



2008 Minerals Yearbook

PLATINUM-GROUP METALS [ADVANCE RELEASE]

PLATINUM-GROUP METALS

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In 2008, Stillwater Mining Co. (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. MMC Norilsk Nickel (Moscow, Russia) was the majority owner of SMC. SMC produced 15,500 kilograms (kg) of platinum and palladium in 2008, 7% less than the 16,700 kg that it produced in 2007 (Stillwater Mining Co., 2009, p. 49). Defense National Stockpile Center reported no PGM sales in 2008; 18 kg of iridium and 261 kg of platinum remained in the stockpile. Palladium stocks were exhausted in 2004 (table 1).

In 2008, the automobile industry continued to be the major consumer of PGMs. Autocatalysts accounted for approximately 81% of rhodium consumption, 47% of palladium consumption, and 44% of platinum consumption on a global basis (Jollie, 2009, p. 52–56).

Production

Primary.—During 2008, the Stillwater Mine produced 8,300 kg of palladium and 2,500 kg of platinum, 2% and 5% less, respectively, relative to production in 2007. PGM production from the East Boulder Mine was 4,660 kg (3,600 kg of palladium and 1,060 kg of platinum), which was a 17% decrease in palladium production and a 13% decrease in platinum production compared with those of 2007. Palladium and platinum production for SMC each were down by 7% compared with production in 2007. Production of rhodium in 2008 was 62 kg, about one-half of production in 2007 (Stillwater Mining Co., 2009, p. 50). The company milled 1.06 million metric tons of ore from the mines, a 9% drop relative to that of 2007. The lower production resulted from operational restructuring in response to lower metal prices. Operations at the smaller East Boulder Mine were briefly halted and the workforce was downsized, with a portion of the workforce reassigned to the higher grade Stillwater Mine, replacing higher cost contract workers. SMC cut back on capital expenditures, curtailed nonessential services, and slashed marketing and exploration budgets in order to ensure continued operations. SMC planned to produce 15,400 kg of PGMs in 2009, including 11,500 kg from the Stillwater Mine and 3,890 kg from the East Boulder Mine. SMC's proven and probable reserves are contained in the J-M Reef, an ore body that occurs within the layered igneous rocks of the Stillwater Complex. At yearend 2008, the company reported a total proven and probable reserve of 778,000 kg of palladium and platinum, with an in-situ palladium to platinum ratio of about 3.55 to 1 (Stillwater Mining Co., 2009, p. 6).

In 2008, exploration continued at several sites in the United States. The most advanced project was PolyMet Mining Corp.'s (Vancouver, British Columbia, Canada) NorthMet Mine in the Duluth Complex in northeast Minnesota. PolyMet received

a draft environmental impact statement from the Minnesota Department of Natural Resources in December. PolyMet planned to review the document and submit any comments (PolyMet Mining Corp., 2008b). PolyMet entered into a strategic partnership with Glencore International AG (Baar, Switzerland) such that Glencore would purchase PolyMet's production of copper, nickel, and PGMs from the NorthMet Mine for 5 years (PolyMet Mining Corp. 2008a; 2009, p. 2–5). Franconia Minerals Corp. (Spokane, WA) completed its drilling program at the Birch Lake project, located in the Duluth Complex, and planned to move toward final feasibility determination in 2010 (Franconia Minerals Corp., 2009, p. 2). Nevoro, Inc. (Toronto), through its wholly owned Aurora Platinum Corp. (formerly Aurora Metals Ltd.) (Vancouver), continued exploration on PGM-bearing chromitites in the Stillwater Complex, MT, and drilling was planned to continue in 2009 (Nevoro Inc., 2008). SMC terminated its investment interest in Pacific North West Capital Corp. (Vancouver) that was performing exploration at Goodnews Bay, AK (Stillwater Mining Co., 2009, p. 31). In Alaska, Pure Nickel, Inc. (Toronto) continued exploration of the nickel-copper-cobalt-PGM MAN property 265 kilometers (km) south-southeast of Fairbanks (Pure Nickel, Inc., 2009, p. 10).

Secondary.—In 2008, recycling of autocatalysts provided a substantial secondary source of PGMs. The global recovery of platinum from autocatalysts rose by 7% in 2008, reaching 31,300 kg, with recovery increasing by 71% in Japan, 50% in China, 14% in Europe, and 7% in the rest of the world relative to 2007 quantities. In North America, recovery of platinum from catalytic converters was an estimated 19,000 kg of platinum, a slight increase relative to that in 2007, and roughly 61% of global autocatalyst recycled material (Jollie, 2009, p. 26).

About 36,400 kg of palladium was recovered from autocatalysts globally in 2008, an increase of 15% compared with that of 2007. Palladium recovery in Europe increased by 22% to 11,400 kg, and that in North America increased by 6% to 19,400 kg relative to that in 2007. Roughly 53% of global recycled palladium came from North America, an increase from that of 2007 because of the increased use of palladium in catalytic converters in North America at the end of the last decade (Jollie, 2009, p. 34). In 2008, global recovery of rhodium from autocatalysts increased by 7% to 6,380 kg (Jollie, 2009, p. 42).

SMC's recycling program recovered 12,400 kg of PGMs in 2008, up nearly 7% as compared with that of 2007. The sale of the recycled material was \$475.4 million in 2008, which was up 46% from the 2007 sales value (Stillwater Mining Co., 2009, p. 21).

Consumption

In 2008, global platinum sales totaled 229,000 kg, a 3% decrease compared with sales in 2007. Platinum use in the autocatalyst sector grew owing to stricter emission standards and to the growth in production of light-duty diesel vehicles in Europe. Many of the vehicles now have a platinum-based oxidation catalyst as well as a platinum-coated particulate filter, thus increasing the average platinum loading per vehicle. However, the partial replacement of platinum by palladium in autocatalysts led to lower platinum consumption. Automakers have largely removed platinum from three-way, or gasoline catalysts and have increased substitution of less-expensive palladium for as much as 25% of the platinum in diesel engines.

Investment demand increased by 150% in 2008 relative to that of 2007. Platinum holdings in exchange-traded funds (ETFs) totaled 9,330 kg at the end of 2008, a 54% increase from that of 2007 (Jolie, 2009, p. 29).

Global palladium sales were 249,000 kg in 2008, nearly unchanged from those of 2007. Purchases for investment increased to 12,400 kg, 54% higher than those of 2007. Holdings in ETFs totaled 11,500 kg at the end of 2008, a 32% increase from that of 2007 (Jolie, 2009, p. 38).

In 2008, U.S. apparent consumption of refined platinum was estimated to be about 138,000 kg, a 12% decrease from the apparent consumption of 2007 of 156,000 kg. Apparent domestic palladium consumption was estimated to be about 106,000 kg, a 26% increase from the 84,100 kg of 2007.

Palladium.—Palladium use in autocatalysts decreased by 4% globally to 136,000 kg in 2008 compared with 2007 consumption. Demand in Europe rose by 3%, despite a decline in production of light-duty vehicles. The increase was owing to a small change in catalyst formulations in gasoline vehicles, and more importantly, to an increase in palladium use in diesel vehicles. Palladium was also being used increasingly in diesel particulate filters along with platinum. Demand in North America plummeted to 41,800 kg, a 21% decrease relative to that of 2007, owing to the global economic crisis and a decrease in vehicle purchases. Vehicle purchases in the United States decreased by 36% in December 2008 compared with those in December 2007. Palladium demand in China increased to 12,000 kg, an 18% increase relative to that of 2007. Palladium demand for autocatalysts in the rest of the world increased by 8% to 26,000 kg (Jollie, 2009, p. 31–34).

On a global basis, palladium consumption by the jewelry industry increased by 20% in 2008 compared with that of 2007. The increase was largely a result of increased gold and platinum prices, which led a greater number of manufacturers to substitute palladium for these metals. China was again by far the leading user of palladium for jewelry, at 76% of world consumption in that sector. Consumption in China increased to 20,200 kg of palladium, 30% higher than that of 2007. The much smaller markets in Europe and North America also showed increases in palladium usage in jewelry. Consumption in Europe was 1,400 kg of palladium, a 13% increase relative to that of 2007, and consumption in North America was 1,870 kg, a 9% increase relative to that of 2007. In contrast, consumption in Japan was 2,330 kg of palladium, a 21% decrease relative to that of 2007 (Jollie, 2009, p. 35–36).

World palladium consumption in dental alloys was 19,600 kg in 2008, unchanged from consumption in 2007. Roughly 44% of the global consumption came from Japan and about 43% from North America. The chemical industry consumed 10,900 kg of palladium in 2008, a 7% decrease from that in 2007. The global decrease was the result of an expected slowdown in the construction of new plants as well as the global economic problems in the fourth quarter. In the chemical industry, palladium is used mainly as a catalyst in manufacturing bulk chemicals, including purified hydrogen peroxide, nitric acid, purified terephthalic acid, and vinyl acetate monomer, the latter of which is a component of many resins and plastics. The electronics industry increased its consumption of palladium for the seventh consecutive year. Consumption was up by 7% in 2008, to 41,200 kg, as compared with that of 2007. The leading use of palladium in the electronics industry was for multilayer ceramic capacitors, which are widespread in electronic circuitry. Significant amounts of palladium also were used in hybrid integrated circuits, which are miniaturized electronic circuits constructed of individual devices, such as semiconductor devices and passive components, bonded to a substrate or printed circuit board. Use of palladium in other applications decreased by 6% in 2008 compared with that of 2007. Such uses included stationary source emission control and petroleum refining catalysts. Palladium use in investment products increased by 54%, to 12,400 kg in 2008 from 8,090 kg in 2007 (Jollie, 2009, p. 38).

Platinum.—Global use of platinum in the autocatalyst sector decreased by 8% to 118,000 kg in 2008 compared with that in 2007. Consumption in Europe was about 62,800 kg of platinum in 2008, about 2% less than that of 2007, and accounted for more than one-half of the global total. The proportion of light-duty diesel vehicles in Europe decreased slightly to 52% of all light-duty vehicles. Consumption in this sector for North America decreased by 34% in 2008 relative to that of 2007 owing to the decrease in automobile purchases in response to the global financial crisis. Light-duty vehicle production decreased sharply in North America in 2008. In Japan, platinum demand in the autocatalyst sector decreased by about 2%. In China, where almost all cars are gasoline-powered, use of platinum for autocatalysts in 2008 rose to 5,750 kg, a 6% increase relative to consumption in 2007. This increase was as a result of the 10th consecutive year of record automobile sales as well as tighter emission standards. Consumption of platinum for autocatalysts decreased slightly in other areas of the world despite increasingly stringent emission standards (Jollie, 2009, p. 24).

In 2008, global consumption of platinum in jewelry decreased for the sixth consecutive year to the lowest level in 17 years, as a result of high prices in the first half of the year. Consumption in this sector was 42,500 kg of platinum, a 6% decrease compared with that of 2007. Consumption in North America decreased by 11%, and consumption in Japan plummeted by 69% in 2008 relative to consumption in 2007. Consumption in China increased by 9% from the same time period. China remained by far the leading consumer in this sector, at 26,400 kg; it accounted for 62% of global consumption. In Europe, platinum consumption in the jewelry industry was 6,070 kg, a decrease of 3% compared with that in 2007 (Jollie, 2009, p. 26–28).

Global use of platinum in the chemical sector decreased by 6% in 2008, to 12,300 kg compared with that of 2007 as a result of thrifting. The purchases of platinum by the petroleum refining industry increased by 20% to 7,620 kg in 2008, because of increased refining capacity in some regions of the world. The global consumption of platinum in electrical applications decreased by 12%, to 7,000 kg in 2008, as compared with that of 2007, owing to decreased purchasing by the computer hard drive manufacturing industry. Platinum consumed in the glass industry decreased to 12,100 kg in 2008, a 17% drop compared with that of 2007. The drop was largely a result of a decrease in industrial demand for fiberglass, which caused a delay in the construction of factories. Consumption in other end uses rose slightly to 15,500 kg. Demand in the dental sector decreased, as a result of the high prices in the first half of the year. Investment demand for platinum rose to 13,200 kg, an increase of 150% in 2008 relative to that of 2007. By yearend 2008, the two ETFs contained 9,330 kg of platinum, an increase of 54% relative to that of 2007 (Jollie, 2009, p. 28–29).

In 2008, the U.S. Mint sales of platinum American Eagle Bullion coins increased by 272% to 1,048 kg from 281 kg in 2007 with the great majority of sales in September and October, when the platinum price had reached the lowest level of the year (U.S. Mint, 2009).

Other PGMs.—Global rhodium consumption in 2008 decreased to 21,400 kg, an 18% decrease compared with that of 2007. A majority of rhodium use, 81% in 2008, was in the production of autocatalysts. In 2008, rhodium use in autocatalysts decreased by 14%, the first decrease in this sector since 2001. Demand for rhodium in the autocatalyst sector plummeted in North America as a result of falling vehicle production, a trend toward smaller vehicles, and rhodium thrifting. Rhodium demand also decreased in Europe and Japan in 2008 relative to that in 2007 owing to decreased vehicle production. Use of rhodium in the glass manufacturing sector decreased to 1,180 kg, a 36% drop in 2008 as compared with that in 2007. The decrease was a result of lessened demand for flat panel glass and a reduction of rhodium content of alloys used in the industry. Rhodium was also released onto the market by some cathode-ray tube glass factories that closed in China. Consumption of rhodium in the chemical sector rose by 8% to 2,120 kg in 2008 owing to construction of new oxoalcohol manufacturing plants in Asia. Demand from the electrical sector as well as other applications was up by 4% from that of 2007, at 778 kg (Jollie, 2009, p. 42).

Global consumption of ruthenium decreased for the second successive year. Demand decreased by 37% to 20,100 kg in 2008 relative to that in 2007. The consumption of ruthenium in electrical applications fell to 12,900 kg, a 47% decrease relative to that of 2007; consumption of primary ruthenium decreased in the hard disk industry as a result of thrifting and increased recycling. Ruthenium use in thick film chip resistors and in the production of plasma display panels fell in 2008, and its use in the chemical sector fell to 4,320 kg in 2008, an 8% decrease compared with that in 2007. Global consumption of iridium decreased to 3,100 kg in 2008, a 2% drop compared with 2007 consumption, reflecting a 40% decrease of iridium use in the electrical sector. Fewer iridium crucibles were manufactured

for crystal-growing in 2008 than in previous years. The crystals were used in telecommunications and medical imaging, and the global economic slowdown resulted in lower demand in both those sectors in 2008 relative to that in 2007. Use of iridium in spark plugs in the aerospace and automotive industries was about the same in 2008 as in 2007 (Jollie, 2009, p. 43).

Prices

According to Platts Metals Week, the 2008 annual average price of palladium decreased slightly, whereas the platinum price increased by 21% compared with the 2007 annual average prices. As for the other PGMs, the 2008 iridium annual price increased slightly, the 2008 rhodium annual price increased by 5%, and the ruthenium 2008 annual price dropped by 43% compared with the 2007 prices (table 1).

Iridium.—In January, the price of iridium was \$450 per troy ounce; where it remained for the first half of the year. The price rose to \$460 per troy ounce in August, but then fell as a result of the global economic downturn, and ended the year at \$430 per troy ounce.

Palladium.—Palladium price began the year at \$373 per troy ounce and rose in February following the electricity shortage in South Africa that resulted in all platinum mines being shut down for 5 days. Palladium price reached its peak of \$585 per troy ounce in early March, and then fell throughout the rest of that month. The price rose briefly in June in response to reports that the Russian state palladium stocks could be depleted within 5 years, and then the price fell steadily throughout the rest of the year, ending the year at \$185 per troy ounce.

Platinum.—In 2008, the platinum price reached its alltime high annual average of \$1,578 per troy ounce. Platinum price began the year at \$1,545 per troy ounce. In late January, the electricity shortage in South Africa resulted in platinum mines being shut down for 5 days, and the platinum price responded on supply fears, and hit a series of record high prices during February to an alltime high of \$2,275 per troy ounce on March 4. The price remained near the \$2,000-per-troy-ounce mark until July, when it began a steady drop in response to the global economic downturn. The price reached its lowest point of the year of \$760 per troy ounce in late October. The platinum price ended the year at \$912 per troy ounce. In December, platinum and gold prices reached parity for the first time in 10 years.

Rhodium.—The rhodium price began the year at \$6,850 per troy ounce. The South African mine closures at the end of January caused the rhodium price to spike, and it rose by more than \$2,000 per troy ounce in less than a month, to \$9,100 per troy ounce in late February. The price continued to rise, marking a continuous series of record highs, to reach an alltime high of \$10,050 per troy ounce in mid-June. The price then began to drop in August in response to a slowdown in North American vehicle production, and auto company and speculator sales drove the price down to \$8,000 per troy ounce in early August. The price continued to plummet, and with slowing global vehicle production, the rhodium price fell by nearly \$1,000 per troy ounce in a single day in early September. The price continued to fall on rumors of selling by hedge funds or by auto companies, and was \$1,450 per troy ounce in early November. The price hit a low for the year of \$1,000 per troy ounce in late

November, more than 90% below its peak in June. The rhodium price rose slightly in December and ended the year at \$1,260 per troy ounce.

Ruthenium.—The ruthenium price began the year at \$415 per troy ounce and stayed above the \$400 per troy ounce mark until early April. Increased amounts of recycled material from the hard disk industry pushed the price lower, to \$300 per troy ounce at the end of June. With the global economic slowdown, demand from the hard disk sector fell, and the ruthenium price fell steadily lower to \$230 per troy ounce at the end of October, and to \$200 per troy ounce at the end of November. The price continued to slip and ended the year at \$100 per troy ounce.

Foreign Trade

In 2008, the U.S. net import reliance as a percentage of apparent consumption was estimated to be 89% for refined palladium and 97% for refined platinum. Imports of refined palladium in 2008 increased by 7% to 120,000 kg from 113,000 kg in 2007, with three countries accounting for about 91% of refined palladium imports in 2008—Russia (61%), South Africa (18%), and the United Kingdom (12%). Imports of platinum, including waste, scrap, and coins decreased by 17% in 2008 to 150,000 kg, from 181,000 kg in 2007. Excluding waste and scrap, three countries accounted for 79% of imports of platinum in 2008—South Africa (46%), the United Kingdom (23%), and Germany (10%). Other refined PGM imports were down by 5% in 2008 compared with those of 2007. Imports of iridium were down by 25%; those of osmium and rhodium were down by 52% and 24%, respectively, whereas imports of ruthenium were up by 2% compared with those of 2007. Three countries accounted for 76% of the imports of other PGM in 2008—South Africa (30%), Germany (27%), and the United Kingdom (9%) (tables 2 and 3).

Exports of PGMs in 2008 decreased from those in 2007, with the exception of platinum waste and scrap, which rose slightly (table 4). Exports of palladium and platinum decreased by 37% and 46%, respectively, and exports of rhodium decreased by 10% compared with exports in 2007. Exports of iridium, osmium, and ruthenium dropped by 21% during the same time period.

World Review

In 2008, world mine production of PGMs decreased to 465,000 kg compared with 512,000 kg in 2007 (table 5). South Africa, the world's leading producer of PGMs, accounted for 59% of total mine production in 2008, Russia accounted for 26%, Canada accounted for 6%, and the United States and Zimbabwe each accounted for 3%. In 2008, platinum production from South Africa totaled 146,000 kg, which represented 77% of world platinum production and a 9% decrease relative to South African production in 2007. Global output of palladium dropped to 204,000 kg, with Russia and South Africa accounting for 43% and 37%, respectively, of the total. World production of other PGMs (iridium, osmium, ruthenium, and rhodium) in 2008 decreased by 9% as compared with that of 2007. South Africa was the dominant producer, accounting for 75% of the global total production of other PGMs.

Australia.—Platinum Australia Ltd. (West Perth) completed significant work on updating the 2003 feasibility study at the Panton PGM Project in Western Australia. Completion of the feasibility study was put on hold as a result of decreased metal prices (Platinum Australia Ltd., 2009, p. 4).

Botswana.—In 2008, MMC Norilsk Nickel produced 2,960 kg of palladium and 591 kg platinum as byproducts from its nickel operations at the Tati Mine. These quantities represented decreases for palladium and platinum production of 38% and 21%, respectively, compared with production in 2007 (MMC Norilsk Nickel, 2009, p. 63).

Canada.—North American Palladium Ltd. (Toronto, Ontario, Canada) produced 6,600 kg of palladium in 2008, a 26% decrease relative to 2007 production, as a result of their Lac des Isles Mine being placed on care-and-maintenance status in October in response to lower metal prices (North American Palladium Ltd., 2009).

In the Sudbury region, Marathon PGM Corp. (Toronto) completed a definitive feasibility study of its Marathon PGM-copper property. The Marathon deposit was planned as an open pit, with mining planned to start in 2012 and with a projected mine life of 10 years. Expected production was 90,000 metric tons per year of a single concentrate containing copper, PGMs, gold, and silver, which was to be shipped to a third-party smelter. Marathon [in a joint venture with Gossan Resources Ltd. (Winnipeg, Manitoba)] continued drilling at the Bird River Project, Manitoba, and results indicated two zones with potential for bulk-minable ore bodies (Marathon PGM Corp., 2009, p. 1). Canadian Royalties Inc. (Montreal, Quebec) put its nickel-copper-PGM Nunivak Nickel Project (formerly known as the Raglan South Nickel Project) in the Raglan area of Quebec on hold as a result of low metal prices (Canadian Royalties Inc., 2009). Xstrata plc (Zug, Switzerland) continued to produce PGM as byproducts from nickel mining operations at Sudbury, although production figures were not released. The company expanded its Raglan nickel mine in northern Quebec (Jollie, 2009, p. 21).

Vale Inco (Toronto) produced 7,190 kg of palladium and 5,160 kg of platinum as byproducts of its nickel operations at Sudbury. These production data reflect production increases for platinum and palladium of 19% and 21%, respectively, relative to production in 2007 (Vale Inco, 2009, p. 43–44).

Finland.—North American Palladium Ltd. (Toronto, Ontario, Canada) terminated the Arctic Platinum Project, a joint venture with Gold Fields Ltd. (Johannesburg, South Africa). The project was begun in 2005 by the two companies and focused on exploration and mine development at a series of PGM as well as copper and nickel deposits. North American Palladium cited high steel and diesel prices as well as the strong euro against the dollar as factors in its decision. Gold Fields decided to shelve the project for the time being because of falling metal prices (Seccombe, 2008).

Russia.—In 2008, Russia accounted for 43% of global mine production of palladium, 17% of other PGMs, and 12% of platinum production. MMC Norilsk Nickel produced 84,000 kg of palladium and 19,700 kg of platinum, which were decreases of 11% and 13%, respectively, compared with production in 2007 (MMC Norilsk Nickel, 2009, p. 63). Russia's alluvial

production was 5,910 kg of platinum, slightly higher than the 5,750 kg of platinum produced in 2007 (Jollie, 2009, p. 21).

South Africa.—South Africa accounted for 77% of platinum, 75% of other PGMs, and 37% of palladium produced worldwide in 2008. In 2008, South African production of platinum dropped relative to that of 2007 as a result of various problems, including the energy-related 5-day mine closure in January, cutback on production in response to the global economic crisis late in 2008, as well as safety-related mine closures, labor unrest, problems retaining skilled workers, and geological issues. The world's leading PGM producer, Anglo Platinum Ltd. (Johannesburg) produced 74,200 kg of platinum and 41,000 kg of palladium in 2008, a decrease of 4% for platinum and 5% for palladium relative to production in 2007. Rhodium production was 7,990 kg in 2008, a decrease of 9% relative to that of 2007. Production from Anglo Platinum's wholly owned mines was as follows: the Rustenburg Section produced 21,800 kg of platinum, a 4% decrease from 2007 production; the Amandelbult Section produced 14,300 kg of platinum, 20% less than that in 2007; Mogalakwena (formerly PPRust) produced 5,520 kg; 9% more than that in 2007; Lebowa Mine produced 2,260 kg of platinum, 23% less than that in 2007; and Twickenham Phase I production was 308 kg of platinum, a 13% increase from 2007 production. Anglo Platinum joint-ventures production was as follows: the Union Section, 85% owned with the Bakgatla-Ba-Kgafela Traditional Community, produced 9,600 kg of platinum, the same as that in 2007; Bafokeng-Rasimone Mine, a 50-50 joint venture with Royal Bafokeng Resources (Pty.) Ltd. (Johannesburg), produced 5,300 kg of platinum, a 10% drop from that in 2007; and Modikwa Mine, a 50-50 joint venture with African Rainbow Minerals Ltd. (ARM) (Sandton), produced 4,080 kg of platinum, an increase of 14% relative to that in 2007. Anglo Platinum had two pool and share agreements (P&SAs) with Aquarius Platinum South Africa. At the Kroondal Mine, refined production increased by 52% to 6,100 kg of platinum. The second P&SA is the Marikana Mine, which continued its ramp up, and produced 1,020 kg of refined platinum, an increase of 46% from 2007 levels. The Marikana ramp up was expected to continue until it reached steady-state production of 2,300 kg/yr of platinum during 2010. The Mototolo Platinum Mine, a 50-50 joint venture with XK Platinum Partnership, which consists of Xstrata and Kasigo Platinum Venture (Pty.) Ltd., had its second full year of production in 2008, with a reported 2,610 kg of platinum produced, which was a 9% decrease relative to that of 2007. The Western Limb Tailings Retreatment plant produced 1,300 kg of platinum, a 5% decrease from 2007 production (Anglo Platinum Ltd., 2009, p. 107–121).

Impala Platinum Holdings Ltd.'s (Johannesburg) refined production of platinum in 2008 was 30,600 kg, a 9% decrease compared with that of 2007. Production from its majority-owned Marula operation was 2,200 kg of platinum, an increase of 5% from 2007 production. Marula ramp up fell behind schedule as a result of shortages in skilled labor, safety-related stoppages, and labor strikes. Full production of 4,040 kg/yr was expected in 2011. Impala completed a feasibility study of the Marula Merensky extension, and had planned to bring the project onstream in 2014 with expected production of 3,580

kg/yr of platinum, but the project was put on hold indefinitely, as a result of low metal prices. At the Leeuwkop project, some preparatory work was completed at the shaft site, but the project was subsequently put on hold indefinitely as a result of the drop in metal prices (Impala Platinum Holdings Ltd., 2009, p. 51–67).

In 2008, Northam Platinum Ltd. (Johannesburg) reported production of 8,800 kg of PGMs in concentrate, a 14% decrease with production in 2007 (Northam Platinum Ltd., 2009, p. 5).

Lonmin plc (London, United Kingdom) reported production for 2008 of 22,800 kg of platinum and 10,600 kg of palladium, a decrease of 16% and 15%, respectively, relative to 2007 production. Rhodium production decreased to 3,560 kg, a 13% reduction relative to that of 2007. Ruthenium production was 5,670 kg, 16% less than in 2007, and iridium production was 1,280 kg, 23% less than that of 2007. Production decreased as a result of safety-related stoppages, the Eskom power outage in January, and high levels of absenteeism, as well as available face length constraints, which were being addressed through accelerated ore reserve development. Open pit operations at the Marikana Mine were suspended in December as a result of low metal prices. Hybrid mining, a mixture of stoping methods and mechanized development, was undertaken in the latter part of the year to address the poor performance of mechanized mining. Mining continued at the Pandora Joint Venture, of which Lonmin has a 42.5% interest, along with Anglo Platinum (42.5%), Mvelaphanda Resources Ltd. (Sandton) (7.5%), and Bapo Ba Mogale Tribe (7.5%) (Lonmin plc, 2009, p. 4–6, 114).

Aquarius announced that production from its wholly owned Everest Mine was 2,340 kg of platinum, 1,160 kg of palladium, and 398 kg of rhodium during 2008, decreases of 28%, 30%, and 29%, respectively, compared with 2007 production. Operations at the Everest Mine were suspended in early December as a result of subsidence of the mined-out portion of the mine. The mine was to be closed for at least 6 months to address the problem.

Aquarius had two P&SAs with Anglo Platinum, at the Kroondal and Marikana Mines. Production from the Kroondal Mine, reported as metal in concentrate, decreased by 4% relative to that in 2007 at 7,300 kg of platinum. Production during 2008 from the Marikana Mine was 2,580 kg of platinum, a slight drop from that of 2007. Production from the Chromite Tailings Retreatment Plant [a joint-venture project between Aquarius (50%), GB Mining and Exploration Ltd. (Johannesburg) (25%), and Sylvania South Africa Ltd. (West Perth) (25%)] was 151 kg of platinum, 55 kg of palladium, and 40 kg of rhodium, increases of 8% for platinum and palladium and of 3% for rhodium production (Aquarius Platinum Ltd., 2009, p. 15–16).

ARM platinum division had several joint ventures in South Africa—Modikwa Platinum Mine, 50% jointly owned with Anglo Platinum; Nkomati Nickel Mine, 50% with MMC Norilsk Nickel; and Two Rivers Platinum Mine, a project in which ARM held 55% and Implats 45%. Production from Modikwa was 4,200 kg of PGM, and from Nkomati, production was 1,300 kg of PGM, both reported on a 100% basis. Modikwa and Nkomati production increased by 15% and 25%, respectively, relative to that of 2007. Two Rivers produced 3,420 kg of PGM during 2008, operating at close to full capacity. The mine had a surface

ore stockpile of more than 243,000 t at yearend and planned to process the ore during the first half of 2009 (African Rainbow Minerals Ltd., 2009, p. 28).

Eastern Platinum Ltd.'s (Vancouver) Crocodile River Mine produced 3,670 kg of PGMs in concentrate, a 9% increase from that in 2007 (Eastern Platinum Ltd., 2009).

Xstrata's Elandsfontein Platinum Mine produced close to 3,110 kg of platinum in its first full year of production. Production at Mototolo was lower owing to unforeseen geological conditions at the Lebowa Shaft, which negatively impacted ore grade and volume. Mining conditions were expected to improve in 2009 (Xstrata plc, 2009, p. 47–48).

Ridge Mining plc (London) expected commissioning of its Blue Ridge project in early 2009. The Sheba's Ridge project was put on hold (Jollie, 2009, p. 19).

Platinum Australia Ltd. had two projects in South Africa. The Smokey Hills project, in the Bushveld Complex, was in the development phase, and was expected to deliver its first concentrate for refining in early 2009. A bankable feasibility study was underway at the Kalahari Platinum Project, for which Platinum Australia entered into a joint-venture agreement with ARM. The Kalahari Platinum Project is planned as an open pit mine initially, with production forecast of 6,000 to 9,000 kilograms per year (kg/yr) of platinum, palladium, and rhodium (Platinum Australia Ltd., 2009, p. 2).

Zimbabwe.—In 2008, production from Impala's Mimosa Mine was 2,520 kg of platinum, down slightly relative to production in 2007. Mimosa's Wedza phase 5 expansion was commissioned in April, and was due for completion in the first half of 2009. In 2008, production from Impala's Zimplats Mine was 5,600 kg of PGMs, a decrease of 5% compared with 2007 production. At the Zimplats-managed Ngezi Mine, the phase I underground expansion was on schedule, the development of the first of two new portals was completed in September 2008, and the concentrator was expected to be commissioned in April 2009. Full production of 5,600 kg/yr was expected to be achieved in June 2009 (Impala Platinum Holdings, Ltd., 2009, p. 59–64).

Anglo Platinum's Unki project, located near Gweru, was planned as a 120,000-metric-ton-per-month operation, with potential for increasing the mine and concentrator capacity. Anglo Platinum entered into an agreement with the Zimbabwe Government in which 31.3% of the PGM mining claims were released to the Government in exchange for empowerment credits; the agreement was expected to become effective in 2009 (Anglo Platinum Ltd., 2009, p. 79).

Outlook

The global economic crisis that unfolded in the latter half of 2008 had major repercussions for the PGM industry because it resulted in lowered demand for industrial metals such as the PGMs.

The primary end use for palladium, platinum, and rhodium is the automotive industry; therefore, the outlook for that industry will have the greatest impact on the consumption and prices of these PGMs. Automobile production has decreased in Europe and the United States, and although demand for automobiles continues to rise in other areas of the world such as China,

India, and Russia, it is not likely to be enough to compensate for the decrease in auto production elsewhere. Therefore, an overall decrease in demand for PGM in that sector is expected. Recent actions by some Governments in the form of lower vehicle taxes and incentives to scrap older vehicles for newer, environmentally friendly automobiles may support vehicle demand somewhat. Additionally, in Europe, Euro V light-duty vehicle emission standards were expected to result in greater use of platinum in diesel particulate filters. In the electronics sector, palladium demand is likely to remain weak as a result of the slowdown in the global economy, and production volumes are expected to remain depressed. However, because palladium competes with gold in some applications such as plating and connectors, the large price difference between the two metals might lead to a trend of increasing use of palladium in those areas. In the industrial sector, including the glass and chemical industries, demand was expected to drop because of the drop in construction of manufacturing facilities. The demand for platinum in the jewelry sector was expected to rise worldwide because of the price drop. Demand in the investment sector will be price dependent but is expected to remain strong for both platinum and palladium. On the supply side, platinum production is expected to increase somewhat or remain level from South Africa through 2009. However, production from South Africa will be dependent on several issues including timelines for new projects and ramp ups, stability of power supplies, availability and retention of skilled workers, quick resolution of labor disputes, and improved safety records. Supply from Zimbabwe is unpredictable because of the volatile political situation in that country. The consumption of rhodium is expected to decrease as a result of lower vehicle demand as well as the thrifting that was undertaken when the rhodium price had reached record highs. Ruthenium demand, which is tied to the electronics sector, was expected to drop in response to lowered purchasing in that sector. Iridium demand was likely to weaken in response to lower uses such as spark plugs in the aerospace industry.

The launch of two ETFs in 2007 also affected the PGM industry by removing metal from the market. Investment in these funds started slowly but accelerated as the year went on and as PGM prices increased, then dropped. Because of the volatile PGM pricing, investment in these funds is likely to continue to increase.

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TABLE 1
SALIENT PLATINUM-GROUP METALS STATISTICS¹

		2004	2005	2006	2007	2008
United States:						
Mine production:						
Palladium, Pd content: ²						
Quantity	kilograms	13,700	13,300	14,400	12,800	11,900
Value	thousands	\$102,000	\$87,100	\$150,000	\$148,000	\$136,000
Platinum, Pt content: ²						
Quantity	kilograms	4,040	3,920	4,290	3,860	3,580
Value	thousands	\$110,000	\$113,000	\$158,000	\$162,000	\$182,000
Refinery production:						
Palladium, Pd content:						
Quantity	kilograms	5,480	5,220	5,660	7,410	7,650
Value	thousands	\$41,000	\$34,100	\$58,700	\$85,100	\$87,300
Platinum, Pt content:						
Quantity	kilograms	16,700	6,360	6,870	8,930	7,400
Value	thousands	\$456,000	\$184,000	\$253,000	\$375,000	\$376,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	3,230	3,010	2,800	3,410	2,550
Osmium, Os content	do.	75	39	56	23	11
Palladium, Pd content	do.	127,000	139,000	119,000	113,000	120,000
Platinum, includes waste, scrap, and coins, Pt content	do.	86,400	106,000	114,000	181,000	150,000
Rhodium, Rh content	do.	13,200	13,600	15,900	16,600	12,600
Ruthenium, Ru content	do.	18,800	23,200	36,000	48,700	49,800
Exports, refined:						
Iridium, osmium, and ruthenium, gross weight	do.	1,090	1,080	3,390	8,190	6,450
Palladium, Pd content	do.	31,500	27,000	53,100	41,800	26,400
Platinum, Pt content	do.	20,000	20,700	45,500	28,900	15,600
Rhodium, Rh content	do.	314	615	1,600	2,210	1,980
Stocks, National Defense Stockpile, December 31:						
Iridium, Ir content	do.	501	189	111	18	18
Palladium, Pd content	do.	568	--	--	--	--
Platinum, Pt content	do.	649	261	261	261	261
Price, average:						
Iridium ³	dollars per troy ounce	185.33	169.51	349.45	444.43	448.34
Palladium ⁴	do.	232.93	203.54	322.93	357.34	355.12
Platinum ⁴	do.	848.76	899.51	1,144.42	1,308.44	1,578.26
Rhodium ⁴	do.	983.24	2,059.73	4,561.06	6,203.09	6,533.57
Ruthenium ³	do.	64.22	74.41	193.09	573.74	324.60
Employment		1,580	1,620	1,719	1,625	1,364
World, mine production ^c , PGM content	kilograms	472,000 ^r	505,000 ^r	514,000 ^r	512,000 ^r	465,000

^cEstimated. ^rRevised. do. Ditto. -- Zero.

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

²Source: Stillwater Mining Co., 2008 annual report, p. 49.

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

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

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM, BY COUNTRY¹

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)
2007	622	\$20,100	65,900	\$2,620,000	3,940	\$145,000	10,200	\$330,000	101,000	\$446,000	58	\$964
2008:												
Australia	--	--	--	--	--	--	824	53,300	131	6,540	2	80
Austria	--	--	--	--	--	--	1	95	5	154	651	20,400
Belgium	--	--	1,820	96,900	27	1,840	--	--	--	--	--	--
Bolivia	--	--	--	--	--	--	--	--	14,000	1,450	--	--
Brazil	--	--	225	12,500	--	--	1	48	24,500	32,100	--	--
Canada	8	394	3	160	4	145	445	23,200	3,970	50,200	66	1,190
Chile	--	--	--	--	--	--	--	--	20,100	20,700	--	--
China	--	--	--	--	(2)	4	11	586	1,320	8,900	--	--
Colombia	--	--	--	--	1,150	42,000	--	--	346	8,350	--	--
Germany	162	4,840	1,530	82,200	792	40,300	3,360	81,500	7,330	196,000	(2)	9
Hong Kong	--	--	--	--	--	--	4	241	2,580	14,100	--	--
Israel	--	--	--	--	184	5,080	--	--	35	2,030	1	4
Italy	2	115	732	37,200	41	2,260	877	49,400	(2)	3	--	--
Japan	--	--	280	15,100	35	1,290	50	1,500	4,730	63,600	--	--
Korea, Republic of	--	--	--	--	--	--	11	350	4,350	48,200	--	--
Mexico	--	--	--	--	52	2,360	44	1,350	1,520	65,600	--	--
Norway	--	--	671	36,100	--	--	--	--	--	--	--	--
Russia	--	--	830	44,800	1,680	78,300	--	--	--	--	--	--
South Africa	1	49	26,300	1,280,000	4	44	652	33,400	--	--	--	--
Switzerland	--	--	497	12,300	1	49	353	9,330	--	--	3	90
United Kingdom	30	1,430	12,800	710,000	69	3,610	513	26,900	107	1,950	11	603
Venezuela	--	--	--	--	--	--	--	--	4,360	835	--	--
Other	9	380	57	2,540	(2)	14	31	871	2,820	72,200	--	--
Total	212	7,210	45,700	2,330,000	4,040	177,000	7,180	282,000	92,200	593,000	734	22,400

-- Zero.

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

²Less than 1/2 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 COUNTRY¹

Country	Unwrought palladium		Palladium, other		Iridium ²		Osmium ²		Ruthenium ²		Rhodium ²	
	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)
2007	101,000	\$1,120,000	11,600	\$129,000	3,410	\$41,900	23	\$192	48,700	\$655,000	16,600	\$2,650,000
2008:												
Belgium	2,340	32,300	88	994	--	--	--	--	314	3,160	1,360	247,000
Canada	771	15,000	954	14,800	--	--	--	--	--	--	--	--
China	50	573	27	519	(3)	3	8	56	--	--	--	--
Estonia	--	--	--	--	--	--	--	--	2,110	21,200	--	--
Germany	386	4,760	139	1,410	330	5,060	4	46	22,700	181,000	979	145,000
Japan	2,940	11,400	177	605	1	19	--	--	615	3,850	6	1,730
Norway	6,150	73,400	--	--	--	--	--	--	--	--	186	14,100
Russia	65,000	716,000	3,440	47,600	--	--	--	--	8,410	54,700	1,490	322,000
South Africa	20,500	229,000	327	2,780	1,410	19,100	--	--	11,700	123,000	6,740	1,280,000
Switzerland	245	3,210	1,190	11,200	--	--	--	--	--	--	--	--
United Kingdom	13,500	156,000	347	4,220	765	11,900	--	--	3,520	33,600	1,550	408,000
Other	1,790	25,600	117	1,450	43	512	--	--	541	4,860	268	57,600
Total	114,000	1,270,000	6,810	85,500	2,550	36,600	11	101	49,800	426,000	12,600	2,470,000

-- Zero.

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

²Unwrought and other forms.

³Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY¹

Country	Palladium		Platinum		Platinum, waste and scrap		Iridium, osmium, ruthenium		Rhodium	
	Quantity, Pd content	Value	Quantity, Pt content	Value	Quantity, Pt content	Value	Quantity, gross weight	Value	Quantity, Rh content	Value
	(kilograms)	(thousands)	(kilograms)	(thousands)	(kilograms)	(thousands)	(kilograms)	(thousands)	(kilograms)	(thousands)
2007	41,800	\$298,000	28,900	\$763,000	54,400	\$924,000	8,190	\$145,000	2,210	\$401,000
2008:										
Australia	536	5,690	13	983	1	23	3	24	--	--
Belgium	130	2,000	117	2,750	5,070	31,400	3	24	(2)	28
Brazil	125	1,670	76	3,380	--	--	5	57	44	12,100
Canada	3,160	35,300	587	20,900	903	28,100	39	671	49	14,000
China	547	7,000	689	28,800	75	284	195	2,950	288	41,700
Czech Republic	148	391	--	--	--	--	--	--	--	--
France	597	5,100	101	3,390	3	42	20	137	(2)	3
Germany	3,790	23,300	4,060	158,000	28,100	285,000	130	1,150	351	45,200
Hong Kong	1,340	13,700	707	22,300	--	--	377	4,650	27	8,710
India	123	550	96	6,530	(2)	13	16	164	8	1,050
Israel	2,200	7,120	8	180	--	--	3	68	--	--
Italy	1,660	16,300	716	37,600	2	14	36	577	72	3,930
Japan	2,240	17,100	2,680	102,000	2,980	169,000	1,040	12,800	773	165,000
Korea, Republic of	570	2,900	235	9,610	171	612	2	14	1	156
Mexico	285	912	245	8,360	(2)	25	165	4,610	3	497
Singapore	64	619	14	367	--	--	1,840	17,000	--	--
South Africa	43	209	--	--	925	40,500	--	--	(2)	3
Spain	176	1,280	11	180	--	--	1	6	--	--
Switzerland	333	4,150	2,960	87,800	2	138	125	2,010	--	--
Taiwan	2,290	9,410	524	13,800	--	--	914	12,300	354	8,450
United Kingdom	5,140	33,100	939	32,400	16,500	630,000	913	11,600	4	580
Other	931	9,260	798	31,300	11	547	624	9,720	5	668
Total	26,400	197,000	15,600	570,000	54,700	1,190,000	6,450	80,600	1,980	302,000

-- Zero.

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

²Less than ½ unit.

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

TABLE 5
PLATINUM-GROUP METALS: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Kilograms)

Country ³	2004	2005	2006	2007	2008
Palladium:					
Australia ⁴	800	550	750 ^r	600	700
Botswana	2,500	1,900	2,000	5,000 ^r	3,000
Canada	12,000	10,415 ⁵	10,493 ⁵	16,000 ^r	15,000
Japan ⁶	5,300	5,400	5,400	5,500	5,500
Poland ^{7,8}	10	10	10	10	10
Russia	97,000	97,400	98,400	96,800	87,700
Serbia	19 ^{r,9}	19 ^{r,9}	15 ^r	15 ^r	15
South Africa	76,403 ⁵	82,961 ⁵	86,265 ⁵	83,643 ^{r,5}	75,536 ⁵
United States ¹⁰	13,700 ⁵	13,300 ⁵	14,400 ⁵	12,800 ⁵	11,900 ⁵
Zimbabwe	3,564 ⁵	3,879 ⁵	4,022 ⁵	4,180 ^{r,5}	4,386 ⁵
Total	211,000	216,000	222,000	225,000^r	204,000
Platinum:					
Australia ⁴	200	111	209 ^r	142 ^r	200
Botswana	500	300	300	700 ^r	600
Canada	1,000 ^r	7,000 ^r	7,500 ^r	7,000 ^r	7,000
Colombia	1,209 ⁵	1,082 ⁵	1,438 ⁵	1,526 ^{r,5}	1,500
Ethiopia	--	--	5 ^r	9 ^r	10
Finland	705	800	800	800	800
Japan ⁶	750	760	760	770	770
Poland ^{7,8}	20	20	20	20	20
Russia	28,000	29,000	29,000	27,000	23,000
Serbia	-- ^{r,9}	3 ^{r,9}	2 ^r	2 ^r	2
South Africa	153,239 ⁵	163,711 ⁵	168,125 ⁵	160,940 ^{r,5}	146,140 ^{p,5}
United States ¹⁰	4,040 ⁵	3,920 ⁵	4,290 ⁵	3,860 ⁵	3,580 ⁵
Zimbabwe	4,438 ⁵	4,834 ⁵	4,998 ⁵	5,306 ^{r,5}	5,642 ⁵
Total	194,000^r	212,000^r	217,000^r	208,000^r	189,000
Other platinum-group metals:					
Canada	4,000 ^r	5,000	5,000 ^r	4,000 ^r	4,000
Russia	15,000	15,500	15,600	14,500	12,500
South Africa	46,759 ⁵	56,309 ⁵	53,138 ⁵	59,449 ^{r,5}	54,091 ^{p,5}
Zimbabwe	809 ⁵	862 ⁵	864 ⁵	1,695 ^{r,5}	1,804 ⁵
Total	66,600^r	77,700	74,600^r	79,600^r	72,400
Grand total	472,000^r	505,000^r	514,000^r	512,000^r	465,000

^pPreliminary. ^rRevised. -- Zero.

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

²Table includes data available through May 7, 2009. 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.

³In addition to the countries listed, China, Indonesia, and the Philippines are thought 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.

⁴PGM 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.

⁵Reported figure.

⁶Production derived entirely from imported ores.

⁷Based on official Polish estimates.

⁸Estimates based on reported platinum- and palladium-bearing final (residual) slimes and then average Pt and Pd content from electrolytic copper refining.

⁹Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

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