PLATINUM-GROUP METALS

By Henry E. Hilliard

The lack of shipments from Russia in the first half of 1997 caused increasing tightness in the major platinum-group metals (PGM) market, stimulating an increase in the price for platinum from a low of under $350 per troy ounce in February to over $490 per troy ounce in June. During the same period, the price of palladium increased from $124.73 per troy ounce in January to a 17-year high of $245.50 on August 5. Despite the later resumption of Russian shipments, borrowing cost remained high, supporting the platinum price above $400 through November and palladium prices above $200 through December.

Global mine production of PGM increased by about 2% over 1996 production to 288,000 kilograms, taking output to a 5-year high. South Africa, the world's largest producer, increased its platinum and palladium output by 2%. Production in Russia, the world's second largest producer, was essentially unchanged. In the United States, production of platinum and palladium at the lone domestic mine was up by more than 38%. Mine production of the other four PGM remained unchanged at about 15,600 kilograms.

The automobile industry continued to be the major consumer of PGM. In 1997, autocatalysts accounted for approximately 64% of world platinum demand, 61% of palladium demand, and 90% of rhodium demand. Despite the overall increase in vehicle sales in 1997, demand for platinum by the automotive industry fell by 1,600 kilograms to 56,900 kilograms owing to the further adoption of palladium-based technology. The growing use of palladium by the automotive industry continued unabated in 1997, with palladium-rich and palladium-only autocatalysts remaining in the forefront of emission control technology. The drive to attain increasingly lower emissions to meet the lower standards required by U.S. and European legislation has led to the widespread use of closed-coupled catalysts with high palladium loadings. In addition, underflow catalysts, traditionally the domain of platinum-rhodium formulations, are now being replaced by their palladium counterparts. The United States leads the world in establishing strict emission standards. Beginning in 1996, automobiles were required to be in compliance with the Clean Air Act of 1990. This act required a 40% reduction in hydrocarbon and a 60% reduction in nitrous oxide emissions, and durability standards of 10 years or 100,000 miles for emission control systems. In Europe, Stage II emission standards took effect in January 1996 for new models and from the beginning of 1997 for all new vehicles.

Platinum finds a variety of industrial uses due to its unique chemical and physical properties. The electronic and glass industries were in the forefront of demand. Growth in the personal computer market has been instrumental in the growth of both markets. The glass industry has benefited from the need for high-quality glass for liquid crystal displays and cathode ray tubes, while the electronic sector benefited from the demand for data storage disks that are often coated with platinum alloys. The addition of a thin platinum-cobalt layer improves the data storage capabilities of the disk, allowing more data to be stored in a smaller space.

Consumer demand was strong for iridium in January 1997, as prices increased from $110 per troy ounce at the start of the month to $200 at the end. The use of iridium in process catalysts has traditionally been small. However, substantial quantities are now being sold for a new process being adopted in several acetic acid plants. Also, a major Japanese automaker was using iridium in the autocatalyst system of one of its popular models. Iridium is also being used in a small number of automotive spark plugs, principally in the United States. Demand for iridium and ruthenium was driven by world consumption of chlorine, which is used in the production of polyvinyl chloride. Iridium and ruthenium are both required for coating anodes used in the production of chlorine.

At the beginning of 1997, the Engelhard unfabricated price for rhodium was $235 per troy ounce. In late January the price sank to around $200, it lowest price in more than 20 years. The price was largely unaffected by gains in platinum and palladium prices during February, trading at around $205. Owing to a lack of supplies from Russia, the price rose gradually over the next 2 months. At the end of April, it reached $310 and increased to $375 in June. The price drifted down to $300 during August and September before recovering to $350 in mid-October and closing out the year at $360. Demand for rhodium by automakers in Japan and Europe increased slightly in 1997 but North American demand was somewhat less owing to the use of palladium only catalysts. This decline will likely be reversed in the next few years as U.S. vehicles become subjected to new high speed certification tests. Nitrogen oxides emissions increase at high speeds and it will be difficult to meet the new standards using palladium only catalysts.

Legislation and Government Programs

Environmental Regulations.—On July 16, the Environmental Protection Agency (EPA) signed its final new standards for ozone and particulate matter. The new standards for particulate matter call for regulation of particles 2.5 microns or smaller in concentrations of 15 micrograms per cubic meter annually and 65 micrograms per cubic meter daily. The new standards are scheduled to take effect between 2000 and 2002. EPA's current standards call for regulation of particulates of 10 microns or smaller in concentrations of 50 micrograms per cubic meter annually and 150 micrograms per cubic meter daily. This is the first update in 20 years for ozone and 10 years for particulate matter. The metal mining industry strongly opposed the tighter standards on the amounts of allowable ozone and soot particles, saying it was concerned with the science and cost of implementing the standards. EPA maintained that the new rules will be implemented in a cost-effective way.

Defense National Stockpile Actions.—On June 13, the administrator of the Defense Logistics Agency's Defense National Stockpile Center (DNSC) announced that the DNSC was loaning 2,520 kilograms of platinum from the National Defense Stockpile (NDS) to the U.S. Mint for use in the Mint's coinage program (Defense National Stockpile Center, 1997). The terms of the agreement between the Mint and the Stockpile involve a loan of 2,520 kilograms of 99.95% platinum to the Mint. The Mint was required to return a like amount of similar quality platinum before the agreement expires in the year 2003. If the occasion should arise, the Stockpile has the right to require the return of its platinum upon 30 days notice. The actual transfer of the material took place starting on June 13, 1997. The move involved taking the platinum from DNSC vaults in the Treasury depository at West Point, NY, and delivering it to the Mint. This was an internal Government transaction. No money changed hands nor was the material placed in commercial commodity markets. In September 1997, the U.S. Mint unveiled its first platinum bullion coin made from the metal borrowed from the DNSC. The platinum Eagles were issued in one-ounce, half-ounce, quarter-ounce and tenth-ounce sizes.

In its 1997 *Report to Congress on National Defense Stockpile Requirements* for strategic and critical materials, the U.S. Department of Defense recommended to Congress that all stockpiled metals except platinum, iridium, beryllium, and refractory-grade bauxite be eliminated from the NDS. The report, which is submitted every 2 years, recommended keeping 605 kilograms of palladium (value, $1.82 million) and 782 kilograms of iridium (value, $1.96 million). Current NDS inventory for these metals is: 39,300 kilograms of palladium and 920 kilograms of iridium. The Defense Logistics Agency is not expected to change its sales approach as a result of these recommendations as it is going to take years to dispose of all the surplus material at the current level of sales authority.

Production

The Stillwater Mine, in Nye, MT, is the only U.S. primary PGM producer. Stillwater posted full year production of 8,400 kilograms of palladium and 2,610 kilograms of platinum in 1997, increases of 2,300 kilograms palladium and 770 kilograms platinum over production in 1996. The increases were the results of an expansion program that allowed Stillwater to reach an ore throughput of 1,810 metric tons per day in the fourth quarter of 1997. Stillwater was in the process of completing a feasibility study to determine the optimum size of the mine and ways to increase production. The alternatives include deepening the existing 594-meter shaft and/or increasing lateral development around the shaft. With this expansion, Stillwater projected that ore throughput would increase from 1,810 tons per day to between 2,720 and 2,990 tons per day. Reportedly the expansion would lead to approximately a 9,330-kilogram increase in production of PGM at the Stillwater mine. Stillwater also proceeded with work at the fully permitted East Boulder project, 21 kilometers west of the Stillwater Mine. The East Boulder project was halted in late 1996 owing to declining metal prices. The company successfully completed the first phase of the expansion in November 1997 by restarting East Boulder and authorizing the acquisition of a tunnel-boring machine. Once the tunnel-boring machine has been received, it will be assembled and put in place to drill a 6-kilometer tunnel 5 meters in diameter that will provide access to the J-M Reef. The J-M Reef extends 45 kilometers, and the average width of the ore body is about 3 meters. The average grade of Stillwater's proven and probable reserves was reported as 25 grams of PGM per ton of ore. Stillwater officials expected tunnel boring to begin in the second half of 1998. Plans for East Boulder reportedly indicate production would begin in the second half of 2002 and be at full capacity of about 15,600 kilograms per year PGM in 2003 (Stillwater Mining Co., 1997).

Consumption

Demand for platinum in the Western World weakened slightly in 1997 and was estimated to be about 56,900 kilograms–down 2.7% from 58,500 kilograms in 1996. The decline was due to another fall in the use of platinum-rich catalyst systems on gasoline vehicles in Europe. The majority of North American vehicles continued to be equipped with platinum-based auto catalyst systems, and platinum demand was little changed in 1997. Consumption of platinum by Japanese carmakers was estimated to have risen slightly, in line with an increase in the production of export models, many of which were equipped with platinum-rich catalysts. Demand for palladium was estimated to have expanded by 39,500 kilograms, reaching 231,400 kilograms, spurred by a recovery in capacitor production and another advance in demand from the auto industry (Johnson Matthey, 1997). In the United States, California's low emission vehicle (LEV) legislation was expected to have a substantial impact on palladium use. About 1 million cars meeting LEV limits are projected to be manufactured for the 1998 model year and most will carry additional palladium catalysts. If, as expected, LEV legislation is adopted on a wider basis, it will lead to significant growth in palladium consumption.

Prices

Platinum prices peaked on June 6 at $490 per troy ounce after hovering in the $350 to $360 range for the first 5 months of the year. Owing to the lack of shipments from Russia and the uncertainty of when shipments would resume, prices remained above $400 through November 10, when the price fell to $395, closing out the year at about $350. Palladium prices began the year in the $123 to $130 range, peaking in June at $240. Again, the price increase was spurred by the lack of shipments from Russia. The price fell below $200 in July but rallied briefly on August 4 to $246 before falling back to $197 on September 2. The price rose to $201 on September 11 and remained above $200 for the remainder of the year. Rhodium began the year at about $235 on January 6 and continued to rise, peaking at $375 on June 9. The price fell back to $360 on June 19 and remained at about that level for the remainder of the year.

Foreign Trade

U.S. net import reliance as a percentage of apparent consumption in 1997 was estimated to have been 84% for platinum and 78% for palladium. Imports accounted for 97% of primary supply for platinum and 92% for palladium in 1997, if Government stockpile sales are excluded. Total U.S. imports, excluding waste and scrap, totaled 77,300 kilograms, with a value of $926.5 million. As usual, South Africa accounted for about 60% of the imported platinum and 22% of the palladium while Russia accounted for 10% of the platinum and 47% of the palladium. The second largest source was the United Kingdom, with 14% for platinum and 15% for palladium, followed by Germany and Belgium. Imports from Canada were affected by industrial actions which halted mining at Inco in June and Falconbridge in August. Refined output of PGM in Canada was reduced slightly; however, the total impact on PGM shipments was small.

World Review

Russia—The price of palladium increased to a 17-year high of $245 per troy ounce at the London morning fixing on August 5. On the New York Mercantile Exchange, the September contract for palladium was up $6.90, to $222.50 per troy ounce. Traders cited speculative trading, along with the uncertainty over the quantity of palladium Russia would deliver, as the main reasons for the market's unusual behavior. Russia exported 123 tons in 1996, which accounted for two-thirds of the world's supply. During the first half of 1997, Russian shipments of palladium were limited. This created a shortage, causing the price to increase to over $200 per troy ounce. Palladium had traded in the range of $115.75 to 149.95 per troy ounce in 1996. Russian exports of palladium resumed to Japan on July 10, platinum shipments began 2 weeks later. To complicate the situation further, the Russians reportedly shipped palladium only in ingots, not sponge, which is the widely used form of palladium for catalytic converters and other applications. Autocatalyst manufacturers were affected most by the shortages because in recent years manufacturers have been using more palladium-base catalytic converters in place of the traditional three-way converters. The shortage of palladium sponge forced most autocatalyst manufacturers to buy ingots and pay refiners to return them as sponge. As a result, a large premium developed for palladium sponge over ingots (Platt's Metals Week, 1997b).

The Krasnoyarsk nonferrous metals plant changed hands when Norilsk Nickel reached an agreement in principle to hand over its ownership to the Krasnoyarsk territorial government to pay off its regional tax debt. Krasnoyarsk, which accounts for about 95% of all PGM refined in Russia, uses as its feed material a 30% concentrate from the Norilsk nickel mining complex. Krasnoyarsk supplies the privately owned Sabin Metal Corp. refinery of Chicago with precious-metals-bearing slags, refinery residues, electronic scrap, and spent catalysts through a joint venture called SAKRAS (Platt's Metals Week, 1997c).

South Africa.—PGM, along with byproduct cobalt, copper, gold, nickel, and silver, occurs in South Africa in three separate layered reefs associated with mafic rocks of the Rustenburg Layered Suite of the Bushveld Complex. They are the Merensky Reef, the UG2 Chromite Layer, and the Platreef. The PGM occur as alloyed native metals, as platinoid minerals (e.g., sperrylite and braggite) and in copper, nickel, cobalt, and iron sulfide minerals (e.g., chalcopyrite, pentlandite, and pyrrhotite) (South Africa Department of Minerals and Energy, 1997). Rustenburg Platinum Mines Ltd., a subsidiary of Anglo American Platinum Corp., Ltd. (Amplats) is the largest single South African PGM producer, and operates three geographically separate sections, all on the western limb of the Complex. The other mines on the western limb are the two adjoining Impala Platinum Ltd. Mines, Bafokeng North Mine, and Wildebeestfontein South Mine; the two Lonrho Platinum Division mines, Eastern Platinum Ltd., and Western Platinum Ltd.; and Northam Platinum Ltd., which is controlled by Gold Fields of South Africa Ltd.

South Africa produced 192,600 kilograms of PGM in 1997, about 2% more than in 1996. Amplats was by far the largest producer. In April, Amplats announced that it had expanded its Potgietersrust concentrator capacity from 250,000 tons per day to 375,000 tons per day and that it planned to establish a new PGM mine at Boschkoppie, situated in the Rustenburg area. The company anticipates that available resources will, over the life of the project, provide some 60 million tons of ore for milling at an estimated combined platinum, palladium, rhodium, and gold head grade of 6.1 grams per ton. The company expects annual platinum output to be about 7,780 kilograms of refined metal when the mining operations reach full production in 2002. The life of the mine is reportedly expected to be a minimum of 25 years (Metal Bulletin, 1997).

Australia-based Aquarius Platinum NL announced in March that it will start mining in the second half of 1998, on schedule, at its Kroondal platinum project in South Africa. The chromite and platinum deposit, situated in the Bushveld complex in the Transvaal, reportedly has a total identified mineral resource of 24.5 million tons grading 5.5 grams per ton of predominately platinum, palladium, and rhodium. The operator of the mine, Kroondal Platinum Mines Pty. Ltd., plans to develop a 1.2 million ton-per-year mechanized underground mine, involving stoping the Leader, Parting, and Main seams as a single unit. Reportedly, studies have suggested that this mining method would have several benefits, including lower capital and operating cost, and a smaller workforce. On-site processing facilities will consist of crushing, dense media separation, grinding, and flotation circuits to produce a high-grade PGM concentrate. At an in-situ head grade of 5.5 grams per ton PGM and gold, and a mining rate of 1.3 million tons per year of UG-2 chromite, the project was forecast to produce 5,400 tons of concentrate annually containing 3,110 kilograms of platinum, 1,550 kilograms of palladium, 467 kilograms of rhodium, and 40 kilograms of gold. The project was expected to produce 65.3 tons of PGM over a 14-year mining life (Minerals Investor, 1997).

Zimbabwe.—The Australian company, BHP Minerals, announced the first shipment of PGM from its Hartley Mine in Zimbabwe. The mine is a 67:33 joint venture between manager BHP and Australia's Delta Gold. The PGM, in the form of a gray-black powder, were shipped to England to be refined by Johnson Matthey. Shipments from Hartley were expected weekly, rising to twice a week as production increases. Full production from the mine was expected to be reached before the end of 1998. At full production, ore extraction reportedly will total 2.16 million tons per year, to produce 4,670 kilograms per year platinum, 3,420 kilograms of palladium, 358 kilograms of rhodium, and 715 kilograms of gold. At the same time, Delta Gold is on the verge of commissioning a feasibility study into another platinum deposit in Zimbabwe that could eventually lead to a mine bigger than the

Hartley Mine. The Ngezi deposit, 50 kilometers south of Hartley, reportedly has sufficient resources to support a mine for 15 to 20 years with double the full production output of the Hartley Mine (Platt's Metals Week, 1997a).

Current Research and Technology

New Process Uses Less Platinum in Coating Power Tube Grids.—Sputter-coating power tube grids with a platinum-base coating, instead of cladding, reduces the quantity of precious metals required by 15% to 30%, according to one fabricator. Ordinarily, platinum-clad molybdenum grid wire is produced with a very thick precious metals coating. However, coating the wire by the sputter process reportedly not only saves material cost, but is capable of reducing secondary emissions. An active diffusion barrier prohibits interdiffusion of the core and coating, and produces highly consistent coating. The sputter process is computer-controlled, which eliminates thickness variations. It also enables codeposition of alloys and compounds that cannot be mechanically worked or alloyed by other techniques (Advanced Materials & Processes, 1997).

Nanotubes Containing Platinum Prepared.—Nanosized carbon tubes filled with metal are known to have industrial applications as catalysts, as nanowires for conducting electricity, and as composite materials. The preparation and structure of carbon nanotubes and the encapsulated metal determine the form that the active metal will take. Researchers at Tohoku University, Japan, prepared uniform platinum-filled carbon nanotubes, with metal deposited only within channels. The researchers used a template method involving the electro-oxidation of aluminum plate. The resulting aluminum oxide-film template was an array of parallel, straight channels of nanometer-scale diameter. Carbon was deposited on the channel walls by thermal decomposition of propene. Platinum was loaded onto this carbon film by impregnating it with an ethanol solution of hexachloroplatinic acid at room temperature. The chloroplatinic acid was then reduced to platinum in the channels by either heat treatment at 500 °C under hydrogen or by treating with excess $NaBH_4$ (sodium borohydride) solution at room temperature. The template was then removed with hydrofluoric acid and a platinum metal/carbon nanotube composite was obtained (Platinum Metals Review, 1997).

Ruthenium Intermetallic Compound Undergoing Test for Possible Use In Sparkplugs.—A new generation of sparkplug material, which fulfills the stringent requirements of the modern automotive industry, is undergoing test work in laboratories. The novel electrodes make use of an intermetallic compound, ruthenium aluminide, with an unusual blend of properties. Unlike conventional alloys, which are mixtures of phases without any particular chemical formula, intermetallic compounds are single phases based on definite atomic formulae, with a fixed or narrow range of chemical composition. The chemical bonding may range from metallic to purely ionic, or partly ionic or covalent. Intermetallics are characterized by high melting points and great strength, particularly at high temperatures. These properties make intermetallics potential candidates for use as high-temperature structural materials. However, the main potential application for ruthenium aluminide is in sparkplug electrodes. An extensive test program for ruthenium aluminide-based sparkplug electrodes reportedly has found that the material possesses; (1) the toughness to withstand the thermal shock associated with cycling between temperatures of 60 °C and 3,000 °C, (2) resistance to arc erosion and oxidation, and (3) the necessary thermal conductivity to conduct heat rapidly from the working face, preventing pre-ignition even in high-performance engines (Mintek Bulletin, 1997).

Outlook

Demand for PGM by the automotive industry for use in catalytic converters will continue to drive the world PGM market in the next decade. While no major growth has been forecasted, more than 15 million cars and light trucks were sold in the United States in each of the last 2 years. There have been only 5 years when U.S. sales have exceeded 15 million units; however, the demand for light trucks and sport utility vehicles should help maintain demand at this level for the next few years. Demand for PGM can be expected to increase further as manufacturers introduce catalysts with higher PGM loadings to meet stricter emissions standards in the United States and Europe. The use of PGM in sparkplugs, especially in the United States, could also increase demand.

The outlook for increased demand in electrical applications is mixed. After falling sharply in 1996, demand rebounded somewhat in 1997 owing to increased production of multilayered ceramic capacitors (MLCC) which are attached to printed circuit boards by silver-palladium leads. After 1997, demand is expected to be limited by continued miniaturization, selective plating, and, to a lesser extent, substitution by nickel. Also, as the size of MLCC's become smaller, the older, larger types of capacitors will be replaced with surface mounted MLCC's, which use less metal than leaded capacitors. With selective plating, only tiny specs of gold or palladium are placed on electronic contacts, thereby reducing the amounts of precious metals required.

Demand for PGM in jewelry is expected to rise as significant expansion in the U.S. and Chinese markets is accompanied by modest growth in Europe. Demand for PGM items in Japan and other parts of Asia was down sharply in 1997 as retail sales fell by 20% during the first 7 months of the year.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF PLATINUM GROUP METALS IN 1997 1/

(Kilograms)

Country	Ores and concentrates	Waste and scrap	Refined					
			Platinum	Palladium	Rhodium	Iridium	Osmium	Ruthenium
Imports:								
Australia	--	160	1,620	27	1	--	--	--
Belgium	--	92	4,960	15,800	132	--	--	2
Canada	--	455	2,500	3,670	(2/)	(2/)	--	--
Chile	--	15	90	--	--	--	--	--
China	--	--	13	2,840	130	3	--	--
Colombia	--	40	109	--	--	--	--	--
France	--	537	9	292	31	(2/)	--	(2/)
Germany	--	209	4,300	6,430	263	175	--	214
Hong Kong	--	507	(2/)	27	--	--	--	--
India	--	59	--	30	(2/)	--	--	--
Ireland	--	10	--	41	--	--	--	--
Italy	--	137	228	1,480	2	(2/)	--	(2/)
Japan	--	20	156	9,950	36	3	--	2
Mexico	(2/)	155	17	5	2	--	--	--
Netherlands	--	295	229	101	49	--	--	--
Norway	--	--	369	2,590	16	1	--	5
Russia	--	(2/)	1,590	65,200	6,880	198	--	897
South Africa	--	11	45,900	19,500	5,090	677	54	8,750
Switzerland	--	140	3,910	8,290	1,080	27	--	491
United Kingdom	--	2,150	10,800	11,700	669	778	(2/)	1,180
Other	--	324	476	230	--	--	--	--
Total	(2/)	5,310	77,300 3/	148,000	14,400	1,860	54	11,500
Exports:								
Australia	--	--	2,450	106	--	--		
Belgium	--	865	5,550	7,610	(2/)	--		
Canada	1	705	795	2,320	(2/)	7 4/		
Chile	--	--	2	2	--	--		
Finland	--	--	846	--	--	--		
France	--	1	879	920	--	--		
Germany	80	3,040	693	1,580	2	13 4/		
Hong Kong	--	--	157	206	1	33 4/		
Ireland	--	--	1,020	692	84	2 4/		
Israel	--	1	65	228	--	--		
Italy	--	45	259	3,840	--	6 4/		
Japan	46	1,630	2,910	2,940	6	87 4/		
Korea, Republic of	3	--	812	2,110	80	2 4/		
Malaysia	--	--	120	44	--	--		
Mexico	5	3	52	7,890	(2/)	1 4/		
Netherlands	--	--	260	2,460	(2/)	5 4/		
Singapore	--	--	4	106	(2/)	--		
South Africa	3	--	9	1,640	2	--		
Sweden	--	107	80	142	--	3 4/		
Switzerland	178	(2/)	4,080	2,580	24	2 4/		
Taiwan	--	--	141	4,010	(2/)	7 4/		
United Kingdom	369	6,470	1,700	2,070	18	403 4/		
Uruguay	--	--	5	10	--	--		
Venezuela	--	1	26	--	--	--		
Other	8	4	111	304	65	3 4/		
Total	693	12,900	23,000	43,800	282	574 4/		

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.
3/ Of this amount, 1,260 kilograms was in the form of platinum coins.
4/ Includes osmium and ruthenium.

Source: Bureau of the Census.

TABLE 2
PLATINUM-GROUP METALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Kilograms)

Country 3/	1993	1994	1995	1996	1997 e/
Platinum:					
Australia e/ 4/	100	100	100	100	100
Canada e/ 5/	5,000	6,000	9,320	8,080 r/	7,550
Colombia	1,722	1,084	973	669	500
Finland e/	60	60	60	60	60
Japan 6/	661	691	730	816 r/	680
Russia e/	20,000	15,000	18,000	17,000 r/	17,000
Serbia and Montenegro e/	10 7/	10	10	10	10
South Africa e/ 5/	109,000	114,000	118,000	123,000 r/	125,000
United States e/ 8/	2,050	1,960	1,590	1,840	2,610
Zimbabwe	4	7	10 e/	100 r/ e/	100
Total	139,000	139,000	149,000	151,000 r/	154,000
Palladium:					
Australia e/ 4/	400	400	400	400	400
Canada e/ 5/	6,000	7,000	5,950	5,160 r/	4,810
Finland e/	100	100	100	100	100
Japan 6/	1,183	1,277	2,174	2,180 r/	1,900
Russia e/	50,000	40,000	48,000	47,000 r/	47,000
Serbia and Montenegro	72	50	50 e/	50 e/	50
South Africa e/ 5/	48,000	47,800	49,400	54,800 r/	55,900
United States e/ 8/	6,780	6,440	5,260	6,100	8,400
Zimbabwe	11	17	20 e/	120 r/ e/	120
Total	113,000	103,000	111,000	116,000 r/	119,000
Other platinum-group metals:					
Canada e/ 5/	1,440	1,970	803	697 r/	651
Russia e/	4,000	3,000	3,600	3,500 r/	3,500
South Africa e/ 5/	19,000	22,100	22,800	11,400 r/	11,500
Total	24,400	27,100	27,200	15,600 r/	15,700
Grand total	276,000	269,000	287,000	283,000 r/	288,000

e/ Estimated. r/ Revised.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through April 29, 1998. Platinum-group metal production by Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

3/ In addition to the countries listed, China, Indonesia, and the Philippines are believed to produce platinum-group metals and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan.

4/ Platinum-group metals recovered from nickel ore processed domestically. Platinum-group metals extracted from exported ores are believed to be included in the production figures for Japan and may be included in figures for other receiving countries.

5/ Country reports only total of platinum-group metals produced. Figures for constituent metals are estimates.

6/ Production derived entirely from imported ores.

7/ Reported figure.

8/ Estimates for the Stillwater Mine from published sources. A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.