

# The Platinum Group Metals

By Gill Burke

The *Platinum Group of precious Metals* (PGMs) includes Palladium, Iridium, Osmium, Rhodium and Ruthenium, as well as Platinum itself. All the PGMs occur naturally as alloys with other group members and many of their uses are interchangeable. The metals arrange themselves in a triad of pairs, palladium being paired with platinum, osmium with ruthenium and iridium with rhodium. Platinum and palladium, the most abundant of the group, are over one hundred times as rare as gold. Like gold, platinum has a demand as a store of wealth.

All the PGMs exhibit several remarkable properties including resistance to corrosion and oxidation even at high temperatures, extensive and sometimes unique catalytic activity, high melting points and great strength.

## Uses

The major uses for *platinum* is as jewelry and in auto catalytic converters to reduce nitrous oxide and other harmful emissions from vehicle exhausts. Indeed, two thirds of USA 1987 consumption of platinum and rhodium was in emission control systems. Thus the platinum market became severely destabilised in December 1988 when the Ford Motor Company announced it had developed and tested a platinum free autocat. Subsequently the patent for the new autocat revealed the main components to be palladium and rhodium, so what the PGMs lost on the roundabouts they gained on the swings. Demand for PGMs for autocat use will increase even further following EEC proposals that emission standards equivalent to USA-1983 levels be applied by 1993.

For the purposes of this study the more significant uses of the PGMs are in electronics and related fields. Thus platinum is used in thick-film and thin-film electronic devices. For hybrid microcircuits small amounts of platinum are added to silver, palladium and gold

thick-film pastes in various combinations to improve solderability and bond strength and to enhance durability. Telecommunications, fuel injection systems and military applications are among the main markets for platinum bearing pastes. Platinised sensors are being used more and more for temperature control and gas detection. A developing electronic application is sputtered thin-film, which forms contact surfaces on silicon wafers. This will have increased potential as gallium arsenide wafers come into general use.

Large platinum crucibles are commonly employed in the electronics industry for melting the specialised materials from which single crystals are grown, where operating temperatures do not require using iridium but are still too high for refractory ceramics.

Electronics accounts for about one third of western world *palladium* consumption. There has been strong growth of demand from Japan since 1987 where palladium is used in making so called *multi-layer ceramic capacitors* (MLCCs) and *thick-film hybrid integrated circuits* (HICs). MLCC production accounts for about three times as much palladium as HIC. There is an expanding market, in telecommunications, computers and peripherals and in automotive controls and instrumentation for thick-film HIC incorporating MLCC.

In early 1989 the price of palladium surged following reports of 'cold fusion' experiments in the UK and the USA. In these an electric current passed between two electrodes, one made of palladium, set in 'heavy' water containing deuterium and lithium, generated a great deal of heat. This, it was argued was caused by nuclear reaction. Another experiment used titanium rather than palladium for the electrode. Their was subsequently much critical scientific comment on the experiments and by April the price of palladium had fallen back.

Thick-film pastes containing palladium and *ruthenium* are used to print the conductor and resistor tracks of many hybrid circuits and in a variety of discreet components including chip capacitors, resistors and conductors. Ruthenium's brittleness is a drawback however, and research is focusing on copper-ruthenium alloy.

*Iridium* has a wide range of industrial uses some of which, as the Johnson Matthey annual report on Platinum (1988) points out, are hard to identify and evaluate with accuracy. However, 11 per cent of iridium use is as crucibles for the electronics industry since it can withstand even higher temperatures than platinum. There is a trend towards larger crucibles, some of which can weigh up to 10 kg each.

*Osmium* is the least used PGM, but displays an extremely high density and melting point. Its main use is to harden other PGM alloys

### Production and reserves

The PGMs are key strategic minerals in terms of supply disruption and fears of 'resource war', because over 80 per cent of Western world supply comes from one source, the Republic of South Africa. These crucial deposits lie on the Merensky Reef and Upper Group chromite seam (UG-2) in Bophuthatswana and the Bushveld complex at Rustenburg in the Transvaal. Production there is dominated by Impala and Rustenburg mines which between them produce in excess of 2.3 Moz of platinum - some 72% of world supply.

In 1988 the US Bureau of Mines calculated that a USA embargo on six strategic and critical minerals from South Africa (cobalt, chromium, manganese, PGMs, rutile and vanadium) would cost the USA 1.85 billion US dollars (GUSD) per year between 1988-1992. This average direct annual cost included about 1.4 GUSD for platinum and 384 MUSD for rhodium.

Under Section 303(a)(2) of the Comprehensive Anti-Apartheid Act of 1986, PGMs were certified as strategic minerals essential for the economy or defence of the USA and unavailable in adequate quantities from reliable or secure suppliers. In 1987 an expert panel recommended the USA purchase rhodium for the National Defense Stockpile. It has been commented that there is no need to further increase the GSA stockpile since so much platinum and palladium is stored in the nation's automobiles.

At present the US Department of Defense maintains a stockpile authorised by PL 101-189 (See Table 2).

The other main source of PGMs is the Soviet Union, which supplies about 15 per cent of Western world demand. Hargreaves and Fromson (1983) claim that these two main producers collude on pricing and supply structure, and have the financial muscle to support the market. Johnson Matthey have assessed USSR sales to the West as 440 koz in 1988 and a potentially similar amount in 1989.

**Table 2**  
**PGM: USA stockpile status**  
**November 29, 1989**  
**(thousand troy ounces)**

	Goal	Total inventory
Iridium	86 000	29 590
Palladium	2 150 000	1 264 601
Platinum <sup>1</sup>	1 310 000	452 641
Rhodium <sup>1</sup>	30 000	*
Ruthenium <sup>1</sup>	65 000	*

<sup>1</sup> Old goal

\*Added June 1, with interim requirements

Source:  
Mining Annual Review 1990

The production of platinum is dominated by the Republic of South Africa not least because the platinum-palladium ratio in the PGMs there is about 2.5:1, whilst in the USSR it is only about 0.4:1. However, about 72 per cent of world mine production of palladium comes from the USSR. Soviet palladium-rich PGMs are in the main a by-product of nickel mining. Mining operations are at Norilsk in Siberia and on the Tura River, central Urals.

The United States inaugurated its first major source of PGMs in 1987, when the Stillwater Mine in Montana came on stream after more than two decades of exploration and development. There are also, as yet undeveloped, deposits in Michigan.

Other current sources of PGMs are Bolivia, Canada, again a by-product of nickel mining; Australia, where the Yilgarn region of Western Australia produces a few thousand ounces per year; Colombia, historically one of the oldest sources where platinum mining commenced in 1778 ('platina' - Spanish for 'little silver' gave the metal its name), and Zimbabwe.

Exploration and development of PGM prospects has increased markedly over recent years, although it will be some considerable while before any production comes from most of this. Prospecting is being undertaken in a wide variety of places including Sierra Leone, New Zealand, the Philippines and the UK Shetland Isles. Even so, as it is generally more profitable to spend time looking for PGMs in countries where they have been found already, exploration continues in South Africa, Canada, Australia and, presumably, the USSR. World resources of PGM were estimated in 1988 to be 3.3 Goz.

### Producing Companies

#### South Africa

*Impala Platinum Holdings Ltd* is a subsidiary of *General Mining Union Corp. Ltd* (Gencor). Major shareholders are

*Consolidated Nominees (Pty) Ltd.* (54%), *National Selections Ltd.* (5%) and *Industrial Selections Ltd* (5%).

The company holds mining leases over a total of 12 086 ha in the Bafokeng Tribal Area in Bophuthatswana near Rustenburg, Transvaal. The group operates the *Bafokeng South and North* and the *Wildebessfontein South and North* mines. There is a concentrator, smelter and sulphuric acid plant near Rustenburg and a nickel-copper refinery and platinum metals refinery at Springs, Transvaal. The installed capacity of the mines and refineries is 1Moz platinum a year.

A wholly owned subsidiary company *Gazelle Platinum Ltd* is developing a new mine, Karee, east of Rustenburg. The first metal is expected to be produced in 1990. Full output of 100 koz per year platinum is expected by 1991. Impala needs the estimated eventual output of 300 koz per year from Karee

as it's Merensky reef reserves become exhausted and it's mining lease there expires in 2003.

*Rustenburg Platinum Mines.* is part of the Rustenburg Group of companies. Beneficial share ownership is held by *Johannesburg Consolidated Investment Co. Ltd.* (32.62%) and by *Anglo American Corp of South Africa Ltd* (23.79%). The company is the largest of the South African mining operations. It operates three major mines in the Merensky Reef producing platinum, palladium, rhodium ruthenium, iridium, osmium, gold, silver, copper and nickel. Platinum is the primary product. Through its mines the company controls accessible Merensky and UG-2 ore reserves over a total distance of 55 km in length down to depths well in excess of 1 000 meters.

A further 50 kt/month operation may be established at Lebowa, Maandagshoek, operated by a subsidiary com-

pany, *Lebowa Platinum Mines Ltd (Lebowa Plats)*. Lebowa is currently expanding the Atok mine, which will take monthly production of ore from the Merensky Reef from 29 kt to 70 kt by end August 1991. In addition, Lebowa Plats and Rustenburg through their jointly owned subsidiary Potgietersrus Platinum may establish a mine on the Platsreef, northern Transvaal, by 1993.

Processing and refining is carried out in South Africa by *Rustenburg Refiners Pty Ltd*. Refining was previously also done in the UK at Royston, Hertfordshire, where the plant was managed by *Matthey Rustenburg Refiners (MRR)*, the holding company being jointly owned by Rustenburg and the *Johnson Matthey Group*. The UK refinery closed in mid-1989, as did another plant in South Africa and were replaced by a new refinery in Bophuthswana.

The new plant had been expected to considerably shorten processing time

**Table 3**  
**PGM mine production, reserves and reserve base**  
**(kg metal content)**

	1984	1985	1986	1987	1988	Reserve (%)	Reserve base (%)
Canada <sup>1</sup>	10 369	10 534	12 190	10 930	12 541	0.4	1.1
Colombia	314	362	447	680	810	na	na
Japan <sup>2</sup>	1 658	2 050	2 116	2 160	1 817	-	-
Republic of South Africa*	106 557	115 000	123 000	131 000	133 000	88.4	88.3
USA	455	470	500	3 600*	5 100*	0.4	1.1
Other market economies	647	584	747	630	732	0.3	0.1
USSR*	106 000	109 000	112 000	115 000	117 000	10.5	9.4
<b>Total</b>	<b>226 000</b>	<b>238 000</b>	<b>251 000</b>	<b>264 000</b>	<b>271 000</b>	<b>100.0</b>	<b>100.0</b>

\* Estimates

<sup>1</sup> Platinum metals content of concentrates, residues and matte exported, <sup>2</sup> Metal production

Source:

British Geological Survey, US Bureau of Mines

**Table 2**  
Control of palladium mining in 1989  
(share in %)

	Controlling company	Base country	Share	Producer	Country	Prod (t)
1	AAC	RSA	100	Rustenburg	RSA	18.0e
			42	Palabora	RSA	0.0s
2	Sanlam	RSA	67	Impala	RSA	8.7e
3	Inco	Canada	100	Inco	Can	5.2
4	Rembrandt	RSA	33	Impala	RSA	4.3e
5	Lonrho	UK	100	Westplats	RSA	4.0e
6	Chevron	USA	50	Stillwater	USA	2.6e
7	Manville	Canada	50	Stillwater	USA	2.6e
8	Western Mining	Australia	100	Western Mining	Australia	0.7e
9	Brascan	Canada	50	Falconbrdg	Can	0.3e
10	Trelleborg	Sweden	50	Falconbrdg	Can	0.3e

e = estimated; Total Western world production 1989 = 46.8 t.

Source:  
RMG Database

**Table 3**  
Control of platinum mining in 1989  
(share in %)

	Controlling company	Base country	Share	Producer	Country	Prod (t)
1	AAC	RSA	100	Rustenburg	RSA	41.0e
			42	Palabora	RSA	0.0s
2	Sanlam	RSA	67	Impala	RSA	22.0e
3	Rembrandt	RSA	33	Impala	RSA	11.0e
4	Lonrho	UK	100	Westplats	RSA	7.0
5	Inco	Canada	100	Inco	Inco	4.0s
6	Manville	Canada	50	Stillwater	USA	0.8e
7	Chevron	USA	50	Stillwater	USA	0.8e
8	Choco Pac	Colombia	100	Choco Pac	Colo	0.4e
9	Western Mining	Australia	100	Western Mining	Australia	0.2e
10	RTZ	UK	58	Palabora	RSA	0.1s

e = estimated; Total Western world production 1989 = 87.3 t

Source:  
RMG Database

for PGMs especially recovery of rhodium, which could take up to a year at the old refineries. Teething troubles at the new plant however, had left production behind schedule by the end of the year for all PGMs but especially rhodium. Estimates have been made of a 30koz rhodium shortfall by the time normal production levels are achieved in early 1990. Consequently, the perceived shortage of physical metal pushed rhodium prices up sharply during December 1989.

Johnson Matthey plc is the sole marketing agent for the group's products, although part of Rustenburg's output is sold direct to the *Engelhardt Corporation* under long-term agreements.

*Northam Platinum Ltd* is a new development with an estimated start-up in

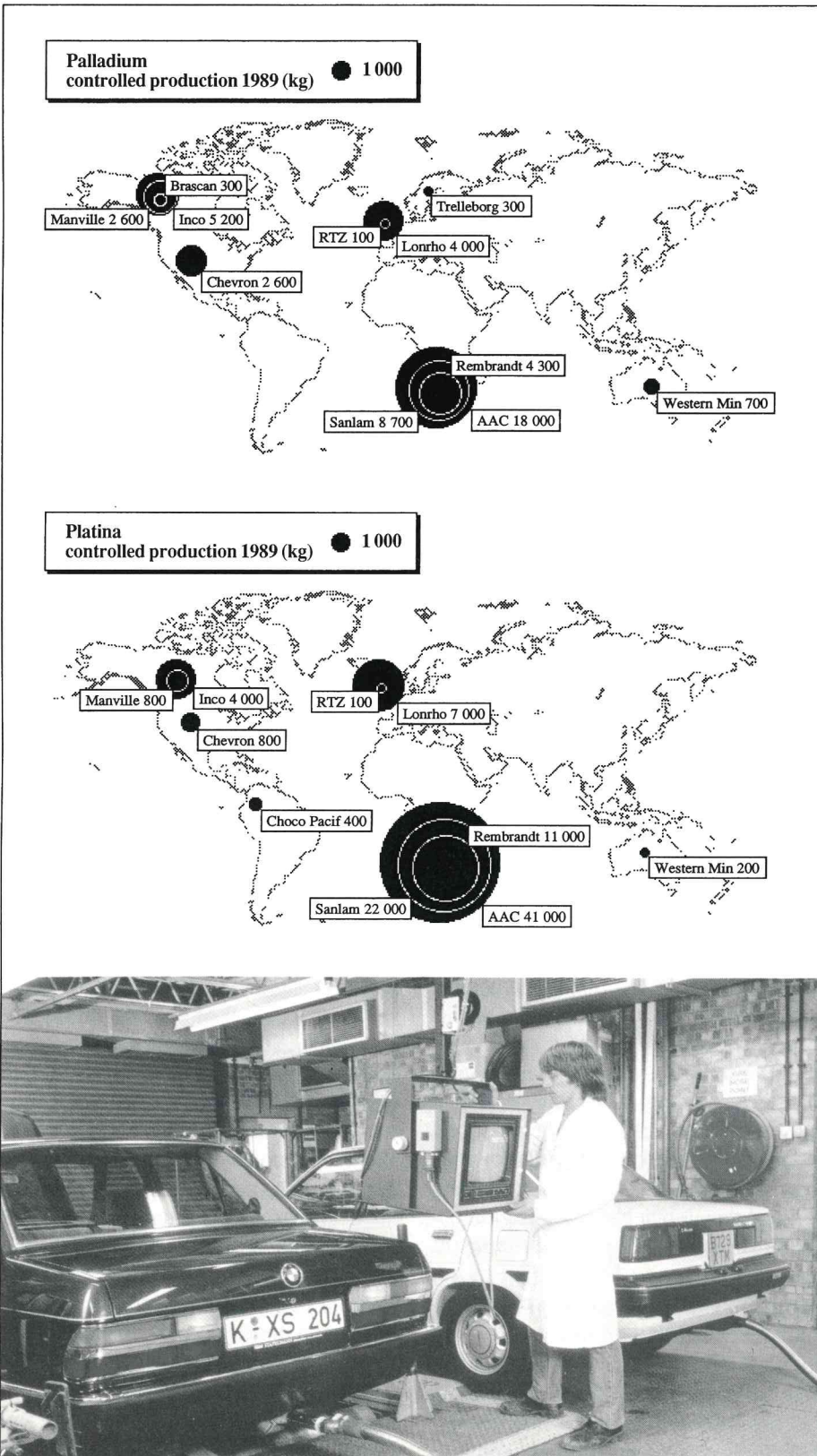
1991. Northam was 78% owned by *Goldfields of South Africa (GFSa)*, in which *Consolidated Goldfields plc. (CGF)*, London, had a 48% stake. CGF also had a 12% direct holding in Northam. This has been retained following CGF's being acquired by the Hanson Group in 1989. GFSa however, has been sold by Hanson to the South African finance house, *Rembrandt* and to *Asteroid*, previously a GFSa subsidiary.

The Northam development represents a sizeable future addition to world PGM supply. Output is forecast to be 90 kt milled per month in 1992 rising to a target level of 150 kt/month by 1995. The mine has reserves, at that rate, for excess of 100 years. Northam will be mined at greater depth than any of the

established Transvaal producers and geothermal gradients will be far higher. At 2 000 meters depth the virgin rock temperature is 65C° necessitating costly refrigeration techniques. However, grades are said to be higher than those of established mines, so production costs are expected to compare favourably with competitors. Anticipated production is of 350 koz PGM per year of which 200 koz could be platinum.

Western Platinum Ltd (Westplats) has been controlled by *Lonrho South Africa*, a member of the *Lonrho Group*, since it was formed in 1963. Lonrho achieved 99.4 per cent ownership in 1987 when the Canadian *Falconbridge* sold its 49 per cent interest, partly in order to disinvest in South Africa, but also as a debt reduction move.

Today the main use of platinum and rhodium is in emission control systems, eg catalytic converters. Photo below shows cars being tested to check the purity of their exhaust gases.



The Westplat mine is in the Marikana district east of Rustenburg. The company has its own base metals refinery on the mine. This produces precious metals concentrates which are sent for treatment by a subsidiary company, *Western Platinum Refinery Ltd*, at Brakpan on the East Rand. The company began developing its UG-2 deposits in 1982, earlier than Rustenburg and Impala.

Of the three producers, it is almost certainly milling the highest proportion of ore from this source. Output of PGM reached 274 koz in the year to September 1988, and a new plant constructed to mill and treat a further 1 Mt of ore from 1989. The plant has the capacity to treat the mine's current annual production of 4 kt smelter matte.

Further expansion is planned to occur through Eastern Platinum, a fellow subsidiary of the Lonrho group. The company was formed in 1987 to exploit reserves for which Western held, or intended to apply for a mineral lease and which lie to the north and east of Western's current operations in the Transvaal.

*Barplats Mines* is a wholly owned subsidiary of *Barplats Investments Ltd*. This in turn is 59% owned by *Rand Mines Ltd*, one of South Africa's oldest mining houses and the mining arm of the *Barlow Rand Group*. *Barplats Mines* have two mining operations:

*Kennedy Vale Mine* (previously *Rhodium Reefs Ltd*). The orebody lies below a vanadium deposit on the Merensky and UG-2 reefs. The mine is scheduled to come into production in 1996, yielding 180 kt/month.

*Crocodile River Mine* (previously *Lefkochrysos mine*, after the Greek for "white gold"), is a new medium sized PGM mine on the Merensky and UG-2 reefs. The aim is to extract ore from outcrop areas, beginning at depths of only 20 meters below the surface. Estimated initial yield would be 170 koz annually. ■