PLATINUM-GROUP METALS

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Increasing demand for palladium, platinum, and rhodium, mainly from the automotive sector, led to deficits in supplies for these metals in 1999. Of the three metals, palladium had the largest deficit owing to increased demand from the automotive sector and protracted delays in exports from Russia, the world's largest producer. Russia accounted for 58% of U.S. palladium supply and 11% of U.S. platinum supply in 1999. Continued delays in supplies from Russia caused palladium prices to rise to $363.20 per troy ounce (ounce) in 1999 from an average of $130.39 per ounce in 1996.

The ratios of platinum-group metals (PGM) used within autocatalysts in more recent years has been changing, with a gradual shift away from platinum to increased palladium loading. Demand for platinum in autocatalysts rose to a peak of more than 59,000 kilograms (kg) in 1996 from about 1,700 kg in 1960. Since then, platinum's consumption in autocatalysts has declined steadily to around 27,000 kg in 1999. Platinum's decline, in contrast to the growth of palladium and rhodium, can be explained by increased palladium loadings in autocatalysts, which is more efficient at curbing hydrocarbon (HC) emissions. Global demand for palladium in autocatalysts increased to about 189,000 kg in 1999 from about 12,000 kg in 1990 (Johnson Matthey, 2000a). Rhodium's growth was somewhat slower, but increased steadily to an estimated 15,800 kg in 1999 from 10,400 kg in 1990. Rhodium's rise was in line with more stringent restrictions on nitrogen oxide (NO_x) emissions from automobile exhausts for which it is a good reducing agent. In the United States, palladium demand increased to an estimated 5,100 kg in 1999 from 2,300 kg in 1998. National Low Emission Vehicle (NLEV) standards, to be phased in by 2001, with emphasis on lowering HC emissions, will likely lead to further growth of palladium's use in this sector (Johnson Matthey, 2000b).

The high price and unavailability of palladium caused some catalyst manufacturers to start developing new catalyst formulations that use less palladium and more platinum and rhodium. This shift caused the price of rhodium to rebound to more than $900 per ounce in 1999 from a low of about $300 per ounce in 1997.

World mine production of PGM increased by about 8%, to 378,000 kg compared with that of 1998. South Africa, the world's largest producer, increased its palladium and platinum output by about 12% to 194,600 kg. Production in Russia, the world's second largest producer, was estimated to have increased by 7% to 112,000 kg. PGM production in the United States was down by more than 8%.

The automotive industry continued to be the major consumer of PGM. In 1999, autocatalysts accounted for approximately 97% of rhodium demand, 63% of palladium demand, and 29% of platinum demand. Despite the overall increase in vehicle sales in 1998, demand for platinum by auto manufacturers declined, owing to the further adoption of palladium-based technology. Demand for platinum in jewelry manufacture, on the other hand, continued to grow and has become platinum's largest single application (Metal Bulletin Monthly, 2000). Platinum jewelry fabrication rose in all regions, with demand in China rising by 37% to more than 26,400 kg. Demand for platinum metal in the industrial sector continued to increase; demand was expected to be up by 3,000 kg and reach a total of 40,400 kg. The most rapidly growing application was the use of platinum to enhance the memory storage capacity of hard drives in personal computers. The market for these disks was expected to grow by 10% in 1999 (Johnson Matthey, 1999).

Consumer demand for iridium was essentially unchanged in 1999. Prices increased from $410 per ounce to $415 per ounce and remained at that level for most of the year. The use of iridium in process catalysts has traditionally been small, although substantial quantities were sold for use in a new process at several acetic acid plants. Also, a major Japanese automaker used iridium in the autocatalyst system of one of its popular models. Iridium was 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 were required for the coating of anodes used in the production of chlorine.

Demand for rhodium by automakers in Europe and Japan increased in 1999, but North American demand decreased somewhat owing to the use of palladium-only catalysts. This decline likely will be reversed in the next few years as U.S. vehicles become subjected to new high-speed certification tests. NO_x emissions increase at high speeds, and it will be difficult to meet the new standards if palladium-only catalysts are used.

Legislation and Government Programs

The Annual Materials Plan (AMP) lists the proposed maximum quantity of each commodity that may be sold and/or purchased by the Department of Defense (DOD) for the National Defense Stockpile in a given fiscal year. Before any material may be bought or sold for the stockpile, the Congress must enact specific enabling legislation. After receiving congressional authority, DOD develops the AMP, which is submitted to the Congress by February 15 of each year. Prior to submission, the AMP is coordinated with the Market Impact Committee—composed of other government agencies,

including the U.S. Geological Survey—that advises DOD on the projected domestic and foreign economic effects of proposed stockpile transactions. The AMP is effective on the first day of the fiscal year. If DOD proposes significant changes to the AMP during the fiscal year, a revised AMP is submitted to the Congress. The revisions become effective 45 calendar days after their submission. In fiscal year 1999, DOD sold 136.23 kg of iridium, 4,668.11 kg of palladium, and 3,112.56 kg of platinum. The revised fiscal year 2000 AMP calls for the sale of 138.41 kg of iridium; 6,220.70 kg of palladium; and 3,887.94 kg of platinum (U.S. Department of Defense, 2000).

Production

The Stillwater Mining Co. operates the Stillwater Mine in Nye, MT. Stillwater is the only primary palladium-platinum producer in the United States. In 1999, the Stillwater Mine reported production of 12,722 kg of palladium and platinum, 8.6% lower than production of 13,810 kg in 1998. Of the 12,722 kg produced, palladium accounted for 9,798 kg, and platinum accounted for 2,924 kg. Mine production is defined as the quantity of PGM contained in concentrate when it was shipped to the smelter. The company milled 625,000 metric tons (t) of ore in 1999, 4% less than in 1998. The mill head grade was 20.5 grams per ton (g/t) of combined palladium and platinum in 1999, compared with 21.5 g/t in 1998. East Boulder, Stillwater's new mine, is expected to begin production in 2001. The $270 million project was being developed as a 2,000-ton-per-day (t/d) underground mine near Big Timber, MT. At 2,000 t/d, Stillwater anticipates that annual production will be between 14,000 and 15,500 kg of palladium and platinum.

Stillwater operates a smelter and base metal refinery (BMR) at its metallurgical complex in Columbus, MT. At the smelter, concentrate was treated to produce matte containing approximately 20.22 kilograms per ton of palladium and platinum. The matte subsequently was sent to the BMR, which produced a filter cake that was 60% palladium and platinum. The filter cake was sent to metal refiners in California, New Jersey, and Germany, where it was converted into palladium and platinum sponge for sale to end users. The company also recovered small amounts of copper, gold, nickel, rhodium, and silver. The company continued its program of processing spent automotive catalysts for the recovery of PGM. In 1998, approximately 139 t of spent catalyst was processed in the smelter at a rate of 1 t/d. In 1999, Stillwater processed about 323 t of spent catalyst. The usual procedure was to blend concentrate from the mill with spent catalysts. The smelter is expected to increase the recycling of spent automotive catalyst to 2 t/d in 2000 (Stillwater Mining Co., 2000).

Proven and probable reserves for the company are contained in the J-M Reef in southern Montana. The average ratio of palladium to platinum contained in the reef is 3.3 to 1. At yearend 1999, proven and probable reserves contained 504,300 kg of palladium and platinum in 20.8 million metric tons (Mt) of ore grading 21.8 g/t of combined palladium and platinum.

Consumption

Platinum.—In 1999, demand for platinum by U.S. automakers declined for the third consecutive year, despite increased auto sales in the United States and Canada. Platinum demand declined because PGM loadings on catalytic converters have, over the last few years, shifted toward palladium-rich catalysts. The shift accelerated in 1999 owing primarily to the introduction of the NLEV program, which placed particular emphasis on the control of HC emissions. About one-third of new U.S. vehicles met these stricter standards in 1998. Essentially all vehicles manufactured after 2001 will meet the stricter standards. Tighter HC limits reinforced the current trend toward the use of palladium-based catalysts on gasoline-powered vehicles, owing to their superior performance regarding HC. In 1999, global demand for platinum grew by 4% to reach 173,870 kg, owing to expansion of platinum jewelry fabrication in China and the United States (Johnson Matthey, 1999).

Palladium.—In 1999, demand for palladium in the United States grew sharply, rising to about 87,400 kg. The increase was driven by higher sales of automobiles and sport utility vehicles (SUV). The larger engines of SUV required correspondingly larger volumes of catalysts to control emissions. Also, more cars manufactured in 1999 met or surpassed the NLEV standards, with more manufacturers increasing the palladium loadings in catalysts to meet these standards.

Despite sharp increases in prices during 1999, demand for palladium in multilayer ceramic capacitors (MLCC), which used a palladium-silver coated electrode, continued to be significant. Widely used in mobile phones, automobiles, and other consumer electronics, production of these devices increased by 18% in 1999. Base metal electrodes were expected to account for about 33% of the MLCC manufactured in 1999, up from about 25% in 1998. The world's largest maker of MLCC, located in Japan, reportedly will stop using palladium in its ceramic capacitors in the near future because of the metal's high price. In the United States, lower demand for MLCC was more than offset by the wider use of palladium in the plating of leadframes, connectors, and other electrical applications (Roskill Information Services Ltd., 1999).

Higher prices contributed to lower demand for palladium in dental and jewelry alloys. Consumption in the domestic chemical industry was adversely affected by worsening economic conditions in Asia (American Metal Market, 1999).

Rhodium.—Consumption of rhodium in the United States was estimated to have increased modestly in 1999 to about 5,000 kg, stimulated by increased demand by automakers. Rhodium was added to some palladium-only catalyst systems in order to meet more rigorous emissions control standards. Autocatalysts accounted for more than 90% of demand. Rhodium's other principal application was in the manufacture of specialty chemicals. Demand from this sector was weak, as consumers drew down existing stocks to cover process losses. World consumption of rhodium for autocatalysts in 1999 was estimated by Johnson Matthey to have been about 15,800 kg, up

5% from 15,200 kg in 1998. World demand for all applications was estimated to have been about 16,300 kg.

Iridium and Ruthenium.—Demand for ruthenium remained strong in 1999 as it was used in a new process that manufactured feed stock for the production of solvents and synthetic fibers. Consumption of ruthenium in catalysts used in the Kellogg advanced ammonia process was also strong in 1999. The process operated at less stringent conditions than with traditional base metal catalysts, and thus substantially reduced energy costs. The largest consumption of ruthenium was in the production of resistors for the electronics industry. Increased production of resistors, for use in consumer electronics, was somewhat offset by the miniaturization of components. Reduced sales of iridium automotive and process catalysts were somewhat offset by strong demand for crucibles for growing synthetic crystals, especially single crystal sapphires. Iridium also was used in autocatalysts for cars fitted with gasoline direct injection engines. While some believe that such engines will have problems meeting new, more stringent government emissions standards in the future, demand for iridium in the auto sector rose 2.7% to about 1,200 kg in 1999 (American Metal Market, 1999). Demand for iridium also benefitted from its increasing use in anodes for the electroplating of zinc onto steel—a process that is replacing traditional methods of coating steel parts used in the automotive industry.

Prices

In what has become an annual event, Russian shipments of PGM were delayed again in 1999, exerting upward pressure on palladium and platinum prices. In response to concerns about delayed shipments, prices for palladium rose above the price of platinum. Palladium prices also rose higher than gold prices for the first time. In fact, palladium settled higher than gold prices for most of 1999. Palladium prices, which reached $384 per ounce on April 20, traded at $353 per ounce on April 27 (Metal Bulletin, 1999). From June through November, the price of palladium varied within the range of $40 per ounce. In early December 1999, the price rose above $400 per ounce and reached a record high of $454 per ounce on December 29.

Platinum prices also rose in 1999, although the increase was not nearly as dramatic as the increase for palladium. It is important to note that Russian exports tended to have a greater impact on the palladium market, because they accounted for more than 40% of world palladium supply as compared with less than 20% of the world platinum market. Thus, in response to delayed shipments from Russia, palladium futures contracts on Nymex rose past platinum prices. The Platt's Metals Week annual average for platinum in 1999 was $378.949 per ounce compared with $374.606 in 1998.

Another PGM that benefitted from Russian supply uncertainty was rhodium. Like platinum, rhodium was affected by the 1998 Russian budget legislation with the result that little to none was exported in 1999. The shortage of rhodium, which is used in autocatalysts, pushed the price to near $1,000 per ounce in December 1999. Platt's Metals Week's annual average for rhodium was $616.041 per ounce in 1999.

World Review

Russia.—The Krasnoyarsk nonferrous metals plant, now owned by the Krasnoyarsk territorial government, accounted for about 95% of all PGM refined in Russia. The plant used a 30% concentrate from the Norilsk nickel mining complex as its feed material. Krasnoyarsk supplied the privately owned Sabin Metal Corp. refinery in Chicago with precious-metals-bearing slags, refinery residues, electronic scrap, and spent catalysts through a joint venture called SAKRAS (Platt's Metals Week, 1997). In April 1999, Krasnoyarsk received the first consignment of platinum concentrate from South Africa's Impala Platinum Holdings Ltd. for processing under a tolling agreement negotiated in 1998. The Krasnoyarsk plant has also received offers to process raw materials for metallurgical plants in Belarus and Kazakhstan. Krasnoyarsk was Russia's leading producer of blister platinum, gold, palladium and platinum ingots and powder, powdered iridium, osmium, rhodium, ruthenium, and technical silver (Mining & Metals Report, 1999).

Platinum exports from Russia ceased after the first few months of 1999 owing to legislation enacted in 1998 which restricted PGM exports to authorized "State Organs." Russia's sole PGM exporter, Almazjuvelirexport, did not fit this description and neither did any other Russian organization. At stake were Russian deliveries of at least 31,100 kg of platinum, worth $428 million. Rhodium, worth another $220 million, was also affected (Platt's Metals Week, 1999).

South Africa.—Along with byproduct cobalt, copper, gold, nickel, and silver, PGM occurs in South Africa in three separate layered reefs associated with mafic rocks in the Rustenburg Layered Suite of the Bushveld Complex in the Transvaal. The reefs are the Merensky Reef, the UG2 Chromite Layer, and the Platreef. The PGM occurs as alloyed native metals, as platinoid minerals (such as sperrylite and braggite) and in copper, nickel, cobalt, and iron sulfide minerals (such as chalcopyrite, pentlandite, and pyrrhotite (Republic of South Africa Department of Minerals and Energy, 1997a).

Rustenburg Platinum Mines Ltd., a subsidiary of Anglo American Platinum Corp., Ltd., (Amplats) was the largest single South African PGM producer and operated three geographically separate sections, all on the western limb of the Bushveld Complex. The other mines on the western limb are the two adjoining Impala Platinum Ltd. (Implats) 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. (Republic of South Africa, Department of Minerals and Energy, 1997b).

In 1999, South Africa produced about 224,900 kg of PGM, about 11% more than in 1998. Amplats was by far the largest producer. In February 1999, Implats announced that the reopening of Barplats Mining Ltd.'s mothballed Crocodile River Mine would be subjected to a detailed feasibility study, scheduled to be completed near the end of 1999. The company was also conducting a prefeasibility study at its Everest South

property to examine the possibility of mining the UG2 reef using methods similar to those being adopted at the Kroondal Platinum Mine. Impala also acquired the right to invest in mining development on the Winnaarshoek property, owned by the Canadian company, Platexco Inc. In March 1999, Impala announced that it had taken a 15% stake in Aquarius Platinum Ltd., which is a platinum prospect at Marikana, near Rustenburg. Lonmin Platinum was undertaking an expansion program, which involved an upgrade of its smelter and the Karee concentrator, providing capacity to process about 9.7 Mt per year of ore. Plant construction and mine development, started in December 1998 at Kroondal Platinum Mine, commenced production during May 1999 with full production planned for January 2000 (Republic of South Africa, Department of Minerals and Energy, 1999c).

With the Kroondal and Bafokeng mines reaching full production in 2000, South Africa could increase its already substantial share of the world PGM market. Kroondal, which will have its production smelted and refined by Impala Platinum, plans to add 3,100 kg of platinum to the market in 2000, while the Impala joint venture with the Bafokeng tribe will add another 3,000 kg during 2000 and reach more than 6,000 kg by 2002. This would boost South Africa's platinum output to more than 124,000 kg (Engineering & Mining Journal, 1999).

Current Research and Technology

A modified matte-smelting route for PGM concentrates containing high levels of chromite has been demonstrated with an industrial furnace by a PGM producer. Slightly reducing smelting conditions were used to stabilize Cr^{2+} relative to Cr^{3+}, leading to a significant increase in chromium solubility in the slag. Concentrates containing elevated levels of Cr_2O_3 can be smelted under these conditions without solid chromium spinel building up on the furnace hearth, and since a conventional PGM-bearing matte is produced, the downstream processes do not have to be modified. The relaxation of the chromite constraint enabled flotation recoveries of the PGM to be improved without detrimental effects to the smelting process. Researchers were also examining alternative pretreatment and smelting options to treat concentrates with wider variations in chromite and sulfur content. The objective was to improve PGM collection, and to increase the efficiency of SO_2 capture, as well as allowing more flexibility in the feed material. One process option also aims to separate the PGM from the base metals as early as possible in the process (Mintek Annual Review, 1999).

Iridium Catalyst Converts Methanol to Acetic Acid.—A patent awarded to a U.S. chemical company describes a method for producing acetic acid from methanol using a fixed-bed heterogenous iridium-based catalyst. Current processes use liquid-phase carbonylation to avoid catalyst loss, but have the disadvantage of mass transfer limitations and need to be run under pressure to achieve cost-effective reaction rates. Other heterogenous systems for this process have the disadvantage of costly catalyst leaching (Today's Chemist, 1999).

Palladium Alloy Used to Detect Hydrogen.—Palladium and several alloys of palladium containing silver have applications as hydrogen-sensitive metals. As hydrogen is absorbed by palladium on a substrate, the resistance of the metal changes, and the change can be detected electronically. A limitation of this method is that as palladium dissociates and absorbs hydrogen, it undergoes a phase change, causing hysteresis. Furthermore, the phase transformation may damage the layer of palladium. Researchers at the Lewis Research Center in Ohio may have solved these problems by using a hydrogen-sensitive alloy containing palladium and titanium. The palladium-titanium alloy does not undergo a phase change in the presence of hydrogen, and the change in resistance takes place even after repeated exposure to environments containing hydrogen. The titanium also acts as trapping sites for hydrogen, thus reducing the diffusion of hydrogen through the alloy and yielding a larger change in resistance (NASA Tech Briefs, 1998).

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. Demand for palladium can be expected to increase further as manufacturers introduce catalysts with higher palladium loadings to meet stricter emissions standards that require further reductions of HC emissions from motor vehicles. Sport utility vehicles and light trucks emit three to four times as much pollution as passenger automobiles. These popular vehicles, which account for almost 50% of the U.S. market for new passenger vehicles, historically have not been required to meet low emissions requirements. New clean air standards, however, are expected to bring them into compliance within the next few years, significantly increasing demand for PGM. The use of PGM in spark plugs, especially in the United States, could also increase demand.

The outlook for increased palladium demand in electrical applications will decline in the long term. After falling sharply in 1996, demand rebounded somewhat in 1997 owing to increased production of MLCC, which are attached to printed circuit boards by silver-palladium leads. In 1999, palladium demand was limited by continued miniaturization, substitution of base metals, and selective plating. Higher prices for palladium led to the substitution of nickel in MLCC, a trend that is likely to continue. Also, as the size of MLCC become smaller, the older, larger types of capacitors will be replaced with surface-mounted MLCC, which use less metal than leaded capacitors. However, the rapid growth in demand for MLCC in 1999, meant that overall demand for palladium from this sector increased marginally.

Demand for platinum in 1999 grew only slightly. Sales to Japan for jewelry fabrication declined but were offset by strong jewelry demand in China and the United States. Usage in automotive catalyst has matured, with the majority of new demand going to palladium. Long-term platinum demand will show higher growth owing to increased use in diesel automotive catalysts.

On the supply side, new projects were under development that could add more than 25,000 kg to the annual world production of palladium. The largest will be Stillwater

Mining's East Boulder underground mine in Montana. East Boulder is expected to begin production in 2001 at an annual capacity of about 15,550 kg of PGM. The other projects, located in South Africa and Zimbabwe, could add another 6,000 to 8,000 kg of PGM to the world market.

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

TABLE 1
SALIENT PLATINUM-GROUP METALS STATISTICS 1/

(Kilograms metal content, unless otherwise specified)

		1995	1996	1997	1998	1999
United States:						
Mine production:						
Palladium 2/		5,260	6,100	8,430	10,600	9,800
Value	thousands	$25,900	$25,600	$49,900	$98,500	$114,000
Platinum 2/		1,590	1,840	2,610	3,240	2,920
Value	thousands	$21,700	$23,500	$33,300	$39,000	$35,600
Refinery production:						
Palladium		NA	NA	NA	NA	14,400
Value	thousands	NA	NA	NA	NA	$168,000
Platinum		NA	NA	NA	NA	14,000
Value	thousands	NA	NA	NA	NA	$172,000
Imports for consumption, refined:						
Iridium		1,450	1,810	1,860	1,950	2,270
Osmium		73	NA	54	71	23
Palladium		124,000	146,000	148,000	176,000	189,000
Platinum, includes waste, scrap and coins		71,500	75,800	77,300	96,700	129,000
Rhodium		9,600	9,650	14,400	13,500	10,500
Ruthenium		7,520	15,600	11,500	8,880	11,400
Exports, refined:						
Iridium, osmium, and ruthenium (gross weight)		84	122	574	905	851
Palladium		26,000	26,700	43,800	36,700	44,000
Platinum		15,000	12,700	23,000	14,300	19,400
Rhodium		741	187	282	811	114
Stocks, National Defense Stockpile, December 31:						
Iridium		920	920	920	920	784
Palladium		39,300	39,300	39,300	38,800	28,200
Platinum		14,100	14,100	14,100	13,700	7,060
Price, average per troy ounce						
Iridium 3/		$74.14	$74.00	$205.42	$441.85	$411.40
Palladium 4/		$153.35	$130.39	$184.14	$289.76	$363.20
Platinum 4/		$425.36	$398.07	$396.59	$374.61	$378.94
Rhodium 4/		$463.30	$308.30	$298.00	$619.83	$904.35
Ruthenium 3/		$26.72	$47.56	$40.51	$47.95	$40.70
Employment		500	500	550	620	815
World, mine production		326,000 r/	324,000 r/	333,000 r/	348,000 r/	378,000 e/

e/ Estimated. r/ Revised. NA Not available.

1/ Data are rounded to no more than three significant digits; except for prices.

2/ Source: Stillwater Mining Co., 1999 10-K report, p. 26.

3/ Price data are annual averages of daily Engelhard unfabricated quotations published in Platt's Metals Week.

4/ Price data are annual Engelhard unfabricated quotations published in Platt's Metals Week.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY 1/

(Kilograms metal content, unless otherwise specified)

Country	Platinum grain and nuggets		Platinum sponge		Other unwrought platinum		Platinum, other		Platinum waste and scrap		Platinum coins	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
1998	2,670	$32,900	72,700	$888,000	10,200	$125,000	11,200	$124,000	3,580	$37,400	451	$6,380
1999:												
Argentina	--	--	--	--	--	--	--	--	182	3,200	--	--
Australia	(2/)	6	--	--	--	--	1,730	20,800	45	701	32	401
Belgium	390	4,510	1,940	21,000	533	6,000	11	146	--	--	--	--
Brazil	--	--	--	--	--	--	355	4,390	1	343	--	--
Canada	77	999	--	--	34	407	736	9,410	1,040	4,290	104	1,360
Chile	--	--	3	40	9	133	7	82	16	1,170	--	--
China	--	--	--	--	--	--	52	491	--	--	1	23
Colombia	3	50	--	--	1,060	10,900	(2/)	3	1	12	--	--
Costa Rica	--	--	--	--	--	--	--	--	110	1,050	--	--
France	--	--	100	1,180	3	40	1	7	159	1,500	--	--
Germany	1,020	13,100	2,910	35,300	808	10,400	1,200	16,000	337	8,160	--	--
Hong Kong	--	--	--	--	(2/)	3	(2/)	5	232	2,880	--	--
India	--	--	30	390	--	--	3	30	--	--	--	--
Ireland	143	1,670	--	--	30	443	1	13	41	591	--	--
Israel	--	--	--	--	237	5,560	--	--	58	209	--	--
Italy	58	780	347	4,410	--	--	--	--	36	591	--	--
Japan	191	2,460	150	1,720	23	313	1,220	15,200	788	484	--	--
Korea, Republic of	--	--	--	--	--	--	30	450	62	1,270	--	--
Malaysia	(2/)	3	--	--	--	--	--	--	16	194	--	--
Mexico	47	580	--	--	12	162	--	--	122	2,000	--	--
Netherlands	(2/)	2	--	--	(2/)	4	73	818	3	26	--	--
Norway	23	255	503	5,850	--	--	--	--	--	--	--	--
Peru	--	--	--	--	5	59	--	--	--	--	--	--
Russia	2,010	25,400	1,160	13,500	2,540	32,500	6,270	70,000	2	31	--	--
Saudi Arabia	--	--	35	792	--	--	--	--	9	73	--	--
Singapore	--	--	--	--	--	--	271	3,210	--	--	--	--
South Africa	1,800	22,700	59,500	526,000	7	83	44	515	--	--	--	--
Spain	--	--	3	32	--	--	147	1,700	1	7,020	--	--
Switzerland	--	--	748	8,950	2,350	26,900	3,430	33,100	--	--	--	--
Taiwan	--	--	245	3,500	1	17	--	--	--	--	--	--
United Kingdom	345	3,780	10,600	114,000	177	2,120	861	10,900	16,400	11,500	27	346
Other	--	--	5	35	(2/)	3	7	130	9	178	5	137
Total	6,100	76,300	78,300	737,000	7,820	96,000	16,500	187,000	19,700	47,500	169	2,270

See footnotes at end of table.

TABLE 2-Continued
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY 1/

(Kilograms metal content, unless otherwise specified)

Country	Unwrought palladium		Palladium, other		Iridium 3/		Unwrought osmium		Unwrought ruthenium		Rhodium 4/	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
1998	160,000	$1,440,000	16,300	$139,000	1,950	$23,800	71	$814	8,880	$12,700	13,500	$265,000
1999:												
Argentina	--	--	--	--	--	--	--	--	--	--	--	--
Australia	--	--	--	--	--	--	--	--	--	--	--	--
Belgium	10,700	113,000	1,150	8,030	--	--	--	--	--	--	466	13,000
Brazil	--	--	--	--	--	--	--	--	--	--	--	--
Canada	4,620	48,400	147	975	1	12	--	--	--	--	7	173
Chile	--	--	80	763	--	--	--	--	--	--	1	16
China	754	8,330	148	1,750	4	18	--	--	--	--	13	384
Colombia	--	--	--	--	--	--	--	--	--	--	--	--
Costa Rica	--	--	--	--	--	--	--	--	--	--	--	--
France	--	--	--	--	179	2,910	--	--	268	594	13	460
Germany	4,300	49,300	2,320	35,100	204	2,780	5	69	995	1,290	245	6,350
Hong Kong	84	960	--	--	--	--	--	--	--	--	--	--
India	--	--	10	108	--	--	--	--	--	--	--	--
Ireland	--	--	23	386	--	--	--	--	--	--	6	173
Israel	(2/)	6	--	--	--	--	--	--	--	--	--	--
Italy	601	6,090	17	179	--	--	--	--	--	--	(2/)	5
Japan	6,880	42,900	289	1,660	8	143	--	--	(2/)	2	180	5,220
Korea, Republic of	--	--	43	476	--	--	--	--	--	--	--	--
Malaysia	--	--	--	--	--	--	--	--	--	--	--	--
Mexico	6	69	--	--	--	--	--	--	--	--	16	215
Netherlands	--	--	--	--	(2/)	4	--	--	--	--	--	--
Norway	1,280	14,200	403	4,060	--	--	--	--	--	--	19	520
Peru	--	--	25	290	--	--	--	--	--	--	--	--
Russia	99,000	1,120,000	10,500	120,000	--	--	--	--	953	1,100	2,450	54,600
Saudi Arabia	35	347	--	--	--	--	--	--	--	--	--	--
Singapore	--	--	--	--	--	--	--	--	--	--	--	--
South Africa	25,000	277,000	2,480	29,000	1,060	9,090	18	203	8,720	11,000	5,390	146,000
Spain	--	--	--	--	--	--	--	--	--	--	--	--
Switzerland	4,780	48,800	5,180	56,500	3	68	--	--	--	--	(2/)	9
Taiwan	--	--	--	--	--	--	--	--	--	--	--	--
United Kingdom	6,490	74,200	1,290	16,000	807	10,100	--	--	473	781	1,720	48,800
Total	165,000	1,810,000	24,100	275,000	2,270	25,100	23	272	11,400	14,700	10,500	276,000

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Unwrought and other forms of iridium.

4/ Unwrought and other forms of rhodium.

TABLE 3
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY 1/

(Kilograms metal content, unless otherwise specified)

	Palladium		Platinum		Platinum, waste and scrap		Iridium, osmium and ruthenium		Rhodium	
Country	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
1998	36,700	$200,000	14,300	$158,000	6,570	$184,000	905	$11,300	811	$15,600
1999:										
Australia	1,180	15,300	2,900	31,800	--	--	(2/)	5	(2/)	8
Belgium	541	3,160	40	422	168	4,550	--	--	8	240
Bolivia	--	--	88	861	--	--	--	--	--	--
Brazil	124	684	177	1,080	--	--	1	25	--	--
Canada	1,220	7,140	939	11,300	350	10,900	136	1,930	1	104
Chile	--	--	1,130	3,290	--	--	--	--	--	--
China	3,850	18,800	6	49	--	--	(2/)	3	--	--
Costa Rica	--	--	62	205	--	--	--	--	--	--
Denmark	23	81	20	99	2	99	--	--	--	--
Finland	2	13	105	703	--	--	--	--	--	--
France	455	3,250	547	5,810	(2/)	9	10	138	(2/)	6
Germany	3,170	30,200	2,630	24,000	1,100	26,600	78	1,090	32	1,200
Guatemala	19	47	--	--	--	--	--	--	--	--
Hong Kong	335	4,400	1,730	20,100	(2/)	20	2	39	1	161
Iceland	3	13	2	11	--	--	--	--	--	--
India	44	153	35	415	3	99	(2/)	9	(2/)	52
Israel	3,300	4,790	12	102	--	--	(2/)	4	--	--
Italy	1,340	14,000	311	3,730	11	292	5	43	19	346
Japan	6,300	51,700	4,530	52,800	338	9,690	100	1,040	14	1,570
Korea, Republic of	2,010	17,100	148	1,820	--	--	1	8	17	492
Malaysia	37	193	69	813	--	--	--	--	(2/)	6
Mexico	33	270	84	809	(2/)	22	1	23	(2/)	18
Netherlands	1,280	12,600	159	809	2	172	--	--	--	--
New Zealand	48	271	3	19	--	--	--	--	1	24
Norway	81	330	1	6	--	--	--	--	--	--
Philippines	64	168	7	44	(2/)	4	--	--	--	--
Singapore	50	222	38	250	(2/)	3	--	--	--	--
South Africa	1,920	17,200	10	80	2	35	1	3	(2/)	3
Spain	193	457	4	39	--	--	--	--	--	--
Sweden	201	1,730	77	427	36	979	--	--	--	--
Switzerland	1,090	3,520	1,200	14,700	(2/)	9	1	28	(2/)	40
Taiwan	11,800	43,400	172	1,710	--	--	2	56	--	--
Thailand	86	493	11	90	--	--	(2/)	3	(2/)	14
United Kingdom	2,960	17,900	1,530	15,500	5,640	267,000	504	6,560	(2/)	74
Venezuela	--	--	19	275	--	--	--	--	--	--
Other	193	2,050	571	5,890	--	--	9	146	17	947
Total	44,000	272,000	19,400	200,000	7,660	320,000	851	11,200	114	5,310

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

TABLE 4
PLATINUM-GROUP METALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Kilograms)

Country 3/	1995	1996	1997	1998	1999 e/
Platinum:					
Australia e/ 4/	100	100	100	100	100
Canada 5/	5,945 r/	5,155 r/	4,813 r/	5,640 r/	5,442 6/
Colombia	973	672 r/	409 r/	437 r/	440
Finland e/	60	60	60	60	50
Japan 7/	730	816	693	533 r/	750
Russia e/	27,000 r/	25,000 r/	25,000 r/	25,000 r/	27,000
Serbia and Montenegro e/	10	10	10	10	5
South Africa 5/	102,000 e/	105,000 e/	115,861 r/	116,483 r/	131,000
United States 8/	1,590	1,840	2,610	3,240	2,920 6/
Zimbabwe	7 e/	100 e/	345 r/	2,730 r/	2,000
Total	139,000 r/	139,000 r/	150,000 r/	154,000 r/	169,000
Palladium:					
Australia e/ 4/	400	400	400	400	400
Canada 5/	9,319 r/	8,082 r/	7,545 r/	8,905 r/	8,592 6/
Finland	95 r/	182 r/	180 e/	180 e/	150
Japan 7/	2,174	2,182 r/	1,899 r/	4,151 r/	5,500
Russia e/	85,000 r/	80,000 r/	80,000 r/	80,000 r/	85,000
Serbia and Montenegro e/	50	50	50	50	25
South Africa 5/	51,000 e/	52,600 e/	55,675 r/	56,608 r/	63,600
United States 8/	5,260	6,100	8,430	10,600	9,800 6/
Zimbabwe e/	17	120	245 r/	1,855 r/ 6/	1,000
Total	153,000 r/	150,000 r/	154,000 r/	163,000 r/	174,000
Other:					
Canada e/ 5/	803	697	651	742 r/	716
Russia e/	3,600	3,500	3,500	3,500	3,700
South Africa 5/	29,797 r/	30,636 r/	24,930 r/	27,052 r/	30,300
Zimbabwe	--	5 e/	27	189	100
Total	34,200 r/	34,800 r/	29,100 r/	31,500 r/	34,800
Grand total	326,000 r/	324,000 r/	333,000 r/	348,000 r/	378,000

e/ Estimated. r/ Revised. -- Zero.

1/ World totals, U.S. data, and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

2/ Table includes data available through May 2, 2000. Platinum-group metal (PGM) 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 PGM, 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. A part of this output not specifically reported by country is, however presumably included in this table credited to Japan.

4/ PGM recovered from nickel ore that is processed domestically. PGM in exported nickel ore are extracted in the importing countries, such as Japan, and are believed to be included in the production figures for those countries.

5/ Country reports only total of PGM produced. Figures for constituent metals are estimates.

6/ Reported figure.

7/ Production derived entirely from imported ores.

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