental	265	255	250	255	260	210	180	100	50	**50**
Electronics	210	255	325	300	340	270	255	265	35	**80**
Jewellery	35	30	30	30	50	50	50	45	35	**35**
Other	(10)	25	20	20	25	25	25	20	20	**20**
Total	**680**	**885**	**1,340**	**1,525**	**1,840**	**1,985**	**2,095**	**2,410**	**1,905**	**1,640**
Japan										
Autocatalyst: gross	90	125	145	180	245	480	600	510	505	**515**
recovery	(30)	(30)	(25)	(30)	(45)	(50)	(55)	(50)	(40)	**(40)**
Chemical	20	20	20	20	20	20	20	20	20	**20**
Dental	500	550	580	600	620	590	545	470	475	**485**
Electronics	1,280	1,400	1,600	990	1,390	1,060	980	990	260	**155**
Jewellery	120	120	115	115	110	105	105	150	140	**165**
Other	10	15	10	10	10	10	10	15	10	**10**
Total	**1,990**	**2,200**	**2,445**	**1,885**	**2,350**	**2,215**	**2,205**	**2,105**	**1,370**	**1,310**
North America										
Autocatalyst: gross	450	525	950	1,230	1,680	2,820	3,490	2,805	2,375	**635**
recovery	(70)	(75)	(85)	(110)	(105)	(115)	(125)	(155)	(200)	**(260)**
Chemical	65	60	70	70	70	70	75	65	75	**75**
Dental	400	410	410	410	415	390	350	230	190	**205**
Electronics	420	450	545	490	550	460	405	485	250	**250**
Jewellery	5	5	5	5	10	10	10	10	0	**0**
Other	25	55	65	90	55	55	50	5	15	**45**
Total	**1,295**	**1,430**	**1,960**	**2,185**	**2,675**	**3,690**	**4,255**	**3,445**	**2,705**	**950**
Rest of the World										
Autocatalyst: gross	50	65	55	90	175	220	260	425	480	**500**
recovery	0	0	0	0	(5)	(5)	(5)	(10)	(10)	**(25)**
Chemical	40	45	55	85	80	75	80	75	90	**90**
Dental	45	50	50	55	55	40	35	20	10	**10**
Electronics	105	125	150	240	270	285	350	420	125	**225**
Jewellery	50	50	50	65	90	70	70	50	55	**60**
Other	10	20	15	20	50	25	25	20	20	**20**
Total	**300**	**355**	**375**	**555**	**715**	**710**	**815**	**1,000**	**770**	**880**

Rhodium Supply and Demand

'000 oz	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Supply										
South Africa	278	330	342	359	377	400	410	457	452	**485**
Russia	80	80	80	110	240	110	65	290	125	**90**
North America	17	15	13	5	16	16	18	17	23	**28**
Others	1	1	1	2	3	4	8	3	4	**9**
Total Supply	**376**	**426**	**436**	**476**	**636**	**530**	**501**	**767**	**604**	**612**
Demand by Application										
Autocatalyst: gross	356	379	464	424	418	483	509	793	566	**600**
recovery	(25)	(34)	(37)	(45)	(49)	(57)	(65)	(79)	(88)	**(99)**
Chemical	11	10	13	21	36	31	34	39	44	**42**
Electrical	9	8	8	9	9	6	6	7	6	**6**
Glass	3	14	17	53	43	34	35	42	41	**37**
Other	12	11	9	9	10	10	9	10	10	**11**
Total Demand	**366**	**388**	**474**	**471**	**467**	**507**	**528**	**812**	**579**	**596**
Movements in Stocks	**10**	**38**	**(38)**	**5**	**169**	**23**	**(27)**	**(45)**	**25**	**16**

Notes to tables

Supply figures are estimates of sales by the mines of primary pgm.

With the exception of the autocatalyst sector, **demand** estimates are net figures, demand in each sector being total purchases by consumers less any sales back to the market. Thus, annual totals represent the amount of primary metal that is acquired by consumers in a particular year. We continue to exclude the CIS from our demand estimates.

Movements in stocks in a given year reflect changes in stocks held by fabricators, dealers, banks and depositories but excluding stocks held by primary refiners and final consumers. A positive figure indicates an increase in stocks; a negative figure indicates a rundown in stocks.

Gross autocatalyst demand is purchases of pgm by the auto industry for manufacture of catalytic converters. **Autocatalyst recovery** is pgm recovered from scrapped catalytic converters and is allocated to the region in which the converter was scrapped.

Investment: small refers to the long-term holding of metal in the form of coins, and bars weighing 10 oz or less. **Investment: large** is in the form of 500 g and 1 kg bars in Japan and includes platinum held on account for subscribers to accumulation plans.