

# Platinum | 2001

by Alison Cowley and Mike Steel

Summary and Outlook	3
Supplies, Mining and Exploration	13
Platinum	23
Palladium	33
Other Platinum Group Metals	39
Prices and Futures Markets	42

## Special Report

PGM Mining in Canada and Zimbabwe	19
-----------------------------------	----

Supply and Demand Tables	47-52
Glossary	inside back cover



Johnson Matthey



# Summary & Outlook

## Platinum

- Autocatalyst demand rebounded by 14 per cent as diesels gained market share and auto makers bought more platinum for use on gasoline vehicles.
- Consumption in jewellery fell 1 per cent as weakness in Japan outweighed growth in China and the rest of the world.
- Strong offtake for the manufacture of computer hard disks and LCD glass boosted industrial demand by 8 per cent.
- Investment demand was negative as investors sold back large bars in Japan and sales of coins halved.
- Supplies rose by 9 per cent as a doubling of Russian sales outweighed a decline in output from western mines.
- Following the record deficit in 1999, another shortfall in 2000 helped propel prices to \$625 in December, 50 per cent above the January low.

## Overview

Demand for platinum in 2000, at 5.6 million oz, was marginally up on the record level achieved in 1999, but the pattern of consumption was significantly different from that of recent years. Sales to the auto industry rose after declining in each of the previous three years, while industrial demand grew once again. However, jewellery demand fell for the first time in seventeen years, and net investment was negative with significant numbers of large bars being sold back to the market by investors in Japan.

The largest growth sector was the auto industry where demand increased by 250,000 oz to reach 1.84 million oz. In the European car market, the share taken by diesel engines rose to almost one third and this, coupled with the

imposition of Euro Stage III emissions regulations, boosted platinum use. In North America the major portion of the increase in demand came from stock building by auto companies that expect to use more of the metal to replace palladium in future.

Industrial demand rose by 110,000 oz to 1.45 million oz, with further increases in the use of the metal in computer hard disks and in plant for the production of speciality glass, especially for liquid crystal displays.

A fall in jewellery fabrication in Japan was the cause of the first decline in this sector since 1985. Increased recycling of old jewellery, combined with a loss of market share to white gold at the cheaper end of the market, led to a 20

Platinum Supply and Demand '000 oz		
	1999	2000
<b>Supply</b>		
South Africa	3,900	3,800
Russia	540	1,100
North America	270	285
Others	160	105
<b>Total Supply</b>	<b>4,870</b>	<b>5,290</b>
<b>Demand</b>		
Autocatalyst: gross	1,610	1,840
recovery	(420)	(470)
Jewellery	2,880	2,840
Industrial	1,340	1,450
Investment	180	(60)
<b>Total Demand</b>	<b>5,590</b>	<b>5,600</b>
Movements in Stocks	(720)	(310)



per cent fall in Japanese demand. As a result, Japan was overtaken as the largest market for platinum jewellery by China, where demand exceeded 1 million oz for the first time. Total jewellery demand fell by 40,000 oz to 2.84 million oz.

Investment demand was weak, with sales of coins and investment bars halving to 40,000 oz and a net sellback of 100,000 oz of large bars in Japan.

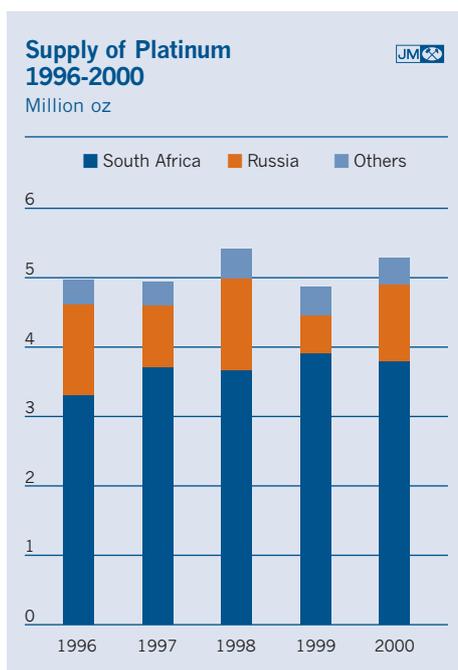
Supplies of platinum rose by 420,000 oz to 5.29 million oz and would have been significantly higher if the output of mines in South Africa had met plans. A combination of exceptionally bad weather in the first quarter and a strike at Anglo Platinum later in the year, reduced South African supplies by 100,000 oz compared with 1999. The shortfall was

more than made up for by higher shipments from Russia. Freed from the restrictions imposed by the Clause 19 problem of the previous year, Russian supplies more than doubled to 1.1 million oz.

Despite the 9 per cent increase in total supplies, they once again failed to match the level of demand. The deficit, at 310,000 oz, was not as large as in 1999, but the combined shortfall of just over 1 million oz in two years put pressure on the price of platinum, which rose steadily through the year from a low of \$414 in January to a high of \$625 in December.

## Supply

The South African platinum industry enjoyed record profits in 2000 and all the major mining companies announced plans to expand output. Expansion plans already underway had been expected to yield increased output in 2000. However, extraordinarily heavy rainfall in the early part of the year reduced mining and milling rates at both Anglo Platinum's and Impala's operations in the Rustenburg area. This, coupled with a strike at Anglo Platinum in September, outweighed increased production at Lonmin and Kroondal and resulted in a 3



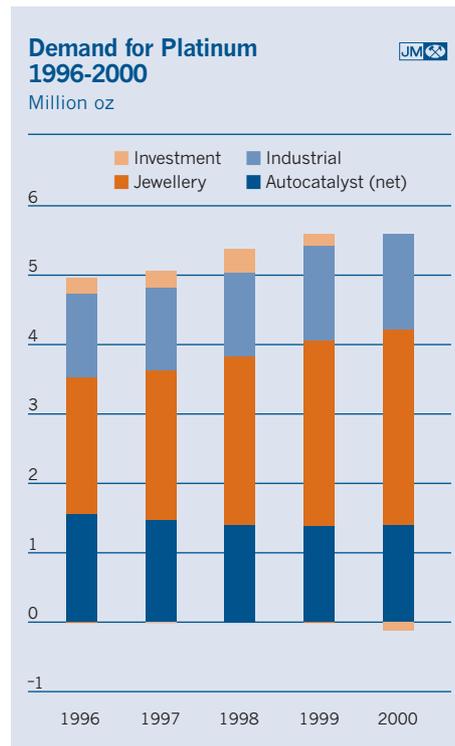
per cent fall in South African supplies to 3.8 million oz.

Assuming that operational problems do not recur on last year's scale, the South African platinum mines should produce significantly more platinum in 2001. Further growth can be expected in future years, with the existing mining companies having already announced expansions totalling around 2 million oz, and having indicated that they plan to increase output even more. The basket of pgm prices was at an all time high in 2000 and South African producers are using the funds generated from the buoyant market to invest to meet expected growth in demand.

The most aggressive expansion is by Anglo Platinum, which has scheduled an increase in its platinum output from the 1.87 million oz produced in 2000 to 3.5 million oz by 2006. Impala, directly and through its subsidiary Barplats, is planning to add 250,000 oz to its capacity. The company will also increase its refinery output through its concentrate purchase agreements with Aquarius and Messina, assuming their projects proceed as planned.

The third largest South African producer, Lonmin, had already committed to add at least 200,000 oz to output at its mines and in April 2001 announced a joint venture with Anglo Platinum that will mine a further 250,000 oz of platinum. Northam, the other current producer, expects to increase its output by 50,000 oz by mining UG2 ore for the first time.

After a year of sharply reduced sales in 1999, Russia exported 1.1 million oz of platinum last year. Delays in presidential approval of export quotas and licences prevented sales in the first quarter of the year and it was not until April that metal began to flow to the west. Thereafter, strong demand enabled the Russians to supply platinum in excess of current production levels without negatively impacting the rising price.



However, not all Russian production from last year was sold; the alluvial producers of Koryak and Kondyor in the Far East of Russia were once again denied export quotas. As a result their only option was to sell metal on the internal market, where the prices offered by Gokhran and the Central Bank were substantially lower than the world price. It is reported that the producers declined to sell at least part of their output in 2000 in protest against the discount.

As in the previous four years, the granting of export licences and quotas has again been problematic in early 2001. Reports suggest that President Putin signed the quotas in mid March, but the procedures for issuing export licences appear to have delayed exports and there was little sign of Russian sales until April. The indications are that one year quotas have been granted to Norilsk Nickel and, for the first time, to the alluvial producers of the Far East. Without knowledge of the level of quotas, the impact this may have on total Russian shipments in 2001 is difficult to predict.

Supplies from other western mines declined by 9 per cent in 2000. Although

production at Stillwater was up, a strike at Falconbridge impacted Canadian output and supplies from Zimbabwe fell due to the closing in 1999 of the Hartley Platinum mine.

## Demand

After sixteen years of continuous growth in jewellery demand, the rising price of platinum began to have a negative effect in 2000, and demand fell back by 1 per cent to 2.84 million oz. The decline was entirely due to weakness in the Japanese jewellery market, where fabrication demand fell by 20 per cent to 1.06 million oz. In contrast, jewellery manufacturers' demand for platinum grew in all other regions, although at lower rates than in recent years. Demand in China rose to 1.1 million oz and for the first time exceeded the level of Japan.

Retail sales of platinum pieces dropped by 4 per cent in Japan but, despite its rising price, platinum maintained its market share amongst products priced at over ¥37,500. At lower levels, where the cost of the precious metal is a more significant component of the overall price of the product, platinum

lost some market share to gold. The loss was almost entirely to white gold, indicating that the fashion for white metal jewellery continued in Japan.

Demand for platinum from jewellery manufacturers fell more sharply than the decline in pieces purchased. The wholesale and retail chain in Japan is complex and has provided opportunities for inventory reduction as the economy has stagnated in recent years. The high price of platinum in 2000, coupled with the poor economic outlook in Japan, appears to have encouraged some holders of old jewellery stock to return products for melting.

In China, consumers' desire for platinum jewellery continued on its upward path and demand exceeded 1 million oz for the first time. In the second half of the year, however, a number of difficulties became apparent. The mark up on platinum jewellery in China is lower than in most other markets; as the price of platinum rose during the year, retail prices failed to keep pace and margins for manufacturers and wholesalers were squeezed.

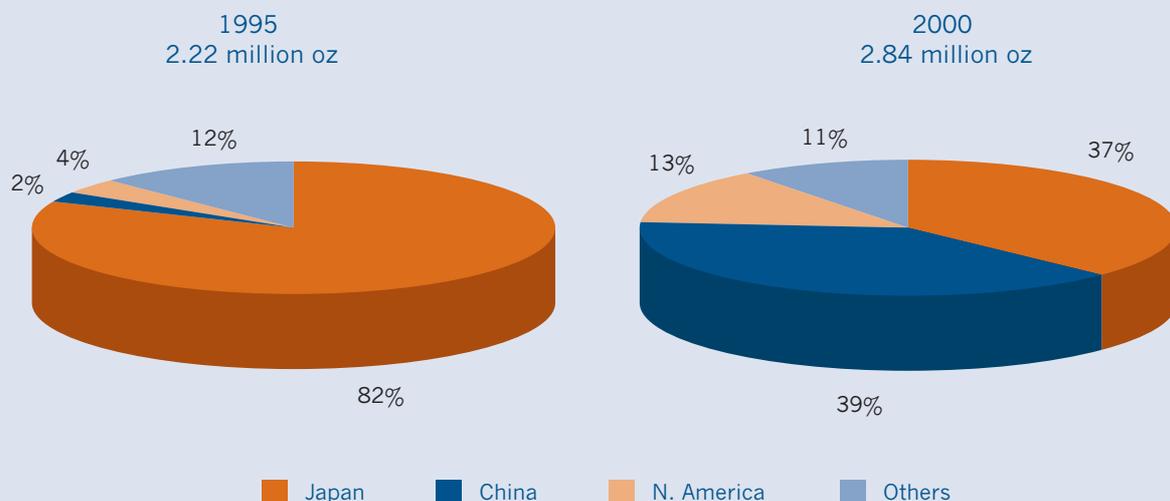
In addition, there was a burst of

activity by the Chinese tax authorities investigating the payment of import and local taxes on many goods, including jewellery, which appears to have caused some manufacturers to reduce, or even temporarily halt, their activities.

Consumption of platinum jewellery grew again in the USA as strong economic growth for much of the year fuelled sales of upmarket products. Platinum also benefited from a continued fashion trend towards white metal jewellery. Demand for platinum jewellery remains concentrated in the bridal sector but imports of lightweight chain are significant and a number of domestic manufacturers have begun to compete in this market segment.

Growth in the USA may be lower this year as the deceleration of the US economy that began in the last quarter of 2000 is expected to have an impact on consumer spending on luxury goods. This, coupled with the high price of platinum relative to gold, is likely to limit the penetration of platinum into the price sensitive fashion jewellery sector, although it should have less impact in the bridal market, where further increases in

Platinum Demand for Jewellery by Region  
1995 and 2000





Valero Energy Corporation's Krotz Springs refinery in Louisiana, USA

platinum demand can be expected.

In Europe the greatest advance for platinum in 2000 occurred in the UK market, where the weight of platinum jewellery submitted for hallmarking increased by 28 per cent. As in many other developing markets for platinum jewellery, the UK bridal sector has been the first segment to show substantial growth, but some retailers have now started to offer other platinum jewellery products, such as lightweight chain imported from Italy.

In the auto sector, demand for platinum grew for the first time since 1996, with purchases by auto makers rising by 230,000 oz to 1.84 million oz. Much of the increase was due to the growth in sales of diesel cars in Europe and the need for heavier catalyst loadings to meet Euro III emission standards. These came into effect for new models in January 2000 and will apply to all vehicles this year. Further growth in demand can be expected in 2001 as more European consumers buy modern, fuel-efficient, diesel engines.

Most auto makers worldwide have become increasingly concerned about the rising price of palladium, and perhaps also its future availability, and are exploring ways to reduce their dependence on palladium by using more platinum in catalysts fitted to gasoline engines. Developments in catalyst technology are making it increasingly

feasible to substitute at least part of the palladium currently used by platinum, possibly by also adding some rhodium to the pgm mix. However, palladium is likely to remain to meet the most severe emissions regulations, especially in multi-brick systems where palladium-rich catalysts close to the engine manifold can be combined with platinum-rich bricks in the cooler underfloor position.

Some auto companies appear to have bought more platinum than they needed last year in order to build up stocks of the metal for future usage. This was the main reason for the 16 per cent increase in platinum demand in the North American auto sector in 2000.

In California, the Zero Emission Vehicle (ZEV) mandate is due to come into effect in 2005. After a thorough review last year, the California Air Resources Board (CARB) confirmed the legislation in January 2001. This will support the introduction of fuel-cell powered cars. The growing membership of the California Fuel Cell Partnership, which now includes eight major auto companies and a number of energy and fuel-infrastructure suppliers, reflects the momentum behind the development of fuel cell vehicles.

There was an 8 per cent increase in demand for platinum for industrial applications in 2000, with the greatest gains in the electrical and glass sectors, which grew by 23 and 28 per cent respectively.

The penetration of platinum techno-

logy into the manufacture of computer hard disks continued last year. Magnetic layers made from alloys containing platinum are now used in more than 90 per cent of all hard disks manufactured and this proportion is expected to increase further in 2001.

Manufacturing of high precision glass for liquid crystal displays (LCDs) advanced sharply in 2000. LCD technology is now gaining share of the markets for computer displays and televisions, and is already widely used in smaller electronic goods such as digital cameras and mobile phones. The consequent growth in demand for LCD glass stimulated expansion in plants to manufacture this material. As platinum-rhodium equipment is used in the manufacture of LCD glass there was a burst of activity in purchasing metal for this application which contributed to an increase demand in the glass sector to 255,000 oz.

Demand for platinum fell in the manufacture of traditional products such as nitric acid for fertilisers, and catalysts for the chemical and petroleum industries. This was largely balanced by continuing growth in demand for smaller uses such as spark plugs, sensors, medical devices and pharmaceuticals.

For the first time in twenty years net investment in platinum was negative. Bullion coin sales were largely confined to the American Eagle, but sales by the US Mint declined by over 60 per cent to 27,000 oz. The continuing interest in platinum from numismatists in the USA was shown as they purchased almost 25,000 oz of proof platinum Eagles, and 9,500 oz of Library of Congress bimetallic coins in platinum and gold. Some bullion coins and bars were sold back to the market by investors who took the opportunity afforded by high prices to realise profits. Net sales of coins and small investment bars, at 40,000 oz, were just under half of the previous year's level.

Positive demand in the small investment sector in 2000 was outweighed by

sales back to the market by holders of large platinum bars in Japan. The price of platinum in yen terms rose to levels not seen in Japan since 1990 and encouraged investors to sell three to four times as many bars as they bought last year. With the yen price of platinum having been below ¥2,000 for most of the 1990s, it is to be expected that a further significant proportion of the large bars sold over the past decade may be returned to the market if prices remain significantly above that level.

## Outlook

After two years of deficits the platinum market is expected to move closer to balance in 2001. Despite reduced forecasts of economic activity, demand for platinum is expected to rise once again. The main driver is likely to be the auto industry as sales of diesel-powered vehicles in Europe increase and as more manufacturers worldwide seek to add platinum to autocatalysts on gasoline vehicles to reduce their dependence on palladium.

Demand for platinum in industrial applications is also expected to rise,

though probably at a lower rate than over the past two years as the effects of a slowdown in world economic activity become more pronounced.

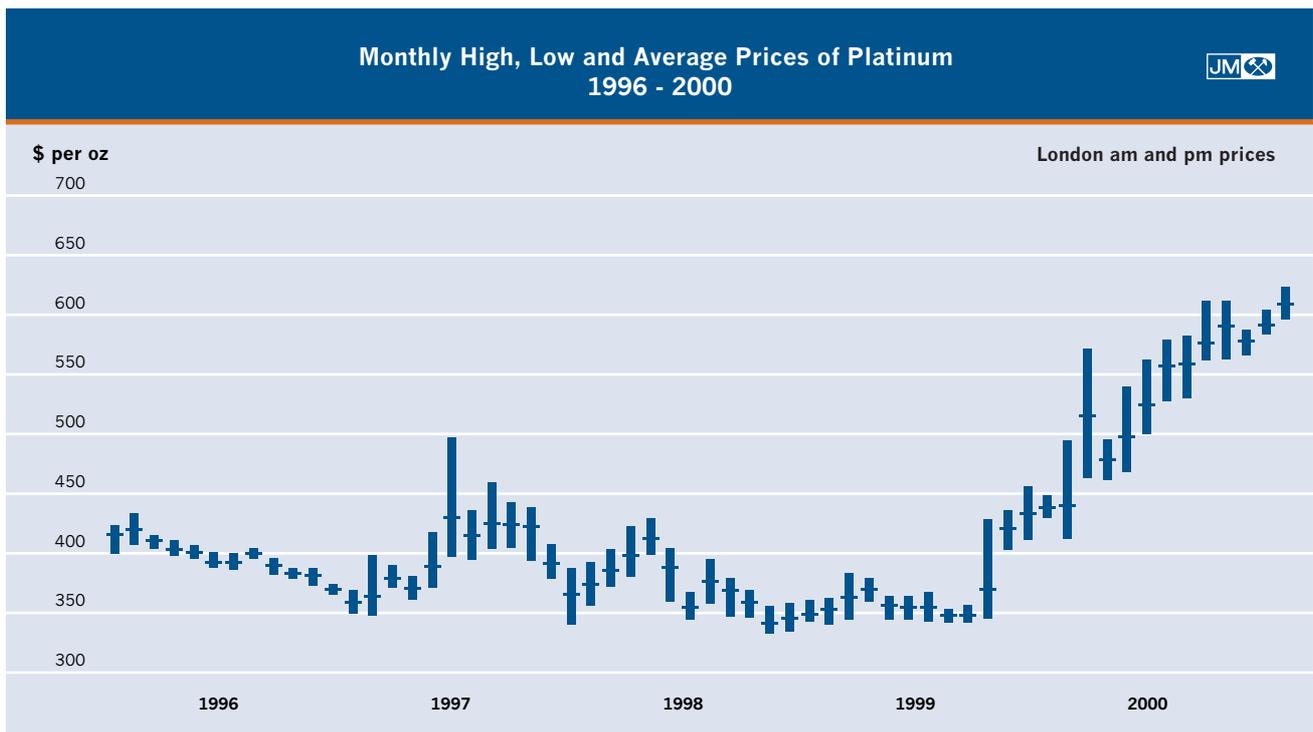
The outlook for jewellery demand in 2001 is less assured. The fashion for white metal jewellery seems certain to continue but the higher price of platinum over the past year has resulted in some demand at the cheaper end of the market moving to white gold. This is likely to be exacerbated in Japan by the continuing weakness of the economy and the decline in consumer spending.

Jewellery demand in China may also prove to be price sensitive and, additionally, is currently being negatively influenced by the level of tax inspections.

Despite this, there is evidence of a strong first quarter in China and if the price of platinum were to stay below the \$600 level there would be a good prospect of demand remaining around the 1 million oz level in 2001. Other jewellery markets, in North America and Europe, seem likely to be less affected by the issues of price and economic activity and consumption there is expected to grow modestly.

Western supplies of platinum should increase by up to 10 per cent as expansions in South African and North American mining capacity come on stream. Assuming they avoid the problems encountered last year, South African mines should produce at least 300,000 oz more than in 2000, with Anglo Platinum being the main contributor to the increase. The probable level of Russian sales is more difficult to assess. Platinum stocks held by the government may no longer be substantial, but Norilsk and the alluvial producers are thought not to have sold all of last year's production and, subject to the level of export quotas given, may be able to sell in excess of their current output in 2001.

With supply a little easier and demand expected to be moderately higher, the market is expected to move closer to balance and, therefore, the price of platinum is not expected to change greatly from its current level. The sensitivity to price of jewellery demand is expected to set limits on both the upper and lower levels of price, which for the next six months we expect to remain in the range \$550 to \$625.



# Palladium

- Demand fell by 5 per cent as increases in the palladium price began to impact some market sectors.
- Auto industry purchases of palladium declined by 4 per cent as some auto makers used metal from stocks.
- Burgeoning demand for capacitors saw electronics demand rise 8 per cent, even though palladium lost share to base metals.
- Demand in dentistry and other applications fell by 21 per cent in response to the higher price.
- Total supplies declined by 3 per cent as Russian shipments fell back to 5.2 million oz and western sales were marginally lower than in 1999.
- A second successive large deficit drove the palladium price to a series of all-time records, culminating in a high of \$972 in December.

## Palladium Supply and Demand

'000 oz

	1999	2000
<b>Supply</b>		
South Africa	1,870	1,860
Russia	5,400	5,200
North America	630	635
Others	160	95
<b>Total Supply</b>	<b>8,060</b>	<b>7,790</b>
<b>Demand</b>		
Autocatalyst: gross	5,880	5,650
recovery	(195)	(230)
Dental	1,110	820
Electronics	1,990	2,140
Other	585	520
<b>Total Demand</b>	<b>9,370</b>	<b>8,900</b>
Movements in Stocks	(1,310)	(1,110)



## Overview

Demand for palladium last year was 5 per cent lower than in 1999, but this did not stop the price rising to unprecedented levels. A dramatic climb to \$800 in February on the back of a squeeze on TOCOM was followed by a retreat to \$600 after the exchange authorities imposed trading restrictions. However, the fundamental imbalance between mine supply and demand continued to exert pressure on the market. The price rose to a series of all-time highs and, towards the end of the year, approached \$1,000; a barrier that was subsequently breached in January 2001.

Despite the rise in the price demand remained strong, but more users switched from palladium to other metals in the electronics and dental sectors, and there were signs of likely future substitution in autocatalysts. The use of palladium in the auto industry increased significantly in 2000 but this was not reflected in purchases by auto companies due to changes in patterns of stock

building compared with the previous year. Although slightly down on the record level of 1999, demand last year, at 8.9 million oz, was the second highest ever. It seems probable, however, that it will fall more sharply in the current year.

Russia, the dominant supplier of palladium, has two sources of metal – fresh production by Norilsk Nickel and government controlled stocks. Norilsk has a ten year quota for exporting palladium and various spokesmen for the company have made it clear that exports were made steadily throughout 2000, a claim supported by trade data. Sales from government stocks were erratic and may have been influenced by a power struggle between the Ministry of Finance and Central Bank over control of the stocks and the level of sales in 2000.

Supplies of palladium from South Africa fell marginally, mainly due to reduced output at Anglo Platinum and Impala following flooding in the early part of the year, and a strike at Anglo in

the third quarter. North American supplies rose as output at Stillwater and North American Palladium increased, although a prolonged strike at Falconbridge offset much of the improvement. Elsewhere, the closure of Hartley Platinum in 1999 severely impacted supplies from Zimbabwe.

Two extra western sources of palladium were significant last year, just as they had been in 1999. The first was sales from the US Defense Stockpile by the Defense Logistics Agency (DLA) – in 2000 the DLA sold 185,510 oz of palladium. The second, which is more difficult to quantify, was sales from stocks built up by hedge funds in the mid 1990s. The most significant holder of such stocks is believed to have been the Tiger Management fund, which in March 2000 announced that it was to close. Although much of the palladium this fund had acquired was probably sold in 1999, we suspect that the residual metal it held was liquidated before the closure of the

fund at the end of March.

The DLA continues to run its stockpile down and if sales are maintained at the rate of the last two years, will have exhausted it by 2005. As ever, it is impossible to be sure how much palladium remains in Russian stocks and what government policy will be towards their sale.

Several of the major companies in the auto industry are thought to hold significant inventories of palladium and these may currently be providing liquidity to the market through leasing deals. However, as these and other consumer stocks are gradually used for manufacturing, it seems clear that within a few years the palladium market will return to a more fundamental supply-demand situation, with supplies limited to the level of current production.

## Supply

Russia is the world's principal supplier of palladium and throughout the 1990s supplied metal both from new production and from stockpiles built up in earlier years. Uncertainties about the level of sales from these stocks and the quantities that remain have added greatly to the volatility of the metal's price, especially during the period of substantially increased consumption over the past five to six years.

Although the Russian stocks are generally regarded as being under government control the exact stewardship has changed during the last few years. Until the mid 1990s they were under the control of the Ministry of Finance. It is believed the metal was then transferred to the Central Bank. More recently, since the ascent to power of President Putin, the control of much of the stock appears to have reverted to the Ministry. Precise information is difficult to obtain as details of pgm holdings and movements remain a state secret in Russia.

In 1999, Norilsk Nickel was granted, by presidential decree, a ten year quota

for exporting palladium and various spokesmen for the company made it clear that sales were made steadily throughout 2000. It seems probable that Norilsk's production will be exported similarly this year, with much of the metal being shipped under long term contracts negotiated since the ten-year quota was agreed. The level of sales from government stocks is as difficult to divine as ever. In 2000, we estimate that total Russian sales were 5.2 million oz.

The early months of 2001 have seen some significant movements of palladium from Russia. In January the USA imported 874,000 oz of the metal, while in February the Swiss trade statistics recorded a total of 1.91 million oz as being imported into the country. At the time of publication of the latter figure the Swiss customs office was reported as saying that the metal had come from toll free storage in Zurich where it had been stored for a very long time. At short notice, and after briefly being in technical

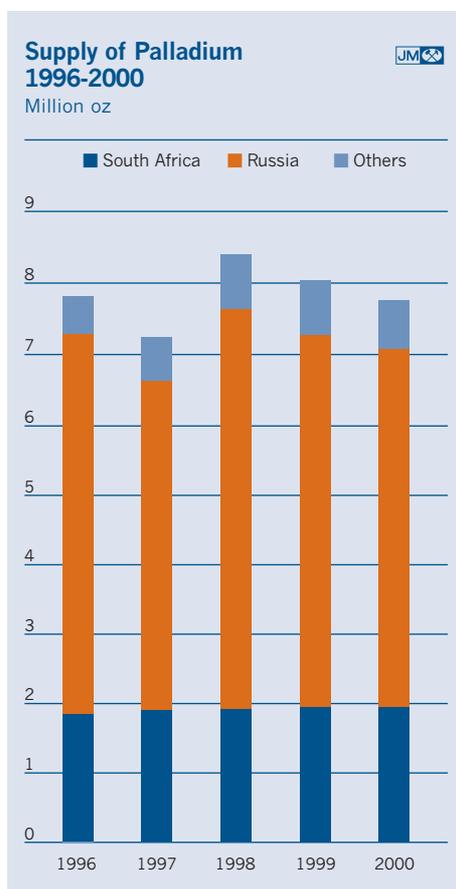
default, the Russia government made a large debt repayment to the Paris Club of international creditors at the end of February. It therefore seems possible that the need to raise funds quickly may have led to liquidation of stocks of palladium held in Zurich. Whether the Russian government will make further sales from its stocks in 2001 is difficult to judge.

Supplies from western mines had been expected to grow in 2000 as South African and North American miners progressed their expansion plans. In the event this did not happen, due to operational problems at mines in both regions. As a result, western supplies fell by 3 per cent to 2.59 million oz.

If the South African mines can avoid the problems of 2000, their supplies of palladium should rise by around 10 per cent this year, in line with their expected improvement in platinum production. Output should also increase sharply in North America, with North American Palladium planning to more than double its production in 2001 and extra metal coming from Stillwater, Inco and Falconbridge.

## Demand

Despite greater use of palladium in autocatalysts demand from the auto industry, in terms of purchases of metal, fell by 4 per cent last year to 5.65 million oz. In 1998 and 1999 many of the major auto makers had increased their stocks of palladium in anticipation of greater use to meet tighter regulations. In 2000, however, there was a more varied approach to inventories. In the first half of the year it appears that some companies that had built up stocks earlier decided to use some of this metal after the price of palladium rose sharply to reach \$800 in February at the time of problems on TOCOM. Delays in sales of palladium from Russian stocks may also have persuaded some companies to draw on their own inventories at that time in the expectation that more metal



would be available later in the year at lower prices.

Exports of palladium by Russia did increase in the last four months of the year but the price continued to rise. It seems likely that some auto makers had by then become uncomfortable about their level of inventories compared to expected future use and decided to rebuild stocks in this period. Despite this, we estimate that, over the year, stocks of palladium held by auto companies fell by 340,000 oz in 2000.

Actual use of palladium in autocatalysts fitted to cars and trucks increased by 24 per cent last year as the legislation controlling emissions from vehicles was tightened in all the major regions.

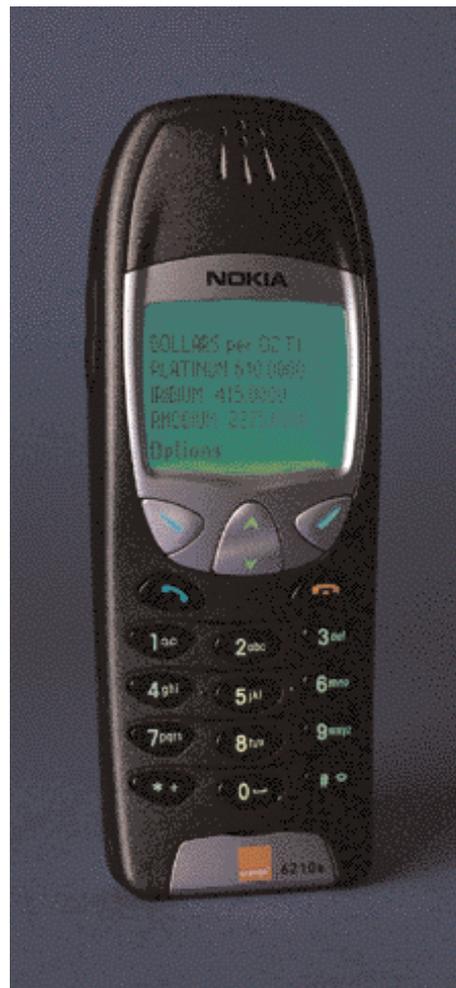
In Europe, the Stage III EU legislation came into effect for all new models from January 2000; while, in Japan, the introduction of Japanese Low Emission Regulations (JLEV) commenced in October

2000. In the USA, the proportion of vehicles sold meeting LEV standards increased significantly and a small number were sold complying with the even more demanding ULEV limits. In all three regions the new regulations restrict the emissions of unburned hydrocarbons (HC) severely and most auto makers have adopted catalysts with heavier loadings of palladium to meet these standards.

Demand for palladium in the electronics industry recovered to exceed 2 million oz again in 2000. At first sight this was a surprising result as the electronics industry has been working hard to substitute palladium with base metals in the largest electronics application – multi layer ceramic capacitors (MLCC). Since base metals were first introduced in the mid 1990s the proportion of MLCC manufactured using palladium has steadily fallen and it declined from 62 to 46 per cent last year. However, the production of MLCC in 2000 rose by 47 per cent and to meet this demand all available capacity for manufacturing capacitors, both base metal and palladium, was required. As a result, demand for palladium in the electronics sector rose by 8 per cent to 2.14 million oz.

The steady increase in the penetration of base metal technology across the full range of capacitor manufacture, and the construction of more factories capable of manufacturing MLCC with base metal electrodes, makes palladium demand in this market particularly vulnerable to a future downturn in production activity. The electronics industry is notoriously cyclical and statistics on the production and sales of electronics goods in early 2001 indicate that this year is likely to see sharply reduced activity; this could in turn result in a substantial decline in palladium offtake by the industry.

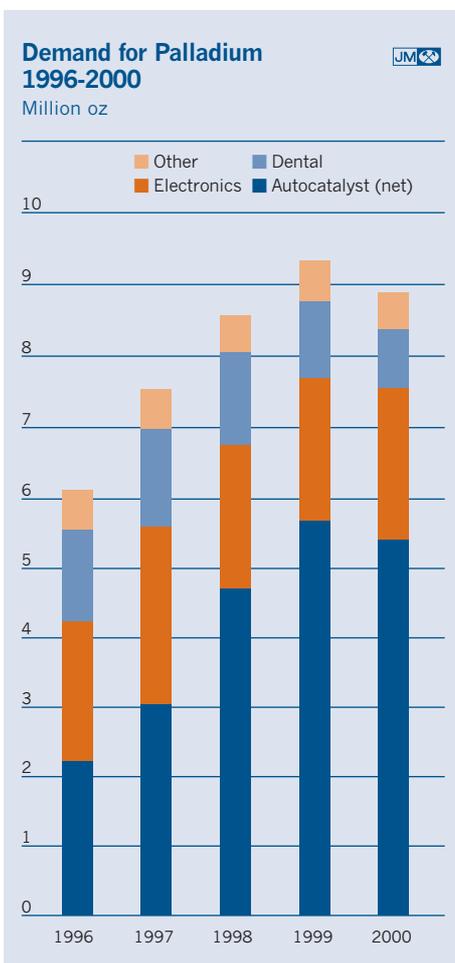
The dental sector experienced a 26 per cent decline in palladium consumption in 2000 to 820,000 oz and a further fall can be expected this year. Palladium



*Palladium demand benefited from strong sales of mobile phones in 2000*

alloys first became popular in Europe and the USA in place of higher priced gold materials but the price relationships have significantly altered in the last 2-3 years with the result that the use of palladium has begun to decline sharply.

In Japan, a government-backed health insurance scheme supports the use of a dental alloy containing 20 per cent palladium. In response to the increasing palladium price, the system was altered in April 2000 to allow for half yearly adjustments to the level of subsidy paid, to reflect actual precious metal prices over the preceding six months. However, at times when prices are rising, as happened for much of last year, the new system can still result in the cost of materials exceeding the government subsidy; this has caused some alloy manufacturers to switch to alternative materials.



Demand for palladium in other applications fell by 11 per cent last year to 520,000 oz. There was a 15 per cent decline in the jewellery sector as manufacturers strove to reduce the palladium content of both platinum and white gold alloys. In the petroleum industry demand fell even more sharply as the use of palladium in hydrocracking catalysts was superseded by base metal alternatives. Partly offsetting declines in these two sectors was an increase in demand from the chemical industry for a palladium catalyst used to make vinyl acetate monomer.

## Outlook

During 2000 the rising price of palladium began to have a negative impact on demand for the metal. Substitution with other metals gained ground in the electronics and dental sectors in particular and many auto companies stated publicly their desire to reduce their dependence on the metal. The rate at which this substitution proceeds will have a major impact on the long term outlook for the palladium market.

Once the largest application for palla-

dium, the electronics sector showed a somewhat surprising increase in demand in 2000 despite a further loss in market share for palladium in MLCC production. With signs that the electronics goods market has encountered one of its cyclical downturns, component manufacturers are cutting back production. It therefore seems likely that demand for palladium from this sector will fall sharply in 2001.

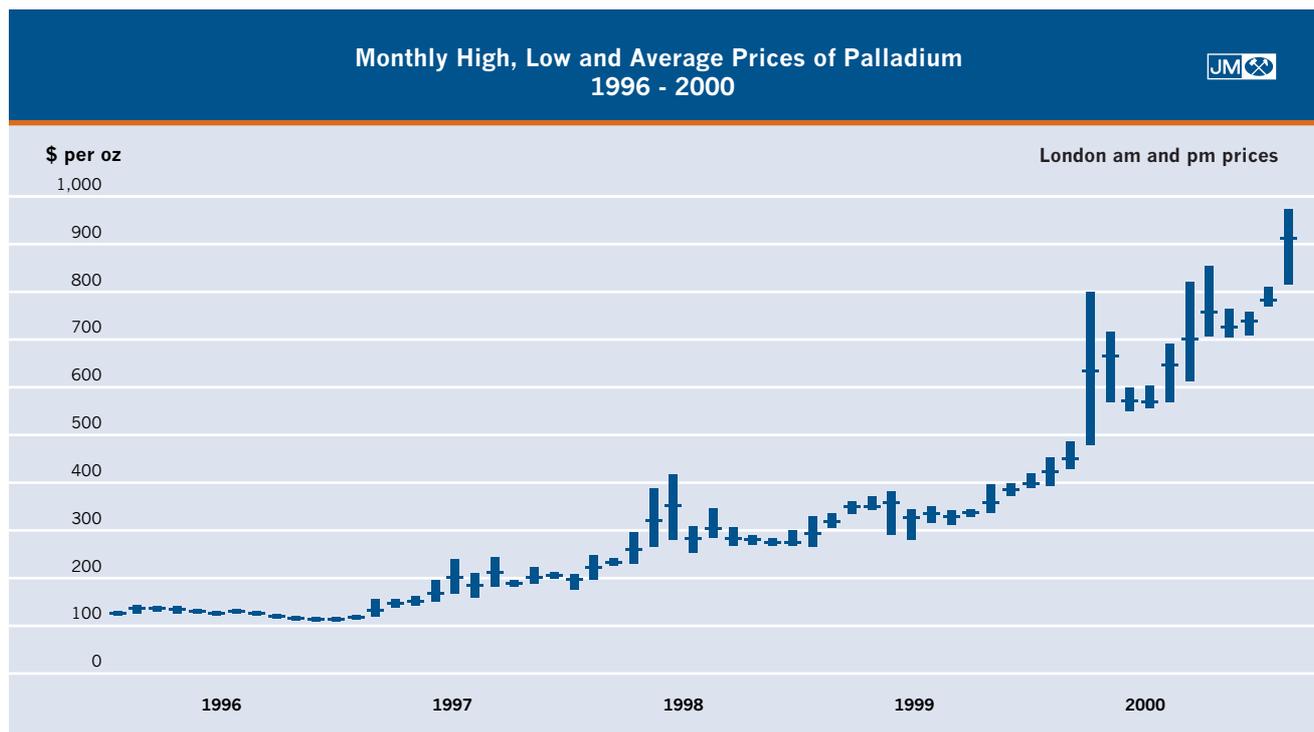
Last year saw a 21 per cent fall in the use of palladium in other non-automotive applications. A further decline is to be expected in 2001, although possibly not as steep as last year as those uses that are most price sensitive have already seen significant substitution of palladium.

Supplies from western mines are expected to increase, as expansions in South African and North American mines come on stream. Sales of palladium by the DLA in the first three months of 2001 were 180,100 oz and exhausted its plan for fiscal year 2001, leaving its residual stockpile at 542,000 oz. The DLA plans to sell a further 300,000 oz in the fiscal year starting October 2001.

The total level of supplies in 2001 will, as ever, depend primarily on the

level of Russian sales. Norilsk Nickel is believed to be supplying palladium steadily from its ten-year quota for sales of palladium, but uncertainties about the ultimate level of sales from government controlled stocks have again been a major feature in the first quarter of 2001. This helped drive the price to \$1,094 in January and then, after extra Russian metal appeared on the market in March, back down below \$700.

The decline in price since the high of January may help to slow down the move away from palladium in some sectors, but it seems certain that much of the substitution now underway is irreversible. At the same time as demand is falling, production at western mines is accelerating. The substantial gap between consumption and fresh production that has existed for the past five years is therefore likely to close. However, the market still needs extra supplies from Russian government stocks and remains highly susceptible to changes in Russian sales policy. That policy is difficult to predict, but if sales are steady we expect the price to trade in the \$550 to \$750 range for the next six months.





# Supplies, Mining and Exploration

## South Africa

Supplies of platinum from South Africa fell by 100,000 oz to 3.8 million oz in 2000. The decline was mainly due to operational problems caused by heavy rainfall in February and March, and a strike at Anglo Platinum, factors which more than offset additional output from expansion projects. Sales of palladium were down slightly, at 1.86 million oz, but rhodium shipments rose by 47,000 oz to 457,000 oz, due to additional mining of UG2 ore and sales from stocks.

Although the South African platinum industry enjoyed record profits in 2000, the two largest producers had a disappointing year in terms of pgm production. Exceptionally heavy rainfall in early 2000 had a serious impact on operations at both Anglo Platinum and Impala, while the former also lost production later in the year due to a strike.

In contrast, Lonmin increased pgm production, as record milling rates offset a decline in pgm yields. Refined output at Northam was stable, while new producer Kroondal made its first significant contribution to pgm supplies.

A substantial increase in South African supplies of pgm can be expected during 2001. At Anglo Platinum, expansions at Bafokeng Rasimone, Middelpunt Hill and Amandelbult are due to approach full capacity. Lonmin's output is forecast to rise again, following the commissioning of new UG2 processing plant, while Kroondal is upgrading its concentrator. Refined production from UG2 mining will begin at Northam and at Impala's rehabilitated Crocodile River mine. Assuming that the industry encounters no serious

operational or labour problems, platinum output should breach the 4 million oz barrier for the first time.

Beyond 2001, a major expansion of platinum mining in South Africa is in prospect. In May 2000, Anglo Platinum stated its intention to raise platinum capacity from about 2 million oz in 1999 to 3.5 million oz by 2006. New projects at Maandagshoek, Waterval and Union have already been confirmed, and further announcements are expected this year.

The company is also to participate in the Pandora joint venture with Lonmin, exploiting mineral rights adjacent to the latter's Eastern Platinum mine.

Other producers also have ambitious expansion plans. Lonmin announced in November 2000 that it had raised its expansion target to 870,000 oz of platinum by 2007. Impala has confirmed that it will proceed with the construction of a mine at Winnaarshoek, and is also re-evaluating the Kennedy's Vale project. Aquarius Platinum expects to start construction of a new mine at Marikana during 2001, and is undertaking a feasibility study of a project at Everest South (which it acquired from Impala last year). Finally, a new entrant, SouthernEra, is redeveloping the mothballed Messina mine, with the intent of starting production on a limited scale from August 2001. Assuming that pgm prices remain strong, and that none of these projects encounters serious technical difficulties, South African platinum supplies could rise by over 2 million oz in the course of this decade.

## Anglo Platinum

At Anglo Platinum, total refined platinum output fell by 7 per cent to

### PGM Supplies: South Africa

'000 oz

	1999	2000
Platinum	3,900	3,800
Palladium	1,870	1,860
Rhodium	410	457



1.87 million oz in 2000. Early in the year, heavy rain caused flooding at some of the group's mines, while underground production was also hit by a four week strike during September and October. The company estimates that these problems resulted in the loss of around 120,000 oz of platinum.

Platinum output was also affected by a 6 per cent decline in the head grade, to 5.05 grams per tonne. This decrease was largely due to the processing of lower-grade ore during the build-up in production at expansion projects at Bafokeng Rasimone, Middelpunt Hill and Amandelbult. Higher throughput of UG2 at some of the group's mines also had an impact on grade; at Anglo Platinum's existing mines, this ore type generally has a lower pgm content than Merensky Reef.

Palladium production fell in line with that of platinum, down 7 per cent to 947,000 oz. However, rhodium output fell by less than 4 per cent, to 165,000 oz, largely because of the higher rhodium content of UG2 ore - typically over 10 per cent of the total pgm, compared with less than 5 per cent in the Merensky Reef.

During 2000 and early 2001, Anglo Platinum announced a number of new expansions. On the Eastern limb of the



*The mill at Barplats' recently reopened Crocodile River mine*

Bushveld Complex, a new UG2 mine is to be constructed at Maandagshoek; shaft sinking commenced in March this year and mining is expected to begin in early 2002. At full capacity, this operation will produce around 162,000 oz of platinum annually. On the Western Bushveld, an expansion at Rustenburg Section is planned to add 395,000 oz of platinum per annum, with production starting in 2002. This project involves the construction of a concentrator to process UG2 ore from new decline shafts on the farm Waterval as well as from existing Rustenburg shafts. There will also be an expansion of UG2 mining at Union Section, which is expected to contribute 94,000 oz of platinum annually from 2002.

Most recently, Anglo Platinum and Lonmin announced an agreement to establish a joint venture covering lease areas adjacent to the latter's Eastern Platinum mine. At full production, which will be attained in around six years, the new Pandora mine will process 3.6 million tonnes of ore yielding 250,000 oz of platinum annually.

A proposed joint venture with Kroondal Platinum was to have added a further 200,000 oz of platinum output. However, the project collapsed in February 2001 after failing to receive the approval of the boards of Kroondal and its majority shareholder, Aquarius Platinum.

In order to provide sufficient processing capacity for its expansion programme, in February 2001 Anglo Platinum announced plans to build a new smelter complex at Pietersburg on the Eastern Bushveld. Furnace matte from the new smelter will be transported to Rustenburg for further treatment. As pgm output builds up, the group is also expected to undertake some debottlenecking at its Rustenburg refineries.

Together with projects already underway, the new expansions described above will raise annual platinum production capacity at Anglo Platinum to nearly 3 million oz. Further capacity increases are expected to be announced during 2001, in order to meet the group's objective of raising platinum output to 3.5 million oz per annum by 2006.

## Impala Platinum

Refined platinum output from Impala's mines fell last year by 7 per cent to 1 million oz, affected by a decline in mill throughput, lower head grades and a drop in recoveries. Palladium production was down 10 per cent at 471,000 oz, while that of rhodium (which was unusually high in 1999 due to the processing of residues) decreased by 16 per cent to 159,000 oz.

Heavy rains in early 2000 caused serious operational problems at the

concentrators, and led to the build up of a large stockpile of unprocessed ore. Attempts to work off this backlog during the second half of the year were halted because the increased milling rate caused a significant reduction in recoveries; Impala now intends to process this material once an upgrade of its UG2 concentrator has been completed. The expanded UG2 plant was due to be commissioned in March 2001, and processing of the stockpile should therefore add to production this year.

Over the last four years, platinum production from Impala's existing mines in the Rustenburg area has varied between 1 and 1.075 million oz per annum, and output is unlikely to change significantly in the future. However, the company has expansion prospects elsewhere in South Africa. In June 2000, it was announced that Impala was to acquire 100 per cent of the shares in Canadian company Platexco, owner of the Winnarshoek project on the Eastern Bushveld. The transaction was finalised in December, and development of a new underground mine is expected to commence by the beginning of 2002. Platinum output is planned to be nearly 200,000 oz per annum at full capacity. Impala may initially mine shallow UG2 ore from open pits in order to accelerate the start up of production.

A second, smaller project is already underway at Crocodile River. In February 2000, the board of Barplats (in which Impala has an 85 per cent stake) decided to reopen the mine, which has been mothballed since 1991. Opencast mining at the Maroelabult section began in December 2000, in preparation for the start of milling at the refurbished concentrator a month later. At full production, the plant will process 75,000 tonnes of ore per month, yielding 50,000 oz of platinum annually.

Impala has a third potential expansion at Barplats' Kennedy's Vale mine, though this project is still in its

early stages. A drilling programme is underway in order to provide more detailed information about the orebody; if the results are positive, a full feasibility study will be undertaken.

## Lonmin Platinum

Lonmin's platinum output rose by 8 per cent to 660,000 oz in the financial year to September 2000, while that of palladium and rhodium rose by 4 per cent to 293,000 oz and 89,000 oz respectively. A strategy of maintaining substantial surface stockpiles of ore enabled the company to maximise capacity utilisation at the concentrators, leading to a 7 per cent increase in mill throughput. This more than offset a slight decline in the yield of pgm into matte.

Output is expected to rise again this year, with the build up in production from two new shafts: the Newman incline at Eastern Platinum, and a converted ventilation shaft at Karee. Ore from these projects will be concentrated at a new UG2 circuit (the Karee B-Stream), which was commissioned in January 2001. A bottleneck in smelter capacity will be addressed with the start up of a new furnace, planned for October 2001.

During 2000, Lonmin announced that it had raised its expansion target to 870,000 oz of platinum per annum by 2007. Two more vertical shafts are being developed in order to provide access to deeper ore reserves, which will be required during the later stages of the expansion programme. Development of Eastern Platinum's Saffy shaft began last year, while construction of the Wilkinson shaft at Karee got underway in early 2001; both are expected to enter production around 2006. By then, Lonmin will need to have invested in additional concentrating and refining capacity.

Lonmin is also to participate in a joint venture with Anglo Platinum to exploit mineral rights adjacent to its existing Eastern Platinum mine. The project will be managed by Lonmin and

the pgm output split equally between the partners. Further details are provided in the section on Anglo Platinum on page 14.

## Northam Platinum

Northam's refined platinum output was stable in 2000, at around 190,000 oz, as a reduction in the refining pipeline offset declines in both milled tonnage and head grade. Production of palladium and rhodium was also little changed, at around 90,000 oz and 16,000 oz respectively.

Last year's mill throughput was affected by a shortage of developed ore reserves. The Merensky Reef in the upper areas of the mine had been largely mined out, while development at deeper levels had been restricted due to earlier cash shortages. During 2000, Northam's revitalised financial situation permitted a significant increase in the rate of underground development - essential to maintain platinum output from the Merensky Reef. The company has completed a decline system to access Merensky ore from the new 15 level, and has started to extend mining infrastructure into adjoining lease areas acquired from Anglo Platinum in January last year. As a result of this transaction, Anglo Platinum now has a shareholding of around 22.5 per cent in Northam.

In January 2000, Northam

announced plans to expand total pgm production by mining significant quantities of UG2 reef for the first time. A new UG2 concentrator was commissioned at the start of 2001, and the mill reached its design throughput of 75,000 tonnes of ore per month in February. The project is expected to add approximately 50,000 oz of platinum to Northam's annual output.

## Aquarius Platinum

In 2000, the Kroondal Platinum mine (in which Aquarius holds an 86 per cent share) produced 124,000 oz of pgm in concentrate, up from around 25,000 oz the previous year. During the year, mill throughput built up to planned levels, while grades and recoveries improved as a higher proportion of ore was drawn from underground. However, Kroondal has yet to reach its target production rate of 100,000 oz of platinum per annum, mainly because the head grade of underground ore has been lower than expected.

In August 2000, Kroondal Platinum announced plans to set up a joint venture with Anglo Platinum, with the aim of trebling the mine's platinum production to 300,000 oz. The ore reserves for the expansion project were to have been contributed by Anglo, which owns adjacent mineral rights. However, the project failed to receive the final approval



Shallow UG2 ore is mined from this decline shaft at Kroondal Platinum

of the Kroondal and Aquarius boards, and the agreement lapsed at the beginning of February 2001.

Kroondal now intends to pursue a more modest expansion on its own. The concentrator is being upgraded by installing a regrind mill and additional flotation cells, with the aim of increasing capacity and improving recoveries. The new plant will be commissioned by mid 2001, and will add about 50,000 oz of platinum to Kroondal's annual capacity. As a result, the mine's life will be reduced to around eight years, compared with 13 years at the original production rate.

Aquarius has a second pgm project at Marikana, where construction is scheduled to begin in the first half of 2001 and open-cast mining of UG2 ore about a year later. At full production, annual output is forecast to average 94,000 oz of platinum, 48,000 oz of palladium and 17,000 oz of rhodium.

In July 2000, Aquarius acquired three Eastern Bushveld properties from Impala: Everest South, Chieftain's Plain and a portion of Everest North. A feasibility study is currently underway at Everest South, which will involve the sinking of a trial shaft in order to assess the structure of the orebody and extract a bulk sample of ore. The results of this study are due early in 2002.

## Messina Platinum

The Messina Platinum project, located on the northern edge of the Eastern Bushveld, is being redeveloped by the Canadian company SouthernEra. The latter acquired Impala's 54 per cent stake in the project in 1999, and since then has increased its interest to over 70 per cent.

In February 2000, SouthernEra completed a feasibility study based on a mine producing around 160,000 oz of pgm per annum. Rehabilitation of the Voorspoed shaft began in mid year, and during the final quarter the company took a bulk ore sample and began trial mining in order to verify the feasibility

study assumptions.

Full-scale production at Messina is expected to commence in 2005. In the meantime, the company intends to build a small concentrator that will treat around 20,000 tonnes of ore per month, starting in August 2001. This is planned to yield just under 50,000 oz of combined pgm and gold per annum.

## Russia

Russian sales of platinum and rhodium increased sharply in 2000 following the resolution of the Clause 19 issues that had prevented exports for much of the previous year. Sales of palladium had been less affected in 1999 as the primary producer Norilsk Nickel had been given a ten year quota and export licence for its production. With Norilsk exporting steadily, the major uncertainty for Russian palladium supplies during most of 2000 was the level of shipments from the stocks controlled by the government.

Early in January 2000 Vladimir Putin, then acting president of Russia, signed an amendment to Clause 19 of the 1999 budget bill removing the restriction on exports of platinum that had been imposed by the Duma in December 1998. However, it was not until March that export quotas for 2000 were signed and not until May that exports of platinum from Russia began to flow.

Throughout the year there were conflicting indications about Russian intentions on platinum sales, with the State treasury Gokhran indicating that it did not intend to sell any platinum in 2000. The major producer Norilsk Nickel had not been able to sell all its 1999 production due to Clause 19, and therefore had reserves on which to draw, though it seems unlikely that it would have been granted an export quota for more than its annual production.

The smaller, alluvial producers of the Far East of Russia, Kondyor and Koryak,

applied for export quotas for their platinum but were not granted them in 2000. Both were reluctant to sell to Gokhran or the Central Bank at internal prices that were set substantially below the level of the free market. However, Vneshtorgbank was granted a platinum export quota for the first time and is reported to have bought metal from the Amur artel that controls the Kondyor mine, before exporting via Almaz, the only body officially permitted to export pgm from Russia. It is believed that Koryak may have sold some metal to Gokhran and kept some in stock.

Norilsk is the only primary producer of palladium and in March 1999 a decree signed by President Yeltsin gave the company the right to export its output for a period of ten years. This long term arrangement is believed to have influenced the way in which Norilsk sells its metal, with more palladium being sold on long term contracts to western consumers and less being sold on a spot basis directly into the market. As a result, although several Norilsk spokesmen confirmed that the company was exporting palladium steadily throughout the year, the impression was gained in the market that only limited quantities of metal were being sold.

Even more uncertainty surrounded sales of palladium from government controlled stocks. From the middle of the 1990s the substantial growth in world demand for palladium has been satisfied in no small part by sales of stocks held by

### PGM Supplies: Russia '000 oz

	1999	2000
Platinum	540	1,100
Palladium	5,400	5,200
Rhodium	65	290



either the Russian Ministry of Finance or the Central Bank of Russia. It is estimated that about half of the 29 million oz of palladium exported by Russia in the period from 1994 to 1999 came from these reserves. The exact holdings by these two bodies remains a secret under Russian law but there is much anecdotal evidence of a struggle between the Central Bank and Ministry of Finance for control of the stocks. It is believed that in the mid 1990s the Central Bank acquired much of the metal from the Ministry, but it appears that under the new Putin administration control of most of the metal has shifted back to the Ministry of Finance.

With its revenues boosted by high palladium and nickel prices, Norilsk was able to move forward with the \$5.5 billion ten year investment programme announced in April 1999. A major refurbishment of the Talnakh concentrator was completed with the commissioning in July last year of new flotation cells designed to improve efficiencies and increase the proportion of massive sulphide ore mined at the Talnakh shafts that can be treated locally rather than being transported to the older Norilsk concentrator. In October a plan to reconstruct the Norilsk concentrator, which dates back to 1948, was announced.

There is evidence that in the mid 1990s Norilsk Nickel was contemplating closing mining operations at the Medvezhiy Ruchey open pit of the original Norilsk-1 mining area, and perhaps also at the adjacent Zapolyarniy underground mine. Revenues from base metals were falling as most of the massive ores at these operations had been mined out many years earlier and grades of nickel and copper of the remaining disseminated ores were significantly lower than at the newer Talnakh mines. However, the rising prices of palladium and platinum have had a material impact on revenues from the Norilsk-1 operations, and it is now believed that Norilsk plans to expand mining here.



Aerial view of North American Palladium's open pit operations

## North America

Supplies of platinum and palladium from North America were up slightly at 285,000 oz and 635,000 oz respectively in 2000. Stillwater and North American Palladium recorded increases in production, but these gains were partly offset by lower output from Falconbridge, which suffered a prolonged strike at its Sudbury operations.

## Canada

Nickel production at Inco rose by 10 per cent to 199,000 tonnes in 2000. However, this had little impact on pgm output because the increase came mainly from the company's Manitoba division, where the pgm content of the ore is low, and from its Indonesian operation, PT Inco, where the ore does not contain pgm. Although the company reported further improvements in grade at its Sudbury operations, this was not reflected in pgm deliveries, which were down slightly at 342,000 oz.

In January 2001, Inco stated that it expects pgm production to rise by more than 20 per cent this year. We believe that part of this increase will come from the Copper Cliff North mine, where Inco has begun to extract a small deposit with a grade of over 16 grams of pgm per tonne. This is exceptionally rich in

comparison with typical Sudbury ores, which are believed to average less than 2 grams per tonne.

At Falconbridge, nickel and pgm output fell sharply in 2000. Industrial action at the company's Sudbury operations began in August, reducing mine output to about 20 per cent of normal levels. This was partly offset by expansion at the Raglan mine in northern Quebec, which achieved its design milling rate of 1 million tonnes per annum during the second half of 2000. Nevertheless, Falconbridge reported a 16 per cent decline in total nickel production from Canadian ores. The strike at Sudbury continued until late February 2001, and will have a significant impact on pgm output this year.

Production of pgm by Falconbridge was also affected by metallurgical difficulties, leading to a build-up in stocks of

PGM Supplies: North America '000 oz		
	1999	2000
Platinum	270	285
Palladium	630	635
Rhodium	18	16



unrefined metal. These problems were resolved towards the end of 2000, and release of metal from the refining pipeline should partly offset the effects of the strike this year.

The North American Palladium mine at Lac des Iles produced around 95,000 oz of palladium last year, up nearly 50 per cent compared with 1999. Although mill throughput was virtually unchanged at around 893,000 tonnes, the average pgm content improved significantly as the mine exploited a zone of higher-grade ore. Recoveries were also up on the previous year.

The company is currently undertaking an ambitious expansion programme which is planned to raise annual palladium output to at least 250,000 oz. Further details are given in a special feature on page 19.

## United States of America

Expansion at Stillwater's Nye mine remains seriously behind schedule, and the mine is not expected to reach its design capacity of 3,000 tons per day for several years. In 2000, the milling rate improved by 10 per cent to just over 2,000 tons per day, but this gain was offset by a decline in head grade due to the processing of some lower-grade ores. As a result, pgm output increased by around 5 per cent to 350,000 oz of palladium and 100,000 oz of platinum. Stillwater expects to achieve a milling rate of 2,500 tons per day in 2001, with pgm production rising to approximately 500,000 oz.

The company is constructing a second pgm mine at East Boulder, about 18 miles from Nye, which is planned to produce more than 400,000 oz of pgm. Commissioning of a new concentrator started in late 2000, while development of mineable ore reserves is due to get underway this year. Further details of Stillwater's expansions can be found on page 20.

## Exploration in North America

In the last two to three years, high palladium prices have triggered a surge of exploration for pgm in North America. Much of the exploration activity is concentrated in areas where pgm are already mined - for example, there are currently dozens of exploration projects at various stages of development in the Sudbury area. Among these are two which involve major South African producers: Impala has an agreement with Mustang Minerals, while Anglo Platinum is funding exploration by Pacific North West Capital. Both joint ventures are investigating potential deposits of shallow, relatively low-grade ore in River Valley area, about 50 kilometres east of the Sudbury nickel mines. These are probably the most advanced of the current wave of pgm exploration projects in North America.

Other sites of intensive exploration in North America include the Lac des Iles area in Ontario, close to the existing North American Palladium mine, and the Duluth Complex in northern Minnesota, which has long been known to host pgm. There are many other areas of activity, from Alaska in the far north to Nevada in the southern USA. However, most of the North American exploration projects are at a very early stage, and even the most advanced are still several years away from any possibility of commercial production.

## Zimbabwe

Following the closure of Hartley Platinum in June 1999, Zimbabwe's only primary pgm production comes from the small Mimosa mine. Platinum supplies from Zimbabwe fell by 65,000 oz to around 15,000 oz in 2000.

The Mimosa mine, located close to Zvishavane in the south of Zimbabwe, is currently the country's only primary pgm producer. It is a small-scale operation,

with an annual mill feed of some 300,000 tonnes of ore yielding around 15,000 oz of platinum. In January 2000, it was announced that Anglo American was to acquire Mimosa as part of a buy-out of its parent company, Zimasco, but this deal has since fallen through. It remains possible that one of South Africa's platinum producers will purchase Mimosa.

In the past, mining investment in Zimbabwe has often been deterred by political and economic instability, combined with unfavourable fiscal and foreign exchange regimes. This year, there is the prospect of a new framework for investment in platinum mining, with the government expected to relax foreign exchange restrictions and reduce the tax rate on platinum operations.

In March 2001, this improved climate for investment was reflected in the announcement that funding had been obtained for the development of Zimplats' Ngezi open-cast mine. Impala is to pay \$50 million to acquire a 50 per cent stake in the project, with the remainder of the estimated \$50 million capital requirement being provided by debt finance. In addition, Impala and South African bank ABSA have spent \$16 million on purchasing a 50 per cent stake in Zimplats (which is listed on the Australian Stock Exchange) from its former majority shareholder, Delta Gold. Production at Ngezi is planned to start during 2002; further details of the project are provided in the special feature on page 21.

### PGM Supplies: Zimbabwe & Others '000 oz

	1999	2000
Platinum	160	105
Palladium	160	95
Rhodium	8	3



## The outlook for PGM supplies:

### New mines and expansions in North America and Zimbabwe

While there is no question that South Africa and, to a lesser extent, Russia will continue to dominate world pgm production for the foreseeable future, high prices are encouraging the development of pgm mining in other countries. Expansions are currently underway at North America's two primary pgm producers, North American Palladium and Stillwater, while the possibility of significant pgm production in Zimbabwe has been revived with the recent announcement of funding for Zimplats' Ngezi project. New mines and expansions in Canada, the USA and Zimbabwe could add over 800,000 oz of palladium and 350,000 oz of platinum to annual pgm production by the middle of this decade.

### Canada

In Canada, pgm have traditionally been produced as by-products of nickel and copper mining by Inco and Falconbridge. As recently as the 1940s, the nickel deposits of the Sudbury Basin were the world's largest single source of pgm, and these deposits still produce substantial amounts of metal – around 550,000 oz of platinum, palladium and rhodium in 2000. Palladium

typically accounts for 55-60 per cent of the pgm content of the Sudbury ores, with the remainder mainly platinum; the rhodium content is small.

Since the mid 1990s, fluctuations in nickel and copper prices have encouraged some rationalisation of mining at Sudbury, leading to the closure of several of Inco's lower-grade, higher-cost mines. However, this has had little impact on pgm output because the focus has shifted to mining areas of higher grade ore.

High pgm prices are likely to result in some increases in pgm output in future. In January 2001, Inco announced that it had discovered several zones of pgm-rich ore in the Sudbury region that could be mined from existing mining infrastructure. It has already started mining a small deposit at the Copper Cliff North Mine, which is reported to contain 500,000 tonnes of ore with an exceptionally high grade of over 16 grams of pgm per tonne. Other discoveries include those at Totten and Kelly Lake, where pgm grades are estimated to be 4.8 and 3.6 grams per tonne respectively.

Another significant source of by-product pgm is Falconbridge's Raglan mine on the Ungava peninsula in the far north of Quebec. An expansion was completed last year, and should lead to higher output from Raglan in 2001. The processing pipeline for Raglan's ores is particularly long, because concentrate from the mine has to be transported by ship from the remote mine site to the company's smelter at Sudbury; the pgm are then sent for refining in Norway. The palladium:platinum ratio in Raglan's ore is thought to be about 3:1.



It was not until 1993 that primary pgm production began in Canada on a significant scale, at the Lac des Iles operation now owned by North American Palladium. This is essentially a palladium mine: the ore contains only around one ounce of platinum for every ten ounces of palladium, while the rhodium content is negligible. The Lac des Iles deposit is one of several pgm occurrences in the area, and further exploration is being carried out by North American Palladium and other companies.

Although the average grade at Lac des Iles is relatively low, at less than 2 grams per tonne, the pgm are not confined to a narrow reef but occur throughout extensive areas of mineralisation. For example, the Roby Zone (the source of current production) is about one kilometre long, 815 metres wide and at least 650 metres deep. This makes it possible to mine the deposit using low-cost, open-cast, bulk mining techniques.

North American Palladium produced 95,000 oz of palladium last year, and is currently undertaking an expansion that is planned to take output to an average of 250,000 oz per annum. Initially, in 2002 and 2003, output is planned to be even higher as the mine will exploit a relatively rich zone of ore. Development of a new open pit commenced in mid 2000; ore has been stockpiled ahead of the commissioning of a 15,000 tonne per day mill, which is expected to start operations during the second quarter of 2001.

## USA

The USA has only one primary pgm producer, the Stillwater Mining Company, which operates a mine at Nye in Montana. Stillwater exploits a pgm-bearing layer

known as the J-M (Johns-Manville) reef, which is probably the richest deposit currently being exploited anywhere in the world. The mill head grade is typically between 0.65 and 0.7 oz per ton (equivalent to 22-24 grams per tonne), with a palladium:platinum ratio of just over 3:1.

Mining the J-M reef is challenging, because it dips steeply and has been partly eroded so that areas of high-grade ore are not continuous. This has made it difficult to mine large quantities of ore and, despite an ambitious expansion programme, mill throughput at Nye remains relatively modest – just under 700,000 tons in 2000, yielding 430,000 oz of pgm. Although last year saw an acceleration of underground development and the commissioning of additional ore conveying capacity, it is expected to take several years for the operation to reach its design rate of 3,000 tons per day. In September 2000, Stillwater announced a three year operating plan under which mill throughput at Nye will gradually increase to 2,800 tons per day by 2003. Refined pgm output is planned to rise from around 500,000 oz in 2001 to 665,000 oz in 2003.

Stillwater is also constructing a second pgm mine at East Boulder, about 18 miles from Nye. Last year, two tunnel-boring machines intersected the pgm-bearing J-M reef, and during the fourth quarter an initial drilling programme was undertaken in order to provide further information about the orebody. Construction of underground infrastructure is underway, and during 2001 the company plans to begin developing mineable ore reserves. At full production of 2,000 tons of ore per day, East Boulder should produce more than 400,000 oz of pgm annually.



*Surface infrastructure at Stillwater's East Boulder project*



## Zimbabwe

Zimbabwe's Great Dyke has long been seen as a significant potential source of pgm but over the years a series of trial mines and one large project have all closed, leaving the small Mimosa mine as Zimbabwe's only primary pgm producer. The Hartley Platinum mine, which closed in June 1999, was the victim of unexpected geological problems and low mining productivity.

The Great Dyke is a geological feature running through the heart of Zimbabwe for about 550 kilometres in a roughly north-south direction. The pgm occur in a layer known as the Main Sulphide Zone, which is typically about 3 metres thick. However, the economic mining width may be as little as one metre, depending on grade, metal prices and the chosen mining method. The pgm content is lower than that of South African ores, with head grades generally below 4 grams per tonne, of which about 55 per cent is platinum. The reef can be difficult to mine, because it is not visible to the naked eye; this can lead to off-reef mining, which reduces head grades because of the dilution of ore with waste rock.

Although the political situation in Zimbabwe is delicate, the government has proposed a new, more favourable tax regime for platinum mines, intended to provide the stimulus for fresh investment. Zimplats recently announced that it had raised the necessary funds for the development of its Ngezi open-pit mine, with Impala Platinum injecting \$50 million and taking a 30 per cent stake in the project. The remainder of the

estimated \$50 million capital requirement has been raised through debt financing. Production at Ngezi is planned to start during 2002, with ore being trucked for processing at the Hartley concentrator and smelter (now known as the Selous Metallurgical Complex), which Zimplats acquired following the mine's closure in 1999. The resulting matte will be refined by Impala Refining Services. Annual production is planned to be around 98,000 oz of platinum, 85,000 oz of palladium and 8,000 oz of rhodium.

There is also the possibility of a modest expansion at Mimosa which is owned by the local chrome mining company, Zimasco. An expansion that would treble platinum output has been under consideration for several years, but is unlikely to proceed until Mimosa gains access to outside investment. Although a proposed acquisition of Zimasco by Anglo American collapsed in 2000, it is possible that one of South Africa's platinum producers will purchase Mimosa and fund an increase in output.

A third potential site of pgm production is Anglo American's Unki project, at Shurugwi in central Zimbabwe. The development of a new mine, producing around 120,000 oz of pgm per annum, was announced in February 1998. Progress has since been stalled by political and economic problems, but the prospect of a new fiscal regime may lead to the reactivation of this project.



# Platinum

## Jewellery

After 16 years of continuous growth, demand for platinum in jewellery fell back 1 per cent in 2000, due to a sharp decline in the market in Japan. In contrast, consumption of platinum jewellery continued to grow elsewhere in the world, with demand in China exceeding 1 million oz for the first time. In the final quarter of the year, as the price of platinum rose over \$600, signs of price sensitivity began to appear in the low-value sector in all jewellery markets.

## Europe

In Europe, demand for platinum in jewellery continued to rise steadily, with fabrication up 15,000 oz to 200,000 oz in 2000. There was strong growth in platinum jewellery fabrication in the UK, and an increase in the use of platinum in watch-making in Switzerland. Fabrication in the two other major manufacturing nations, Italy and Germany, was little changed.

The export market has always been important for Italian jewellery makers and the strength of the US market in particular led to increased demand for platinum from Italy, notably for the manufacture of lightweight chain products. Domestic sales are traditionally more significant for German manufacturers; last year consumer confidence was low in Germany and retail sales of jewellery fell. As a result, despite some increase in exports of platinum products, especially rings, there was a small decline in platinum demand in Germany in 2000.

Growth in the UK market was reflected in a 28 per cent increase in the weight of platinum pieces submitted for hallmarking last year. Since 1994, manu-

facturers have enjoyed strong growth in demand for platinum jewellery from local consumers, and most production is for sale in the domestic market. Platinum has become established as a premium metal for bridal jewellery, which continues to account for virtually all fabrication demand. However, some retailers have recently started to offer non-bridal products, such as lightweight platinum chain imported from Italy, and this may encourage local manufacturers to expand their product ranges.

Platinum demand in Switzerland is heavily influenced by the fortunes of the premium watch sector. The market was depressed in 1998 and 1999 in the wake of the economic crisis in developing Asian nations, which affected demand for luxury goods from Europe. The situation improved sharply last year, in line with economic recovery in South East Asia, combined with growth in the US market. As a result, production of platinum watches in Switzerland rose by 43 per cent.

## Japan

Demand for platinum from the Japanese jewellery sector fell by 20 per cent to 1.06 million oz in 2000. The decline was mainly due to manufacturers meeting part of their platinum requirements by recycling old stocks of finished jewellery, thereby reducing their fresh purchases of platinum. We believe that high metal prices stimulated reductions in stocks held by wholesalers and retailers and also tempted some consumers to sell back unwanted jewellery items bought in earlier years.

Although retail sales of platinum jewellery items increased during the first quarter, the market contracted from April

### Platinum Demand: Jewellery

'000 oz

	1999	2000
Europe	185	200
Japan	1,320	1,060
North America	330	380
Rest of the World	1,045	1,200
<b>Total</b>	<b>2,880</b>	<b>2,840</b>



onwards, as retailers and manufacturers adjusted their price tags in response to higher bullion prices. At the same time, the fragility of Japan's economy prompted consumers to reduce their spending on luxury products. Demand for fashion jewellery was most severely affected, with sales of neckchain, bracelets and earrings falling by at least 15 per cent. In contrast, there was growth in the bridal ring sector, largely due to a millennium-related boom in the number of marriages. For the year as a whole, unit sales of platinum jewellery fell by 4 per cent compared to 1999.

White metal jewellery remains extremely popular in Japan but, with the rise in bullion prices, it has become more difficult for platinum to compete in lower-price segments of the market. White gold and even silver have become increasingly acceptable to young consumers who desire white jewellery products but do not want to pay the premium for platinum. In addition, the attraction of other consumer products, such as the popular WAP phones with internet connections, may have drawn money away from the jewellery market.

Japan's economic situation worsened during the first quarter of 2001, and with platinum prices remaining high there seems little prospect of a recovery in demand this year. Although platinum remains firmly entrenched in higher-value segments of the market, especially bridal and diamond-set products, its share of the inexpensive fashion jewellery market is likely to be further eroded in 2001 and we expect retail sales to decline again this year. Purchases of platinum by jewellery manufacturers are, however, forecast to stabilise, due to a decrease in recycling as industry stocks of old jewellery become depleted.

## North America

Demand for platinum from US jewellery makers rose by 15 per cent to 380,000 oz in 2000. Sales of upmarket jewellery products were fuelled by strong economic growth, while the fashion trend towards white metal jewellery continued.

Platinum is firmly established in the bridal sector, and there was further growth in consumer demand for platinum wedding bands last year. US manufacturers continue to increase their ranges of platinum bridal jewellery, and some are now introducing very lightweight platinum rings in order to meet the price targets set by mass market retailers.

While demand remained concentrated in the bridal sector, the increasing popularity of white metal jewellery also helped to expand platinum's presence in the fashion jewellery market. A number of domestic manufacturers expanded production of pendants, mainly diamond-set, for use with lightweight platinum chain. Although US manufacture of chain is increasing, much of this product is still imported from Europe.

The outlook for 2001 is mixed. The deceleration of the US economy is expected to have a sharp impact on consumer spending on luxury items this year. At the same time, high bullion prices are likely to restrict manufacturers'

ability to offer inexpensive platinum jewellery, and may also encourage a shift to lighter-weight designs or to lower-priced white gold. On the other hand, we expect platinum to gain additional share in the bridal sector and to make further inroads into the market for upscale fashion jewellery. Demand for platinum jewellery fabrication is therefore expected to expand again, although the rate of growth is likely to be lower than in recent years.

## Rest of the World

Sales of platinum to Chinese jewellery makers rose by 16 per cent to 1.1 million oz in 2000, outstripping Japan for the first time. This figure was achieved despite a slowdown in platinum purchases towards the year end, when higher metal prices reduced manufacturers' profitability and tax inspections further inhibited their activity.

Demand for platinum was extremely strong, at both the manufacturing and retail levels, in the periods leading up to the Chinese New Year in February 2000 and the May holidays, two of the key jewellery seasons in China. However, as the year progressed, the price of platinum rose faster than retail jewellery prices and this began to squeeze manufacturing margins. By the fourth quarter margins

had been sufficiently eroded for many manufacturers to cut back production and retailers were forced to live off stocks. This situation was exacerbated by a series of government inspections to verify payment of sales taxes, which also interrupted production during the period.

Consumers' demand for white metal jewellery was maintained, with the most popular products being lightweight rings and pendant chains. As platinum has become less profitable some manufacturers have started to produce white gold jewellery in similar styles as cheaper substitutes. There has also been an increase in imports of white gold jewellery, principally lightweight chain from Italy.

Changes last year in the regulations covering the assay standards for jewellery alloys in China established that platinum alloys should contain not less than 95 per cent platinum plus palladium. With the current high price of palladium, this is likely to result in most alloys containing 95 per cent platinum; jewellery made from these alloys will be marked Pt950 rather than Pt900, as before. Although the regulation only came into effect in Shanghai in February 2001, and will apply later in other cities, manufacturers and retailers may have been reluctant to build stocks of products last year that would not meet the new standard.



*The hallmarking of platinum jewellery pieces continues to rise in the UK.*

An easing of platinum bullion prices and a gradual increase in retail jewellery prices, combined with the depletion of retail stocks during the Chinese New Year, led to a recovery in fabrication demand during the first quarter of 2001. If this level of activity were to be maintained, consumption of platinum in China this year would exceed that of 2000. Manufacturing profit margins will be the key factor, for there appears to be no slackening in consumer demand for platinum jewellery.

Fabrication in other Asian countries is largely for export to Japan, China and the USA, although there is a small domestic market for platinum jewellery in Taiwan. Excluding China, platinum demand in the Rest of the World was up slightly at 100,000 oz in 2000, with only India showing significant growth.

Jewellery manufacturers in India have long been established as important suppliers of gem-set gold jewellery to developed markets. The growing popularity of white metal jewellery, combined with the availability of a skilled and inexpensive workforce, has stimulated development of platinum fabrication over the last two to three years. Most production is rings, pendants and bracelets for export to the USA. Small amounts of platinum jewellery are also being bought by wealthy domestic consumers.

Elsewhere in Asia, platinum jewellery manufacturers have traditionally relied on Japan as their principal export market. The downturn in Japanese demand has therefore had a negative effect on fabrication, although the impact has been softened by increased exports to China and the USA.

## Autocatalyst

After three years of decline, demand for platinum in autocatalysts recovered by 14 per cent to total 1.84 million oz in 2000. In Europe, tighter emissions legislation stimulated a sharp rise in the use of platinum on

diesel vehicles, while Japanese auto makers began to switch from palladium to platinum on domestic gasoline models. There was also an increase in sales of platinum to car companies in North America, but this was mainly due to additional purchasing for stock; actual consumption on catalysts declined slightly.

## Europe

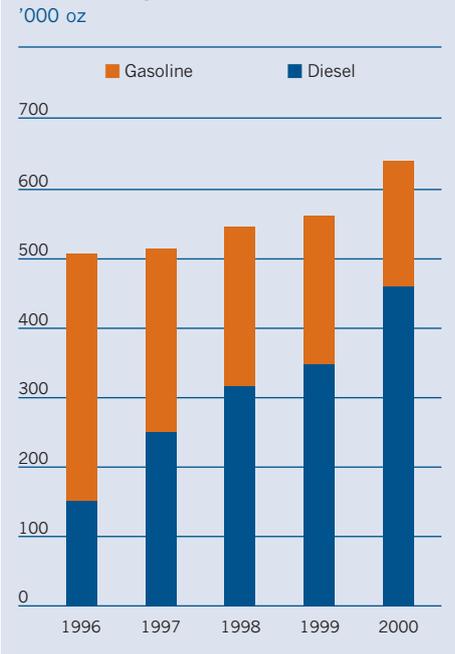
Sales of platinum to European auto makers rose by 80,000 oz to reach 640,000 oz in 2000, setting a new record for this region. A sharp increase in consumption of platinum in the diesel sector greatly outweighed a further switch to palladium-rich technology on gasoline cars.

While total passenger car sales in western Europe declined by 2 per cent last year, the diesel sector enjoyed strong consumer demand. High gasoline prices and improved engine technology helped to lift sales of fuel-efficient diesel vehicles by 14 per cent to take nearly a third of the total market. At the same time, there was a significant increase in average platinum loadings on diesel catalysts, following the imposition of Stage III EU emissions legislation on new models from January 2000. Together, these factors lifted total platinum consumption on diesel vehicles by around a third last year.

In contrast, use of platinum in the gasoline sector declined by around 20 per cent. Although high palladium prices have encouraged car companies to review their catalyst strategies, this had little impact on the pgm mix in 2000. The development and testing of new catalysts is a lengthy process, and manufacturers therefore continued to implement earlier plans to adopt palladium-rich catalysts on gasoline cars.

European demand for platinum is expected to rise strongly in 2001. In the gasoline sector, most auto makers intend to make greater use of platinum, and some will start to re-introduce platinum-rich technology this year. As a result, the

European Demand for Platinum in Autocatalysts 1996-2000



use of platinum on catalysts for gasoline vehicles will increase for the first time since 1995. There will also be a further increase in loadings on diesel catalysts, with Stage III legislation applying to all new vehicles from January 2001.

## Japan

Higher vehicle production, the introduction of stricter emissions legislation and changes in the pgm mix on autocatalysts contributed to an increase in sales of platinum to Japanese car companies last year. Demand rose by 40,000 oz to reach 290,000 oz, the highest level since 1994.

Despite weak economic conditions, the Japanese auto market made a modest recovery in 2000. Passenger car production rose by around 5 per cent, largely due to higher domestic sales. There was also a small increase in exports, with higher sales to North America and Asia offsetting a steep dip in shipments to Europe.

Japanese Low Emission Vehicle (JLEV) regulations came into force for new models from October 2000, and will apply to all new vehicles from 2002. In practice, most auto makers have moved



Growing markets for platinum: autocatalysts for heavy duty trucks (above) and motorcycles (below)

quickly to comply with the new legislation, and a significant proportion of cars sold in Japan last year met JLEV limits. The Japanese Environmental Agency has issued guidelines providing a framework for further reductions of between 25 and 75 per cent in NOx and HC emissions. Manufacturers are meeting these lower limits voluntarily on some domestic models.

Concerns about the price and availability of palladium have already begun to have an impact on the pgm mix in Japan. Where possible, car companies have chosen to increase platinum loadings in order to meet JLEV regulations. As a result, demand for platinum on domestic vehicles was up sharply last year and is expected to grow substantially in the next two to three years.

In contrast, the use of platinum on export models was little changed in 2000. Many of these vehicles, especially those sold in North America, carry highly-loaded, palladium-rich catalysts in order to meet strict HC emissions standards. While Japanese auto makers are expected to add some platinum to the catalyst systems used on exports, the change is likely to be less rapid and less

significant than on vehicles for sale in the domestic market.

## North America

Purchases of platinum by auto makers in North America rose by 85,000 oz to total 620,000 oz in 2000. This increase was mainly due to additions to stocks. Actual consumption in autocatalysts declined by around 4 per cent, following further adoption of palladium-rich technology on low emission vehicles.

Light duty vehicle sales rose by 3 per cent to 19 million units in 2000. However, production fell by 2 per cent due to a sharp increase in imports, which took 17 per cent of the North American market last year. The popularity of foreign-designed vehicles was also reflected in a higher market share for cars produced at US transplant factories owned by Japanese and European auto makers. Since these companies tend to make greater use of platinum-rhodium technology than their US competitors, this shift was positive for platinum demand.

The gradual tightening of emissions legislation continued to be the most important influence on pgm consumption. Last year, a large majority of vehicles sold in

the USA met LEV limits, with a smaller number attaining ULEV standards. Most models were fitted with highly-loaded, palladium-rich catalyst systems in order to meet LEV regulations, so this led to a small decline in total use of platinum and another jump in palladium consumption.

Soaring palladium prices have provided a strong incentive for manufacturers to reconsider their catalyst strategies. Those companies that had moved most heavily towards palladium have already begun to reintroduce platinum-rhodium technology in a limited number of applications, and this will have a positive impact on demand for platinum in 2001. Over the next few years, we expect all companies to increase the proportion of platinum in the pgm mix.

Tightening emissions legislation will also add to platinum demand over the next few years. In December 1999, the Environmental Protection Agency announced Tier 2 legislation, which will result in the gradual tightening of emissions limits between 2004 and 2009. Gasoline cars may be able to meet the stricter standards through the use of new, cleaner engines and more advanced catalyst systems without needing to add extra pgm. However, we expect this legislation to trigger the widespread use of catalysts on heavy duty vehicles for the first time; since many of these are diesel, this should make a significant contribution to platinum demand.

### Platinum Demand: Autocatalyst

'000 oz

	1999	2000
Europe	560	640
Japan	250	290
North America	535	620
Rest of the World	265	290
<b>Total</b>	<b>1,610</b>	<b>1,840</b>



## Rest of the World

In the Rest of the World, the use of platinum on autocatalysts reached 290,000 oz last year, an increase of 25,000 oz compared with 1999. This gain was mainly due to a substantial expansion of vehicle production in South America. Stricter emissions legislation in Korea, India and China also had a small impact on demand.

Brazil and Argentina enjoyed a strong recovery in vehicle production last year, following a slump in 1999. Platinum consumption also benefited from the introduction of new catalyst technology by some car companies. With no significant changes in emissions legislation on the horizon, manufacturers have been able to reduce average pgm loadings by upgrading to more advanced catalyst formulations. In some cases, they have also taken the opportunity to increase their use of platinum-based technology at the expense of palladium.

In contrast, Mexican demand for platinum declined last year, despite record vehicle output. Around three quarters of vehicles built in Mexico are for export, mainly to North America, and platinum consumption was affected by the adoption of palladium-based systems to meet US LEV standards.

There was a small increase in sales of platinum to Korean auto makers in 2000, following a revision of the Korean Clean Air Act and the implementation of tighter standards based on California's LEV legislation. The new regulations will be phased in over the period to 2005, and will make Korean emissions legislation among the strictest in the world. The main impact will be on palladium, although we also expect further modest increases in platinum demand.

In China, standards equivalent to European Stage I regulations were introduced during 2000, although in practice there is likely to be some delay in compliance, since unleaded fuel is not yet universally available. We estimate

that about half the new cars sold in China last year carried a pgm catalyst. Indian emissions regulations continued to tighten: new Bharat II limits, equivalent to EU Stage II, were introduced in seven cities during 2000 and will be extended to cover a wider area of the country this year. Indian manufacturers are generally adopting platinum-rich systems to meet the new limits.

## Autocatalyst Recovery

The recovery of platinum from scrapped autocatalysts rose by 50,000 oz to 470,000 oz last year. Most of this growth occurred in North America, where higher pgm prices encouraged an increase in the percentage of catalysts recovered from scrapped vehicles.

The USA has the world's most developed network for the recovery of pgm from spent autocatalysts, and the majority of scrap yards systematically remove catalytic converters from scrapped vehicles. However, until recently some smaller vehicle dismantlers considered it uneconomic to collect the catalyst. With the rise in pgm prices, many of these began to remove the catalytic converter for the first time in 2000, and this contributed to an increase in the amount of platinum recovered.

Most of the vehicles scrapped in the USA last year were built before the use of palladium technology became widespread, and therefore carried platinum-rich catalysts. Average platinum loadings on autocatalyst scrap increased again, reflecting changes in US Federal emissions legislation which took place in the early 1990s.

In Europe, there was modest growth in the recovery of platinum from spent autocatalysts. The collection of catalytic converters is still mainly confined to Germany and some northern European countries, but catalyst recycling networks are expected to develop across the region over the next few years. This will be encouraged by EU regulations which

### Platinum Demand: Autocatalyst Recovery '000 oz

	1999	2000
Europe	(30)	(40)
Japan	(60)	(60)
North America	(315)	(350)
Rest of the World	(15)	(20)
<b>Total</b>	<b>(420)</b>	<b>(470)</b>



state that by 2005 no less than 85 per cent of a car's weight must be recycled.

The recovery of pgm in Japan did not grow last year, with the gloomy economic outlook encouraging consumers to keep their vehicles longer before scrapping them. In the Rest of the World region, only small numbers of scrapped autocatalysts are collected, although the market is gradually developing, especially in countries such as Korea and Mexico, where catalyst-forcing legislation has been in place since 1991.

## Chemical

Demand for platinum from the chemical industry totalled 270,000 oz in 2000, a decline of 50,000 oz compared with the previous year. This fall was mainly due to lower sales of process catalysts used in the production of benzene and paraxylene. In the nitric acid sector, weak demand for nitrogen fertilisers led to a number of plant closures in the USA and Europe.

Following significant investment in paraxylene production in 1999, additions to capacity were more modest last year. This resulted in a significant decline in demand for platinum in process catalysts, especially in the Rest of the World region. Losses of platinum in this process are small, so demand occurs mainly when new plants are constructed.

In contrast, there was an increase in

## Platinum Demand: Chemical '000 oz

	1999	2000
Europe	80	85
Japan	20	20
North America	95	90
Rest of the World	125	75
<b>Total</b>	<b>320</b>	<b>270</b>



the use of platinum in catalysts for silicones production. These silicones are used mainly in the manufacture of pressure-release adhesives, and are also in increasing demand for a variety of construction and consumer applications, including waterproof sealants, speciality rubbers, and cosmetics such as lipstick. Since most of the platinum is lost in the production process, increasing output of silicones has been reflected in higher platinum consumption.

Sales of platinum to the nitric acid industry were weak last year. European producers were affected by reduced demand for fertilisers, due to an increase in the proportion of land set aside from agricultural production in 1999, and the availability of cheap imports. The resulting erosion of fertiliser prices contributed to the closure of nitric acid plants in the UK, Sweden, France and the Netherlands. In North America, grain stocks were at high levels following four years of good harvests. This led to a downturn in fertiliser sales and triggered a series of rationalisations in the nitric acid industry.

## Electrical

Consumption of platinum in electrical applications jumped by 85,000 oz to reach 455,000 oz in 2000. This was largely due to a significant increase in the average platinum content of hard disks,

which outweighed a decline in worldwide disk production. Demand for platinum in thermocouples was also strong, reflecting increases in world steel production and investment in semiconductor and speciality glass plants.

The typical storage capacity of a computer's hard disk has risen rapidly in recent years, from around 250 megabytes in the mid 1990s to 30 gigabytes or more by the end of last year - a thousand-fold increase. Platinum has played an important role in this development. Its addition to the magnetic alloy layer on which data is recorded improves the strength of the magnetic field, and hence the storage capacity of the disk. As a result, during the last three to four years, manufacturers have adopted platinum in an increasing proportion of their disks. We estimate that over 90 per cent of disks produced in 2000 contained platinum, up from about 75 per cent the previous year.

Last year also saw a significant increase in the average weight of platinum per disk, which in turn contributed to a sharp improvement in the density at which data could be recorded. This had both positive and negative implications for platinum demand. Higher storage capacity has enabled manufacturers to reduce the average number of disks per hard drive - until recently, hard drives contained at least two disks, but single-disk devices are now becoming increasingly common. As a result, the number of hard disks produced in 2000 fell by 7 per cent, despite an increase in PC shipments of more than 14 per cent.

A further rise in the average platinum content per disk is expected to boost demand in 2001, despite industry forecasts of a slowdown in computer sales. Platinum demand will also benefit from the application of hard disk technology to other electronics goods, such as video recorders and auto navigation systems.

Platinum's second major application

in the electrical industry is in thermocouples, used to monitor temperatures in the production of steel, semiconductors and glass. All three sectors generated strong demand for thermocouples last year. Steel production rose by 6 per cent, while there was a surge of capacity additions in the semiconductor and LCD glass industries.

Fuel cells currently make only a small contribution to platinum consumption in the electrical sector, but the prospects of significant demand in the longer term continue to improve. Last year saw further progress towards the commercialisation of proton exchange membrane (PEM) fuel cells for transport applications. Several major auto companies demonstrated fuel cell cars; most of these were powered by hydrogen gas stored in tanks, but some carried on-board reformers capable of generating hydrogen from a liquid fuel such as gasoline or methanol.

The Californian legislation that requires zero emission vehicles to be sold in the State from 2005 continues to provide momentum for the development of fuel cell cars. The growing membership of the California Fuel Cell Partnership (an industry body for research, development and promotion) illustrates the extent to which fuel cells have been embraced by the automotive and associated industries. This organisation now encompasses eight major car

## Platinum Demand: Electrical '000 oz

	1999	2000
Europe	70	80
Japan	75	90
North America	120	145
Rest of the World	105	140
<b>Total</b>	<b>370</b>	<b>455</b>





Zero Emission Vehicle legislation is stimulating rapid progress in the development of fuel cell cars

companies, together with several government bodies concerned with transport and the environment, fuel cell manufacturers, and a number of energy and fuel-infrastructure suppliers.

The source of hydrogen for the fuel cell remains the principal technological barrier to commercialisation. To date, most prototypes have been powered by hydrogen gas stored in tanks, but for ease and safety of refuelling, a liquid fuel such as methanol or gasoline is preferable. These can be transformed into hydrogen gas by means of an on-board reformer, but there remain some technical issues to be resolved. The most significant of these is the time taken for the reformer to reach operating temperature. As a result, it can take several minutes before sufficient hydrogen gas is generated, and therefore it is likely that early fuel cell vehicles will carry a store of pure hydrogen as well as a reformer.

Although the automotive sector is the largest potential market for fuel cells, in the short term most platinum demand will come from stationary power generation. Phosphoric acid fuel cells (PAFC) already play a small role in this market, and during 2000 the world's largest PAFC plant, rated at 1 MW, was

installed in Alaska. Meanwhile, PEM fuel cells are showing considerable promise for smaller-scale power generation. Last year, over one hundred small cells were produced for testing, mainly in residential applications. Commercial production of these units - which typically have a power output of between 2 and 7 kW - is expected to start within the next two years. Larger PEM fuel cells, with a power rating of up to 250 kW, are also undergoing field testing but are still several years from commercialisation.

## Glass

The use of platinum in glass production rose strongly in 2000, largely due to the construction of new capacity for high-quality glass used in liquid crystal displays (LCDs). There was also some investment in other sectors of the glass industry. Overall sales to glass makers rose by 55,000 oz to reach 255,000 oz.

In the LCD sector, demand for platinum glass-making equipment is being driven by the increasing use of flat-screen displays in a wide range of electronic applications, including desktop and portable computers, televisions, digital

cameras and mobile phones. Industry expectations are that world requirements for LCD glass will more than double in the period to 2003. This has brought significant investment in new capacity; last year, new plants were constructed in North America, Korea and Japan, and all major LCD glass manufacturers are planning further expansions. Although some of these plans may be scaled back in the light of the current slowdown in the electronics market, demand for platinum is expected to remain strong in the near future.

The glass market has also benefited from another aspect of growth in the electronics market, since the majority of desktop PC displays are still based on traditional cathode-ray tubes. These are manufactured with the same technology used for television tubes, which employs significant quantities of rhodium-platinum alloys in the glass forming process. Investment has also been encouraged by consumer demand for televisions in developing Asian economies, with new television glass plants being constructed in China and India last year.

Conditions were positive in the glass fibre market in 2000. The industry has seen growing use of glass-reinforced composites in the construction and transport sectors. To satisfy consumer demand for fuel-efficient vehicles, car makers are using more lightweight, glass-reinforced thermoplastics in place of steel. In the

### Platinum Demand: Glass

'000 oz

	1999	2000
Europe	20	20
Japan	65	65
North America	25	50
Rest of the World	90	120
<b>Total</b>	<b>200</b>	<b>255</b>



construction industry, glass fibre composites provide more resistance to corrosion than traditional materials, plus longer life and lower maintenance costs.

## Petroleum Refining

Demand for platinum in petroleum refining declined slightly to 105,000 oz last year, its lowest level since 1994. A limited amount of investment in reforming capacity in Asia was insufficient to offset the impact of refinery closures in the USA and Europe.

Over the last few years, there has been a trend towards rationalisation of refinery capacity in mature markets, with new investment taking place mainly in developing markets in Asia and Latin America, where demand for petroleum products is growing and environmental regulations are less strict. During 2000, there were further refinery closures in North America and Europe, leading to a decline in platinum consumption.

Although rationalisation in these regions is now thought to be largely complete, there is unlikely to be a significant recovery in demand for platinum. Investment in reforming capacity seems certain to be limited while refiners concentrate on making the changes necessary to meet new limits on the sulphur content of gasoline and diesel. The European Commission has already mandated a maximum sulphur

content of 50 ppm for both gasoline and diesel, which will be enforced from 2005, and is considering further reductions.

In the USA, the Environmental Protection Agency has proposed new sulphur limits, although the precise requirements and timing of the legislation have not yet been settled.

In the rest of the world, platinum demand was steady last year. While there were no major new projects requiring large purchases of platinum, there were some incremental increases in reforming and isomerisation capacity at existing refineries.

## Other

Demand for platinum in other applications continues to rise steadily, with consumption up 30,000 oz to 365,000 oz in 2000. There were gains across a range of applications, including spark plugs, oxygen sensors, medical devices, dental alloys and turbine blades.

Tighter emissions legislation continued to influence demand for platinum in oxygen sensors last year. Stage III European emissions legislation, which came into effect for new models from January 2000, made on-board diagnostic (OBD) systems compulsory on passenger cars for the first time. While all catalysed vehicles carry at least one oxygen sensor to monitor the engine's air:fuel ratio, the introduction of OBD regulations has resulted in the use of additional sensors to verify that emissions remain within legislated limits.

In North America, vehicles have carried OBD systems for some years. However, the number of sensors per car is gradually increasing as low emission vehicles account for an increasing proportion of sales. This trend has been partly offset by a slight reduction in the average weight of platinum in each sensor.

There was further growth in the use of platinum in spark plugs last year. North America is the principal market for

### Platinum Demand: Other

'000 oz

	1999	2000
Europe	90	100
Japan	35	35
North America	190	210
Rest of the World	20	20
<b>Total</b>	<b>335</b>	<b>365</b>



this application; in 2000, we estimate that around 95 per cent of vehicles sold in the USA carried platinum-tipped plugs, up from 90 per cent the previous year. The use of platinum plugs is less widespread in Europe, although demand continues to increase gradually. In contrast, there was a decline in consumption in Japan, where some car manufacturers have begun to use iridium-based alloys in place of platinum.

Platinum's use in biomedical applications expanded again in 2000. The use of catheters in minimally-invasive treatments for arterial disease continues to grow, with better, smaller devices enabling the treatment of patients who would previously have required invasive surgery. Technical developments are also encouraging the use of pacemakers and similar devices to treat a wider range of heart conditions.

Dental applications consumed more platinum last year. The combination of low prices for gold and record prices for palladium has resulted in greater use of high-gold alloys, which often contain a small percentage of platinum as a hardening agent.

Demand for platinum in the coating of turbine blades rose modestly in 2000. Platinum coatings have traditionally been used only on blades closest to the jet engine, since these are subject to the highest temperatures and therefore require the greatest thermal resistance. In line

### Platinum Demand: Petroleum Refining

'000 oz

	1999	2000
Europe	15	10
Japan	5	5
North America	40	35
Rest of the World	55	55
<b>Total</b>	<b>115</b>	<b>105</b>



with the development of engines which run at higher temperatures, there is a trend towards using platinum to improve the durability of so-called "second-stage" blades, further from the engine.

## Investment

Net demand for platinum coins and small bars more than halved to 40,000 oz in 2000, mainly as a result of rising bullion prices. While sales of new coins amounted to some 65,000 oz, we believe that around 25,000 oz of platinum was supplied back to the market through the melting of old bars and coins. Most of this recovered metal was consumed in the US jewellery industry. In Japan, the steady rise in the yen price of platinum encouraged investors to sell a net 100,000 oz of large investment bars back to the market in 2000.

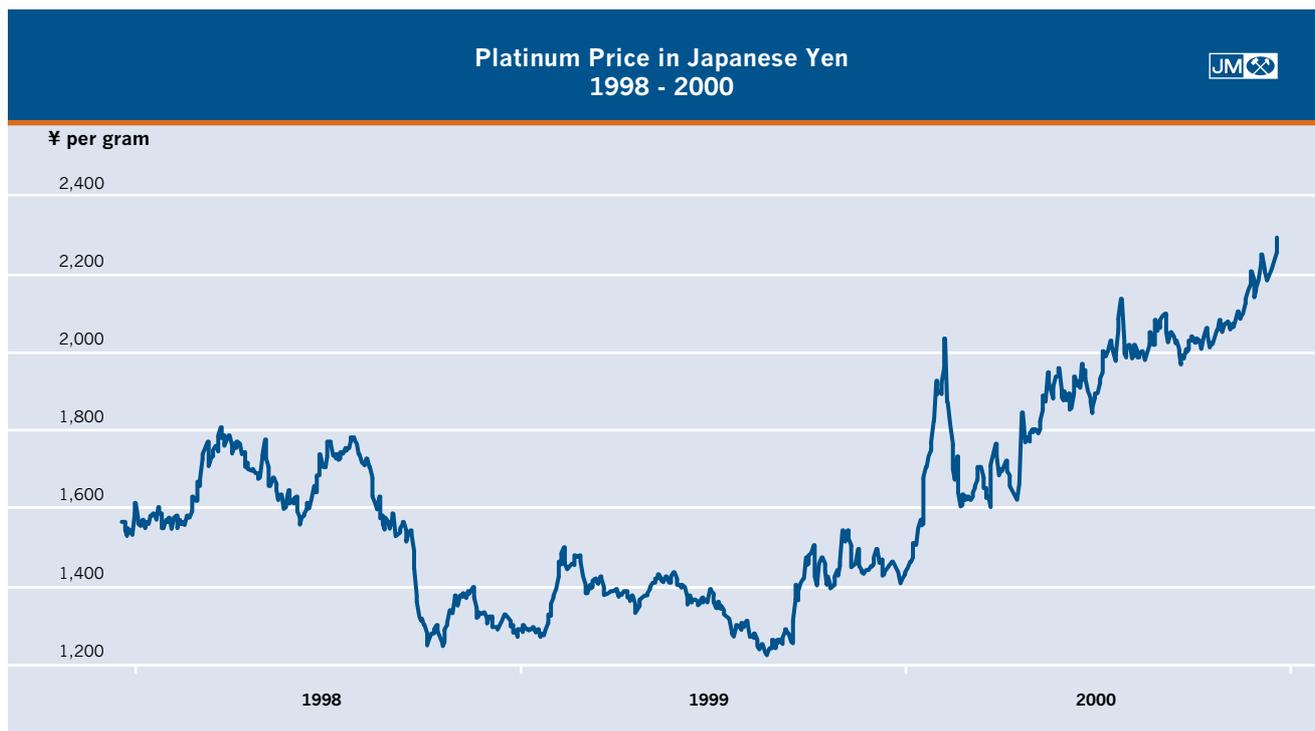
The US Mint's platinum Eagle series continues to dominate the small investment market, despite a steep fall in sales from a high of over 150,000 oz in 1998. Although consumer demand for high-quality proof Eagles was stable at just

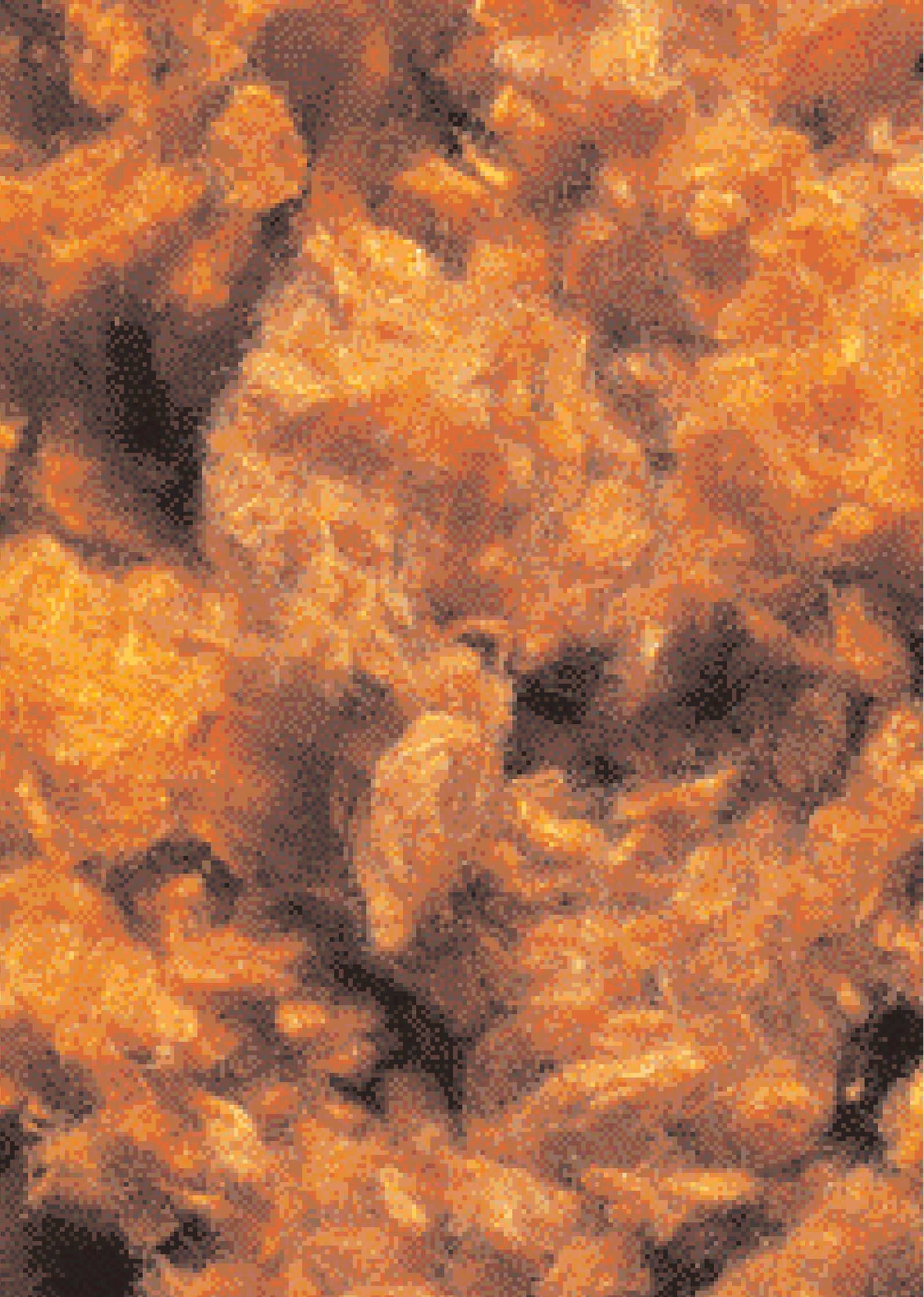
under 23,000 oz, sales of the bullion coin plunged by over 60 per cent to 27,000 oz in 2000. This decline was probably due to a combination of factors, including the strong performance of alternative investment media such as equities, as well as the higher price of platinum.

In February 2000, it was reported that the Defense Logistics Agency (DLA) had requested the return of the 196,000 oz of platinum which had been loaned to the US Mint in support of its platinum Eagle programme, in order to sell the metal as part of its stockpile disposal programme. In December it was announced that the DLA had formally transferred to the US Mint 50,000 oz of platinum and this should enable the Mint to continue its proof Eagle programme, currently scheduled to run until 2002, and to produce a limited number of bullion coins. The fate of the remaining 146,000 oz held by the Mint is unclear. At present, we expect minting levels for the Eagle this year to be similar to those in 2000, although demand for bullion coins could benefit from the sharp decline in world stock markets that occurred during March 2001.

Platinum Demand: Investment '000 oz		
	1999	2000
<b>Coins and small bars</b>		
Europe	5	0
Japan	20	5
North America	60	35
Rest of the World	5	0
	<b>90</b>	<b>40</b>
<b>Large bars in Japan</b>	<b>90</b>	<b>(100)</b>
<b>Total</b>	<b>180</b>	<b>(60)</b>

In Japan, the price of platinum in yen terms doubled from a low of just over ¥1,200 per gram in September 1999 to over ¥2,400 per gram in January 2001. This rise encouraged many investors to take profits by selling back 500g and 1kg bars bought at lower prices in earlier years. We estimate a net sellback of 100,000 oz last year and, if prices remain well above ¥2,000 per gram, expect further disinvestment in 2001.





# Palladium

## Autocatalyst

After five years of rapid growth in demand for palladium in autocatalysts, last year saw a reduction in purchasing by the auto industry. Demand fell by 4 per cent to 5.65 million oz as auto makers responded to the higher prices by adjusting their levels of stock. In contrast, actual consumption of palladium in catalysts fitted to cars and trucks manufactured in 2000 rose by 24 per cent, to meet increasingly stringent emissions legislation throughout the world.

It now seems clear that in both 1998 and 1999 some auto makers anticipated substantial growth in their consumption of palladium to meet increasingly tough standards for hydrocarbons. They responded by purchasing large quantities of the metal for future use and to protect themselves against increases in price and potential long term market shortages. They may also have been concerned by the delays in shipments of palladium from Russia that had occurred in the early months of 1997 and 1998.

The policies auto makers adopted towards inventories in 2000 are more difficult to assess. We believe that in the first half of the year some of the major North American auto makers responded to the high price of palladium by drawing down stocks built up in the preceding two years. After reaching a peak of \$800 in February, the price retreated during the March to May period, and users may have been lulled into believing that substantial quantities of Russian metal would be sold throughout the rest of the year. However, Russian shipments remained erratic and it was not until mid September that significantly more metal became available. Despite increased

shipments by Almaz in the period to the end of November, the price continued to rise steadily. We believe that this was at least partly caused by auto companies purchasing metal to replenish stocks run down in the first half of the year. With the Russian state treasury Gokhran indicating that it planned to sell no pgm in 2001, auto makers (and other users) may have moved to ensure they had adequate stocks for the following year.

It is clear that, because of their strategic nature, policies towards holding stocks vary between companies and are difficult to quantify precisely. Overall, we estimate that palladium inventories held by auto companies declined by about 340,000 oz in 2000, after increases of nearly 2 million oz over the two previous years. Whatever their views towards stocks, the response by auto makers worldwide to the record levels of the palladium price in the latter half of 2000 is clear - they wish to reduce their dependence on the metal if at all possible. This is likely to result in larger quantities of platinum and rhodium being used in future, although palladium seems certain to remain an important component of autocatalysts due to its ability to control hydrocarbon emissions.

In Europe, tighter Stage III emissions regulations came into force for all new models from January 2000 and applied to all cars produced from January 2001. Most manufacturers in Germany were already fitting catalysts designed to meet Stage III standards in advance of the due date, encouraged by domestic tax incentives. With the new standards in force, incentives to meet Stage IV levels of emissions are now available and a number of manufacturers are already

### Palladium Demand: Autocatalyst

'000 oz

	1999	2000
Europe	1,530	1,920
Japan	600	505
North America	3,490	2,800
Rest of the World	260	425
<b>Total</b>	<b>5,880</b>	<b>5,650</b>
<b>Autocatalyst recovery</b>	<b>(195)</b>	<b>(230)</b>



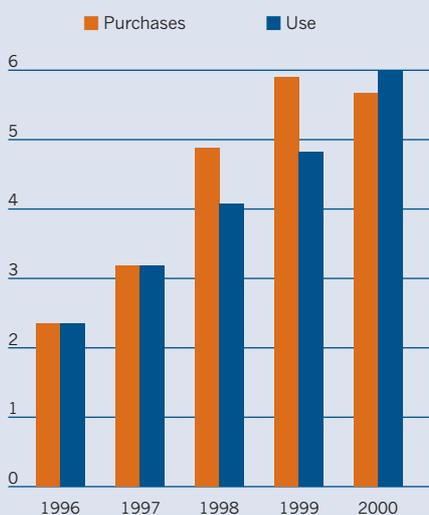
standardising on catalysts that will meet these, even stricter, regulations.

Most auto makers in Europe are adding more palladium to catalysts designed to meet the Stage III and Stage IV limits. As a result, European demand for palladium in autocatalysts in 2000 rose by 25 per cent to 1.92 million oz. Plans to increase palladium loadings were put in place before the sharp increase in price experienced last year. As a result, many auto makers, worried about the increased cost of emissions control systems, are now seeking to minimise their use of the metal, either through thrifting of total pgm loadings, or by substituting some of the palladium with platinum and rhodium.

The use of palladium in autocatalysts fitted to cars manufactured in Japan also rose in 2000; exports to the USA grew by 7 per cent and more palladium was required to meet the US LEV standards in that country. Tighter legislation also came into operation in Japan, with the introduction in October 2000 of Japanese Low Emission Vehicle (JLEV) standards, but manufacturers appear to have added

## Palladium Autocatalyst Demand 1996-2000

Million oz



platinum rather than palladium to their catalysts to comply with the new domestic regulations. There was no repeat of the stock building that occurred in 1999 and overall purchases of palladium by the auto industry in Japan declined 16 per cent to 505,000 oz.

In addition to the JLEV standards, the Japanese Environmental Agency has put forward for government consideration a set of technical guidelines for even tougher emissions limits. These suggest further reductions in permitted emissions of HC and NOx of between 25 per cent and 75 per cent from the JLEV rules. Compliance with these suggested standards is at present voluntary, but a number of auto makers have launched models that meet the new proposals and have highlighted their compliance in promotional advertising for the new vehicles.

Despite poor sales in the last two months of the year, the North American market for cars and light-duty trucks grew by 3 per cent overall in 2000. Imports increased strongly but domestic production levels were 2 per cent down on the 1999 level. The proportion of vehicles manufactured to LEV standards rose and this led to higher palladium consumption to meet the tighter HC emission

levels demanded by these regulations.

In the Rest of the World, demand for palladium grew by 65 per cent last year to 425,000 oz. In Mexico, production of cars and trucks rose by 25 per cent: as about three quarters of these vehicles were destined for North America there was a substantial growth in palladium demand for catalysts to meet the LEV standards north of the border. Demand also expanded in Brazil and Argentina as economic activity continued its gradual recovery from the crash of 1997. In Asia, the South Korean auto industry, despite undergoing painful restructuring, boosted exports by 11 per cent and this led to higher demand for palladium. In addition, Korea introduced its own LEV legislation in January 2000.

## Autocatalyst Recovery

The amount of palladium recovered in 2000 from scrapped autocatalysts rose by 18 per cent to reach 250,000 oz. About two thirds of this metal was recovered from catalytic converters removed from vehicles that had been scrapped in North America. Although an extensive network exists in the USA to collect used converters and extract the pgm-bearing contents, most of the metal was finally refined outside the country, in Europe, Japan, Canada and South Africa.

The greatly increased quantities of palladium used by the auto industry since the middle of the 1990s can be expected to lead to a substantial growth in recovery from scrapped autocatalysts in due course. However, the average life of cars in most regions of the world is 8-10 years and, although the quantities of palladium recovered are increasing, it will be another 4-5 years before they are comparable with the amounts of platinum that are recovered from auto recycling.

## Chemical

Demand for palladium in the chemical industry rose by 20,000 oz to 260,000 oz in 2000.

Sales of palladium process catalysts remained strong, but consumption of palladium in the nitric acid industry continued its gradual decline.

In Europe, there were significant sales of palladium for a catalyst used in the production of vinyl acetate monomer, a chemical that is widely employed in the manufacture of polymers, resins, films and laminates. In contrast, demand for palladium process catalysts in North America declined in comparison with 1999, when there were significant purchases of palladium for an intermediate process in the production of artificial fibres.

Demand for palladium process catalysts in the Rest of the World is principally for bulk petrochemicals such as purified terephthalic acid (PTA). Investment in the production of PTA - a feedstock used in the manufacture of packaging materials and artificial fibres - has been the mainstay of palladium demand in this region for several years. During 2000, new plants were built in several countries in Asia and the Middle East, while there were also capacity expansions at a number of existing sites. Further investment in this process is expected to take place this year.

In the nitric acid industry, where palladium catchment gauze is used to capture platinum lost from the catalyst, high metal prices are leading to a gradual

### Palladium Demand: Chemical

'000 oz

	1999	2000
Europe	65	95
Japan	20	20
North America	75	65
Rest of the World	80	80
<b>Total</b>	<b>240</b>	<b>260</b>



erosion of palladium demand. In the USA, most nitric acid plants operate at high pressures and the industry has largely abandoned the use of catchment because of the increased cost of palladium. In other regions plants generally operate at low or medium pressures, which require fewer catchment gauzes. Companies here have generally retained the use of catchment systems, but in some cases have reduced the number of gauzes and settled for slightly lower platinum recoveries.

## Dental

During 2000, it was the dental sector in which high palladium prices had their most significant negative impact. Demand was down by 26 per cent to 820,000 oz - the lowest figure for 17 years. The use of palladium alloys decreased world-wide, with the sharpest declines occurring in the USA and Germany. In comparison, there was a more modest fall in consumption in Japan. The Japanese market is generally less price sensitive than other countries, because treatment using the Kinpala alloy, which contains 20 per cent palladium, qualifies for a subsidy under the state health insurance scheme. However, demand is not entirely insulated from price movements, because the level of subsidy does not necessarily reflect the current cost of alloy components.

Although the government now revises reimbursement rates twice a year, there is a time lag of several months before the adjustment takes place. In an environment of rising prices, such as existed in 2000, repayment levels may fall below the intrinsic metal value of the alloy, temporarily discouraging its use.

Japanese demand has also been affected by changes in the state health insurance scheme introduced in 1999, requiring patients to make higher contributions to their medical care. In last year's depressed economic climate,

this triggered a decline in attendance at dental practices and a reduction in the number of reconstructive dental procedures. These factors contributed to a decline of 14 per cent in the use of palladium dental alloys in Japan last year.

Elsewhere, the rising palladium price has triggered a rapid shift to alternative products. In Europe, where the use of palladium dental alloys is concentrated in Germany, demand plunged by 44 per cent last year, as the impact of high dollar prices was exacerbated by a weak euro. In North America, palladium consumption fell by one third. Dental laboratories are switching from palladium to high gold and, especially in Europe, base metal alloys; in addition, technical improvements are encouraging the greater use of metal-free materials such as porcelain.

## Electronics

During 2000, palladium continued to lose market share to base metals in the manufacture of multi-layer ceramic capacitors (MLCC). Despite this, the increase in production of MLCC was such that demand for palladium in electronics actually increased last year. But the high price of palladium has made its future in this sector less secure.

Manufacturers of MLCC increased their output by 47 per cent in 2000 to 620 billion units, and to achieve this result needed to utilise fully all their production capabilities. As a result, although the proportion of MLCC containing palladium electrodes fell, from 62 per cent in 1999 to 46 per cent last year, the amount of palladium consumed in this application rose by 5 per cent to 1.82 million oz. The need for more MLCC was driven by buoyant markets for mobile phones and other consumer electronic products. There was especially strong demand for capacitors in more complex cellular phones, especially the WAP (wireless application protocol) models used for

### Palladium Demand: Dental

'000 oz

	1999	2000
Europe	180	100
Japan	545	470
North America	350	230
Rest of the World	35	20
<b>Total</b>	<b>1,110</b>	<b>820</b>



internet communications.

Over the last decade the electronics industry has experienced several severe fluctuations in consumer demand and manufacturing activity. In late 2000 and, even more so, in the first quarter of 2001 there have been clear indications that the rate of increase in demand for electronic goods has peaked. In particular, sales of the newer WAP phones are likely to expand much more slowly than had been anticipated; virtually all manufacturers have reported a slowdown in sales growth and instituted cutbacks in production. It also seems clear that manufacturers of components for mobile phones and other electronic devices have entered the current phase of declining activity with substantial inventories. We therefore expect production of MLCC to fall significantly in 2001.

Developments in technology in

### Palladium Demand: Electronics

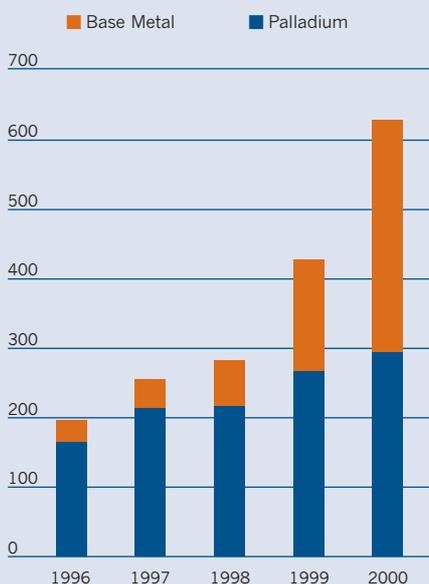
'000 oz

	1999	2000
Europe	255	265
Japan	980	990
North America	405	465
Rest of the World	350	420
<b>Total</b>	<b>1,990</b>	<b>2,140</b>



## MLCC Production by Electrode Type 1996-2000

Billions



recent years have resulted in comparable performance of palladium and nickel based MLCC for most applications. The slowdown in the electronics industry will give MLCC makers the opportunity to concentrate on producing cheaper nickel based products rather than those containing precious metals and consequently their demand for palladium is likely to decline sharply this year.

MLCC production accounts for over 80 per cent of demand for palladium in electronics, and is sensitive to price since the palladium content of the MLCC is a significant proportion of the materials cost. This is less so for other applications in the sector, such as hybrid integrated circuits (HIC) and the plating of lead frames, and demand for these uses is not expected to change significantly. However, in its application in the plating of connectors, palladium is in competition with gold, having originally been introduced as a cheaper alternative to the then more highly priced yellow metal. With the reversal of the relative prices of the metals over the last two to three years, several users are considering returning to gold plating, and some have already done so.

The recovery of palladium from old scrap is an important component of net demand in electronics. Although there is pressure to increase recycling for environmental reasons, the success of miniaturisation and thrifting programmes in recent years has resulted in the grades of precious metal in electronic scrap falling significantly. The amount of palladium recovered in 2000 is estimated to have been around 340,000 oz world-wide, some 15 per cent lower than in the preceding year.

## Other

The use of palladium in other applications fell sharply in 2000, largely due to the sale back to the market of metal recovered from petroleum refining catalysts. There was also a decline in demand from the jewellery sector, as fabricators in Japan and China adopted platinum alloys with lower palladium contents.

In the petroleum sector, palladium's principal use is in catalysts for hydro-cracking. This process can utilise either base metals or palladium, the choice depending on a number of technical considerations as well as the cost of the catalyst itself. For example, palladium is more durable in some circumstances, and also gives gasoline with a higher octane value, whereas base metal catalysts produce more middle distillate products such as diesel and jet fuel.

### Palladium Demand: Other '000 oz

	1999	2000
Europe	75	65
Japan	115	110
North America	60	15
Rest of the World	95	70
<b>Total</b>	<b>345</b>	<b>260</b>



Several US refineries have recently taken the decision to adopt base metal catalysts in place of palladium. During 2000, this trend was accelerated by rising palladium prices, with some companies changing catalysts more quickly than originally planned in order to recover the metal and sell at high prices. As a result, demand from the petroleum refining industry was negative last year.

Consumption of palladium by the jewellery industry fell by around 15 per cent last year. Demand was affected by a sharp decline in the fabrication of platinum jewellery in Japan, and by the adoption of platinum jewellery alloys with a lower palladium content in China. This was offset to some extent by the increased use of white gold worldwide in order to meet consumer demand for inexpensive white jewellery; many white gold alloys contain palladium as a whitening agent.

In Japan, platinum jewellery has traditionally been made using alloys containing 10 or 15 per cent palladium. In recent years there has been a move towards materials with a higher platinum content, especially in the bridal market, and this trend continued last year. Palladium demand was also affected by a decline in sales of platinum chain, which is typically fabricated from Pt850 alloys. Some manufacturers have started to experiment with lower-content palladium alloys, containing cheaper metals such as silver and copper in place of some of the palladium.

The Chinese platinum jewellery industry has also made extensive use of alloys containing 10 per cent palladium. However, manufacturers are now moving towards Pt950 as a result of new regulations governing the purity of platinum jewellery, which were introduced in September 2000. High palladium prices are also encouraging the adoption of alloys containing alternative metals.

# Automotive Emissions Legislation in California

It was pollution in the city of Los Angeles that first gave birth to the control of emissions from road vehicles and, ultimately, to the introduction of autocatalysts in 1975. Much of the world has followed this initiative by introducing limitations on allowable emissions, but California has continued to lead the way in driving standards forward in the search for cleaner air.

## History

The first reported episode of smog formation in Los Angeles occurred as early as 1943 but it was not until 1966 that auto tailpipe emission standards for hydrocarbons (HC) and carbon monoxide (CO) were adopted in California, the first such standards in the world.

Initial emissions regulations were met by engine modifications, but in 1975 the first two-way (or oxidation) catalytic converters came into use as part of the Motor Vehicle Emission Control Program of the California Air Resources Board (CARB). They were followed a year later by the first three-way catalytic converters, to control HC, CO and nitrogen oxides (NOx).

### Some Key Dates in Californian Emissions Control

- 1947** California passes Air Pollution Control Act
- 1960** Motor Vehicle Pollution Control Board established in California
- 1967** Federal Act allows California to set its own emissions standards
- 1968** Inaugural meeting of California Air Resources Board (CARB)
- 1975** First catalytic converters come into use in California
- 1990** CARB approves Low and Zero Emissions Vehicles standards
- 1998** CARB approves LEV II emissions standards
- 1999** California Fuel Cell Partnership formed
- 2001** ZEV mandate for 2003 confirmed

## Low Emissions Vehicle (LEV) Program

In 1990, CARB approved standards for Low and Zero Emissions Vehicles that would apply from 1994 to 2005. These were based upon the progressive introduction of four classes of vehicles, each with increasingly stringent emissions requirements:

- TLEV** transitional low emissions vehicles
- LEV** low emissions vehicles
- ULEV** ultra low emissions vehicles
- ZEV** zero emissions vehicles

Currently, auto makers are required to comply with a Fleet Average NMOG (Non-Methane Organic Gas) standard, which is tightened each model year. In the period to 2005, manufacturers may certify vehicles in any combination of the LEV categories in order to satisfy this standard.

## LEV II Program

CARB approved new proposals in November 1998, referred to as LEV II, for a strengthening of the regulations from 2004. The new standards will require light trucks, including sports utility vehicles (SUVs), pick-ups and small vans, as well as some vehicles currently in the medium duty class, to meet the same emissions standards as passenger cars. A further significant ruling is that diesels will be subject to the same standards as gasoline powered vehicles.

Other requirements of the LEV II program are that auto makers must reduce fleet average emissions levels each year through to 2010; NOx standards for low and ultra-low emissions vehicles will be reduced by 75 per cent from the LEV level; and durability standards will be extended from 100,000 to 120,000 miles. The program also permits credits for vehicles that achieve near-zero emissions, such as fuel cells, hybrids and cars meeting a new super ultra low emissions vehicle (SULEV) standard.

## Zero Emissions Vehicles (ZEV)

As part of its 1990 LEV Program, CARB mandated that 2 per cent of passenger cars produced and offered for sale in California in 1998 by the seven major auto manufacturers should be zero emissions vehicles. This percentage was to rise gradually and reach 10 per cent in 2003, but the mandate was modified in 1996 to eliminate the 1998-2002 requirement.

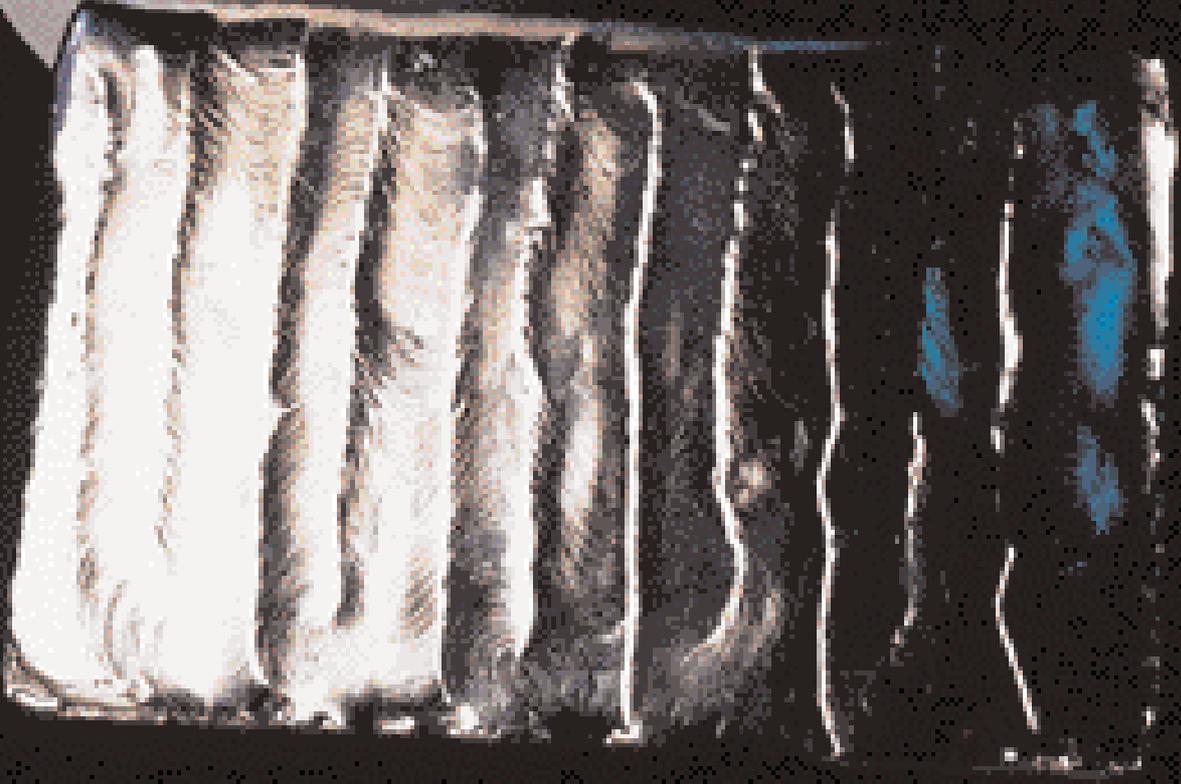
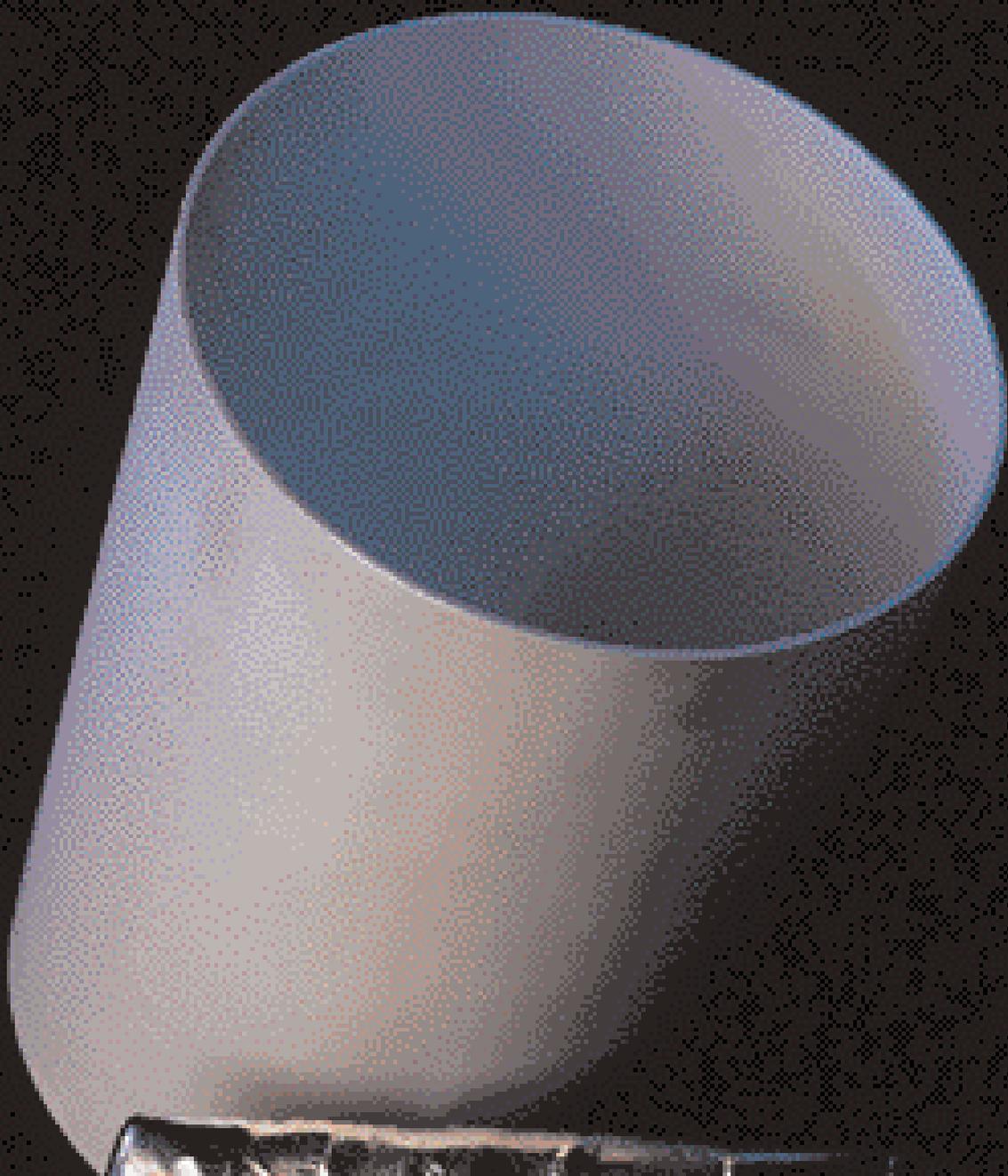
The 1998 LEV II program introduced a system whereby manufacturers could meet up to 60 per cent of the ZEV requirement through the sales of partial zero emissions vehicles (PZEVs), with five PZEVs being sold in place of each ZEV required. The emissions criteria for a PZEV were the same as for a SULEV except that the durability requirement was extended from 120,000 to 150,000 miles.

In August 2000 an extensive review of the ZEV program was published. Subsequently, in January 2001, CARB voted to keep the ZEV mandate in place, although the rules were revised to reduce the number of pure ZEV required in the period to 2006, while raising the minimum ZEV requirement to 16 per cent in 2016.

### TLEV, LEV, ULEV and ZEV Standards for Passenger Cars

Class	NMOG g/m	CO g/m	NOx g/m
TLEV	0.156	4.200	0.600
LEV	0.090	4.200	0.500
ULEV	0.055	2.100	0.500
ZEV	zero	zero	zero

*based on 100,000 miles durability*



# Other Platinum Group Metals

## Rhodium

The market for rhodium in 2000 was characterised by strong consumer demand and tight physical availability, which combined to force the price up from \$1,000 at the beginning of the year to just over \$2,000 at the end of December, having touched \$2,600 in August. This was despite record shipments of the metal from Russia.

## Autocatalyst

Demand for rhodium in autocatalysts rose in all regions. Additional rhodium was needed to meet tougher emissions standards in Europe, Japan and the USA, while several automakers increased rhodium loadings to help them minimise the growth in palladium demand that was also occurring last year. It seems likely that many companies may follow this trend in future years as they try to reduce their dependence on palladium.

In Europe, the introduction of Euro III standards in January 2000 resulted in heavier average loadings of rhodium in autocatalysts. Further increases can be expected in future as a higher proportion of vehicles is built to meet the Stage IV legislation that will come into effect from 2005. In Germany, the largest car market in Europe, the government is already providing tax incentives for vehicles meeting the tighter regulations.

Japan also saw the introduction of more stringent emissions legislation in 2000, although the new standards were not enforced until October. Many auto makers chose to fit catalyst systems capable of meeting the new limits ahead of the deadline and this helped boost demand for rhodium. Several of the

major Japanese auto companies are making strenuous efforts to reduce their consumption of palladium and some have already begun to use higher loadings of rhodium and platinum to help them meet their objective. We believe that some companies may have added to their stocks of rhodium during 2000 in the expectation of higher use of the metal in future years.

The high price of palladium has also led US auto makers to consider adopting a strategy employing more rhodium and platinum to meet their own tougher domestic emissions standards. New legislation coming into force in North America over the next few years bears most heavily on hydrocarbon emissions, for which palladium is particularly effective as a catalyst. However, the addition of rhodium to palladium-only catalysts helps minimise the overall pgm loadings used. There is circumstantial evidence here too that auto makers increased their stocks of rhodium in anticipation of increased future use.

Imports of rhodium by the USA in January 2000 rose dramatically, with no less than 161,000 oz of the metal being imported from Russia. As this coincided with a period when the rhodium price was rising sharply we conclude that most, if not all, of the metal was not seen by the market at large but was acquired by one or more auto companies either directly from Almaz or through an intermediary.

The amount of rhodium recovered from the processing of scrapped autocatalysts rose last year by 20 per cent to 78,000 oz. Over half the increase came from catalytic converters removed from cars scrapped in North America, where

### Rhodium Supply and Demand

'000 oz

	1999	2000
<b>Supply</b>		
South Africa	410	457
Russia	65	290
North America	18	16
Others	8	3
<b>Total Supply</b>	<b>501</b>	<b>766</b>
<b>Demand</b>		
Autocatalyst: gross	509	793
recovery	(65)	(78)
Chemical	34	35
Electrical	6	6
Glass	35	42
Other	9	9
<b>Total Demand</b>	<b>528</b>	<b>807</b>
Movements in Stocks	(27)	(41)



rhodium levels in autocatalysts increased significantly in the early years of the 1990s.

## Other

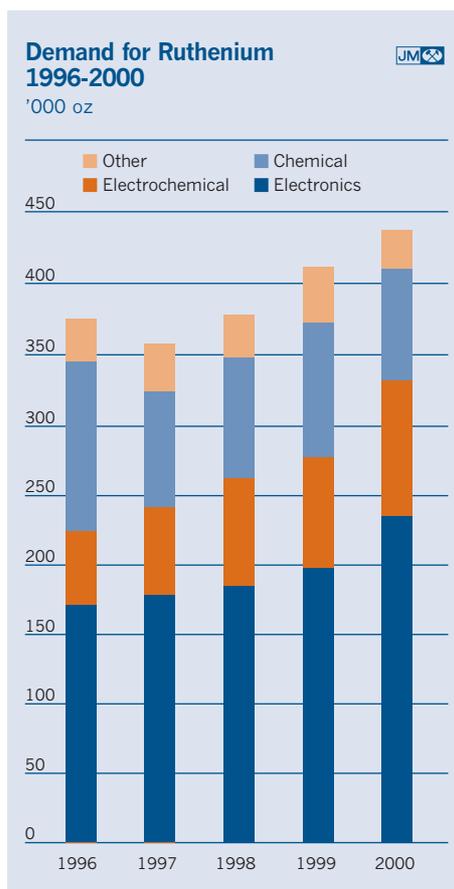
Demand for rhodium in other applications rose by almost 10 per cent to 92,000 oz last year. Sales to the glass industry were particularly strong, with rhodium demand increasing by a fifth to 42,000 oz, largely as a result of investment in new plants to manufacture the high quality, thin glass used in liquid crystal displays (LCDs). Equipment made from rhodium-platinum alloys is used to control the flow of molten glass during the production process. The wider application of LCDs in computer screens and in other consumer electronic devices such as mobile phones

is expected to double demand for LCD glass and most of the major manufacturers have begun, or are planning, significant expansions in their production capacity over the next 2-3 years. Demand in other applications that use rhodium was similar to that of 1999.

## Ruthenium & Iridium

Continuing strong growth in the electronics industry was the main driving force behind increased demand for both ruthenium and iridium during 2000. Total consumption of ruthenium rose by 7 per cent to reach 439,000 oz, while the use of iridium increased by 30 per cent to 127,000 oz, driven by a dramatic 180 per cent growth in demand for crucibles for crystal growing.

The principal application for ruthenium in the electronics industry is in thick film pastes used in the manufacture of resistors. These components are incorporated into the majority of electronic products and manufacturers have therefore benefited from the global expansion in, for example, the markets for computers and mobile phones. Last year there was a 35 per cent increase in the production of resistor chips and networks, although the resulting rise in demand for ruthenium was somewhat lower, at 19 per cent, due to the continuing trend towards



miniaturisation of electronic components.

During 2000 there was an explosive growth in the demand for mobile phones with worldwide production of these devices growing by almost 50 per cent. This in turn generated a comparable need for lithium-based crystals, which are used in surface acoustic wave (SAW) filters to prevent signal interference between individual phones. These crystals are grown in iridium crucibles and, in order to meet demand, there was a significant increase in production capacity during the year which led to an almost threefold rise in iridium usage in this application. Demand was also lifted by increased use of yttrium aluminium garnet (YAG) crystals in industrial applications, such as laser cutting, and medical procedures, including cosmetic surgery.

Within the chemical sector, both iridium and ruthenium are used in the production of speciality and bulk chemicals. For iridium, the most

significant source of demand is the Cativa process for acetic acid production. This employs an iridium catalyst promoted with ruthenium, in contrast to traditional routes based on rhodium or base metals. The need for replacement catalysts for the plants currently operating with Cativa technology supported demand for both metals during 2000.

Ruthenium is a more versatile, and less expensive, catalyst than iridium and is used in a wider range of chemical processes. In recent years demand has been augmented by the Kellogg Advanced Ammonia Process (KAAP) which employs a ruthenium catalyst for the production of ammonia in place of the traditional iron based system. This process generated demand during 2000 for a new plant that is due for completion in Trinidad in 2002. Ruthenium catalysts are also used in the production of a number of speciality and fine chemicals; investment in new processes in this sector had increased in 1999, but demand softened slightly in 2000.

The electrochemical sector accounts for a significant proportion of total demand for both ruthenium and iridium. Electrodes coated with either ruthenium or a mixture of ruthenium and iridium are employed in a number of electrochemical processes. The most important of these is the chlor-alkali process which is used to produce chlorine and caustic soda from brine.

### Ruthenium Demand by Application

'000 oz

	1999	2000
Chemical	95	79
Electrochemical	80	97
Electronics	197	235
Other	39	28
<b>Total Demand</b>	<b>411</b>	<b>439</b>



### Iridium Demand by Application

'000 oz

	1999	2000
Automotive	34	14
Electronics	21	59
Electrochemical	18	19
Other	25	35
<b>Total Demand</b>	<b>98</b>	<b>127</b>



Demand for both metals rose during 2000 following increased consumption of the two end products, a trend that is expected to continue for the foreseeable future due to the myriad uses for each. The use of iridium, in particular, continues to benefit from a shift away from pure ruthenium to mixed ruthenium-iridium coatings.

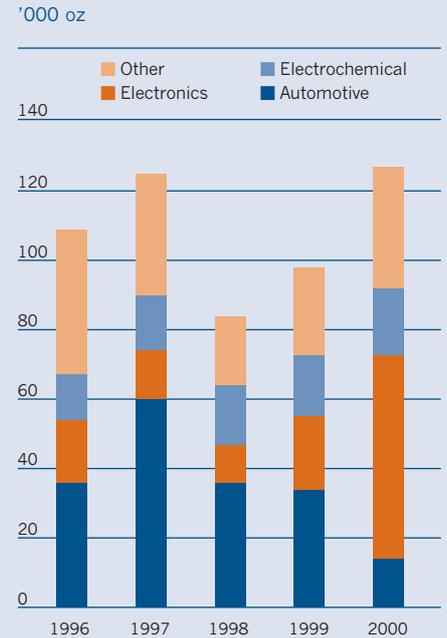
The adoption by Mitsubishi Motor Company (MMC) of an iridium based autocatalyst system on its gasoline direct-injection (GDI) engine has generated significant demand for iridium in recent years, with the system being fitted to vehicles sold in Japan and, with some modification, Europe. This catalyst, however, proved unsuitable for meeting the tighter emissions standards introduced in both these regions during 2000. As a result, MMC is now changing to a catalyst formulation that does not

use iridium and this led to a sharp drop in demand during 2000.

The use of iridium in spark plugs and medical applications increased during 2000. Iridium is a highly durable material and its incorporation into spark plug alloys imparts higher reliability and longer lifetimes, properties which are of particular interest to auto companies. Within the medical sector, iridium alloys are used in the form of electrodes attached to medical implants, such as pacemakers, and to catheters used to open blocked arteries.

Ruthenium demand for other applications fell slightly during 2000, mainly due to a decrease in the use of ruthenium-titanium pipe in off-shore drilling and geothermal projects. This can be attributed to a reduction in the number of such projects last year.

**Demand for Iridium 1996-2000**



## Other PGM Supplies

### Rhodium

Supplies of rhodium rose by more than 50 per cent to reach 766,000 oz in 2000. The previous year, shipments from Russia had been affected by restrictions on rhodium and platinum sales introduced under Clause 19 of the 1999 budget bill. The amendment of this clause in January 2000 paved the way for a sharp increase in rhodium exports from Russia; we estimate that sales by Almaz totalled 290,000 oz last year.

Much of this metal was shipped to North America, with US trade statistics revealing a massive import of 161,000 oz of rhodium from Russia in January 2000. This shipment alone exceeded Russian total sales in any year except 1997. As there was no obvious impact on market liquidity, with the price continuing to rise steadily throughout the early part of the year, it seems likely that most of this metal was acquired by auto companies, either directly or through an intermediary.

Supplies of rhodium from South Africa also rose sharply, despite a decline in platinum output last year. This was largely due to the sale of some rhodium from producer stocks. Increased mining from the rhodium-rich UG2 reef also had some impact on output; the rhodium content of UG2 ore is about twice that of the Merensky Reef.

World supplies of rhodium are expected to decline steeply this year. Russian production is estimated to be less than 100,000 oz per annum, and state stockpiles must therefore have been heavily depleted last year. In 2001, we expect that Russian exports will be closer to annual output. Meanwhile, South African supplies are expected to be similar to those of last year, with a rise in production offsetting a decline in sales from stocks.

### Ruthenium & Iridium

Supplies of iridium were sufficient to meet consumer demand in 2000, and prices remained stable throughout the year. However, there was a significant shortage of liquidity in the ruthenium market, reflected in a rise in the price from \$46 in January to a peak of \$170 in August.

South African production of ruthenium declined, reflecting a fall in platinum output and a reduction in recoveries of minor pgm from residues. In addition, we believe that sales by South African producers were below the level of refined output last year. Meanwhile, Russian exports – which have typically totalled about 30,000 oz per annum in recent years – were negligible in 2000.

# Prices & Futures Markets

## Platinum

Platinum advanced strongly during 2000, rising from a low of \$414 in January to a peak of \$625 in December. During the early part of the year, uncertainty over Russian exports was the key factor behind the rally. Although Almaz made intermittent sales from May onwards, platinum maintained its gains, supported by strong consumer demand and limited physical availability. During December, platinum climbed to a series of highs, after concerns about Russian supplies were reactivated by reports that Gokhran did not plan to sell metal during 2001.

Platinum declined sharply in early **January** 2000, falling from \$442 on the 4th, the first day of trading, to the year's low of \$414 on the 6th. The fall was in response to news that Vladimir Putin, then acting president of Russia, had signed a revision to Clause 19 of the 1999 budget bill. This amendment provided the legal framework for the resumption of platinum exports (which had been held up since April 1999), and prompted selling by both dealers and funds. From mid month onwards, bullish sentiment returned as it became clear that regular

shipments would not resume immediately. Consumer demand was also strong and this led to an increasing physical shortage of metal, with lease rates rising from 30 per cent on the 13th to over 75 per cent on the 28th. The price also made strong gains, reaching \$495 at the month end.

Although lease rates began to retreat, the platinum price continued to climb during the first three weeks of **February**, peaking at an eleven year high of \$575 on the 17th. Continued concerns about delays in Russian shipments stimulated heavy buying on TOCOM, with the exchange recording an exceptional trading volume equivalent to 5.47 million oz on the 8th. Meanwhile, the rally was reinforced by a steep ascent in the palladium price, which recorded a series of all-time highs before peaking at \$800 on the 21st. However, platinum's gains were quickly eroded. Expectations of an imminent resumption of Russian platinum exports caused the price to retreat to \$465 on the 25th, although it then recovered to \$490.

Platinum dipped to \$465 on 2nd **March**, responding to reports that Vladimir Putin had signed a decree enabling the start of platinum shipments.

This decline was short-lived: another rise in lease rates, a continued lack of Russian material in the market, and strikes at two South African producers saw the price bounce back to \$496 on the 22nd. It retreated slightly at the month end, slipping to \$482 on the 31st.

**April** saw some wide swings in the platinum price. It spiked to \$521 on the 5th, stimulated by strong consumer demand and fund buying on NYMEX, then sank back to \$488 on the 10th. Over the next two weeks, the price moved between \$470 and \$510, responding to conflicting reports about Russian sales. From the 27th onwards, platinum began a rapid ascent, surging to \$525 on the 28th. The rally was prompted by a continued lack of Russian metal in the market, combined with a renewed rise in lease rates to over 70 per cent.

During the first half of **May**, lease rates fell back to 45 per cent, and the price also retreated, to just above \$500. Physical demand provided strong support at this level, and an announcement by Anglo Platinum that it planned to increase annual platinum production by 1.5 million oz by 2006 had no impact. In mid month, platinum embarked on another climb, soaring to \$565 on the

### Average PGM Prices in \$ per oz

Average	Platinum	Palladium	Rhodium	Iridium	Ruthenium
1999	377.03	358.18	907.25	414.82	40.01
2000	544.92	681.74	1,998.00	415.00	129.83
Percentage Change	45%	90%	120%	0%	224%

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



24th. The rally was motivated by market expectations of higher demand in auto-catalysts, following news that General Motors was planning to increase its use of platinum by 10 per cent by 2002.

The price was subsequently supported at around \$550 by a report that Gokhran, Russia's State Fund, would not export any platinum during the year.

Platinum slid to \$540 in mid **June**, as a fall in lease rates to 30 per cent stimulated some long liquidation by investors. This decline was quickly reversed; the price surged to \$580 on the 27th, with fund purchasing in a thin market the main factor behind the rally. There was still concern about Russian supplies – especially among Japanese investors – despite the release of Swiss trade statistics showing the import of 224,000 oz of platinum from Russia in May.

Early **July** saw another dip in the platinum price, which dropped to \$532 on the 5th in response to Russian selling. However, a remarkable rally in palladium – which gained over \$200 during the month – helped platinum regain the \$580 level by the end of July. Concerns that supplies of pgm from Russia would prove insufficient were the main influence on the markets, while platinum was also bolstered by continued physical demand.

Prices for both metals jumped higher at the start of **August**, triggered by a lack of Russian metal in the spot market. Palladium recorded a new all-time high of \$855 on the 2nd, lifting platinum to a peak of \$612 – its highest fixing since December 1988. The rally ended abruptly, however, with reports that Norilsk Nickel expected contract shipments to Japan to commence in September or October. Platinum dropped swiftly to \$564 on the 7th, before trading around \$570 for the next three weeks. These lower prices stimulated strong buying from consumers, causing the price to recover to \$598 on the 30th.

Platinum continued to make gains in

## Platinum Prices in 2000

London am and pm fixings

\$ per oz	High	Low	Average
January	495.00	414.00	441.36
February	573.00	465.00	516.33
March	496.00	463.00	480.03
April	525.00	470.00	498.50
May	563.00	502.00	526.10
June	580.00	540.00	558.88
July	583.00	532.00	560.00
August	612.00	564.00	577.80
September	612.00	565.00	592.40
October	588.00	568.00	579.42
November	605.00	586.00	593.42
December	625.00	599.00	610.50



early **September**, revisiting its high of \$612 on several occasions. However, the price began to weaken from mid month, despite the start of strike action at Anglo Platinum's mines on the 18th. The decline appeared to be triggered by concern over rising fuel prices and the potential impact on the world economy; this encouraged some investors to liquidate long positions on NYMEX and TOCOM. As a result, platinum sank to a low of \$565 on the 27th.

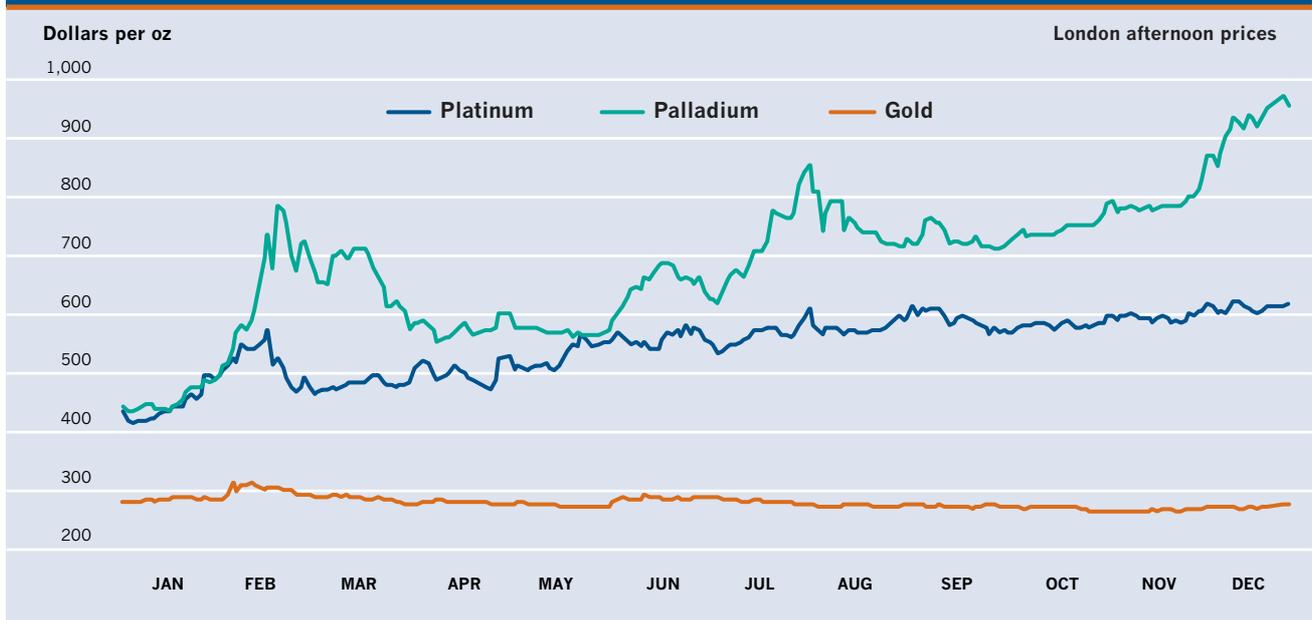
The price stabilised temporarily during **October**, trading in a \$575 to \$585 range for most of the month. Further speculative selling was deterred by the strike at Anglo Platinum, which caused a reduction in mine output over a period of four weeks before coming to an end on the 16th. It was subsequently reported that the group's platinum production would fall below 2 million oz in 2000.

Platinum rallied in early **November**, reaching \$600 on the 3rd and trading close to this level until the 13th. The gains were generally attributed to reports quoting Russia's Deputy Finance Minister Rudakov, suggesting that Gokhran did not plan to export any pgm in 2001.

Market sentiment was also affected by an announcement by Anglo Platinum, stating that 55,000 oz of production had been lost due to the strike and that the group's platinum output would fall to 1.9 million oz in 2000. Although the price edged down to \$586 on the 16th, following reports that tax inspections in China had caused a dip in buying by local jewellery companies, it climbed back above \$600 at the month end in the wake of fund buying on NYMEX.

The ascent continued during the first few days of **December**, with platinum touching \$625 on the 4th. The rise was driven by speculation about a possible shortage of Russian pgm supplies in 2001, which encouraged continued purchasing by investors. TOCOM was the main focus of activity, with the general public said to hold long positions of around 500,000 oz. After dipping briefly to \$599 on the 6th, platinum continued its rally, reaching a new peak of \$625 on the 13th – its highest price since August 1987. It continued to trade above \$600 for the rest of the month, recording \$611 at the year's final London fixing on the 29th.

## Daily Platinum, Palladium and Gold Prices in 2000



## Palladium

The palladium price set a series of all-time records in 2000, culminating in a fixing of \$972 on 27th December. After starting January at \$440, palladium began to rally later that month, stimulated by strong industrial demand and a shortage of metal from Russia. The rally was given impetus by investors scrambling to cover short positions on TOCOM, and the price spiked to \$800 on 21st February. After retreating to \$600 in April, palladium reached a new peak of \$855 in August following a lull in sales by Almaz. This record was exceeded in December, when concern about Russian supplies in 2001 triggered heavy buying. After trading at around \$440 during the first two weeks of **January**, palladium began to rally strongly during the second half of the month. Driven by strong consumer demand and a shortage of metal from Russia, the price rose steadily to reach \$488 on the 28th.

Palladium's ascent steepened during **February**, and the price rose to a high of

\$800 in London on the 21st. This remarkable gain was largely due to panic buying on TOCOM, where private investors were reported to hold short positions totalling around 650,000 oz. Attempts at short covering only added to the rally's momentum, causing palladium to repeatedly open limit-up on TOCOM and making it impossible for investors to close out their positions. On the 23rd, the exchange authorities suspended trading of palladium futures, and froze prices in order to prompt the orderly liquidation of contracts. The following day, Japanese traders closed out 225,000 oz of their long positions, and the palladium price fell abruptly to \$700.

The decline was arrested by continuing shortages of physical metal, which helped to support palladium at around \$700 for much of the first three weeks of **March**. From the 20th onwards, the price fell steeply, sinking to \$575 on the 31st in line with a significant improvement in physical availability. Initially, Russia was rumoured to be the source of the additional metal, but news that Tiger Management was to close its largest fund led to speculation that it had liquidated

its remaining palladium holdings.

The price continued to retreat in early **April**, dipping to \$555 on the 11th. It recovered to \$600 on the 28th, but lost ground again during **May**, falling to \$560 on the 22nd. This decline was mainly due to increased liquidity in the market, although sentiment was also affected by Swiss trade data showing the import of just over 1 million oz of Russian palladium in March. Market rumour suggested that this metal may have been used as collateral for a loan, rather than being sold.

Palladium staged a recovery during **June**. It reached \$691 on the 19th, boosted by strong physical demand, a jump in lease rates, and a bout of short covering on TOCOM (which in April had lifted trading restrictions on palladium contracts with delivery months of February 2001 or later). The price then began to drift lower, weakening to a fix of \$635 on 30th June.

This retreat was short-lived, with the rally finding renewed impetus during **July**. Once again, the triggers were a combination of consumer purchasing and a lull in Russian sales; as the price climbed, short covering added to the momentum.

On the 17th, palladium breached the \$700 level for the first time since March, and it continued steeply upwards to a peak of \$822 on the 31st.

The rally culminated on 2nd **August**, with palladium spiking to a new record fix of \$855. After reaching this peak, the price immediately went into a steep decline, plunging to \$716 by the month end. Sentiment was affected by press reports indicating that Russian exports to Japan could commence the following month, and by news that the US Defense Logistics Agency planned to sell an additional 100,000 oz of palladium from its stockpile before the end of September.

Palladium rebounded briefly to \$765 on 8th **September**, responding to heavy industrial buying and a continued shortage of metal. But in the second half of the month, more Russian palladium came onto the market, and the price drifted down to \$711 on the 28th.

The rate of Russian selling eased in early **October**, and with consumer demand remaining strong, palladium recouped its losses of the previous month. After rallying sharply to \$742 on the 6th, the price stabilised temporarily before making further gains towards the month end, fixing at \$758 on the 31st.

The rally gathered pace during early **November**, following reports that Gokhran did not expect any pgm to be

Palladium Prices in 2000 London am and pm fixings			
\$ per oz	High	Low	Average
January	488.00	433.00	452.09
February	800.00	483.00	635.69
March	718.00	573.00	665.93
April	600.00	553.00	573.08
May	605.00	560.00	571.17
June	691.00	572.00	647.09
July	822.00	616.00	702.94
August	855.00	710.00	760.38
September	765.00	708.00	728.38
October	758.00	712.00	739.65
November	811.00	772.00	783.99
December	972.00	818.00	914.03

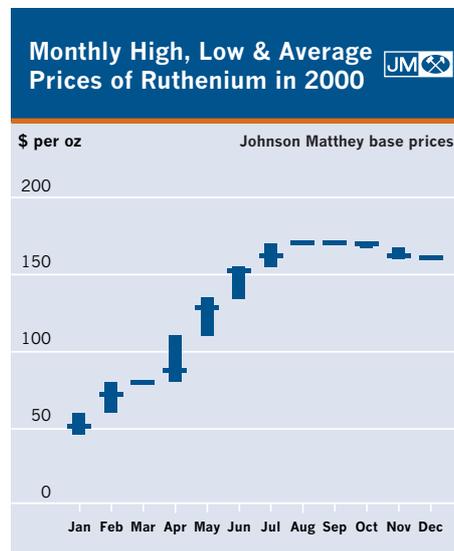
sold from Russian state stockpiles in 2001. This triggered a rush of short covering, and palladium jumped by nearly \$40 to reach \$794 on the 3rd. Over the next three weeks, strong consumer demand supported the price in a \$775-\$785 trading range, despite the sale of large volumes of metal – possibly of Russian origin – on the London fixings. In the final days of November, the level of physical selling waned significantly; there was an immediate reaction in the price, which leapt to \$811 on the 30th.

Palladium made further dramatic gains in **December**. It was reported that Norilsk Nickel had exhausted its palladium export quota for 2000, while the Russian government had no plans to sell more metal; this suggested that there would be no substantial deliveries of metal from Russia before the year end. The market was also concerned about another interruption to supplies in early 2001, despite assurances from Norilsk that its long term quota for palladium would enable it to continue shipments in the New Year. The price climbed rapidly to \$940 on the 12th, and remained close to this level during the next week, despite

evidence that consumer demand had begun to ease. With price movements exaggerated by thin trading conditions over the Christmas period, palladium set a new all-time high of \$972 on 27th December, before retreating to \$954 at the year's final London fixing.

## Other PGM

Strong consumer demand and tight physical supply boosted rhodium to an eight year peak of \$2,600 in August 2000. The price



weakened to \$1,625 in October, in line with increased sales from Russia, before recovering to \$2,025 at the year end. Industrial and speculative buying propelled ruthenium to a high of \$170 in August, but iridium was unchanged at \$415 throughout the year.

The Johnson Matthey base price for rhodium climbed steeply from \$1,000 at the start of 2000 to \$2,525 in February. The rally was underpinned by strong demand from Asia, particularly from car companies, coupled with a lack of physical availability. There were also

reports of speculative purchasing.

These gains were eroded during March and April, with the price slipping back to \$1,600. However, strong consumer demand combined with a shortage of metal subsequently led rhodium higher. The price peaked at \$2,600 in August but in late September, there was a significant increase in Russian selling and rhodium sank to \$1,625 on 4th October.

Sales of rhodium by Almaz began to ebb in mid October, and the price stabilised before beginning to climb again the following month. Reports that Gokhran did not intend to sell any pgm in 2001

also stimulated the market, and rhodium reached \$2,200 on 8th November. It subsequently drifted lower, despite sporadic offers of Russian material, to end the year at a JM base price of \$2,025.

While the JM base price for iridium was unchanged at \$415 throughout 2000, ruthenium saw some significant gains. Propelled by buying from consumers and speculators, the price rose from \$46 at the beginning of the year to reach \$170 in July. It stabilised at this level until late October, when the market began to ease slightly. The price edged down to \$160, where it remained until the end of the year.

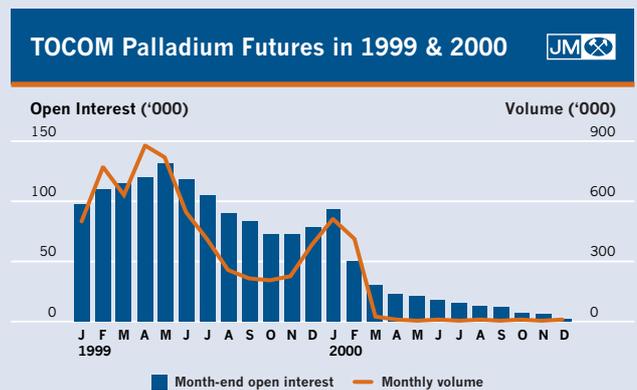
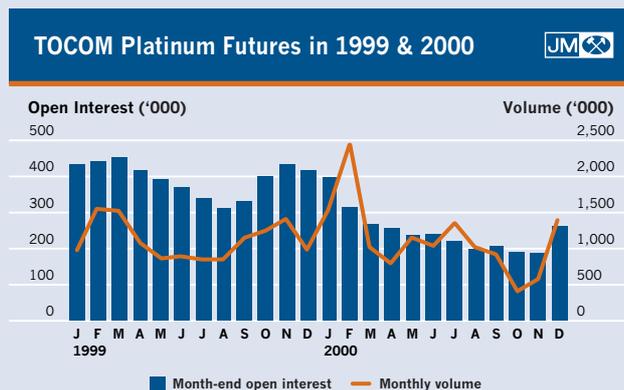
## Futures Markets

### Platinum

The platinum futures contract on TOCOM was actively traded during 2000, with annual turnover up 2 per cent at 15.6 million lots. The most active month was February, when over 2.4 million contracts changed hands, as platinum prices spiked briefly to over ¥2,000 per gram. Open interest also peaked in this month, reaching 425,189 contracts on the 8th before falling to 316,657 lots at the month end.

Volumes remained high until September, due to continued price volatility combined with restrictions on trading in palladium futures; these motivated some investors to switch to platinum instead. Although activity then declined, December saw a surge of activity, with 1.4 million contracts changing hands as the platinum price rose to almost ¥2,500 per gram. Open interest also increased, from the year's low of 180,216 contracts on 29th November to 262,150 contracts a month later.

In contrast, activity on NYMEX was subdued, with annual volume falling by 44 per cent to 319,924 contracts. Open interest also declined, from 11,953 contracts at the end of 1999 to 8,429 lots a year later.



### Palladium

Trading of the palladium futures contract on TOCOM was particularly active during January and February 2000, with nearly 1 million contracts changing hands. Japanese investors had built up substantial short positions in the expectation that a resumption of Russian sales would drive prices lower. When the palladium price began to climb steeply during February, investors were unable to cover their positions due to limits on daily price movements imposed by TOCOM. The exchange introduced emergency measures on 23rd February, effectively suspending free market trading and freezing prices.

Volumes on TOCOM subsequently collapsed, with only 82,525 contracts being traded between March and December. Open interest declined from a peak of 98,665 contracts on 9th February to just 2,099 lots at the year end.

Trading volumes on NYMEX declined sharply in 2000, down 35 per cent to 50,766 contracts for the year. There was a surge of activity in February, when nearly 14,000 contracts changed hands. Open interest also peaked in February, reaching 3,543 on the 7th; it had declined to just 1,848 contracts by the year end.

# Supply and Demand Tables

Platinum Supply and Demand	48
Platinum Demand by Application: Regions	49
Palladium Supply and Demand	50
Palladium Demand by Application: Regions	51
Rhodium Supply and Demand	52

## 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.

From 1993, demand numbers for **Europe** include an estimate of net consumption in the former COMECON countries of eastern Europe. From 1996, consumption in China is incorporated into our figures for the **Rest of the World** region. 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.

## Platinum Supply and Demand

'000 oz	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Supply</b>										
South Africa	2,770	2,750	3,360	3,160	3,370	3,390	3,700	3,680	3,900	3,800
Russia	1,100	750	680	1,010	1,280	1,220	900	1,300	540	1,100
North America	220	200	220	220	240	240	240	285	270	285
Others	70	120	130	140	100	130	120	135	160	105
<b>Total Supply</b>	<b>4,160</b>	<b>3,820</b>	<b>4,390</b>	<b>4,530</b>	<b>4,990</b>	<b>4,980</b>	<b>4,960</b>	<b>5,400</b>	<b>4,870</b>	<b>5,290</b>
<b>Demand By Application</b>										
Autocatalyst: gross	1,565	1,550	1,685	1,870	1,850	1,880	1,830	1,800	1,610	1,840
recovery	(205)	(230)	(255)	(290)	(320)	(350)	(370)	(405)	(420)	(470)
Chemical	240	215	180	190	215	230	235	280	320	270
Electrical	175	165	165	185	240	275	305	300	370	455
Glass	120	80	80	160	225	255	265	220	200	255
Investment: small	175	145	125	155	75	110	180	210	90	40
large	240	110	180	240	270	130	60	105	90	(100)
Jewellery	1,470	1,510	1,615	1,740	1,810	1,990	2,160	2,430	2,880	2,840
Petroleum	150	120	105	90	120	185	170	125	115	105
Other	140	150	165	190	225	255	295	305	335	365
	<b>4,070</b>	<b>3,815</b>	<b>4,045</b>	<b>4,530</b>	<b>4,710</b>	<b>4,960</b>	<b>5,130</b>	<b>5,370</b>	<b>5,590</b>	<b>5,600</b>
Western Sales to China	(20)	0	20	50	130	-	-	-	-	-
<b>Total Demand</b>	<b>4,050</b>	<b>3,815</b>	<b>4,065</b>	<b>4,580</b>	<b>4,840</b>	<b>4,960</b>	<b>5,130</b>	<b>5,370</b>	<b>5,590</b>	<b>5,600</b>
Movements in Stocks	110	5	325	(50)	150	20	(170)	30	(720)	(310)
	<b>4,160</b>	<b>3,820</b>	<b>4,390</b>	<b>4,530</b>	<b>4,990</b>	<b>4,980</b>	<b>4,960</b>	<b>5,400</b>	<b>4,870</b>	<b>5,290</b>
<b>Demand By Region</b>										
Europe	785	860	895	935	880	840	875	910	995	1,095
Japan	2,050	1,870	1,975	2,145	2,215	2,005	1,885	1,795	1,820	1,410
North America	815	705	760	940	1,015	1,180	1,250	1,325	1,080	1,215
Rest of the World	420	380	415	510	600	935	1,120	1,340	1,695	1,880
	<b>4,070</b>	<b>3,815</b>	<b>4,045</b>	<b>4,530</b>	<b>4,710</b>	<b>4,960</b>	<b>5,130</b>	<b>5,370</b>	<b>5,590</b>	<b>5,600</b>
Western Sales to China	(20)	0	20	50	130	-	-	-	-	-
<b>Total Demand</b>	<b>4,050</b>	<b>3,815</b>	<b>4,065</b>	<b>4,580</b>	<b>4,840</b>	<b>4,960</b>	<b>5,130</b>	<b>5,370</b>	<b>5,590</b>	<b>5,600</b>



## Platinum Demand by Application: Regions

'000 oz	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Europe</b>										
Autocatalyst: gross	480	575	610	605	560	515	510	545	560	640
recovery	(5)	(5)	(5)	(10)	(15)	(20)	(25)	(30)	(30)	(40)
Chemical	55	50	40	50	55	60	70	60	80	85
Electrical	30	30	20	25	25	25	45	45	70	80
Glass	20	15	15	30	35	40	20	25	20	20
Investment: small	40	35	25	45	10	5	5	5	5	0
Jewellery	85	85	105	100	120	125	150	160	185	200
Petroleum	30	20	25	25	15	15	15	15	15	10
Other	50	55	60	65	75	75	85	85	90	100
<b>Totals</b>	<b>785</b>	<b>860</b>	<b>895</b>	<b>935</b>	<b>880</b>	<b>840</b>	<b>875</b>	<b>910</b>	<b>995</b>	<b>1,095</b>
<b>Japan</b>										
Autocatalyst: gross	380	350	320	290	270	245	255	240	250	290
recovery	(35)	(45)	(50)	(45)	(40)	(50)	(50)	(55)	(60)	(60)
Chemical	20	20	15	15	20	20	20	20	20	20
Electrical	50	50	45	45	45	45	65	55	75	90
Glass	35	20	30	80	105	80	85	80	65	65
Investment: small	65	40	55	40	35	25	25	25	20	5
large	240	110	180	240	270	130	60	105	90	(100)
Jewellery	1,260	1,290	1,350	1,450	1,480	1,480	1,390	1,290	1,320	1,060
Petroleum	15	10	10	5	5	5	5	5	5	5
Other	20	25	20	25	25	25	30	30	35	35
<b>Totals</b>	<b>2,050</b>	<b>1,870</b>	<b>1,975</b>	<b>2,145</b>	<b>2,215</b>	<b>2,005</b>	<b>1,885</b>	<b>1,795</b>	<b>1,820</b>	<b>1,410</b>
<b>North America</b>										
Autocatalyst: gross	620	525	600	790	820	850	800	775	535	620
recovery	(165)	(180)	(200)	(230)	(260)	(275)	(290)	(310)	(315)	(350)
Chemical	100	90	75	65	70	80	80	80	95	90
Electrical	65	55	65	75	115	130	100	105	120	145
Glass	20	15	15	20	25	30	45	20	25	50
Investment: small	40	65	40	65	25	75	145	175	60	35
Jewellery	20	35	45	55	65	90	160	270	330	380
Petroleum	50	35	40	5	40	60	50	40	40	35
Other	65	65	80	95	115	140	160	170	190	210
<b>Totals</b>	<b>815</b>	<b>705</b>	<b>760</b>	<b>940</b>	<b>1,015</b>	<b>1,180</b>	<b>1,250</b>	<b>1,325</b>	<b>1,080</b>	<b>1,215</b>
<b>Rest of the World</b>										
Autocatalyst: gross	85	100	155	185	200	270	265	240	265	290
recovery	0	0	0	(5)	(5)	(5)	(5)	(10)	(15)	(20)
Chemical	65	55	50	60	70	70	65	120	125	75
Electrical	30	30	35	40	55	75	95	95	105	140
Glass	45	30	20	30	60	105	115	95	90	120
Investment: small	30	5	5	5	5	5	5	5	5	0
Jewellery	105	100	115	135	145	295	460	710	1,045	1,200
Petroleum	55	55	30	55	60	105	100	65	55	55
Other	5	5	5	5	10	15	20	20	20	20
<b>Totals</b>	<b>420</b>	<b>380</b>	<b>415</b>	<b>510</b>	<b>600</b>	<b>935</b>	<b>1,120</b>	<b>1,340</b>	<b>1,695</b>	<b>1,880</b>

## Palladium Supply and Demand

'000 oz	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Supply</b>										
South Africa	1,270	1,260	1,395	1,500	1,600	1,690	1,810	1,820	1,870	1,860
Russia	2,150	2,100	2,400	3,300	4,200	5,600	4,800	5,800	5,400	5,200
North America	420	450	415	410	470	455	545	660	630	635
Others	70	70	70	70	70	95	95	120	160	95
<b>Total Supply</b>	<b>3,910</b>	<b>3,880</b>	<b>4,280</b>	<b>5,280</b>	<b>6,340</b>	<b>7,840</b>	<b>7,250</b>	<b>8,400</b>	<b>8,060</b>	<b>7,790</b>
<b>Demand By Application</b>										
Autocatalyst: gross	355	490	705	975	1,800	2,360	3,200	4,890	5,880	5,650
recovery	(85)	(95)	(100)	(105)	(110)	(145)	(160)	(175)	(195)	(230)
Chemical	225	205	190	185	210	240	240	230	240	260
Dental	1,165	1,195	1,210	1,265	1,290	1,320	1,350	1,230	1,110	820
Electronics	1,855	1,830	2,015	2,230	2,620	2,020	2,550	2,075	1,990	2,140
Jewellery	210	205	210	205	200	215	260	235	235	200
Other	65	60	35	115	110	140	140	115	110	60
<b>Total Demand</b>	<b>3,790</b>	<b>3,890</b>	<b>4,265</b>	<b>4,870</b>	<b>6,120</b>	<b>6,150</b>	<b>7,580</b>	<b>8,600</b>	<b>9,370</b>	<b>8,900</b>
Movements in Stocks	120	(10)	15	410	220	1,690	(330)	(200)	(1,310)	(1,110)
	<b>3,910</b>	<b>3,880</b>	<b>4,280</b>	<b>5,280</b>	<b>6,340</b>	<b>7,840</b>	<b>7,250</b>	<b>8,400</b>	<b>8,060</b>	<b>7,790</b>
<b>Demand By Region</b>										
Europe	620	675	680	885	1,340	1,525	1,840	1,985	2,095	2,430
Japan	1,800	1,780	1,990	2,200	2,445	1,885	2,350	2,215	2,205	2,045
North America	1,095	1,155	1,295	1,430	1,960	2,185	2,675	3,690	4,255	3,420
Rest of the World	275	280	300	355	375	555	715	710	815	1,005
<b>Total Demand</b>	<b>3,790</b>	<b>3,890</b>	<b>4,265</b>	<b>4,870</b>	<b>6,120</b>	<b>6,150</b>	<b>7,580</b>	<b>8,600</b>	<b>9,370</b>	<b>8,900</b>



## Palladium Demand by Application: Regions

'000 oz	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Europe</b>										
Autocatalyst: gross	5	40	115	260	650	860	1,100	1,370	1,530	1,920
recovery	0	0	0	0	0	(5)	(5)	(5)	(10)	(15)
Chemical	70	75	65	60	65	65	70	65	65	95
Dental	300	300	265	255	250	255	260	210	180	100
Electronics	200	210	210	255	325	300	340	270	255	265
Jewellery	35	35	35	30	30	30	50	50	50	45
Other	10	15	10	25	20	20	25	25	25	20
<b>Totals</b>	<b>620</b>	<b>675</b>	<b>680</b>	<b>885</b>	<b>1,340</b>	<b>1,525</b>	<b>1,840</b>	<b>1,985</b>	<b>2,095</b>	<b>2,430</b>
<b>Japan</b>										
Autocatalyst: gross	95	85	90	125	145	180	245	480	600	505
recovery	(30)	(35)	(30)	(30)	(25)	(30)	(45)	(50)	(55)	(50)
Chemical	25	20	20	20	20	20	20	20	20	20
Dental	420	450	500	550	580	600	620	590	545	470
Electronics	1,160	1,130	1,280	1,400	1,600	990	1,390	1,060	980	990
Jewellery	120	120	120	120	115	115	110	105	105	95
Other	10	10	10	15	10	10	10	10	10	15
<b>Totals</b>	<b>1,800</b>	<b>1,780</b>	<b>1,990</b>	<b>2,200</b>	<b>2,445</b>	<b>1,885</b>	<b>2,350</b>	<b>2,215</b>	<b>2,205</b>	<b>2,045</b>
<b>North America</b>										
Autocatalyst: gross	220	320	450	525	950	1,230	1,680	2,820	3,490	2,800
recovery	(55)	(60)	(70)	(75)	(85)	(110)	(105)	(115)	(125)	(155)
Chemical	80	65	65	60	70	70	70	70	75	65
Dental	400	400	400	410	410	410	415	390	350	230
Electronics	425	405	420	450	545	490	550	460	405	465
Jewellery	5	0	5	5	5	5	10	10	10	10
Other	20	25	25	55	65	90	55	55	50	5
<b>Totals</b>	<b>1,095</b>	<b>1,155</b>	<b>1,295</b>	<b>1,430</b>	<b>1,960</b>	<b>2,185</b>	<b>2,675</b>	<b>3,690</b>	<b>4,255</b>	<b>3,420</b>
<b>Rest of the World</b>										
Autocatalyst: gross	35	45	50	65	55	90	175	220	260	425
recovery	0	0	0	0	0	0	(5)	(5)	(5)	(10)
Chemical	50	45	40	45	55	85	80	75	80	80
Dental	45	45	45	50	50	55	55	40	35	20
Electronics	70	85	105	125	150	240	270	285	350	420
Jewellery	50	50	50	50	50	65	90	70	70	50
Other	25	10	10	20	15	20	50	25	25	20
<b>Totals</b>	<b>275</b>	<b>280</b>	<b>300</b>	<b>355</b>	<b>375</b>	<b>555</b>	<b>715</b>	<b>710</b>	<b>815</b>	<b>1,005</b>



## Rhodium Supply and Demand

'000 oz	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Supply</b>										
South Africa	220	278	278	330	342	359	377	400	410	457
Russia	110	80	80	80	80	110	240	110	65	290
North America	18	19	17	15	13	5	16	16	18	16
Others	0	1	1	1	1	2	3	4	8	3
<b>Total Supply</b>	<b>348</b>	<b>378</b>	<b>376</b>	<b>426</b>	<b>436</b>	<b>476</b>	<b>636</b>	<b>530</b>	<b>501</b>	<b>766</b>
<b>Demand By Application</b>										
Autocatalyst: gross	301	305	356	379	464	424	418	483	509	793
recovery	(16)	(22)	(25)	(34)	(37)	(45)	(49)	(57)	(65)	(78)
Chemical	25	18	11	10	13	21	36	31	34	35
Electrical	10	7	9	8	8	9	9	6	6	6
Glass	12	7	3	14	17	53	43	34	35	42
Other	14	13	12	11	9	9	10	10	9	9
<b>Total Demand</b>	<b>346</b>	<b>328</b>	<b>366</b>	<b>388</b>	<b>474</b>	<b>471</b>	<b>467</b>	<b>507</b>	<b>528</b>	<b>807</b>
Movements in Stocks	2	50	10	38	(38)	5	169	23	(27)	(41)
	<b>348</b>	<b>378</b>	<b>376</b>	<b>426</b>	<b>436</b>	<b>476</b>	<b>636</b>	<b>530</b>	<b>501</b>	<b>756</b>
<b>Demand By Region</b>										
Europe	101	119	127	129	139	154	165	175	178	200
Japan	99	63	68	68	59	64	70	75	84	154
North America	111	110	127	139	224	170	137	177	167	331
Rest of the World	35	36	44	52	52	83	95	80	99	122
<b>Total Demand</b>	<b>346</b>	<b>328</b>	<b>366</b>	<b>388</b>	<b>474</b>	<b>471</b>	<b>467</b>	<b>507</b>	<b>528</b>	<b>807</b>

