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# 2006 Minerals Yearbook

## PLATINUM-GROUP METALS

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# Platinum-Group Metals

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In 2006, Stillwater Mining Company (SMC) (Billings, MT) was the only domestic mine producer of platinum-group metals (PGMs) from its Stillwater Mine near Nye, MT, and its East Boulder Mine south of Big Timber, MT. SMC was majority owned by Mining and Metallurgical Company (MMC) Norilsk Nickel (Moscow, Russia). SMC produced 18,700 kilograms (kg) of PGMs in 2006, 8% more than the 17,200 kg that it produced in 2005 (Stillwater Mining Company, 2007, p. 2). Defense National Stockpile Center (DNSC) (2007) reported PGM sales results under Basic Ordering Agreement DLA-Iridium-003. In 2006, only DNSC sales took place in January and February and for the calendar year, sales were 78 kg of iridium and no platinum, which left 111 kg of iridium and 261 kg of platinum in the stockpile. Palladium stocks were exhausted in 2004 (table 1.)

In 2006, the domestic automobile industry continued to be the major consumer of PGMs. Autocatalysts accounted for approximately 86% of rhodium consumption, 55% of platinum consumption, and 54% of palladium consumption.

## Production

***Primary.***—During 2006, the Stillwater Mine produced 9,770 kg of palladium and 2,950 kg of platinum. The increase in production at the Stillwater Mine was caused by an expansion of the ore production rate to 2,750 metric tons per day (t/d) from 2,026 t/d. PGM production from the East Boulder Mine was 5,380 kg (4,630 kg of palladium and 1,340 kg of platinum) an 11% increase compared with that of 2005 (Stillwater Mining Company, 2007, p. 16, 40). Palladium and platinum production for SMC were up by 8.3% and 9.5%, respectively, compared with those of 2005. SMC defined mine production as the quantity of PGMs contained in concentrate at the time it was shipped to the smelter. The company milled 1.29 million metric tons (Mt) of ore from the mines, slightly more than in 2005 (Stillwater Mining Company, 2007, p. 40). Value of domestic palladium and platinum production increased 72% and 40% respectively owing to the large price increases.

SMC processed ore from the mines through a flotation concentrator adjacent to the mine shaft. The mill had a recovery rate for PGMs of 91%. The flotation concentrate, 1.5% of the original ore on a dry weight basis, was filtered and transported to the company's metallurgical complex in Columbus, MT.

At the SMC metallurgical complex, the concentrates from both mines are processed first at the precious metal smelter. The concentrate, which contains 1 to 2 kilograms per metric ton (kg/t) PGMs, is fed into an electric arc furnace (EAF) along with spent autocatalysts and limestone. The resulting matte, which contains 6 to 8 kg/t PGMs, is granulated and fed into a top-blown rotary converter (TBRC). The furnace slag is shipped back to the Stillwater Mine's mill to capture more of the PGMs. The TBRC produces matte that contains 12 to 19 kg/t PGMs that is granulated and transported to the refinery. The slag from the TBRC is returned to the EAF for further treatment. The smelter has an offgas processing facility that captures more than 99.7% of the sulfur dioxide ($SO_2$) produced by the smelter and produces gypsum cake that is sold to a local agricultural supply wholesaler. In 2006, the smelter capacity was approximately 120 metric tons (t) of concentrate and spent catalytic converter material per day (Stillwater Mining Company, 2007, p. 17).

The refinery has several circuits that further process the smelter matte to produce PGM filter cake, nickel sulfate hexahydrate crystals, and copper cathodes. The PGM filter cake contains 60% to 65% PGMs and is shipped to Johnson Matthey plc (London, United Kingdom) facilities in the United States and to Heraeus Precious Metal Management, Inc. (New York, NY) for toll refining. The metal was returned to the company as 99.95% purity sponge. The gold, rhodium, and silver are also returned to the company's account. During 2006, total byproduct (copper, nickel, gold, and silver plus mined rhodium) sales were $42.6 million, up 99% as compared with 2005 byproduct sales of $21.4 million.

SMC's proven and probable reserves are contained in the J-M Reef, a 45-kilometer-long ore body, in the Beartooth Mountain Range in south-central Montana. At the end of 2006, the company had a total proven and probable reserve of 717,000 kg of palladium and platinum, with a metal ratio of 3.6 to 1 palladium to platinum (Stillwater Mining Company, 2007, p. 21).

In 2006, there were several sites under investigation to determine if further investments will be warranted. Much of this activity was in Alaska, Michigan, Minnesota, and Montana. The most advanced project was PolyMet Mining Corp.'s (Vancouver, British Columbia, Canada) NorthMet Mine in northeast Minnesota. The company announced that it will start mine production in mid-2008 and metal production in the fourth quarter of 2008. When the mine is developed, it would be the first combined base- and precious-metal mine in the State of Minnesota and the third PGM mine in the United States (PolyMet Mining Corp., 2006). Franconia Minerals Corporation (Spokane, WA) was exploring the nearby Birch Lake project, located in the Duluth Complex. Early estimated annual production from the copper-nickel-PGM project, including the Birch Lake Mine and the Maturi Mine, was 2,000 kg of palladium and 1,000 kg of platinum (Franconia Minerals Corporation, 2007). Near SMC's mines is Beartooth Platinum Corporation's (Toronto, Ontario, Canada) Stillwater Complex. Although still in the early phases of exploration, Beartooth has found palladium, platinum, and rhodium at multiple sites in Montana along the J-M Reef (Beartooth Platinum Corporation, 2006). In Alaska, the Pure Nickel Inc. (Toronto) was exploring

the nickel-copper-cobalt-PGM MAN property located 265 kilometers (km) south-southeast of Fairbanks (Pure Nickel Inc., 2006).

***Secondary.***—In 2006, recovery and recycling of autocatalysts provided a growing secondary source of PGMs. The strength of the price of platinum in 2006, which averaged $1,144.42 per troy ounce, helped support the profitability of the recovery and recycling businesses. The global recovery of platinum from autocatalysts rose by 11% in 2006, reaching 26,600 kg, with recovery increasing in Europe and North America. In North America, recovery of platinum from catalytic converters rose by more than 2,000 kg in 2006 to an estimated 18,000 kg of platinum (Jollie, 2007, p. 20-23).

Global palladium recovered from autocatalysts in 2006 was 24,900 kg, an increase of 28% compared with that of 2005. In Europe, a combination of higher palladium loading on autocatalysts and an increase in the number of autocatalysts being recycled, owing to increased regulations, has led palladium recovery to increase by 33% to 6,800 kg compared with that of 2005. Palladium recovery in North America increased by 28% to 15,600 kg from 12,100 kg in 2005, owing to an efficient infrastructure, the higher palladium loading in automobiles produced around 1995, and a higher palladium price (Jollie, 2007, p. 30-33).

In 2006, global recovery of rhodium from autocatalysts increased 24% to 5,290 kg, owing to the large price jump and increased recycling activity in Europe and North America (Jollie, 2007, p. 39, 52).

SMC's recycling program recovered 10,900 kg of PGMs in 2006, up 68% as compared with that of 2005. The sale of the recycled material was $269.9 million in 2006, which was up from $90.7 million. Adding more scrap material to the smelter adds little to the overall operating cost of production and increases the grade of the matte (Stillwater Mining Company, 2007, p. 18).

## Consumption

In 2006, global platinum sales were about 239,000 kg, a 3% increase compared with that of 232,000 kg in 2005. Increased use of platinum in catalytic converters was offset by a decrease in platinum demand from the jewelry industry owing to the increase in the price for that metal. Increased sales of diesel cars in Europe, rising light vehicle (passenger and light trucks) output, and tighter emission regulations combined to increase the consumption of platinum in autocatalysts to 130,000 kg, an 11% increase compared with that of 2005. Palladium global sales decreased to 231,000 kg in 2006, a 7% decrease compared with 248,000 kg in 2005. The decrease was driven by the jewelry industry purchasing 13,500 kg less in 2006, a 30% drop, as compared with that of 2005, and 11,000 kg less in consumption in other end uses, a 71% drop as compared with that of 2005. The decrease was partially offset by growth in the use of palladium in autocatalysts and electronics (Jollie, 2007, p. 2-5).

In 2006, U.S. apparent consumption of refined platinum was estimated to be about 76,200 kg, and apparent domestic palladium consumption was estimated to be about 88,600 kg.

***Palladium.***—Palladium used in autocatalysis increased by 4% to 125,000 kg in 2006 compared with 2005 consumption. Although demand from the European autocatalysts industry dropped, it was offset by increases in use in the rest of the world. The drop in consumption in Europe was because of a rise in the market share of diesel vehicles, rising above 50% in 2006. Prior to 2006, palladium was not used in diesel autocatalysis; however there was a marginal increases in 2006. For the rest of the world, gasoline vehicles are the dominate automobile and can use a palladium- or platinum-based autocatalysts. Since palladium was much cheaper than platinum, many autocatalysts manufacturers have substituted palladium in place of the more than three times more expensive platinum. The increase in demand from the autocatalysts industry was more than offset by a reduction in consumption from the jewelry industry (Jollie, 2007, p. 4-5, 30-33).

After a large increase in consumption of palladium by the Chinese jewelry industry in 2005, global consumption dropped 30% in 2006 as compared with that of 2005. China's jewelry industry purchases of palladium in 2006 decreased 37%, to 24,000 kg from 37,000 kg in 2005. However, global consumption by the jewelry industry in 2006 was 7% higher than that of 2004. China was the reason for the unprecedented rise and fall in consumption of palladium in jewelry; 80% of the world consumption of palladium for jewelry manufacture was in China in 2006. The majority of the remaining palladium consumption for jewelry was by Japanese jewelry manufactures (13%), with some consumption in Europe and the United States (Jollie, 2007, p. 33-35).

Palladium consumption in dental alloys dropped 470 kg to 25,000 kg in 2006, with more than one-half of the consumption in Japan. The chemical industry consumed 13,000 kg in 2006, slightly more than 2005. The main uses of palladium in the chemical industry were as catalysts in manufacturing bulk chemicals, including purified hydrogen peroxide, nitric acid, purified terephthalic acid (PTA), and vinyl acetate monomer. In 2006, much of the increased consumption was because of increased production of hydrogen peroxide. The electronics industry increased its consumption of palladium by 10% in 2006, to 33,000 kg, as compared with that of 2005. Most of the palladium used in the electronics industry was for multilayer ceramic capacitors for uses in all types of electronic goods. Palladium also can replace other more expensive or environmentally hazardous metals in electronic end uses, such as gold, lead, and platinum. Other applications for palladium consumed 71% less in 2006, compared with that of 2005. The majority of the drop was due to a downturn in use in coins and physical investment. The increase in the price of palladium made retail sales difficult (Jollie, 2007, p. 35-35).

***Platinum.***—Growth in the diesel-powered light vehicle sector in Europe continued to be the major reason for the increase in consumption of platinum in autocatalysts. In 2006, European automakers consumed 67,200 kg of platinum, an increase of 6,200 kg. Sales of diesel vehicles continued to rise, and about one-half of all new light vehicles in Western Europe were diesel. Many auto manufacturers were fitting vehicles with catalyzed soot filters and diesel oxide catalytic converters that have increased platinum consumption. Although platinum has

traditionally been the metal of choice in diesel catalysts, with the price difference and new technologies, palladium has started to replace some of the platinum.

The use of platinum in China and North America also increased. In China, the consumption of platinum used in autocatalysts jumped to 4,820 kg in 2006 from 3,580 kg in 2005 owing to increased production of light vehicles and more stringent emission regulations. In North America, the demand for platinum in autocatalysts increased 10% in 2006 as compared with that of 2005 owing to the increases in the number of diesel vehicles, both light and heavy duty. Japanese consumption of platinum decreased slightly in 2006 as compared with that of 2005, owing to increased substitution of platinum for the cheaper palladium in three-way catalysts (Jollie, 2007, p. 20-23).

In 2006, global consumption of platinum in jewelry dropped for the fourth year in a row, by 18% compared with consumption in 2005, to 49,900 kg, the lowest level in 14 years, largely as a result of high and volatile prices. The China jewelry industry purchased 13% less platinum and Japan consumed 29% less in 2006 as compared with that of 2005. These drops were because of a large price surge, which caused many jewelers to reduce their inventories of platinum jewelry, which led to a reduction of platinum jewelry on display or produced. Retail demand for platinum jewelry also suffered losses to palladium and white gold jewelry. The rest of the world saw similar reduction in consumption in 2006 (Jollie, 2007, p. 23-25).

Global use of platinum in chemical catalysts rose by 11% in 2006, to 11,200 kg compared with that of 2005. Consumption of platinum-based catalysts for the production of nitric acid and paraxylene silicon decreased but were offset by increases in consumption of platinum-based catalysts used in PTA in Asia. The purchases of platinum by the petroleum refining industry increased to 6,380 kg in 2006, because of increased refining capacity in South Asia. The global consumption of platinum in electronics increased by 18%, to 13,300 kg in 2006, as compared with that of 2005 owing to increases in hard drive manufacturing. Platinum consumption in the fuel cell sector was relatively low, but saw an increase owing to the development of prototypes (Jollie, 2007, p. 26-27).

Platinum consumed in the production of liquid crystal display (LCD) glass and other glasses increased in 2006 by 8%, to 12,000 kg compared with that of 2005, with most of the increased consumption coming from increased capacity in the LCD industry in Asia. Consumption in other end uses, such as anticancer drugs, coatings on turbine engines, medical components, oxygen sensors in automobiles, and spark plugs, increased, while consumption of platinum in dental alloys decreased slightly in 2006 (Jollie, 2007, p. 25-27). In 2006, U.S. Mint sales of platinum American Eagle Bullion coins decreased by 32% to 421 kg from 622 kg in 2005 owing to the large increase in price of the coins (U.S. Mint, 2007).

***Other PGMs.***—Global rhodium consumption in 2006 rose by 4% to 31,000 kg compared with that of 2005. A majority of this, 86% in 2006, was used in the production of autocatalysts. In 2006, increased consumption in autocatalysts used in Asia outweighed the decreases in consumption in Europe and North America. The decreases in Europe and North America were caused by increased in prices and reduction in loading on autocatalysts. Other uses of rhodium were, in descending order, LCD glass manufacturing, chemicals, electrical applications, and jewelry (Jollie, 2007, p. 38).

Global consumption of ruthenium increased by 45% to 40,100 kg in 2006 owing to a 78% increase in consumption in the electronic industries in 2006 as compared with that of 2005. A new type of computer hard drive, called perpendicular magnetic recording (PMR), was a significant portion of the increases in consumption. Some of the other uses for ruthenium, in descending order, are conductive paste used in resistor components, plasma display panels, jewelry alloying components, and chemical processors to manufacture acetic acid and polymers.

Consumption of iridium increased to 4,080 kg in 2006, a slight increase compared with 2005 consumption owing to the increased use in spark plugs and in electrochemical processes (Jollie, 2007, p. 39).

## Prices

According to Platts Metals Week, the 2006 annual average price of palladium was $322.93 per troy ounce, which was a 59% increase compared with that of 2005. The 2006 average annual platinum price was $1,144.42 per troy ounce, a more than 27% increase compared with the average annual 2005 price. As for the other PGMs, the 2006 iridium annual price increased by 106%, the 2006 rhodium annual price increased by 121%, and the ruthenium 2006 annual price increased by 159% compared with the 2005 prices (table 1.)

***Iridium.***—In January, the price of iridium was $195 per troy ounce; it more than doubled by May 12 to $400 per troy ounce, where it remained for the rest of the year. The price jump was attributed to a strong physical demand which dissipated in mid-May.

***Palladium.***—The price of palladium began the year at $267 per troy ounce and quickly climbed to the highest point in 2006, at $407 per troy ounce on May 12. After the high point, the price quickly dropped back down to $286 per troy ounce on June 13. The price slowly climbed until early September, when in reached $350 per troy ounce, after which the price dropped again to under $300 per troy ounce in early October. The price rose again, back up to around $330 per troy ounce, where it ended the year.

***Platinum.***—The price of platinum began the year at $985 per troy ounce, which was the lowest point of 2006. The price climbed above the $1,000-per-troy-ounce level and remained above this level the entire year. Throughout the year, the price would climb and fall several times. One such time was in mid-May when the price reached a high of $1,335 per troy ounce and then dropped down to $1,132 per troy ounce in mid-June. By the end of June, the price climbed again and fell again. The price jumped dramatically on November 22, to $1,360 per troy ounce, an all time record price of platinum. During the same time, many thought the rumors that an exchange traded fund (ETF) was to be offered for platinum. An ETF is essentially paper platinum products, with each share representing a physical allotment of platinum that is held in trust. A platinum

ETF follows the platinum price, with a fee structure to cover administrative and storage costs. A platinum ETF would provide an easily accessible investment. It was thought by analysts that a launch of an EFT would cause a supply shortage and it was thought that this was why the price jumped (O'Connell, 2006). This rise was short lived as the rumors were not true, and the next day the price decreased back to $1,150 per troy ounce and ended the year at $1,120 per troy ounce.

***Rhodium.***—The price of rhodium reached an all time high of $6,275 per troy ounce on May 19 and averaged $4,561 per troy ounce in 2006. This represented a 121% increase compared with the 2005 annual price of $2,060 per troy ounce. The price had been increasing since early 2004 when the price was $500 per troy ounce. The price increase was attributed to the declining availability of the metal. With less metal for sale from Russia and increasing consumption from automobile, chemical production, and glass manufactures there was less material available. Speculation reportedly also played a part in the increase in prices.

***Ruthenium.***—For the first 6 months, the price of ruthenium followed a similar trend to that of iridium, starting the year at $87 per troy ounce and more than doubling to $180 per troy ounce in late-May. In October, there was a fear of shortages of ruthenium, and the price started climbing rapidly, ending November at a price of $375 per troy ounce. In the month of December, the price jumped 60% to $600 per troy ounce. The interyear price increased 590%. According to some analysts, demand for ruthenium was increasing from all end uses, which caused a panic, and many were stockpiling the material causing the supply shortage. When investors heard about the new PMR technology, speculative buying reportedly began (Adams, 2006).

## Trade

In 2006, the U.S. net import reliance as a percentage of apparent consumption was estimated to be 75% for refined palladium and 90% for refined platinum. Imports of refined palladium in 2006 decreased by 17% to 119,000 kg from 139,000 kg in 2005, with three countries accounting for about 79% of refined palladium imports in 2006—Russia (37%), the United Kingdom (22%), and South Africa (21%.) Imports of platinum, including waste, scrap, and coins, increased by 7% in 2006 to 114,000 kg from 106,000 kg in 2005, with four countries accounting for 76% of imports of platinum in 2006—South Africa (33%), Germany (21%), the United Kingdom (13%), and Canada (9%.) Other refined PGM imports were up by 37% in 2006 compared with those of 2005. South Africa accounted for 60%, Germany accounted for 21%, and the United Kingdom accounted for 10% of other PGM imports in 2006 (tables 2 and 3.)

In 2006, the United States exported 74,900 kg of platinum (45,600 kg in 2005), 53,100 kg of palladium (27,000 kg in 2005), 1,600 kg of rhodium (615 kg in 2005), and 3,390 kg of other PGM (1,080 kg in 2005) (table 4.) The large increases in exports of all PGMs were because of the large jump in price and weakening of the U.S. dollar. A large amount of palladium and platinum was shipped to Switzerland, where high-quality luxury watches were manufactured. Palladium and platinum were also shipped in large quantities to the United Kingdom and Japan (in descending order), where palladium and platinum jewelry was popular. Japan also imported large amounts of PGMs for automotive catalyst and electronic end uses.

## World Industry Structure

In 2006, world mine production of PGMs increased slightly to 518,000 kg compared with 510,000 kg in 2005 (table 5). South Africa, the world's leading producer of PGMs, accounted for 59% of total mine production in 2006, Russia accounted for 28%, Canada accounted for 5%, and the United States accounted for 4%. South Africa, which accounted for 77% of world platinum production, increased its output of platinum by 4% in 2006 to 170,000 kg. Global output of palladium climbed to 224,000 kg, with Russia and South Africa accounting for 44% and 38%, respectively, of the total. South Africa production of other PGMs (iridium, osmium, ruthenium, and rhodium) in 2006 decreased 8% as compared with that of 2005; however, it remained the dominant world mine producer of other PGMs, with 71% of the global total.

## World Review

***Australia.***—Platinum Australia Limited (West Perth, Australia) completed a bankable feasibility study on the Panton project in 2003, but it was determined that it was not commercially viable. With the recent price increases, Platinum Australia and Sally Malay Limited (Perth) entered into a joint-venture agreement to complete a new feasibility study and develop the Western Australian project (Platinum Australia Limited, 2007, p. 12-13).

***Botswana.***—Tati Nickel Mining Company's (Francistown, Botswana), 85% owned by LionOre Mining International Ltd. (Toronto), Phoenix open pit produced 1,100 kg palladium and less than 200 kg platinum in 2006 (LionOre Mining International Ltd., 2007, p. 10).

***Canada.***—North American Palladium Ltd. (NAP) (Toronto) produced about 7,380 kg of palladium and 694 kg of platinum in 2006 at the Lac des Iles Mine compared with 5,510 kg of palladium and 586 kg of platinum in 2005. The boost in production was propagated by the startup of underground operations in April and improvements in the milling operation. Although this was a 32% increase as compared with that of 2005, it was still below that of the 2004 production. NAP continued to explore underneath the current mine and discovered an indicated and inferred resource of 85,000 kg of palladium and 6,000 kg of platinum (North American Palladium Ltd., 2007, p. 3, 5-7, 9-13).

The rest of Canada's PGM production was a byproduct of nickel mining in the Raglan and Sudbury areas, as was the exploration for new projects. In the Sudbury region, Marathon PGM Corporation (Toronto) announced that it will complete a feasibility study by 2008 for the Marathon PGM-Cu Property near Marathon, Ontario (Marathon PGM Corporation, 2007, p. 1-3). NAP joined Companhia Vale do Rio Doce (CVRD) (Rio de Janeiro, Brazil) in a joint-venture agreement to explore potential nickel-copper-PGM mineralization at the old

Shebandowan Mine, located 100 km southwest of Thunder Bay, Ontario (North American Palladium Ltd., 2007, p. 9-13). Canadian Royalties Inc. (Montreal, Quebec) plans to have updated the reserve calculation for the nickel-copper-PGM Raglan South Nickel Project in early 2007 (Canadian Royalties Inc., 2006). StarField Resources Inc. was exploring an early stage palladium-platinum-nickel-cobalt-copper Ferguson Lake property in Nunavut and was planning to have the scoping study completed by late 2007 (StarField Resources Inc., 2007).

In 2006, there were major changes in ownership of the two major nickel producers. Inco Limited was taken over by CVRD in October, and Falconbridge Limited was acquired by Xstrata plc (Zug, Switzerland). In 2006, CVRD operations in Canada produced 11,200 kg of PGMs, 16% lower than that of 2005, owing to the reduction in mine output from PGM–producing mines in Ontario. Although Xstrata did not release data for PGM production, it was thought that output increased from the Fraser Copper deposit, which was a comparably rich PGM deposit, and increased mill capacity in Raglan caused production of PGMs to increase slightly. Xstrata was also developing the Nickel Rim South deposit in Sudbury and will probably increase PGM production with startup scheduled for 2010 (Jollie, 2007, p. 18-19).

***India.***—There was little news about the exploration 70-30 joint venture between Platinum Mining Corporation of India PLC (PMCI) (London) and Ferro Alloys Corporation (FACOR) (Orissa, India). The project's goal was to develop the FACOR-operated Boula Chromite Mine, in the Eastern Indian State of Orissa, into a PGM mine (Platinum Mining Corporation of India PLC, 2007).

***Finland.***—NAP and Gold Fields Ltd. (Johannesburg, South Africa) formalized an agreement to develop the Artic Platinum Project located in northern Finland, about 60 km south of Rovaniemi. The project consists of several advanced-stage PGM deposits (North American Palladium Ltd., 2007, p. 16).

***Russia.***—In 2006, Russia accounted for 44% of global mine production of palladium, 21% of other PGM production, and 13% of platinum production. Despite the importance of the Russian PGM mining industry to the world market, information on production, reserves, and sales have historically been difficult to obtain because such data were considered to be confidential under Russian law. In late 2003, a bill to declassify PGM data (with the exception of Government stocks and sales) was enacted, and the first year of released PGM data were for 2005. In 2006, Norilsk disclosed that it produced 98,400 kg of palladium and 23,400 kg of platinum. Compared with that of 2005, this was a 2% increase in palladium and no change in platinum production; other PGM production data were not published. Reported reserves for the deposits on the Taimyr Peninsula and the Kola Peninsula as of December was 2,500 t of PGM (1,970 t of palladium, 516 t of platinum, and 15 t of other PGM) (MMC Norilsk Nickel, 2007, p. 8, 60).

Russia's alluvial platinum production was 6,500 kg, relatively unchanged in 2006 as compared with 2005 production (Klapwijk and others, 2007, p. 29).

***South Africa.***—South Africa accounted for 77% of platinum, 38% of palladium, and 71% of all PGMs produced worldwide in 2006. In 2006, South African production of PGMs was up slightly compared with that of 2005; palladium production rose by 2%, platinum production rose by 4%, and other PGM production decreased by 8%. The increase in production was because of the addition of two mines (Everest and Two Rivers) and rehabilitation of a third mine (Crocodile River).

The world's leading PGM producer, Anglo Platinum Limited (Johannesburg) increased its refined PGM production by 13,000 kg, to 144,000 kg in 2006. The company accounted for 47% of the total South African PGM production and almost 28% of world PGM production in 2006. Palladium and platinum production were up 11% and 12%, respectively, as compared with 2005 production; however, ruthenium was down 4% durring the same time period. In 2006, the increases in production were recorded at wholly owned Amandelbult (7%) and Rustenburg (1%) Mines as compared with that of 2005. Production from the Modikwa Platinum Mine, a 50-50 joint venture with African Rainbow Minerals Limited (ARM) (Sandton, South Africa), increased to 4,200 kg of refined platinum, a 5% increase as compared with that of 2005. Union operations also increased 1% in PGM production in 2006. The Bakgatla-Ba-Kgafela Traditional Community acquired 15% of Union on December 1. Increases in PGM production from the two pool and share agreements (P&SAs) with Aquarius Platinum Limited (Johannesburg) attributed to Anglo's overall increases in PGM production. The first P&SA were at the Kroondal Platinum Mine. The second P&SA were for the Marikana operations, which delivered its first full year of production. The P&SAs allow the companies to pool their assets while retaining ownership and sharing the proceeds equally. Production arising from Kroondal was sold to Impala Platinum Limited (Implats) (Johannesburg) under a volume-based concentrate offtake agreement. In 2006, production from Kroondal increased 7% as compared with that of 2005, to 8,200 kg of PGM, of which 4,200 kg was attributed to Anglo. Mine production from the open pit and underground operations at Marikana Platinum Mine was approximatly 1,000 kg of PGMs, of which Anglo's share was more than 400 kg of PGM. This was the first year of production that was attributed to Anglo, and by 2009 Anglo's share could reach 2,300 kg of PGMs. Production from Bafokeng-Rasimone Platinum Mine (BRPM), a 50-50 joint venture with Royal Bafokeng Resources Limited (Johannesburg), increased 12%, to 6,770 kg of PGM in 2006, as compared with that of 2005. The Mototolo Platinum Mine (a 50-50 joint venture with Xstrata), started production in the last quarter of 2006, and Anglo's share of production was 400 kg of PGM and will probably reach full production by the end of 2007. Wholly owned Lebowa Platinum Mines maintained production levels about equal with those of 2005, at 3,480 kg of PGMs in 2006. These increases were partially offset by lower production in 2006 as compared with that of 2005 at the wholly owned Potgietersrust Platinum Limited (PPRust) operations; with increasing complexity of the feed ore and above-normal rainfall in the first quarter of 2006, PGM production decreased by 7%, to 5,950 kg, in 2006 as compared with that of 2005. The Western Limb Tailings Retreatment plant produced 1,000 kg of PGM, 10% lower in 2006 as compared with that of 2005. The drop was expected, owing to processing the older, higher-grade tailings first. Low-volume mining continued at

the Twickwnham Mine as it underwent a prefeasibility study to expand production; in 2006, the mine produced 200 kg of PGM. Additional production from several potential new projects (Booysendal, Der Brochen, Ga-Pasha, and Pandora joint venture) in South Africa and expanded production from current operations will ensure that Anglo will remain the leading producer of PGMs in the world (Anglo Platinum Limited, 2007, p. 8-10, 36-46, 86).

Implats refined production of PGMs decreased by 7% in 2006, to 33,600 kg, as compared with production in 2005. Production from the Impala Mine sharply dropped owing to the lower ore grade, because of an increase of lower grade Merensky Reef material. The decrease from Impala Mines was partially offset by majority-owned Marula operation's dramatic recovery. A new mining plan was instituted, and production of platinum increased 73%, to 1,700 kg, as compared with that of 2005 (Jollie, 2007, p. 12-14; Klapwijk and others, 2007, p. 25). In December, Implats acquired 29.9% of the African Platinum plc's (Afplats) (London) Leeuwkop project. Full production could be reached by 2010 and is expected to produce 9,000 kg/yr of gold and PGM (Impala Platinum Holdings Limited, 2006).

In 2006, Northam Platinum Limited (Johannesburg) produced 6,940 kg of platinum, relatively unchanged as compared with that of 2005 production, while palladium dropped 12% to 2,990 kg in 2006 as compared with that of 2005. The main reason for the decrease in production was that the mill processed about the same amount of ore, but there was an increase in the lower-grade UG2, owing to the geological complexity of the Merensky Reef (Jollie, 2007, p. 15).

Lonmin Plc (London) had four separate interruptions in the processing centers. Lonmin's Number One smelter was down for scheduled maintenance at the beginning of the year, and then in April the smelter was shut down owing to a leak reportedly because of an installation oversight. In September, fires lead to another stoppage of the smelter. The second leak happened in late December and was to have shut the smelter down for an estimated 135 days to replace the smelter's lining. Loss of production because of smelter shutdowns and other bottlenecks caused an estimated loss of output ranging from 900 to 1,200 kg of PGMs. Lonmin hoped to limit the loss of production by recommissioning old smelters (Klapwijk and others, 2007, p. 26). In mid-December Lonmin offered to purchase AfriOre Limited (Road Town, Tortola, British Virgin Islands); if approved, it will probably add 8,000 kg of PGM production by 2013 from Akanani project (Jollie, 2007, p. 15).

Aquarius announced that its production of PGMs for 2006 was 13,500 kg, excluding operation in Zimbabwe, and was 36% higher than that of 2005. Other than the two P&SAs with Anglo, Aquarius also produced from the wholly owned Everest complex, which began producing this year, and from Chromite Tailings Retreatment Plant, a joint-venture project between Aquarius (50%), GB Mining and Exploration Ltd. (Johannesburg) (25%), and Sylvania South Africa Ltd. (25%) (Aquarius Platinum Limited, 2007, p. 1-8).

ARM platinum division had several joint ventures operating in South Africa—Modikwa Platinum Mine, 50% jointly owned with Anglo; Nkomati Nickel Mine, 50% with LionOre; and Two Rivers Platinum Mine, a project in which ARM held 55% and Implats 45%. The Two Rivers Mine was commissioned in July, and platinum production was 1,700 kg. For 2007, Two Rivers Mine was expected to double production from that in 2006. Nkomati Nickel Mine was nearing the end of the underground mining of the high-grade massive sulphide body and in 2006 the mine produced 1,600 kg of PGM. In 2007, the underground operation was expected to cease and the plan is to expand the concentrators and start open pit mining the lower grade deposit material. Although the ore grade will decrease, mine and mill capacity will increase, and production of PGM is expected remain close to the same level (African Rainbow Minerals Limited, 2007, p. 40-41; Jollie, 2007, p. 16; Klapwijk and others, 2007, p. 26, 28).

Barplats Investments Limited's (Gauteng, South Africa) Crocodile River Mine, 69% owned by Eastern Platinum Limited (Vancouver), increased palladium production by 1,000 kg and platinum production by 400 kg in 2006 more than the 2005 production levels. The mine originally opened in 2004 but was recommissioned in 2006 and now has a measured and indicated resource of 163,000 kg of gold and PGM (Eastern Platinum Limited, 2007).

Eland Platinum Holdings Limited (Bryanston, South Africa) will begin mining its Elandsfontein Platinum Mine, near Brits, North West Province, in early January 2007. The mine will continue to operate for 5 years as an open pit, producing almost 5,000 kg/yr of gold and PGM; then underground operations will continue for 35 years. Metal production will increase once the underground operations commence, and resources were estimated to be 671,000 kg of gold and PGM (Eland Platinum Holdings Limited, 2006; 2007).

A bankable feasibility study was scheduled to be completed on Sheba's Ridge Mine, a joint venture between Ridge Mining plc's (London) and Anglo, by the end of 2007. The mine was estimated to have a resource of 590,000 kg of gold and PGM and an estimated annual production of 8,500 kg of palladium, 3,000 kg of platinum, and 155 kg of rhodium. Ridge Mining had begun construction of the Blue Ridge Mine and could be at full capacity by early 2009. The estimated resources are 166,000 kg of PGMs and gold and an estimated annual production of 2,300 kg of platinum, 1,000 kg of palladium, 680 kg of ruthenium, 400 kg of rhodium, and 77 kg of iridium during the 18-year life span of the mine (Ridge Mining plc, 2007, p. 4-8).

The prefeasibility study for the Project 1 area of the Western Bushveld Joint Venture (WBJV) was completed in late December. Partners of the joint venture are Anglo (37%), Platinum Group Metals Ltd. (Vancouver) (37%), and Africa Wide (26%), an accredited Black Economic Empowerment company, which were pleased with the projected annual output of 7,800 kg of combined gold, palladium and platinum during mine's life of 18 years. The WBJV has three projects and the first project will probably complete the bankable feasibility study by yearend 2007 (Platinum Group Metals Ltd., 2007).

Platinum Australia completed a bankable feasibility study for Smokey Hills PGM Project. The project, located on the Eastern Limb of the Bushveld Complex, was estimated to have resources of 31,000 kg of gold and PGMs. The company also has a joint venture with ARM in the Northwest Province. The Kalplats project was undergoing a prefeasibility study and had

an estimated resource of 106,000 kg of gold and PGM (Platinum Australia Limited, 2007, p. 5-9).

***Zimbabwe.***—In 2006, PGM production increased by 4% as compared with 2005 production, with platinum production up 5%, palladium up 3%, and other PGMs up 4%. The completion of the Wedza IV expansion at the 50-50 joint venture between Aquarius and Zimplats Holdings Limited (Harare, Zimbabwe) Mimosa Mine was the main source of the increased PGM production in 2006. Wedza Phase V expansion was expected to be implemented in 2007 at a cost of $23.2 million and could lift the annual production to 3,100 kg. The Zimplats-owned Ngezi Mine and produced 6% more platinum and 4% less palladium in 2006 compared with that of 2005 (Jollie, 2007, p.19; Klapwijk and others, 2007, p. 28).

Anglo's Unki project, located near Gweru, was forecast to begin production by 2009; however, the project was still subject to certain Zimbabwean and South African regulatory and fiscal approvals and development costs were under review in light of the economic and exchange-rate environment in Zimbabwe (Anglo Platinum Limited, 2007, p. 58).

Although Zimbabwe had proven to be a popular site for exploration and mining of PGMs, much of the refining took place in South Africa. In March, the Government of Zimbabwe released a draft paper which discussed the plan to acquire 51% of all precious metals mines. This plan had yet to be finalized or enacted; however, it could cause foreign investors to become reluctant to invest in new operations (Klapwijk and others, 2007, p. 28).

## Outlook

Since palladium, platinum, and rhodium are dependent on the autocatalysts end use, the outlook of the automotive industry will have the greatest impact on the consumption and prices of these PGM. An increase in diesel car sales in Europe can be expected to cause a strong increase in the use of platinum in the region in 2007 and beyond. Stricter emissions regulation in China, Europe, Japan, and other parts of the world is also expected to lead to higher average PGM loadings on catalysts, especially on light-duty diesel vehicles, as particulate matter emissions become more closely controlled. Palladium will be increasingly used in diesel catalytic converters but platinum will continue to be the dominant metal. In the United States, thrifting to reduce platinum loadings and substitution in favor of a much cheaper palladium is likely to lead to a reduction in the use of platinum in autocatalysts. Average palladium loading levels on autocatalysts are expected to increase in Europe and Japan at the expense of platinum as more stringent particulate emission standards are introduced. A shift toward greater use of palladium in preference to platinum on gasoline-vehicle autocatalysts by a number of manufacturers is also likely to provide a modest increase in palladium use in Asia and Europe. In Europe, however, production of gasoline-fueled automobiles is expected to decline while sales of diesel engines continue to rise, which will partially offset some of the expected growth from switching to palladium, as will further thrifting by all catalyst producers. In the electronics sector, component sales are expected to increase. Increased demand for palladium, however, will be somewhat offset by a combination of miniaturization and substitution of nickel and silver for palladium in multilayer ceramic capacitors. The sale of platinum jewelry is expected to drop worldwide, assuming the price continues to be high and white gold and palladium are used as substitutes.

There was a perceived supply surplus of platinum in 2006. On the supply side, platinum production is expected to increase from new mines opening in South Africa and Zimbabwe. The consumption of platinum is expected to be lower owing to lower jewelry consumption and thrifting in industrial uses; therefore, a supply surplus is expected to continue. As for palladium, there was a perceived oversupply in the world in 2006. However, a supply deficit could develop as production of palladium will most likely remain flat or decline, and consumption is expected to increase. Production of ruthenium and other minor PGMs is expected to increase, as much of the growth in mining is in the UG2 ore, which is higher in minor PGMs than the Merensky Reef (Adams, 2006). The consumption of many of these metals is expected to increase, especially rhodium and ruthenium, which could lead to a supply deficit. Production from South Africa will be dependent on a quick resolution of labor disputes with the upcoming negotiations of new contracts between mining companies and unions in 2007.

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TABLE 1
SALIENT PLATINUM-GROUP METALS STATISTICS[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| United States: | | | | | | |
| Mine production: | | | | | | |
| Palladium, Pd content:[2] | | | | | | |
| Quantity | kilograms | 14,800 | 14,000 | 13,700 | 13,300 | 14,400 |
| Value | thousands | $162,000 | $91,400 | $102,000 | $87,100 | $150,000 |
| Platinum, Pt content:[2] | | | | | | |
| Quantity | kilograms | 4,390 | 4,170 | 4,040 | 3,920 | 4,290 |
| Value | thousands | $76,500 | $93,100 | $110,000 | $113,000 | $158,000 |
| Refinery production: | | | | | | |
| Palladium, Pd content: | | | | | | |
| Quantity | kilograms | 5,700 | 7,250 | 5,480 | 5,220 r | 5,660 |
| Value | thousands | $62,200 | $47,300 | $41,000 | $34,100 r | $58,700 |
| Platinum, Pt content: | | | | | | |
| Quantity | kilograms | 15,200 | 17,000 | 16,700 | 6,360 r | 6,870 |
| Value | thousands | $265,000 | $379,000 | $456,000 | $184,000 r | $253,000 |
| Imports for consumption, refined: | | | | | | |
| Iridium, Ir content | kilograms | 2,100 | 2,200 | 3,230 | 3,010 | 2,800 |
| Osmium, Os content | do. | 36 | 53 | 75 | 39 | 56 |
| Palladium, Pd content | do. | 117,000 | 105,000 | 127,000 | 139,000 | 119,000 |
| Platinum, includes waste, scrap, and coins, Pt content | do. | 84,700 | 88,500 | 86,400 | 106,000 | 114,000 |
| Rhodium, Rh content | do. | 8,630 | 12,000 | 13,200 | 13,600 | 15,900 |
| Ruthenium, Ru content | do. | 9,890 | 15,900 | 18,800 | 23,200 | 36,000 |
| Exports, refined: | | | | | | |
| Iridium, osmium, and ruthenium, gross weight | do. | 94 | 145 | 1,090 | 1,080 | 3,390 |
| Palladium, Pd content | do. | 42,700 | 22,300 | 31,500 | 27,000 | 53,100 |
| Platinum, Pt content | do. | 27,800 | 22,200 | 20,000 | 20,700 | 45,500 |
| Rhodium, Rh content | do. | 349 | 479 | 314 | 615 | 1,600 |
| Stocks, National Defense Stockpile, December 31: | | | | | | |
| Iridium, Ir content | do. | 784 | 562 | 501 | 189 | 111 |
| Palladium, Pd content | do. | 5,870 | 1,170 | 568 | -- | -- |
| Platinum, Pt content | do. | 649 | 649 | 649 | 261 | 261 |
| Price, average: | | | | | | |
| Iridium[3] | dollars per troy ounce | $294.62 | $93.02 | $185.33 | $169.51 | $349.45 |
| Palladium[4] | do. | $339.68 | $203.00 | $232.93 | $203.54 | $322.93 |
| Platinum[4] | do. | $542.56 | $694.44 | $848.76 | $899.51 | $1,144.42 |
| Rhodium[4] | do. | $838.88 | $530.28 | $983.24 | $2,060.00 | $4,561.06 |
| Ruthenium[3] | do. | $66.33 | $35.43 | $64.22 | $74.41 | $193.09 |
| Employment | | 1,580 | 1,540 | 1,580 | 1,620 | 1,720 |
| World, mine production, PGM content | kilograms | 433,000 r | 466,000 r | 481,000 r | 510,000 r | 518,000 e |

eEstimated. rRevised. -- Zero.

[1]Data are rounded to three significant digits, except prices.

[2]Source: Stillwater Mining Co., 2006 annual report, p. 40.

[3]Price data are annual averages of daily Engelhard unfabricated quotations published in Platts Metals Week.

[4]Price data are annual Engelhard unfabricated quotations published in Platts Metals Week.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF PLATINUM, BY COUNTRY[1]

| Country | Grain and nuggets | | Sponge | | Other unwrought | | Other | | Waste and scrap | | Coins | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) |
| 2005 | 358 | $10,000 | 68,100 r | $1,940,000 | 1,740 | $48,000 | 7,020 | $144,000 | 29,100 | $139,000 r | 23 | $574 r |
| 2006: | | | | | | | | | | | | |
| Argentina | -- | -- | -- | -- | 220 | 7,610 | -- | -- | -- | -- | -- | -- |
| Australia | 1 | 27 | -- | -- | -- | -- | 949 | 37,000 | -- | -- | 5 | 52 |
| Austria | -- | -- | -- | -- | -- | -- | 9 | 178 | -- | -- | -- | -- |
| Belgium | -- | -- | 1,400 | 50,600 | -- | -- | 2 | 61 | -- | -- | -- | -- |
| Brazil | -- | -- | 866 | 31,400 | -- | -- | 2 | 65 | 102 | 6,610 | -- | -- |
| Canada | 10 | 356 | -- | -- | 5 | 80 | 503 | 16,800 | 9,380 | 39,300 | 48 | 546 |
| Chile | -- | -- | -- | -- | -- | -- | -- | -- | 10 | 389 | -- | -- |
| China | -- | -- | -- | -- | 1 | 15 | 15 | 309 | 29 | 1,590 | -- | -- |
| Colombia | 12 | 374 | -- | -- | 273 | 9,670 | -- | -- | 1,080 | 5,070 | -- | -- |
| Czech Republic | -- | -- | -- | -- | 11 | 61 | -- | -- | 2 | 98 | -- | -- |
| Dominican Republic | -- | -- | -- | -- | -- | -- | -- | -- | 1 | 40 | -- | -- |
| El Salvador | -- | -- | -- | -- | -- | -- | -- | -- | 4 | 139 | -- | -- |
| France | -- | -- | -- | -- | -- | -- | 5 | 76 | 712 | 3,250 | -- | -- |
| Germany | -- | -- | 2,050 | 75,000 | 1,240 | 44,300 | 4,420 | 89,800 | 15,800 | 87,800 | -- | -- |
| Greece | -- | -- | -- | -- | -- | -- | -- | -- | 12 | 364 | -- | -- |
| Hong Kong | -- | -- | -- | -- | -- | -- | 1 | 33 | -- | -- | -- | -- |
| India | -- | -- | 54 | 1,860 | 1 | 20 | (2) | 2 | -- | -- | -- | -- |
| Ireland | -- | -- | -- | -- | -- | -- | 6 | 64 | -- | -- | -- | -- |
| Israel | -- | -- | -- | -- | -- | -- | 24 | 164 | -- | -- | -- | -- |
| Italy | 1 | 33 | 268 | 6,690 | -- | -- | 1,180 | 43,800 | -- | -- | -- | -- |
| Japan | -- | -- | 364 | 13,800 | 498 | 18,500 | 16 | 309 | 911 | 40,400 | -- | -- |
| Jordan | -- | -- | -- | -- | -- | -- | -- | -- | 1,810 | 825 | -- | -- |
| Korea, Republic of | -- | -- | -- | -- | (2) | 7 | 7 | 243 | 7,630 | 4,370 | -- | -- |
| Lebanon | -- | -- | -- | -- | -- | -- | -- | -- | 3 | 26 | -- | -- |
| Malaysia | -- | -- | -- | -- | -- | -- | -- | -- | 9 | 841 | -- | -- |
| Mexico | -- | -- | -- | -- | 4 | 121 | -- | -- | 21 | 704 | -- | -- |
| Netherlands | -- | -- | -- | -- | (2) | 5 | -- | -- | -- | -- | -- | -- |
| Norway | -- | -- | 775 | 27,500 | -- | -- | 9 | 182 | -- | -- | -- | -- |
| Philippines | -- | -- | -- | -- | -- | -- | -- | -- | 51 | 1,210 | -- | -- |
| Russia | -- | -- | 3,440 | 123,000 | 694 | 27,500 | 25 | 780 | -- | -- | (2) | 3 |
| South Africa | -- | -- | 36,700 | 1,300,000 | 827 | 32,000 | 431 | 15,100 | -- | -- | -- | -- |
| Switzerland | -- | -- | 128 | 4,580 | 3,720 | 138,000 | 173 | 5,340 | -- | -- | -- | -- |
| Taiwan | -- | -- | -- | -- | -- | -- | -- | -- | 230 | 8,860 | (2) | 9 |
| Thailand | -- | -- | -- | -- | -- | -- | -- | -- | 11 | 294 | -- | -- |
| Trinidad and Tobago | -- | -- | -- | -- | -- | -- | -- | -- | 1 | 89 | -- | -- |
| Turkey | -- | -- | -- | -- | -- | -- | -- | -- | 1 | 27 | -- | -- |

See footnotes at end of table.

TABLE 2—Continued
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM, BY COUNTRY[1]

| Country | Grain and nuggets | | Sponge | | Other unwrought | | Other | | Waste and scrap | | Coins | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) |
| 2006—Continued: | | | | | | | | | | | | |
| United Kingdom | 210 | $6,530 | 12,000 | $431,000 | 68 | $1,860 | 759 | $23,100 | 1,600 | $30,900 | 11 | $271 |
| Total | 234 | 7,320 | 58,100 | 2,070,000 | 7,560 | 280,000 | 8,540 | 233,000 | 39,400 | 233,000 | 65 | 881 |

[r]Revised. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Less than ½ unit.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY[1]

| Country | Unwrought palladium | | Palladium, other | | Iridium[2] | | Unwrought osmium | | Unwrought ruthenium | | Rhodium[3] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity, Pd content (kilograms) | Value (thousands) | Quantity, Pd content (kilograms) | Value (thousands) | Quantity, Ir content (kilograms) | Value (thousands) | Quantity, Os content (kilograms) | Value (thousands) | Quantity, Ru content (kilograms) | Value (thousands) | Quantity, Rh content (kilograms) | Value (thousands) |
| 2005 | 124,000 | $776,000 | 15,200 | $79,700 | 3,010 | $16,700 | 39 | $362 | 23,200 | $49,800 | 13,600 | $821,000 |
| 2006: | | | | | | | | | | | | |
| Australia | -- | -- | 425 | 2,800 | -- | -- | -- | -- | -- | -- | -- | -- |
| Austria | -- | -- | 5 | 80 | -- | -- | -- | -- | -- | -- | -- | -- |
| Belgium | 1,250 | 12,900 | 75 | 795 | -- | -- | -- | -- | -- | -- | 1,260 | 158,000 |
| Brazil | 232 | 2,670 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Canada | 1,340 | 12,100 | 178 | 3,280 | 161 | 1,670 | -- | -- | -- | -- | -- | -- |
| China | 350 | 2,960 | -- | -- | (4) | 3 | 9 | 57 | -- | -- | 1 | 46 |
| Dominican Republic | -- | -- | (4) | 2 | -- | -- | -- | -- | -- | -- | (4) | 3 |
| Estonia | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 200 | 19,100 |
| France | -- | -- | 17 | 164 | -- | -- | -- | -- | -- | -- | -- | -- |
| Germany | 282 | 2,920 | 140 | 936 | 381 | 3,950 | 7 | 100 | 10,200 | 64,700 | 1,010 | 148,000 |
| India | 799 | 8,220 | -- | -- | -- | -- | -- | -- | -- | -- | (4) | 8 |
| Ireland | -- | -- | -- | -- | (4) | 2 | -- | -- | -- | -- | (4) | 5 |
| Italy | 1,600 | 16,900 | 9 | 78 | 6 | 118 | -- | -- | 10 | 158 | 181 | 21,500 |
| Japan | 2,670 | 14,200 | 1,110 | 2,270 | 16 | 204 | -- | -- | 45 | 81 | 54 | 6,590 |
| Korea, Republic of | -- | -- | 13 | 156 | -- | -- | -- | -- | -- | -- | -- | -- |
| Luxembourg | 8,300 | 78,500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Mexico | 3 | 26 | 7 | 24 | -- | -- | -- | -- | -- | -- | 1 | 29 |
| Netherlands | -- | -- | -- | -- | 11 | 34 | -- | -- | -- | -- | -- | -- |
| Norway | 3,220 | 32,700 | -- | -- | -- | -- | -- | -- | -- | -- | 228 | 5,900 |
| Russia | 28,900 | 288,000 | 14,900 | 112,000 | -- | -- | -- | -- | 865 | 5,160 | 1,020 | 141,000 |
| Singapore | -- | -- | -- | -- | -- | -- | -- | -- | 780 | 1,730 | -- | -- |
| South Africa | 24,200 | 238,000 | 468 | 4,990 | 903 | 8,300 | 40 | 330 | 23,500 | 113,000 | 8,430 | 983,000 |
| Spain | 9 | 91 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sweden | -- | -- | -- | -- | (4) | 10 | -- | -- | -- | -- | -- | -- |
| Switzerland | 1,010 | 9,220 | 1,410 | 12,300 | -- | -- | -- | -- | -- | -- | 84 | 8,740 |
| Taiwan | -- | -- | 2 | 11 | -- | -- | -- | -- | -- | -- | -- | -- |
| Thailand | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3 | 149 |
| United Kingdom | 26,100 | 248,000 | 205 | 1,260 | 1,320 | 15,900 | -- | -- | 504 | 3,070 | 3,380 | 425,000 |
| Total | 100,000 | 967,000 | 19,000 | 141,000 | 2,800 | 30,100 | 56 | 487 | 36,000 | 187,000 | 15,900 | 1,920,000 |

-- Zero.

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

[2]Unwrought and other forms of iridium.

[3]Unwrought and other forms of rhodium.

[4]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4

U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY[1]

| Country | Palladium | | Platinum | | Platinum, waste and scrap | | Iridium, osmium, ruthenium | | Rhodium | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity, Pd content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, gross weight (kilograms) | Value (thousands) | Quantity, Rh content (kilograms) | Value (thousands) |
| 2005 | 27,000 | $122,000 | 20,700 | $448,000 r | 24,900 | $482,000 | 1,080 r | $7,200 r | 615 | $2,880 r |
| 2006: | | | | | | | | | | |
| Argentina | -- | -- | 2 | 65 | -- | -- | -- | -- | -- | -- |
| Australia | 501 | 4,110 | 55 | 927 | 3 | 33 | 2 | 18 | 1 | 11 |
| Austria | -- | -- | 106 | 1,810 | -- | -- | 1 | 3 | -- | -- |
| Belgium | 1,380 | 8,220 | 35 | 804 | -- | -- | 3 | 22 | (2) | 8 |
| Bolivia | -- | -- | -- | -- | -- | -- | -- | -- | (2) | 22 |
| Brazil | 823 | 8,240 | 452 | 13,200 | 25 | 239 | 1 | 5 | -- | -- |
| Bulgaria | 28 | 101 | 1 | 18 | -- | -- | -- | -- | -- | -- |
| Cambodia | -- | -- | 1 | 29 | -- | -- | -- | -- | -- | -- |
| Canada | 3,340 | 27,100 | 1,150 | 27,700 | 2,260 | 21,500 | 82 | 792 | 101 | 15,400 |
| Chile | -- | -- | 286 | 7,520 | -- | -- | -- | -- | -- | -- |
| China | 668 | 6,010 | 2,650 | 75,200 | 9 | 114 | 94 | 1,340 | 81 | 13,200 |
| Colombia | 44 | 363 | 1 | 24 | -- | -- | -- | -- | -- | -- |
| Costa Rica | 11 | 19 | -- | -- | -- | -- | -- | -- | -- | -- |
| Cyprus | -- | -- | (2) | 7 | -- | -- | 1 | 9 | -- | -- |
| Czech Republic | 12 | 47 | (2) | 4 | -- | -- | -- | -- | -- | -- |
| Denmark | 56 | 708 | 2 | 41 | -- | -- | -- | -- | -- | -- |
| Dominican Republic | 3 | 36 | -- | -- | -- | -- | -- | -- | (2) | 23 |
| Egypt | -- | -- | 21 | 240 | -- | -- | -- | -- | (2) | 7 |
| Finland | 4 | 56 | 12 | 233 | -- | -- | -- | -- | -- | -- |
| France | 706 | 4,520 | 84 | 1,730 | -- | -- | 38 | 290 | -- | -- |
| Georgia | 13 | 132 | -- | -- | -- | -- | -- | -- | -- | -- |
| Germany | 4,400 | 18,800 | 2,900 | 71,600 | 7,120 | 81,000 | 131 | 886 | 49 | 5,340 |
| Ghana | 1 | 5 | -- | -- | -- | -- | -- | -- | -- | -- |
| Greece | (2) | 5 | (2) | 7 | -- | -- | -- | -- | 2 | 86 |
| Guatemala | -- | -- | -- | -- | -- | -- | 1 | 23 | -- | -- |
| Haiti | 5 | 30 | -- | -- | -- | -- | -- | -- | -- | -- |
| Hong Kong | 440 | 3,290 | 581 | 13,800 | 10 | 124 | 321 | 3,230 | 4 | 644 |
| Hungary | -- | -- | (2) | 3 | -- | -- | -- | -- | -- | -- |
| Iceland | 13 | 77 | 1 | 15 | -- | -- | -- | -- | -- | -- |
| India | 149 | 985 | 81 | 1,680 | -- | -- | (2) | 6 | 4 | 569 |
| Indonesia | -- | -- | (2) | 3 | -- | -- | -- | -- | -- | -- |
| Ireland | 110 | 290 | 261 | 5,490 | -- | -- | 4 | 87 | -- | -- |
| Israel | 1,010 | 3,750 | 33 | 620 | -- | -- | -- | -- | (2) | 4 |
| Italy | 2,650 | 27,100 | 1,930 | 65,400 | 126 | 2,100 | 1 | 9 | 6 | 1,110 |
| Japan | 3,670 | 38,400 | 5,590 | 165,000 | 4,470 | 77,100 | 1,160 | 10,100 | 1,240 | 63,600 |
| Jordan | -- | -- | -- | -- | 1 | 7 | -- | -- | -- | -- |
| Korea, Republic of | 477 | 3,080 | 213 | 6,530 | -- | -- | 8 | 110 | (2) | 20 |
| Kuwait | 9 | 116 | -- | -- | -- | -- | -- | -- | -- | -- |
| Liechtenstein | 8 | 84 | 8 | 186 | -- | -- | -- | -- | -- | -- |
| Malaysia | 12 | 70 | 9 | 196 | 85 | 914 | 104 | 2,560 | -- | -- |
| Malta and Gozo | -- | -- | (2) | 3 | -- | -- | -- | -- | -- | -- |
| Mexico | 239 | 770 | 206 | 4,930 | 1 | 6 | 1 | 20 | 4 | 650 |
| Monaco | 13 | 248 | -- | -- | -- | -- | -- | -- | -- | -- |
| Morocco | -- | -- | (2) | 4 | -- | -- | -- | -- | -- | -- |
| Netherlands | 59 | 615 | 90 | 1,350 | -- | -- | 2 | 12 | -- | -- |
| Netherlands Antilles | -- | -- | (2) | 6 | -- | -- | -- | -- | -- | -- |
| New Zealand | 84 | 1,030 | 6 | 114 | -- | -- | -- | -- | -- | -- |
| Norway | 57 | 874 | 79 | 1,210 | -- | -- | -- | -- | -- | -- |
| Oman | 1 | 5 | -- | -- | -- | -- | -- | -- | -- | -- |

See footnotes at end of table.

TABLE 4—Continued
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY[1]

| Country | Palladium | | Platinum | | Platinum, waste and scrap | | Iridium, osmium, ruthenium | | Rhodium | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity, Pd content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, Pt content (kilograms) | Value (thousands) | Quantity, gross weight (kilograms) | Value (thousands) | Quantity, Rh content (kilograms) | Value (thousands) |
| 2006—Continued: | | | | | | | | | | |
| Pakistan | -- | -- | -- | -- | -- | -- | (2) | $5 | -- | -- |
| Philippines | 20 | $73 | 16 | $329 | -- | -- | -- | -- | -- | -- |
| Poland | 20 | 94 | 4 | 72 | -- | -- | -- | -- | -- | -- |
| Qatar | 1 | 9 | -- | -- | -- | -- | -- | -- | -- | -- |
| Romania | 7 | 59 | 4 | 91 | -- | -- | -- | -- | -- | -- |
| Russia | -- | -- | 1 | 26 | -- | -- | -- | -- | -- | -- |
| Saudi Arabia | 32 | 374 | 4 | 76 | -- | -- | -- | -- | -- | -- |
| Seychelles | (2) | 3 | -- | -- | -- | -- | -- | -- | -- | -- |
| Singapore | 51 | 524 | 51 | 1,160 | 1,530 | $15,700 | 660 | 5,820 | 1 | $88 |
| Slovakia | 22 | 50 | -- | -- | -- | -- | -- | -- | -- | -- |
| Slovenia | 4 | 15 | -- | -- | -- | -- | -- | -- | -- | -- |
| South Africa | 7 | 43 | 19 | 434 | -- | -- | -- | -- | (2) | 37 |
| Spain | 226 | 1,380 | 7 | 110 | (2) | 4 | 1 | 18 | -- | -- |
| Suriname | -- | -- | 10 | 198 | -- | -- | -- | -- | -- | -- |
| Sweden | 28 | 441 | 14 | 339 | -- | -- | -- | -- | -- | -- |
| Switzerland | 18,000 | 187,000 | 4,550 | 149,000 | 1 | 23 | 30 | 241 | -- | -- |
| Taiwan | 3,800 | 13,200 | 1,330 | 34,000 | -- | -- | 444 | 3,510 | 88 | 4,660 |
| Thailand | 266 | 1,090 | 66 | 1,240 | -- | -- | -- | -- | -- | -- |
| Trinidad and Tobago | 3 | 20 | -- | -- | -- | -- | -- | -- | -- | -- |
| Turkey | 3 | 32 | 1 | 27 | -- | -- | -- | -- | -- | -- |
| United Arab Emirates | 3 | 44 | 1 | 19 | -- | -- | -- | -- | (2) | 68 |
| United Kingdom | 9,530 | 38,000 | 22,500 | 511,000 | 13,800 | 395,000 | 299 | 6,670 | 18 | 2,600 |
| Venezuela | 23 | 191 | 6 | 152 | -- | -- | -- | -- | -- | -- |
| Vietnam | 2 | 7 | 10 | 189 | -- | -- | -- | -- | -- | -- |
| Total | 53,100 | 402,000 | 45,500 | 1,170,000 | 29,400 | 594,000 | 3,390 | 35,800 | 1,600 | 108,000 |

[r]Revised. -- Zero.

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

[2]Less than ½ unit.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 5
PLATINUM-GROUP METALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

| Country[3] | 2002 | 2003 | 2004[e] | 2005[e] | 2006[e] |
|---|---|---|---|---|---|
| Palladium: | | | | | |
| Australia[4] | 810 | 820 [e] | 800 [r] | 800 [r] | 800 |
| Botswana[e] | 1,300 | 2,200 | 2,500 | 1,900 | 2,000 |
| Canada | 12,210 | 12,808 | 12,000 [r] | 13,500 [r] | 14,000 [p] |
| Japan[5] | 5,618 | 5,500 [e] | 5,300 | 5,400 [r] | 5,400 |
| Poland[e, 6, 7] | 12 | 12 | 12 | 12 | 12 |
| Russia[e] | 96,000 | 97,000 | 97,000 | 97,400 | 98,400 |
| Serbia and Montenegro[e, 8] | 25 | 20 | 20 | 20 [r] | -- |
| South Africa | 63,758 | 70,946 | 76,403 [r, 9] | 82,961 [r, 9] | 85,000 |
| United States[10] | 14,800 | 14,000 | 13,654 [9] | 13,312 [9] | 14,401 [9] |
| Zimbabwe | 1,943 | 3,449 | 3,564 [9] | 3,879 [9] | 4,000 |
| Total | 196,000 | 207,000 | 211,000 [r] | 219,000 [r] | 224,000 |
| Platinum: | | | | | |
| Australia[e, 4] | 200 | 225 | 200 [r] | 200 | 200 |
| Botswana[e] | 300 | 500 | 500 | 300 | 300 |
| Canada | 9,202 | 6,990 [e] | 7,000 [r] | 9,000 [r] | 9,000 [p] |
| Colombia | 661 | 828 [e] | 1,209 [9] | 1,082 [9] | 1,100 |
| Ethiopia | NA | NA | NA | NA | 5 |
| Finland | 508 | 461 [e] | 705 | 800 | 800 |
| Japan[5] | 762 | 770 [e] | 750 | 760 [r] | 760 |
| Poland[e, 6, 7] | 20 | 20 | 20 | 20 | 20 |
| Russia[e] | 27,000 | 28,000 | 28,000 | 29,000 [r] | 29,000 |
| Serbia and Montenegro[e, 8] | 5 | 5 | 5 | 5 [r] | -- |
| South Africa | 132,897 | 148,348 | 153,239 [r, 9] | 163,711 [r, 9] | 170,000 |
| United States[10] | 4,390 | 4,170 | 4,040 [9] | 3,920 [9] | 4,292 [9] |
| Zimbabwe | 2,306 | 4,270 | 4,438 [9] | 4,834 [9] | 5,100 |
| Total | 178,000 | 195,000 | 200,000 [r] | 214,000 [r] | 221,000 |
| Other platinum-group metals: | | | | | |
| Canada[e] | 2,960 [r] | 1,730 [r] | 7,164 [r, 9] | 5,000 [r] | 5,000 [p] |
| Russia[e] | 14,500 | 15,000 | 15,000 | 15,500 | 15,600 |
| South Africa | 39,986 | 46,856 | 46,759 [r, 9] | 56,309 [r, 9] | 52,000 [9] |
| Zimbabwe | 480 | 851 | 809 [9] | 862 [9] | 900 |
| Total | 57,900 [r] | 64,400 [r] | 69,700 [r] | 77,700 [r] | 73,500 |
| Grand total | 433,000 [r] | 466,000 [r] | 481,000 [r] | 510,000 [r] | 518,000 |

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through April 29, 2007. 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 thought to be included in the production figures for those countries.

[5]Production derived entirely from imported ores.

[6]Based on official Polish estimates.

[7]Estimates based on reported platinum and palladium-bearing final (residual) slimes and then average Pt and Pd content from electrolytic copper refining.

[8]In June 2006, Montenegro and Serbia formally declared independence from each other and dissolved their union. Mineral production data for 2006, however, still reflect the unified country.

[9]Reported figure.

[10]A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.